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WAR DEPARTMENT

TECHNICAL MANUAL

TO

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3, FOR MEDIUM TANKS M3 AND M4 AND RELATED GUN MOTOR CARRIAGES

SEPTEMBER 25, 1943

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TECHNICAL MANUAL
No. 9-1750E

WAR DEPARTMENT, ORDNANCE OFFICE
Washington, September 25, 1942

ORDNANCE MAINTENANCE
Guiberson Diesel T1400 Engine, Series 3, for Medium Tanks M3 and M4 and Related Gun Motor Carriages

Prepared under the direction of the

Chief of Ordnance

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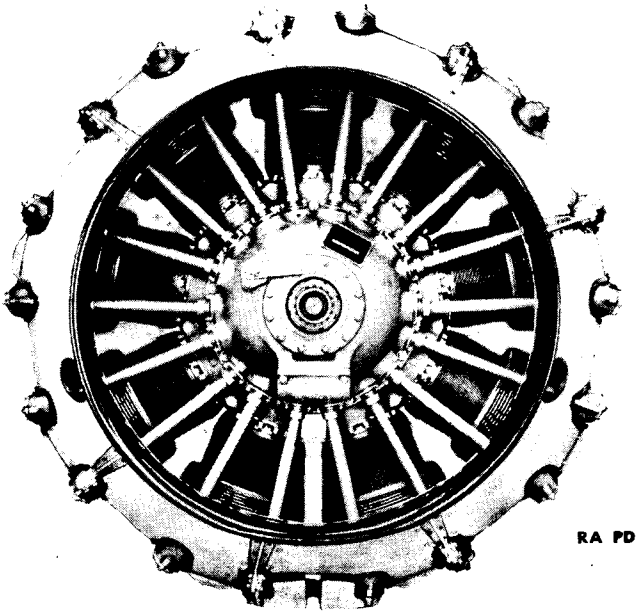

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Figure 1—Front of Engine

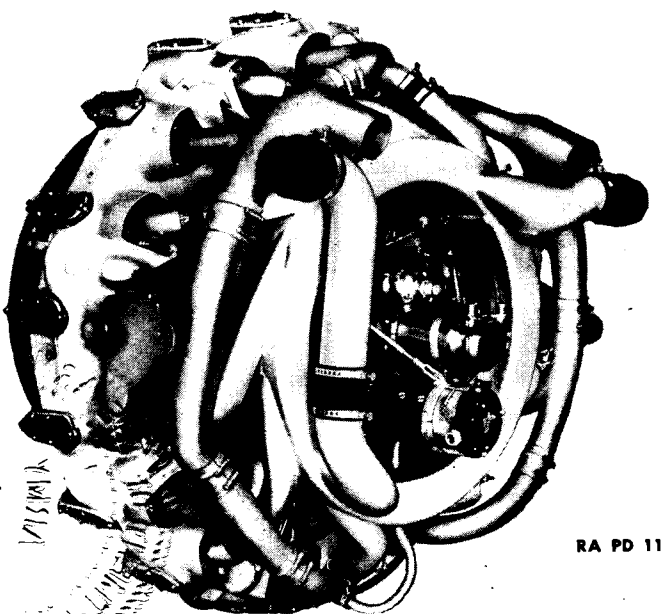

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Figure 2—Rear of Engine

Section I

GENERAL DESCRIPTION AND SPECIFICATIONS

1. SCOPE.

This manual is published for the information and guidance of ordnance maintenance personnel. It contains detailed instructions for inspection, disassembly, assembly, maintenance and repair of the Guiberson Diesel Engine, Model T1400, Series 3. Section XII of this manual lists all Standard Nomenclature Lists, Technical Manuals and other publications pertinent to the materiel described herein.

2. DESCRIPTION.

a. General Description.

(1) The Guiberson Diesel Engine, Model T1400, is a nine-cylinder radial engine, air-cooled, and using fuel oil for fuel. Cooling fins around the cylinder heads and barrels are provided for heat radiation, and baffles direct the flow of air to the cylinders.

(2) The engine is mounted vertically in the tank with the intake and exhaust manifolds to the rear, with the cowling and flywheel facing the front of the tank. Therefore, the manifold side of the engine is referred to as the rear of the engine, and the cowling and flywheel side of the engine is referred to as the front.

(3) The cylinders fire counterclockwise, facing the front of the engine, the firing order being 1-3-5-7-9-2-4-6-8. No. 1 cylinder is at the top of the engine.

(4) Air is drawn into the intake manifold through a vertical air horn and air cleaner at each side of the engine. The air is compressed in the combustion chamber to a ratio of 14 to 1. Compression raises the temperature of the air sufficiently to ignite the fuel oil, when it is injected.

(5) Fuel is pumped into the fuel channel of the engine by a fuel supply pump. However, individual injection pumps, at each cylinder, build up pressure that forces the fuel into the cylinders. These injection pumps also measure the correct amount of fuel which is forced into the combustion chamber through a fuel injector at each cylinder.

(6) The operation of the fuel injection pumps is controlled by a fuel control assembly at the rear of the engine. The injection pump

plungers ride on the levers of the fuel control lever assembly. These levers move up and down, actuated by the lobes of the fuel cam ring over which they operate, to move the injection pump plungers up and down. The position of the plunger on the lever determines the length of stroke, and amount of fuel injected.

(7) Valve tappets operate on the valve cam in the "nose" or front crankcase section. The intake valve tappets operate over the lobes of one cam, while the exhaust valve tappets are operated by a different cam.

(8) A decompression plate is also located in the front crankcase section. When the decompression lever in the tank is set at "decompression," the exhaust valve tappets rest on the lobes of the decompression plate and are held open.

(9) Lubrication of moving parts of the engine is accomplished by oil which is forced through drilled passages and by oil splash created by moving parts within the crankcase. Oil is pumped from an external tank and circulated through the engine. Before it is returned to the tank it is passed through oil coolers to reduce the temperature.

(10) A complete description of the various parts of the engine follows:

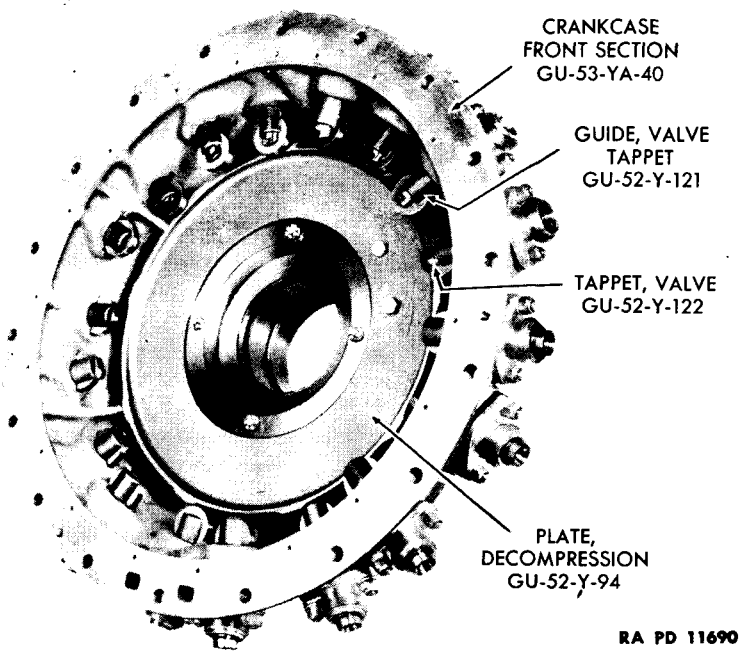

Figure 3—The Crankcase Front Section and Decompression Plate

GENERAL DESCRIPTION AND SPECIFICATIONS

b. Detailed Description.

(1) CRANKCASE.

(a) The crankcase is in four sections. The front and rear center sections are bolted together at the center line of the cylinders, and carry the cylinder barrel mounting studs.

(b) The rear center section is in turn bolted to the rear mounting section of the crankcase. Mounting brackets of the rear mounting crankcase section bolt to the engine mounting beam.

(c) The front crankcase section contains the valve tappets and guides, and the decompression plate (fig. 3), and is bolted to the front center crankcase section.

(d) Hardened bearing liners on which the crankshaft bearings operate are pressed into the two center sections of the case. Fuel injection pumps are in the rear mounting section. The fuel channel is bored in the rear mounting section between the fuel pump bosses.

(2) CYLINDERS. Heat-treated aluminum alloy cylinder heads are screwed and shrunk onto forged steel barrels. Cooling fins are provided by an aluminum alloy muff or sleeve on the barrels and cooling fins are also provided on the cylinder heads to provide ample radiation surface. Cylinder bores are bored, ground and honed to mirror finish and held within extremely close limits. Valve seats made of special materials are shrunk in the cylinder heads. The rocker boxes are cast integral with the heads.

(3) PISTONS (fig. 54). Aluminum alloy pistons of special heat-resisting quality have three compression rings, two oil rings above the piston pin and one scraper ring in the skirt. The two oil rings are in one groove. The pistons are forged. The full floating piston pins have aluminum alloy plugs for the piston pin retaining device.

(4) MASTER ROD (fig. 33). The master rod is an "I" section of forged steel, heat-treated, machined and polished. The crankpin bearing is an integral type, precision bored, steel-backed, lead-bronze bushing. The link rods operate on knuckle pins in the master rod. These are secured in the master rod by retaining rings. The master rod is drilled to provide pressure lubrication to the knuckle pin bushings.

(5) LINK RODS. Each link rod is an "I" section, completely machined and polished. The knuckle pin bushings and piston pin bushings are pressed into the link rods. All bearings are jig-bored for alinement and center distance.

(6) CRANKSHAFT (fig. 33). The front and rear crankshafts are heat-treated steel forgings drilled throughout for lightness and plugged to form forced feed oil passages. The shaft is of the one-throw design and is completely machined. The crankpin is carburized for hardness and is accurately ground to size. The crankpin step is accurately ground and fitted to a ground hole in the rear cheek, where it is clamped in place. A floating counterweight is used on the rear crankshaft. The shaft is supported by two roller bearings referred to as main bearings,

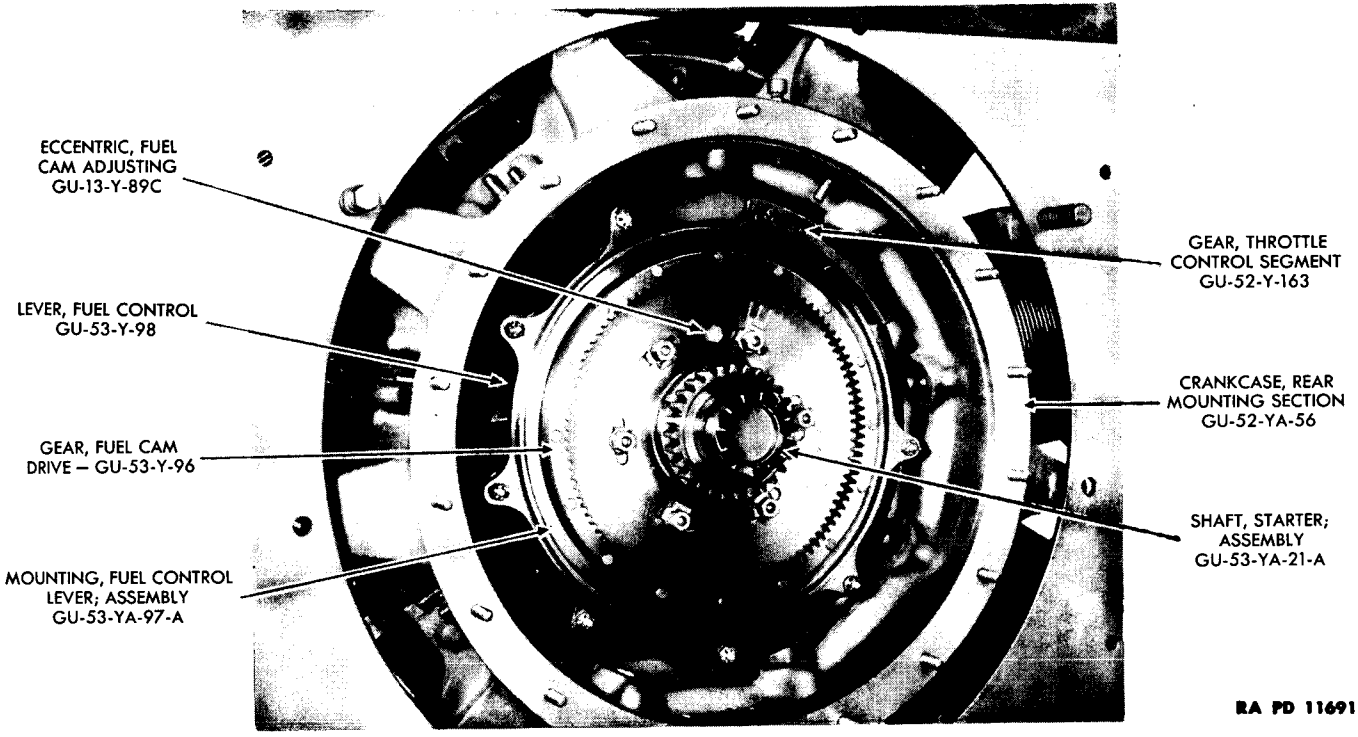

Figure 4—The Fuel Control Assembly

and one ball thrust bearing at the forward end. The flywheel end of the shaft is machined with a spline (modified aeronautical—SAE 40), modified in length for the flywheel hub.

(7) FUEL CONTROL LEVER ASSEMBLY (figs. 13 and 70).

(a) Fuel control levers are mounted so that the rollers in the ends of the levers operate on a fuel cam ring. The levers move up and down as the rollers contact the lobes of the fuel cam ring.

(b) A throttle control segment gear moves the fuel control lever assembly as the throttle is operated.

(c) The fuel injection pump plungers ride on the levers of the fuel control lever assembly (fig. 13). As the levers move up and down over the lobes of the fuel cam ring, the plungers move up and down to operate the fuel injection pumps.

(d) Turning the fuel control lever assembly by means of the throttle control segment gear and throttle gear, changes the location of the injection pump plungers on the fuel control levers. This determines the length of the plunger stroke and the amount of fuel injected.

(8) FUEL CAM RING AND DRIVE GEAR (fig. 4). The fuel cam ring is of forged steel heat-treated and machined all over. It is secured to the fuel cam drive gear by six bolts. Slots in the drive gear permit the fuel cam ring to be turned relative to the drive gear for fuel timing the motor. A fuel cam adjusting eccentric extends through the drive gear for adjusting the fuel cam ring when the securing nuts are loosened.

(9) VALVE CAM. The valve cam is of completely machined forged steel, and the cam track and gear are hardened. The intake and exhaust cams are on different planes, with four lobes on each cam. The cam ring is carried on a bronze bushing. The cam drive gear is integral with the cam ring, turning $\frac{1}{8}$ engine speed in the direction opposite to the crankshaft rotation. The cam gear meshes with an intermediate gear operated by the crankshaft gear.

(10) VALVE OPERATING MECHANISM (fig. 3).

(a) The tappets, which operate the valves, have rollers which ride on the valve cam ring. The tappets fit into heat-treated steel guides which have a threaded aluminum adapter at the top. The push rod housing nut screws onto this threaded adapter, sealing out dirt.

(b) The push rods, which set on the valve tappets and operate the valve rockers, are made of light steel tubing with pressed-in ball ends, hardened and ground. The push rod is fully enclosed. The top end fits into a socket in the rockers. The inner end of the push rod (marked with an arrow) has a ball check valve that lets lubricating oil into the push rod, but keeps it from draining out of the push rod. Each rocker is mounted on a bearing. The rocker mechanism is enclosed.

(c) The push rod housing is a tube flanged at one end. The push rod housing nipple in the rocker box receives the straight end of the

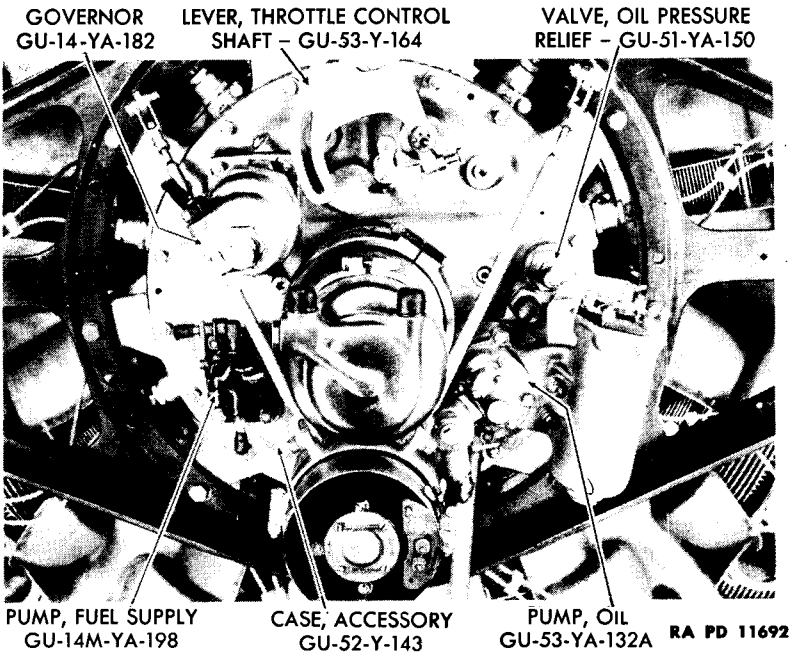

Figure 5—The Accessory Case with Accessories Mounted

push rod tube. Push rod housing nuts retain a packing ring which securely seals the push rod housing assembly from dust or oil leaks.

(11) ACCESSORY CASE (fig. 5). The accessory case is an aluminum alloy casting, attached to the rear mounting section of the crankcase and contains the entire gear train. Standard SAE flange mountings are provided for the starter, generator and fuel supply pump. The accessory case also carries the oil pump, oil pressure relief valve, throttle control shaft, outlet oil connections and case vent holes and has a mounting for the governor. Directly above the starter flange is a small removable inspection plate to permit adjustment of the fuel cam ring. Drilled ducts are provided for the oil from the lubricating oil pressure pump to the crankshaft and intermediate and idler gear bushings. A cored duct is incorporated for the bypassed oil and the oil from the scavenging pump.

(12) INTAKE MANIFOLD (fig. 6). The intake manifold is composed of the intake manifold, intake elbows and flanges, connecting hoses, and clamps. Intake elbows connect the manifold with each cylinder head.

(13) EXHAUST MANIFOLD (fig. 7). The exhaust manifold is composed of two halves, one for the right side and one for the left side of the engine. Branch pipes connect the exhaust ports with the exhaust manifold and are clamped to the exhaust manifold. The outlet pipe size is ample for each half of the manifold.

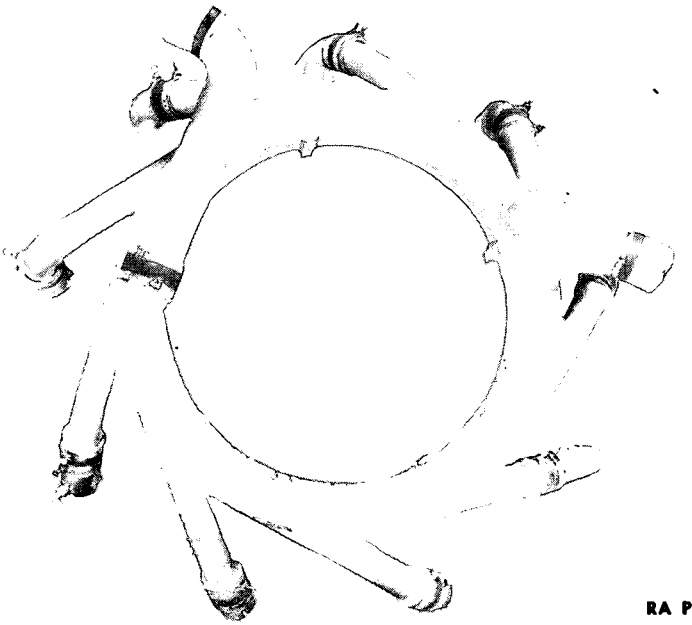

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Figure 6—The Intake Manifold

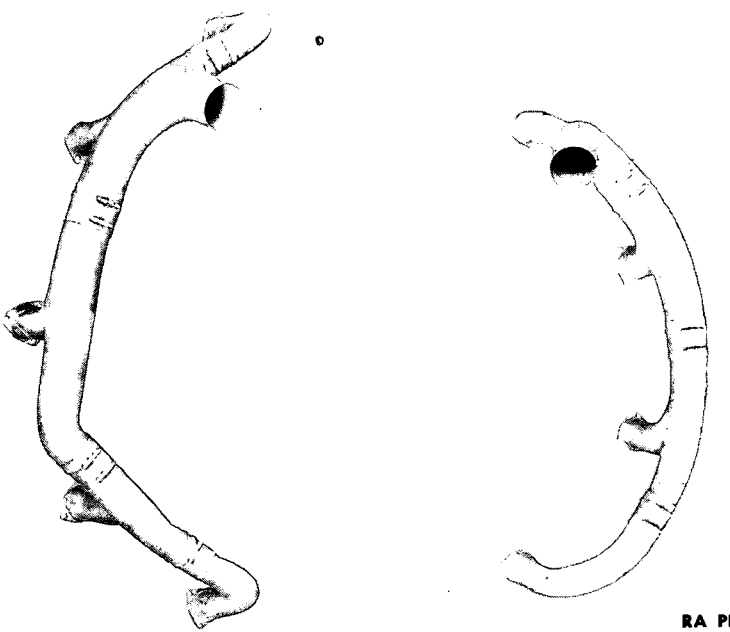

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Figure 7—The Exhaust Manifold

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

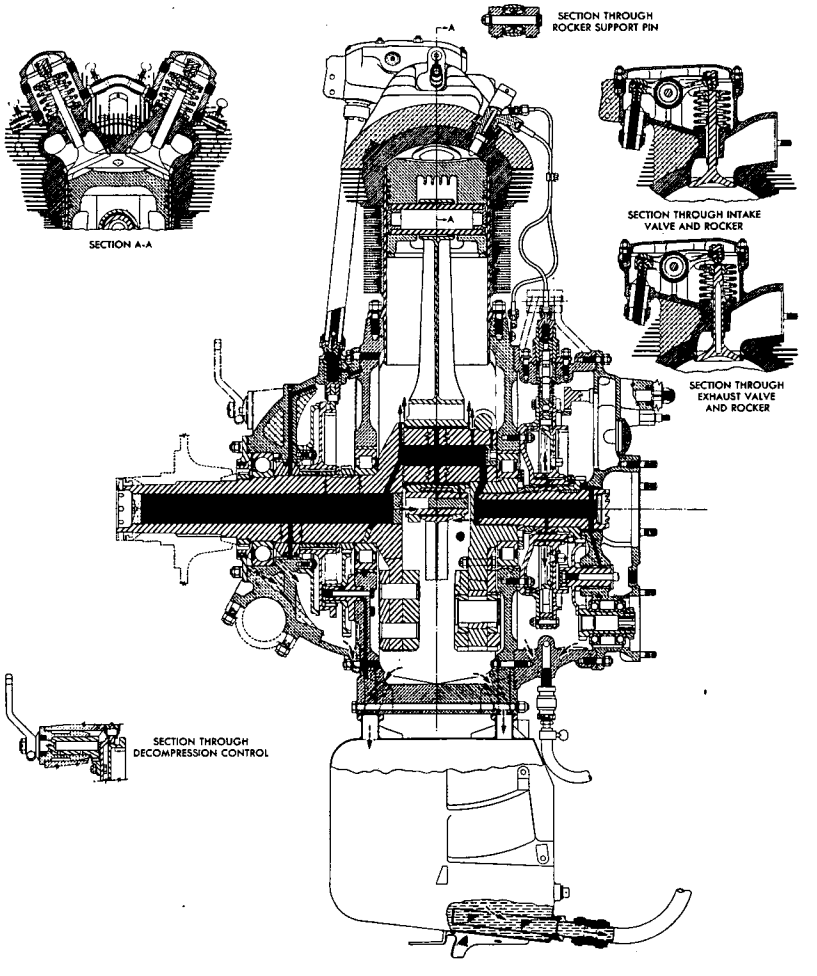


Figure 8—Lubricating Oil Diagram

GENERAL DESCRIPTION AND SPECIFICATIONS

(14) LUBRICATING OIL SYSTEM (figs. 8 and 9).

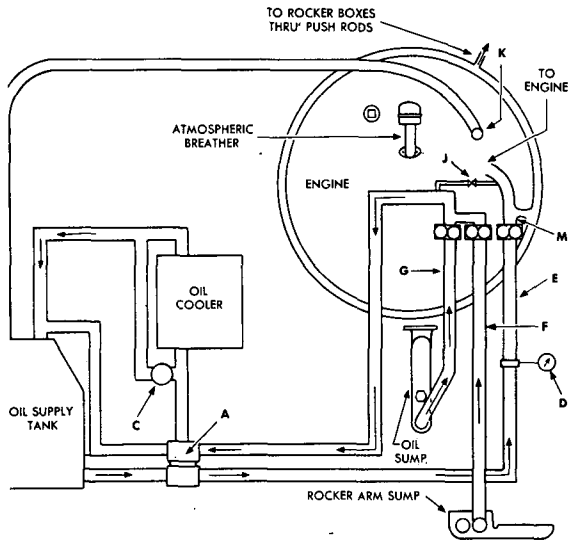
(a) When it is necessary to change the grade of oil, drain the entire oil system, including the storage tank, the sump and the filter. If a cartridge type filter is used on the tank, renew the filter cartridge before refilling the system with new oil.

(b) The following table should be observed for the operation of the engine:

Oil Inlet Temperature During Operation

ATMOSPHERIC TEMPERATURE	MINIMUM	MAXIMUM	SAE
Below 32 F	100 F	180 F	30
Above 32 F	100 F	180 F	50

The minimum oil pressure should be not less than 70 pounds per square inch with 160 F oil at 800 revolutions per minute and a maximum of 95 pounds per square inch at 2,325 revolutions per minute with no load. The operating pressure at 2,000 revolutions per minute should be approximately 85 pounds per square inch.



A – VALVE SECTION OF TEMPERATURE REGULATOR VALVE
C – COOLER PROTECTION VALVE
D – OIL TEMPERATURE GAUGE CONNECTION
E – PRESSURE PUMP INLET
F – ROCKER BOX SCAVENGER INLET
G – OIL SUMP SCAVENGER INLET
J – OIL PRESSURE RELIEF VALVE
K – AIR BREATHER HOLE
M – THE OIL PUMP HAS A BUILT-IN FULL FLOW LUBRICATING OIL FILTER

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Figure 9—Lubricating Oil Paths

(c) The lubricating system is made up of a storage tank, oil filters, a combination oil pump, the engine, and an oil cooler. The combination oil pump consists of a pressure pump, a scavenger pump for the crankcase, and a separate scavenger pump for the rocket boxes. The two scavenger pumps are connected together on the outlet sides of the gear compartments. A single outlet from the crankcase scavenger pump housing serves as the outlet for both scavenger pumps. See figure 28 for the various parts of the oil pump assembly.

(d) Oil from the supply tank goes to the pressure pump which forces the oil through the Cuno oil filter into a cored passage in the accessory case. Part of the oil is bypassed by the spring loaded pressure relief valve into a second cored passage which is connected to the oil return line. This excess oil then goes through the oil cooler and back to the main supply tank. The cartridge type filters are connected to the pressure side of the scavenger gears of the oil pump. The oil moves slowly through this type of filter, leaving the small particles of dirt or carbon in the filter cartridges. This filtered oil returns directly to the oil tank.

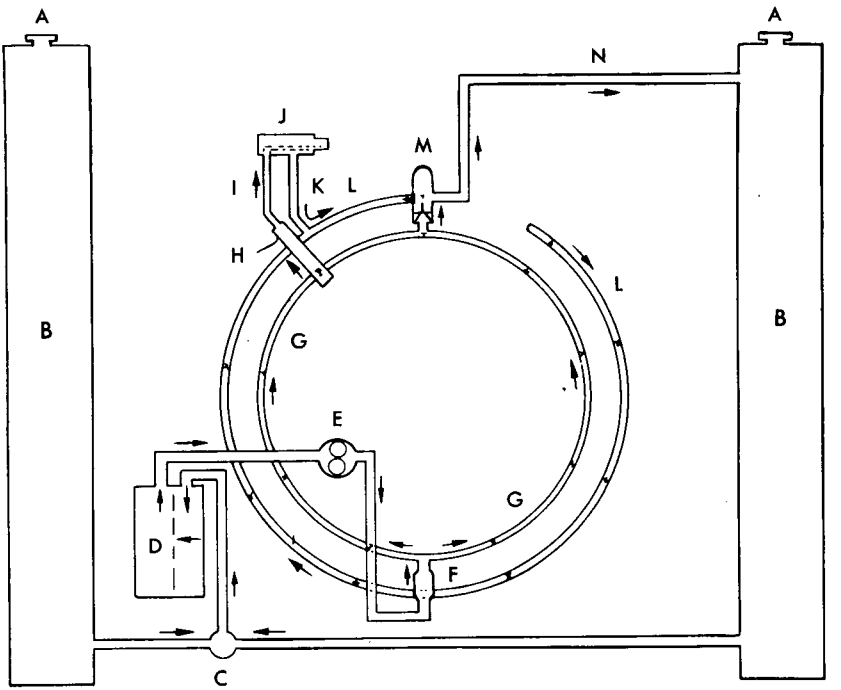
(e) The oil which lubricates the moving parts of the engine is forced by the pressure pump from the cored passage through a drilled oil line to a circular groove located in the accessory case. This groove is located immediately behind the starter jaw bushing. Oil passages are drilled in the accessory case from this circular groove to the intermediate gear, the idler gear, and the governor mounting pad.

(f) The starter jaw bushing is drilled to connect the circular groove in the accessory case with a groove in the starter jaw. Through this path the oil is forced to the center of the crankshaft which is drilled to serve as a gallery line to supply oil to the master rod bearing, the knuckle pin bushings, and the valve cam. Pressure-forced oil from the crankshaft lubricates the valve cam and fuel cam gear. The gear train is lubricated by the oil from the starter jaw, intermediate gear, and idler gear bushings, which also receive pressure lubrication.

(g) The oil which lubricates the parts in the crankcase and accessory case is splashed by the rotating parts to lubricate the piston pins. As the oil falls to the bottom of the case it passes into the oil sump, from which it is pumped by the main scavenger pump. The oil is returned through the joint return line to the cooler and oil supply tank.

(h) Push rods, tappets, and rockers are lubricated by oil that passes from the crankshaft through the drilled passage in the front crankcase section to a circular groove machined in the front center section of the crankcase. Holes are drilled in the front crankcase section to connect the circular groove with holes drilled in each of the tappet guides. During the operation of the engine a hole in the tappet body comes in contact with the hole in the tappet guide to meter the shot of oil going into the hollow tappet body. Part of this oil lubricates the tappet body in the tappet guide. Another part of the oil passes by the check ball in the tappet end of the push rod to lubricate the push rod ends before

GENERAL DESCRIPTION AND SPECIFICATIONS



KEY

A TANK VENT	H INJECTION PUMP
B FUEL TANK	I PRESSURE LINE
C TANK VALVE	J INJECTOR
D FUEL OIL FILTER	K DRIP LINE
E SUPPLY PUMP	L FUEL RETURN RING
F ONE WAY CHECK VALVE	M REGULATOR VALVE
G FUEL CHANNEL	N RETURN LINE

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Figure 10—Diagrammatic Sketch of Fuel Oil Paths

passing on through the rocker to lubricate the rocker bearing. The oil which collects in the rocker boxes drains through a system of intercylinder drain tubes to the rocker box covers of No. 5 and No. 6 cylinders. The oil is then pumped through the rocker box scavenger oil pump into the joint return line, which directs the oil into the oil cooler and to the oil supply tank. The oil is then ready to repeat the cycles previously described.

(i) Lubrication for the valve cam intermediate gear is supplied by pressure oil through drilled passages in the front center section of the crankcase connecting the machined groove with the gear mounting spindle.

(j) A breather line from the right-hand breather opening (from starter end) is connected to the top of the oil supply tank through inlet connections in the oil tank. This line acts as a pressure stabilizing line between the air space in the oil tank and the crankcase. NOTE: It is recommended that an atmospheric breather should be connected to the inspection plate opening in the accessory case.

3. FUEL SYSTEM.

a. Fuel Supply Pump. Fuel from the tanks is drawn through a combination cloth and disk filter by the fuel supply pump. The fuel supply pump is mounted on the accessory case. The fuel supply pump gear, on the inside of the accessory case, is driven by the idler gear which meshes with the gear on the starter shaft. The fuel supply pump has a built-in safety bypass valve to protect the pump in case the flow of fuel should become restricted on the outlet side of the pump.

b. Fuel Oil Paths (fig. 10).

(1) Fuel enters the fuel channel of the engine through a one-way check-valve located at the bottom of the rear mounting section of the crankcase. This check-valve allows fuel to enter the fuel channel but the check prevents it from draining back out again.

(2) From the check-valve the fuel goes to the fuel channel, which is a drilled passage in the rear mounting section of the crankcase connecting the injection pump mounting holes. Fuel is supplied through this channel to each of the fuel injection pumps and passes from the pumps through the injector and into the combustion chamber.

c. Fuel Pressure Regulator (fig. 11).

(1) The pressure by which the fuel is forced through the channel to the injection pumps is controlled by a fuel pressure regulator located at the top of the engine between No. 1 and No. 2 fuel injection pumps.

(2) This regulator has a spring-operated valve which restricts the fuel passage until sufficient pressure is built up to overcome the spring pressure. Adjustment is made by removing the cap, loosening the lock

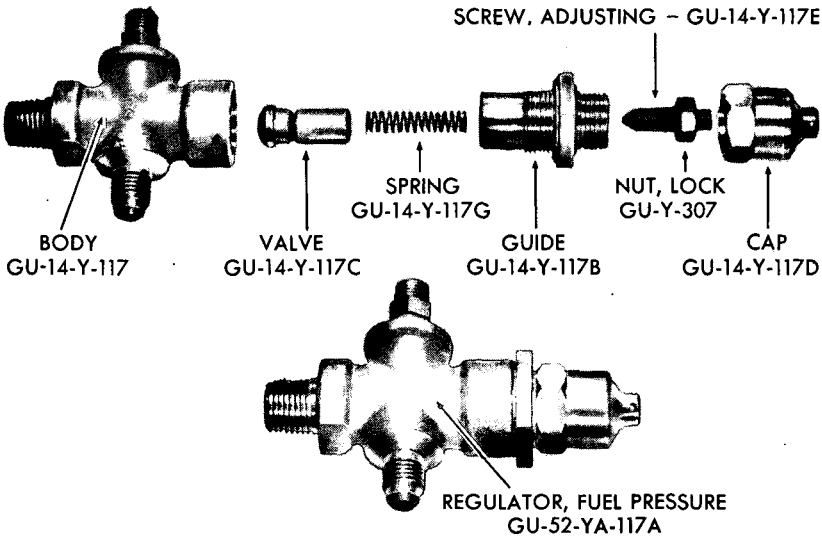


Figure 11—The Fuel Pressure Regulator Assembly

nut and turning the adjusting screw to increase or decrease the spring pressure. This valve is set to open at a pressure of six pounds per square inch.

d. Fuel Injection Pump (figs. 12 and 13).

(1) The fuel must be injected into the combustion chamber under extremely high pressure to overcome the resistance of the highly compressed air. This pressure is built up by a fuel injection pump at each cylinder, which also controls the quantity of fuel injected. The injection pumps are connected to the injectors by a heavy wall, high pressure tubing.

(2) The plunger of the injection pump rides on a lever on the fuel control plate assembly (fig. 13). The lever in turn operates on the fuel cam ring, moving up and down over the cams on the fuel cam ring. This moves the injection pump plunger up and down. Operation of the throttle shifts the position of the levers, changing the contact point of the plunger to a higher or lower position on the lever. This changes the length of the plunger stroke, and regulates the amount of fuel injected on each stroke.

(3) When the plunger is at the downward end of the stroke, fuel enters the pump through the inlet port above the plunger. A one-way check-valve allows fuel to flow through but prevents it from dropping back.

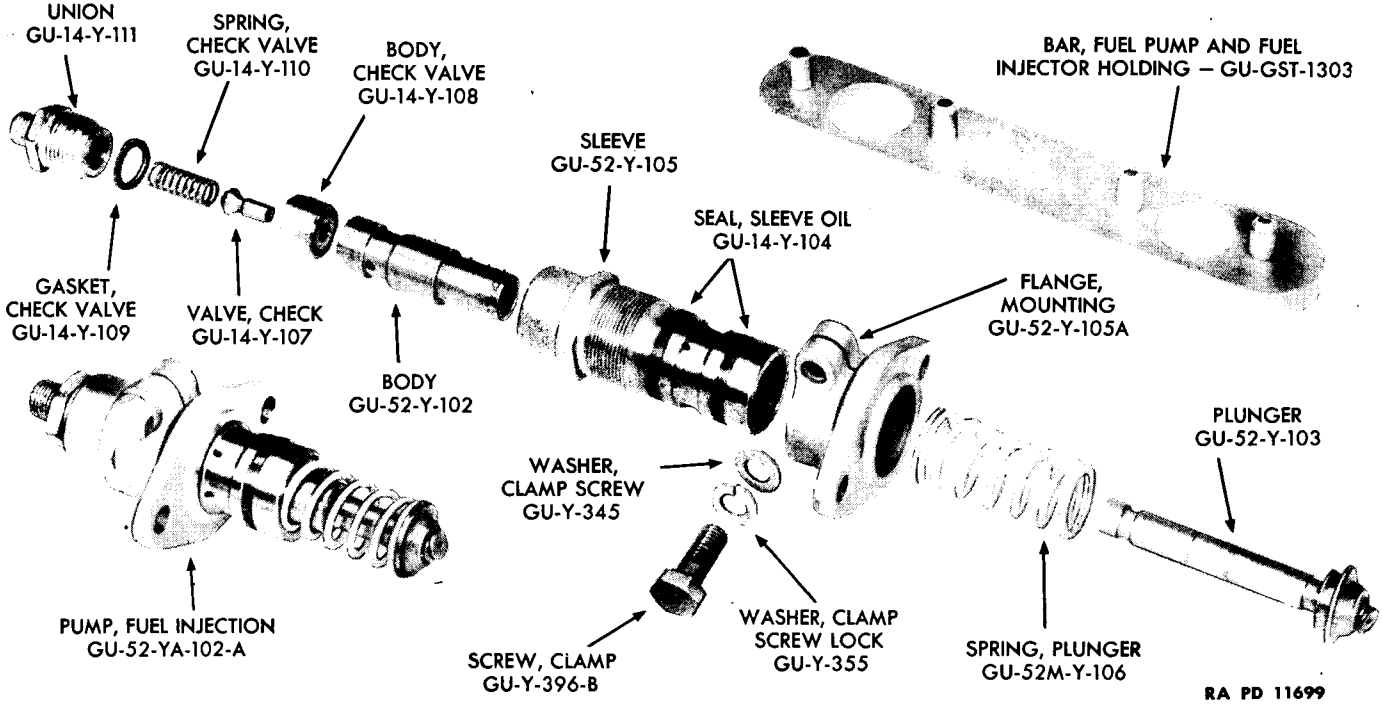
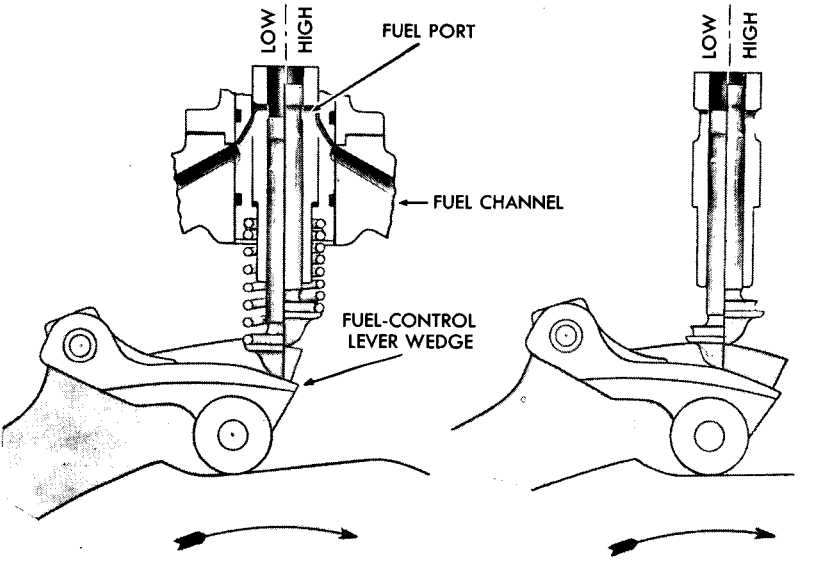


Figure 12—The Fuel Injection Pump Assembly

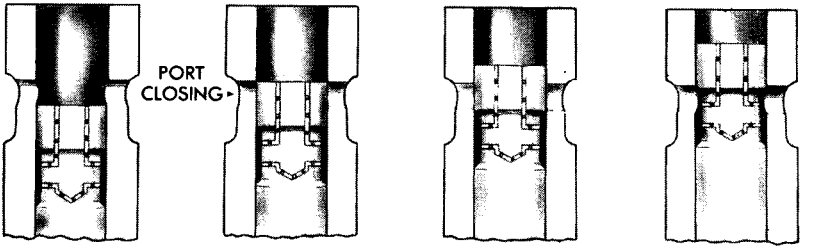
GENERAL DESCRIPTION AND SPECIFICATIONS



WIDE OPEN THROTTLE POSITION
ILLUSTRATION 1

SHUT-OFF THROTTLE POSITION
ILLUSTRATION 2

WIDE OPEN THROTTLE POSITIONS



START OF STROKE
ILLUSTRATION 3

START OF INJECTION
ILLUSTRATION 4

END OF INJECTION
ILLUSTRATION 5

END OF STROKE
ILLUSTRATION 6

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Figure 13—The Fuel Pump Principle

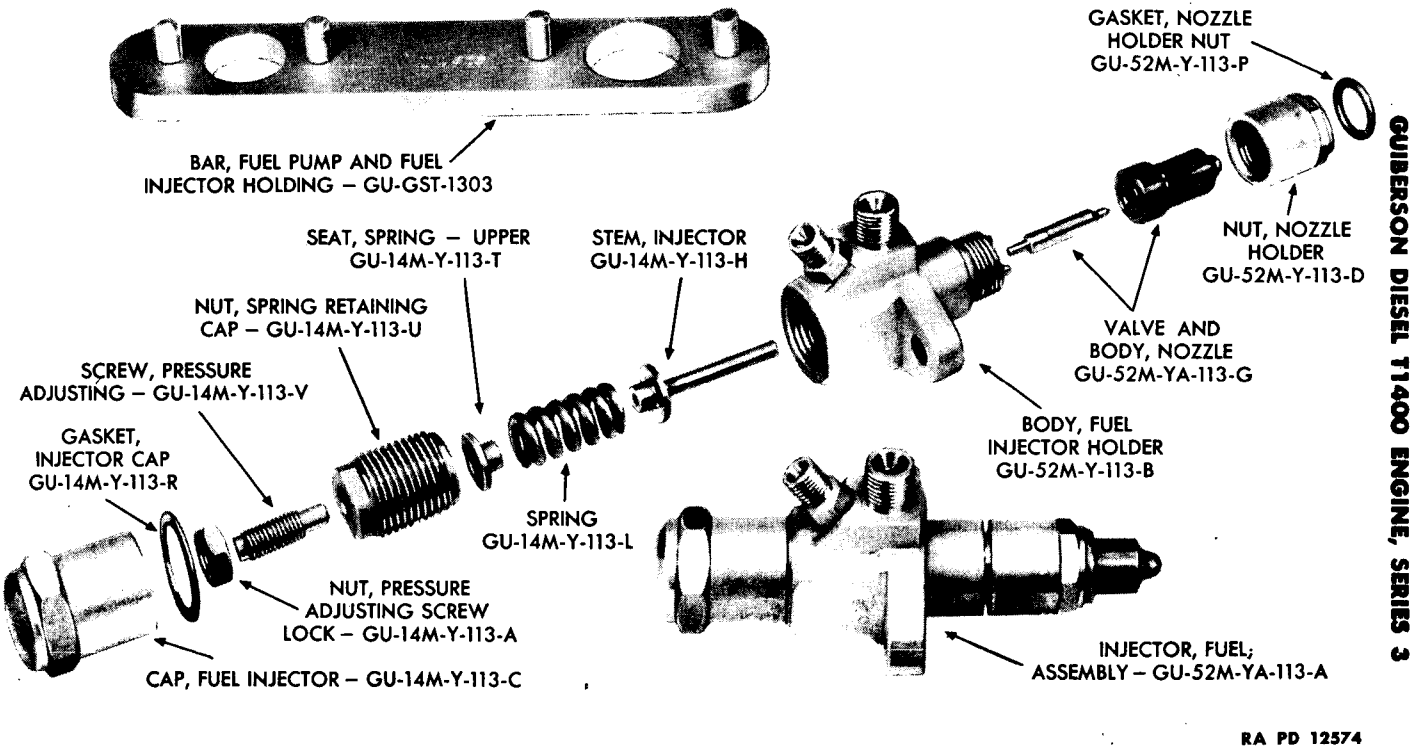

Figure 14—The Fuel Injector Assembly

(4) As the plunger moves upward, the fuel is trapped above it, creating hydraulic pressure. As the plunger continues to rise, the pressure builds up until the injector releases the fuel into the combustion chamber.

(5) The quantity of fuel which can be trapped above the plunger depends upon the amount of fuel which is allowed to pass through the inlet port, which in turn depends upon the throttle position governing the bottom position of the plunger stroke.

(6) This is shown in figure 13. As the throttle lever is moved from the shut-off position to the wide-open position, the fuel control lever moves from the position in illustration 2 to the position in illustration 1. As this is done, the low position of the plunger moves down as seen by comparing the left-hand position of the plunger marked "Low" in illustration 1 and illustration 2. This low position creates an opening of the intake port, with the plunger below port opening. By adjusting the throttle, the length of the plunger stroke and the size of the intake port opening can be adjusted to any desired position between the shut-off and wide-open positions. Illustration 3 shows the maximum opening of the inlet port with a wide-open throttle. As the plunger reaches the position shown in illustration 4 the fuel is trapped above the plunger. The only means of escape for this fuel is through the injector and into the cylinder until the plunger reaches the position shown in illustration 5. At this position fuel comes through the drilled hole in the center of the plunger to the cutaway diameter and from there out into the fuel channel. After injection is thus completed, the fuel pump plunger continues to rise to the position of illustration 6.

e. The Fuel Injector (fig. 14). The fuel injector injects the charge of fuel from the injection pump into the combustion chamber of the cylinder. The valve is held against its seat in the nozzle body by the injector stem which is actuated by a spring. When the fuel pressure from the injection pump overcomes the force of the spring, the valve moves back out of its seat in the nozzle body. Fuel is forced through the nozzle body and is injected into the combustion chamber. After the fuel is injected, the fuel pressure drops until the spring again forces the valve back against its seat in the nozzle body, stopping the injection. Any excess fuel remaining in the injector after the injection is returned to the fuel tank through the fuel return ring.

4. TABULATED DATA.

a. General.

(1) NAME. The Guiberson Radial Diesel Engine.

(2) MODEL. T1400.

(3) MANUFACTURER. Guiberson Diesel Engine Co., Dallas, Texas.

(4) SERIAL NUMBERS.
Location—On name plate on nose.
Series 2—Beginning at 52.
Series 3—Beginning at 3.

(5) IDENTIFICATION.
Series 2—Cylinder barrel outside diameter, 7½ in.
Series 3—Cylinder barrel outside diameter, 8⅜ in.

b. General Specifications.

Bore	5¾ in.
Stroke	6 in.
Number cylinders	9
Cylinder arrangement	Radial
Total piston displacement	1,402 cu in.
Rated crankshaft rpm	2,325 max.
Cooling media	Air
Cycle	4 stroke
Compression ratio	14:1
Fuel injection	Solid
Rotation (facing front)	counterclockwise

c. Performance.

Maximum rpm	2,325
Rated BHP at 2,200 rpm	350–375

d. Fuel Consumption with Specified Fuel.

Gallons per hour at 2,200 rpm—full power	20.5

e. Temperatures.

Exhaust flange temperature at the stud nearest the center of the head, maximum	500 F
Cylinder flange temperature, maximum	300 F

f. Dimensions (Over-all).

Over-all diameter	53 in.
Length with Coffman Starter and 30-volt generator	41⅞ in.

g. Center of Gravity.

Horizontal—forward of mounting ring by approximately 6 in.
Vertical—crankshaft center.

5. REFERENCE TO OPERATION MANUALS.

Many second echelon operations are often done by ordnance maintenance personnel. For information on these operations, refer to the using troop TM for information.

6. ECHELON BREAKDOWN OF MAINTENANCE OPERATIONS.

a. Definitions of Words Used in the Attached List of Repair Jobs Allocated to the Various Echelons:

(1) SERVICE. Consists of cleaning, lubricating, tightening bolts and nuts, and making external adjustments of subassemblies or assemblies and control.

(2) REPAIR. Consists of making repairs to, or replacement of, the part subassembly or assembly that can be accomplished without completely disassembling the subassembly or assemblies and does not require heavy welding or riveting, machining, fitting, and/or alining.

(3) REPLACE. Consists of removing the part subassembly or assembly from the vehicle and replacing it with a new or reconditioned or rebuilt part, subassembly or assembly, whichever the case may be.

(4) REBUILD. Consists of completely reconditioning and placing in serviceable condition any unserviceable part, subassembly or assembly of the motor vehicle including welding, riveting, machining, fitting, alining, assembling and testing.

b. Echelon Breakdown of Operations.

(1) ENGINE	ECHELONS 2nd	3rd	4th
Bearings, master rod—Replace			X
Cam ring—Recondition and Replace			X
Crankshaft—Recondition and Replace			X
Crankshaft bearings—Replace			X
Cylinder—Replace		X	
Cylinder—Recondition			X
Engine—Clean and Service	X		
Engine—Rebuild			X
Engine—Remove and Replace	X		
Engine front and rear supports—Replace and Repair		X	
Flywheel—Replace		X	
Flywheel hub—Replace			X
Intake pipe—Replace		X	
Manifold, exhaust and mufflers—Replace	X		
Manifold, exhaust, and mufflers—Repair		X	
Piston, assembly—Replace		X	
Piston pin—Fitting			X
Piston rings—Fitting			X
Rod, articulated, assembly—Recondition and Replace			X
Rod, master, assembly—Recondition and Replace			X
Rods, valve push—Replace	X		
Starter, breech and tube—Clean, Service or Replace	X		
Starter, breech and tube—Repair		X	
Starter, breech and tube—Rebuild			X
Starter, cartridge type—Clean, Service, Replace	X		
Starter, cartridge type—Repair		X	
Starter, cartridge type—Rebuild			X
Tachometer and cable—Replace	X		
Tachometer and cable—Repair			X
Timing gears—Replace		X	
Valves—Light Grinding and Replace		X	
Valves—Reseat and Reface			X
Valve clearances—Adjust	X		
Valve guides—Replace			X

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	ECHELONS		
	2nd	3rd	4th
Valve lifters—Replace			X
Valve rockers—Replace	X		
Valve rollers—Replace			X
Valve springs—Replace		X	
(2) OILING SYSTEM			
Oil pressure—Adjust	X		
Oil pressure valve—Repair or Replace		X	
Oil pump—Replace	X		
Oil pump—Repair		X	
Oil pump—Rebuild			X
(3) COOLING SYSTEM			
Baffle, intercylinder—Replace	X		
Baffle, intercylinder—Repair and Replace		X	
Cowling—Replace	X		
Cowling—Repair and Replace		X	
Springs, intercylinder baffle—Replace	X		
(4) FUEL SYSTEM			
Fuel filter—Service or Replace	X		
Fuel filter—Repair		X	
Fuel lines, low pressure—Repair or Replace	X		
Fuel lines, high pressure—Replace	X		
Fuel lines, high pressure—Repair		X	
Fuel pump—Replace	X		
Fuel pump—Repair		X	
Fuel pump—Rebuild			X
Governor—Replace		X	
Governor—Rebuild			X
Injector, fuel—Replace	X		
Injector, fuel—Repair		X	
Injector, fuel—Rebuild			X
Pump, fuel injector—Replace		X	
Pump, fuel injector—Repair		X	
Pump, fuel injector—Rebuild			X

Section II

TROUBLE SHOOTING

7. STARTING TROUBLE.

a. Shell Does Not Fire. After four attempts have been made and the shell will not fire, wait five minutes before removing the cartridge from the breech. Then inspect the hole in the cartridge base and the contact pin in the breech housing for foreign matter. Check the starter wiring in the tank to make sure that it is in order, and that there are no loose connections.

b. Shell Fires but Engine Does Not Turn. Check engine to see if it will turn over properly by hand, then make all other checks follow accordingly.

(1) SAFETY DISK. If the safety disk is blown, replace it.

(2) CARTRIDGE. Check identification mark to make sure it is the proper cartridge.

(3) BREECH ASSEMBLY. The gases may be leaking through the assembly because of worn parts. If such is the case, replace the breech assembly.

(4) STARTER. If the above checks are made and the engine does not turn over, replace the starter.

c. Shells Do Not Fire Properly. Sometimes shells "fizzle" instead of firing. This is usually due to defective shells. After such an occurrence, the cap at the back of the starter should be removed and the unburned powder removed from the combustion chamber to prevent damage to the starter.

d. Blown Safety Disk. A blown safety disk is indicated by a loud report when the shell is fired and the engine does not turn over. Replace the safety disk in the starter. Be sure the asbestos side of the safety disk is on the inside. If the disk continues to blow out, examine the safety disk shear ring for nicks. Replace if such is the case.

e. Starter Failure. If necessary to remove the starter, use a 5/8-inch wrench to remove the nuts, lock washers, and flat washers which hold the rods of the starter support to the engine mounting beam. Loosen the clamping rings of the support around the starter and generator, using a 7/16-inch wrench. Remove the palnuts, nuts, and washers from the starter mounting flange, using a 9/16-inch wrench, and pull the starter and support off the accessory case.

8. FUEL SYSTEM TROUBLE.

a. Engine Turns But Does Not Start. If, after two or three shells have been fired and the engine has turned but has not started, the following may be the trouble:

(1) Determine if proper cartridge is being used by noting the identification on the cartridge base.

(2) Inspect the fuel lines for clogging, first between the fuel tanks and the primary filter, then between the primary filter and the fuel pump.

(3) Check fuel supply in fuel tanks.

(4) Disconnect the fuel supply pump discharge line. Remove the fuel supply pump and turn the drive shaft of the pump by hand, *counterclockwise when facing the drive shaft.* If fuel flows from the discharge passage, the supply pump is operative. If fuel does not flow, install a new pump.

(5) Check fuel tank shut-off valves to be sure that they are open.

(6) Check for leaks in fuel lines or in fuel line connections.

(7) Disconnect the fuel line between the fuel tank and the fuel filter at the fuel filter end. If fuel flows from the line, replace the fuel filter and reconnect the line. If fuel does not flow, disconnect the line at the tank end. If fuel does not flow from the tank, drain and replace the tank. If the fuel flows from the tank, blow out the line with compressed air and reconnect it.

b. Faulty Fuel Injectors.

(1) A faulty fuel injector may be indicated by a missing cylinder, loss of power, or fuel knock. In such cases the injectors should be removed and tested. If defective, new injectors should be installed.

(2) To remove fuel injectors, unscrew the injectors and fuel return line nuts from the injector nipples, using a $\frac{5}{8}$-inch open-end wrench on the injector line nut and a $\frac{1}{2}$-inch open-end wrench on the fuel return line nut. Loosen and unscrew the nuts on the fuel pump and the fuel return ring so that the lines can be removed from the injector nipples without bending them. Remove the two palnuts, nuts and washers from each injector, using a $\frac{1}{2}$-inch wrench. Be sure the injectors are numbered to indicate to which cylinder the injector belongs. CAUTION: To prevent dirt and foreign material from entering, cover the openings with push-on caps as soon as the injection lines have been removed.

(3) Thoroughly clean the injectors of any dirt or grit, and place them in lightweight oil to prevent possibility of corrosion.

(4) See paragraph 78 for the disassembly of injectors.

(5) See paragraph 77 for testing of injectors.

c. Faulty Injection Pumps.

(1) A faulty fuel injection pump may be indicated by a missing cylinder, loss of power, or fuel knock. In such cases, the pumps should be removed and inspected. If defective, new pumps should be installed.

(2) To remove injection pump, disconnect the injection line by unfastening the nuts which hold the line to the injector and to the injector pump, using a 5/8-inch wrench. Be sure each pump is numbered to indicate the cylinder to which it belongs. Remove the palnuts, nuts and washers on each side of the injection pump, using a 1/2-inch wrench. Thread the fuel pump adapter of the valve guide and fuel pump puller GU-GST-1365 over the nipple of the injection pump. Remove the injection pump by operating the hammer of the puller.

(3) Clean the injection pump of dirt or foreign matter and place it in a bucket of lightweight oil to prevent corrosion.

(4) See paragraph 79 for the disassembly of the injection pump.

d. Too Much or Too Little Fuel Pressure. Fuel pressure should be set at six pounds per square inch. Fuel pressure is adjusted by loosening the lock nut on the fuel pressure regulator and turning the adjusting screw in or out.

(1) Turn the adjusting screw in to increase pressure.

(2) Turn the adjusting screw out to decrease pressure.

(3) Tighten the lock nut.

e. Incorrect Throttle Adjustment.

(1) Before making any adjustments of the throttle, be sure that the throttle shaft lever does not bind against the accessory case. There should be 0.020-inch clearance beween the lever and bushing with throttle shaft pushed all the way in. If the throttle shaft lever binds, loosen the clamp bolt and throttle shaft nut, and adjust to give proper clearance.

(2) With the throttle pressed to the floor, and the throttle shaft lever down in wide-open position, there should be 1/16-inch to 1/8-inch clearance between the clevis pin and the end of the throttle shaft lever opening. Adjustment is made by turning the nut below the throttle tie-rod clevis.

(3) Spring pressure should be sufficient to overcome friction in the linkage. Adjustment is made by turning the nut on top of the spring.

(4) Set idle adjustment to 800 revolutions per minute with the engine thoroughly warm.

(5) There is no adjustment necessary on the decompression rod and cable.

f. Incorrect Governor Setting.

(1) The governor control shaft should have approximately 1/4-inch of free travel before it affects the throttle.

(2) If the engine will not reach its speed at 2,325 revolutions per minute with no load, use a screwdriver to turn the adjusting screw in the rear of the governor until engine reaches desired speed.

(3) To remove the governor, disconnect the governor control shaft. Remove the five palnuts, nuts and washers from the governor mounting flange, using a ½-inch wrench. Pull the governor off the mounting studs.

(4) See paragraph 171 for governor disassembly.

9. LUBRICATION SYSTEM TROUBLE.

a. Oil Pressure Drops Suddenly. CAUTION: Stop engine immediately. Check oil level in tank. Check for dirt lodged under oil check in oil pressure relief valve. Check oil line connections. Test oil pump.

b. Incorrect Oil Pressure. NOTE: The minimum oil pressure should be not less than 70 pounds per square inch with 160 F oil at 800 revolutions per minute, and a maximum of 95 pounds per square inch at 2,325 revolutions per minute (no load). The operating pressure at 2,000 revolutions per minute should be approximately 85 pounds per square inch.

(1) To adjust the oil pressure, remove the dome from the oil pressure relief valve, using a ⅞-inch wrench. Loosen the lock nut and use a screwdriver to turn the adjusting screw in or out.

(a) Turn the adjusting screw in to increase oil pressure.

(b) Turn the adjusting screw out to decrease oil pressure.

(c) Tighten the lock nut.

(2) Low oil pressure may be due to defective accessory case or master rod bushing in the case of an engine that has seen considerable service.

10. CARDINAL OPERATING RULES.

a. Turn the Engine Four Revolutions or More on Decompression Before Starting. WARNING: Do not operate the starter when the engine is on decompression.

(1) If the engine has been stopped, observe the following: Set the engine on decompression by pulling the decompression handle forward. Turn the engine four revolutions or more. Set the throttle in the starting position. Release the decompression by pushing on the decompression handle.

(2) Do not have the engine on decompression when the engine is turning at operating speeds.

b. Allow Engine to Warm Up Gradually. It is very important that all parts of the engine be allowed to maintain a temperature equilibrium. The pistons and cylinders especially must be allowed to warm up gradually. The warm-up periods given in the following tables should be observed.

Above 30 F

Operate engine at 1,000 rpm for 2 minutes.
at 1,200 rpm for 2 minutes.
at 1,400 rpm for 2 minutes.

Below 30 F

Operate engine at 1,000 rpm for 5 minutes.
at 1,200 rpm for 5 minutes.
at 1,400 rpm for 5 minutes.

c. Operate Engine Between 1,400 and 2,000 Revolutions Per Minute After Warm-up. Avoid continued low engine speed operation by shifting gears to maintain an engine speed above 1,400 revolutions per minute. The maximum speed of the engine under load should not exceed 2,200 revolutions per minute. For long continued operation it is recommended that the engine speed be less than 2,000 revolutions per minute.

d. Regulate Oil Temperature Within Recommended Range. The oil temperature should be maintained close to the mid-values of the temperatures given below:

Oil Inlet Temperature During Operation

ATMOSPHERIC TEMPERATURE	MINIMUM	MAXIMUM	SAE
Below 32 F	100 F	180 F	30
Above 32 F	100 F	180 F	50

e. Avoid Sudden Stopping. Cool Engine Gradually.

(1) If a hot engine is suddenly stopped, the rate of cooling of the various parts of the engine is quite different from the rate of cooling with the oil and air in circulation.

(2) The engine should be allowed to cool as follows: It should be idled, with the tank out of gear, at 1,200 revolutions per minute for four minutes and then at 1,000 revolutions per minute for two minutes.

f. Use Clean Fuel of the Correct Specifications. Fuel oil of the proper specifications should be used. It is very important that the fuel be kept as free from water and dirt as possible. Those handling the fuel should make every effort possible to keep the fuel clean. A final stage filter should be used between the fuel supply pump and the check valve to the engine.

g. Keep All Connections Tight. Difficulty from leaking lines or connections should be prevented by frequent regular inspection.

h. Check the Injection Nozzles Periodically.

(1) The injection nozzles should be maintained in good condition to obtain the proper power and balance of the engine.

(2) The injectors should be set for 2,600 to 2,650 pounds pressure per square inch on an injector test unit.

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Section III

DISASSEMBLY OF ENGINE

DISASSEMBLY OF ENGINE

11. GENERAL PRECAUTIONS.

a. Before removing parts from the engine, check them for numbering in all cases where it is necessary to reinstall them at the proper cylinder.

b. Injectors and injection pumps should be placed in clean fuel oil in a covered container immediately upon removal. Caps should be installed over the line openings to prevent the entrance of foreign material.

c. Parts should be placed in or on storage bins as removed.

12. REMOVE THE EXHAUST MANIFOLDS (fig. 7).

a. Equipment.
Wrench, open-end, ½-in.

b. Procedure. Remove the brass nuts and lock washers from the exhaust manifold mounting studs at all cylinders. If none of the sections must be replaced, the two halves of the exhaust manifolds can be lifted off as two units, which will make it easier to install them. If sections must be replaced and the manifolds disassembled, it will help in reassembling the manifold to number each section of the manifold to show the cylinder to which it belongs. When the nuts and lock washers have been removed, lift each half of the manifold off the studs as a unit.

13. REMOVE THE ROCKER BOX SCAVENGER HOSE.

a. Equipment.
Pliers

b. Procedure. Loosen the hose clamps at the rocker box scavenger nipple and at the oil pump and remove the hose.

14. REMOVE THE FUEL SUPPLY PUMP HOSE.

a. Equipment.
Pliers

b. Procedure. Fuel is carried through a hose from the fuel supply pump on the accessory case to the fuel check valve at the bottom of the engine where fuel enters the engine. Loosen the clamps at these two points with pliers and remove the hose from the nipples.

15. REMOVE THE INTAKE MANIFOLD (fig. 6).

a. Equipment.
Wrench, open-end, 9/16-in. Wrench, socket, ½-in.

b. Procedure. NOTE: If none of the elbows or hose connections need replacing, it will not be necessary to remove the elbows from the manifold ring.

(1) FREE THE INTAKE ELBOWS.
Wrench, socket, ½-in.
Remove the palnuts, nuts and washers from the intake elbows.

(2) REMOVE THE BRACKETS.
Wrench, open-end, 9/16-in.

Remove the four brackets which hold the manifold to the engine mounting beam.

(3) LIFT OFF THE MANIFOLD.

With a man on each side, lift the manifold off the studs. If the intake elbows are removed from the manifold ring, it will help in reassembly if they are marked to indicate the cylinder to which they belong.

16. REMOVE DRAIN VALVE CABLE CONTROL AND SCAVENGER LINE.

a. Equipment.

Wrench, 3/8-in.
Wrench, 1/2-in.
Wrench, 5/8-in.
Wrench, 3/4-in.
Wrench, 1-in.

b. Procedure.

(1) Remove 1/4-inch bolt to free cable adjustment from the control lever. Cut safety wire and remove support nut. Loosen mounting beam cable support, unfasten cable support at oil sump. Loosen jamb nut at cable end, then back off nut from T valve housing and remove.

(2) Using a 1/2-inch open-end wrench, remove the nuts, palnuts and flat washers which hold the mounting flange of the scavenger line to the accessory case. The scavenger line is a curved metal tubing. A short section of hose is used at the other end of the scavenger line to connect it to the oil sump. Loosen the hose clamps on the oil sump and scavenger line, and pull out the scavenger line. Then remove the hose. Inside this hose is a brass liner which fits into the oil sump passage to prevent oil leakage and collapsing of the hose connection. If the hose it to be replaced, force out the brass liner and save it for installation in the new hose.

17. FREE THE GENERATOR AND STARTER SUPPORT BRACE (fig. 102).

a. Equipment.

Pliers
Wrench, socket, 7/16-in.
Wrench, socket, 5/8-in.

b. Procedure.

(1) FREE THE GENERATOR AND STARTER SUPPORT BRACE ARMS.
Wrench, socket, 5/8-in.

Free the upper ends of the long supporting arms of the generator and starter support brace by removing the nut, lock washer and flat washer that hold the arms to the engine mounting beam.

(2) FREE THE STARTER CLAMP.
Wrench, socket, 7/16-in.

Remove the flat washer and elastic stop nut that hold the clamp around the starter.

(3) REMOVE THE GENERATOR WINDOW STRAP.
Pliers

Remove the window strap from around the generator by loosening the wing nut.

(4) LOOSEN THE GENERATOR CLAMP.
Wrench, socket, 7/16-in.

Loosen the clamp around the generator by loosening the nuts of the clamping bolts.

18. REMOVE THE STARTER AND BRACE (fig. 102).

a. Equipment.
Wrench, socket, 9/16-in.

b. Procedure. Remove the palnuts, hexagon nuts and washers from the starter mounting flange and pull the starter and brace off the studs on the accessory case.

19. REMOVE THE GENERATOR (fig. 102).

a. Equipment.
Wrench, socket, ½-in.

b. Procedure. Remove the palnuts, nuts and flat washers from the generator mounting studs. Pull the generator off the studs.

20. REMOVE THE OIL PUMP (fig. 5).

a. Equipment.
Pliers
Wrench, socket, ½-in.

b. Procedure. Cut the safety wire that runs from the packing nut on the oil filter to the oil pressure relief valve, using pliers. Remove the palnuts, nuts and washers from the oil pump mounting flange and slide the oil pump off the studs on the accessory case.

21. REMOVE THE THROTTLE CONTROLS (fig. 5).

a. Equipment.
Pliers
Wrench, socket, ¾-in.
Wrench, open-end, 7/16-in.

b. Procedure.

(1) REMOVE THE GOVERNOR CONTROL.
Wrench, open-end, 7/16-in.

Remove the nut and washer that hold the ball socket joints at each end of the governor control and remove the governor control.

(2) FREE THE THROTTLE CONTROL SHAFT LEVER.
Wrench, open-end, 7/16-in.

Loosen the throttle control lever clamping screw on the throttle control shaft lever.

(3) REMOVE THE THROTTLE CONTROL SHAFT LEVER.
Pliers Wrench, socket, 3/4-in.

Using pliers, remove the cotter pin from the throttle shaft nut on the throttle control shaft. Using a 3/4-inch socket wrench, remove the nut and washer. Then slide the throttle control shaft lever off the throttle control shaft.

22. REMOVE THE FUEL PRESSURE REGULATOR.

a. Equipment.
Pliers Wrench, open-end, 1/2-in.
Wrench, open-end, 7/16-in.

b. Procedure.

(1) REMOVE THE FUEL PRESSURE REGULATOR LINE.
Wrench, open-end, 7/16-in. Wrench, open-end, 1/2-in.

Remove the fuel pressure regulator line, that extends from the fuel pressure regulator to the fuel return ring, by loosening the nuts at each end (7/16-inch open-end wrench at regulator end and 1/2-inch open-end wrench at fuel return ring end).

(2) REMOVE THE HOSE.
Pliers

Remove the hose from the fuel pressure regulator by loosening the hose clamp.

(3) REMOVE THE BRACKET AND REGULATOR.
Wrench, open-end, 1/2-in.

Remove the nuts which hold the bracket to the engine mounting beam and remove the bracket and regulator.

23. REMOVE THE FLYWHEEL NUT AND FRONT CONE (fig. 101).

a. Equipment.
Pliers Wrench, flywheel hub nut, GU-GST-1554

b. Procedure. Using pliers, remove the safety wire from the pin which locks the flywheel nut to the front crankshaft. Then remove the flywheel nut and front cone, using the flywheel hub nut wrench GU-GST-1554. NOTE: The front cone is in two halves. The halves have a flange which fits into a groove in the flywheel nut. The two halves of the cone are held in place by the flywheel hub when the nut is tightened, but as the nut is being removed, they should be held in place by hand to prevent them from falling out.

DISASSEMBLY OF ENGINE

24. REMOVE THE ENGINE MOUNTING BEAM.

a. Equipment.

Eye, engine lifting, GU-GST-1550
Hoist
Wrench, open-end, 5/8-in.

b. Procedure.

(1) With the front of the engine facing upward, screw the engine lifting eye GU-GST-1550 on the front crankshaft and attach a hoist. Using a 5/8-inch open-end wrench, remove the nuts, washers and bolts from the engine mounting flange. Then lift the engine out of the mounting beam.

(2) NOTE: The engine should be mounted on an engine mounting stand, before proceeding with further disassembling operations, to facilitate working on it. The engine should be mounted so that the rear of the engine projects through the circular opening in the platform on the stand. The engine can be held in place by bolting it to the platform through the flange of the crankcase. A stand with a revolving platform should be used. This will provide ready access to either side of the engine, since the engine must be turned many times during disassembling operations.

25. REMOVE THE FLYWHEEL.

a. Equipment.

Puller, flywheel, GU-GST-1561

b. Procedure. Lift the flywheel off the front crankshaft; then remove the rear cone from the crankshaft by hand. NOTE: the flywheel should be set on boards or wood blocks to prevent damage to the fan.

26. REMOVE THE DECOMPRESSION CABLE.

a. Equipment.

Pliers
Wrench, socket, 9/16-in.

b. Procedure. Remove the clevis pin from the clevis on the decompression cable (pliers) and free the clevis from the decompression lever. Remove cable support bracket by removing three 9/16-inch nuts and palnuts, loosening the 7/16-inch nut at the clamp on the upper end of the support bracket. Remove cable from clamp and cowling.

27. REMOVE THE STEADY REST TUBE.

a. Equipment.

Wrench, open-end, 5/8-in.

b. Procedure. Remove the four palnuts, nuts and flat washers from the steady rest tube clamp. Lift off the clamp. Then slide the steady rest tube out of the assembly.

28. REMOVE THE INJECTOR COVER PLATES (fig. 16).

a. Equipment.

Screwdriver

b. Procedure. Remove the injector cover plates GU-52M-YX-107H1 by freezing the Dzus Fasteners (screwdriver) and sliding the cover plates down out of the brackets.

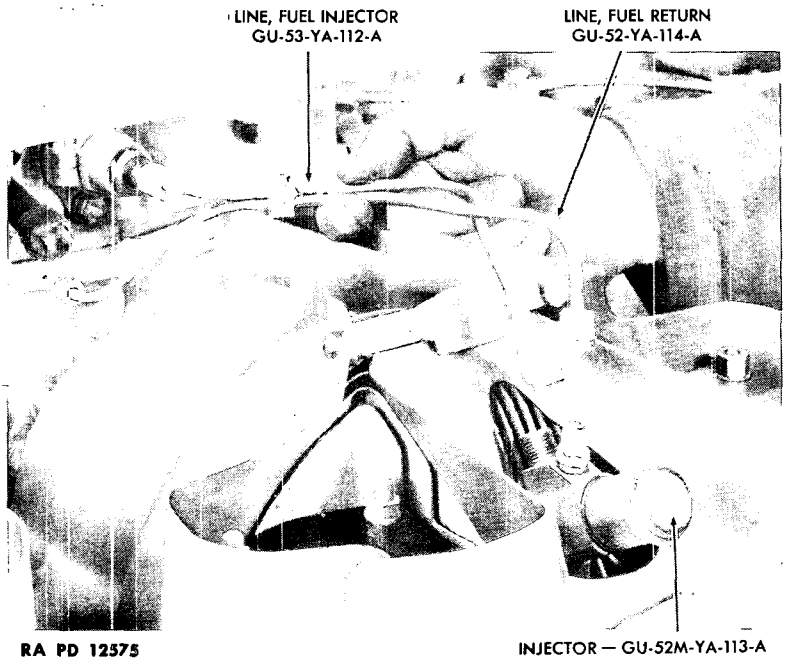

Figure 15—Fuel Injector and Lines

29. REMOVE THE INJECTOR LINES (fig. 15).

a. Equipment.
Wrench, open-end, ½-in. Wrench, open-end, ⅝-in.

b. Procedure.

(1) FREE THE INJECTION LINE.
Wrench, open-end, ⅝-in.

Turn the platform of the engine mounting stand so that the rear of the engine is facing upward. Unscrew the nuts which hold the fuel injection line GU-53-YA-112A to the injector GU-52M-YA-113A and to the injector pump.

(2) FREE THE FUEL RETURN LINE.
Wrench, open-end, ½-in.

Unscrew the nuts which hold the fuel return line GU-52-YA-114A to the injector and to the fuel return ring.

(3) REMOVE THE LINES. Lift off the two lines as an assembly. Repeat this procedure on all cylinders. NOTE: Number the lines

as they are removed so that they can be reinstalled at the correct cylinder. IMPORTANT: *Do not bend these lines.* To prevent dirt and foreign material from entering the injectors and pumps, causing damage, cover the openings with push-on caps as soon as the fuel lines have been removed. Line the cap with a piece of paper to prevent damage to the threads.

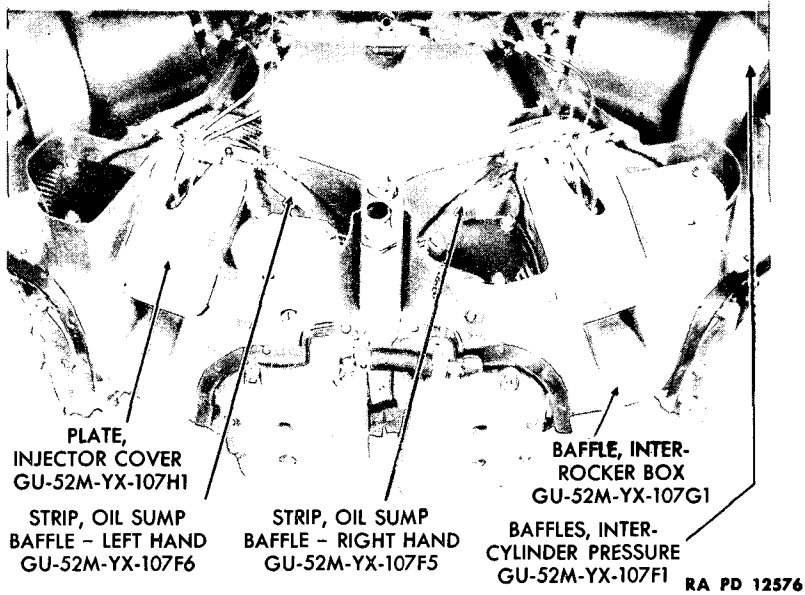

Figure 16—The Baffles

30. REMOVE THE INTERROCKER BOX BAFFLES (fig. 16).

a. Equipment.

Screwdriver — Wrench, open-end, 3/8-in.

b. Procedure. With the accessory case side of the engine up, unscrew the Dzus fasteners which attach the interrocker box baffles GU-52M-YX-107G1 to the intercylinder pressure baffles GU-52M-YX-107F1 at each side. Detach the Dzus fasteners which hold the interrocker box baffles to the cowling. Using a 3/8-inch open-end wrench, remove the two narrow right and left-hand oil sump baffle strips GU-52M-YX-107F5 and 6 at each side of the oil sump. Using a 3/8-inch open-end wrench, remove the bolts, nuts and washers that hold the front of the interrocker box baffles to the intercylinder pressure baffles. Lift off the interrocker box baffles. NOTE: The interrocker box baffles at No. 5 and No. 6 cylinders must be removed from the flanges of the oil sump, by freeing the Dzus fasteners.

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31. REMOVE THE COWLING (fig. 17).

a. Equipment.
Screwdriver

b. Procedure. Turn the engine so that the front of the engine is facing upward. Remove the sections of the cowling GU-52M-YX-107K by freeing the Dzus fasteners.

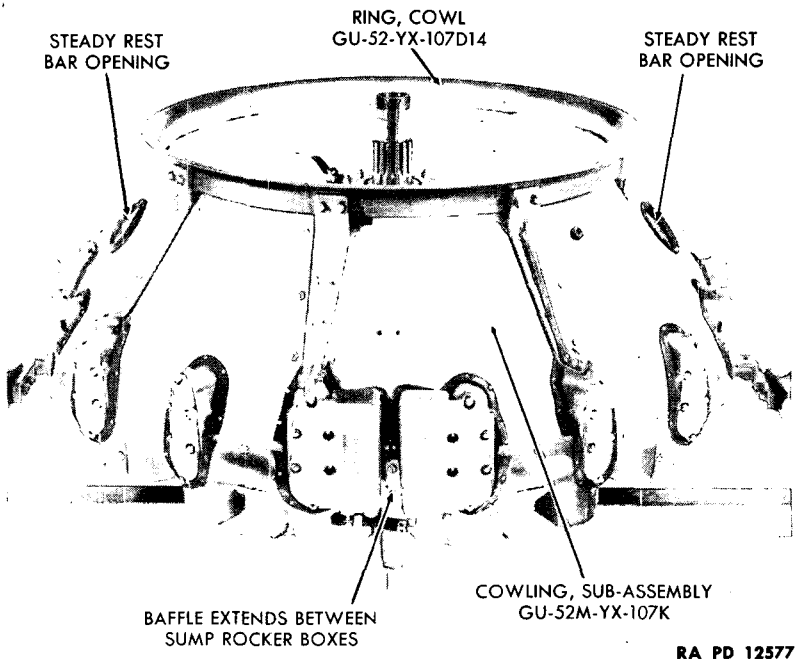

Figure 17—The Engine Cowling

32. REMOVE COWLING RING AND BRACKETS (fig. 17).

a. Equipment.
Pliers
Wrench, socket, 7/16-in.

b. Procedure. Cut the safety wire that holds the nuts where the brackets are attached to the intake rocker box flanges. Using a 7/16-inch socket wrench, remove the nuts, flat washers and bolts. Lift off the cowling ring GU-52-YX-107D14 together with the brackets.

33. REMOVE THE INTERCYLINDER PRESSURE BAFFLES (fig. 16).

a. Equipment.
Screwdriver
Wrench, open-end, 3/8-in.

b. Procedure. Turn the engine so that the accessory case side is facing upward. Using a 3/8-inch open-end wrench, remove the nuts,

washers, spacers, and tie-bolts that hold the intercylinder pressure baffles around the cylinder barrels. Unscrew the Dzus fasteners from the brackets at the forward ends of the intercylinder pressure baffles and remove the intercylinder pressure baffles.

34. REMOVE THE BRACKETS FOR THE INTERCYLINDER PRESSURE BAFFLES.

a. Equipment.
Wrench, open-end, 9/16-in.

b. Procedure. Remove the nut from the crankcase assembly bolt. Lift off the bracket to which the inner cylinder pressure baffle is attached, replacing the nut each time a bracket is removed.

35. REMOVE ROCKER BOX COVERS.

a. Equipment.
Wrench, socket, 7/16-in.

b. Procedure. Unscrew the nuts on the rocker box covers and remove the nuts, washers and covers.

36. REMOVE THE OIL SUMP.

a. Equipment.
Wrench, socket, 9/16-in.

b. Procedure. Turn the platform of the engine mounting stand so that the front of the engine is facing upward. Remove the palnuts, nuts and washers which hold the oil sump to the crankcase. Then lift off the oil sump.

37. DETACH INTERCYLINDER DRAIN LINES.

a. Equipment.
Pliers

b. Procedure. Loosen the clamps on the intercylinder drain lines and remove the lines from the nipples on all cylinders.

38. REMOVE THE FUEL INJECTORS (fig. 15).

a. Equipment.
Wrench, socket, ½-in.

b. Procedure. Remove the two palnuts, nuts and washers from each injector and lift the injectors from the cylinder heads. NOTE: Be sure the injectors are numbered (number appears on front of flange) to indicate to which cylinder the injector belongs. The injectors should be thoroughly cleansed of any dirt or grit and placed in lightweight oil, or clean fuel oil, to prevent possibility of corrosion.

39. REMOVE THE PUSH RODS AND PUSH ROD HOUSINGS (figs. 18 and 19).

a. Equipment.

Remover, push rod, GU-GST-1545
Turner, crankshaft, GU-GST-1502
Wrench, push rod housing nut, GU-GST-1306

b. Procedure.

(1) ATTACH THE CRANKSHAFT TURNER.
Turner, crankshaft, GU-GST-1502

Slip the crankshaft turner GU-GST-1502 over the splined end of the crankshaft, to help in turning the engine. NOTE: There is a wide spline on the crankshaft. As this spline faces each cylinder, the piston in that cylinder is at the top of its stroke. Before the push rods and housings can be removed, the piston must be 80 degrees or more beyond top center, so that the piston will be on the downstroke and there will be sufficient clearance for the valve above the piston. Since the angle between each two cylinders is 40 degrees, the wide spline of the crankshaft should face the second cylinder beyond the cylinder from which the push rods are being removed.

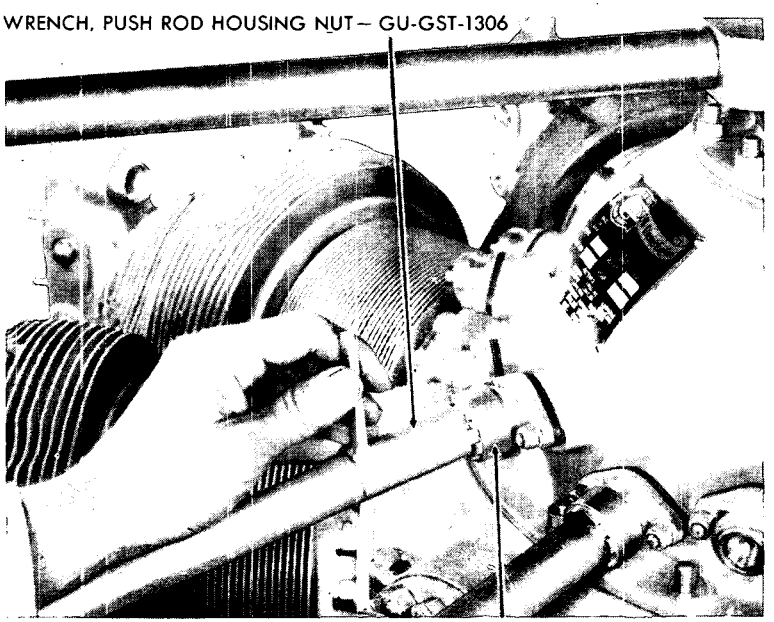

Figure 18—Removing Push Rod Housing Nut

(2) TEST ROCKER ARM FREEDOM. With the wide spline of the crankshaft 80 degrees beyond the cylinder from which the push rods are being removed, move the rocker arms to see if they are free. If they are tight, the valve tappets are resting on a high lobe of the cam and the engine should be turned one complete revolution.

(3) LOOSEN PUSH ROD HOUSING NUTS.
Wrench, push rod housing nut, GU-GST-1306

With the rocker arms free, and the piston 80 degrees or more beyond top center, loosen the push rod housing nuts GU-13-Y-128B at each end of both push rod housings. CAUTION: Do not loosen the push rod housing nuts on each cylinder until the engine has been turned and the piston is on the downstroke. Loosening the nut on the inner end of the push rod housing allows the housing to move out of position, and the valve tappet might be damaged when turning the engine.

(4) REMOVE PUSH ROD AND HOUSING.
Remover, push rod, GU-GST-1545

Fit the push rod remover GU-GST-1545 to a rocker so that the prong of the tool fits behind the upper arm of the rocker, and the base of the tool rests on the lower arm of the rocker. Pushing on the handle of the tool will release the spring pressure on

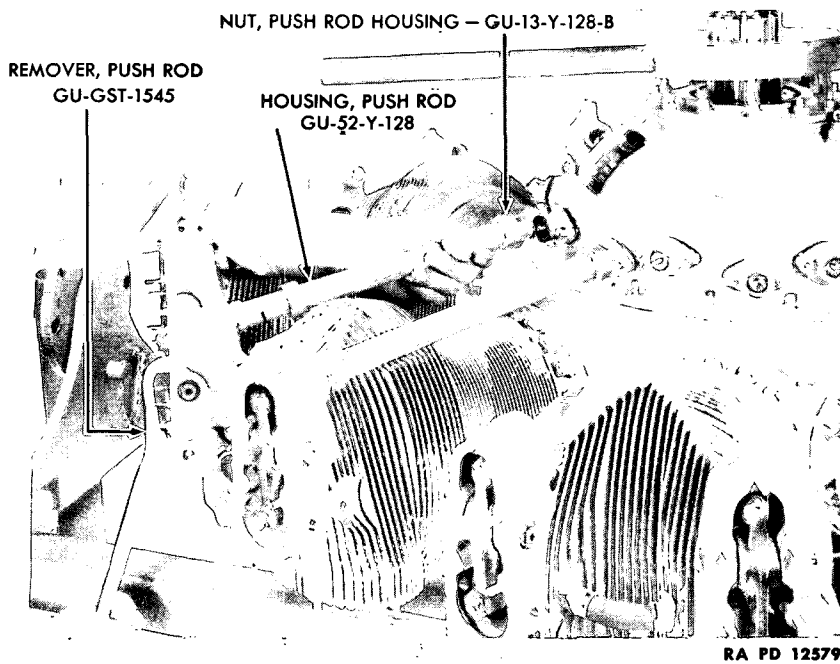

Figure 19—Removing Push Rod and Housing

the push rod so that the push rod and housing will lift out. Remove the other push rod and housing the same way. This same procedure can be followed to remove push rods and housings from the other eight cylinders.

40. REMOVE THE CYLINDER.

a. Equipment.

Turner, crankshaft, GU-GST-1502
Wrench, cylinder hold-down nut, with ½-in. drive, GU-GST-1547

b. Procedure.

(1) NOTE: The cylinder barrel, cylinder head, and rocker assembly are lifted off as a unit. In removing the cylinders, start with No. 8 cylinder, then remove No. 9, and the others in order. This is done because the master connecting rod is in No. 7 cylinder, and this should be the last to be removed so that it can hold the others in position. The piston should be on top dead center, as indicated by the wide spline of the crankshaft, when the cylinder is removed, otherwise the lower piston ring might not extend beyond the crankcase, and be damaged when turning the engine to remove the piston.

(2) Using the ⅝-inch offset open-end wrench and the cylinder hold-down nut wrench GU-GST-1547 with a ½-inch drive, remove the palnuts, nuts and washers from the studs that encircle the cylinder barrel. Then pull the cylinder barrel back off the studs and remove it from the piston assembly. Repeat the operation on the other cylinders, using the crankshaft turner GU-GST-1502 to turn the engine.

41. REMOVE THE PISTON ASSEMBLIES (fig. 20).

a. Equipment.

Driver, piston pin, GU-GST-1510 Nail or similar pointed object

b. Procedure.

(1) REMOVE THE PISTON PIN PLUGS.
Nail

A plug fits over each end of the piston pin. Insert a nail or similar pointed object into the hole in the plug and lift the plug out. NOTE: In working on the piston, it is advisable to hold a hand under the piston pin, in case it falls out.

(2) REMOVE THE PISTON PIN.
Driver, piston pin, GU-GST-1510

Drive the piston pin out of the piston. CAUTION: Support the piston with a hand underneath while removing the piston pin to take any strain off the link rod.

(3) REMOVE THE PISTON. Pull the piston GU-53-Y-37 off the link rod. Repeat this operation on the other eight cylinders, turning each piston to top center before the barrel is removed.

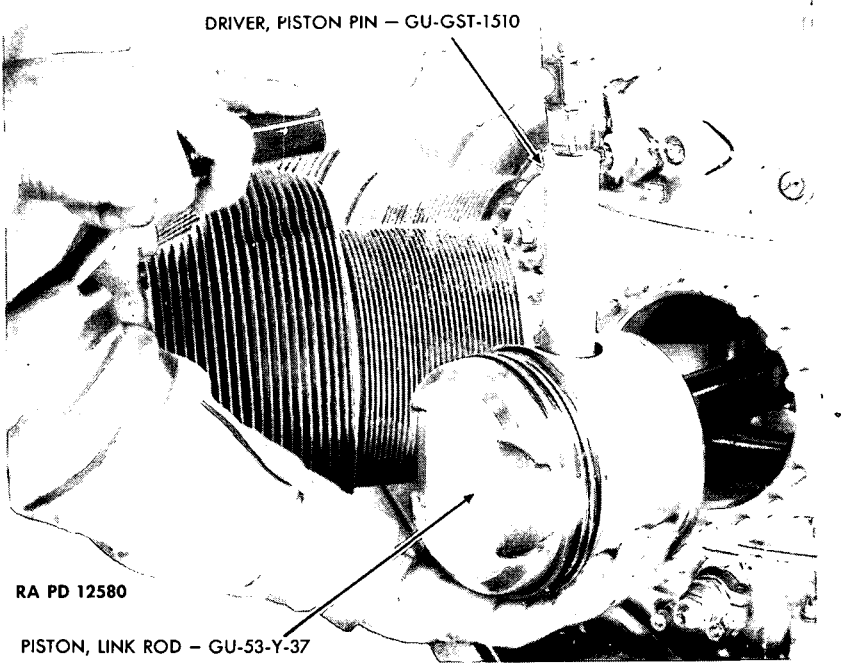

Figure 20—Removing the Piston

NOTE: The cylinder barrels, pistons, piston pins and plugs should all be numbered to indicate the cylinder to which they belong.

42. INSERT RUBBER PROTECTORS OVER CYLINDER MOUNTING STUDS.

a. Equipment.
Protectors, rubber, cylinder stud

b. Procedure. As each cylinder barrel and piston assembly is removed, the connecting rods are free to move back and forth in the cylinder openings, and they might damage or nick the link rods and crankcase. To prevent this, protectors can be cut from a piece of 2-inch rubber hose. Each protector will fit over two studs at the side of the cylinder opening. A flap should be left in the hose to extend down into the cylinder opening. Install these protectors at each cylinder opening as the barrel is removed.

43. REMOVE THE DECOMPRESSION LEVER.

a. Equipment.
Pliers
Wrench, socket, 7/16-in.
Wrench, socket, 3/4-in.

b. Procedure. Loosen the clamp bolt (7/16-in. socket wrench) on the decompression lever. Remove the cotter pin, using pliers, from the

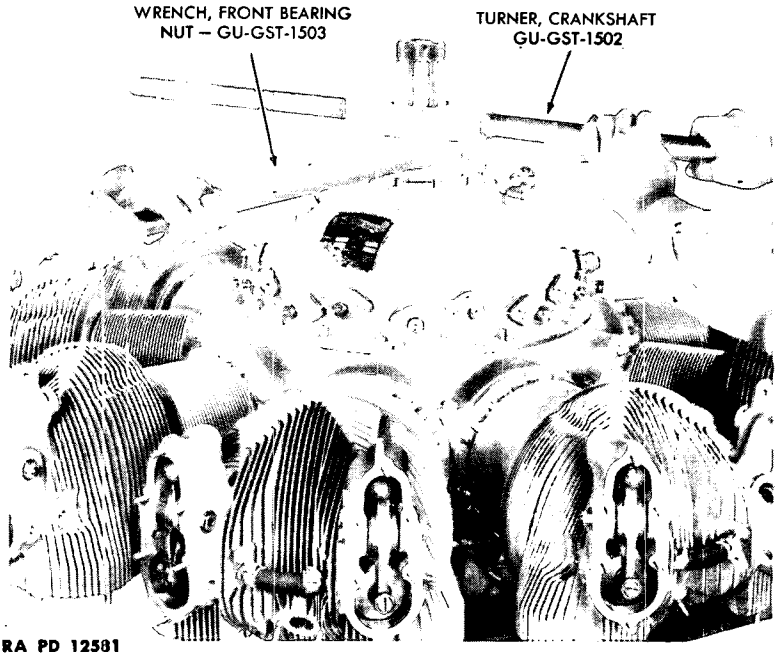

Figure 21—Removing the Front Bearing Nut

nut on the decompression shaft. Remove the nut (¾-in. socket wrench) and flat washer. Lift off the decompression lever.

44. REMOVE THE CRANKCASE FRONT SECTION (figs. 21 and 22).

a. Equipment.

Puller, front crankcase, GU-GST-1501
Turner, crankshaft, GU-GST-1502
Twine
Wrench, adjustable
Wrench, front bearing nut, GU-GST-1503
Wrench, open-end, 9/16-in.
Wrench, socket, 9/16-in.

b. Procedure.

(1) REMOVE FRONT BEARING NUT.
Turner, crankshaft, GU-GST-1502
Wrench, front bearing nut, GU-GST-1503

Place the front thrust bearing nut wrench GU-GST-1503 over the crankshaft and fit the wrench into the bearing nut; then using the crankshaft turner to keep the shaft from turning, drive the nut wrench counterclockwise to loosen and remove the thrust bearing nut.

DISASSEMBLY OF ENGINE

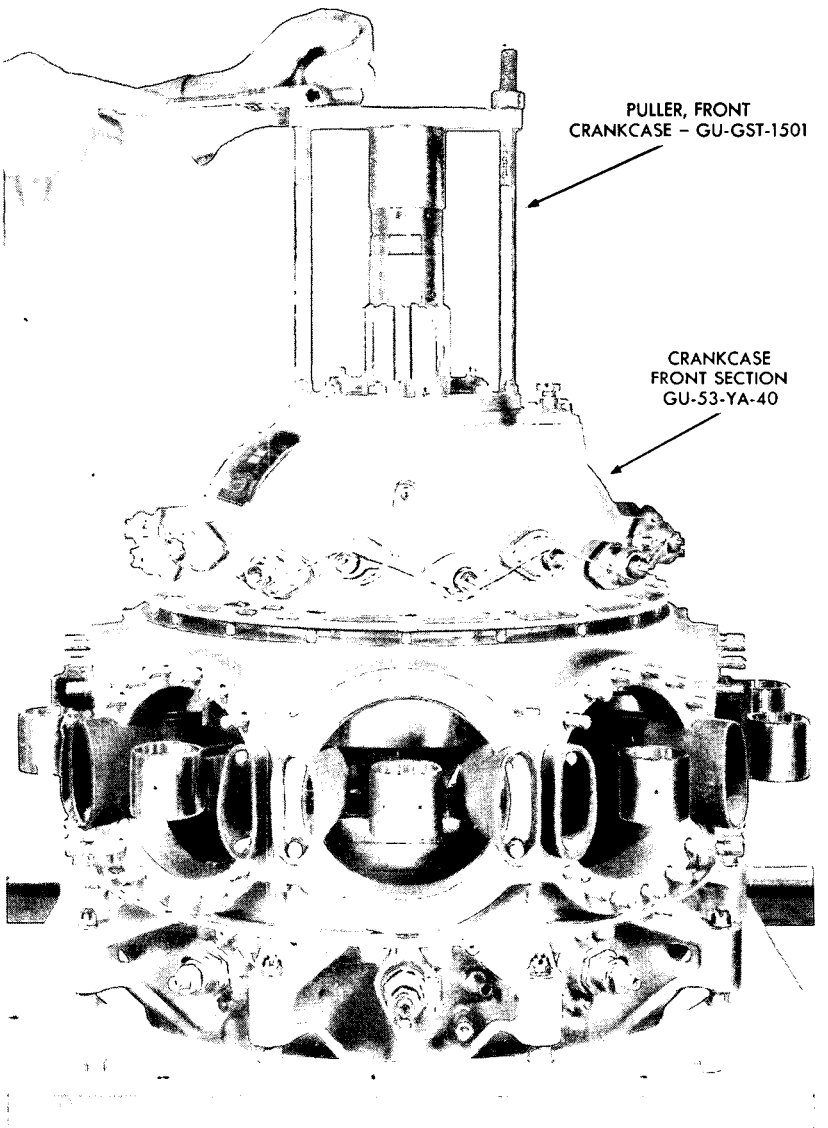

Figure 22—Removing Crankcase Front Section

(2) REMOVE THE FRONT BEARING PLATE AND SEAL RING GLAND. Wrench, socket, 9/16-in.

Remove the nuts, spacers and washers from the front bearing plate and lift off the plate. Lift off the nose plate, seal ring gland, and gasket. NOTE: Pull the tappets out and lace cord or twine around them to hold them out so that they won't interfere while removing the crankcase front section.

(3) REMOVE THE CRANKCASE FRONT SECTION.
Puller, front crankcase, GU-GST-1501 Wrench, open-end, 9/16-in.
Wrench, adjustable

Using a 9/16-inch open-end wrench, remove the crankcase front section hold-down palnuts, nuts and flat washers. Install the front crankcase puller GU-GST-1501 on the studs of the crankcase front section GU-53-YA-40 as shown in figure 22. Place an adapter over the front crankshaft. Use an adjustable wrench to screw down the nuts on the puller evenly on each side. The crankcase front section will be pulled up off its studs. Then remove the cord from the valve tappets.

45. REMOVE THE BEARING FROM CRANKCASE FRONT SECTION (fig. 23).

a. Equipment.
Drift, brass Hammer

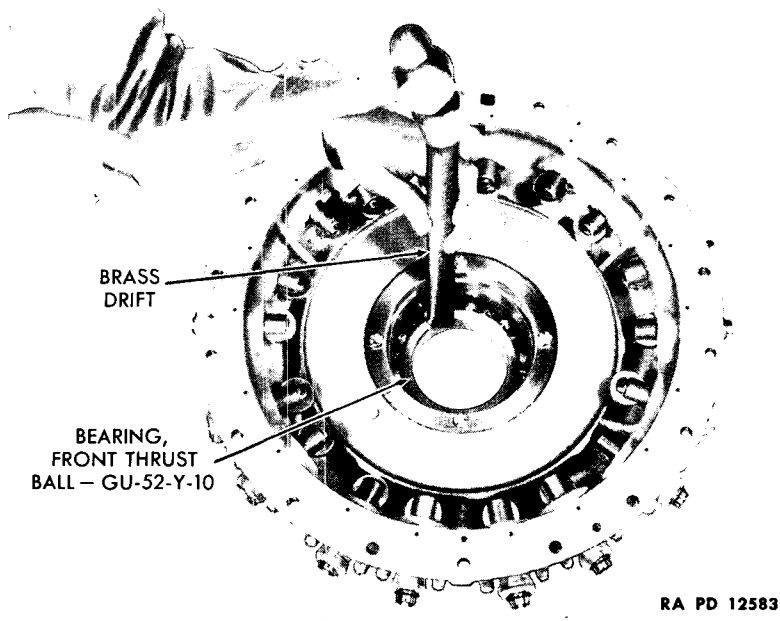

Figure 23—Removing the Front Thrust Ball Bearing

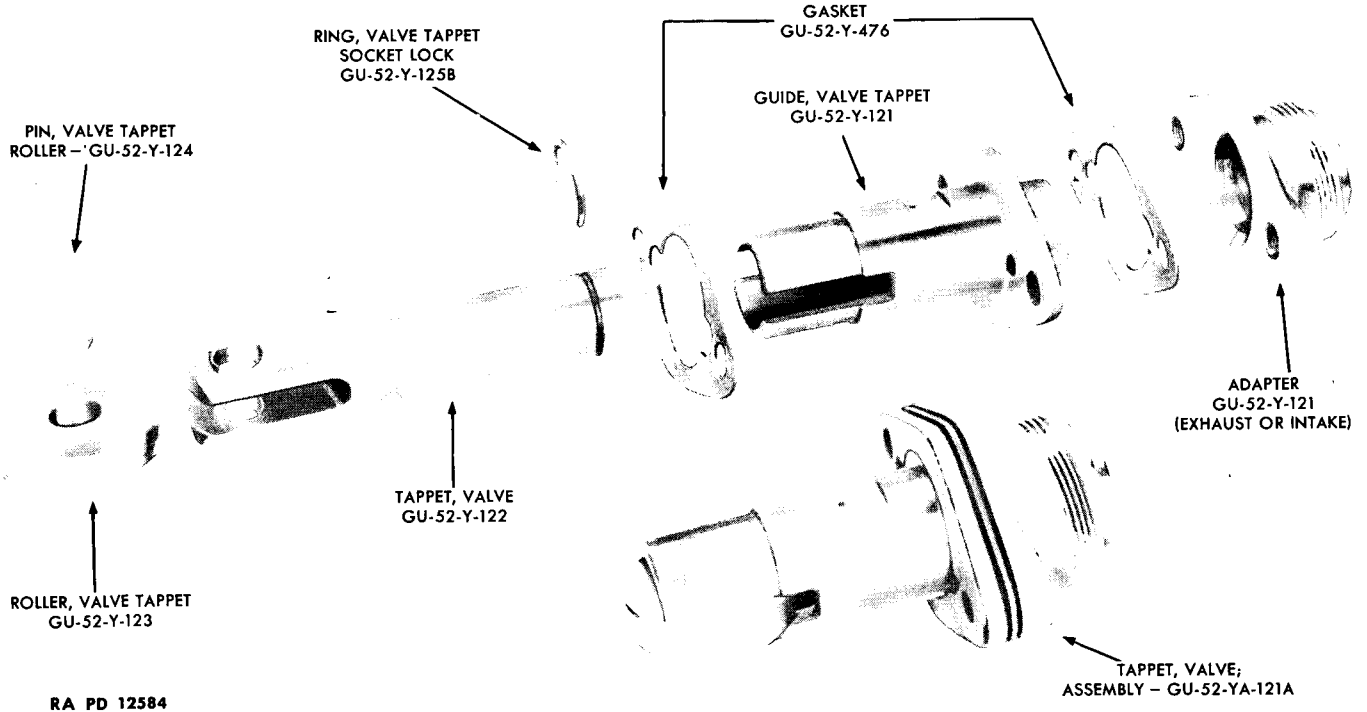

Figure 24—Valve Tappet and Guide Assembly

b. Procedure. Lift out the front bearing seal ring spacer. Using a soft, brass drift, drive the front thrust ball bearing GU-52-Y-10 out of the crankcase front section, being sure to drive on the race and not the balls themselves.

46. REMOVE THE DECOMPRESSION PLATE (fig. 3).

a. Equipment.

Pliers
Wrench, socket, 7/16-in.

b. Procedure. Remove the cotter pins (pliers) and the four castle nuts (7/16-in. socket wrench) that hold the decompression lock plate. Lift out the decompression lock plate and plate. NOTE: The decompression control segment gear is held to the decompression plate by two nuts which are safety-wired together. It does not need to be removed unless the teeth are badly worn or broken.

47. REMOVE THE VALVE TAPPETS AND GUIDES (fig. 24).

a. Equipment.

Hammer, soft
Wrench, socket, 7/16-in.

b. Procedure.

(1) REMOVE THE ADAPTER.
Wrench, socket, 7/16-in.

Using a 7/16-inch socket wrench, remove the two elastic stop nuts and flat washers from each guide adapter GU-52-Y-121. Be careful that the wrench does not ride against the aluminum threads of the adapter. Lift off the adapter.

(2) REMOVE THE TAPPET. Remove the valve tappet lock ring GU-52-Y-125B from the groove in the valve tappet GU-52-Y-122, where it projects through the valve tappet guide GU-52-Y-121. Pull the tappet and valve tappet roller GU-52-Y-123 out of the guide. CAUTION: The valve tappet should be replaced in the guide in the same position as when it was removed. Note this position when removing the tappet from the guide.

(3) REMOVE THE GUIDE.
Hammer, soft

Drive the guide out of the crankcase front section. Then replace the tappet in the guide in the same position as when it was removed.

48. REMOVE THE VALVE CAM (fig. 80).

Lift off the valve cam, the sleeve, and the spacing washer.

49. REMOVE THE FUEL INJECTION PUMPS (fig. 96).

a. Equipment.

Puller, fuel pump, GU-GST-1365
Wrench, socket, thin wall, ½-in.

b. Procedure.

(1) FREE THE INJECTION PUMP.
Wrench, socket, thin wall, ½-in.
Remove the palnuts, nuts and washers on each side of the injection pump.

(2) REMOVE THE INJECTION PUMP.
Puller, fuel pump, GU-GST-1365
Thread the fuel pump adapter of the fuel injection pump puller GU-GST-1365 over the nipple of the injection pump. Operate the sliding hammer of the tool, striking it forcibly back until the injection pump is pulled out. (Be sure the pump is numbered to indicate the cylinder to which it belongs.) Remove the injection pump gasket. Repeat this operation to remove the injection pumps at all cylinders. NOTE: The injection pump should be thoroughly cleaned of dirt or foreign matter, being careful that no dirt enters the internal part of the pump. Place in a bucket of light oil or fuel oil to prevent corrosion.

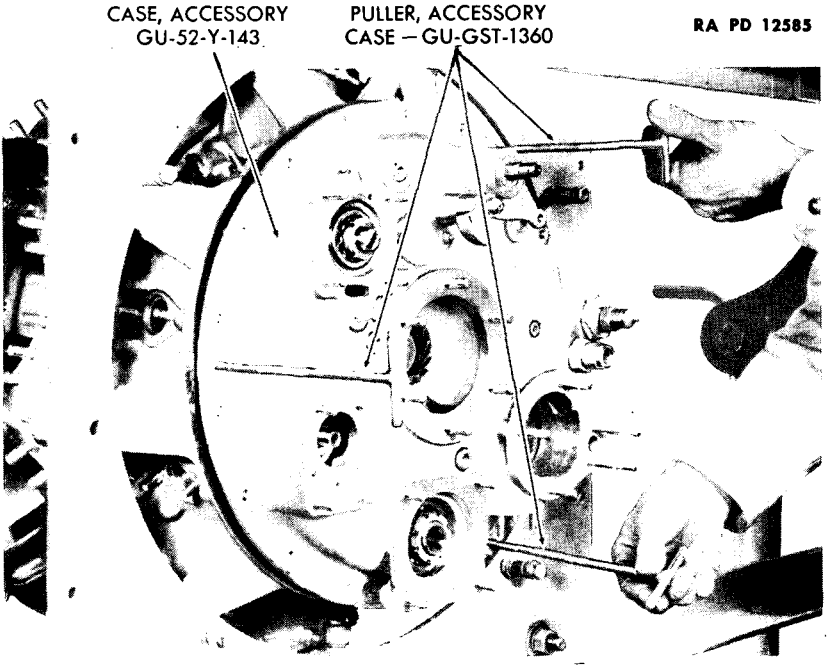

Figure 25—Removing the Accessory Case from the Crankcase

50. REMOVE THE GOVERNOR (fig. 5).

a. Equipment.
Wrench, socket, ½-in.

b. Procedure. Turn the engine so that the rear is up. Remove the palnuts, nuts and washers from the governor mounting flange and remove the governor from the accessory case.

51. REMOVE THE ACCESSORY CASE (fig. 25).

a. Equipment.

Pullers, accessory case, GU-GST-1360 Wrench, socket, ½-in.

b. Procedure.

(1) FREE THE ACCESSORY CASE.
Wrench, socket, ½-in.

Remove the palnuts, nuts and washers from the accessory case mounting studs. NOTE: There may not be sufficient clearance to remove the nut which is directly under the oil inlet to the accessory case GU-52-Y-143. In that event, turn the nut back as far as possible. It can be removed as the accessory is taken off. CAUTION: Before removing the accessory case, be sure that there are no burs on the throttle shaft hexagon nut, or on the edges of the starter shaft gear, that might damage the bushings in the accessory case as the accessory case is being removed.

(2) REMOVE THE ACCESSORY CASE.
Pullers, accessory case, GU-GST-1360

Screw the ends of the accessory case pullers GU-GST-1360 into the openings in the accessory case provided for that purpose. As these tools are screwed in they will bear against the crankcase, forcing the accessory case back off the studs. When the accessory case has been moved out far enough, remove the nut from beneath the oil inlet to the accessory case (if it was not taken off with the case in position). When the accessory case is free, lift it off the studs.

(3) REMOVE STARTER SHAFT ASSEMBLY.

52. REMOVE THE FUEL SUPPLY PUMP (fig. 5).

a. Equipment.

Wrench, open-end, ½-in.

b. Procedure. Remove the palnuts, nuts and washers from the fuel supply pump mounting flange and remove the fuel supply pump from the accessory case.

53. REMOVE THE OIL PRESSURE RELIEF VALVE AND SEAT.

a. Equipment.

Wrench, oil pressure relief valve seat plate, GU-GST-1350
Wrench, open-end, ⅞-in. Wrench, open-end, 1½-in.

b. Procedure.

(1) REMOVE THE OIL PRESSURE RELIEF VALVE.
Wrench, open-end, ⅞-in. Wrench, open-end, 1½-in.

Remove the oil dome from the oil pressure relief valve, using a ⅞-inch open-end wrench. Then, with a 1½-inch open-end

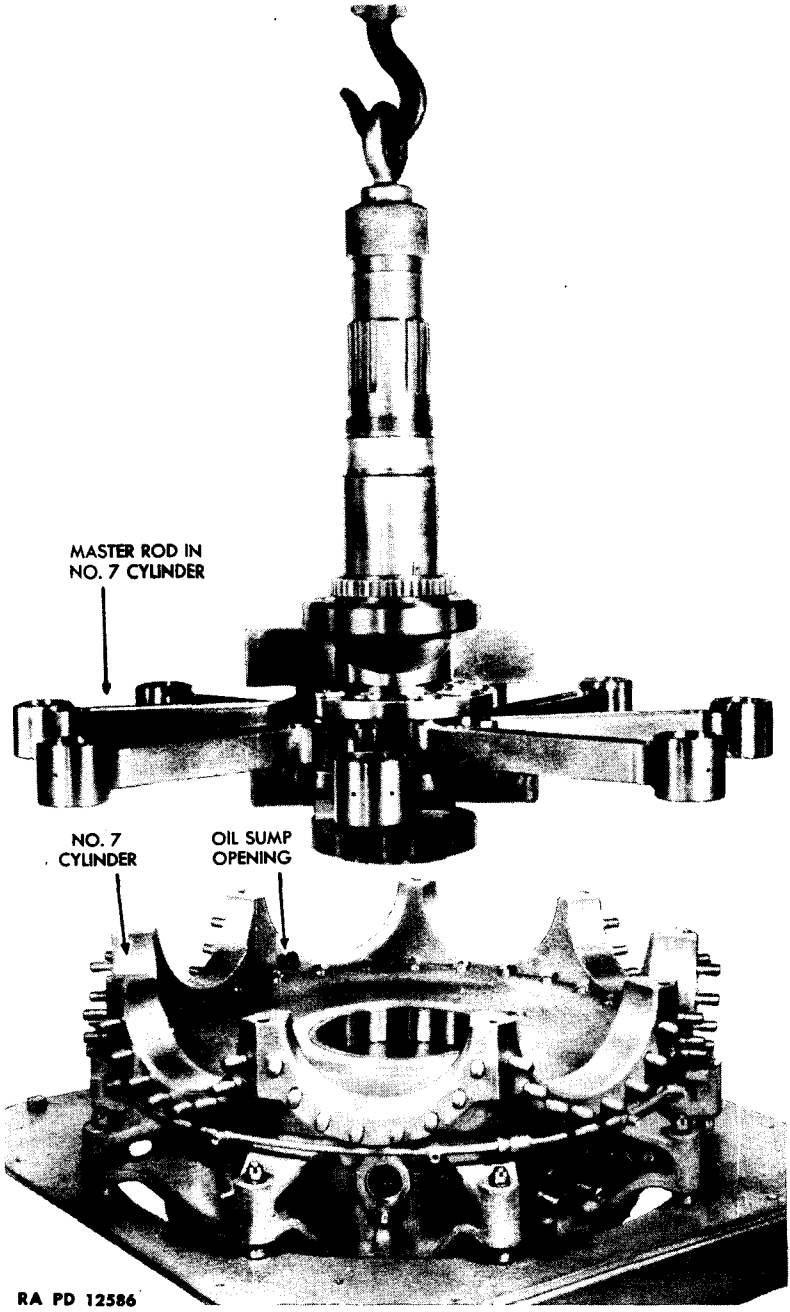

Figure 26—Lifting the Crankshaft out of the Crankcase Rear Center Section

wrench, unscrew the nut which holds the relief valve to the accessory case and remove the relief valve and spring.

(2) REMOVE THE OIL PRESSURE RELIEF VALVE SEAT.
Wrench, oil pressure relief valve seat plate, GU-GST-1350

To remove the oil pressure relief valve seat, insert the oil pressure relief valve seat plate wrench GU-GST-1350 into the slot in the seat and screw the seat out. The seat and valve should be kept together and handled carefully.

54. REMOVE THE CRANKCASE FRONT CENTER SECTION.

a. Equipment.

Hammer, brass	Wrench, socket, 7/16-in.
Remover, crankcase bolt, GU-GST-1338	Wrench, socket, 9/16-in.

b. Procedure.

(1) Turn crankcase mounting stand over until crankcase is again horizontal, with spline end of crankshaft up.

(2) Using a 9/16-inch socket wrench, remove the nuts from the crankcase assembly bolts that hold the front and rear center section of the crankcase together. Tap up with the brass hammer on all the bolts to give sufficient clearance to attach the crankcase bolt remover GU-GST-1338.

(3) Attach the remover to the bolt head and remove the bolts by striking the sliding hammer of the tool forcibly back.

(4) Lift off the crankcase front center section evenly, until it clears the crankshaft. It may be necessary to tap up on the crankcase with a soft hammer to free it.

(5) Remove the safety wire from the intermediate gear cap screws, and, using a 7/16-inch socket wrench, remove the six cap screws and the bolt. Remove intermediate gear and spindle from crankcase.

55. REMOVE THE CRANKSHAFT ASSEMBLY (fig. 26).

a. Equipment.

Eye, engine lifting, GU-GST-1550	Hoist

b. Procedure. Screw the engine lifting eye GU-GST-1550 onto the end of the crankshaft. Using a hoist, lift the crankshaft assembly out of the crankcase rear center section.

56. REMOVE THE FUEL CONTROL ASSEMBLIES (figs. 27 and 70).

a. Equipment.

Pliers	Wrench, socket, ½-in.
Wrench, fuel cam mounting plate lock nut, GU-GST-1551	

DISASSEMBLY OF ENGINE

WRENCH, FUEL CAM MOUNTING PLATE LOCKNUT – GU-GST-1551 RA PD 12587

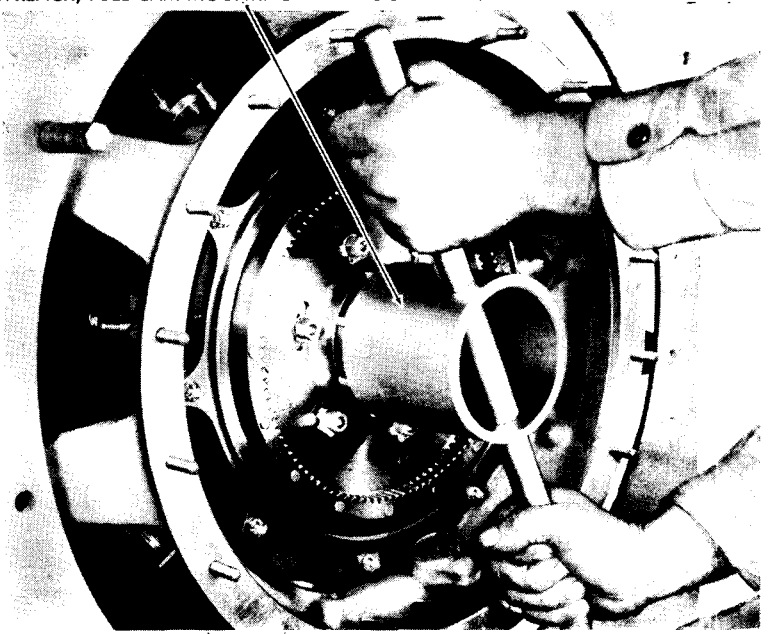

Figure 27—Remove the Fuel Cam Mounting Plate Lock Nut

b. Procedure.

(1) REMOVE THE FUEL CAM RING AND DRIVE GEAR.
Pliers
Wrench, fuel cam mounting plate lock nut, GU-GST-1551

Remove the cotter pin from the lock nut. Using the fuel cam mounting plate lock nut wrench GU-GST-1551, unscrew the lock nut and lift off the spacer. Lift the fuel cam ring and drive gear out of the fuel control lever mounting plate.

(2) REMOVE THE FUEL CONTROL LEVER MOUNTING PLATE. Lift the fuel control lever mounting plate out of the rear crankcase mounting section.

(3) REMOVE THE MOUNTING PLATE.
Wrench, socket, ½-in.

Remove the nuts, washers and spacers that hold the fuel cam mounting plate in place, and lift off the mounting plate.

(4) REMOVE THE LOCK RING.
Wrench, socket, ½-in.

Remove the nuts, washers and safety wire which hold the lock ring in place. Slide the lock ring off the studs.

Section IV

THE INSPECTION

57. GENERAL.

a. When the engine is completely disassembled, all parts should be properly cleaned and thoroughly inspected. A careful inspection will lengthen the period of time that the engine delivers dependable, trouble-free service. The replacement of questionable parts may save considerable time and labor later.

b. This inspection should include a check of all parts for specified fits and clearances. Fits and clearances of various parts are shown in this section of the manual when the inspection of those parts is de-

scribed. In addition, a clearance chart is reproduced in section X of this manual. All parts which have not reached the maximum wear limits, but are worn enough to indicate that the maximum limits will be reached or exceeded before the next overhaul period, should be replaced.

c. During the inspection all steel parts should be magnafluxed to detect internal flaws which may not be apparent on the surface. All aluminum parts should be cleaned and inspected for cracks.

d. Cleaning facilities for thoroughly cleaning engine parts should be provided. Only approved cleaning fluids that are known not to be injurious to steel and aluminum should be used.

e. A separate vat for cleaning bearings, in which no other parts are cleaned, should be available. Oil all bearings immediately after cleaning, cover them and place in a dust tight container, or submerge in clean oil in a covered container.

f. Benches and parts storage tables of wood covered with paper are preferable to metal covered tables for inspection purposes, to prevent nicking parts.

g. Careful attention to cleanliness should be observed while making the inspections. Due to the close fit of many parts, a small amount of dust or dirt between them could result in serious damage. Parts should be handled carefully to avoid nicks or scratches, which might affect engine operation.

58. THE OIL PUMP (figs. 28, 29, 30, 31, and 32).

a. **Equipment.** The following is a list of equipment needed for the disassembly and assembly of the oil pump:

Drift, soft	Vise, soft-jawed
Gage, feeler	Wrench, open-end, 3/8-in.
Micrometer, depth	Wrench, open-end, 7/16-in.
Micrometer, outside	

b. **Description.** The lubricating oil pump is a gear type pump comprising three pumps in one. One set of gears pumps oil from the oil scavenger sump. Another set pumps oil from the scavenger rocker box covers on No. 5 and No. 6 cylinders. The third set of gears is the oil pressure pump, forcing oil through the circulating system. Two gears are used in each unit of the pump. The sump scavenger gears are both integral with their shafts. The oil pump pressure drive gear and the rocker box scavenger drive gear are keyed to the oil pump drive gear shaft. Each set of gears is enclosed in its own housing. The procedure for disassembling the oil pump follows:

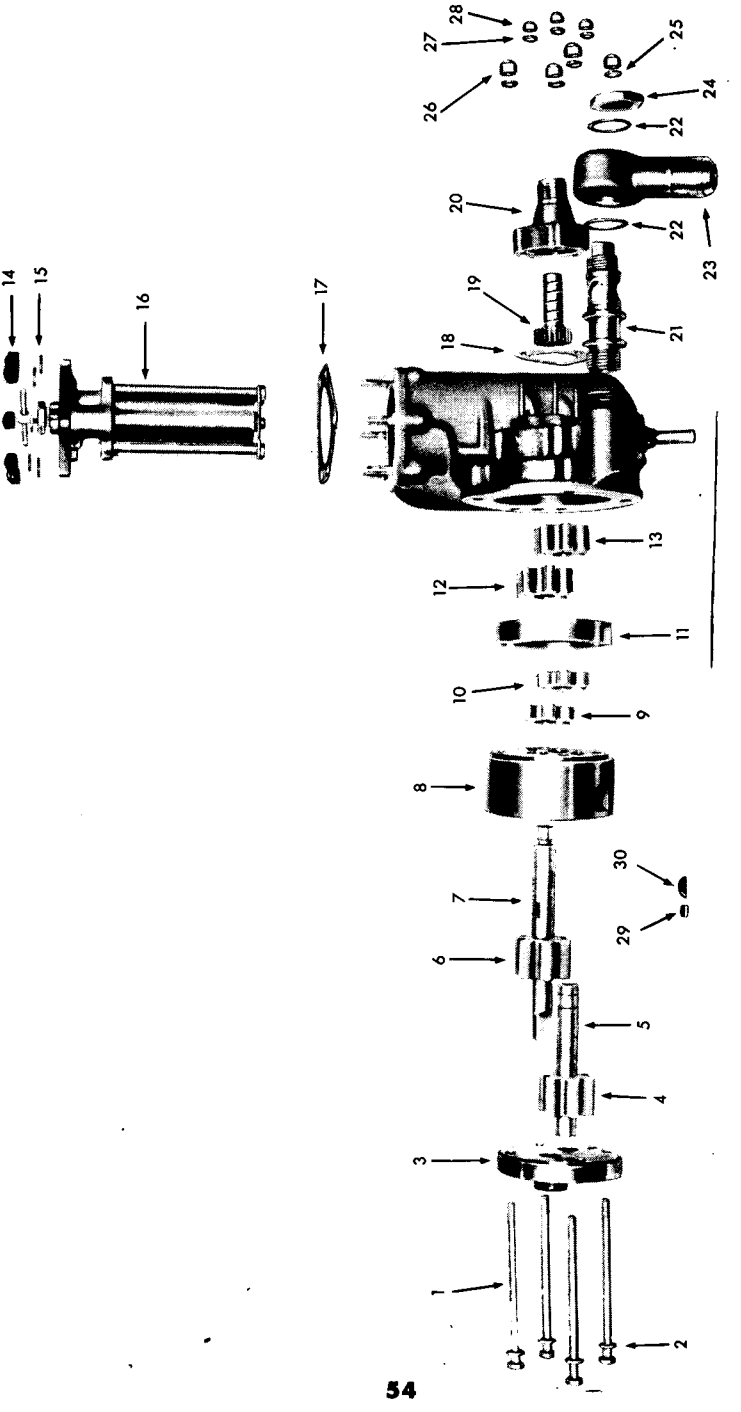

Figure 28—The Oil Pump Assembly

1 — BOLT, OIL PUMP ASSEMBLY - GU-Y-384
2 — WASHER, OIL PUMP ASSEMBLY BOLT - GU-Y-352
3 — PLATE, END, OIL PUMP - GU-13-Y-135
4 — GEAR, OIL PUMP ENGINE SCAVENGER IDLER - GU-14-Y-136A
5 — SHAFT, OIL PUMP IDLER GEAR - GU-53-Y-136
6 — GEAR, OIL PUMP ENGINE SCAVENGER DRIVE - GU-14-Y-137E
7 — SHAFT, OIL PUMP DRIVE GEAR - GU-53-Y-137
8 — BODY, OIL PUMP ENGINE SCAVENGER GEAR - GU-13-Y-132
9 — GEAR, OIL PUMP ROCKER BOX SCAVENGER DRIVE - GU-14-Y-137F
10 — GEAR, OIL PUMP ROCKER BOX SCAVENGER IDLER - GU-14-Y-136B
11 — BODY, OIL PUMP ROCKER BOX SCAVENGER GEAR - GU-13-Y-142
12 — GEAR, OIL PUMP PRESSURE DRIVE - GU-52M-Y-138
13 — GEAR, OIL PUMP PRESSURE IDLER - GU-52M-Y-141
14 — NUT, OIL FILTER MOUNTING STUD - GU-Y-304
15 — WASHER, OIL FILTER MOUNTING STUD - GU-Y-352
16 — FILTER, OIL: SUBASSEMBLY - GU-51-YA-199
17 — GASKET, OIL FILTER - GU-14-Y-473
18 — GASKET, OIL PUMP TACHOMETER GEAR HOUSING CAP - GU-13-Y-471
19 — GEAR, OIL PUMP TACHOMETER DRIVE - GU-13-Y-139
20 — CAP, OIL PUMP TACHOMETER GEAR HOUSING - GU-13-Y-134
21 — FITTING - GU-13-YX-120E
22 — GASKET - GU-13-YX-120F
23 — CONNECTOR - GU-13-YX-120C
24 — NUT - GU-13-YX-120E
25 — WASHER, OIL PUMP ASSEMBLY BOLT - GU-Y-352
26 — NUT, OIL PUMP ASSEMBLY BOLT - GU-Y-304
27 — WASHER, OIL PUMP TACHOMETER GEAR COVER MOUNTING - GU-Y-351
28 — NUT, OIL PUMP TACHOMETER GEAR COVER PLATE MOUNTING - GU-Y-301
29 — KEY, OIL PUMP ROCKER BOX SCAVENGER DRIVE GEAR - GU-13-Y-137B
30 — KEY, OIL PUMP PRESSURE DRIVE GEAR - GU-13-Y-137A

RA PD 125888

Figure 28A—The Oil Pump Assembly—Nomenclature

c. Disassembly Procedure.

(1) REMOVE THE OIL FILTER.
Wrench, open-end, 7/16-in.

Remove the six elastic stop nuts GU-Y-304 and washers GU-Y-352 which hold the oil filter GU-51-YA-199 in the pump. Lift out the oil filter and oil filter gasket GU-14-Y-473.

(2) REMOVE THE TACHOMETER DRIVE.
Wrench, open-end, 3/8-in.

Remove the three nuts GU-Y-301 and washers GU-Y-351 from the tachometer gear housing cap GU-13-Y-134, lift off the cap and gasket GU-13-Y-471 and lift out the tachometer drive gear GU-13-Y-139.

(3) SEPARATING THE OIL PUMP SECTIONS.
Wrench, open-end, 7/16-in.

Remove the four bolts GU-Y-384 with washers GU-Y-352 at each end, which extend through the oil pump and the elastic stop nuts GU-Y-304. Remove the oil pump end plate GU-13-Y-135 exposing the sump scavenger gears GU-14-Y-136A and GU-14-Y-137E. Lift the oil pump gears and plates from the oil pump assembly.

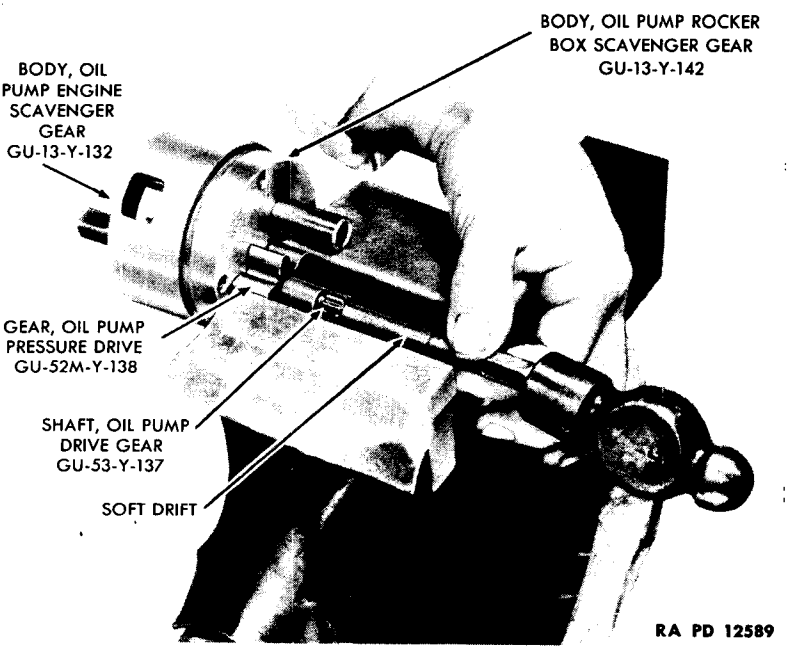

Figure 29—Disassembling the Oil Pump Gears

(4) REMOVING THE OIL PUMP GEARS.

Drift, soft Vise, soft-jawed

Lift out the oil pump pressure idler gear GU-52M-Y-141. Clamp the oil pump pressure drive gear GU-52M-Y-138 in a soft-jawed vise (fig. 29). Drive on the shaft with a soft drift, being sure that the gear plates move back with the shaft so that the oil pump pressure drive gear key GU-13-Y-137A does not damage the plates. When the shaft has been driven out of the pressure gear, remove the key from the shaft and lift off the oil pump rocker box scavenger gear body GU-13-Y-142. The rocker box scavenger drive gear GU-14-Y-137F and key GU-13-Y-137B can then be removed in a similar manner. Lift out the rocker box scavenger idler gear GU-14-Y-136B. Remove the engine scavenger gears and the shafts, being sure there are no burs on the shafts, to complete the disassembly.

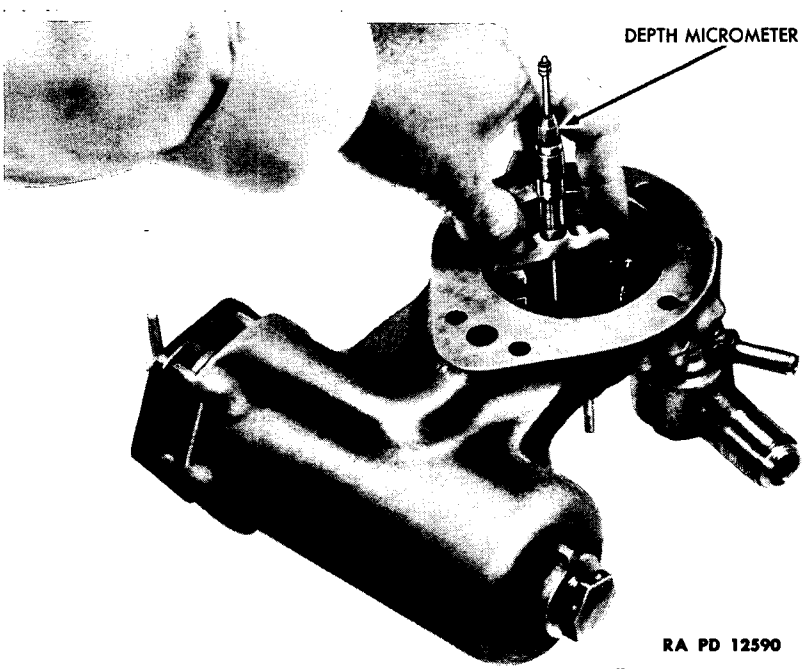

Figure 30—Checking Oil Pump Gear Side Play with Depth Micrometer

d. Inspection.

(1) VISUAL INSPECTION.

Make a visual inspection of all gears and the shafts for chipped teeth or other defects.

(2) CHECK SIDE CLEARANCE OUTSIDE MICROMETER.

Micrometer, depth

Place a depth micrometer over the rim of the gear bodies and measure the depth of the bodies. With an outside micrometer, measure the thickness of the gears, comparing this measurement of the gears with their respective gear bodies. This gear to body clearance should be 0.001 inch to 0.006 inch.

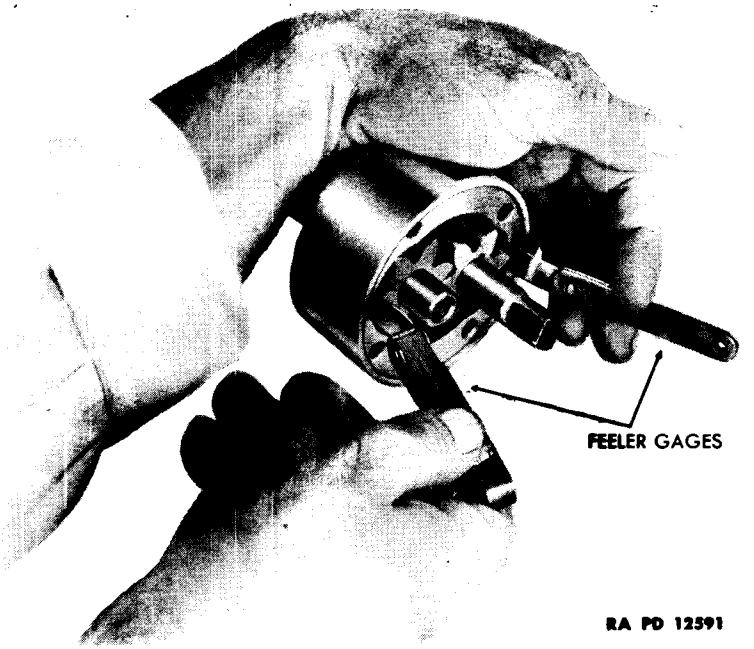

Figure 31—Checking Clearance between Gear Teeth and Housing

(3) CHECK RADIAL CLEARANCE.

Gage, feeler

The clearance between the ends of the gear teeth and housing must also be measured. To do this the gears must be placed on their shafts, although the keys do not need to be inserted. With the gears in place, use a feeler gage at each end to measure the clearance (fig. 31). This clearance should be 0.0015 inch to 0.005 inch.

(4) CLEANING THE OIL FILTER. The oil filter is made up of a deep layer of metal disks. It is cleaned by turning the handle at top. As the handle is turned the disks revolve against the stationary cleaner blades which project into each slot and remove any

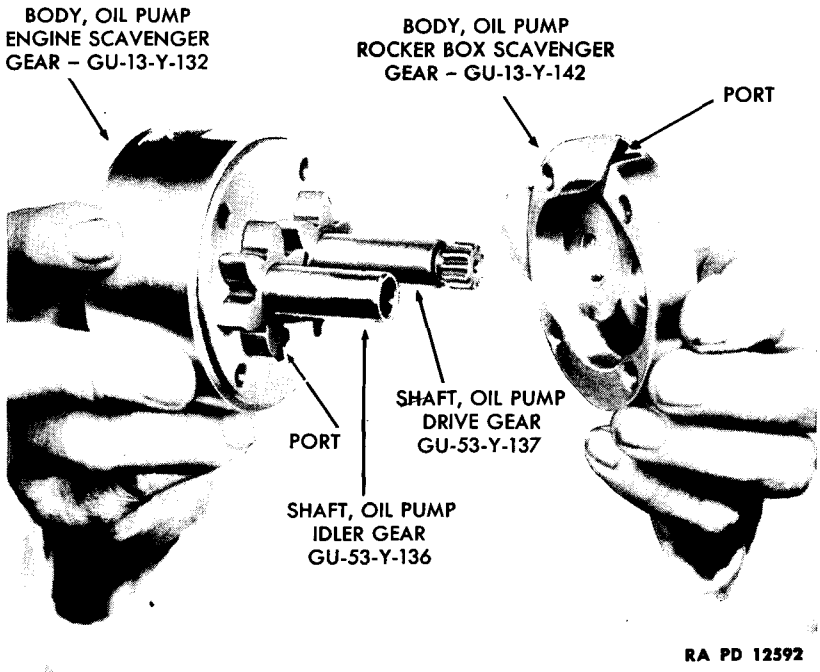

Figure 32—Assembling the Oil Pump Gears

material which may have lodged in the slots. There is no wear on the filter, and it does not require replacement unless it becomes damaged.

e. Assembly Procedure.

(1) INSTALL THE SHAFTS. Hold the oil pump engine scavenger gear body GU-13-Y-132 (the large housing) with the port down, and insert the oil pump drive gear shaft GU-53-Y-137 from the inside of the housing, through the hole at the left. Insert the oil pump idler gear shaft GU-53-Y-136 through the other hole.

(2) INSTALL ROCKER BOX SCAVENGER GEARS AND BODY. Install the rocker box scavenger pump gears (the smallest gears) on the shafts on the outside of the body, with the keyed gear on the drive shaft and with the key in place. Slide the oil pump rocker box scavenger gear body GU-13-Y-142 on the shafts *with the port at the opposite side from the port in the larger body* (fig. 32).

(3) INSTALL PRESSURE PUMP GEARS. Install the pressure pump gears on the shaft, with the key in the drive shaft.

(4) ASSEMBLE THE SECTIONS OF THE PUMP.
Wrench, open-end, 7/16-in.

Install the end plate over the other end of the assembly with the high shoulder of the plate over the drive gear shaft. Insert the gear assembly in the oil pump housing. The drive gear shaft goes through the opening nearest the oil filter. Install the housing bolts, with a washer at both the bolt head and nut, and screw on the elastic nuts.

(5) INSTALL THE TACHOMETER DRIVE.
Wrench, open-end, 3/8-in.

Install a new tachometer gasket, and the gear and housing. Place washers on the studs and install the elastic stop nuts.

(6) INSTALL THE CONNECTIONS.
Install the washers, connections and nut in the order shown in figure 28.

(7) INSTALL THE OIL FILTER.
Wrench, open-end, 7/16-in.

Place a new oil filter gasket on the studs of the oil filter. Install the oil filter, with its washers and nuts.

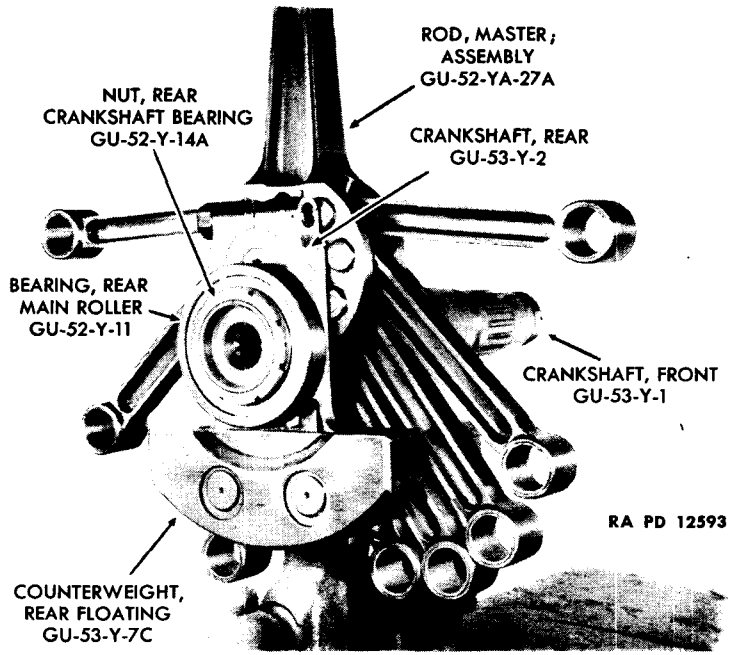

Figure 33—The Crankshaft Assembly

THE INSPECTION

59. REMOVAL OF REAR CRANKSHAFT (figs. 33, 34, 35, 36, and 37).

a. Equipment.

Bar, wood	Wedge, crankshaft, GU-GST-1347
Hammer, soft	Wrench, rear crankshaft bearing nut, GU-GST-1528
Pliers	Wrench, socket, 1⅜-in., with ¾-in. drive
Puller, rear crankshaft bearing, GU-GST-1507	
Vise, soft-jawed	

b. Procedure. NOTE: Clamp the forward cheek or counterweight (the fixed counterweight) of the crankshaft GU-53-Y-1 in a soft-jawed vise. The master connecting rod and three of the rods should be on one side, and the other five rods on the other (fig. 33).

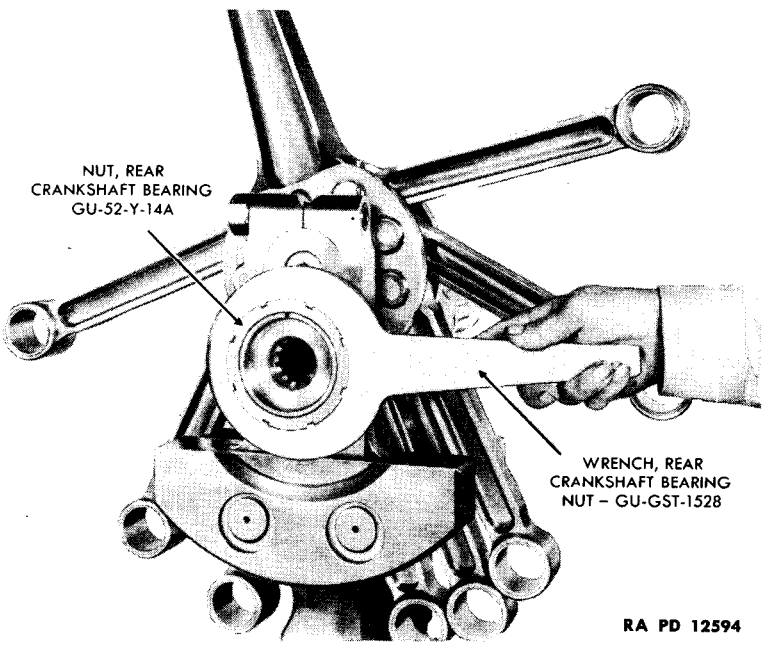

Figure 34—Removing Rear Crankshaft Bearing Nut

(1) REMOVE THE REAR CRANKSHAFT BEARING NUT (fig. 34).

Pliers	Wrench, rear crankshaft bearing nut, GU-GST-1528
Vise, soft-jawed	

Remove the cotter pin which holds the rear crankshaft bearing nut GU-52-Y-14A and then remove the nut. *This nut has a left-hand thread. Turn clockwise to remove it.*

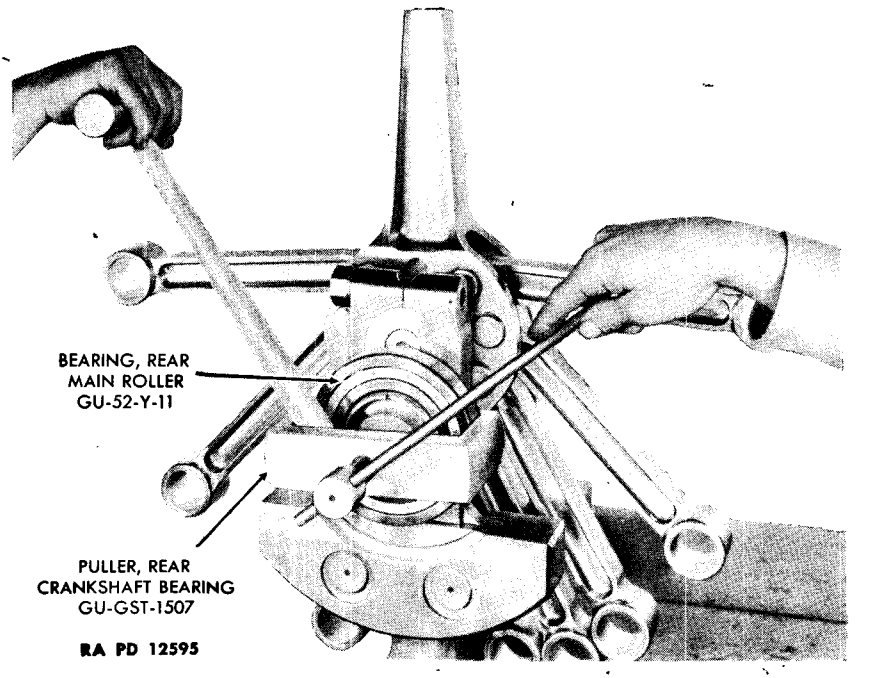

Figure 35—Removing the Crankshaft Rear Main Roller Bearing

(2) REMOVE THE REAR MAIN BEARING (fig. 35).

Bar, wooden
Puller, rear crankshaft bearing, GU-GST-1507

Clamp the fingers of the rear crankshaft bearing puller GU-GST-1507 behind the rear main roller bearing GU-52-Y-11 (fig. 35). An adapter is used on the crankshaft under the puller screw. Turn the screw of the puller against the adapter and crankshaft to pull the rear main roller bearing off the shaft. NOTE: A wooden bar, such as a hammer handle, should be inserted between the puller and the crankshaft to keep the puller from "creeping" around while it is being used. Be careful not to let the puller fingers ride against the crankshaft cheeks, or it might damage them.

(3) REMOVE THE CRANKSHAFT CLAMPING BOLT (fig. 36).

Wrench, socket, 1⅜-in., with ¾-in. drive

(a) NOTE: The crankshaft clamping bolt GU-52-Y-3 on the rear crankshaft is stretched as it is inserted, and is difficult to remove. Turn the master connecting rod so that the channel in it is lined up with the head of the bolt. This is the only place

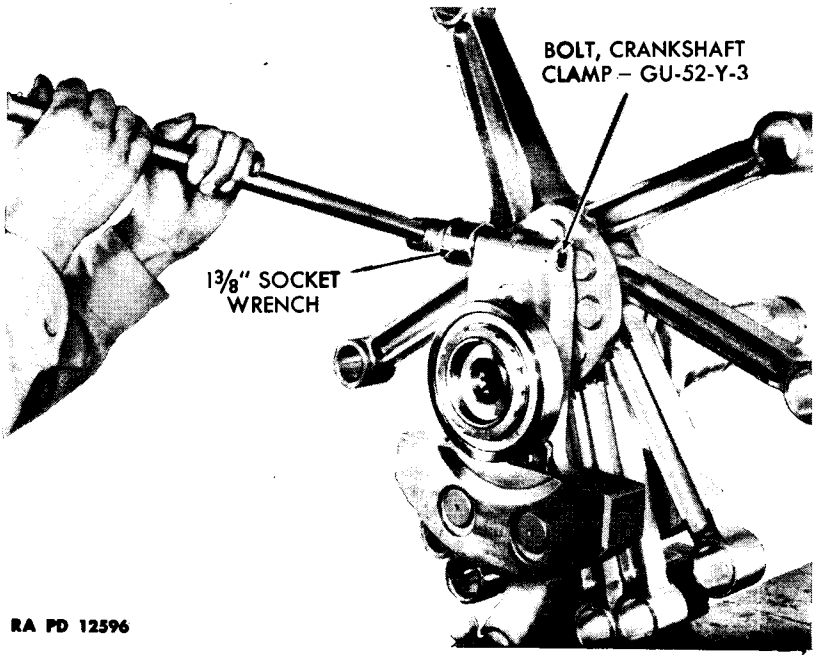

Figure 36—Removing Crankshaft Clamping Bolt

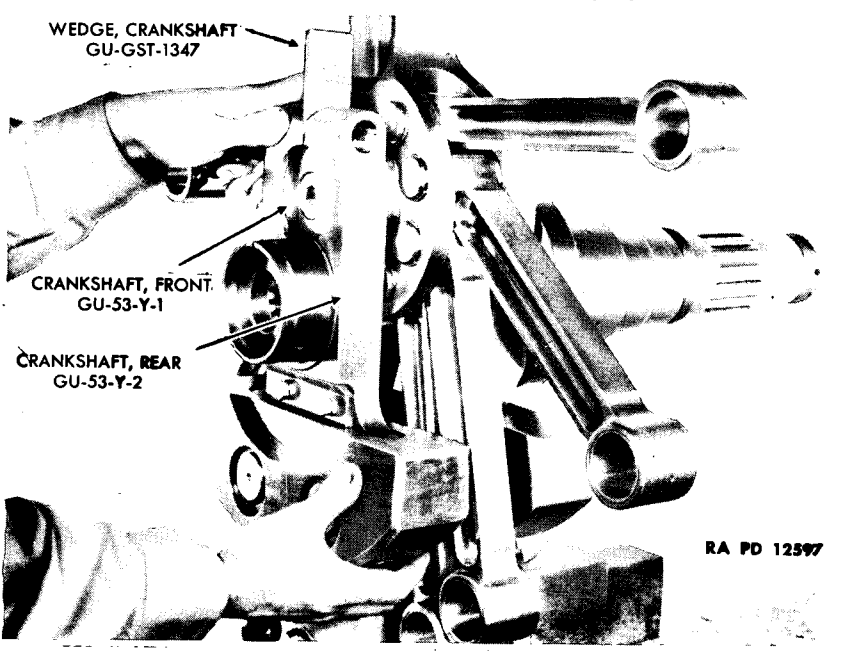

Figure 37—Removing the Rear Crankshaft Assembly

on the rod assembly which will allow sufficient clearance to fit a wrench over the bolt.

(b) Remove the cotter pin from the bolt, and remove bolt and washer. Be careful not to damage the rear crankshaft.

(4) REMOVING REAR CRANKSHAFT (fig. 37).

Hammer, soft — Wedge, crankshaft, GU-GST-1347

Drive the crankshaft wedge GU-GST-1347 down into the "V" opening in the rear crankshaft clamping section (fig. 37). Avoid driving the wedge down too far. It may damage the crankshaft journal. Do not spread the crankshaft over a maximum of 0.004 inch, as it might split the crankshaft. With the clamping section spread, slide the rear crankshaft assembly off the front crankshaft journal, being careful not to cock it.

(5) REMOVE MASTER CONNECTING ROD ASSEMBLY. Examine the front crankshaft assembly to make sure there are no burs which might damage the master rod bushing, then slide the master rod off the front crankshaft journal.

60. INSPECT THE REAR CRANKSHAFT ASSEMBLY (figs. 38 and 39).

a. Equipment.

Gage, feeler — Screwdriver
Micrometer — Wrench, socket, 9/16-in.
Pliers

b. Procedure. NOTE: The floating counterweight GU-53-Y-7C on the rear crankshaft is held in place by two pins GU-53-Y-9A, which permit a slight movement of the counterweight on the crankshaft. The pins fit loosely in inserts in the two sides of the counterweight and in the lower part of the rear crankshaft. The ends of the pins are flanged.

(1) REMOVE THE COUNTERWEIGHT STOP.

Pliers — Wrench, socket, 9/16-in.

Remove the cotter pins from the two castle nuts GU-Y-322 that hold the crankshaft counterweight stop GU-53Y-2D to the rear crankshaft. Remove the nuts GU-Y-322 and washers GU-Y-360 and slide out the bolts GU-Y-422. Lift off the stop. NOTE: Number the pins and the insert openings in the counterweight, so that the pins will be replaced in the proper inserts.

(2) REMOVE THE COUNTERWEIGHT. Move the counterweight up on the crankshaft until the inserts are in line in the counterweight and crankshaft. This will allow sufficient clearance to slide the pins out. Then slide the counterweight off the crankshaft.

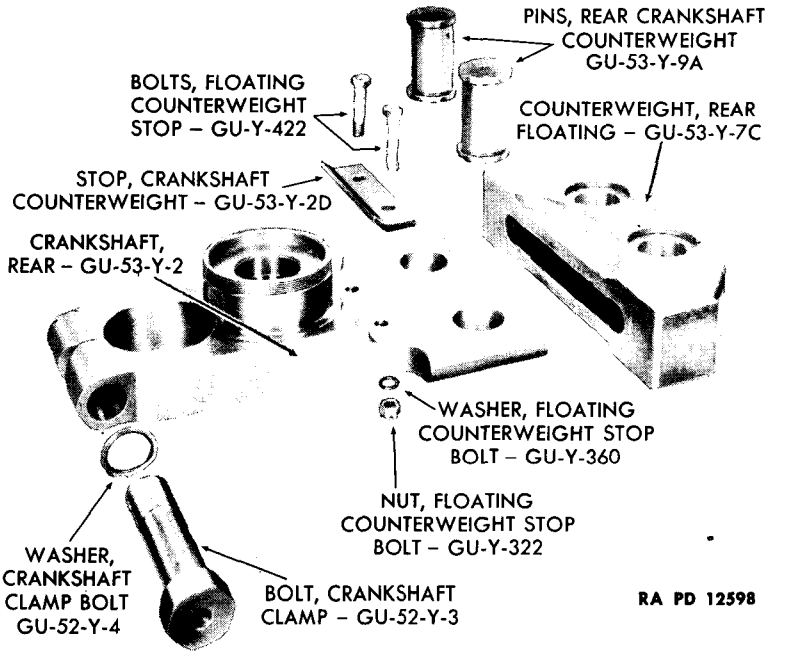

Figure 38—The Rear Crankshaft Assembly

(3) INSPECT THE REAR CRANKSHAFT.
Micrometer

NOTE: Give the rear crankshaft a visual inspection for scratches or nicks.

(a) Bushing. Use an inside micrometer to measure the diameter of the bushing, and note the measurement for checking the clearance when replacing the rear crankshaft.

(b) Inserts. Examine the inserts in the crankshaft and counterweights for nicks or excessive wear. See section V for turning or replacement of inserts.

(c) Pins. Examine the pins for cracks and scuffing or excessive wear. Measure their diameter. If they are out-of-round, or undersized more than 1.247 inches, discard them.

(4) REASSEMBLE THE REAR CRANKSHAFT ASSEMBLY.
Gage, feeler
Screwdriver
Wrench, socket, 9/16-in.

To reassemble the rear crankshaft assembly, slide the counterweight up over the skirt of the rear crankshaft, so that the insert openings are in line. Drop the pins into the properly numbered openings, then pull the counterweight back to bind the pins in position. Place the stop in position above the counterweight. Insert the two bolts into the bolt-holes in the stop and crank-

shaft. Be sure the upper part of the stop is tight against the mating part of the crankshaft. It may be necessary to insert a screwdriver between the stop and counterweight and to pry up on the stop before the bolts will drop through. Then install the washers and castle nuts on the bolts. Replace the cotter pins. The counterweight clearance should then be checked with a feeler gage at the positions indicated by arrows on figure 39. Clearances should be:

Counterweight to crankshaft (side)—0.010L to 0.016L in.
Counterweight to crankshaft (end)—
Lower side of stop to counterweight—0.027 in. min. to 0.040 in. max.

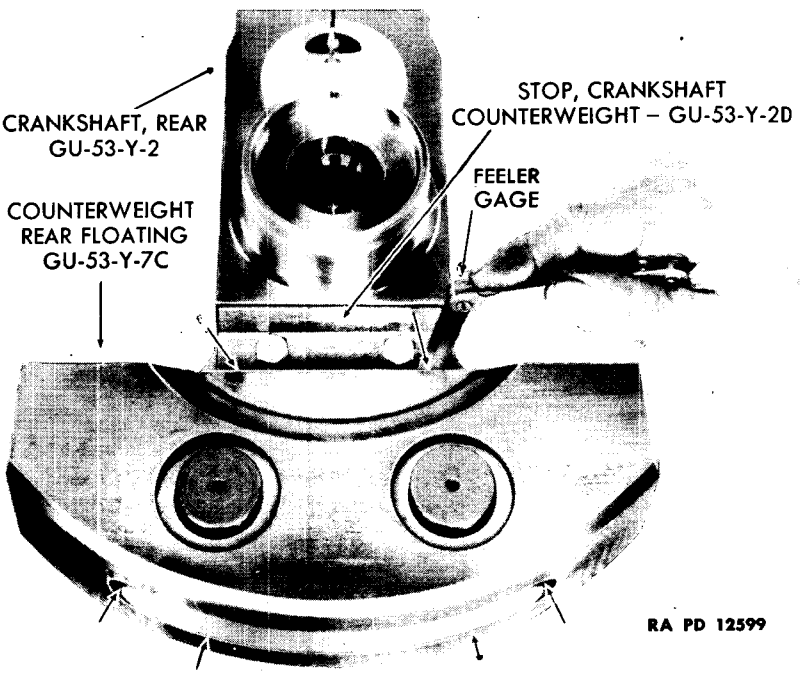

Figure 39—Check Rear Crankshaft Counterweight Clearances at Points Indicated by Arrows

61. INSPECTION OF THE FRONT CRANKSHAFT.

a. Equipment.

Hammer, soft
Micrometer
Pliers
Puller, crankshaft gear and front bearing, GU-GST-1518
Vise
Wrench, Allen, 9/16-in.

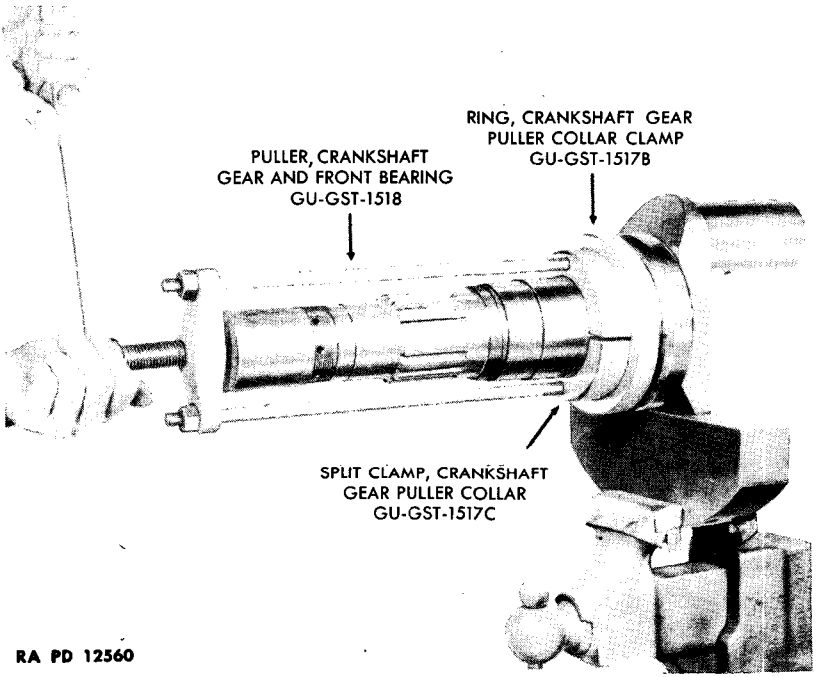

Figure 40—Removing Front Crankshaft Gear

b. Procedure.

(1) REMOVE FRONT CRANKSHAFT GEAR.
Puller, crankshaft gear and front bearing GU-GST-1518

Clamp the two halves of the gear puller split clamp behind the gear, and encircle them with the clamp ring to hold them in place. Screw the puller studs into the two halves of the split clamp. Place the cross-arm of the puller GU-GST-1518 over the studs, and install the nuts on the studs. Place an adapter between the puller screw and the crankshaft. Turn down the puller screw to pull the gear from the shaft. Remove the key from the front crankshaft. It may be necessary to turn a screw (No. 6, 32 thread) into the screw hole in the key to force the key up.

(2) REMOVE THE BEARING FROM THE FRONT CRANKSHAFT.
Puller, crankshaft gear and front bearing GU-GST-1518

Slide the collar GU-GST-1516 of the crankshaft gear and front bearing puller over the bearing with the flange of the collar behind the bearing. Avoid letting the puller hit the crankshaft. Install the studs and cross-arm of the puller (fig. 41). Place an adapter between the puller screw and the end of the front crankshaft. Turn down the puller screw to pull the main bearing off

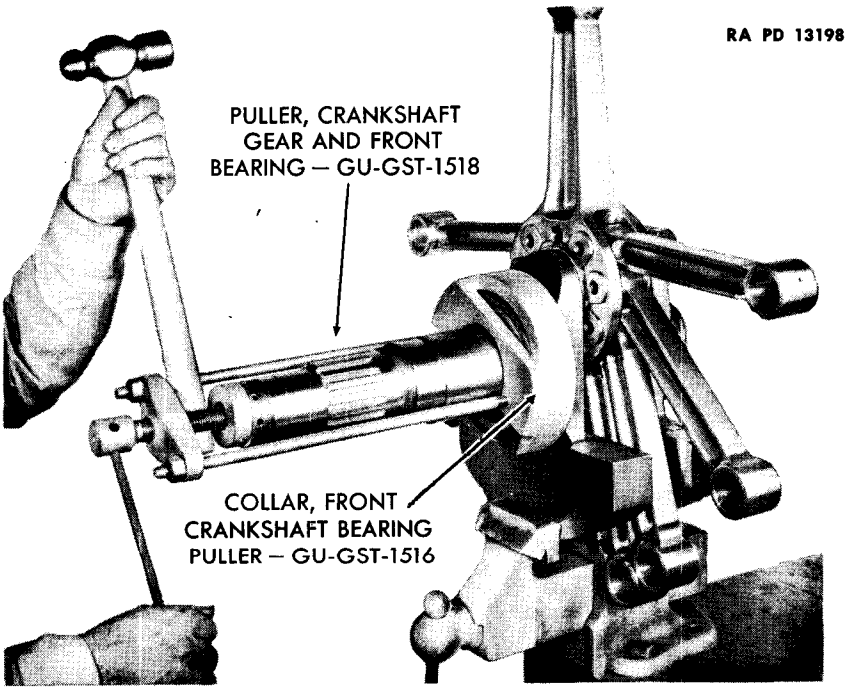

Figure 41—Pulling Front Crankshaft Bearing

the crankshaft. It may be necessary to insert a wood rod or hammer handle between the puller screw and one of the studs to keep the puller from turning.

(3) REMOVE THE CRANKPIN OIL PLUG.

Pliers Wrench, Allen, 9/16-in.

Remove the cotter pin from the front crankshaft journal, then remove the Allen head plug from the crankpin. Be careful not to mar the crankshaft. Clean out the oil passages. Check the oil jets to make sure they are open and tight in the shaft.

(4) CHECK THE CRANKSHAFT.

Hammer, soft Micrometer

NOTE: Make a visual inspection of the crankshaft for scoring or defects. Check the oil passages to make sure that they are clear, and examine the shaft for burs.

(a) Oil Channel Plug. Examine the oil channel plug in the crankshaft for leaks or looseness. If it requires replacing, see section V.

(b) Front Crankshaft Counterweight. The front crankshaft counterweight is riveted together. Strike these rivets with a soft

hammer to test for looseness. Oil will probably ooze up around the rivets as they are struck, but unless rivets are loose they will be satisfactory.

(c) Front Crankshaft Journal. Measure the front crankshaft journal. Measure at each end of the journal and two ways across the shaft. Mark these measurements down for use when assembling the crankshaft and master rod. See clearance chart (par. 180) for front crankshaft journal tolerances.

(5) INSTALL ALLEN HEAD OIL PLUG.

Pliers — Wrench, Allen, 9/16-in.
Vise

When the front crankshaft has been inspected, install the Allen head oil plug in the crankpin. If the cotter pin hole in the crankshaft does not line up with the hole in the Allen plug, use the crankshaft hole as a guide in drilling a new hole in the plug. Then install a new cotter pin. Make sure that the head is sunk below the surface of the shaft.

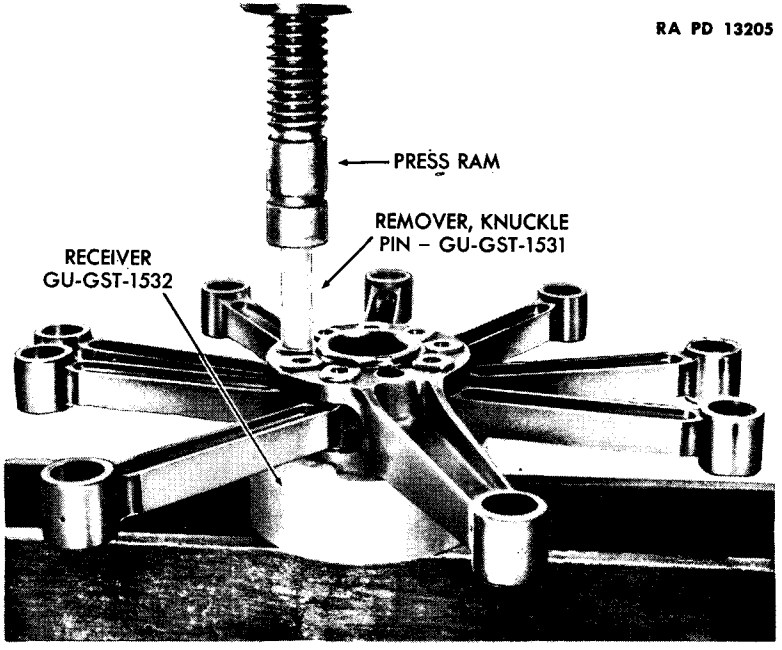

Figure 42—Removing the Knuckle Pins

62. REMOVE THE LINK RODS (figs. 42 and 43).

NOTE: Each knuckle pin GU-52-Y-30 has a flange at one end. A retaining ring GU-52-Y-30C is used at the other end of the knuckle pin, to hold it in place.

a. Equipment.

Press
Receiver, knuckle pin and master rod, GU-GST-1532
Remover, knuckle pin, GU-GST-1531
Splitter, ring
Support, web, GU-GST-1556

b. Procedure.

(1) FREE THE KNUCKLE PIN RETAINING RING.

Press
Receiver, knuckle pin and master rod, GU-GST-1532
Remover, knuckle pin, GU-GST-1531

Place the knuckle pin and master rod receiver GU-GST-1532 on a press. Install the master rod assembly on the receiver, with the master rod in the offset in the receiver provided for the purpose, and with the flanged side of the knuckle pins up. Place the knuckle pin remover GU-GST-1531 on a knuckle pin and use the support web tool GU-GST-1556 between the link rods. Press the pin down to free the retaining ring (fig. 42). Repeat this operation on all the knuckle pins. Remove the master rod assembly and turn it over. Turn the retaining ring so that the gap in the ring is toward the master rod bushing to allow clearance in removing the ring.

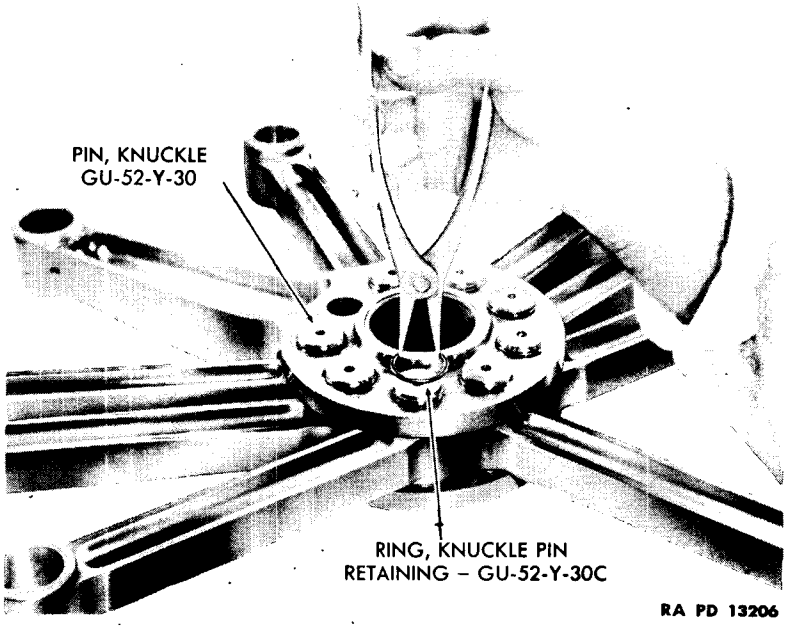

Figure 43—Lifting a Retaining Ring from the Knuckle Pin

(2) REMOVE RETAINING RINGS.
Splitter, ring

Insert the prongs of a retaining ring remover or ring splitter between the ends of the retaining ring and expand the ring so that it clears the groove in which it sets, then lift it out (fig. 43).

(3) REMOVE THE LINK RODS.

Press	Remover, knuckle pin, GU-GST-1531
Receiver, knuckle pin and master rod, GU-GST-1532	Support web, GU-GST-1556

When all the retaining rings have been removed, place the assembly on the receiver on the press with flange side of the knuckle pins down. Place the remover on the knuckle pins and press out. Support the web of the master rod with the web support GU-GST-1556 as each pin is pressed out. Remove the link rods. The pins and rods should be numbered to indicate the cylinder in which they belong. Check and make sure the numbers are legible. If they are not, renumber them.

63. INSPECT LINK RODS (figs. 44 and 45).

a. Equipment.

Aliner, knuckle pin	Micrometer
Gage, telescope	

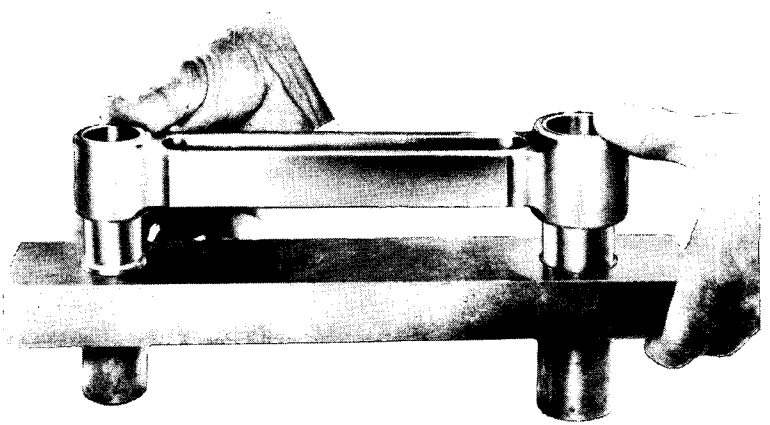

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Figure 44—Checking Link Rod Alinement

b. **Procedure.**

(1) CHECK ALINEMENT.

Aliner, knuckle pin

Place the link rod over a knuckle pin aliner (fig. 44). When the rod is held just above the fixture, no light should appear around the sides of the fixture through the rod bushings. Check the alining tool for rust or roughness. Cover the tool prongs with light oil, and slip the rod down on them (fig. 44). The rod should slide over the upright prongs by hand pressure. If it does not, the rod is out of alinement and should be discarded.

(2) VISUAL INSPECTION. Make a visual inspection of the rod for bad nicks or for cracks. Inspect the bushings for scoring. Check the oil holes in the rods and bushings to make sure they are in line and clear. Check to make sure the ends of the bushing project slightly beyond the sides of the rod.

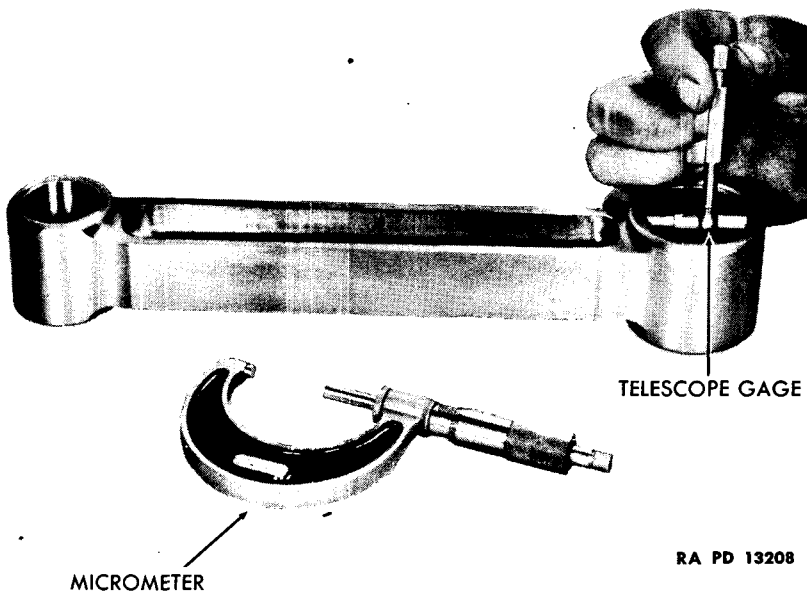

Figure 45—Checking Link Rod Bushing with Telescope Gage

(3) BUSHINGS.

Gage, telescope Micrometer

Measure the bushings at both ends, in line with the rod and across the rod. Use a micrometer on the gage to get the measurements. Mark these down for use in assembling the master rod assembly.

THE INSPECTION

64. INSPECT THE MASTER ROD.

a. Equipment.

Gages, snap — Micrometer

b. Procedure. The master rod is inspected in the same way as the other rods, as covered in paragraph 63. In addition, inspect the pin at the top which holds the piston pin bushing, to make sure it is tight.

65. INSPECT THE KNUCKLE PINS.

a. Equipment.

Micrometer

b. Procedure.

(1) VISUAL INSPECTION.

Give the pins a visual inspection for nicks or scratches. Check the aluminum plug in the end of each pin to make sure it is tight. If it is not tight, the pin must be discarded.

(2) MIKING.

Micrometer

Since the pin is clamped at each end in the master rod, there can be no wear. Therefore, it is not necessary to gage the pins at the ends. However, a micrometer should be used at three points between these ends, and across the rod two ways.

66. ASSEMBLE MASTER ROD (figs. 46 and 47).

a. Equipment.

Drift, knuckle pin inserting, GU-GST-1530
Gage, feeler
Hammer, soft
Press
Receiver, knuckle pin and master rod, GU-GST-1532
Splitter, ring
Support, master rod web, GU-GST-1556

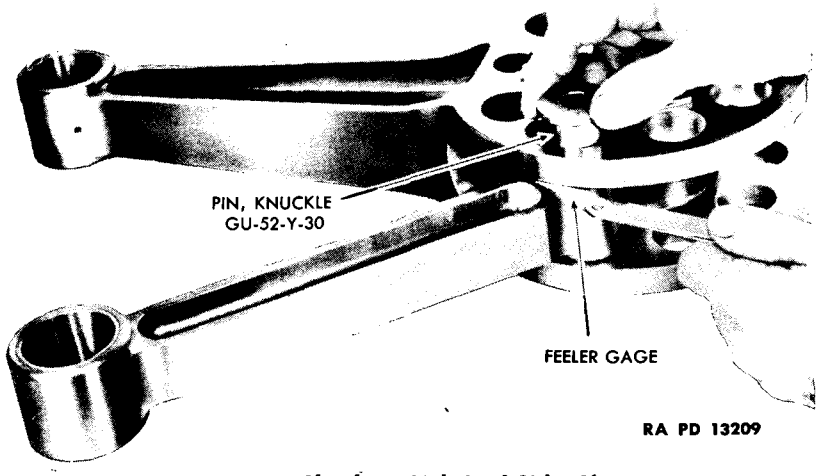

Figure 46—Checking Link Rod Side Clearance

b. Procedure.

(1) INSPECTION.

Gage, feeler

(a) Lay the master rod on a bench with the wide bushing flange of the rod up. Insert a link rod into the proper cylinder number in the master rod. Drop the knuckle pin correspondingly numbered into place, but do not force all the way down. With a feeler gage, check the clearance between the knuckle pin bushing and the side of the master rod. One way of doing this is to remove the knuckle pin and insert the feeler gage between the link rod bushing and master rod. Draw the feeler gage back so that it just misses the opening, and drop the pin in. This clearance is set at 0.006 inch loose to 0.012 inch loose when new, and has a limit of 0.025 inch loose before replacement is necessary. Use a feeler gage all around the bushing, since there may be some variation. If the clearance exceeds the limits, the bushing should be replaced, as described in paragraph 90 of this manual. When a new bushing has been installed, if there is not sufficient clearance, clamp the rod in a vise and file down the bushing *lightly* and *evenly*. Be sure to remove any burs.

(b) The link rod bushings and knuckle pins were gaged in paragraphs 63 and 65. The knuckle pins must fit in the bushings with proper clearance. This clearance is set at 0.0015 inch loose

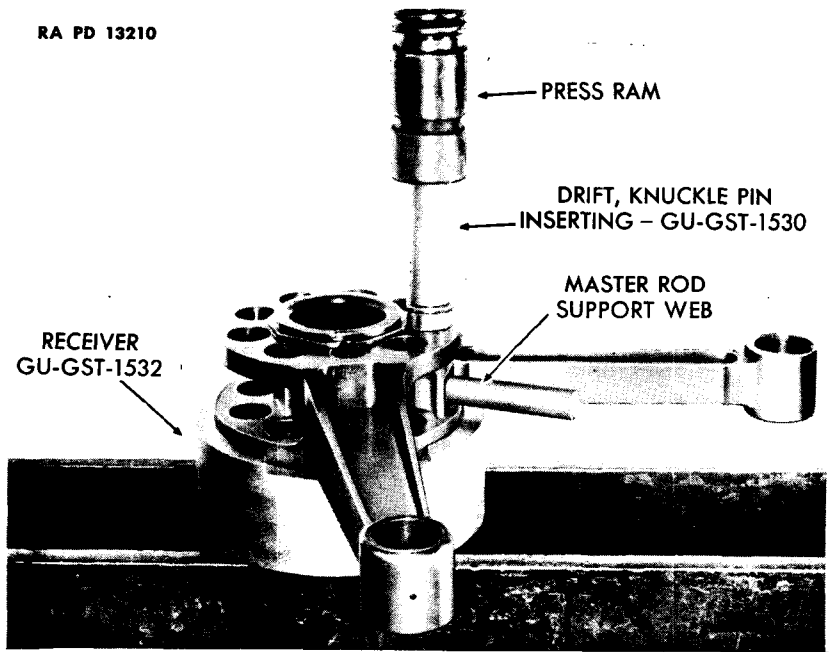

Figure 47—Pressing Knuckle Pins into the Master Rod

to 0.0032 inch loose when new, and has a limit of 0.005 inch loose. Compare the measurements secured for each link rod bushing and the proper knuckle pin. (All rods and pins are numbered according to the cylinder from which they were removed, so the numbers on the link rod and knuckle pin should correspond.) If the clearance is within the limit, the pin is ready to be inserted. If the clearance exceeds the limit the bushing should be replaced, as described in paragraph 92 of this manual.

(2) ASSEMBLY.

Drift, knuckle pin inserting, GU-GST-1530	Receiver, knuckle pin and master rod, GU-GST-1532
Hammer, soft	Splitter, ring
Press	Support, master rod web, GU-GST-1556

(a) Coat the mating surfaces of the pin and master rod with GREASE, general purpose, seasonal grade, and insert the link rod at the proper master rod opening, as indicated by the cylinder number. Line the pin up carefully, with the flat side of the pin flange parallel with a flat side of the hexagon on the master rod. Tap the pin lightly with a soft hammer to hold it in position. Place the master rod on a press, using a master rod receiver GU-GST-1532 to support it (fig. 47). Place the knuckle pin inserting drift GU-GST-1530 on the pin, and press the pin into position. Make sure the flange of the pin is not pressed against the hexagon on the master rod. Use the master rod web support GU-GST-1556 to support the web of the master rod as each pin is installed.

(b) When all pins have been inserted in this manner, remove the master rod assembly from the press and turn it over. Using a retaining ring splitter to spread the rings, install the retaining rings in the grooves in the pins, and with the opening in the ring toward the master rod bushing. When the ring is in position in the pin groove, turn the opening to the side away from the master rod bushing. Repeat this procedure to assemble the other link rods in the master rod. Side clearance of link rod bushings should again be checked at this point.

67. TEST THE OIL PASSAGES IN THE MASTER ROD ASSEMBLY (fig. 48).

a. Equipment.

Hose, air
Tester, master rod assembly oil passages, GU-GST-1371

b. Procedure. After the master rod is assembled, the oil passages must be tested to make sure that they are clear, and also that there are no leaks. This is done by using the tester GU-GST-1371 for master rod assembly oil passages (fig. 48). A washer and plate of the tester are placed underneath one side of the master connecting rod bushing

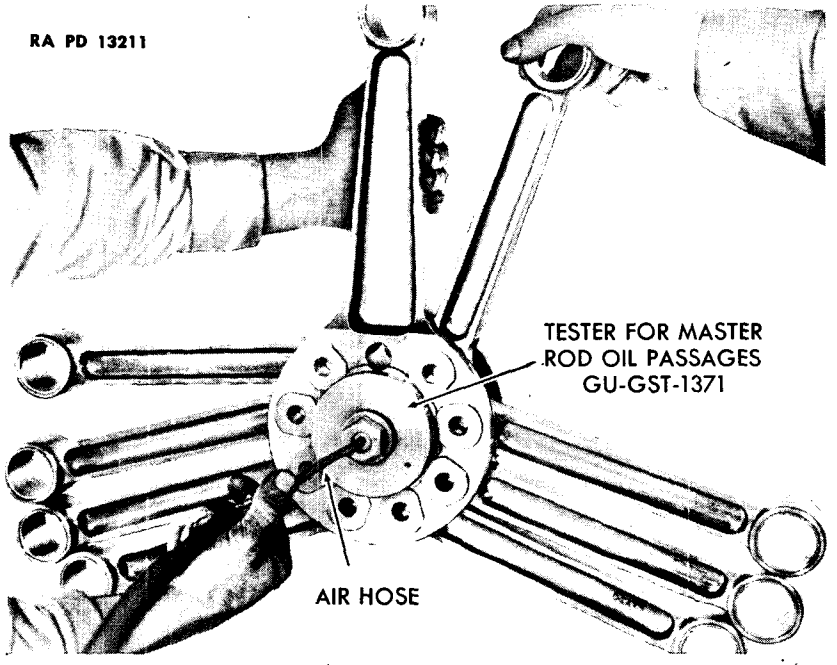

Figure 48—Testing Master Rod Oil Passages

and the bushing filled with OIL, engine, SAE 30. The top plate is then put on and bolted down. The bolt is hollow, with an opening within the master rod bushing. Air pressure is applied through the end of the bolt. Each link rod is then inspected. Oil should be seen at each side of the pin bushing, but it should not come out of the aluminum plug in the end of the pin. If oil does not show at the sides of the bushing, or if it comes out of the aluminum plug, the pin should be replaced.

68. ASSEMBLING THE CRANKSHAFT AND MASTER ROD ASSEMBLY (figs. 49 and 50).

a. Equipment.

Balls and holder, crankshaft clamp bolt stretch measuring, GU-GST-1511
Gage, feeler
Micrometer
Vise, soft-jawed
Wedge, crankshaft, GU-GST-1347
Wrench, socket, 1⅜-in.

b. Procedure.

(1) INSTALL MASTER ROD ASSEMBLY.
Vise, soft-jawed

Oil the journal and bushing with lubricating oil. With the front crankshaft clamped in a soft-jawed vise, slide the master connecting rod assembly onto the crankshaft.

THE INSPECTION

(2) INSTALL REAR CRANKSHAFT.

Balls and holder, crankshaft clamp bolt stretch measuring, GU-GST-1511
Micrometer
Wedge, crankshaft, GU-GST-1347

The front crankshaft on which the rear crankshaft clamps must be free of grease and powder dry before the rear crankshaft is installed. Clean the end of the front crankshaft with SOLVENT, dry-cleaning, and also the bore of the clamping section in the rear crankshaft. Install the crankshaft wedge GU-GST-1347 to spread the clamping section. Then slide the rear crankshaft onto the front shaft. NOTE: the clamping bolt passes through the clamping sections of the rear crankshaft and binds them to the front crankshaft. To provide an extremely tight connection, the bolt is stretched while it is installed. Measure it with a micrometer before installing, placing balls at the end to provide a surface (fig. 49) and using the crankshaft clamp bolt stretch measuring holder GU-GST-1511 to keep them in place. Make a note of the dimension, to determine the stretch later on.

(3) INSTALL CRANKSHAFT CLAMP BOLT.

Gage, feeler Wrench, socket, 1⅜-in.

The bolt passes through a groove in the front crankshaft. To pass through the groove, the rear crankshaft should be approxi-

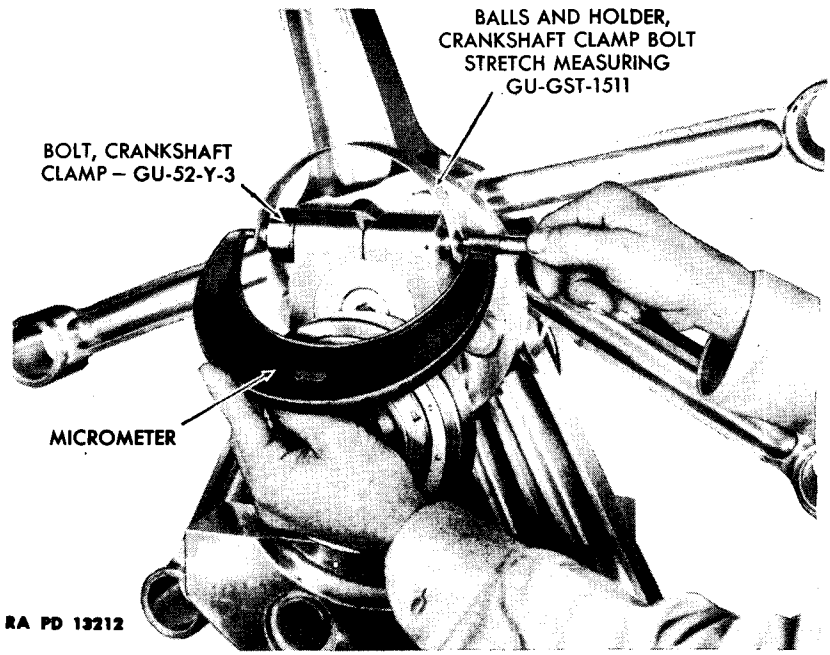

Figure 49—Measuring Clamp Bolt Stretch

mately flush with the end of the front crankshaft. Coat the clamping bolt with white lead and insert it. Lay a rule across the two sides of the cheeks of the crankshaft to line them up as evenly as possible.

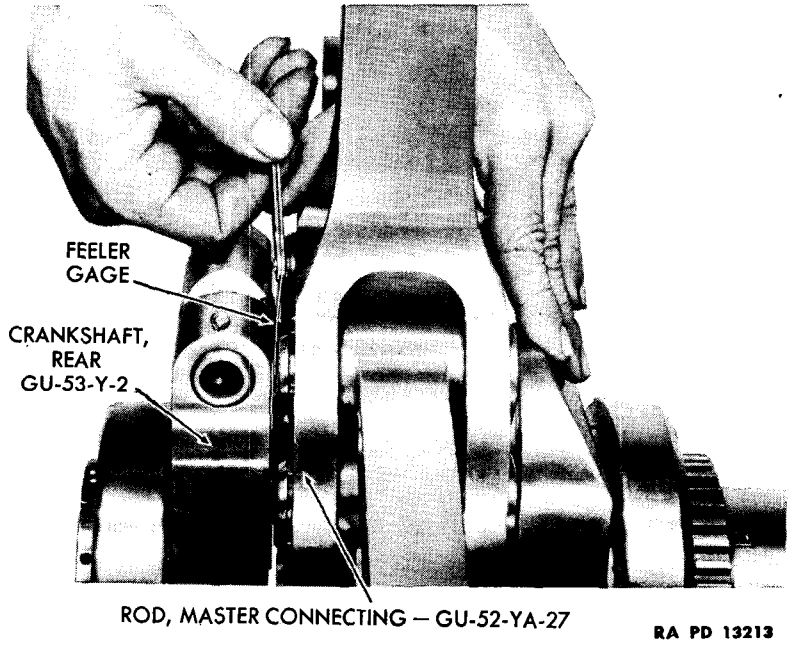

Figure 50—Checking Rear Crankshaft Clearance

Turn the clamping bolt, but do not tighten it too tightly at this point. Check the clearance between the master connecting rod and the rear crankshaft (fig. 50.) Clearance should be 0.015 inch light to 0.025 inch light. Push the master connecting rod as far forward as possible to get the maximum clearance between the master rod and rear crankshaft.

69. INSTALL CRANKSHAFT MAIN BEARINGS (fig. 51).

a. Equipment.

Driver, front crankshaft bearing, GU-GST-1521
Micrometer
Pliers
Vise, soft-jawed
Wrench, rear crankshaft bearing nut, GU-GST-1528

b. Procedure.

(1) MIKE CRANKSHAFT AND BEARING RACE.
Micrometer

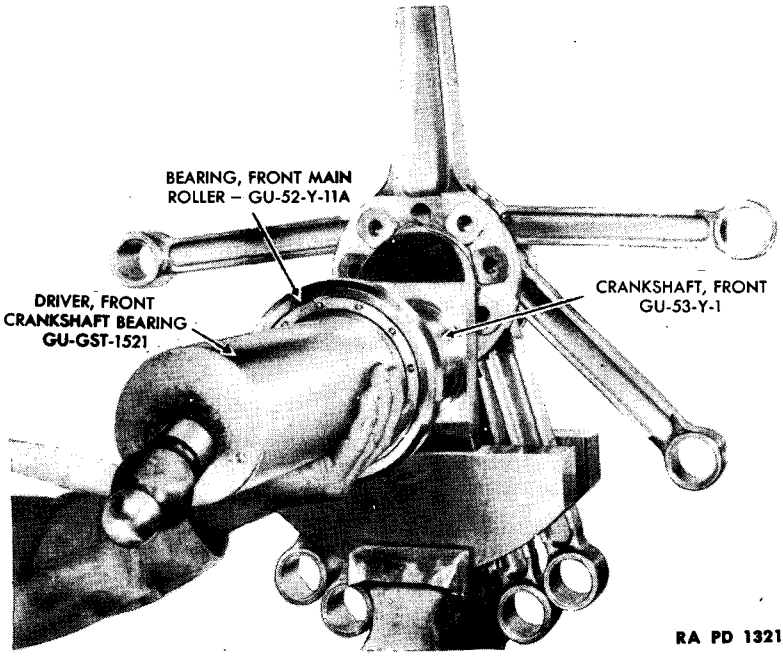

Figure 51—Installing the Front Main Roller Bearing

The crankshaft main bearings are shrunk on the crankshaft to a fit of 0.0005 inch tight to 0.0017 inch tight. Use a micrometer on the crankshaft and on the inside of the bearing race to make sure the fit will be within those limits.

(2) INSTALL BEARINGS.

Driver, front crankshaft bearing, GU-GST-1521
Vise, soft-jawed

Place the bearings in oil and heat until the oil reaches a temperature of 150 F. NOTE: Do not use this oil for lubricating purposes after it has been heated. This will expand the bearings so that they can be driven on the shaft. Clamp the crankshaft in a soft-jawed vise and as soon as the bearings are heated sufficiently, place the bearings on the shaft. The bearing with the chamfer is the front crankshaft bearing, and the chamfer goes to the outside. Place the front crankshaft bearing driver GU-GST-1521 over the bearing (fig. 51) and drive the bearing onto the shaft. Insert the key in the front crankshaft, then slide the gear over the crankshaft with the thick shoulder of the gear toward front main bearing.

(3) INSTALL REAR CRANKSHAFT BEARING NUT.

Pliers
Wrench, rear crankshaft bearing nut, GU-GST-1528

Install the nut (left-hand thread) behind the bearing on the rear crankshaft. Tighten the rear crankshaft bearing nut by exerting hand pressure on the wrench. A cotter pin hole should be in line with the hole in the crankshaft. If this is not so, further tighten by hammering on wrench lightly until holes do line up. Insert cotter pin from the inside of crankshaft up through the lock nut.

70. CHECKING THE CRANKSHAFT FOR RUN-OUT (figs. 52 and 53).

a. Equipment.

Blocks, "V"	Vise, soft-jawed
Indicator, dial	Wrench, socket, 1⅜-in.

b. Procedure. NOTE: After the crankshaft is assembled it should be checked for run-out, or to make sure that the shaft revolves in a straight line when the crankshaft assembly turns. "V" blocks are used to support the crankshaft.

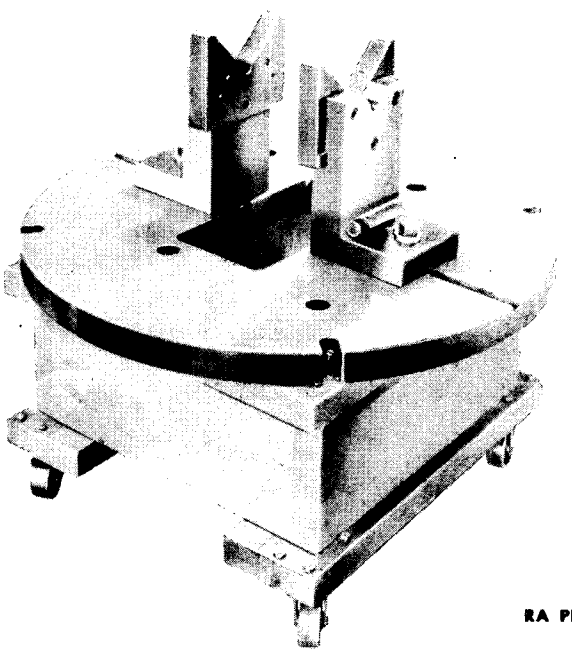

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Figure 52—Crankshaft "V" Block Support

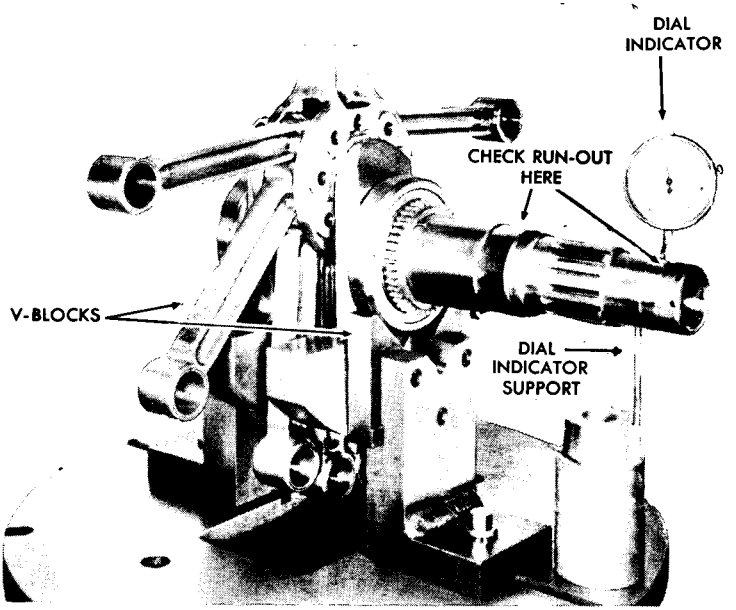

Figure 53—Checking Crankshaft Run-Out

Before placing the crankshaft assembly in the "V" blocks, wipe the jaws of the fixture and the outer races of the bearings clean. Then mount the crankshaft in the "V" blocks, supporting it at the main bearings. Measure the run-out (fig. 53), and measure at the points indicated by the arrows. The link rods should be held at each side as the crankshaft is revolved, to prevent them from knocking together. Insert folded paper or small pieces of wood in the floating counterweight to wedge it in place and prevent it from shifting as it turns. Turn the crankshaft one complete revolution. If the run-out is greater than the limit shown below, tap the rear crankshaft lightly at the side above the counterweight with a rawhide or soft hammer. Turn the crankshaft one revolution again. If the run-out has decreased, continue tapping this side of the rear crankshaft until minimum run-out is obtained. If run-out increases after rear crankshaft has been tapped on this side, tap the other side of the crankshaft to decrease it.

Run-out Limits

At front end of shaft	0.005-in.
At thrust bearing journal	0.004-in.

When the correct run-out has been obtained, replace the crankshaft assembly in a soft-jawed vise and tighten the clamping bolt. This bolt should be stretched to 0.0065 to 0.0075 inch over its original dimension.

Put the assembly back on the "V" blocks and recheck the run-out, to make sure it is still within the limits. If the run-out is not within limits, it shall be necessary to loosen the clamping bolt and reset rear crankshaft as outlined above, again measuring clamping bolt while loose, noting reading for comparison when tightened again. If the run-out is within the limit, insert the cotter pin through the rear crankshaft and clamping bolt. If the openings do not line up, use an opening in the crankshaft as a guide to drill a new hole in the clamping bolt. There should be a slight radius on the edge of the hole, to eliminate any sharp edge which might cut the cotter pin. If a new hole has been drilled, use a reamer to provide this radius. Remove any paper or wood plugs from counterweight that might have been inserted, as outlined.

71. INSPECT THE PISTONS (figs. 54 and 55).

a. Equipment.

Gage, feeler — Splitter, ring
Micrometer

b. Procedure.

(1) INSPECT PISTON PINS.
Micrometer

Inspect the piston pin plugs for surface nicks or damages. Inspect the piston pin for scoring or scratches. Roll the piston pin on a surface plate and inspect for straightness. Hold the pins to the light and inspect the passage through the center for cracks or flaws. A scratch on the inner surface may lead to a crack in the pin. Measure the piston pins. Measure at each end, at the center and at two diameters of the pin at each point.

(2) INSPECT PISTONS.
Micrometer, 5 to 6-in. — Splitter, ring

Carefully remove carbon from the pistons (link rod GU-53-Y-37) (master rod GU-53-Y-37B). Inspect the pistons for scoring and defects, paying particular attention to the ring grooves for burned sections. To remove the rings (compression GU-53-Y-38) dual oil control GU-52-Y-39C) (OIL, beveled, GU-52-Y-39), use a ring splitter to expand the ends. Insert the prongs of the tool between the ends of the ring and spread the ring, then lift it off. Measure the piston for wear. *First,* measure piston 90 degrees from the pin at the top. *Second,* measure the piston 90 degrees from the pin at the bottom. *Third,* measure the piston in line with the pin at the top. *Fourth,* measure the piston in line with the pin at the bottom. Refer to clearance chart for sizes and clearances.

(3) INSTALL PISTON RINGS.
Gage, feeler

(a) The piston rings should be replaced with new rings whenever the pistons are removed. Before installing the new

rings, piston rings and clearance must be measured to make sure that the gap is within limit. To measure piston ring end clearance, insert the piston ring in its respective cylinder barrel about ½ inch from the bottom of the barrel. Use the bottom of the piston, less rings, as a guide and aliner for the ring being measured, pushing piston and pin in the barrel until the ring is about in line with the cylinder mounting flange. Remove piston with feeler gage; measure ring gap clearance. Refer to clearance chart for correct ring gap. If the clearance is too small, the ring can be clamped in a soft-jawed vise and the ring ends lightly filed until correct gap is obtained.

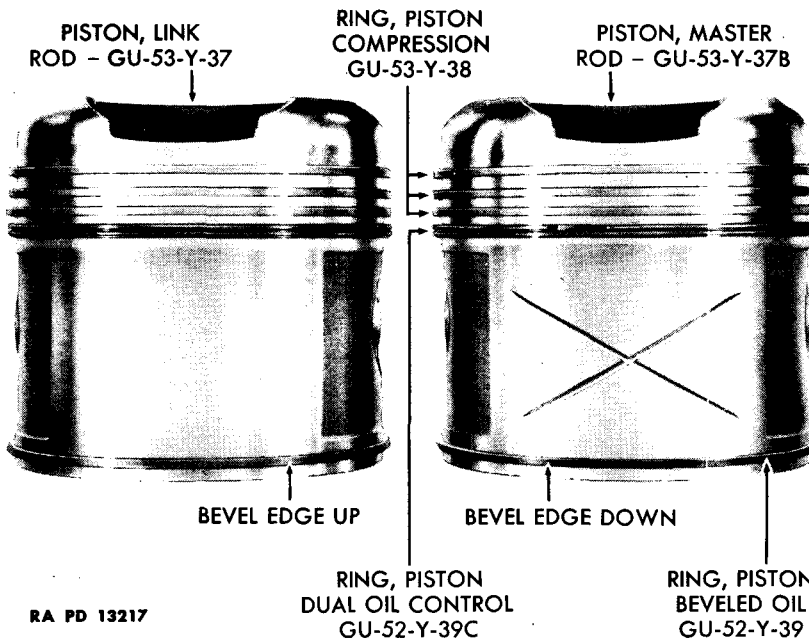

Figure 54—Two Types of Pistons Used

(b) The top three rings are wedge type rings. Two rings are used in the fourth groove and both of these are installed with the scalloped side down. The fifth ring is installed with the beveled side up on all pistons except the master rod piston in number seven cylinder, and acts as an oil scraper ring. On No. 7 piston (the piston on the master connecting rod) the lower or fifth ring is placed on the piston with the beveled edge of the ring down. This piston has an "X" groove in the skirt. Measure the clearance above the rings in the ring grooves. Clearances are shown in the chart in paragraph 180. A straight-edge should be used to line up the rings (fig. 55). The rings are tapered, and

an accurate reading cannot be obtained unless the rings are in position.

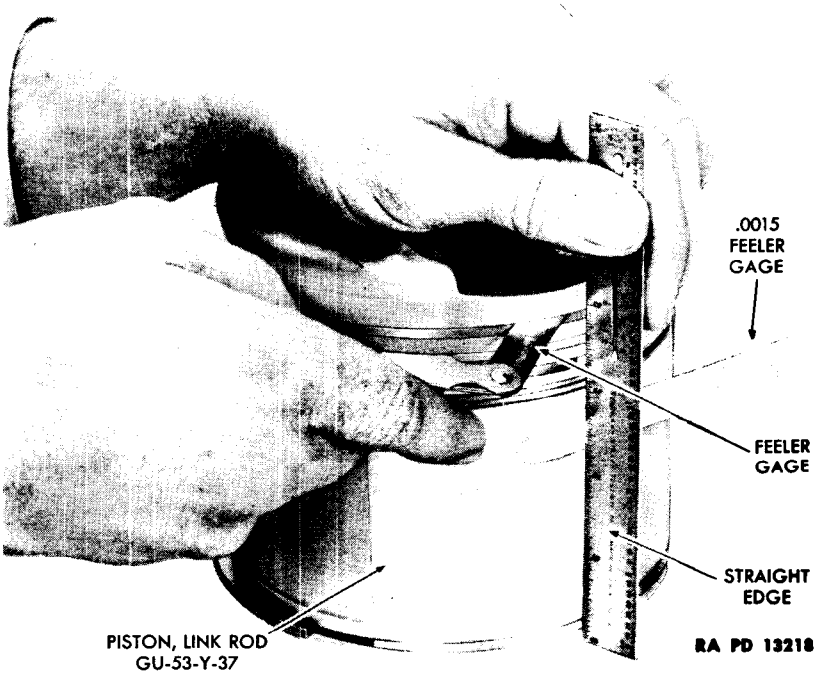

Figure 55—Measuring Piston Ring Side Clearance

72. DISMANTLE THE CYLINDERS (figs. 56, 57 and 58).

a. Equipment.

Block, cylinder mounting	Pin, brass, drift
Compressor, valve spring, GU-GST-1553	Pliers
	Screwdriver
Hammer	Wrench, open-end, 9/16-in.

b. Procedure. NOTE: A special cylinder mounting block over which the cylinder barrel will slide will prove useful as a base in dismantling the cylinder barrels. A round block approximately 4½ inches in diameter and 13 inches long and with a rounded dome (fig. 56) will serve for this purpose.

(1) REMOVE ROCKER ASSEMBLY.

Hammer	Pliers
Pin, brass, drift	Wrench, open-end, 9/16-in.

Check to make sure that the rocker arms are marked "Intake" or "Exhaust." Remove the cotter pin from the rocker shaft and

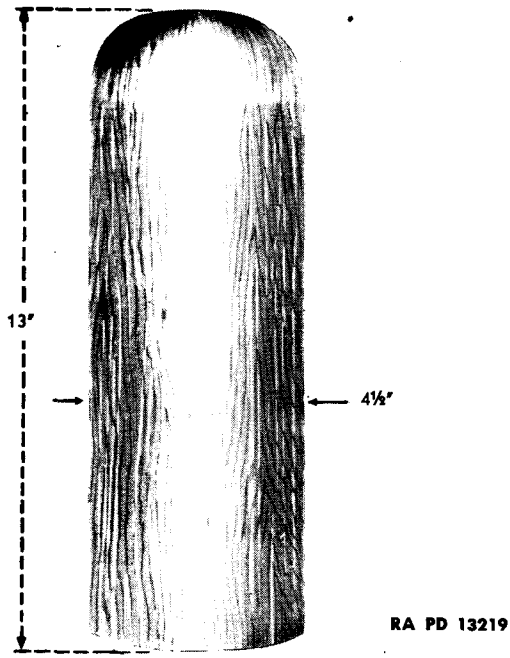

Figure 56—Cylinder Mounting Block

remove the nut. Lift off the washer. Drive out the shaft. Lift out the rocker assembly.

(2) REMOVE VALVE SPRINGS.

Compressor, valve spring, GU-GST-1553
Hammer
Pin, brass, drift
Screwdriver

(a) NOTE: Before attemping to remove the cylinder valve springs GU-52-Y-73 and 74, tap the plate GU-52-Y-76 above the spring lightly. Otherwise the valve spring keeper GU-13-Y-77 may stick to the upper valve spring plate when the spring is compressed.

(b) Place the valve spring compressor GU-GST-1553 in position over the valve spring (fig. 57). Pressing down the handle of the compressor to lock position will compress the valve spring. Remove the two halves of the valve spring keeper GU-13-Y-77. Remove the compressor, then lift out the inner spring and outer spring and the upper and lower plates. Remove the valve lock ring from the valve stem just below the valve keeper position. Inspect the valve stem for burs which might damage the valve guides when removing the valves. Remove the mounting block, taking care not to let the valves drop out of the barrel. Remove the valves. Repeat this operation to remove the valve operating

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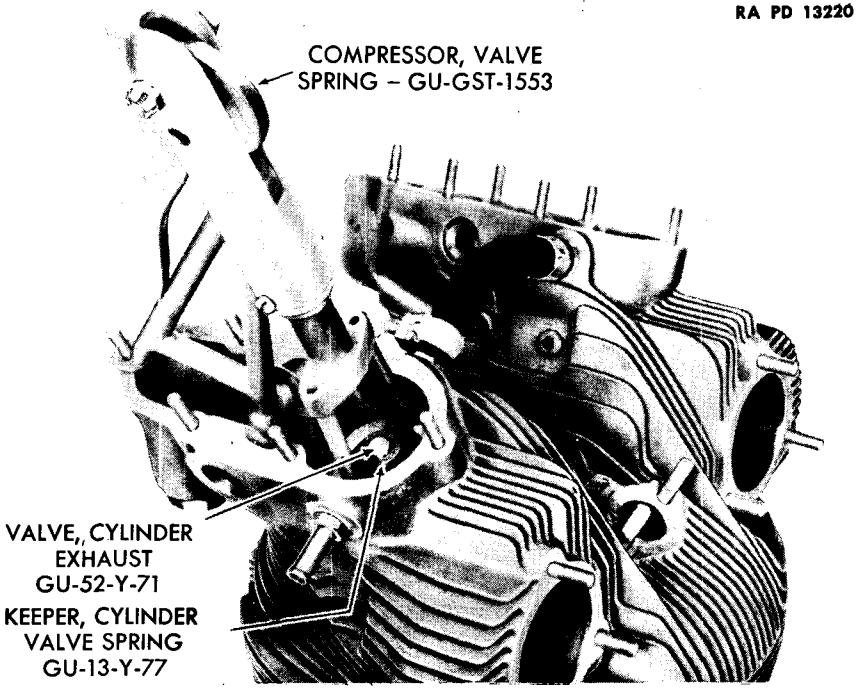


Figure 57—Removing the Valve Operating Mechanism

mechanism from all cylinders. NOTE: The valves should be placed on a valve holding board or in a similar arrangement where they can be numbered to show the cylinder from which they were removed.

73. INSPECT THE CYLINDERS (figs. 59 and 60).

a. Equipment.

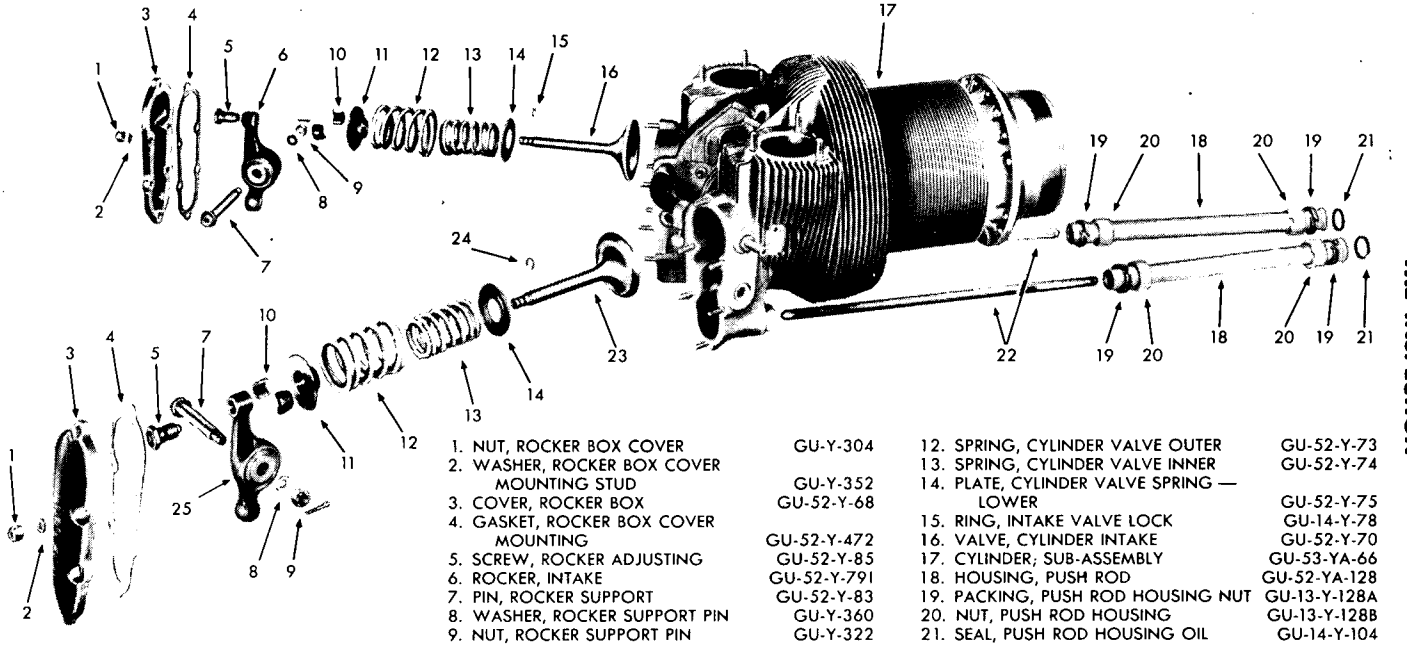
Gage, telescope — Micrometer

b. Procedure.

(1) CYLINDER BARRELS.
Micrometer

(a) The cylinder barrels should be given a thorough visual inspection for scoring and defects. Cylinder heads should be inspected for cracks. If any are discovered, the head and barrel are replaced as a unit. Check the push rod housing nipples for oil leaks.

(b) Check the cylinder barrel for taper and for out-of-round (fig. 59). The maximum worn diameter of the cylinder is 5.762 inches at ¾ inch from the top of the barrel. Cylinder barrels that exceed the diameter of 5.762 inches should be discarded.



1. NUT, ROCKER BOX COVER	GU-Y-304	12. SPRING, CYLINDER VALVE OUTER	GU-52-Y-73
2. WASHER, ROCKER BOX COVER MOUNTING STUD	GU-Y-352	13. SPRING, CYLINDER VALVE INNER	GU-52-Y-74
3. COVER, ROCKER BOX	GU-52-Y-68	14. PLATE, CYLINDER VALVE SPRING — LOWER	GU-52-Y-75
4. GASKET, ROCKER BOX COVER MOUNTING	GU-52-Y-472	15. RING, INTAKE VALVE LOCK	GU-14-Y-78
5. SCREW, ROCKER ADJUSTING	GU-52-Y-85	16. VALVE, CYLINDER INTAKE	GU-52-Y-70
6. ROCKER, INTAKE	GU-52-Y-791	17. CYLINDER; SUB-ASSEMBLY	GU-53-YA-66
7. PIN, ROCKER SUPPORT	GU-52-Y-83	18. HOUSING, PUSH ROD	GU-52-YA-128
8. WASHER, ROCKER SUPPORT PIN	GU-Y-360	19. PACKING, PUSH ROD HOUSING NUT	GU-13-Y-128A
9. NUT, ROCKER SUPPORT PIN	GU-Y-322	20. NUT, PUSH ROD HOUSING	GU-13-Y-128B
10. KEEPER, CYLINDER VALVE SPRING	GU-13-Y-77	21. SEAL, PUSH ROD HOUSING OIL	GU-14-Y-104
11. PLATE, CYLINDER VALVE SPRING — UPPER	GU-52-Y-76	22. ROD, PUSH; ASSEMBLY	GU-52-YA-127A
		23. VALVE, CYLINDER EXHAUST	GU-52-Y-71
		24. RING, EXHAUST VALVE LOCK	GU-52-Y-78A
		25 — ROCKER, EXHAUST	GU-52-Y-79E

Figure 58—The Cylinder and Valve Assembly

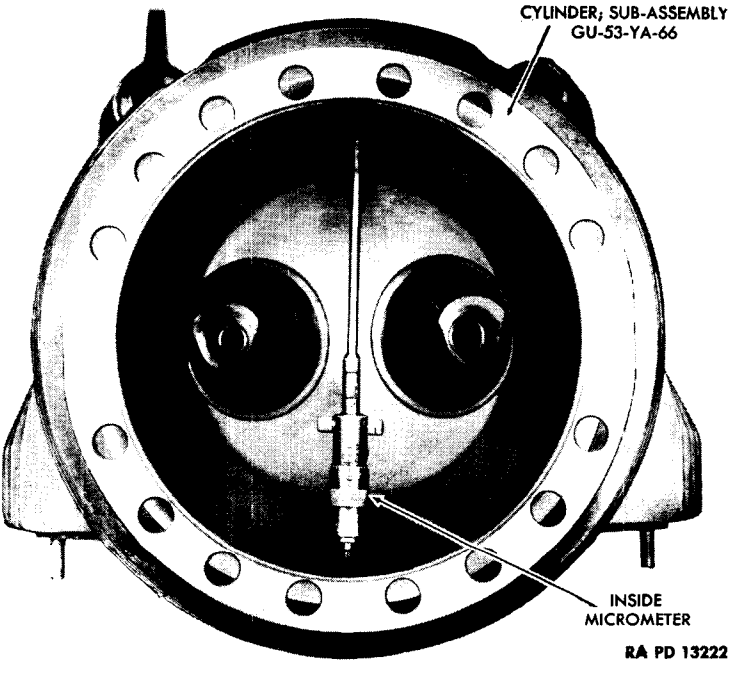


Figure 59—Measuring the Cylinder Barrel with a Micrometer

(2) VALVE GUIDES AND SEATS.

Gage, telescope Micrometer

Examine the valve seats for pitting. If necessary, they should be ground smooth, according to the instructions in section V. Examine the valve guides for galling. If galled, replace according to the instructions in section V of this book. Measure the inside diameter of the valve guides, and get a reading from the gage.

The maximum valve guide clearance is:

	CENTER	END
Intake	0.008 in.	0.012 in.
Exhaust	0.010 in.	0.012 in.

74. INSPECT VALVES AND VALVE OPERATING MECHANISM.

a. Equipment.

Indicator, dial Vise, soft-jawed
Micrometer

b. Procedure.

(1) INSPECT THE PUSH RODS.

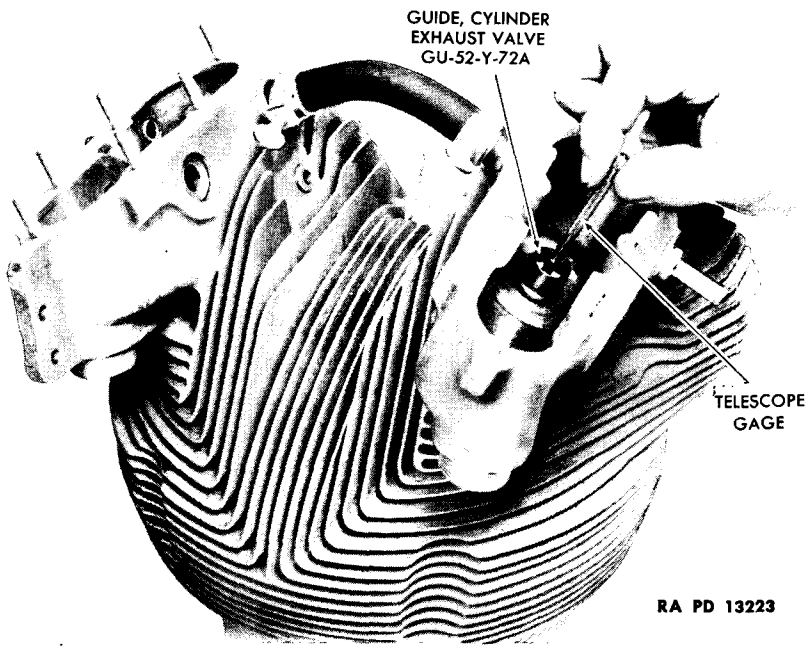


Figure 60—Measuring a Valve Guide

(a) Make a visual inspection of each push rod for defects. Roll the push rod on a surface plate to make sure that the rods are not bent.

(b) Also make an inspection of each push rod housing for defects and to make sure that the housing is not sprung out of shape. Defective push rods and housings should be replaced.

(2) INSPECT THE TAPPETS, GUIDES AND GUIDE ADAPTERS. Make a visual inspection of each valve tappet, guide and guide adapter, watching for damaged threads on the adapters and defects in the surfaces of the tappets and guides. See that the tappet rollers operate freely, and that there are no flat surfaces on the rollers. Check the tappet pins for wear. Check for galling of the tappet housing. Inspect socket for wear, roughness, or unevenness.

(3) INSPECT THE VALVE SPRINGS. Line the valve springs up and examine to make sure that all of them are approximately the same height. Examine for broken ends. Check spring pressure which should be:

Inner spring	84 lb, at 1½ in.
Outer spring	94 lb, at 1½ in.

(4) INSPECT THE ROCKER ARM.

Indicator, dial Vise, soft-jawed

Inspect the push rod socket to make sure that it is in good condition. See that the rocker arm revolves freely on the bearing on which it operates. Check the ball end on the rocker adjusting screw to see that it is free and is securely retained. Clamp the inner race of the bearing tightly in a soft-jawed vise and place a dial indicator spindle against the outer races and move the rocker arm sideways. If clearance exceeds 0.010 inch replace the bearing.

(5) VALVE INSPECTION.
Micrometer

(a) Carefully remove carbon accumulations, and make a visual inspection of the valve stems for pitting and scoring. Check the valve seat for excessive wear. Check the valve face for burning, pitting and wear. Check to make sure valve face and seat have good contact surface. If not good, grind smooth. Valve seat should be minimum 1/16 inch to maximum approximately 1/8 inch.

(b) Measure the valve stem diameter. The original diameter was:

Intake	0.4325 in.
Exhaust	0.5585 in.

Valves under 0.004 inch should be replaced.

75. INSTALL THE VALVE ASSEMBLIES.

a. Equipment.

Block, cylinder mounting
Compressor, valve spring, GU-GST-1553
Drift, soft
Hammer, soft
Pliers
Wrench, open-end, 9/16-in.

b. Procedure.

(1) REPLACE THE VALVES.
Block, cylinder mounting

Oil the valve stems and insert them into the valve guides from the inside of the cylinder. The intake and exhaust valves and guides are different sizes, so it will be impossible to get the valves into the wrong guides. Place the cylinder barrel over the cylinder barrel mounting block (fig. 56). This block will hold the valves in position.

(2) REPLACE LOCK RINGS.
Pliers.

With the barrel upright on the mounting block, replace the lock rings in the last groove of the valve stems, being sure that the right-sized ring is used on each stem. Press the rings into

the grooves, making sure that the ring is secure in its groove. Do not scuff the valve stems while installing the lock rings.

(3) REPLACE VALVE SPRINGS.

Compressor, valve spring, GU-GST-1553 Hammer, soft

(a) Drop the lower valve spring washer, with the straight opening, into place over the valve stem and on the guide. Place the inner spring on the washer, making sure that it is within the inner flange, and not cocked. Then replace the outer spring over the inner spring. Replace the top washer with tapered opening on top of the valve springs.

(b) Install the valve spring compressor GU-GST-1553 on the rocker box (fig. 57). Push the handle of the compressor down to lock position to compress the valve springs. Replace the valve keepers on the valve stems with the small end of the keeper down. Make sure that the ridges in the keepers fit into the grooves in the valve stems, and that the keepers are evenly spaced around the valves. Remove the valve spring compressor and take the cylinder off the mounting block. Tap the end of the valve to seat the keepers. Gas check valve seats (section V, par. 79, for this check).

(4) REPLACE ROCKER ASSEMBLY.

Drift, soft Wrench, open-end, 9/16-in.

Oil the bearings in the rocker arms and install them in the rocker boxes with the shoulder side of the bearing toward the inside. Insert the rocker shafts with the head on the inside, driving them through with a soft drift. Then install the washer and nut. Draw the nut up tight, then check the rocker to make sure the bearing operates freely. Insert a cotter pin. NOTE: Repeat this operation to install the valves and rockers on all cylinders.

76. INSPECT THE FUEL INJECTION LINES.

Examine the fuel injection lines for cracks or defects. Blow through them to make sure they are clear. Check the seat to make sure it is smooth.

77. CHECK INJECTION PRESSURE (figs. 61 and 62).

a. Equipment.

Brush, soft wire Unit, test, fuel injector

b. Procedure. Clean the carbon from the external parts of the injectors. Use a soft wire brush which will not injure the four small holes

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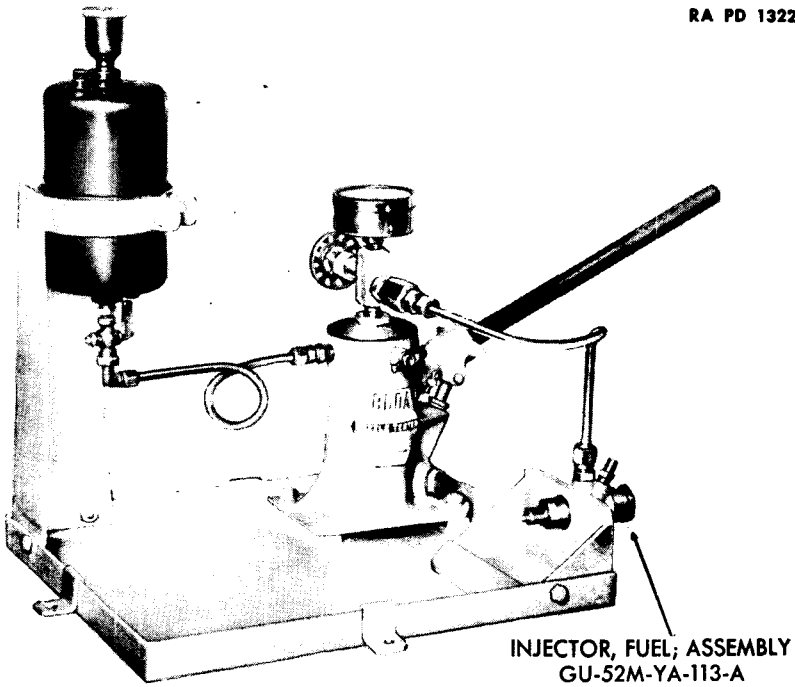

Figure 61—Fuel Injector Test Unit

in the valve body. Do not let dirt enter the injector. Attach the assembly to the fuel injector test unit and test the injection pressure and atomization (fig. 61). The desired pressure required to break or open the nozzle spray valve is 2,650 pounds. The nozzle has four spray holes, which should release an evenly distributed fan-shaped spray pattern (fig. 62). The valve should break sharp and clean, without leaking or dripping, either before or after the injection occurs. NOTE: Faulty injector valve operation is most commonly caused by dirt or other foreign materials contained in the fuel. Dirt prevents the valve from closing or causes the pintle valve to stick in the nozzle body. In either case it will be necessary to disassemble the nozzle.

78. INSPECT THE FUEL INJECTOR (fig. 14).

a. Equipment.

Bar, fuel pump and fuel injector holding, GU-GST-1303
Screwdriver
Stick, orangewood
Vise
Wrench, open-end, 9/16-in.
Wrench, open-end, 11/16-in.
Wrench, open-end, 13/16-in.
Wrench, open-end, 1 1/16-in.

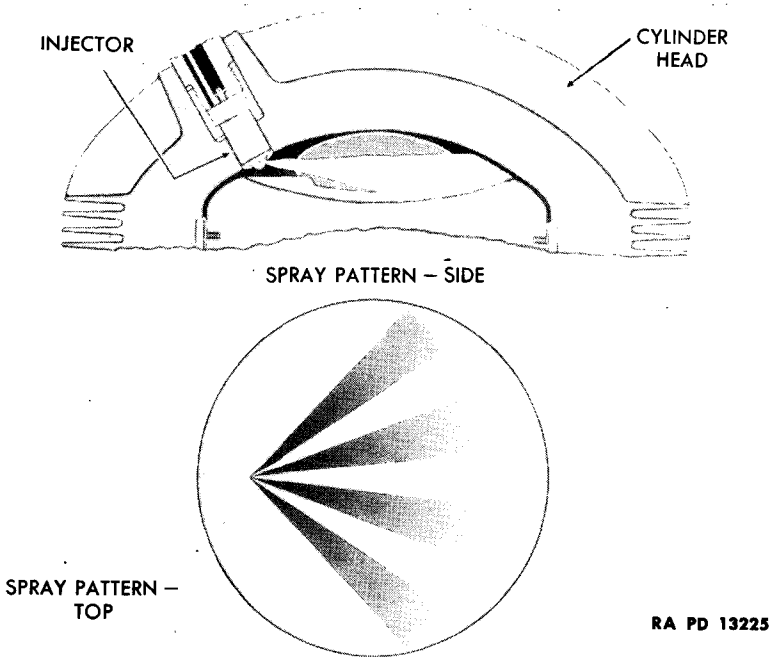

Figure 62—The Injector Spray Pattern

b. Procedure.

(1) DISASSEMBLE FUEL INJECTOR.

Bar, fuel pump and fuel injector, holding, GU-GST-1303	Wrench, open-end, 9/16-in.
Screwdriver	Wrench, open-end, 11/16-in.
Vise	Wrench, open-end, 13/16-in.
	Wrench, open-end, 1 1/16-in.

The injector is placed in an injector holding bar GU-GST-1303 in disassembling it. This holding bar is also used in disassembling the injection pumps. Insert the nozzle end of the fuel injector into the smaller opening in the holding bar, with the prongs of the holding bar fitting into bolt holes in the injector mounting flange. Then clamp the holding bar in a vise.

Remove the fuel injector cap and gasket. Loosen the locking nut and use a screwdriver to remove the adjusting screw. Remove the adjusting body and lift out the adjusting screw seat, spring and stem guide. Turn the hexagon on the nozzle holder and remove the nozzle holder, lift out the nozzle and pintle stem. CAUTION: The hands should be covered with clean oil when handling the injector or injection pump. *Do not touch the large diameter of the pintle with the hand.* Hold the pintle by the small diameter. The pintle is made of special alloy. Perspiration from the fingers might start corrosion.

(2) CLEAN PINTLE AND NOZZLE.

Stick, orangewood

Wash the pintle and nozzle in SOLVENT, dry-cleaning, by splashing and brushing with a soft orangewood stick. Cloth or paper might leave lint on the pintle. Rub the pintle in the nozzle and on the seat, using lard oil for a cleaner. Time and patience are often required in removing particles of dirt from the pintle. No abrasive should be used in rubbing the pintle in the nozzle as the clearance is approximately 0.00015 of an inch. This is much less than the diameter of particles of any commercial compound, Then wash thoroughly with SOLVENT, dry-cleaning.

(3) ASSEMBLE THE INJECTOR.

Screwdriver
Wrench, open-end, 9/16-in.
Wrench, open-end, 11/16-in.
Wrench, open-end, 13/16-in.
Wrench, open-end, 1 1/16-in.

To assemble the injector, place the pintle stem in the nozzle. Hold the body in the hand and place the nozzle on the dowels of the body. Insert the nozzle into the nozzle holder. Then screw the holder onto the body. Drop the stem guide into the other side of the body, over the end of the pintle stem. Insert the spring and adjusting screw seat, then install the adjusting body. Insert the adjusting screw and lock nut. Replace the gasket and screw on the cap. Test the injector on the injector test unit. If the test shows the injector operates effectively, cover nipples with caps and place the injector in fuel oil or light weight lubricating oil.

(4) ADJUST INJECTION PRESSURE.

Screwdriver
Wrench, open-end, 9/16-in.
Wrench, open-end, 1 1/16-in.

To adjust the injection pressure to 2,600 pounds minimum and 2,650 pounds maximum, remove the cap, loosen the locking nut and turn the adjusting screw. Then replace the fuel injector cap.

79. INSPECT THE FUEL INJECTION PUMP (fig. 12).

a. Equipment.

Bar, fuel pump and fuel injector, holding, GU-GST-1303
Drift, fiber
Pliers
Vise
Wrench, open-end, ½-in.
Wrench, open-end, ⅞-in.
Wrench, open-end, 1¼-in.

b. Procedure.

(1) REMOVE PLUNGER AND SPRING. The fuel injection pumps were adjusted at the factory and will require only a minimum amount of attention between overhauls. However, the pumps may be

disassembled and reassembled with new parts without seriously disturbing the original adjustments. The plunger GU-52-Y-103 and spring are removed together. The end of the spring is screwed into a groove in the pump sleeve. Holding the pump mounting flange in one hand, twist the spring in a clockwise direction from the ball end of the plunger to free it from the retaining groove. Then lift the spring and plunger straight up and out of the fuel pump body GU-52-Y-102 (fig. 63). Be careful not to cock the plunger in removing it, as a clean, sharp plunger head is necessary for proper injection, and the edge of the head might be damaged in rubbing against the fuel pump body. The spring locks into a groove in the plunger in the same way that it locks in the fuel pump sleeve. Grasp the outer end of the plunger and turn it to free the spring.

(2) REMOVE UNION AND SPRING.

Bar, fuel pump and fuel injector, holding, GU-GST-1303	Pliers
	Vise
	Wrench, open-end, 7/8-in.

With the plunger and spring removed, clamp the fuel pump and fuel injector holding bar horizontally in a vise, and place the injection pump in the larger of the two openings, with the union end up. Use a 7/8-inch open-end wrench on the hexagon of the union to remove the union from the sleeve. Then use small pliers to lift out the spring.

(3) REMOVE THE SLEEVE.

Wrench, open-end, 1/2-in. Wrench, open-end, 1 1/4-in.

Next remove the sleeve from the mounting flange. To do this, loosen the clamp on the mounting flange and turn the hexagon on the sleeve until the sleeve can be lifted out of the mounting flange. Remove the two oil seal rings.

(4) REMOVE CHECK VALVE AND GASKET.

Drift, fiber

The two sections of the body, the check valve and gasket, are within the sleeve. Support the sleeve on a block of wood. Tap lightly with a fiber drift on the body until the gasket seal is broken. The parts can then be lifted out with the fingers. NOTE: The check valve, spring and body can be removed from the pump without removing the pump from the crankcase or disassembling other parts. If the pump sleeve is not turned, the pump adjustment will not be changed.

(5) INSPECT FUEL INJECTION PUMP PARTS.

(a) Clean all the parts of the fuel injection pump, and examine the surface for scratches and defects. Examine the head of the plunger to make sure the edge is clean and sharp for accurate injection. Make sure all passages are clear.

(b) The two rubber oil seals on the sleeve of the fuel injection pump should be replaced whenever the fuel pump has been disassembled. Do not interchange check valves and bodies or fuel pump plungers and plunger bodies. If necessary to replace parts, make replacements in pairs.

(c) Do not attempt to lap check valves, pump bodies and plungers. If parts are worn, scratched or galled, discard them and replace them with new pairs of parts.

(d) In testing the plunger spring for compression, the springs when compressed to 1⅜ inches should produce a force of 26½ pounds, plus or minus 2½ pounds, and when compressed to one inch should produce a force of 52 pounds, plus or minus 2½ pounds. CAUTION: Handle fuel pump bodies and plungers with clean hands and tools. Keep parts submerged in oil at all times when disassembled.

(6) ASSEMBLE INJECTION PUMP.

Bar, fuel pump and fuel pump injector, holding, GU-GST-1303	Wrench, open-end, ⅞-in.
	Wrench, open-end, 1¼-in.

(a) To assemble the injection pump install an oil seal in the groove next to the threads. Place the mounting flange over the two prongs at the largest opening in the fuel injection pump holder. Insert the sleeve into the flange and screw it down until the bottom of the flange of the sleeve is approximately 3/64 inch from the top of the mounting flange.

(b) Install the copper gasket on the body. Insert the fuel pump body. Note the slight bevel on the inside bore in the check valve body. This is the seat for the check valve, and the body should be inserted so that this side is up. Insert the check valve body directly on top of the fuel pump body in the sleeve. Replace the gasket over it, with the bevel side up. Install the check valve in the check valve body.

(c) Place the spring on top of the shoulder of the check valve. Make sure that the gasket is in position, and then install the union. Remove the union and inspect the gasket to make sure the union is bearing on it evenly, then tighten the union down again.

(d) Coat the plunger with light oil and insert the plunger into the smaller end of the spring and twist to fit the spring into the groove in the plunger. Remove the pump from the holder and insert the larger end of the spring into the body. Be sure to

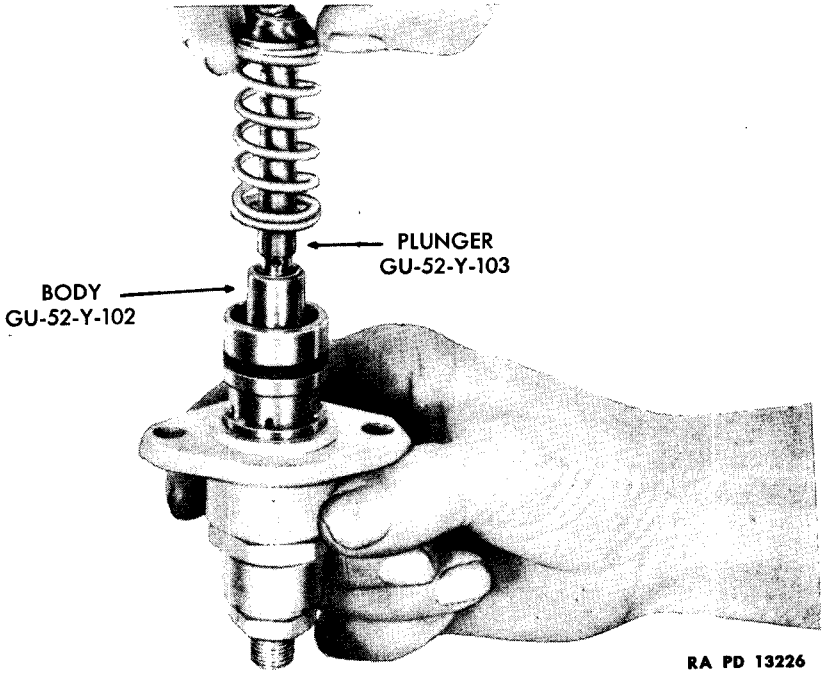

Figure 63—Inserting the Plunger into the Injection Pump

drop the plunger straight into the body (fig. 63) to prevent damaging the edge. Then twist the spring to lock it in place. CAUTION: *Do not force the plunger into the body under any condition.*

80. INSPECT THE FUEL CHECK VALVE.

There is a ball check within the valve which allows fuel to flow through, but forms a seal so that it cannot flow back again. Suck on the nipple. If the check is in good condition, a vacuum will form which will make the nipple cling to the tongue. Inspect the threads for burs or roughness. If the check valve is defective, it should be replaced.

81. INSPECT THE FUEL PRESSURE REGULATOR (fig. 11).

a. Equipment.

Wrench, open-end, 3/4-in. Wrench, open-end, 1-in.

b. Procedure.

(1) DISSSEMBLE THE FUEL PRESSURE REGULATOR.

Wrench, open-end, 3/4-in. Wrench, open-end, 1-in.

Unscrew the dome cap from the fuel pressure regulator. Re-

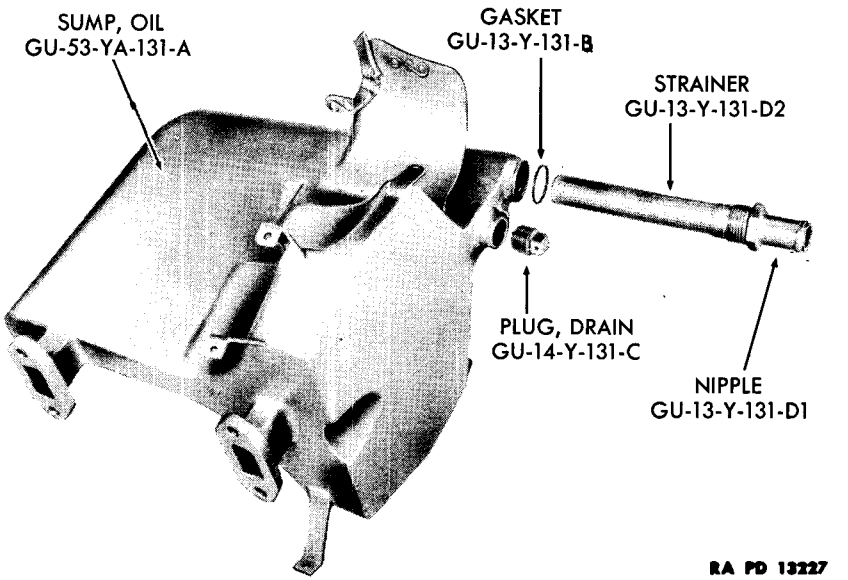

Figure 64—The Oil Sump

move the guide below the dome cap. The spring and valve can then be lifted out of the body.

(2) INSPECTION. Give all parts a visual inspection for defects.

(3) ASSEMBLE THE FUEL PRESSURE REGULATOR.

Wrench, open-end, 3/4-in. Wrench, open-end, 1-in.

To assemble the fuel pressure regulator, drop the valve into the body and insert the spring in it. Install a gasket on the guide. Screw the guide down tight into the body. Replace the dome cap with a gasket underneath.

82. INSPECT THE OIL SUMP (fig. 64).

a. Equipment.

Wrench, open-end, 1/2-in. Wrench, open-end, 1 1/4-in.

b. Procedure.

(1) DISASSEMBLE OIL SUMP.

Wrench, open-end, 1/2-in. Wrench, open-end, 1 1/4-in.

Remove the oil strainer GU-13-Y-131-D2 and gasket GU-13-Y-131-B. The drain plug GU-14-Y-131-C can also be removed. The strainer should be washed and the oil sump GU-53-YA-131-A flushed out thoroughly. Clean the drain plug.

(2) INSPECTION. Inspect the sump for cracks and leaks. Inspect the Dzus fastener spring for looseness and breakage. This is the only inspection the oil sump requires.

(3) ASSEMBLE OIL SUMP.
Wrench, open-end, ½-in. Wrench, open-end, 1¼-in.

To assemble the oil sump, place the gasket on the strainer. Insert the strainer into the sump and tighten the nipple GU-13-Y-131-D1. Install the drain plug.

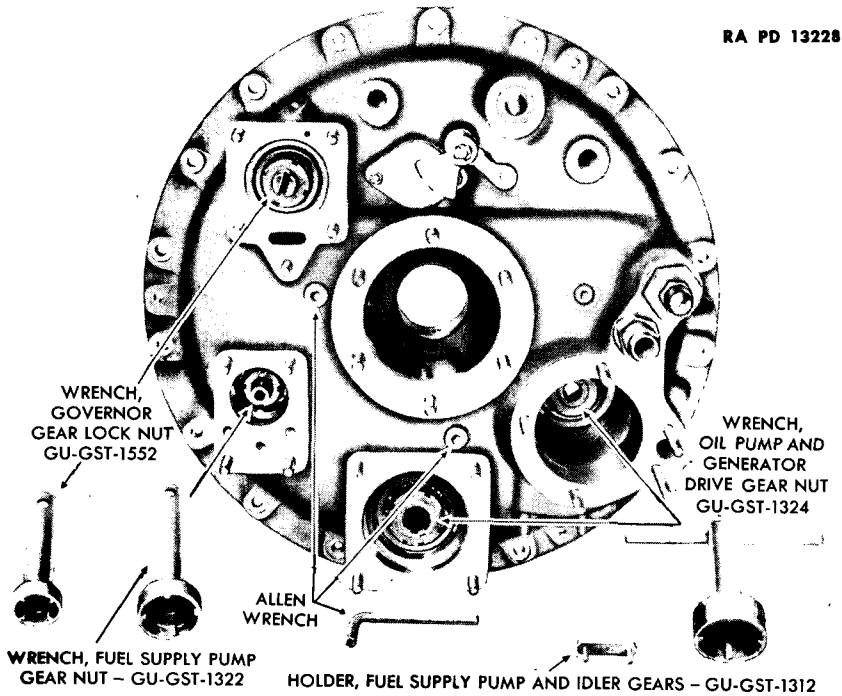

Figure 65—The Accessory Case and Special Tools for Dismantling It

83. DISASSEMBLY OF ACCESSORY CASE ASSEMBLY (figs. 65, 66 and 67).

a. Equipment.

Drift, soft
Hammer, soft
Holder, fuel supply pump and idler gears, GU-GST-1312
Puller and adapters, accessory case gears, GU-GST-1367
Screwdriver
Vise, soft-jawed
Wrench, Allen, 7/32-in.
Wrench, Allen, 5/16-in.
Wrench, fuel supply pump gear nut, GU-GST-1322
Wrench, governor gear lock nut, GU-GST-1552
Wrench, oil pump and generator drive gear nut, GU-GST-1324
Wrench, socket, ½-in. (thin wall)

b. Procedure.

(1) FREE THE ACCESSORY CASE GEARS.

Drift, soft	Wrench, Allen, 5/16-in.
Hammer, soft	Wrench, fuel supply pump gear nut, GU-GST-1322
Holder, fuel supply pump and idler gears, GU-GST-1312	Wrench, governor gear lock nut, GU-GST-1552
Screwdriver	Wrench, oil pump and generator drive gear nut, GU-GST-1324
Vise, soft-jawed	Wrench, socket, ½-in. (thin wall)
Wrench, Allen, 7/32-in.	

(a) Clamp the accessory case in a vertical position in a soft-jawed vise. Bend the locking washer clips out of the nuts on the oil pump, fuel supply pump, governor and generator drive gears.

(b) Remove the Allen head nuts which are behind the fuel cam intermediate gear and idler gear in the accessory case.

(c) Install the fuel supply pump and idler gear holder GU-GST-1312 between the fuel cam intermediate gear and the oil pump drive gear to lock the teeth. Through the starter mounting opening, use a 7/32-inch Allen wrench to hold the bolt on the fuel cam intermediate gear. Remove the cotter pin from the castle nut on the other side of the accessory case and remove the nut. Remove the bolt and washer. Leave the gear in place.

(d) Using the oil pump and generator drive gear nut wrench GU-GST-1324, and with the gear holder still in place, unscrew the nuts on the oil pump and generator gears. *These have left-hand* threads. *Turn clockwise to remove.* Lift off the locking washer clips.

(e) Install the gear holder between the teeth of the fuel supply pump gear and the idler gear to lock the teeth. Through the starter mounting opening, use a 7/32-inch Allen wrench to hold the bolt head on the idler gear. Remove the cotter pin from the castle nut on the other side of the accessory case, and remove the nut. Remove the bolt and washer, but leave the gear in place.

(f) Using the governor gear lock nut wrench GU-GST-1522, remove the governor gear nut and washer *(left-hand thread).*

(g) Using the fuel supply pump gear nut wrench GU-GST-1322, remove the fuel supply pump gear nut and washer *(left-hand thread).*

(h) Drive the oil pump, fuel supply pump, governor, and generator gears out of the accessory case.

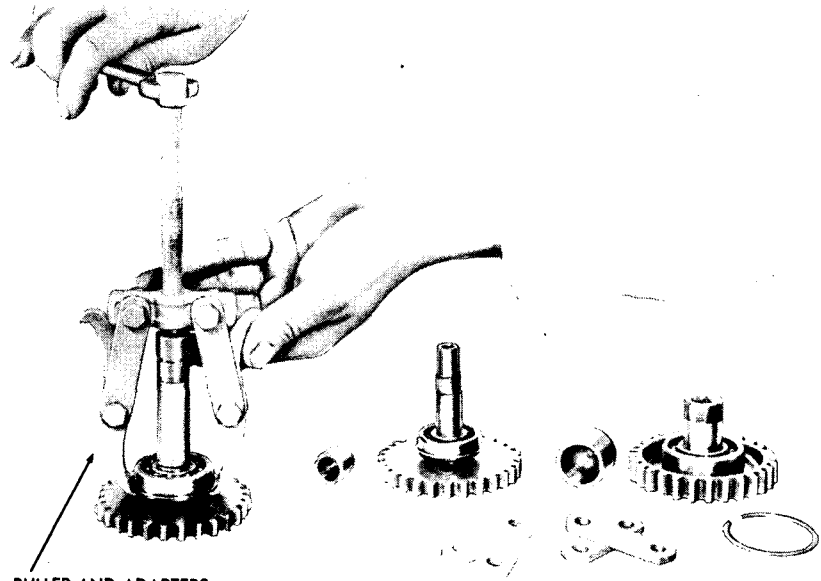

Figure 66—Removing Accessory Case Gear Bearings

(2) REMOVE FRONT BEARINGS (fig. 66).

Puller and adapters, accessory case gears, GU-GST-1367

NOTE: A bearing is used at each end of each shaft, with a spacer between them. These bearings have lock rings on the outside of the accessory case, so that the bearings cannot be driven through the accessory case. The front bearing will come out when the gears and shafts are driven out. The rear bearings can then be driven out from the front or gear side of the case.

(a) An accessory case bearing puller GU-GST-1367 is used to remove the front bearings from the fuel supply pump, oil pump, governor and generator drive gear shafts. An adapter is placed over the shaft to provide a surface on which the screw of the puller can operate. The fingers of the puller are inserted under the bearing. Turning down the center bolt of the puller will lift the bearing up and off the shaft. In removing the bearing from the oil pump gear shaft, the lock ring must be removed from the bearing and the fingers of the puller clamp in the groove from which the lock ring was removed, since there is not sufficient clearance to attach the puller fingers under the bearings.

(b) Three adapters are provided. Two sets of arms for the puller are also provided. The long arms are used in removing

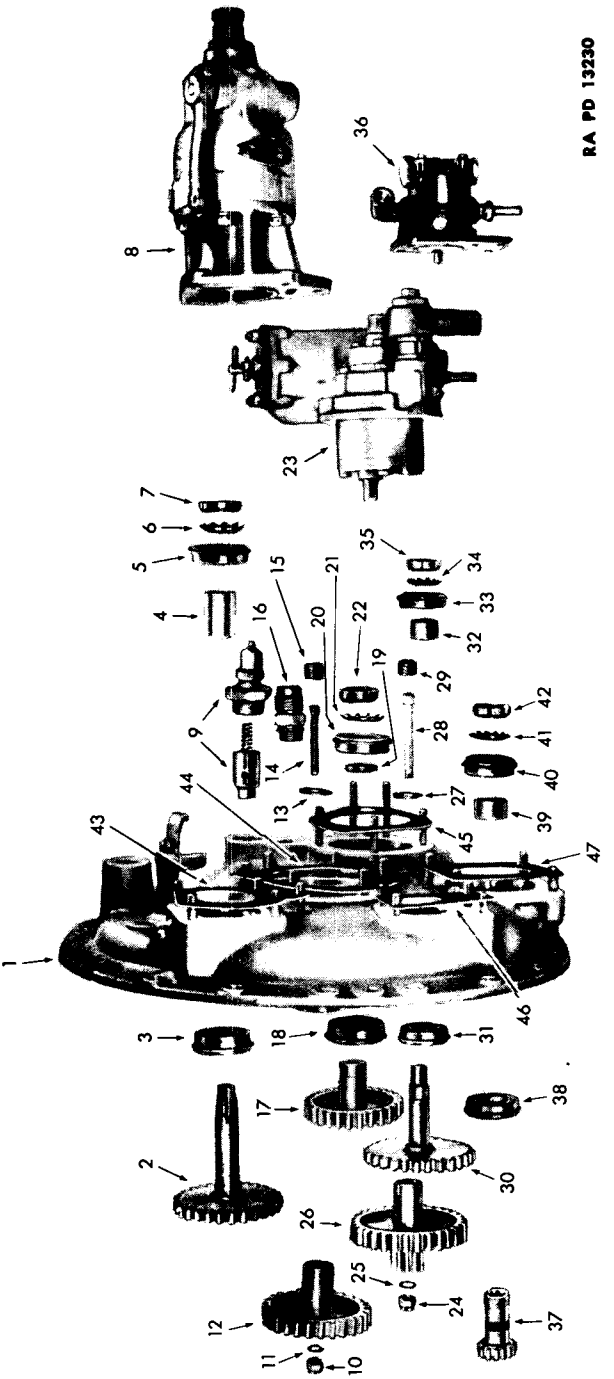

Figure 67—Exploded View of Accessory Case Assembly

1 — CASE, ACCESSORY - GU-52-Y-143
2 — GEAR, GOVERNOR DRIVE - GU-14-Y-175
3 — BEARING, GOVERNOR DRIVE GEAR - GU-14-Y-175C
4 — SPACER, GOVERNOR DRIVE GEAR BEARING - GU-13-Y-175G
5 — BEARING, GOVERNOR DRIVE GEAR - GU-14-Y-175C
6 — WASHER, GOVERNOR DRIVE GEAR LOCK - GU-14-Y-175E
7 — NUT, GOVERNOR DRIVE GEAR LOCK - GU-14-Y-175F
8 — GOVERNOR - GU-14-YA-182
9 — VALVE, OIL PRESSURE RELIEF: SUBASSEMBLY - GU-51-YA-150
10 — WASHER, IDLER GEAR BOLT - GU-Y-354
11 — NUT, IDLER GEAR BOLT - GU-Y-313
12 — GEAR, IDLER - GU-53-Y-145
13 — WASHER, INTERMEDIATE AND IDLER GEAR - GU-53-Y-145B
14 — BOLT, IDLER GEAR - GU-Y-403
15 — PLUG, INTERMEDIATE AND IDLER GEAR COVER - GU-Y-459
16 — CONNECTION, OIL LINE - GU-14-YX-120G
17 — GEAR, OIL PUMP DRIVE - GU-14-Y-146
18 — BEARING, OIL PUMP DRIVE GEAR - GU-51-Y-149
19 — SPACER, OIL PUMP DRIVE GEAR BEARING - GU-13-Y-149A
20 — BEARING, OIL PUMP DRIVE GEAR - GU-51-Y-149
21 — WASHER, OIL PUMP DRIVE GEAR LOCK - GU-13-Y-148
22 — NUT, OIL PUMP DRIVE GEAR LOCK - GU-14-Y-147
23 — PUMP, OIL - GU-14-YA-132A
24 — WASHER, INTERMEDIATE GEAR BOLT - GU-Y-354
25 — NUT, INTERMEDIATE GEAR BOLT - GU-Y-313
26 — GEAR, ACCESSORY CASE INTERMEDIATE - GU-53-Y-169
27 — WASHER, IDLER AND INTERMEDIATE GEAR - GU-53-Y-145B
28 — BOLT, INTERMEDIATE GEAR - GU-Y-404
29 — PLUG, INTERMEDIATE AND IDLER GEAR COVER - GU-Y-459
30 — GEAR, FUEL SUPPLY PUMP DRIVE - GU-14-Y-158
31 — BEARING, FUEL SUPPLY PUMP DRIVE GEAR - GU-51-Y-159
32 — SPACER, FUEL SUPPLY PUMP DRIVE GEAR BEARING - GU-14-Y-159A
33 — BEARING, FUEL SUPPLY PUMP DRIVE GEAR - GU-51-Y-159
34 — WASHER, FUEL SUPPLY PUMP DRIVE GEAR LOCK - GU-13-Y-161
35 — NUT, FUEL SUPPLY PUMP DRIVE GEAR LOCK - GU-14-Y-160
36 — PUMP, FUEL SUPPLY - GU-14-YA-198
37 — GEAR, GENERATOR DRIVE - GU-52-Y-166
38 — BEARING, GENERATOR DRIVE GEAR - GU-52-Y-171
39 — SPACER, GENERATOR DRIVE GEAR BEARING - GU-52-Y-173
40 — BEARING, GENERATOR DRIVE GEAR - GU-52-Y-171
41 — WASHER, GENERATOR DRIVE GEAR LOCK - GU-52-Y-168
42 — NUT, GENERATOR DRIVE GEAR BEARING LOCK - GU-52-Y-167
43 — GASKET, GOVERNOR MOUNTING - GU-14-Y-468
44 — GASKET, STARTER MOUNTING - GU-14-Y-465
45 — GASKET, OIL PUMP MOUNTING - GU-13-Y-469
46 — GASKET, FUEL SUPPLY PUMP - GU-41-Y-466
47 — GASKET, GENERATOR MOUNTING - GU-13-Y-463

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Figure 67A—Exploded View of Accessory Case Assembly (Nomenclature)

the governor gear bearing. The short arms are used for removing oil pump, fuel supply pump and generator bearings.

84. INSPECTION OF ACCESSORY CASE ASSEMBLY.

a. Equipment.

Gage, Telescopic — Micrometer

b. Procedure. Give all gears a visual inspection for scoring, chipped teeth, etc. Inspect bearings to make sure they roll freely, and that there are no flat surfaces, chipped balls and excessive wear. Use a micrometer on the intermediate and idler shafts and a telescopic gage on the bushings in which they fit to determine the clearance. This was from 0.0015 to 0.0035 inch loose when new, and has a limit of 0.008 inch loose before the bushing must be replaced.

c. With telescopic gage measure diameter of accessory case starter jaw bushing, comparing this measurement with outside diameter of starter shaft. See paragraph 87 for starter shaft inspection.

85. ASSEMBLY OF ACCESSORY CASE ASSEMBLY (figs. 67, 68 and 69).

a. Equipment.

Driver, fuel supply pump gear, GU-GST-1369
Driver, governor gear, GU-GST-1370
Driver, oil pump gear, GU-GST-1368
Gage, feeler
Hammer, soft
Holder, fuel supply pump and idler gears, GU-GST-1312
Indicator, dial
Pliers
Wrench, Allen, 7/32-in.
Wrench, Allen, 5/16-in.
Wrench, fuel supply pump gear, GU-GST-1322
Wrench, governor gear lock nut, GU-GST-1552
Wrench, oil pump and generator drive gear nut, GU-GST-1324
Wrench, oil pressure relief valve seat, GU-GST-1350
Wrench, socket, ½-in. (thin wall)

b. Procedure.

(1) REPLACE BEARINGS AND GEARS.

Driver, fuel supply pump gear, GU-GST-1369
Driver, governor gear, GU-GST-1370
Driver, oil pump gear, GU-GST-1368
Hammer, soft

(a) Replace the lock ring in the oil pump gear bearing. Replace the bearings on the governor, fuel supply pump, generator and oil pump gear shafts by laying the gears face down on a bench and pressing the bearings on with the special bearing drivers listed under a above (fig. 68). Press only on the inner race of the bearings. Make sure that bearings are pressed down to the shoulders of the gears, and that they turn freely after they are pressed on.

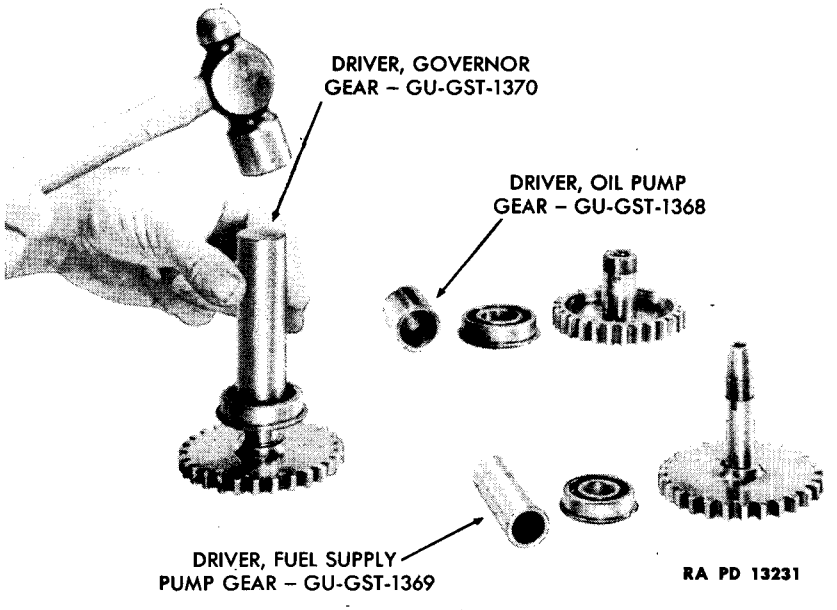


Figure 68—Replacing Accessory Case Gear Bearings

(b) Replace the gears and bearings in their positions in the case, driving them in with a soft hammer. Replace the spacers on the shafts from the rear of the case. Then replace the rear bearings, pressing them in with the same bearing drivers that were used to install the front bearings. Press only on the inner race where possible. Install new lock washers on the shafts with the prongs out and the tip on the inside of the washer in the groove in the shaft.

(2) REPLACE OIL PUMP, FUEL SUPPLY PUMP, GOVERNOR AND GENERATOR DRIVE NUTS.

Wrench, fuel supply pump gear nut, GU-GST-1322
Wrench, oil pump and generator drive gear nut, GU-GST-1324
Wrench, governor gear lock nut, GU-GST-1552

Screw on the nuts with the bevel side down toward the washer, using special wrenches which were used in removing those nuts. *The oil pump, fuel supply pump, governor and generator nuts are all left-hand threads.* Screw counterclockwise to install them.

(3) INSTALL IDLER AND INTERMEDIATE GEARS.

Gage, feeler
Pliers
Wrench, Allen, 7/32-in.
Wrench, Allen, 5/16-in.
Wrench, socket, ½-in. (thin wall)

(a) Insert the idler gear and intermediate gears into position. Install the large washers and the bolts through the starter opening, inserting the bolts through the gears. Hold the bolt heads with a 7/32-inch Allen wrench and install the castle nuts on the bolts on the gear side of the accessory case. Install new cotter pins in the nuts. Then replace the Allen heads in the accessory case over the bolts.

(b) Next determine the side play of the idler gear and intermediate gear. This is done by measuring with a feeler gage, through the starter opening in the accessory case, the clearance between the flange of the larger washer and the rear of the case. The original side play was from 0.003 inch to 0.017 inch loose, and has a limit of 0.050 inch before replacement.

(4) DETERMINE SIDE PLAY ON GOVERNOR, FUEL SUPPLY PUMP, GENERATOR AND OIL PUMP GEARS.

Gage, feeler Hammer, soft

The side play on the governor, fuel supply pump, generator and oil pump gears is measured from the lock ring to the case. Using a soft hammer, drive the shafts from the rear of the case until the lock rings on the front bearings are as far as possible from the front of the case. Then insert a feeler gage between the lock rings and the case. The side clearance should be:

Governor drive gear.....—0.000 —0.044 in. loose
Fuel supply drive gear.....—0.000 —0.044 in. loose
Oil pump drive gear.....—0.000 —0.044 in. loose
Generator drive gear.....—0.000 —0.044 in. loose

(5) CHECK PLAY BETWEEN GEAR TEETH.

Holder, fuel supply pump and idler gears, GU-GST-1312
Indicator, dial

Next check the play between the teeth of the gears. This is done with a dial indicator. The indicator is attached to the accessory case, with the needle of the indicator resting on a gear tooth (fig. 69). Lock the two other gears of the train with the fuel supply pump and idler gear holder GU-GST-1312, holding it against the gear with the hand. Move the first gear as far as it will turn in one direction, and take a reading on the dial indicator. Then turn the gear as far as it will go in the other direction, and take a reading. The difference between the two readings is the play or backlash between the teeth. Check all gears in the same way.

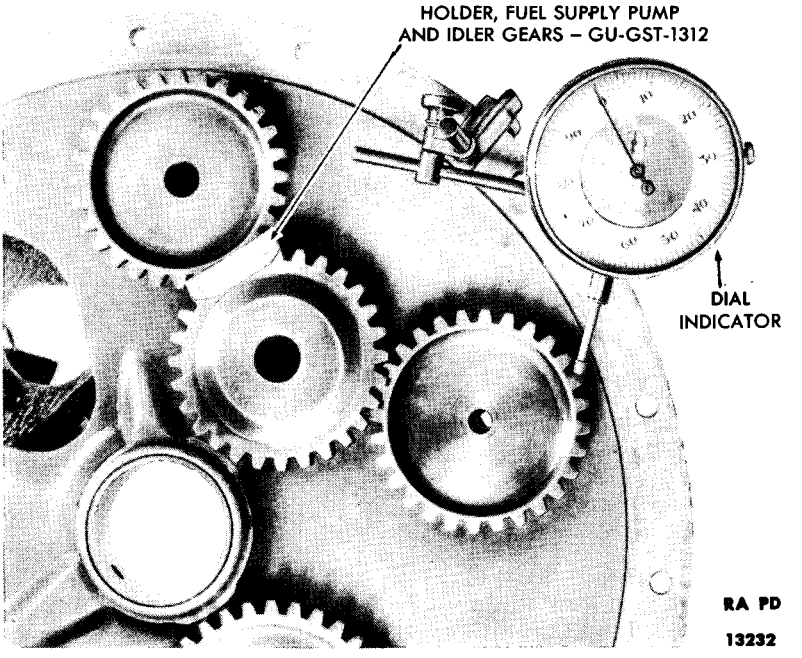


Figure 69—Checking Gear Tooth Play with Dial Indicator

Backlash on Gears, T1400 Engine, Series 3

GEAR COMBINATION	BACKLASH
1. Starter shaft gear and intermediate gear	0.006 in. to 0.010 in.
2. Starter shaft gear and idler gear	0.006 in. to 0.010 in.
3. Intermediate gear and oil pump drive gear	0.004 in. to 0.008 in.
4. Intermediate gear and generator drive gear	0.004 in. to 0.008 in.
5. Intermediate pinion and valve cam gear	0.008 in. to 0.012 in.
6. Idler gear and governor drive gear	0.004 in. to 0.008 in.
7. Idler gear and fuel supply pump gear	0.004 in. to 0.008 in.

(6) REPLACE OIL PRESSURE RELIEF VALVE.

Wrench, oil pressure relief valve seat, GU-GST-1350

Insert the seat of the oil pressure relief valve and tighten it by inserting the oil pressure relief valve seat wrench GU-GST-1350 into the groove in the seat. Oil the valve with light oil and drop it into the seat. Replace the spring over the valve. Install and tighten down the cover.

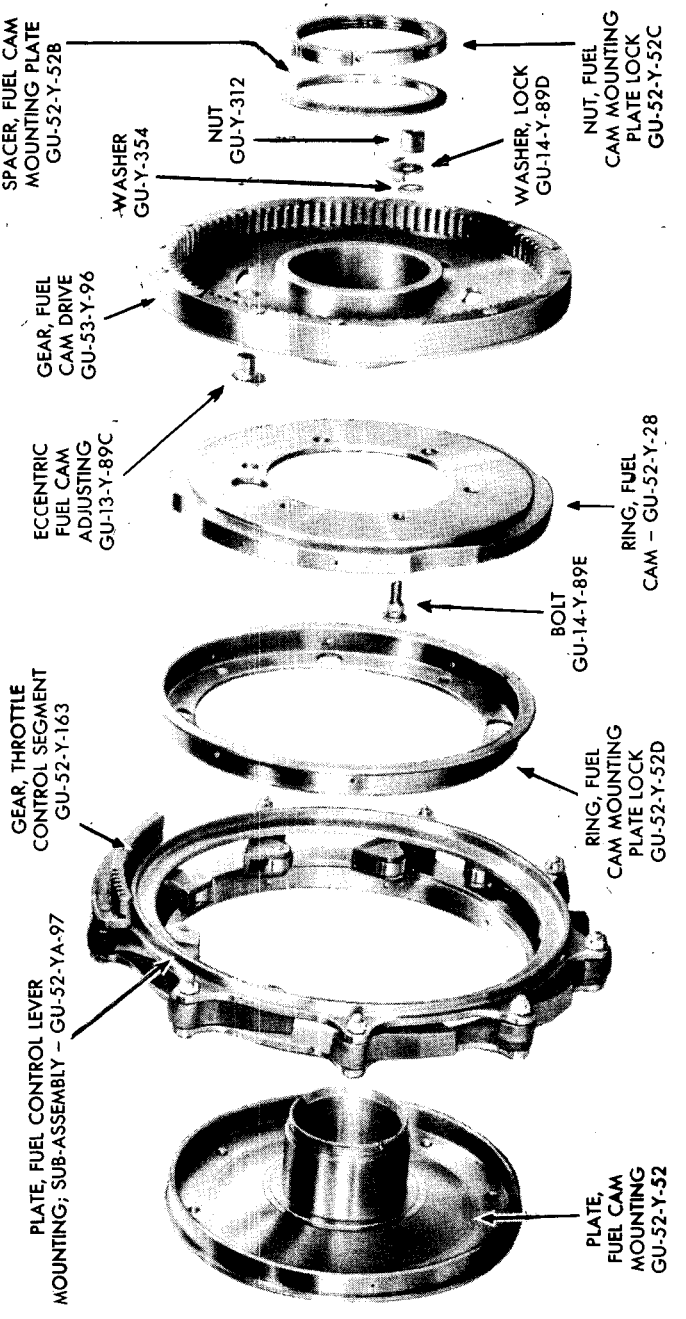


Figure 70—The Fuel Cam and Control Lever Assemblies

THE INSPECTION

86. INSPECT THE FUEL CAM AND CONTROL LEVER ASSEMBLIES (fig. 70).

a. Equipment.

Gage, feeler	Wrench, socket, 7/16-in.
Micrometer	Wrench, socket, ½-in.

b. Procedure. NOTE: The fuel cam drive gear GU-53-Y-96 and ring GU-52-Y-28 are held together by six mounting bolts GU-14-Y-89E. Slots in the drive gear where these bolts enter permit the fuel cam ring to be turned in relation to the drive gear by means of fuel cam adjusting eccentric GU-13-Y-89C. This setting should not be disturbed unless it is necessary to replace one of the parts. If these parts are dismantled, the injector timing will have to be reset.

(1) TO REMOVE THE DRIVE GEAR.
Wrench, socket, ½-in.

Should it be necessary, the six nuts GU-Y-312 can be removed, the flat washers GU-Y-354 and lock washers GU-14-Y-89D lifted out, and the drive gear lifted off the ring..

(2) TO REMOVE THE FUEL CONTROL LEVER ASSEMBLY.
Wrench, socket, 7/16-in.

The fuel control lever assembly should also be kept intact unless it is necessary to dismantle it to replace any parts. If necessary, the fuel control lever mounting plate nuts can be removed and the levers replaced or the assembly dismantled.

(3) INSPECTION.
Gage, feeler Micrometer

(a) Examine the teeth on the fuel cam drive gear for chipping or excessive wear. If the gear is of riveted construction, make sure the rivets are tight and their surfaces smooth.

(b) Inspect the bushings for roughness or galled marks. Check the cam mounting surface and the surface that the fuel control levers ride on, for roughness. Carefully stone out marks.

(c) Measure the clearance of the drive gear bushing on the mounting plate hub. The original clearance was 0.0025 inch loose to 0.0045 inch loose and has a limit of 0.009 inch before replacement of the bushing is necessary.

(d) The side clearance between the fuel cam mounting plate spacer GU-52-Y-52B and the drive gear bushing should be checked with a feeler gage after assembly. The original clearance was 0.008 inch loose to 0.017 inch loose with a limit of 0.025 inch loose before replacement.

(e) Check the surfaces of the fuel control levers for defects and examine to make sure they oscillate freely.

(f) Inspect the rollers for flat surfaces, chips, cracks and excessive play. Check the lever for excessive play in the bushing the mounting bolt goes through. Remove cotter pins. Check the

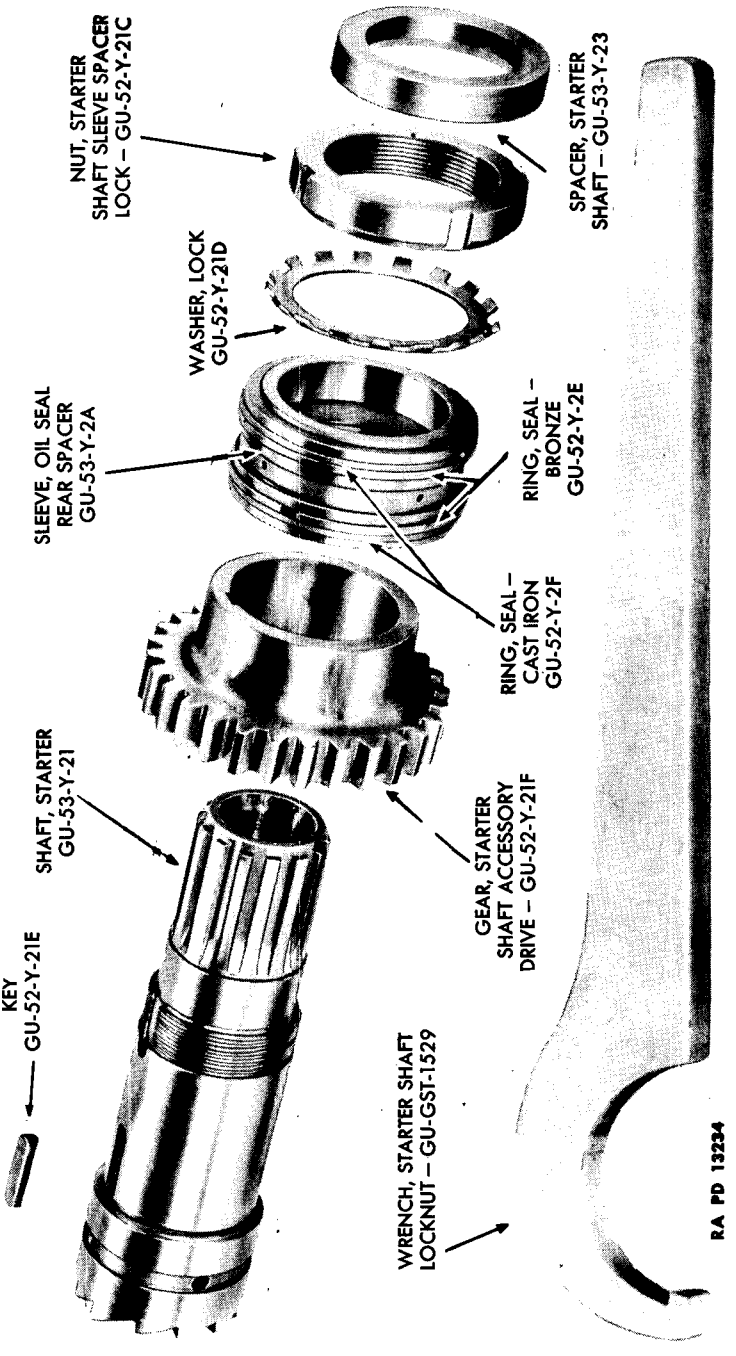


Figure 71—The Starter Shaft Subassembly

nuts for tightness and install new cotter pins. NOTE: After assembly in the engine use a feeler gage to measure the inner clearance and side clearance between the fuel control lever mounting plate and fuel cam mounting plate. Check the fuel control lever mounting plate for galled marks or roughness. Inspect the teeth of the throttle segment gear. Check all threads. Refer to the clearance chart for clearances.

87. INSPECT THE STARTER SHAFT SUBASSEMBLY (fig. 71).

a. Equipment.

Gage, feeler	Vise, soft-jawed
Micrometer	Wrench, starter shaft lock nut, GU-GST-1529
Press	

b. Procedure.

(1) DISMANTLE THE SUBASSEMBLY.

Press	Wrench, starter shaft lock nut, GU-GST-1529
Vise, soft-jawed	

Clamp the starter shaft accessory drive gear GU-52-Y-21F in a soft-jawed vise, with the starter jaw end down. Lift off the starter shaft spacer GU-53-Y-23. Loosen the prongs of the lock washer GU-52-Y-21D and remove the starter shaft sleeve spacer lock nut GU-52-Y-21C, using the starter shaft lock nut wrench GU-GST-1529. Lift off the lock washer and oil seal rear spacer sleeve GU-53-Y-2A. To remove the gear, set the shaft in a press and press it out of the gear. Remove the key GU-52-Y-21E which was under the gear.

(2) INSPECTION.

Gage, feeler — Micrometer

(a) Examine the splines and surfaces of the starter shaft GU-53-Y-21 for roughness or galled areas. Examine the starter dog teeth for chips, burs and worn surfaces. Examine the teeth of the gear for chipping or excessive wear.

(b) Measure the bearing diameter area behind the starter jaw, and note it for reference to make sure there is correct clearance in the accessory case bushing.

(c) Examine the rings on the sleeve to make sure they are in good condition. Measure the ring side clearances and refer to the clearance chart for correct tolerances.

(3) ASSEMBLE THE SUBASSEMBLY.

Press — Wrench, starter shaft lock nut, GU-GST-1529

Install the key in the slot and press the gear over it. Oil the rings on the sleeve and install the sleeve on the shaft. Replace the lock washer and install the lock nut, using the lock nut wrench GU-GST-1529. Lock the washer to the lock nut. Install the spacer on the shaft.

Section V

REPAIR OF ENGINE

88. GENERAL.

Due to its high compression, and the precision manufacture of many of its parts, it is *not recommended* that extensive repairs be made on the Guiberson Diesel engine. Most parts that become defective through long use or damage should be replaced rather than attempting to repair them. If pistons, piston rings, cylinder barrels, main bearings, or other major parts should require servicing, the engine should be torn down for a complete overhaul. For correct procedure in the replacement of parts, refer to the Disassembly, Inspection and Assembly sections of this manual. The sevicing of accessories is covered under the heading referring to each accessory. The recommended procedure for performing service operations is covered in this section of the manual.

89. TO REPLACE VALVE CAM BUSHING.

a. Equipment. The following is a list of tools necessary to replace valve cam bushing:

Alcohol and dry ice	Scraper, hand
Lathe	Tool, Carboloy
Press	

b. Procedure.

(1) TO REMOVE BUSHING.

Lathe — Press

Bore the old bushing out to a wall diameter of 1/32-inch, leaving a shoulder of about ⅛-inch depth at the bottom of the bushing to serve as a base in removing the bushing. Remove the valve cam from the lathe and center it in a press. Press out the remaining shell of the bushing.

(2) TO REPLACE BUSHING.

Alcohol — Scraper, hand
Press — Tool, Carboloy

To insert a new bushing, place the bushing in alcohol and dry ice for about 10 minutes. Place the valve cam on a surface plate on a press. Center the bushing over the hub of the cam and press in, taking care to keep the bushing straight in the hub bore. Break any sharp edges with a hand scraper. Finish-bore with a Carboloy tool.

90. TO REPLACE THE MASTER ROD BUSHING.

a. Equipment.

Fixture, key alining — Scraper, hand
Lathe — Tool, Carboloy
Press

b. Procedure.

(1) TO REMOVE BUSHING.

Lathe — Press

Bore the old bushing out to a shell of 1/32-inch with a shoulder ¼-inch deep at the bottom. Remove the master rod from the lathe and press this shell out of the master rod.

(2) TO REPLACE BUSHING.

Fixture, key alining — Scraper, hand
Press — Tool, Carboloy

(a) NOTE: The bushing is keyed in the master rod and is difficult to install since it must be perfectly alined with the key. Also the operation of installing the bushing must be performed quickly. A simple device for alining the bushing with the key is shown in figure 72. A section of key stock ½ inch thick, 1 inch deep and 4 inches long is welded to a 2-inch by 4-inch piece of ¼-inch stock. The key projects out from the base so that the base can be clamped to the master rod in back of the bushing. When the tool key is lined up with the key in the master rod, and the keyway of the bushing is placed on the key of the tool, the bushing will be guided down the master rod key.

(b) Heat the end of the master rod in oil at not over 450 degrees temperature until the opening is from 0.004 inch to 0.006

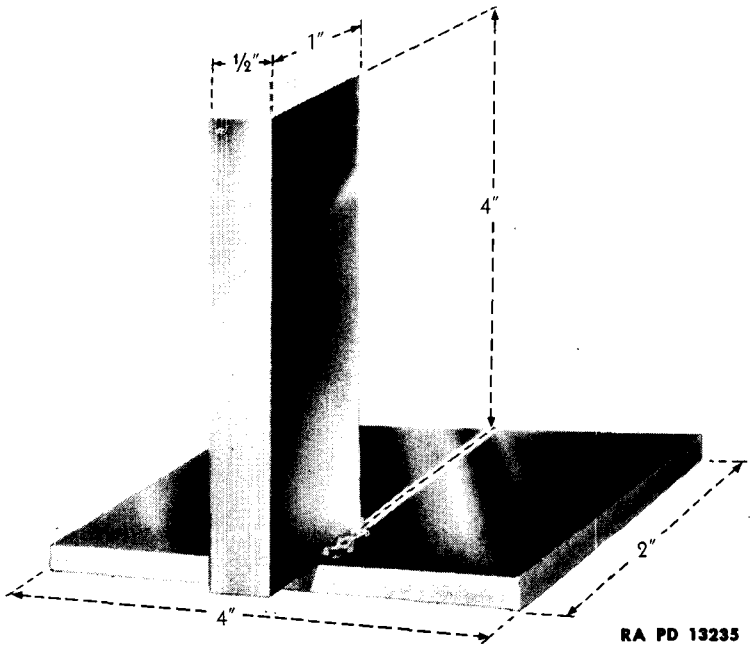


Figure 72—Tool for Alining Master Rod Bushing

inch larger than the outside diameter of the bushing. Then, with the tool clamped to the master rod so that the key is lined up with the master rod key, place the bushing in position, with the keyway over the key, and press it down. This must be done quickly before the master rod can cool. Keep the bushing under the press until it is cooler. When the rod and bushing have cooled, break sharp edges of the bushing with a hand scraper and finish-bore the bushing with a Carboloy tool.

91. TO REPLACE THE MASTER ROD PISTON PIN BUSHING.

a. Equipment.

Alcohol and dry ice	Punch
Hammer	Scraper, hand
Lathe	Tool, Carboloy
Press	

b. Procedure.

(1) TO REMOVE BUSHING.

Hammer	Press
Lathe	Punch

This bushing is doweled through the master rod. Punch out the dowel pin. Bore the old bushing down to a 1/32-inch shell with a shoulder ⅛-inch deep at the bottom. Remove from lathe and press out the shell.

(2) TO RELPACE BUSHING.

Alcohol and dry ice	Scraper, hand
Press	Tool, Carboloy
Punch	

Put a new bushing in alcohol and dry ice for ten minutes. Place the master rod on a surface plate on a press and press the bushing into position. Replace the dowel pin and counter-punch the metal of the rod around the edges to hold it in place. Break any sharp edges of the bushing with a hand scraper, then finish-bore the bushing with a Carboloy tool.

92. TO REPLACE THE LINK ROD BUSHING.

a. Equipment.

Alcohol and dry ice	Press
Lathe	Tool, Carboloy

b. Procedure. Bore out the old bushing to a 1/32-inch shell, leaving a ⅛-inch shoulder at the bottom. Remove the link rod from the lathe and press out the shell. Place a new bushing in alcohol and dry ice for ten minutes. Place the link rod on an anvil with a hole 0.010-inch larger than the outside diameter of the bushing. Press the bushing into position, with equal extension of the bushing on each side of the link rod. Finish-bore the bushing with a Carboloy tool.

93. TO REPLACE STARTER SHAFT BUSHING IN ACCESSORY CASE.

a. Equipment.

Alcohol and dry ice	Scraper, hand
Drill	Tool, Carboloy
Lathe	Tool, easy-out
Press	

b. Procedure.

(1) TO REMOVE BUSHING.

Drill	Press
Lathe	Tool, easy-out

The bushing is doweled to the case with two brass screws. Drill through the dowels and back the screws out with an easy-out or similar tool. Bore the bushing down to a 1/32-inch shell, leaving a ⅛-inch shoulder at the bottom. Remove the accessory case from the lathe and press out the bushing.

(2) TO REPLACE BUSHING.

Alcohol and dry ice	Scraper, hand
Drill	Tool, Carboloy
Press	

Place the bushing in alcohol and dry ice for ten minutes. Aline the accessory case on a press with a supporting anvil under the starter mounting flange. Press the bushing into place. Be sure to keep it straight. Drill and tap through the bushing for a No. 10 x 24 thread and install new dowel pins. Break any sharp edges of the bushing with a hand scraper. Finish-bore the bushing with a Carboloy tool.

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

94. TO REPLACE THE INTERMEDIATE GEAR AND IDLER GEAR BUSHINGS IN THE ACCESSORY CASE.

a. Equipment.

Alcohol and dry ice	Lathe
Button, 1¼-in. with	Press
1-in. pilot	Rod
Drill	Scraper, hand

b. Procedure.

(1) TO REMOVE BUSHING.

Button, 1¼-in. with	Lathe
1-in. pilot	Press
Drill	Rod

These bushings are doweled to the case with two dowel pins on the outside of the case. Drill out these dowel pins. The bushings must be forced through the front, or gear side of the accessory case. Bore the bushings down to 1/32-inch shell with a ⅛-inch shoulder at the bottom. To remove the bushing shell, use a 1¼-inch button that is undersized 0.010 inch with a 1-inch pilot which will fit inside the bushing. Place the pilot in the bushing inside the accessory case. Press the bushing out by inserting a rod through the opening in the accessory case above the bushing, and bearing down on the button.

(2) TO REPLACE BUSHING.

Alcohol and dry ice	Press
Drill	Scraper, hand

Place the new bushing in alcohol and dry ice for 10 minutes and press into position from the outside or front of the accessory case. Drill and tap through the bushing for a 1024 thread and install new dowel pins. Break any sharp edges of the bushing with a hand scraper. Finish-boring is also done from the front of the accessory case. Bevel the shoulder of the bushing to form a radius for the gear.

95. TO REPLACE VALVE GUIDES (fig. 73).

a. Equipment.

Cylinder mounting fixture
Driver, exhaust valve guide, GU-GST-1540
Driver, intake valve guide, GU-GST-1539
Hammer
Puller, valve guide, GU-GST-1541
Ream

b. Procedure. NOTE: A special cylinder mounting fixture to support the guide bosses should be used when installing valve guides. The cylinder barrel mounted on such a fixture is shown in figure 73. The fixture is also shown in the Special Tool section.

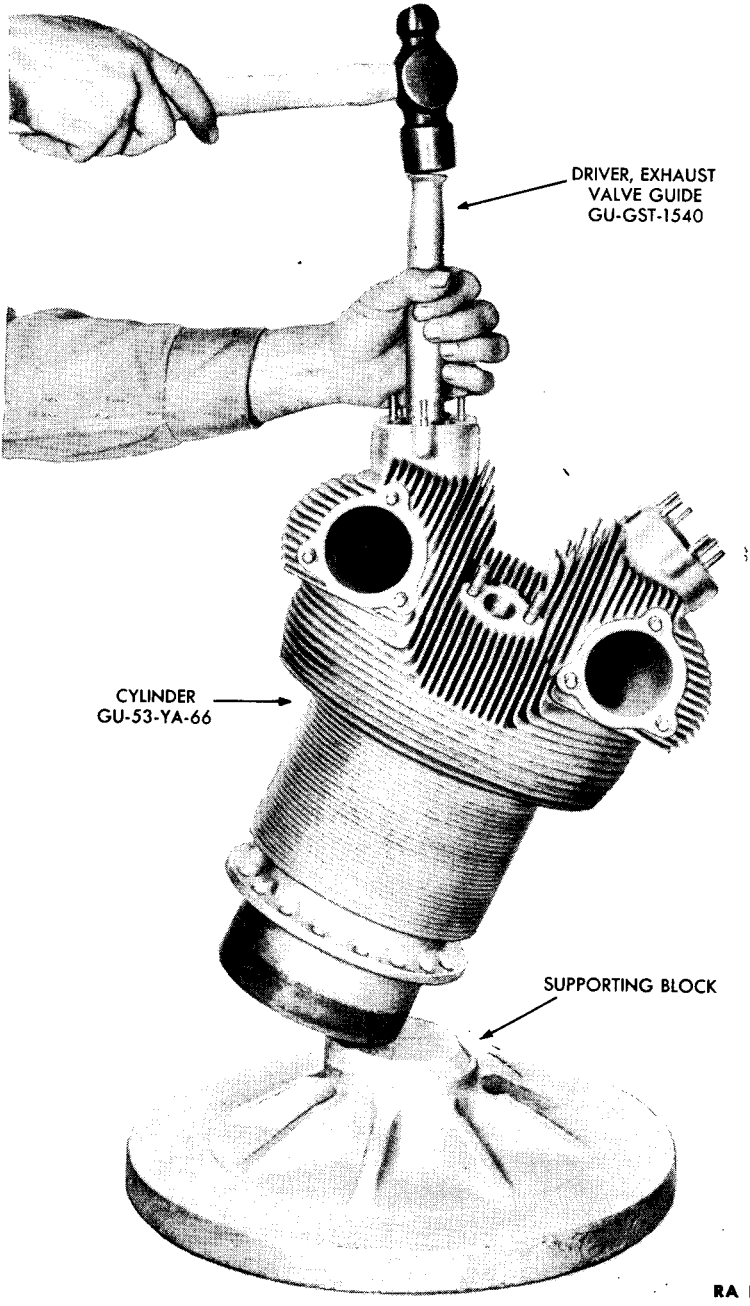


Figure 73—Installing a Valve Guide

(1) TO REMOVE THE VALVE GUIDES.
Puller, valve guide, GU-GST-1541

Install the valve guide puller sleeve in the rocker box around the guide, with the bearing side of the sleeve facing upward. Screw the bolt down into the sleeve. Install the pin from the cylinder barrel opening side, and insert it through the guide, screwing it into the bolt. Screw down the nut so it rests on the bearing in the sleeve. Screwing down the bolt further will pull the guide up into the sleeve. An adapter is provided with the puller for use with the exhaust valve guides, which are larger than the intake valve guides.

(2) TO INSTALL NEW VALVE GUIDES (fig. 73).

Driver, exhaust, valve guide, GU-GST-1540	Fixture, cylinder mounting
Driver, intake valve guide, GU-GST-1539	Hammer
	Reamer

Set the cylinder barrel on the cylinder mounting fixture as shown in figure 73, to support the valve guide boss. Cloth should be wrapped around the lower end of the fixture to protect the cylinder barrel. The cylinder barrel should be so mounted on the fixture that when the guides are being installed, they can be forced straight down. Coat the valve guide with GREASE, gen-

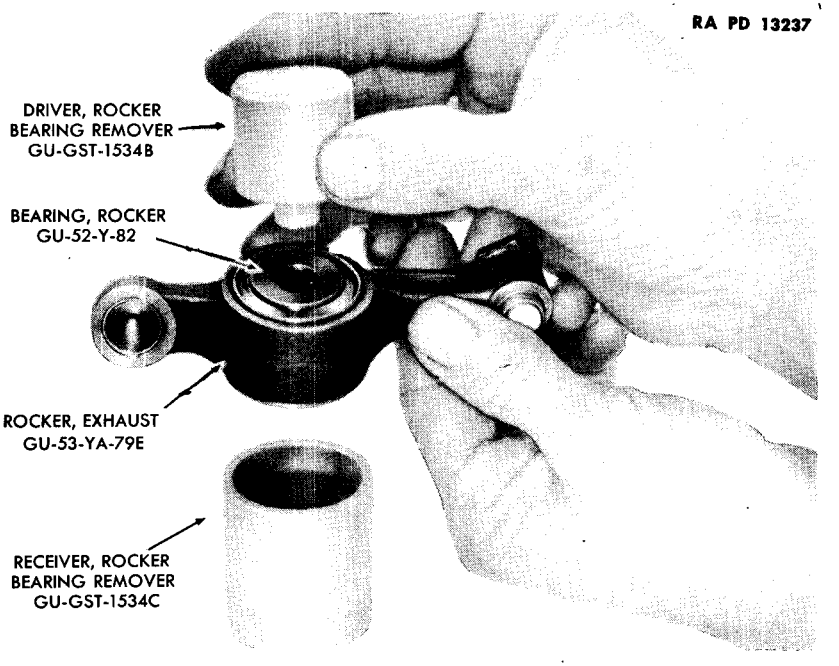


Figure 74—Removing a Rocker Arm Bearing

eral purpose, seasonal grade, and install at the proper valve guide opening. (Exhaust valve guides are larger than intake valve guides.) Place the valve guide driver (exhaust GU-GST-1540, intake GU-GST-1539) on the guide and drive or press the guide into place. Finish ream to size for proper clearance, as shown in section X.

96. TO REPLACE ROCKER ARM BEARING (figs. 74 and 75).

a. Equipment.

Inserter, rocker bearing, GU-GST-1533
Press
Remover, rocker bearing, GU-GST-1534

b. Procedure.

(1) TO REMOVE THE BEARING.

Press
Remover, rocker bearing, GU-GST-1534

Place the rocker on the rocker bearing remover receiver part of the tool GU-GST-1534C with the flanged side of the rocker bearing GU-52-Y-82 down. Place the rocker bearing remover driver GU-GST-1534B part of the tool on the bearing. Install in a press and press on the driver to force out the bearing.

(2) TO INSTALL THE BEARING.

Inserter, rocker bearing, GU-GST-1533
Press

NOTE: Before installing a new rocker bearing, coat the bearing with GREASE, general purpose, seasonal grade. Using the rocker bearing inserter GU-GST-1533, place the rocker on the

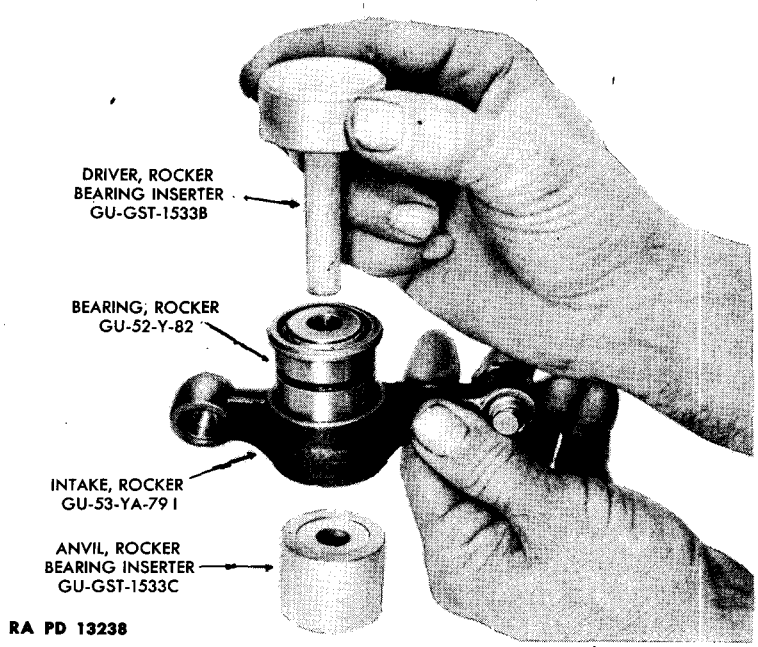


Figure 75—Installing a Rocker Arm Bearing

rocker bearing inserter anvil GU-GST-1533C of the tool with the narrow shoulder of the rocker facing upward and place the bearing in position on the rocker with the flanged side of the bearing facing upward. Use the rocker bearing inserter driver GU-GST-1533B part of the tool, placing the inserter guide through the bearing. Press down on the head of the inserter to force the bearing into place.

97. TO GRIND VALVES (fig. 76).

a. Equipment.

Cloth, crocus	Grinder, valve, GU-GST-1549
Cloth, emery	Machine, valve refacing
Compound, grinding	Solvent, dry-cleaning
Cork	Stone

b. Procedure. NOTE: The cylinder barrels must be removed from the motor to grind the valve seats, so this operation is performed only at the time of an overhaul.

(1) RECONDITIONING THE VALVES.

Cloth, crocus	Machine, valve refacing
Cloth, emery	Stone

(a) If a valve face is pitted or warped, reface it in a standard valve refacing machine. Remove no more metal than is absolutely necessary to true-up the face.

(b) When valves are reground, a sharp edge sometimes remains on the outside diameter of the face. After regrinding valves, it is recommended that this edge be checked, and if necessary, it should be broken to a 0.010-inch minimum radius with a hand stone while the valve is rotating in the valve refacing machine.

(c) Valve stems acquire a glazed surface during operation. Do not disturb this surface unless it is necessary to remove pit marks. Use a stone to remove light scores and burs from the valve. Clean with CLOTH, crocus.

(d) To remove carbon deposits from the valve head, use a fine emery cloth; it is of the utmost importance, however, that emery cloth is not used on the seat or stem. Use old pieces of emery cloth, as new cloth will scratch. Polish the valve head with crocus cloth and SOLVENT, dry-cleaning, to remove all scratches.

(2) GRINDING VALVE SEATS (fig. 76).

Compound, grinding — Solvent, dry-cleaning
Grinder, valve, GU-GST-1549

Lay the cylinder barrel on its side. After the valves have been reconditioned or replaced, coat the valve seat in the cylinder

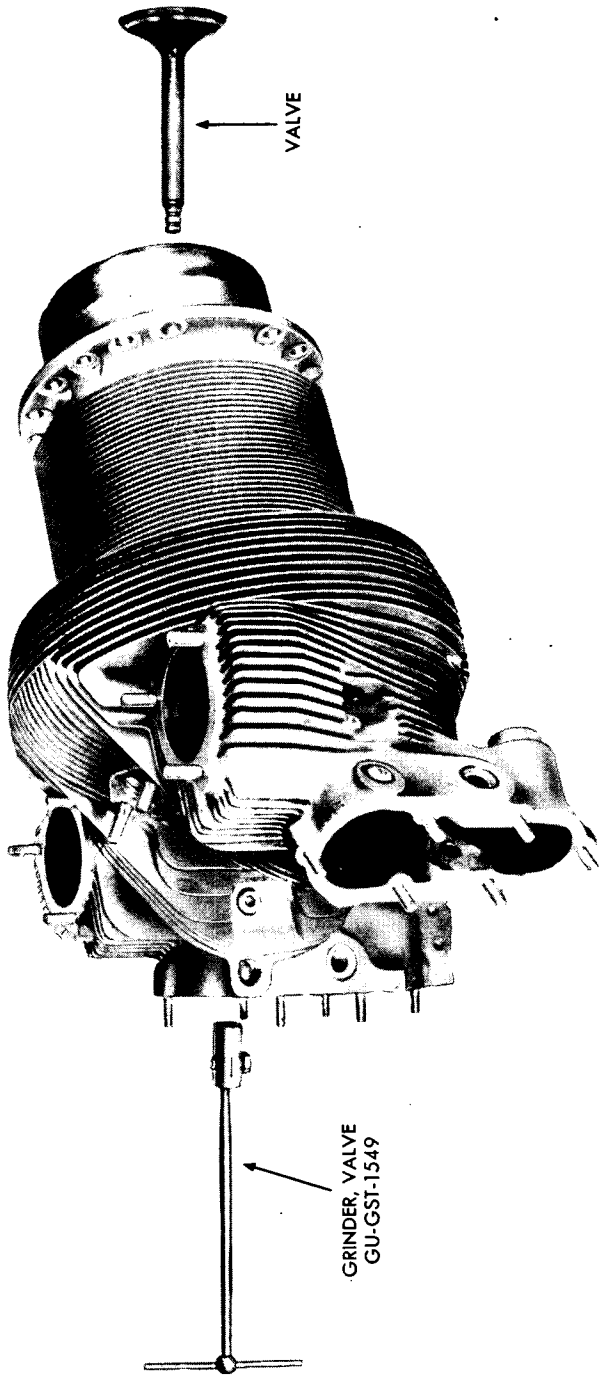


Figure 76—Valve Grinding Equipment

head with a grinding compound and insert the valve stem through the guide until the face of the valve bears against the seat. Be careful not to get the compound on the valve stem. Clamp the valve grinder GU-GST-1549 over the end of the valve stem. Twirl the valve back and forth to grind the seat, with an oscillating movement, frequently lifting it and rotating it from its seat. Continue lapping until desired seat is obtained. Remove the valve and wash it with SOLVENT, dry-cleaning. Clean the used compound from the cylinder seat. Repeat the grinding operations. Wash thoroughly with SOLVENT, dry-cleaning, and dry with compressed air.

(3) TESTING VALVE SEATS.

Cork Solvent, dry-cleaning

To test the fit of the valve in the seats, insert a cork in the injector opening. Insert the valve stems into the guides and cover the valve heads with SOLVENT, dry-cleaning. Look through the valve ports to see if any of the solvent seeps through around the valve heads. If it does, the valves and seats will require further grinding, until a test-proof fit is acquired. After cylinder has been assembled, an additional valve seat check should be made by plugging injector opening, installing plate with seal and air hose connection over the exhaust port. Turn cylinder and barrel up and pour SOLVENT, dry-cleaning, into barrel until valves are covered about one inch. By applying air pressure to exhaust port, check should be made to see if air bubbles are appearing in solvent around exhaust valve seat. Make duplicate check on intake valve. Proceed until all cylinders are checked. Cylinder barrel and head should be dried of solvent and oiled after test.

98. THE FUEL INJECTORS.

See paragraph 78 for complete operation for testing and repairing the fuel injectors.

99. THE FUEL INJECTION PUMPS.

See paragraph 79 for complete operation for disassembling and inspecting the fuel injection pumps.

100. THE ENGINE OIL FILTER.

The Cuno cartridge in the oil pump assembly is cleaned by turning the handle at the top of the filter one complete revolution. This will revolve the disk against the stationary cleaner blades which project into each slot and remove any material which may have lodged in the slots or on the surface of the cartridge. During the 100-hour check, the

filtering unit is removed and washed and the housing flushed with lightweight oil.

101. TIMING: VALVE AND FUEL.

See paragraphs 114 and 130.

102. BLEEDING THE FUEL LINES.

See paragraph 156 of this manual.

103. BALANCING THE CYLINDERS.

See paragraph 156 of this manual.

104. TO REPLACE THROTTLE SHAFT OIL SEAL.

a. Equipment.
Press

b. Procedure. Drive or press the oil seal out of the accessory case. Drive or press a new oil seal into the accessory case.

105. REAR CRANKSHAFT COUNTERWEIGHT INSERTS.

a. Equipment.
Press

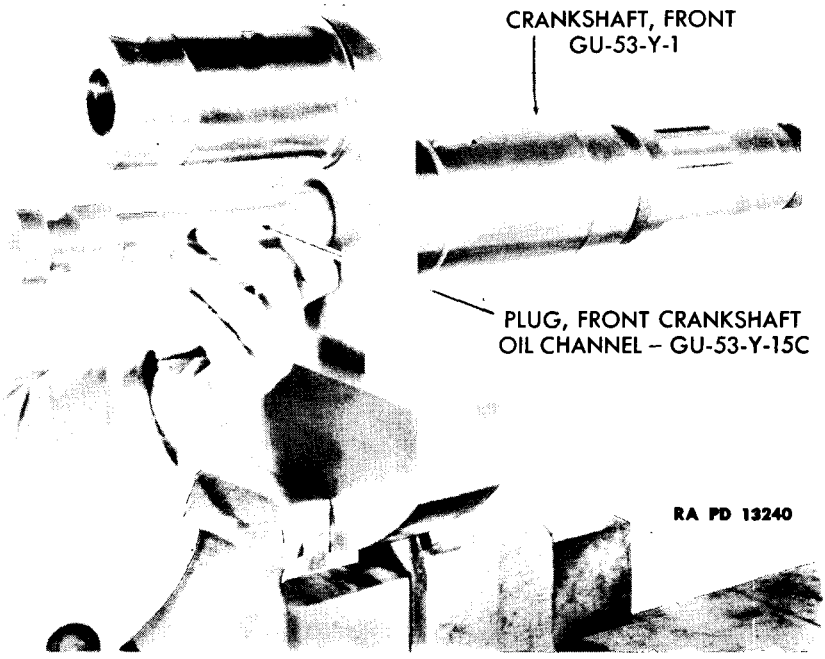


Figure 77—The Front Crankshaft Oil Channel Plug

b. Procedure. NOTE: The inserts in the rear crankshaft counterweight will wear at the top and bottom. They can be turned to provide continued serviceable operation. The turning procedure follows: press the inserts out of the crankshaft counterweight turning them 180 degrees so that the narrower diameter of the insert is vertical with the counterweight. Press the insert into the counterweight, with the radius side of the insert on the side on which it was originally.

106. REPLACING FRONT CRANKSHAFT OIL CHANNEL PLUG (fig. 77).

a. Equipment.

Drill
Hammer, soft
Rod

b. Procedure. Drill out the dowel in the lower side of the front crankshaft bearing journal that holds the front crankshaft oil channel plug GU-53-Y-15C in place. Insert a rod in the front crankshaft and drive out the plug. Install a new plug, driving it into place with a soft hammer. Insert a new dowel pin through the lower side of the front crankshaft bearing journal. The front crankshaft main bearing will be installed over the dowel pin and serve to hold it in place.

Section VI

ASSEMBLY OF ENGINE

107. GENERAL.

When the engine and its subassemblies have been completely disassembled, the parts washed, cleaned, and inspected for wear and defects, serviced or replaced and subassemblies completed, the engine is ready for reassembly. Close attention to specified fits and clearances must be given in assembly to assure engine efficiency in operation and life. In assembly recheck all clearances and measurements made at the time of inspection and follow manufacturer's table of clearances in paragraphs 180 and 181 to assure proper fit.

108. INSTALL THE REAR CENTER SECTION ON THE CRANKCASE REAR MOUNTING SECTION.

a. Equipment. The following is a list of equipment necessary to install the rear center section on the crankcase rear mounting section:

Pliers
Wrench, socket, ½-in.
Stand, engine mounting

b. Procedure. Install the crankcase rear mounting section on the engine mounting stand and bolt it in place through the mounting flange. Install fuel return ring on rear center section. Install a gasket on the crankcase rear mounting section, then bolt the rear center section and rear mounting sections together (½-in. socket wrench). Place washers under the nuts. Safety-wire the nuts in pairs with pliers.

109. INSTALL THE CRANKSHAFT IN THE CRANKCASE (fig. 26).

a. Equipment.

Eye, engine lifting, GU-GST-1550
Protectors, link rod
Hammer, soft
Wrench, socket, 9/16-in.
Hoist

b. Procedure. Attach the engine lifting eye to the front crankshaft and raise the crankshaft on a hoist. (A shim 0.040 to 0.050-in. thick and 1-in. wide should be placed on the crankcase liner to hold the rear crankshaft from the liner.) Lower the crankshaft and master rod assembly into the crankcase, with the master connecting rod in No. 7 cylinder. (No. 1 cylinder is opposite the oil sump openings. Numbers run counterclockwise to No. 7 when facing the front of the engine.) Install valve cam intermediate gear spindle on front center section of

crankcase. Safety-wire five of the six bolts. Do not install gear or intermediate gear bolt as intermediate gear may have to be removed during the timing operation. Lower the crankcase front center section over the rear center crankcase, with the oil sump drain opposite No. 1 cylinder. Bolt the two sections of the crankcase together, with a washer under both the bolt head and elastic stop nut, and with the bolt entered from the top. The long bolt is used at the oil sump openings. Use a soft hammer to drive the bolts through. Then install washers and screw on the elastic stop nuts (9/16-in. socket wrench). Put the link rod protectors over the cylinder hold-down studs between each pair of cylinders.

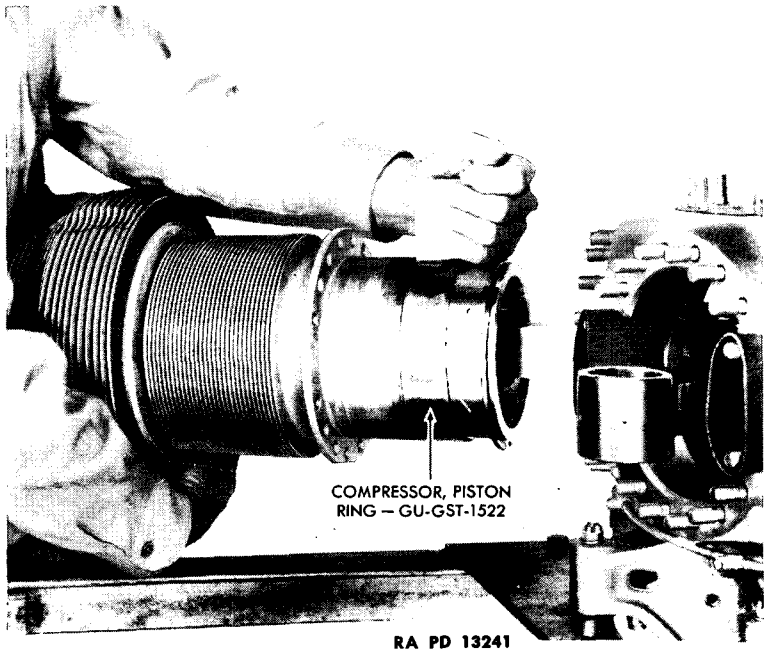


Figure 78—Installing a Cylinder Assembly

110. INSTALL PISTONS AND CYLINDERS (figs. 78 and 79).

a. Equipment.

Bands, rubber	Turner, crankshaft
Compressor, piston ring, GU-GST-1522	Wrench, GU-GST-1547
OIL, engine, seasonal grade	Wrench, torque

b. Procedure. NOTE: With the engine horizontal and front facing upwards, start the installation of the pistons and cylinder barrels at No. 7 cylinder, which has the master rod. As each cylinder and piston is installed, turn the motor with the crankshaft turner until the connect-

ing rod is in its furthest out position. This can be determined by the wide spline on the crankshaft, which faces the cylinder when the piston in that cylinder is at the top of its stroke. Remove the link rod protectors from each cylinder as the piston and cylinder barrel are installed. No. 7 piston has an "X" groove in the skirt of the piston. The piston is installed with the "X" groove toward No. 8 cylinder at the right. Install all pistons so that the piston number is to the front or toward the spline end of the crankshaft.

(1) INSTALL PISTONS, PISTON PINS AND PLUGS. The piston pin is also inserted with the number up. Oil the piston pin and insert it through the piston and link rod bushing. It should require a thumb press fit at 70 degrees temperature. Install the plugs at each end of the piston pin.

(2) SEATING PISTON RINGS AND INSTALLING RUBBER BANDS ON THE CYLINDER BARREL. Turn the piston rings so that all gaps are at the top of the piston and in line. Cover them with oil, working the rings around to spread the oil. Then equal-space the piston ring gaps so that they do not line up. Place four No. 18 rubber bands over the barrel and against the mounting flange to act as an oil seal. Oil the inside of the cylinder barrel, using OIL, SAE 50, spreading it evenly over the barrel surface by hand.

WRENCH, CYLINDER HOLD DOWN NUT – GU-GST-1547

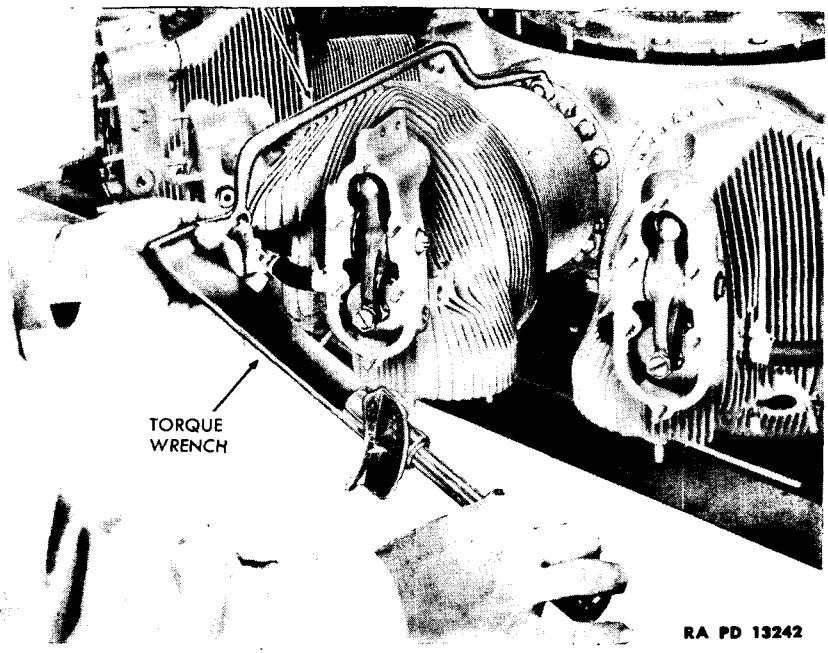


Figure 79—Tightening Cylinder Hold-Down Nuts with Torque Wrench

ASSEMBLY OF ENGINE

(3) INSTALL CYLINDER BARRELS.
Compressor, piston ring, GU-GST-1522
Wrench, cylinder hold-down nut, GU-GST-1547
Wrench, torque

(a) A piston ring compressor GU-GST-1522 is used to hold the piston rings while the barrel is installed, as shown in figure 78. Holding the cylinder barrel so that the push rod openings are to the front of the engine, slide it over the piston, pushing the ring compressor back as the barrel is moved on. The ring compressor can be released as soon as the barrel encloses the upper rings, and moved down to compress the scraper ring. Make sure that the piston pin plugs do not drop out while the barrel is being installed. Move the barrel up on the mounting studs.

(b) Install the washers and nuts, using the cylinder hold-down nut wrench, alternating from front to rear or 180 degrees apart a little at a time on each nut until light torque is obtained. Repeat this operation until all cylinder barrels except No. 4 are installed. Do not install the palnuts. CAUTION: Be careful that nothing is dropped into the inlet or exhaust openings or inside the crankcase while working on the engine.

(c) Tighten the nuts, alternating front to rear or 180 degrees apart, with a torque wrench, exerting 40 foot-pounds of torque. Install the palnuts.

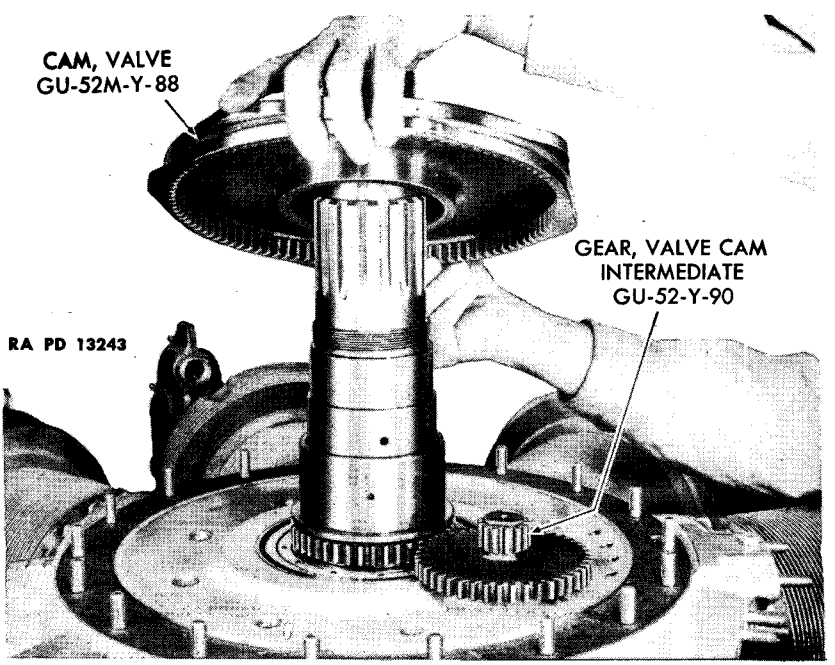


Figure 80—Installing the Valve Cam

111. REPLACE THE VALVE CAM (figs. 80 and 81).

a. Procedure. NOTE: The valve cam GU-52M-Y-88 must be replaced so that intake and exhaust valves will be operated from exactly the same position on their respective cams. The valve cam, intermediate gear GU-52-Y-90 and crankshaft gear are all marked, and if none of these gears has been changed they can be alined according to the marking and valves will be properly timed. Install valve cam intermediate gear with alining mark centered in line with crankcase center section bolt between No. 4 and No. 5 cylinder bases. Refer to figure 88. (Do not install intermediate gear bolt or safety-wire since the valve adjustment may make it necessary to lift intermediate gear.) Install the spacer and sleeve on crankshaft, after oiling both parts. Then install valve cam with mark on valve cam and mark on intermediate gear in perfect alinement.

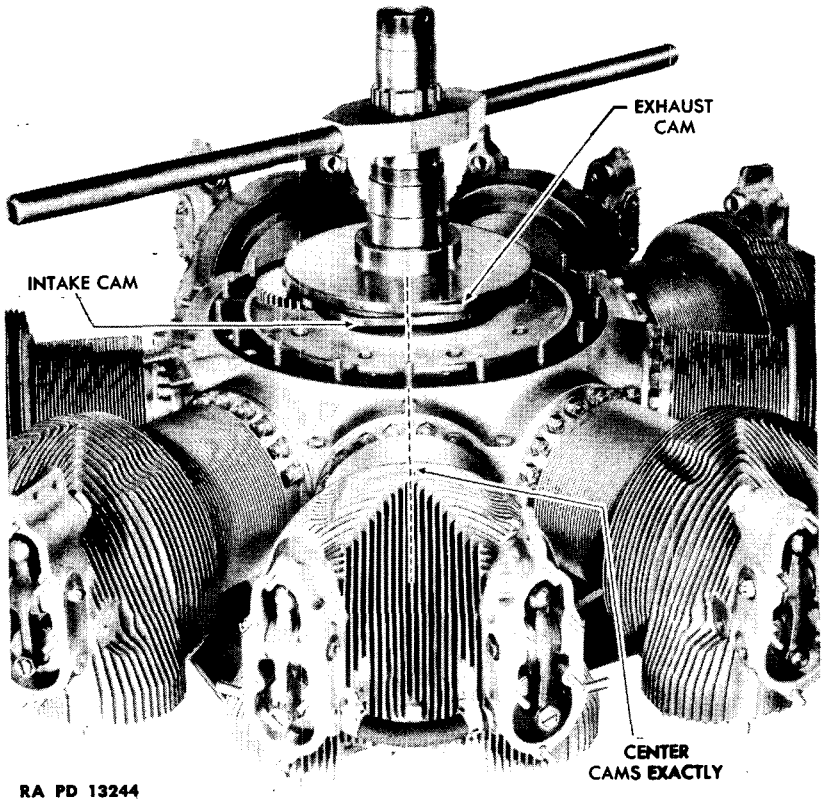
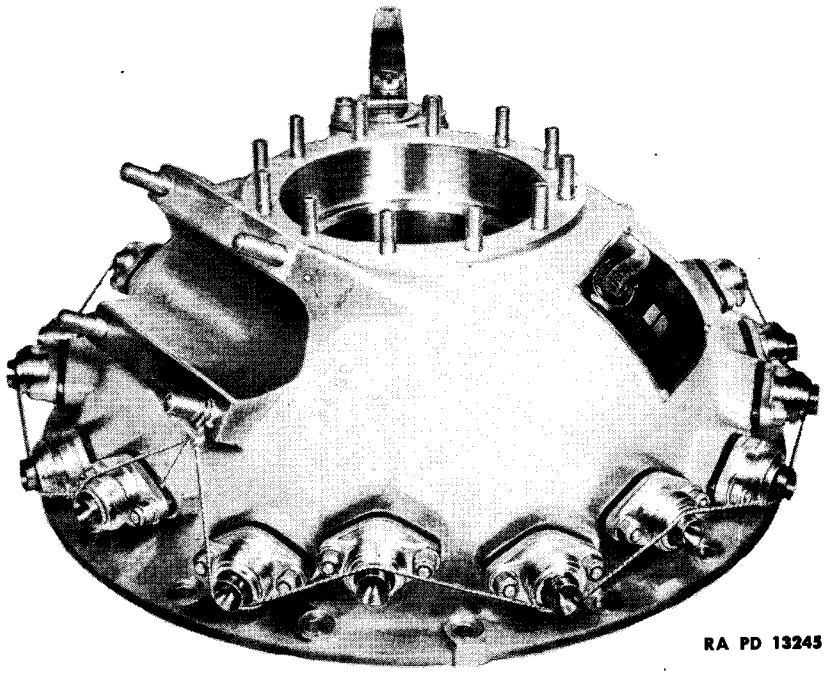


Figure 81—Centering the Valve Cam

b. Centering Valve Cam Intermediate Gear and Valve Cam When Not Marked. Install the valve cam intermediate gear in place on the crankcase front center section. (Do not install the nut or safety-wire the bolt, since the valve cam intermediate gear may have to be removed in timing the engine.) Install spacer and sleeve. Next, install the valve cam so that a line drawn through the center of No. 7 cylinder and the center crankcase stud of No. 7 cylinder will cross the valve cam at the exact center between two lobes of the cam. A lobe on the upper or exhaust cam should be at the right, and a lobe on the lower or intake cam at the left. It is very important that the exact center be reached. If the center point cannot be lined up by moving the valve cam alone, the intermediate gear will also have to be turned. Shift the intermediate gear until the two lobes of the valve cam can be as nearly exactly centered as possible at No. 7 cylinder.



RA PD 13245

Figure 82—Crankcase Front Section with Tappets Tied

112. INSTALL THE CRANKCASE FRONT SECTION (fig. 82).

a. Equipment.

Hammer, soft	Wrench, socket, 7/16-in.
Twine	Wrench, socket, 9/16-in.

b. Procedure. Insert tappet guide in front section with oil slot in line with hole in case. (Note that 10 of the guides are drilled on each side of the mounting flange for oil relief back into the case. Place these in

Nos. 1-2-3-9-8-cylinders.) Then install the rest. Use proper gasket on top of tappet guide flange and then mount guide adapter, holding in place with flat washer and elastic stop nuts. (NOTE: Adapters are marked intake and exhaust; intake go on lower level away from nose, exhaust at upper level.) Tie out all tappets (fig. 82).

c. NOTE: It is advisable to tie the tappets with twine to hold them "out" while installing the crankcase front section as shown in figure 82. Since the section will be removed later, no gasket is necessary at this time. Also, the spacer, bearing, gland and nut are not installed at this time. Place the crankcase over the crankshaft and down on the crankcase studs, with the steady rest tube at No. 5 and No. 6 cylinders. Bolt the crankcase front section down in four places, using flat washers and plain nuts (9/16-in. socket wrench).

113. INSTALL THE PUSH RODS AND HOUSINGS (fig. 19).

a. Equipment.

Remover, push rod, GU-GST-1545
Wrench, push rod housing nut, GU-GST-1306

b. Procedure. NOTE: It is permissible to leave the push rod housings off at this time, since the push rods and housings must be removed later, after timing the engine. Push rods and housings can be installed together, as is done in the following procedure. NOTE: The push rods and housings are interchangeable for both intake and exhaust, and for all cylinders. Oiling of the push rods, installation of the gaskets and inspection of the push rod housing nut packing can be done at time of final installation, if desired. With a push rod in the housing, install the housing with the smooth end of the housing at the rocker box and the flanged end over the valve tappet. Use the push rod remover to compress the valve spring, as shown in figure 19, to allow the push rod and housing to be installed. Tighten the push rod housing nut enough to hold the housing in place, using the push rod housing nut wrench. NOTE: A push rod and housing cannot be installed when a tappet is on the high point of a valve cam lobe, because the tappet will project too far beyond the crankcase. Install the push rods and housings at the cylinders where the tappet is not resting on the high point of the cam. Then turn the crankshaft so that the other tappets are in the same position in relation to the lobes for installation of the push rods.

114. VALVE TIMING THE ENGINE (figs. 83, 84, 85, 86, 87, 88, and 89).

a. Equipment.

Disk, timing, GU-GST-1524
Gage, feeler
Holder, top center indicator, GU-GST-1326
Indicator, dial
Pointer, timing, GU-GST-1523
Scale, 6-in.
Turner, crankshaft, GU-GST-1502
Wrench, valve adjusting, GU-GST-1444

b. Procedure.

(1) LOCATING TOP CENTER FOR NO. 7 PISTON.

Disk, timing, GU-GST-1524
Holder, top center indicator, GU-GST-1526
Indicator, dial
Pointer, timing, GU-GST-1523
Turner, crankshaft, GU-GST-1502

(a) Install the timing disk GU-GST-1524 (with the zero marks on the disk at the top and bottom) and the timing pointer GU-GST-1523 on the front crankshaft with the pointer centered on the wide spline of the crankshaft. Install the top center indicator holder GU-GST-1526 in the fuel injector opening in No. 7 cylinder, and with a dial indicator in place. Be sure the rod is in line with the cylinder, and not diagonal. Place the crankshaft turner GU-GST-1502 on the front crankshaft. NOTE: Timing operations are always performed on master rod cylinder.

(b) The next step is to adjust the timing pointer until it points exactly to 60 degrees on the timing disk, with the master rod piston exactly at top center. NOTE: Objective of this operation is to locate the exact top center of the master rod piston in relation to pointer and timing disk.

1 To perform this operation correctly, turn the crankshaft until the wide spline on the crankshaft is opposite the master rod cylinder. Set the dial indicator at zero. (See position No. 1, fig. 83.) (At this time the dial indicator holder plunger will not be in contact with piston.)

2 Then, with the crankshaft turner, slowly turn the crankshaft counterclockwise until 0.020-inch reading is secured on dial indicator. (NOTE: See position No. 2, fig. 83.)

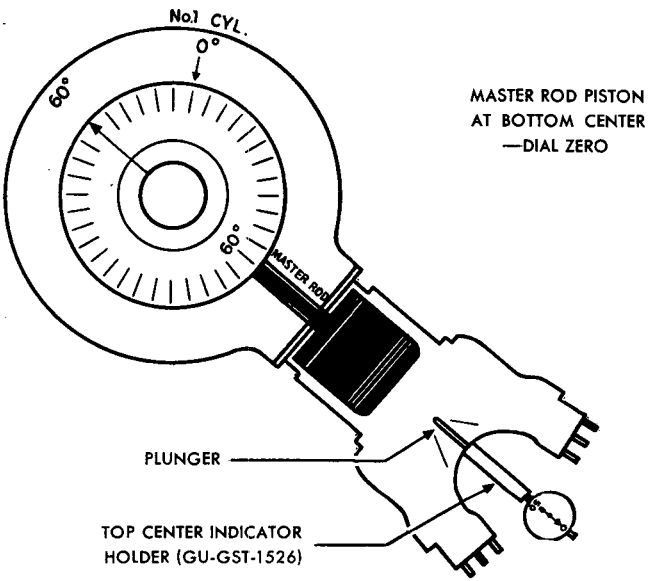
3 Note the reading on the timing disk at this point, marking down the number of degrees the pointer is from the 60-degree mark in line with, and near, the master rod cylinder.

4 Then turn crankshaft clockwise (NOTE: See position No. 3, fig. 83), until the dial indicator again reads 0.020 inch. Note the reading at this point on the timing disk, marking down the number of degrees the pointer is from the 60-degree mark at the master rod cylinder. (See position No. 4, fig. 83.) If the reading is not the same as that taken counterclockwise, divide the difference by two, and move the pointer the number of degrees found as a result of this division, to the low reading side. This should result in proper correction for pointer, but always recheck by repeating above operation.

(c) If the pointer has been moved, recheck correct pointer setting by performing operations outlined in figure 83, from position No. 1 through position No. 4. If the readings now balance on each side of the 60-degree mark, the pointer is correctly set.

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

POSITION NO. 1



POSITION NO. 2

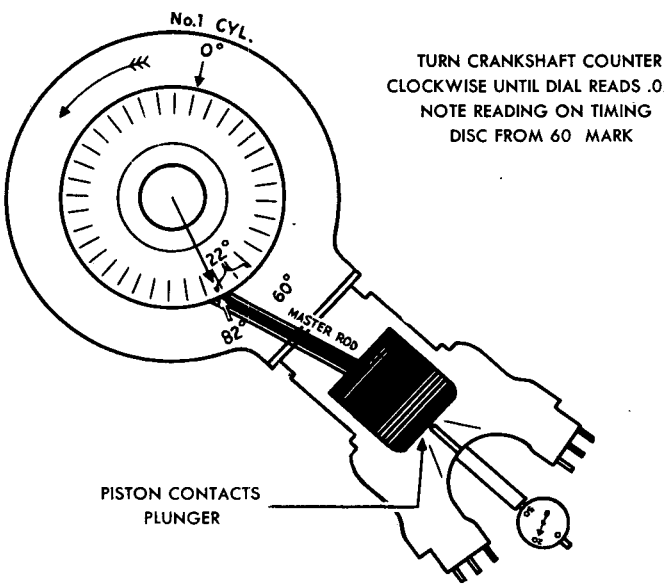


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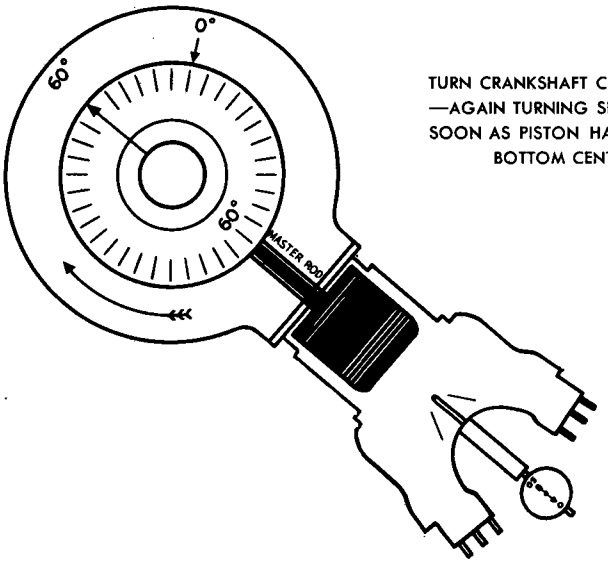
Figure 83—Locating Top Center for No. 7 Piston

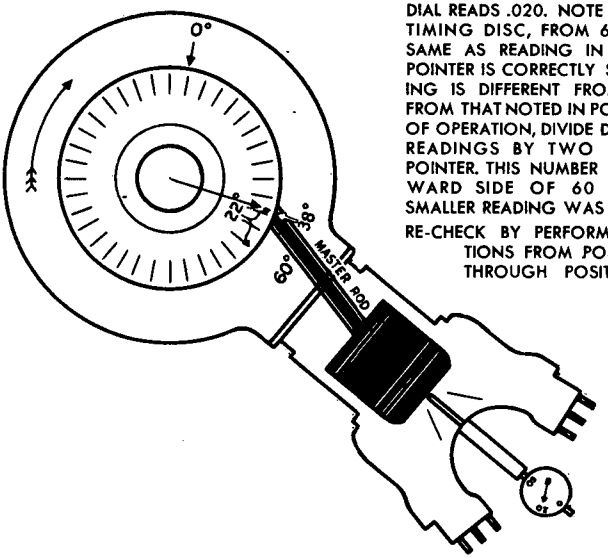
ASSEMBLY OF ENGINE

POSITION NO. 3



TURN CRANKSHAFT CLOCKWISE —AGAIN TURNING SLOWLY AS SOON AS PISTON HAS PASSED BOTTOM CENTER

POSITION NO. 4



TURN CRANKSHAFT CLOCKWISE UNTIL DIAL READS .020. NOTE READING ON TIMING DISC, FROM 60 MARK. IF SAME AS READING IN POSITION 2, POINTER IS CORRECTLY SET. IF READING IS DIFFERENT FROM 60 MARK FROM THAT NOTED IN POSITION NO. 2 OF OPERATION, DIVIDE DIFFERENCE OF READINGS BY TWO AND MOVE POINTER. THIS NUMBER DEGREES TOWARD SIDE OF 60 MARK THAT SMALLER READING WAS SECURED.

RE-CHECK BY PERFORMING OPERATIONS FROM POSITION NO. 1 THROUGH POSITION NO. 4.

RA PD 13246A

Figure 83A—Locating Top Center for No. 7 Piston (Nomenclature)

(d) Turn the crankshaft until the pointer is on the 60-degree mark at the master rod cylinder. The master rod piston is now at top center.

(2) ADJUST EXHAUST AND INTAKE TAPPETS ON MASTER ROD CYLINDER TO 0.085 INCH.

Gage, feeler Wrench, valve adjusting, GU-GST-1444
Turner, crankshaft, GU-GST-1502

Be sure that the engine is not on decompression, and be sure to loosen all adjusting screws. Turn the crankshaft by means of the crankshaft turner, watching the exhaust valve rocker of the master rod cylinder. If the rocker moves, the piston is on the exhaust stroke. Continue turning the crankshaft until both the exhaust and intake rocker arms are free with the wide spline of the crankshaft toward the master rod cylinder. The piston is now at the top of the compression stroke. The next step is to adjust the exhaust and intake rocker adjusting screw on master rod cylinder, using a 0.085-inch feeler gage. Be sure that the feeler gage is between the adjusting screw and valve stem and is not resting on the upper valve spring washer. NOTE: It is important that both rockers be adjusted as nearly identically as possible. Use the valve adjusting wrench to adjust the valve clearance.

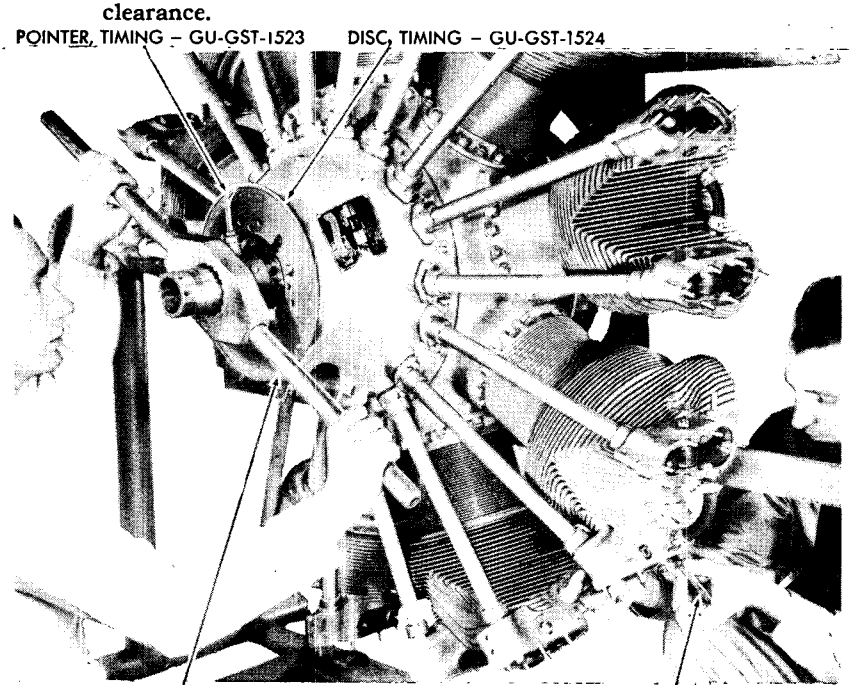


Figure 84—Checking Exhaust Valve Opening

(3) CHECK VALVE OPENING.

Gage, feeler — Turner, crankshaft, GU-GST-1502

(a) Place the fingers on the push rod end of the exhaust valve rocker to press the oil out from under the end of the push rod. Insert a 0.002-inch feeler gage under the adjusting screw. Turn the crankshaft turner in the direction of rotation, or counterclockwise, until a drag is noticed on the feeler gage. Be sure to pull the feeler gage straight back and do not bend it upward. This indicates that the exhaust valve is just starting to open, which will be "before bottom center" as indicated by pointer on timing disk.

(b) Now hold the hand in the same position on the intake valve with a 0.002-inch feeler gage under the intake valve adjusting screw, and continue the crankshaft rotation. When the feeler gage starts to drag, the intake valve is beginning to open. Make a notation of the reading on the timing disk, which is **"before top center."**

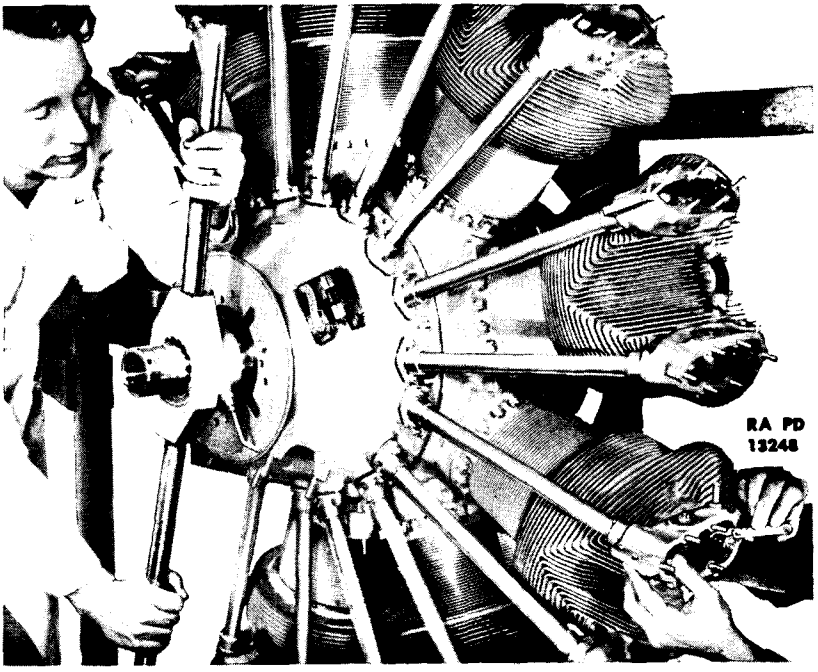


Figure 85—Checking Intake Valve Opening

(c) To obtain the reading of the exhaust valve closing after "top dead center," place the fingers on the exhaust rocker and with the feeler gage under the exhaust valve adjusting screw, continue the counterclockwise crankshaft rotation until there

is a drag on the feeler gage. NOTE: The object of this procedure is to get the intake valve to open the same number of degrees "before top center" that the exhaust valve closes "after top center." Note the difference between the two readings obtained. If these two figures do not balance, the engine is not properly timed. The valve cam was not exactly centered in the procedure outlined in paragraph 111.

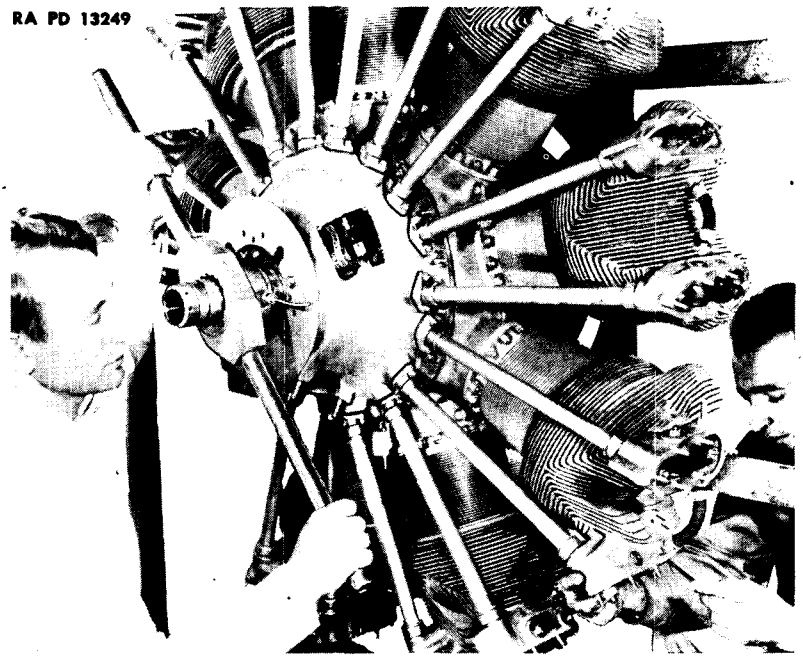


Figure 86—Checking Exhaust Valve Closing

(4) CORRECT THE TIMING. NOTE: It will be necessary to remove the push rods and front crankcase, and to turn the valve cam and valve cam intermediate gear to correct the timing. A computation of the number of degrees which the valve cam and valve cam intermediate gears must be moved to secure correct timing will permit securing the correct timing in the next procedure. If guesswork is depended upon to move the gears the correct amount, the whole procedure, involving removal and installation of the crankcase front section and push rods, may have to be gone through many times to secure correct timing.

(a) The amount of the valve timing error to be corrected is one-half the *difference* between the number of degrees of the intake valve opening before top center and the exhaust valve

ASSEMBLY OF ENGINE

MARK A TOOTH ON THE LARGE INTERMEDIATE GEAR, COUNT THE NECESSARY NUMBER OF TEETH IN EITHER DIRECTION AND MARK THAT TOOTH, AND THE CRANKCASE IN FRONT OF IT. RAISE THE VALVE CAM AND INTERMEDIATE GEARS, AND TURN UNTIL THE FIRST TOOTH MARKED IS AT THE MARK ON THE CRANKCASE.

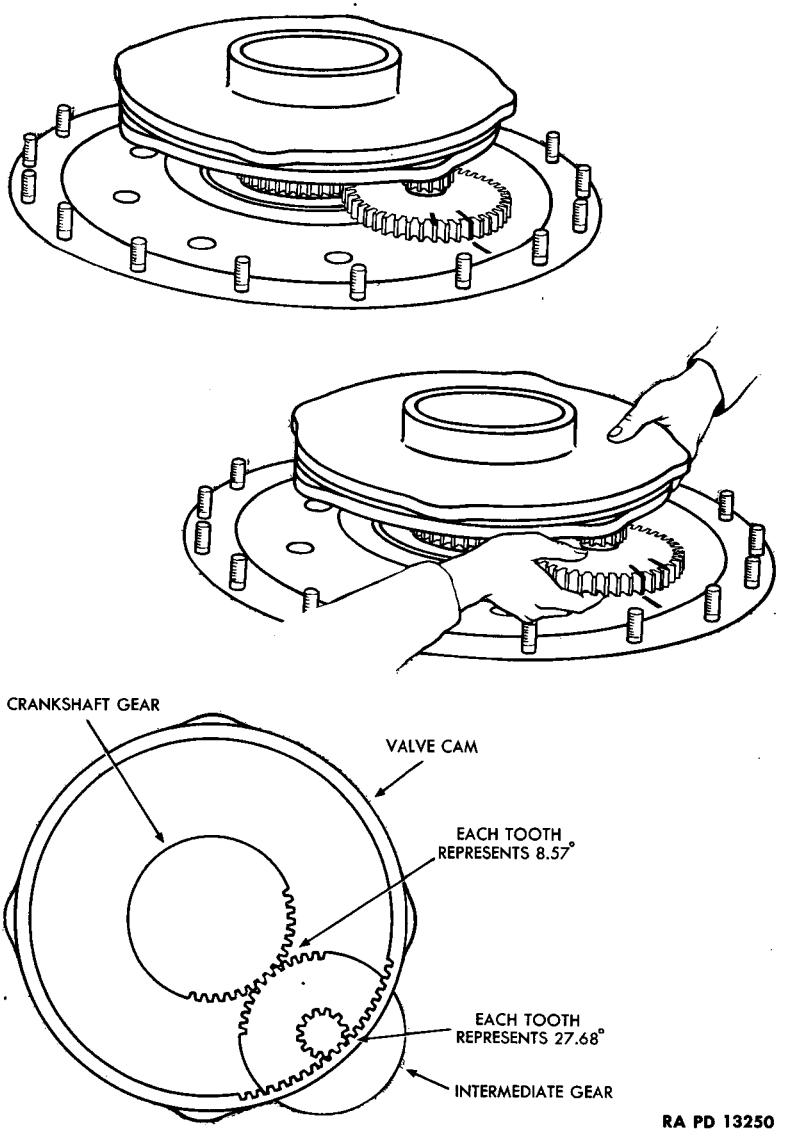


Figure 87—Calculating the Degrees to Correct Valve Timing

closing after top center. Clockwise rotation of either the valve cam or the large gear on the valve cam intermediate gear, or both, advances valve timing. Counterclockwise rotation of either the valve cam or the large gear on the valve cam intermediate gear, or both, retards valve timing.

(b) There are 13 teeth on the small gear of the valve cam intermediate gear. Since the full circumference of the gear is 360 degrees, then each tooth represents approximately 27.68 degrees. There are 42 teeth on the large gear of the valve cam intermediate gear, therefore each tooth represents approximately 8.57 degrees. Therefore, changing the valve cam gear one tooth will advance or retard timing 27.68 degrees, depending upon the direction of rotation. Changing the large gear one tooth will advance or retard timing 8.57 degrees. These figures are too large to exactly split the number of degrees difference between the intake valve opening and the exhaust valve closing in most cases. However, computations in multiples of these figures can be used to enable timing corrections.

(c) For example, if the large gear of the intermediate gear is turned three teeth clockwise in relation to the crankshaft gear, timing has been advanced 25.71 degrees. If the valve cam

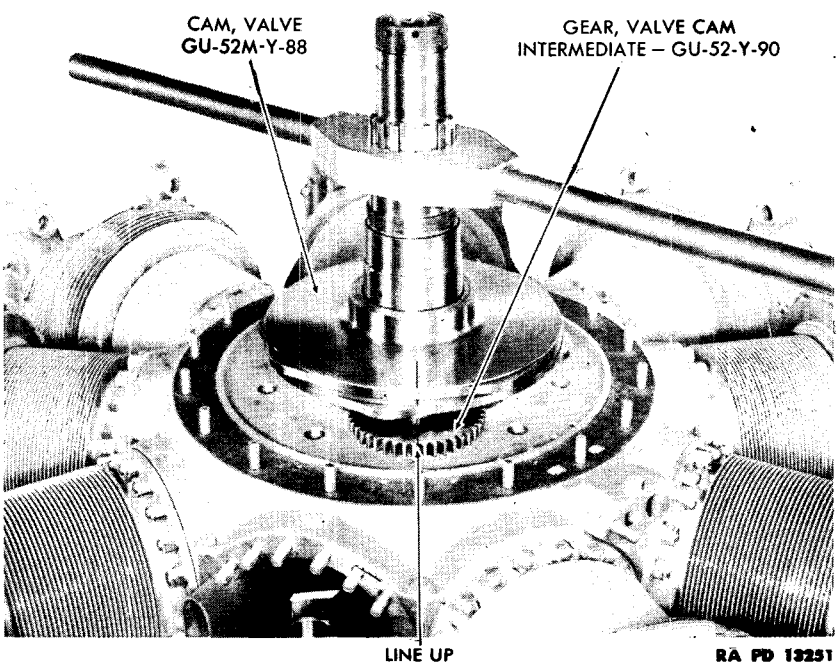


Figure 88—Marking Gears for Valve Timing Correction

is moved one tooth counterclockwise in relation to the small gear of the valve cam intermediate gear, timing will be retarded 27.68 degrees. The total result of moving both gears in this way is a retardation of 1.97 degrees. Reversing the direction in which each gear is turned will advance the timing 1.97 degrees. This is a small enough multiple to correct the timing. A total error of three degrees, on the advance side only, is allowed. NOTE: Precaution must be observed to mark the gears before turning them, since the meshing of the gears cannot be seen. (Use pencil.)

(d) To turn the large intermediate gear in relation to the crankshaft gear, mark one of the exposed teeth. Count either way (depending upon the direction the gear is to be turned) the necessary number of teeth the gear must be turned, and mark that tooth. Mark the crankcase directly in front of that tooth. Insert the fingers under the valve cam and under the large intermediate gear, taking care to keep the small intermediate gear in mesh with the valve cam. Raise the two gears upward until the large intermediate gear is out of mesh with the crankshaft gear. Turn until the first tooth marked is at the mark on the crankcase, then set the intermediate gear back down on the spindle.

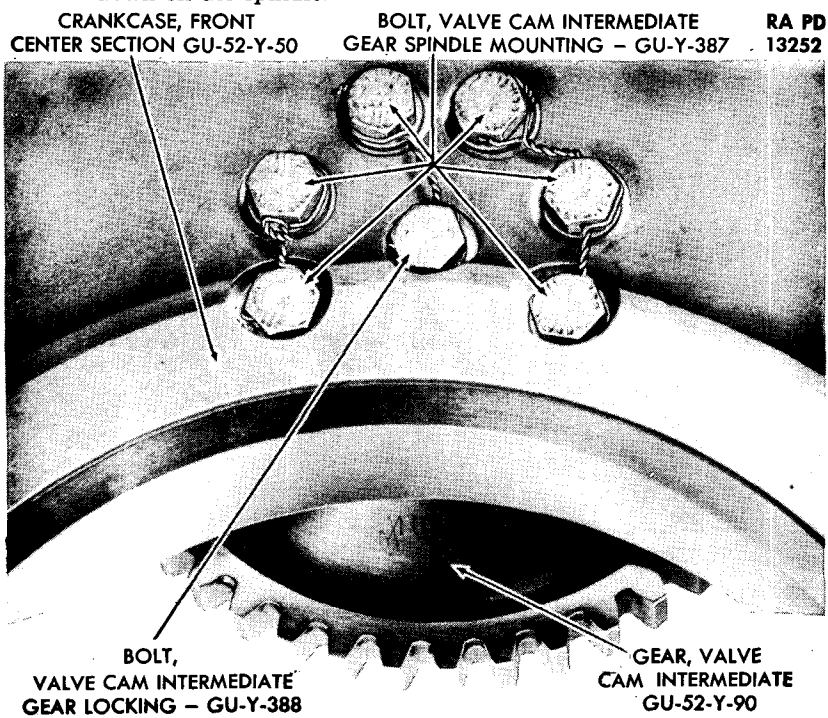


Figure 89—Intermediate Gear Bolts Safety-Wired

(e) The valve cam and large intermediate gear should also be marked before the valve cam is turned, to show the exact distance it is turned.

(f) When the gears have been turned to correct the timing, install the crankcase front section and push rods, and recheck the timing.

(5) COMPLETE THE TIMING OPERATION. When the engine is correctly timed, the crankcase front section and the push rods should again be removed; and the valve cam, intermediate gear and crankshaft gear should be marked (fig. 88) with electric pencil. Thus, during future assembly operations, these parts can be lined up and it will not be necessary to go through the timing procedure. Install the nut on the intermediate gear locking bolt GU-Y-388. Safety-wire the intermediate gear bolt, wiring it (fig. 89) through the cylinder barrel opening of No. 4 cylinder. Then remove the 0.040 to 0.050-inch shim which was placed between the rear of the crankshaft and the bearing liner. Replace the piston and cylinder barrel at No. 4 cylinder opening.

115. INSTALL THE CRANKCASE FRONT SECTION (figs. 90 and 82).

a. Equipment.

Screwdriver — Wrench, open-end, 9/16-in.
Twine

b. Procedure.

(1) INSTALL DECOMPRESSION PLATE AND LOCK RING. Install the decompression plate and lock ring in the crankcase front section.

(2) INSTALL FRONT BEARING SEAL RING SPACER.

Screwdriver

With the crankcase front section face down, install the front bearing seal ring spacer GU-53-Y-12 in the collar of the front crankcase.

(3) INSTALL CRANKCASE FRONT SECTION.

Twine — Wrench, open-end, 9/16-in.

Tie the tappets with twine (fig. 82) to hold them out while installing the crankcase front section. Install a new gasket on the studs of the crankcase front center section, being sure that the oil openings in the gasket line up with those in the crankcase. Place the crankcase front section over the crankshaft and down over the crankcase studs, with the steady rest clamp at No. 5 and No. 6 cylinders. Bolt the crankcase front section down, using flat washers, nuts and palnuts.

ASSEMBLY OF ENGINE

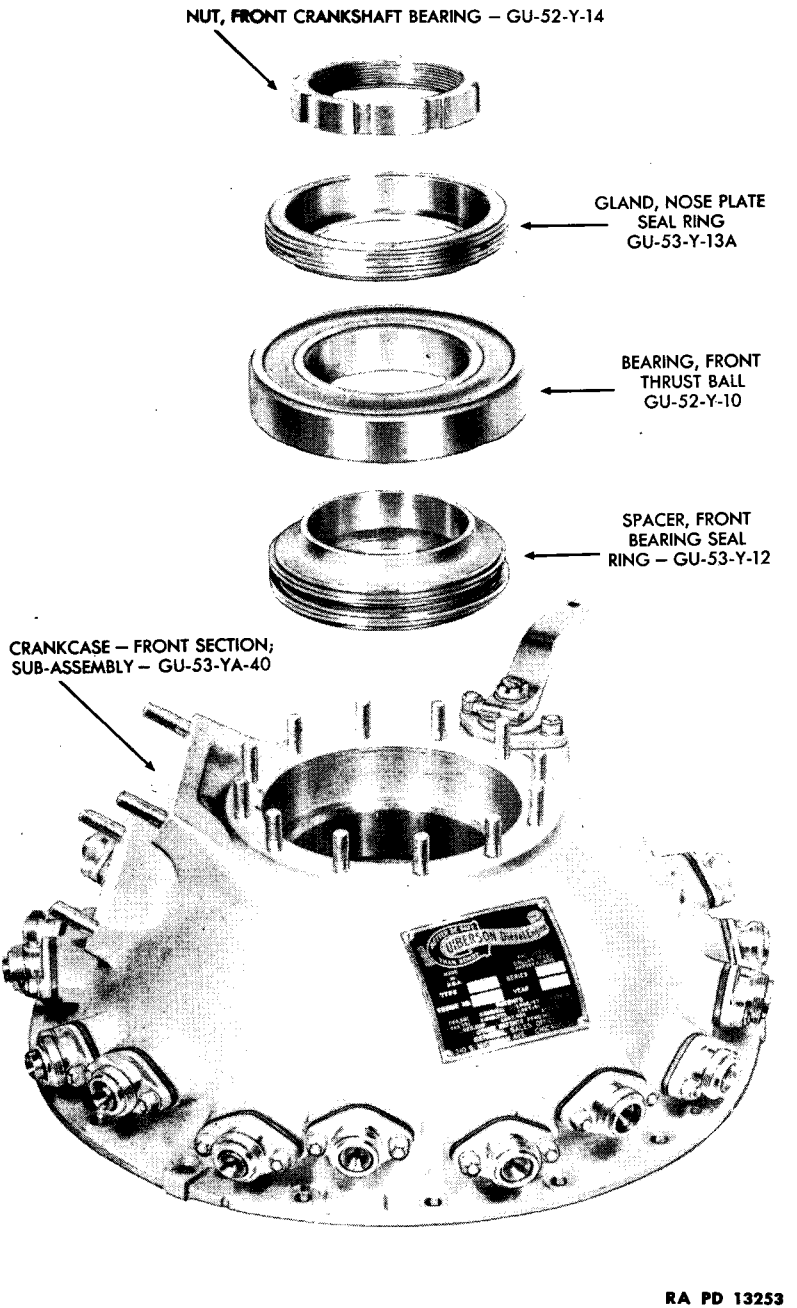


Figure 90—Crankcase Front Section Assembly

116. INSTALL FRONT THRUST BALL BEARING (fig. 90).

a. Equipment.

Driver, front crankshaft bearing, GU-GST-1521
Oil, engine, SAE 50

b. Procedure. Oil the front thrust ball bearing GU-52-Y-10 with OIL, engine, SAE, No. 50. Then install the bearing on the crankshaft with the open side of the bearing towards the engine. Drive it into position with the front crankshaft bearing driver.

117. INSTALL FRONT BEARING PLATES (fig. 91).

a. Equipment.

Micrometer, depth
Wrench, socket, 9/16-in.

b. Procedure. The front bearing plate goes over the studs around the crankshaft, and must put a pinch of from 0.002 to 0.009 inch on the bearing race. Before mounting front bearing plates, use a depth micrometer to measure the distance from the crankcase to the bearing race, and the flange depth on the front bearing plate GU-52-Y-42, as shown in figure 91. These two dimensions should total from 0.024 to 0.031 inch. Since the gasket will compress to 0.022 inch, this clearance will give the right amount of pinch. If the clearance is too

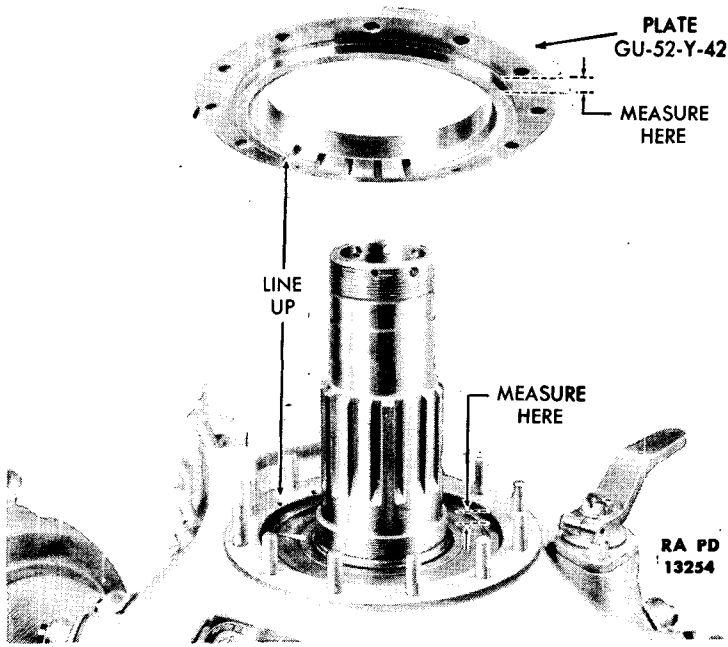


Figure 91—Installing the Front Plate

great, grind down the flange of the front bearing plate to give this clearance. When a clearance of 0.024 to 0.031 inch is obtained, place a new gasket over the studs, being sure that the cutaway of the gasket is in line with the slots in the plate, and with the oil openings in the crankcase front section near the steady rest clamp. Install the nose plate seal ring gland GU-53-Y-13A within the plate. Then install the plate on the studs, placing washers over the studs and install the nuts (9/16-in. socket wrench) to hold the plate in position.

118. INSTALL FRONT CRANKSHAFT BEARING NUT (fig. 90).

a. Equipment.

Hammer, 2-lb. Wrench, front bearing nut, GU-GST-1503
Turner, crankshaft, GU-GST-1502

b. Procedure. While holding the crankshaft with the crankshaft turner, install the front crankshaft bearing nut GU-52-Y-14, using the front bearing nut wrench GU-GST-1503 to tighten it. This nut is turned as tight as possible.

119. INSTALL THE PUSH RODS AND HOUSINGS (figs. 18, 19, and 57).

a. Equipment.

Remover, push rod, GU-GST-1545
Wrench, push rod housing nut, GU-GST-1306

b. Procedure. NOTE: The circular nut at each end of the push rod housing has a packing inside. Examine the condition of this packing, and if it is not in good condition, replace it. Always install new seals between adapter and push rod housing. The push rods and housings are interchangeable for both intake and exhaust, and for all cylinders. Notice the arrow in the end of the push rod. This end goes in toward the crankcase. The rod is drilled to carry oil to the rocker arm. In the arrow end of the rod, a check valve is used which permits oil to go through the rod to the rocker arm, but will not let it return. Thus the push rod is always full of oil. Before installing the push rods, insert an oil can nipple into the oil passage at the arrow end and fill with oil until it comes out the other end. Then insert the arrow end of the rod into the push rod housing so that the arrow will be at the flanged end of the housing. Place the rubber seal over the shoulder of the valve tappet drive adapter, being sure that it is in position and properly lined up. The smooth end of the tubing is inserted at the rocker box and the flanged end is placed over the valve tappet adapter. Use the push rod remover GU-GST-1545 to compress the valve spring, and install the push rod and housing (fig. 19). Tighten the circular nuts, using the push rod housing nut wrench GU-GST-1306 provided for that purpose (also used in

removing these nuts) (figs. 18 and 19). NOTE: A push rod housing cannot be installed when a tappet is on the high point of the cam lobe, because the tappet will project too far beyond the crankcase. Install the push rod housing at the cylinder where the tappet is not resting on the high point of the cam, tightening the housing nut after each installation. Then turn the crankshaft to install the others. (Turn crankshaft until piston is past top center so that valves will not hit top of piston.)

120. ADJUST TAPPETS FOR RUNNING CLEARANCE (fig. 92).

a. Equipment.

Gage, feeler
Wrench, valve adjusting, GU-GST-1444
Turner, crankshaft, GU-GST-1502

b. Procedure. Turn the crankshaft until piston is on top center of compression stroke at No. 1 cylinder. Use a 0.020-inch feeler gage to measure the clearance, and turn the adjusting screw with the valve adjusting wrench GU-GST-1444 to get this clearance. Be sure that the engine is not on decompression while adjusting the valves. Repeat this at the other cylinders, following their firing order rotation, which is 1-3-5-7-9-2-4-6-8. The piston must be at top center on the compression stroke as the valves are adjusted at each cylinder.

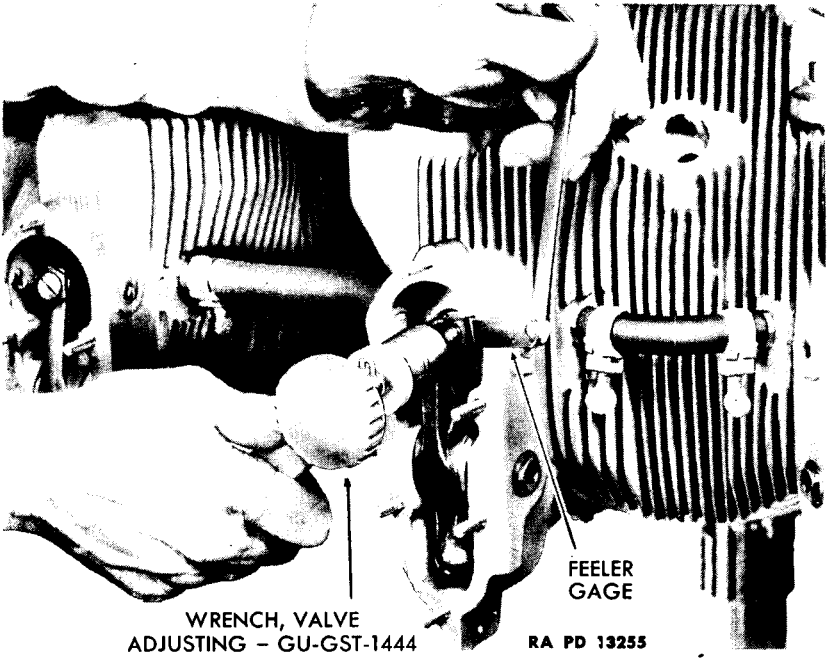


Figure 92—Adjusting the Valve Tappets

ASSEMBLY OF ENGINE

121. INSTALL INTERROCKER BOX AND INTERCYLINDER DRAIN HOSES.

a. Equipment.

Pliers

b. Procedure. Install the interrocker box and intercylinder drain hoses and clamp on the brass fittings, renewing where necessary. Tighten the clamps.

122. INSTALL THE FUEL CONTROL ASSEMBLIES (figs. 27 and 70).

a. Equipment.

Pliers — Wrench, socket, ½-in.
Wrench, fuel cam mounting plate lock nut, GU-GST-1551

b. Procedure.

(1) INSTALL FUEL CAM AND FUEL CONTROL LEVER MOUNTING PLATES.

Pliers — Wrench, socket, ½-in.

Place the fuel cam mounting plate in position on the studs in the rear crankcase, and install a spacer, washer and nut on every other stud (½-in. socket wrench). Slide the fuel control lever mounting plate over the fuel cam mounting plate, with the throttle segment at the top. Install the lock ring, with the large holes in the ring over the nuts and spacers on the fuel cam mounting plate which were previously installed. Secure it in place with four nuts and with a flat washer under the nuts (½-in. socket wrench). Safety-wire the nuts in pairs.

(2) ASSEMBLY FUEL CAM DRIVE GEAR AND FUEL CAM RING.
Wrench, socket, ½-in.

If the fuel cam drive gear and fuel cam ring have been disassembled, place the fuel cam drive gear with the gear side down. Insert the adjusting eccentric into the round opening. Place the fuel cam ring over the gear with the head of the eccentric in the large opening, and install the six bolts. Hold the bolts in place while turning the assembly on its side. Install a flat washer on each bolt, and a lock washer over the flat washer, with the prongs in the slots in the fuel cam drive gear plate. Install the nuts on the bolts, but do not tighten them.

(3) ADJUST FUEL CAM DRIVE GEAR.
Wrench, socket, ½-in.

Adjust the fuel cam drive gear so that the nut under the graduation marks is centered under the marks. Tighten this nut to hold the gear in place and draw the other nuts up snug. The eccentric may have to be turned during the fuel timing operation. Tightening only the one nut at this time will save loosening the others during the fuel timing procedure.

(4) INSTALL FUEL RING AND FUEL CAM DRIVE GEAR.
Pliers
Wrench, fuel cam mounting plate lock nut, GU-GST-1551

Oil the hub of the fuel cam mounting plate, and the bushing in the fuel cam drive gear. Slide the fuel ring and fuel cam drive gear on the hub of the plate, with the gear side out, so that the throttle stop bracket is engaged with the throttle stop. Install the spacer with the bevel side out, and then install the lock nut, using the special lock nut wrench GU-GST-1551. Insert a ⅛-inch cotter key through the lock nut and hub from the inside. Cut it short and bend the ends with pliers so that none protrudes beyond the surface of the lock nut. None of the head of the cotter pin should protrude beyond the taper of the crankshaft. The fuel cam drive gear should be adjusted so that the graduation marks are at No. 1 cylinder.

123. INSTALL THE STARTER SHAFT ASSEMBLY (fig. 93).

a. Equipment.
Hammer, soft
Straightedge

b. Procedure. Before the starter shaft is installed, insert the jaw into the accessory case, pushing it in as far as it will go. Lay a straight-

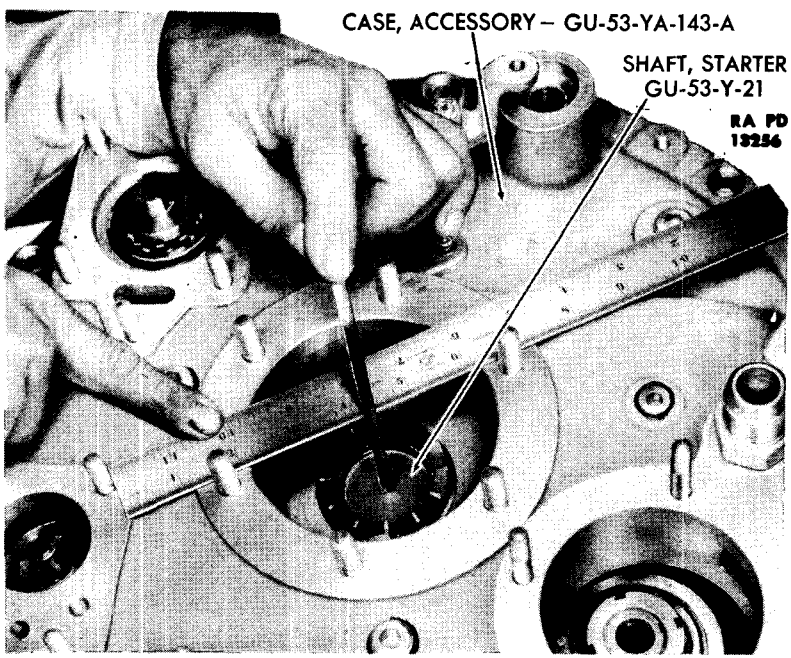


Figure 93—Measuring Starter Shaft Clearance

edge across the opening and measure the distance to the starter jaw (fig. 93). Note the dimension for reference. Insert the splined end of the starter shaft through the hub of the plate, being sure the spacer is on the splined end of the shaft. Drive the shaft in place with a soft hammer.

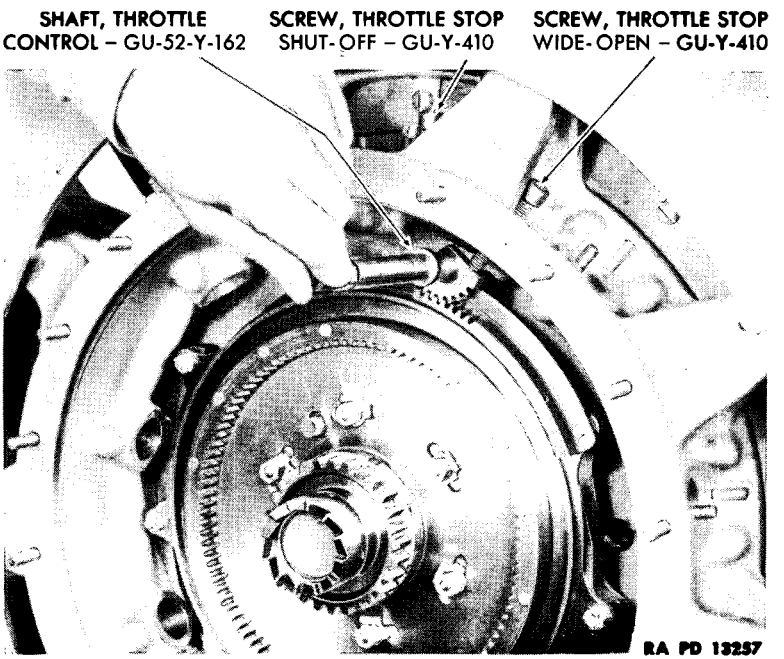


Figure 94—Installing the Throttle Control Shaft

124. INSTALL THE THROTTLE CONTROL SHAFT (fig. 94).

NOTE: The throttle control shaft GU-52-Y-162 must be correctly located over the throttle segment, to assure full-throttle operation. Place the throttle shaft and gear segment, locating the throttle shaft gear on the fuel ring throttle gear so that the operation of the throttle shaft will turn the fuel ring the full distance from the throttle closed position to the throttle wide-open position as controlled by the throttle stop bracket. Place the throttle control shaft in position (fig. 94). The heavy part of the throttle gear at the left (from rear of engine) should extend beyond the segment, and the first tooth of the throttle gear should be directly above the heavy section of the segment. The throttle control shaft is held in position by two adjusting screws. These screws are welded to a strap to hold them in place. If the strap has been broken or removed, the screws will have to be reset. Turn down the throttle stop wide-open screw GU-Y-410 until the top of the screw is 1⅛ inches above the

surface of the crankcase. Do not turn down the screw on the left at this time.

125. INSTALL THE ACCESSORY CASE (figs. 94 and 95).

a. Equipment.

Wrench, socket, ½-in.

b. Procedure. Install a new gasket on the accessory case, being sure that the oil holes in the accessory case mounting gasket GU-14-Y-462 line up with those in the accessory case (fig. 95). Turn crankshaft counterclockwise until the pointer is at top center on the compression stroke. Turn the fuel cam and fuel cam drive gear until the eccentric and the lock nut with the calibrated marks are slightly to the right at the top. With one man holding the throttle shaft control in position (fig. 94), a second man slides the accessory case over the throttle shaft and onto the studs of the crankcase. Be sure that the throttle control shaft does not disengage with the segment gear during the procedure. Install two nuts with plain washers on the studs, drawing them up tight enough to hold the accessory case in position until the engine is fuel-timed. (NOTE: The gears in the accessory case must be engaged with the starter shaft gear and the fuel cam drive gear, before accessory case will go into position.)

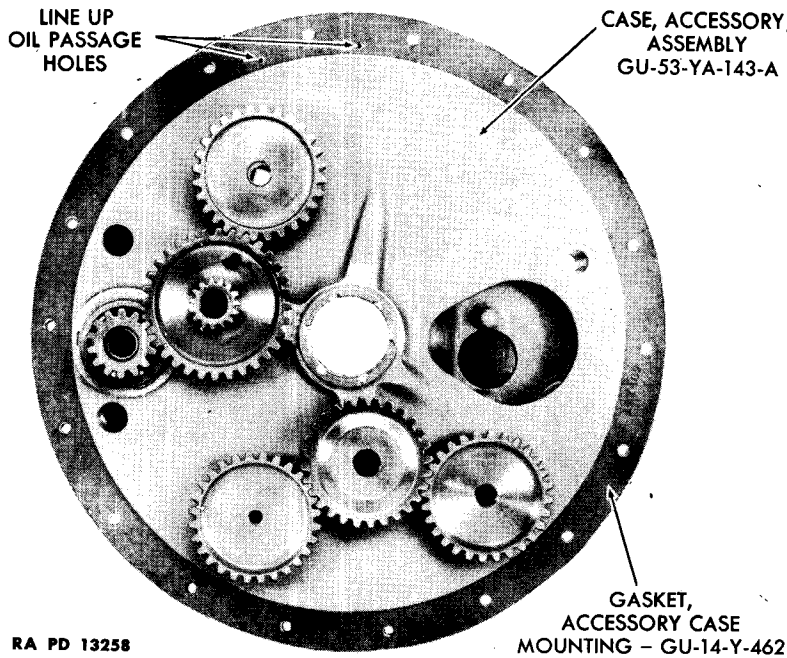


Figure 95—Line Up Oil Holes in Gasket and Accessory Case

ASSEMBLY OF ENGINE

126. REMOVE INSPECTION CAP.

a. Equipment.

Wrench, socket, 3/8-inch.

b. Procedure. Remove the elastic stop nuts and flat washers from the inspection cap on the accessory case, and lift off the cap.

127. INSTALL THE FUEL INJECTION PUMPS (fig. 96).

a. Equipment.

Puller, valve tappet guide and fuel pump, GU-GST-1365

Wrench, socket, 1/2-in.

b. Procedure. NOTE: The fuel injection pumps should be installed with the clamp bolt head toward the accessory case. Each fuel pump is numbered to indicate the cylinder to which it belongs. Be sure that there is a new rubber oil seal on the pump sleeve, and put some oil on the seal. Install a new gasket on the pump. Screw the adapter of the valve tappet guide and fuel pump puller GU-GST-1365 on the nipple of the fuel pump; then force the fuel pump into the crankcase by pushing on the tool so that the pump slides straight in. Do not use the hammer of the puller to strike it in or the rubber seal may be damaged. If the fuel injection pump does not move easily into position, remove it and examine the oil seal. If this is damaged it must be replaced. Replace the washers and nuts (1/2-in. socket wrench) but not the palnuts. CAUTION: The oil seal should be oiled and the fuel pumps installed one

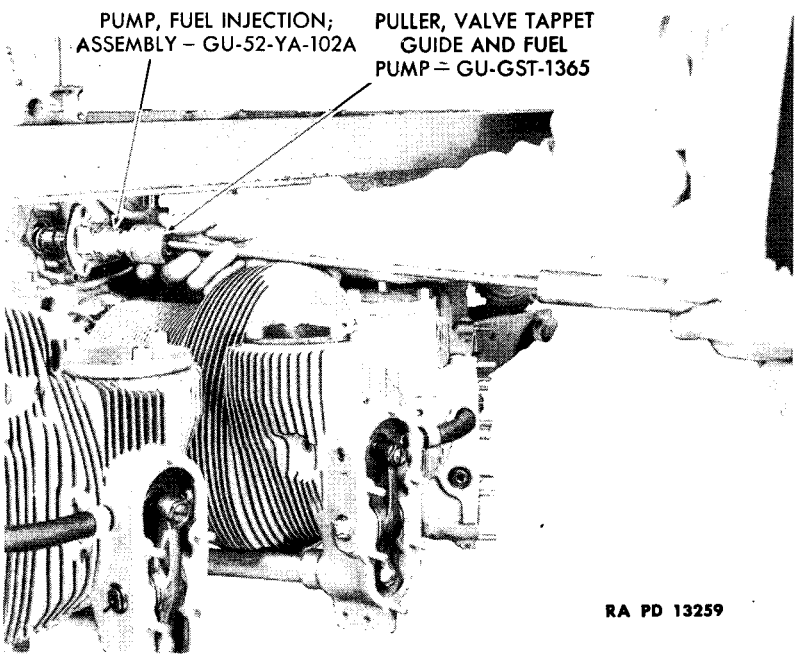


Figure 96—Installing Fuel Injection Pump

at a time. The oil causes the seal to swell, and unless it is inserted immediately, the seal will not pass through the opening.

128. INSTALL FUEL CHECK VALVE.

a. Equipment.

Wrench, open-end, 7/8-in.

b. Procedure. Install the fuel check valve in the opening at the bottom of the motor. Be sure that it is installed so that the ball check will allow the fuel to enter the engine but will not permit it to drain out. The position of the check can be determined by sucking or blowing in the check valve nipple.

129. TEST THE FUEL PUMPS.

When all of the fuel injection pumps have been installed, they should be tested for leaks. Plug the end of the fuel pressure regulator line. Attach a fuel supply hose to the check valve and allow fuel to enter. Leakage will be detected at the oil sump mounting drain holes. If the fuel comes out in quantity, remove the pumps and replace any defective rubber seals. Some fuel may dribble out. In that event, allow the fuel to remain until the rubber oil seals have had a chance to swell. If fuel still leaks, pull the injection pumps and replace any defective rubber oil seals. When all the injection pumps are tight, install the palnuts on the fuel injection pump mounting studs.

130. FUEL TIMING THE ENGINE (figs. 97 and 98).

a. Equipment.

Disk, timing, GU-GST-1524
Holder, fuel pump indicator, GU-GST-1525
Indicator, dial
Pointer, timing, GU-GST-1523
Turner, crankshaft, GU-GST-1502
Wrench, fuel pump adjusting, GU-GST-1419
Wrench, open-end, 7/8-in.
Wrench, socket, 3/8-in.
Wrench, socket, 1/2-in.
Wrench, timing, GU-GST-1302

b. Procedure.

(1) CHECKING THE START OF FUEL INJECTION. NOTE: The purpose of fuel timing is to have the injection of fuel to occur at the right time on the piston strokes. The fuel timing is done at No. 1 cylinder because this cylinder is most accessible.

(a) Remove the union (7/8-in. open-end wrench) on No. 1 cylinder fuel injection pump and remove the spring and check valve. Install the fuel pump indicator holder GU-GST-1525 with the dial indicator (fig. 97). Attach a fuel supply line to the fuel check valve at the bottom of the engine, so that fuel can be admitted to the engine; but do not turn on the fuel at this time.

(b) Turn the throttle shaft to wide-open position. (The fuel container should be higher than the engine so that fuel will flow

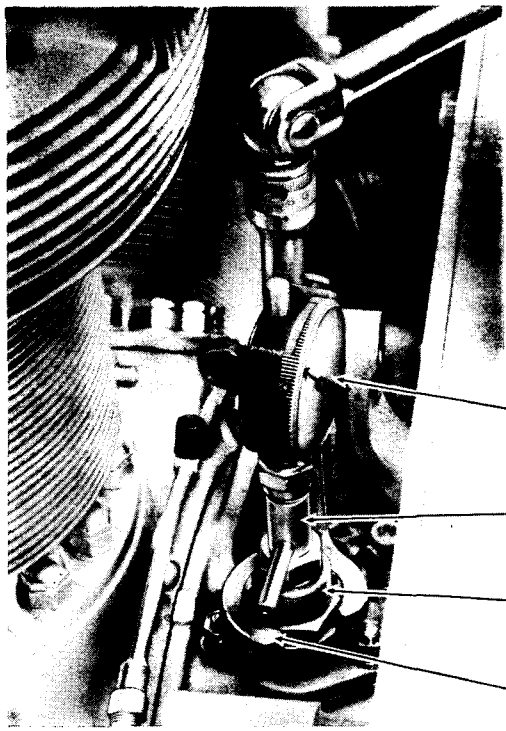


Figure 97—Fuel Timing the Engine

through the supply line to the check valve and fill the fuel channel by gravity flow.)

(c) Turn the throttle shaft to wide (turn to the left) open position, using a 9/16-inch wrench on the throttle shaft as a turner for the shaft.

(d) With the eccentric on the fuel cam and fuel drive gear located so that it can be seen slightly to the right of the inspection opening in the accessory case, turn the crankshaft slowly clockwise and counterclockwise on compression stroke until dial indicator hand reaches lowest point; then adjust dial face to zero at this point. Turn crankshaft counterclockwise on compression stroke until 0.070-inch reading registers on dial indicator. The pointer on the crankshaft should show 36 degrees before top center on the timing disk with the piston on compression stroke, with the dial indicator registering 0.070-inch.

(e) If the pointer does not register 36 degrees on the timing disk but registers within 12 degrees of this 36-degree mark, correction can be made by turning the adjusting eccentric on the fuel cam plate through the inspection opening. To do this, perform the following operations:

1 Wire ½-inch socket to socket handle so that socket will not be pulled from handle and fall into accessory case.

2 Turn crankshaft counterclockwise until first lock nut beyond lock nut with calibrated marks on fuel cam plate is in line with inspection opening. (Do not loosen calibrated lock nut at this time.) Loosen lock nut. Continue turning crankshaft counterclockwise, loosening lock nuts until all five unmarked nuts are loose. Then turn crankshaft counterclockwise again until eccentric and calibrated marked lock nut are in line with inspection opening. Loosen this lock nut slightly or enough so that slight bind is maintained on fuel cam plate and fuel cam.

3 If crankshaft is beyond compression stroke, turn crankshaft clockwise until pointer indicates 36 degrees on timing disk with piston on compression stroke.

4 With 7/16-inch socket wired to socket handle, turn eccentric slowly until 0.070-inch reading is registered on dial indicator.

5 With ½-inch socket wired to socket handle tighten lock nut that can be reached at this point, then turn crankshaft until all are in line with inspection opening and are tightened.

(f) Continue turning crankshaft counterclockwise until next compression stroke on No. 3 cylinder and check the next fuel cam lobe with 0.070-inch dial indicator reading, noting degree mark on timing disk that pointer indicates with dial indicator at 0.070-inch. Continue until all four lobes of fuel cam have been checked. The minimum degree reading should be 36 degrees and the maximum should be 38 degrees before top center on the compression stroke on No. 1 cylinder with the dial indicator registering 0.070 to 0.073-inch. If degree reading on any of four lobes is outside this limit, check lobes for dial indicator setting, returning to zero reading when cam is turned through lowest point on lobe. If lobes differ more than 0.003-inch at lowest point on dial indicator, fuel control lever roller should be rechecked; and if roller is concentric, it may be necessary to replace fuel cam. NOTE: If, when the hand on the dial indicator was at 0.070-inch in step (1) *(d)*, the pointer on the timing disk was more than 12 degrees from the 36-degree mark, the accessory case will have to be removed to make the correction. Remove the two nuts and washers, using a ½-inch socket wrench, and slide the accessory case back just far enough to disengage the gears. In removing the accessory case, keep the thumb on the throttle shaft to prevent it from coming out of position. Turn the crankshaft turner until the timing pointer is at 36-degree mark on the compression stroke, then reinstall the accessory case. A timing wrench GU-GST-1302 is used to move the oil pump gear to aid in installing the accessory case. Install two plain washers

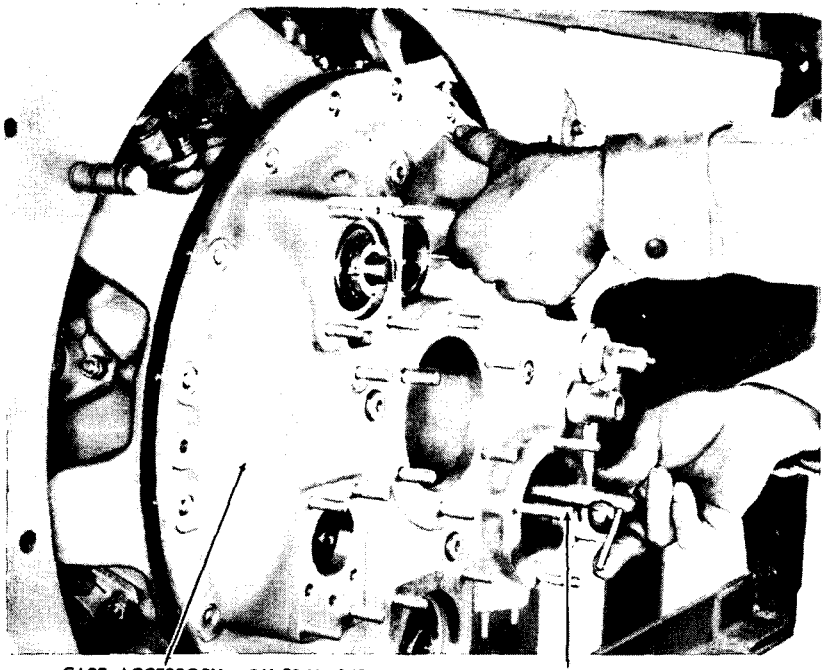


Figure 98—Installing the Accessory Case

and nuts to hold the accessory case in position. Then recheck to make sure that the dial indicator hand shows 0.070-inch reading, when the timing disk pointer is at the 36-degree mark. If it does not, the degree difference will be such that the fuel cam eccentric can be used to correct the timing as explained in steps (1) *(d)* through (1) *(f)*.

(g) When the preceding steps have been completed, allow fuel to enter through the fuel check valve. Plug the fuel opening at the left of No. 1 injection pump. With the timing pointer at the 36-degree mark, with the piston on the compression stroke and the dial indicator registering 0.070-inch, there should be a very slow dripping of fuel from the nipple of the fuel pump indicator holder. If there is too much, or too little, fuel flowing, adjustment is made by moving the fuel pump sleeve up or down. To do this, loosen the clamp bolt on the injection pump, and use fuel pump adjusting wrench GU-GST-1419 to turn the adjusting nut. If there is no fuel at the nipple of the fuel pump indicator holder, turn the nut counterclockwise until fuel drips slowly. If too much fuel is flowing, turn the adjusting nut clockwise until the flow is reduced to a slow drip. Reset dial indicator face to 0.070-inch reading after each adjustment of pump sleeve. The fuel timing is now adjusted to the start of injection. Re-

check fuel flow at nipple of dial indicator holder on other lobes of fuel cam, noting that fuel is dripping slowly on each compression stroke, with pointer at from 36 to 38 degrees before top center and dial indicator registering 0.070 to 0.073-inch. The injection pump port opening has now been set to 0.070 to 0.073-inch and the start of injection has been timed to occur at 36 to 38 degrees before top center at No. 1 cylinder on the compression stroke.

(h) When all the preceding steps have been completed, recheck to be sure that all lock nuts on fuel cam plate are tight. Install the inspection plate on the accessory case using a new gasket, flat washers and new elastic stop nuts. Remove the dial indicator and fuel pump indicator holder, after locking fuel injection pump clamp bolt. Replace the spring, check valve and union in the injection pump.

(2) INSTALLING THE ACCESSORY CASE.

Wrench, socket, ½-in.

Install the balance of the accessory nuts with plain washers and palnuts. There may not be sufficient clearance to install the nut under the oil inlet to the accessory case with the accessory case drawn up tight. Move the accessory case back far enough to install this nut.

(3) ADJUSTING THE OTHER FUEL PUMPS.

Indicator, dial
Holder, fuel pump indicator, GU-GST-1525
Turner, crankshaft, GU-GST-1502

Install the dial indicator and fuel pump indicator holder in the fuel injection pump at each cylinder (in turn). Turn the engine until the dial indicator shows an advance of 0.070-inch. Adjust the flow of fuel to a slow dripping at the nipple of the fuel pump indicator holder by moving the pump sleeve up or down, as covered previously in this section. Remove the timing disk and pointer. Remove the crankshaft turner.

131. INSTALL THE ROCKER BOX COVERS.

a. Equipment.

Wrench, socket, 7/16-in.

b. Procedure. Do not install the inner rocker box covers between No. 5 and No. 6 cylinders, which contain the scavenger sumps. Renew the gaskets, and install the covers of all other cylinders and install the flat washers and elastic stop nuts.

132. INSTALL THE FUEL INJECTORS.

a. Equipment.

Wrench, open-end, ½-in.

b. Procedure. The fuel injectors are numbered to show their proper cylinder. Be sure that a new gasket is at the nozzle end, and insert the nozzle in the injector opening with the nipples toward the accessory case. Install the flat washers, nuts and palnuts. Tighten the nuts alternately, using a torque wrench, applying from 13 to 15 foot-pounds of torque.

133. INSTALL THE OIL SUMP.

a. Equipment.

Wrench, open-end, 9/16-in.

b. Procedure. Install new gaskets on the oil sump studs between No. 5 and No. 6 cylinders and place the sump in position at the sump opening with the wide end of the sump toward the accessory case. Then secure the sump with washers, nuts and palnuts.

134. REPLACE THE SCAVENGER ROCKER BOX COVERS.

a. Equipment.

Wrench, socket, 7/16-in.

b. Procedure. Install the drain line on the brass nipples on the scavenger rocker box covers (if it was removed). The rocker boxes on No. 5 and No. 6 cylinders have special covers to hold the oil drained from the other rocker boxes through the scavenger connections. The scavenger pump gears in the oil pump pick up oil from these scavenger rocker box covers. Use new gaskets and install these covers on No. 5 and No. 6 rocker boxes, using washers and elastic stop nuts.

135. INSTALL THE BRACKETS FOR THE INTERCYLINDER BAFFLES.

a. Equipment.

Wrench, socket, 9/16-in.

b. Procedure. A bracket, which is held in place by the crankcase bolts and nuts, extends between the cylinders and reinforces the intercylinder baffles. Remove the nuts from the crankcase bolts one at a time. Then install a washer and place a bracket on each bolt, with the Dzus fastener angle of the bracket down. Then replace the nut.

136. INSTALL THE INTERCYLINDER BAFFLES (fig. 16).

a. Equipment.

Screwdriver

b. Procedure. Install the intercylinder baffles between the cylinders, clamping them to the brackets by means of the Dzus fasteners.

137. INSTALL THE COWLING (figs. 17 and 99).

a. Equipment.

Pliers
Screwdriver
Wrench, socket, 7/16-in.

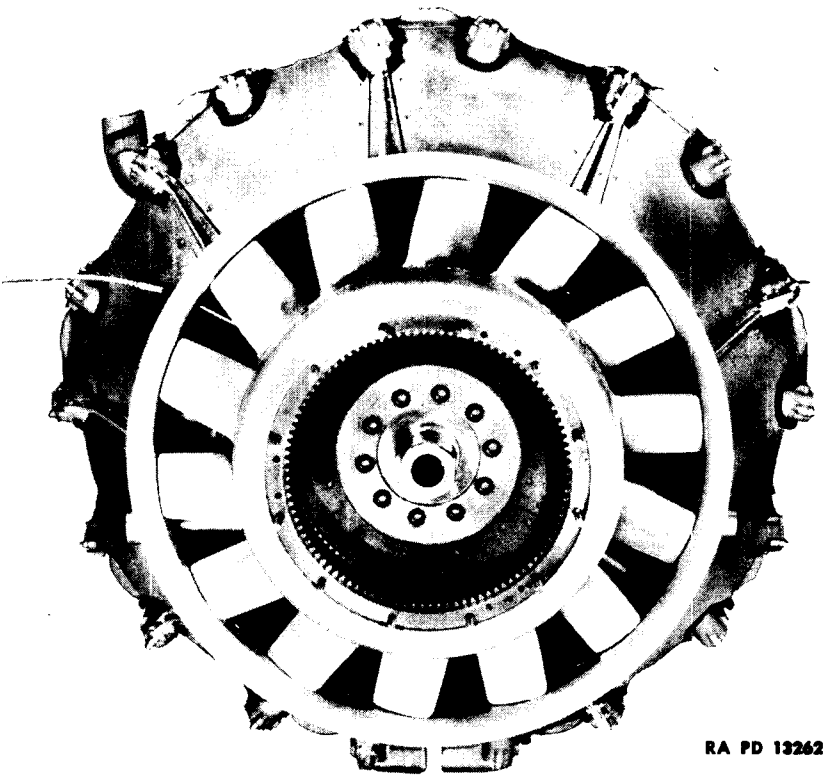


Figure 99—The Engine Cowling

b. Procedure.

(1) INSTALL COWLING RING.

Pliers — Wrench, socket, 7/16-in.

Turn the engine so that the front of the engine is facing upwards. Install the cowling ring with the flat side of the brackets bolted to the intake rocker box flanges, using a flat washer at both the nut and bolt head. One bracket is omitted to provide passage for the steady rest tube. Center the ring around the front crankshaft before the nuts are tightened. The ring may be shifted slightly to center it. Safety-wire the nuts together at each bracket. Be sure the bolts which attach the brackets to the ring do not project through the ring, or the flywheel might strike against them.

(2) INSTALL COWLING SECTIONS.

Screwdriver

Install the sections of cowling over the ring (fig. 99), and attach them to the brackets by means of the Dzus fasteners.

The cowling at the oil sump has a tail which extends down between No. 5 and No. 6 inner rocker boxes. The long section of cowling is installed where the bracket is omitted, and has an opening for the steady rest tube. Another section of cowling with the steady rest tube opening is installed directly opposite. The section of cowling with the small hole is installed at the decompression lever, the small opening providing passage for the decompression cable.

138. INSTALL THE INTERROCKER BOX BAFFLES (fig. 16).

a. Equipment.

Screwdriver
Wrench, open-end, 3/8-in.

b. Procedure. Turn the engine so that the accessory case side is facing upwards. Install the interrocker box baffles, attaching them by the Dzus fasteners to the intercylinder baffles at each side. At No. 5 and No. 6 cylinders, the baffle attaches to the flanges of the oil sump. Install the two narrow strips at each side of the oil sump (fig. 16). Bolt the intercylinder baffles together at each cylinder using a 3/8-inch open-end wrench. A washer is used on each side of the baffle at both the bolt head and nut, with a spacer between the inner washers. Bolt the front of the interrocker box baffles to the intercylinder baffles, using a washer at both the bolt head and nut.

139. REPLACE THE FUEL INJECTION LINES.

a. Equipment.

Wrench, open-end, 1/2-in.
Wrench, open-end, 5/8-in.

b. Procedure. NOTE: There are two injection lines at each cylinder, held together with a clamp at the center which is safety-wired. One line with large nuts carries the fuel from the injection pump to the injector. The other line with the small nuts carries fuel which was not injected back to the fuel return ring. Pressure should never be exerted on these lines. Screw the nuts onto the nipples on the injector. Use a 5/8-inch open-end wrench on the injector line nut and a 1/2-inch open-end wrench on the return line nut. Remove the caps on the nipples at each cylinder as the lines are installed. Start the four nuts on each set of lines before tightening any of them.

140. INSTALL THE INJECTOR COVER PLATES (fig. 16).

a. Equipment.

Screwdriver

b. Procedure. A cover plate is installed over each injector (fig. 16). The channel in the plate allows clearance for the fuel injection lines, the ends wedging under the bracket on the interrocker box baffles. Fasten the lower ends of the plates to the interrocker box baffles by means of the Dzus fasteners.

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

141. INSTALL THE STEADY REST TUBE, DECOMPRESSION CABLE BRACKET, AND DECOMPRESSION CABLE.

a. Equipment.

Wrench, open-end, 7/16-in. Wrench, open-end, 9/16-in.
Wrench, socket, 5/8-in.

b. Procedure.

(1) Slide the steady rest tube through the opening in the cowling, and install the clamp. Use a flat washer, nut and palnut on each stud.

(2) Install the decompression cable bracket after removing three of the 9/16-inch nuts on the thrust bearing plate under the decompression cable lever, then install the bracket over these studs replacing the nuts.

(3) Install the decompression cable clevis to the decompression lever and clamp the cable housing at the upper clamp on the decompression cable bracket, using a 7/16-inch open-end wrench to tighten the clamp bolt.

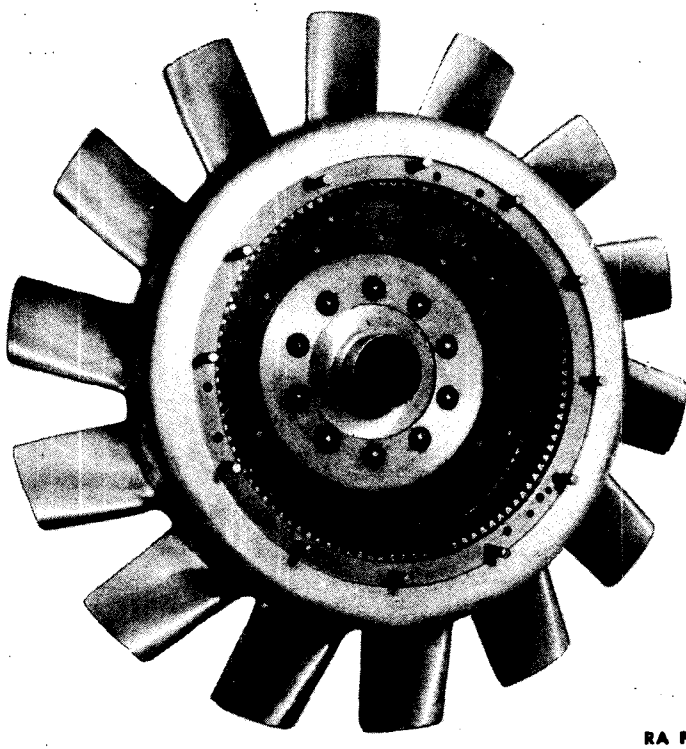


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Figure 100—The Flywheel

(4) Pull the upper end of the decompression cable through the opening in the cowling and install the decompression handle on cable and test the operation of the decompression lever by using the decompression cable linkage.

142. INSTALL THE FLYWHEEL (figs. 100 and 101).

a. Equipment.

Pliers — Wrench, flywheel hub nut, GU-GST-1554

b. Procedure. NOTE: Before installing the flywheel be sure that the cones on each side of the hub are perfectly smooth and free from rust. Also be sure that the front crankshaft is clean and smooth. Coat the inside of the brass cone with GREASE, general purpose, seasonal grade, and slide it on the front crankshaft with the tapered side out. The flywheel can be installed with the front of the engine facing upward, or with the engine in a vertical position. Slide the flywheel onto the front crankshaft. Place the two halves of the front cone in the flywheel nut, so that the tongue in the cone is inserted into the grooves in the nut. Hold them in this position until the nut is screwed in far enough for the flywheel hub to support them. Then tighten the nut, using the flywheel hub nut wrench GU-GST-1554. Insert the locking pin through the holes in the nut and front crankshaft from the inside, and safety-wire it in position, wrapping the wire around the groove in the nut.

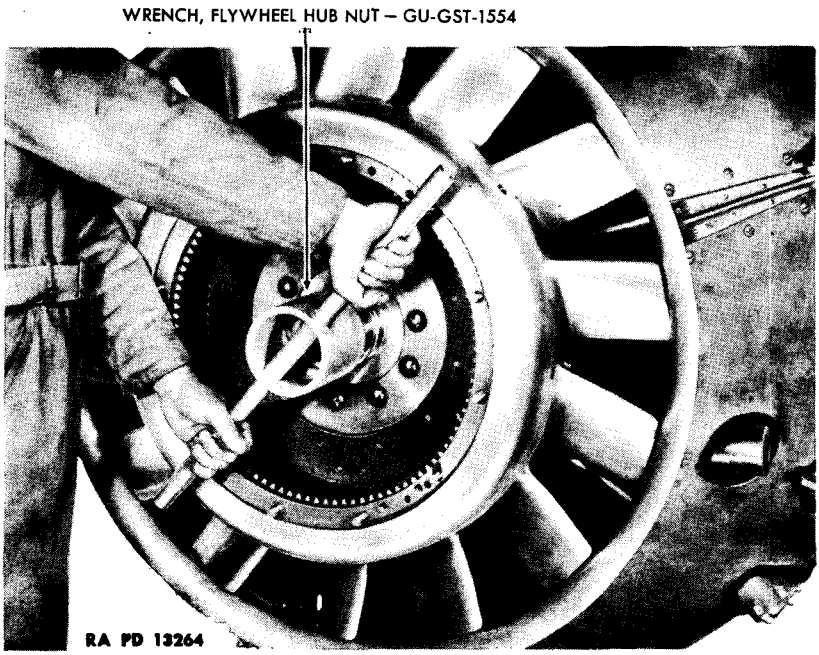

Figure 101—Installing the Flywheel Hub Nut

143. PLACE THE ENGINE ON THE ENGINE MOUNTING BEAM.

a. Equipment.

Hoist
Pliers
Wrench, socket, 5/8-in.

b. Procedure. Lower the engine onto the engine mounting beam in the stand, with the flat side of the mounting beam up toward the engine. Lower the accessory case of the engine through the mounting beam opening. Push the bolts through the bolt holes in the engine mounting flange and mounting beam, using a flat washer at both the bolt head and nut. Tighten the nuts securely (5/8-in. socket wrench). Install cotter pins in the nuts.

144. INSTALL THE THROTTLE CONTROLS (fig. 5).

a. Equipment.

Pliers
Wrench, socket, 7/16-in.
Wrench, socket, 3/4-in.

b. Procedure. Slide the throttle control lever over the throttle control shaft, in the position shown (fig. 5) and replace the washer and nuts (3/4-in. socket wrench). Insert a cotter pin to lock the nut. Tighten the clamp bolt (7/16-in. socket wrench) with a flat washer and lock washer underneath.

145. INSTALL THE FUEL PRESSURE REGULATOR.

a. Equipment.

Wrench, open-end, 7/16-in.
Wrench, open-end, 1/2-in.
Wrench, socket, 1/2-in.

b. Procedure. The fuel pressure regulator is connected to a short section of hose above the accessory case, and is attached to the mounting beam by means of a clamp and two bolts (1/2-in. socket wrench). A fitting is used to connect the hose to the clamp in which the regulator is installed. The fuel pressure regulator line extends from the regulator to the fuel return ring and is held in place by nuts (7/16-in. open-end wrench at regulator end and 1/2-in. open-end wrench at return line).

146. INSTALL THE FUEL SUPPLY PUMP.

a. Equipment.

Wrench, socket, 1/2-in.

b. Procedure. Turn the engine to a perpendicular position. Use a new gasket and place the fuel supply pump on the mounting studs of the accessory case and install the washers, nuts and palnuts.

ASSEMBLY OF ENGINE

147. INSTALL THE GOVERNOR.

a. Equipment.

Wrench, socket, ½-in.

b. Procedure. Use a new gasket and place the governor in position on the studs of the accessory case. Install the flat washers, nuts and palnuts.

148. INSTALL THE GOVERNOR CONTROL.

a. Equipment.

Wrench, open-end, 7/16-in.

b. Procedure. Install the governor control. One end is attached to the throttle control lever and the other to the governor. NOTE: With the throttle in the wide open position there should be 5/16-inch play to the right before the rod attached to the governor arm hits the rod attached to the throttle arm. If the play in the governor arm is more or less than this, it should be adjusted by adjusting the ball socket at each end of the governor arm. If it is impossible to achieve this adjustment, the governor arm must be removed and turned one serration.

149. INSTALL THE OIL PUMP.

a. Equipment.

Pliers	Wrench, socket, ½-in.

b. Procedure. Place the oil pump on the mounting studs and install washers, nuts and palnuts (½-in. socket wrench). Safety-wire through the dome of the oil pressure regulator and one of the holes of the packing nut of the oil filter.

150. INSTALL THE GENERATOR (fig. 102).

a. Equipment.

Pliers	Wrench, open-end, ½-in.
Wrench, open-end, 7/16-in.	Wrench, open-end, ⅝-in.

b. Procedure. With a ½-inch open-end wrench install the generator on the mounting studs, using flat washers, nuts and palnuts. The generator is braced by a clamp around it, which is attached to the engine mounting beam by two arms. Remove the window strap from the generator (pliers) and install the two halves of the clamp just ahead of the strap position, with the brackets up. Use flat washers at both the bolt head and elastic stop nut (7/16-in. open-end wrench). Install the long tie rods, with the clevis at the lower ends straddling the brackets on the clamp. The flat strap that encircles the starter is placed next to the clevis, on the inside. Then insert the bolt from the inside and install the elastic nut (½-in. open-end wrench) with a flat washer at both the bolt head and nut. Install the upper ends of the tie rods in the engine mounting beam. A clevis at the upper end of the tie rod straddles a flat headed mounting stud. Install the bolt with a flat washer under the

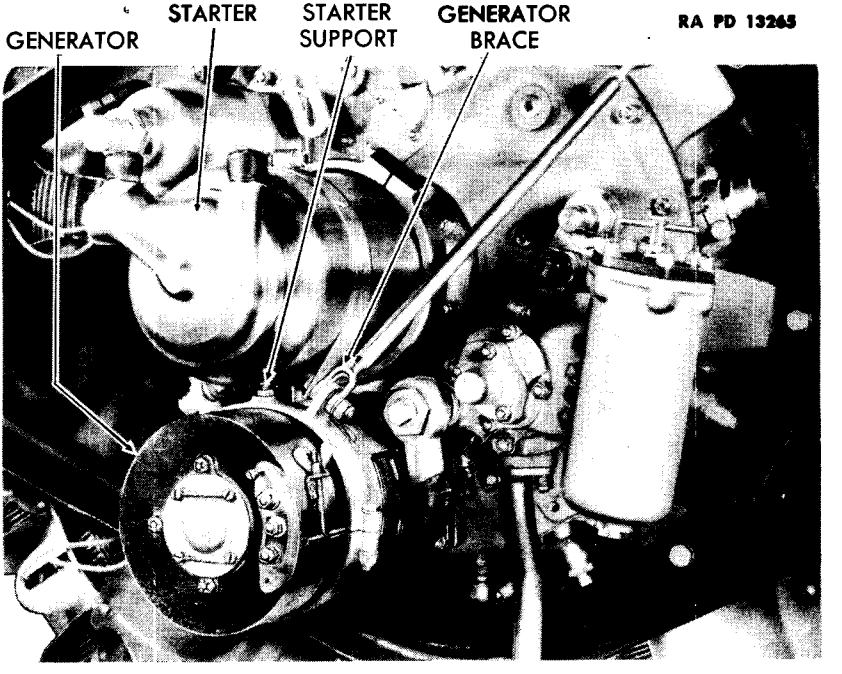

Figure 102—The Generator and Starter Braces

head and nut, then tighten the elastic nut (½-in. open-end wrench). Insert the mounting stud through an opening in the engine mounting beam and install a flat washer, lock washer, and plain nut (⅝-in. open-end wrench).

151. INSTALL THE STARTER (fig. 102).

a. Equipment.

Pliers	Wrench, open-end, ½-in.
Wrench, open-end, 7/16-in.	Wrench, open-end, 9/16-in.

b. Procedure. NOTE: Before the gasket is installed refer to the clearance from the end of the starter jaw to the starter mounting pad of the accessory case which was taken when the starter shaft was installed. Also refer to clearance chart for gasket thickness according to specified clearances. Use a new gasket and install the starter on the mounting studs, with the vents between the starter clamp and the mounting flange within 30 degrees of the top, so the lubricant will not run out. Install washers and elastic stop nuts (9/16-in. open-end wrench). Screw the bolt in the center of the brace around the generator, up to the starter with light tension (½-in. open-end wrench). Clamp the

flat straps at the lower end of the tie rod around the starter, and bolt them together, with a flat washer at the bolt head and elastic nut (7/16-in. open-end wrench). Install the window strap around the generator opening, tightening the wing nut with pliers.

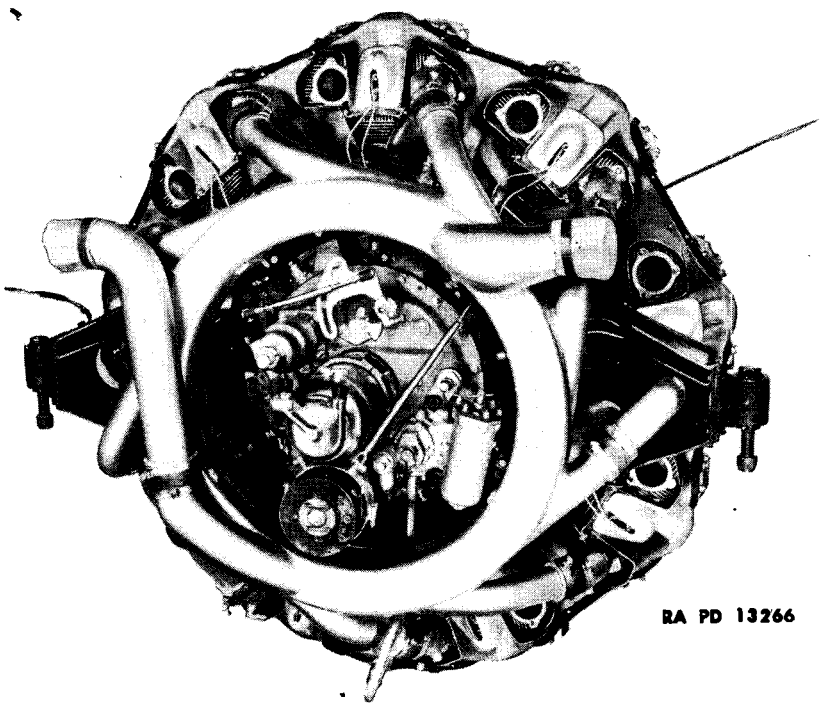

Figure 103—The Intake Manifold

152. INSTALL THE INTAKE MANIFOLD (fig. 103).

a. **Equipment.**

Pliers
Wrench, open-end, 5/8-in.
Wrench, socket, 1/2-in.

b. **Procedure.** NOTE: Care should be taken that no dirt or foreign particles have fallen into the manifold. If the elbows were not removed from the manifold, the entire assembly may be installed as a unit. Install new gaskets and place the elbows on the mounting studs at the intake ports in the position shown (fig. 103). Install nuts and palnuts (1/2-in. socket wrench). Tighten all the hose clamps, using pliers. CAUTION: The inlet ports should be covered to be sure that nothing can drop into the manifold and engine. Install the four braces on the intake manifold and the inner circle of the engine mounting beam. A flat washer is used at both the bolt head and nut (5/8-in. open-end wrench).

153. CONNECT OIL SUMP TO OIL PUMP AND INSTALL CABLE CONTROL DRAIN VALVE.

a. Equipment.

Pliers	Wrench, 3/4-in.
Wrench, 3/8-in.	Wrench, 1-in.
Wrench, 5/8-in.	Wrench, open-end, 1/2-in.

b. Installation of Drain Valve. Install drain valve in fitting in No. 6 intake manifold elbow T valve by inserting drain valve into T, tighten nut, then screw up jam nut. Run cable through cable clamp on front of oil sump and up through cable clamp on engine mounting beam. Place lever and support nut on decompression control shaft. Tighten cable support clamps. Make operating adjustment with decompression control lever. Safety-wire drain valve lever control supporting nut. Install drain hoses between Nos. 5, 6 and 7 intake manifold elbows. NOTE: When drain valve is operating correctly, the decompression lever should activate the drain valve cable control lever so that it opens the drain valve 3/8 inch when in the wide open position.

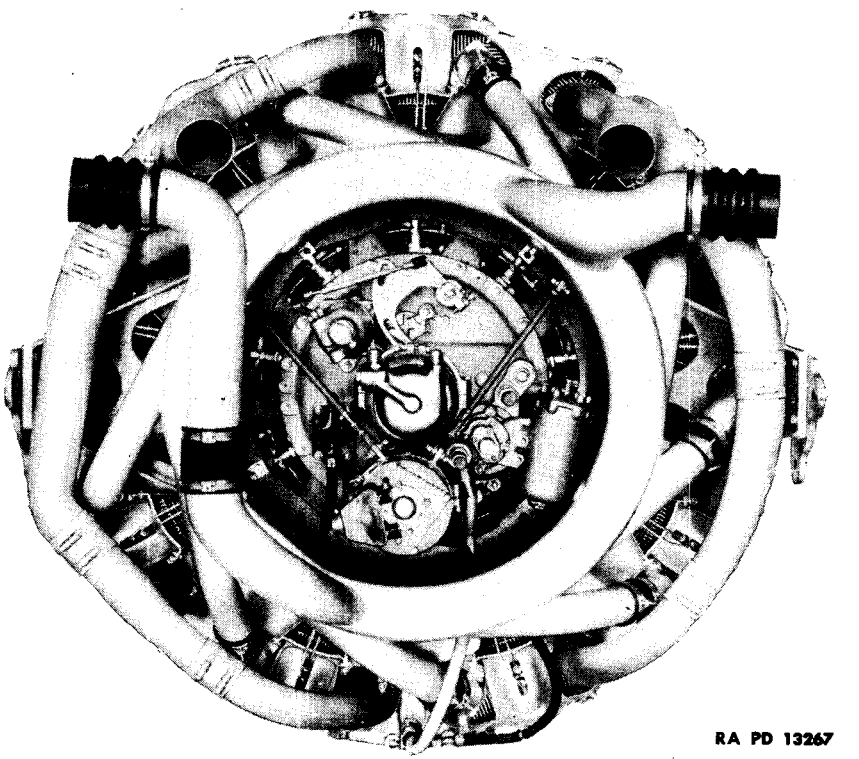

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Figure 104—The Exhaust Manifold

c. **Procedure.** A brass liner fits into the oil sump and the scavenger line to prevent oil leakage. Insert the end of the scavenger line into a short piece of hose and push the hose back so that the line projects through it. Insert the liner into the oil sump opening. The flanged end of the scavenger line bolts to the bottom of the oil pump. Install, using a new gasket, flat washer, a nut and palnut. Place the line over the end of the liner. Slide the hose up over the liner and tighten the hose clamps on the oil sump and scavenger line.

154. INSTALL THE EXHAUST MANIFOLD (fig. 104).

a. **Equipment.**

Wrench, socket, ½-in.

b. **Procedure.** NOTE: If the exhaust manifolds were not disassembled, they can be installed in two sections. If they have been dismantled, assemble them (fig. 104), installing the clamps at each connection. Install each section at the exhaust ports, in the position shown (fig. 104). Use new gaskets. Install lock washers and brass nuts. Attach a paper over the ends of the manifold to prevent anything from falling in.

155. REPLACE FUEL SUPPLY PUMP HOSE AND ROCKER BOX SCAVENGER HOSE.

a. **Equipment.**

Pliers

b. **Procedure.** Run a hose from the lower connection of the fuel supply pump down to the fuel check valve nipple. Tighten it on with thumbscrews. Connect a hose from the nipple on the rocker box scavenger to the nipple on the oil pump, tightening the clamp at each end by means of the thumbscrew.

156. TESTING AND RUNNING-IN THE ENGINE AFTER A MAJOR OVERHAUL.

a. **Equipment.**

Dynamometer
Wrench, injection pump adjusting, GU-GST-1419

b. **Procedure.** The engine should be tested and run-in on a dynamometer (see note at end of this section). After the engine is properly installed on the dynamometer, the procedure for testing and run-in is as follows:

(1) BLEED THE FUEL SYSTEM TO REMOVE AIR.

(a) Open the bleeder valves on the fuel filter, and the pipe plug between No. 1 and No. 9 cylinders. (Loosen these only enough to allow air to escape, or pressure will be lost.)

(b) Put air pressure on the fuel tank to force the fuel up into the engine, until fuel comes out of the bleeder valves and at the pipe plug opening, free of air bubbles. It may be neces-

sary to use two or three pounds of air pressure to force the fuel through the fuel supply pump.

(c) Tighten bleeder valves and pipe plug securely again before starting the engine.

(2) PUMP FUEL UP INTO THE INJECTOR LINES BY MANIPULATING THE THROTTLE.

(a) As fuel enters a cylinder a squeal will be heard due to the extremely high velocity of the fuel through the injector nozzle. Locate the cylinder and mark the fan blade at that cylinder.

(b) Turn the blade to the next firing cylinder (firing order is 1-3-5-7-9-2-4-6-8) and manipulate the throttle again to pump fuel into that cylinder.

(c) Continue this operation with all cylinders in their firing order. Repeat this procedure until the engine has made at least four complete revolutions.

(3) STARTING THE ENGINE.

(a) Place a cartridge in the starter breech.

(b) In cold weather the throttle should be wide open when starting; half-open throttle should be used in warm weather.

(c) Close the starter contact switch. It may require two or three cartridges to start the motor, due to the fact that the fuel lines may not be completely bled.

(d) As soon as the engine starts, set the idling control lever in the idling position.

(4) BALANCE THE CYLINDERS.

Wrench, injection pump adjusting, GU-GST-1419

The cylinders must be balanced to make sure that all are carrying an equal share of the load. This is done by checking the temperature at each exhaust manifold. No manifold should be so hot that a hand cannot be placed on it. A hot manifold indicates that the cylinder is getting too much fuel. The fuel is cut down by turning the adjusting sleeve at the fuel pump clockwise. If the clamp bolt is tight, loosen it to permit turning the adjusting sleeve. The injection lines should be loosened at the pumps to prevent bending the lines. When the temperature of the hot cylinders has been brought down, raise the temperature of any cold cylinders by increasing the fuel supply. This is done by turning the adjusting sleeve of the fuel pump counterclockwise. The object is to get all cylinders as near the temperature of No. 1 cylinder as possible. NOTE: Never change the adjustment of No. 1 cylinder, as this cylinder was correctly timed for desired hole opening and start of the injection. All the other cylinders are balanced to No. 1 cylinder.

ASSEMBLY OF ENGINE

(5) ENGINE RUN-IN.

(a) Operate the engine under light load at 1,200 revolutions per minute for one hour.

(b) Increase the speed to 1,800 revolutions per minute and operate for one hour with ¾ load.

(c) Idle the engine at 800 revolutions per minute with no load and check the balancing of the injection pumps by the heat of the exhaust manifolds.

(d) Operate the engine at 2,000 revolutions per minute for one hour.

(e) Operate the engine at wide open throttle for one hour. NOTE: An engine will usually have a "rough spot" at a certain speed, at which it will vibrate more than at other speeds. If this rough spot occurs at any of the above speeds, operate the engine at a speed just above or below it.

(6) CHECK THE FUEL PRESSURE. Set at six pounds by adjusting the fuel pressure regulator at the fuel supply pump.

(7) CHECK THE OIL PRESSURE. With an oil temperature of 160 F, set the oil pressure at approximately 85 pounds at 2,000 revolutions per minute by adjusting the oil pressure control valve. WARNING: Cooler oil will result in higher pressure. Do not attempt to regulate the oil pressure until the engine is warmed up and the oil has reached a 160 F temperature.

(8) CHECK THE SCAVENGER OIL TEMPERATURE. Do not permit it to run higher than 180 F.

(9) ADJUST THE GOVERNOR. Set the governor by means of the adjusting screw at the back to a maximum speed of 2,200 revolutions per minute under full load or approximately 2,325 revolutions per minute under no load. Screw the adjusting screw clockwise to increase engine speed and counterclockwise to decrease it. NOTE: If a dynamometer is not available, the engine must be tested and run-in after installing it in the tank. With the engine installed, and properly balanced, operate at 1,200 revolutions per minute in fourth gear for one hour, then operate at 1,800 revolutions per minute in fourth gear for one hour. Then proceed with the checking as outlined above.

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

Section VII

ACCESSORIES

157. PESCO 386-A FUEL PUMP SPECIFICATIONS AND DESCRIPTION.

a. Specifications. The Pesco 386-A fuel supply pump is a gear type pump with a rated capacity of 75 gallons per hour at 1,750 revolutions per minute at four inches of mercury inlet depression and 10 inches of mercury discharge pressure. It rotates at engine crankshaft speed and in a counterclockwise direction when viewed from the drive shaft end of the pump. The pump is attached to the engine accessory case by means of studs and nuts, and is connected to the fuel system by means of flexible lines. The relief valve is set at the factory at five pounds per square inch and is not adjustable.

b. Description (fig. 106).

(1) DRIVE AND DRIVEN GEARS. Two gears, meshing with each other, revolve within the specially shaped recess of the pump body. These gears are accurately machined, and the capacity of the pump depends on the clearance between the gears and the body and cover assemblies of the pump.

(2) DRIVE SHAFT SEAL. This self-alining seal provides for conditions of allowable misalinement between the drive gear and the drive shaft. Fluid leaking through the clearance area be-

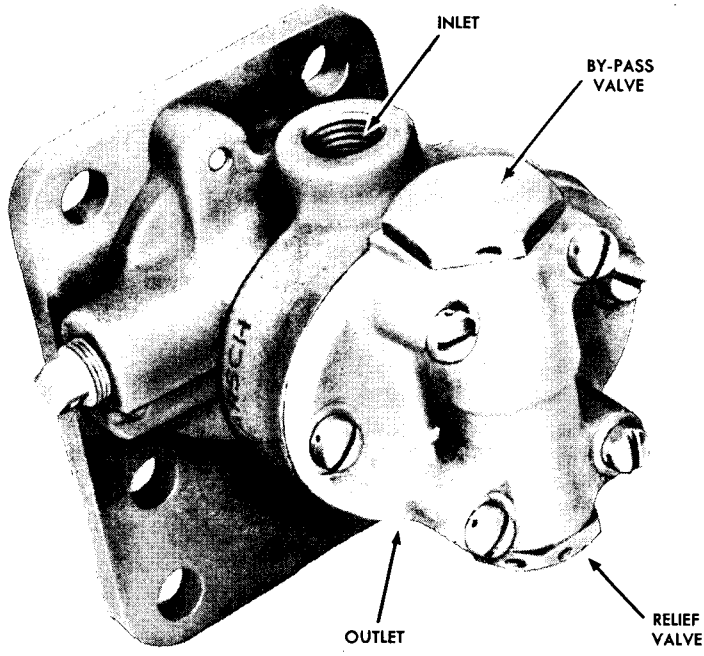

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Figure 105—The Pesco 386-A Fuel Supply Pump

tween the drive gear and the bearing of the body assembly is retained by the seal because of the contact of the flat face of the drive shaft bearing with a soft metal sealing disk. The sealing disk rests on a synthetic rubber ring held by a mounting plate adapter. Two ears on the sealing disk fit into corresponding shaped recesses in the body assembly and prevent the sealing disk from rotating. The flat face of the drive shaft is held against the sealing disk by means of a compression spring placed between the drive gear and the end of the drive shaft. The drive gear is driven by the drive shaft by means of a splined joint, which has freedom enough to allow for a slight misalinement between the pump and drive member of the engine.

(3) FUEL AND OIL DRAIN. Fuel and engine oil which pass through their respective seals are drained from the body assembly of the pump through a ⅛-inch pipe tapped hole in the base assembly located near the adapter plate on the right side of the pump. If a pipe plug is present in this hole, remove it and do not install it unless the pump is to be stored.

(4) BODY ASSEMBLY. This assembly consists of a housing for the drive and driven gears, the shaft seal drains, the shaft seal, and the inlet and discharge ports. A pressed-in sleeve serves as a bearing for the drive gear. The mounting plate adapter is

attached by means of flat head screws to one finished surface, and the cover assembly is attached to the other finished surface by means of fillister head screws drilled for locking wire.

(5) COVER ASSEMBLY. This assembly contains the relief valve assemblies.

(6) RELIEF OR BYPASS VALVES. These spring-loaded valve assemblies are housed in the cover assembly. Their function is to prevent undue fluid pressures being built up within the pump due to operating the pump against a severe restriction or a closed valve on the discharge line. Two valves are provided by the manufacturer, only one of which is operative for a given direction of rotation of the pump. The valve spring retainer marked "Locate by Inlet Port," must be assembled as directed in order for the discharge pressure of the pump to be regulated to five pounds per square inch. When the discharge pressure of the pump exceeds five pounds per square inch, the inlet and discharge of the pump are connected together by the opening of the disk type valve, thereby regulating the discharge pressure.

158. PESCO 386-A FUEL PUMP OPERATION AND INSPECTION ON THE VEHICLE.

a. Operation. Fuel enters the body assembly and is admitted to the gear compartment through a drilled passage. The gears rotate in a direction to carry fuel between teeth of the gears to the discharge port. The meshing of the gears forces the fuel trapped between the teeth on the gears out of the body assembly through the discharge port into the engine fuel system. Drilled passages in the cover assembly connect the relief valve to the suction and discharge ports of the pump.

b. Inspection on the Vehicle. The using arm personnel is responsible for checking the seal of the pump shaft for leaks every 25 hours of tank operation. To check the seal for leaks, proceed as follows:

(1) INSPECTION OF PUMP SHAFT SEAL. Remove the 1/8-inch pipe plug located behind the pump outlet line on the lower side of the base assembly if the plug is present. If fuel continues to drip out of this hole with the fuel tank valves open, the seal is defective and the pump must be replaced. If no leak is present, the seal is satisfactory. *Do not* install the 1/8-inch pipe plug.

(2) INSPECTION OF PUMP FLOW AND MECHANICAL CONDITION. The following procedure outlines a method for making a rough check on the ability of the pump to deliver fuel and a means to determine the pump's mechanical condition without disassembly of the pump.

(a) Open fuel tank valves. (The tanks should be 3/4 full.)

(b) Disconnect the fuel pump discharge line.

ACCESSORIES

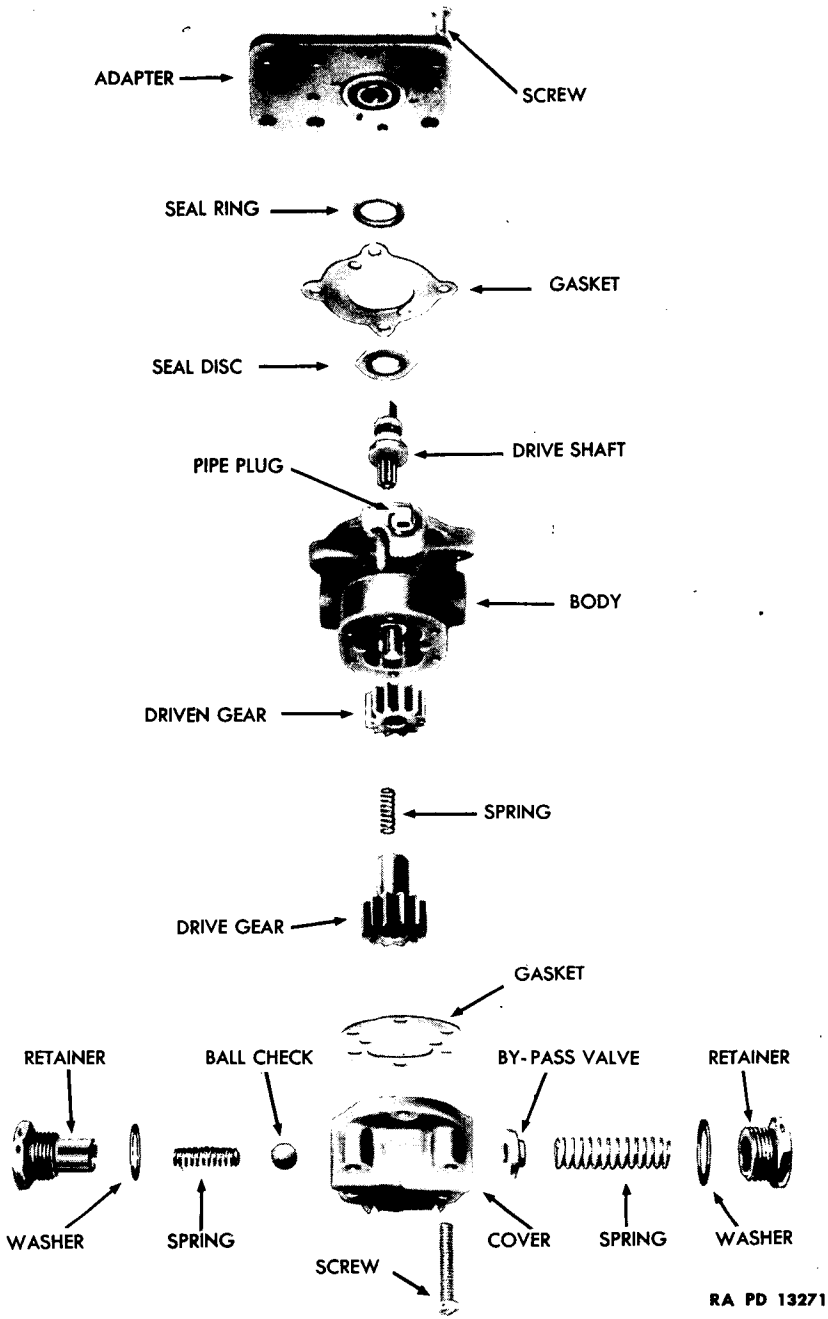

Figure 106—The Pesco 386-A Fuel Supply Pump Assembly

(c) Remove the fuel pump from the engine accessory case (par. 159 a (1) through (3)).

(d) Facing the drive shaft of the pump, rotate it counterclockwise. If fuel flows and the drive shaft turns easily with no hard spots during its rotation, the pump is satisfactory. If the drive shaft turns hard or offers undue resistance during a portion of a complete revolution of the drive shaft, replace or overhaul the pump.

(e) Reverse the above sequence of operations to install a serviceable pump on the engine. Check the fuel lines for leaks upon completion of the job.

159. PESCO 386-A FUEL PUMP REMOVAL, DISASSEMBLY AND CLEANING.

a. Removal from Engine. Use the following procedure for removing the fuel pump from the engine.

(1) Close fuel tank valves.

(2) Using pliers, loosen the hose clamp on the discharge side of the pump. Pull the hose away from the pump fitting.

(3) Using three open-end wrenches having 5/8-inch, 11/16-inch and 3/4-inch openings, disconnect the swivel connector of the inlet fuel line of the pump. Using a 1/2-inch socket wrench with handle, remove the palnuts and nuts from the studs attaching the pump to the engine accessory case. Remove the pump with gasket from the engine.

b. Disassembly (fig. 106). The following list names all the tools necessary to disassemble the pump:

Pliers	Wrench, box, 13/16-in.
Screwdriver	Wrench, box, 15/16-in.

(1) REMOVE RELIEF VALVES FROM THE COVER.

Wrench, box, 13/16-in. Wrench, box, 15/16-in.

Using a soft-jawed vise, clamp the adapter plate of the pump in the vise with the adapter plate horizontal, the relief valves up, and the longer sides of adapter plate contacting the jaws of the vise. Using a 15/16-inch box wrench, remove the retainer on the inlet side from the cover, with a washer, spring and valve disk. Use a 13/16-inch box wrench and remove the retainer, washer, spring and ball on the discharge side from the cover.

(2) SEPARATE THE COVER FROM THE BODY ASSEMBLY.

Pliers Screwdriver

Using pliers, remove the safety wire from the screws attaching the cover to the body assembly. Using a screwdriver, remove the screws attaching the cover to the body assembly. Separate the

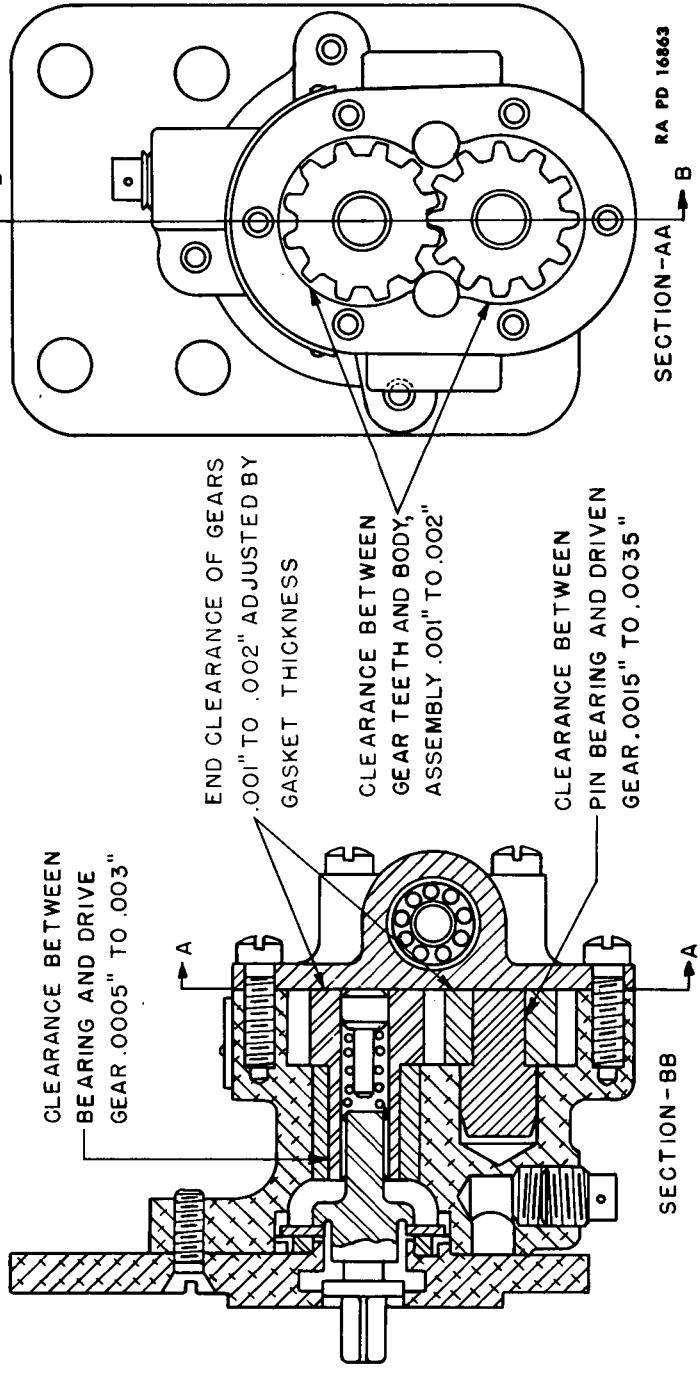

Figure 107—Clearance Diagram for Pesco Pump 386-A

cover with aluminum foil gasket from the body assembly. Remove the pump from the vise and remove the drive gear with spring and driven gear from the body assembly. Remove the spring from the drive gear.

(3) SEPARATE ADAPTER PLATE FROM BODY ASSEMBLY.
Screwdriver

Using a screwdriver, remove the four screws which are used to attach the adapter plate to the body assembly. Separate the adapter plate with gasket from the body assembly. Remove the sealing disk and drive shaft from the body assembly in the order mentioned. Remove the synthetic rubber ring from the adapter plate.

c. Cleaning. Using SOLVENT, dry-cleaning, clean and dry all of the pump parts. Observing the caution note below, remove all burs that were caused in the process of disassembly. CAUTION: The removal of any sharp corners from the internal parts of the pump will result in lowered pump efficiency.

160. PESCO 386-A FUEL PUMP INSPECTION AND REPAIR.

a. Inspection.

(1) If the synthetic rubber ring, on which the sealing disk rests, is cut, misshapen, or deteriorated, use a new ring in assembly.

(2) If the drive shaft is broken, replace with a new shaft. Always use a new sealing disk with a new shaft; finish-lap the new parts together as outlined in **b** of this paragraph.

(3) Replace the body assembly if any of its threads are defective or the gear compartment shows visible signs of being cut by the teeth of the gears. Place the body assembly on a bench (cover surface up) and install the gears. Place a straightedge across the surface of the body assembly in such a way that it intersects the axis of rotation of the gears. If when the straightedge contacts the surface of the body, a 0.0015-inch feeler gage can be inserted between either gear and the straightedge, replace both the body and the gears. If the clearance is less than 0.0015-inch, use a 0.001-inch gasket between the body and the cover. If the straightedge contacts the gears and the surface of the body, use a 0.001-inch aluminum gasket between the body and the cover. If the straightedge rests on the gears, use a feeler gage to measure the distance between the straightedge and the surface of the body assembly. Add 0.001-inch to this dimension to determine the thickness of the gasket to be used between the body and the cover. Remove the drive and driven gears from the body assembly. Machine a metal plug to exactly the size of the bearing in the body. Use this plug to determine the amount of clearance

between the drive gear and the bearing. Use a 1-inch outside micrometer to measure the outside diameter of the drive gear bearing and the outside diameter of the metal plug. Subtract the outside diameter of the drive gear from the outside diameter of the metal plug to determine the clearance. If it is less than 0.0005-inch or more than 0.003-inch, replace both the drive gear and the body.

(4) Install the driven gear in the body assembly. Press the gear toward the axis of the drive gear and, using a narrow feeler gage, measure the clearance between a tooth of the driven gear and the wall of the body assembly opposite the direction of the force applied. Apply the force in the reverse direction and measure the clearance at the same point, using the same tooth of the driven gear. Subtracting the smaller dimension from the larger one gives the clearance between the driven gear and the pin bearing on which the gear rotates. If this dimension is less than 0.0015-inch or greater than 0.0035-inch, replace either the body assembly, driven gear or both.

(5) Install the drive and driven gears in the body. Using a narrow feeler gage, measure the clearance between the gear teeth and the body. If the clearance is less than 0.001-inch or greater than 0.002-inch, replace both gears and the body assembly.

(6) If the gears have cut away the cover to a depth of more than 0.0025-inch, resurface the cover as outlined in this paragraph under **b**.

(7) Examine the valve seats in the cover. If the ball and valve disk seats are pitted and show evidence of a bad leak, replace the defective cover with a serviceable one. If the ball seat has a slight leak, repair it, following the procedure in **b** of this paragraph. When a new cover is used, always use a new valve ball and disk. If the valve disk seat of the cover assembly shows evidence of a slight leak, follow the procedure in **b** of this paragraph.

(8) If the valve disk sealing surface is not flat, follow the procedure in **b** of this paragraph.

(9) If the fuel pump has been leaking, examine the sealing surface of the drive shaft and the sealing disk. If these surfaces are not flat and slightly worn, use the procedure outlined in **b** of this paragraph to remedy this defect. If the sealing surfaces are excessively worn, replace both parts with serviceable ones.

b. Repair.

(1) Non-charging lapping compound method of refinishing the sealing surface of the sealing disk.

(a) Using grade H-41 fine non-charging Carborundum lapping compound, lap the sealing surface of the sealing disk on a

flat cast-iron plate. If the sealing surface does not "clean-up" in three minutes, wash the seal and the plate with SOLVENT, dry-cleaning, and replace the defective sealing disk. A satisfactory sealing surface must be obtained before proceeding with the next step. Wash all compound from the plate and seal with SOLVENT, dry-cleaning.

(b) Using the flat cast-iron plate, dry-lap the sealing surface until a high finish is obtained over the entire sealing surface. Using SOLVENT, dry-cleaning, wash the plate and seal to remove all traces of the lapping compound. The seal is ready for use.

(2) FINE HONE METHOD OF REFINISHING THE SEALING SURFACE OF THE SEALING DISK. If a fine hone having a flat surface is available, lap the sealing surface of the disk against the hone. If the surface does not clean up in three minutes, use the preceding method for refinishing the sealing surface.

(3) REFINISHING THE SEALING SURFACE OF THE DRIVE SHAFT. The sealing surface of this part is nitrided. For this reason more than 0.015-inch cannot be removed from the sealing surface unless provision is made for nitriding this surface. Use the following procedure for lapping the sealing surface of the drive shaft:

(a) Clamp a piece of cast-iron stock of 1-inch diameter in the lathe chuck.

(b) Face the end of the cast-iron piece off, to make a smooth flat surface that is square (90 degrees) with the axis of rotation of the chuck.

(c) Drill a hole 1¼ inches deep and 0.510-inch plus or minus 0.005-inch diameter in the cast-iron piece, holding the drill with a chuck in the tailstock.

(d) Place a small quantity of very fine lapping compound on the sealing surface of the drive shaft. Insert the drive end of the shaft in the drilled hole and lap the sealing surface until smooth. *Do not* remove all of the nitrided surface.

(e) Add kerosene to the lap to polish.

(f) Wash the lap and finish with kerosene; then wash the parts with SOLVENT, dry-cleaning, to thoroughly remove every trace of the compound. CAUTION: If more than one drive shaft sealing surface is to be lapped, repeat the facing operation for each drive shaft.

(4) RESEATING THE BALL SEAT OF THE COVER.

(a) Clamp a piece of brass rod ¾-inch in diameter and four inches long in the chuck of a lathe with one inch of the rod projecting from the jaws of the chuck.

(b) Face off the end of the rod to be flat and perpendicular to the axis of rotation of the chuck.

(c) Turn the exposed end of the rod down to 0.0685-inch plus zero minus 0.002-inch.

(d) Remove the rod and clamp it firmly in a vise, with the axis of the rod vertical and the turned down portion of the rod projecting one inch above the jaws of the vise.

(e) Place the cover on the rod, ball seat up. The rod now firmly supports the valve disk seat for the following operations:

1 Place the valve ball in position on its seat in the cover assembly.

2 Using a soft drive ½-inch in diameter and a small hammer, tap the ball into the seat.

3 Remove the ball and examine the seat. Replace the cover with a serviceable one if the seat is still defective.

(5) REFINISHING OF THE SEALING SURFACE OF THE RELIEF VALVE DISK. Use the same procedure as outlined in **b** (1) of this paragraph.

(6) REFINISHING THE RELIEF VALVE DISK SEAT OF THE COVER.

(a) Turn a piece of cast-iron rod up to the same dimensions as the brass rod, using the same procedure as outlined in **b** (4) of this paragraph.

(b) Using Carborundum non-charging finishing compound grade H-41, medium, lap the seat with the finished end of the cast-iron rod.

(c) Wash the cover and rod thoroughly with SOLVENT, dry-cleaning. CAUTION: The flat finished end of the cast-iron rod must be refinished on the lathe for each seat lapped.

(7) RESURFACING THE FINISHED SURFACE OF THE COVER. If the cover shows gear wear, use Carborundum non-charging lapping compound medium H-41, and a flat cast-iron plate to refinish the surface in contact with the gears. If the surface does not clean up, replace the defective cover with a serviceable one.

161. PESCO 386-A FUEL PUMP ASSEMBLY, TEST AND INSTALLATION.

a. Assembly. The following list mentions all of the tools necessary for this operation:

Pliers	Wrench, box, 13/16-in.
Screwdriver	Wrench, box, 15/16-in.

(1) Place the body assembly, adapter plate side up, on the bench.

(2) Place the drive shaft and seal disk in the pump body, making certain the sealing surface of the disk is against the sealing surface of the drive shaft.

(3) Install the synthetic rubber ring in position on the adapter plate.

(4) Place a new body assembly to adapter plate gasket on the body if the old gasket is defective.

(5) Place the adapter plate on the gasket which rests on the body, making the inlet and outlet ports parallel to the long axis of the adapter plate.

(6) Using a screwdriver, install four flat-headed screws with serrated lock washers attaching the adapter plate to the pump body.

(7) Clamp the adapter plate in a soft-jawed vise, body gear compartment up.

(8) Install the driven gear in the body.

(9) Install the spring inside the drive gear and install the drive gear with spring in the body.

(10) Place a new aluminum foil gasket of the proper thickness (par. 160 a (3)) in position on the body. NOTE: These gaskets are available in three thicknesses; 0.001-inch, 0.0015-inch, and 0.003-inch. The clearance between the gears and the cover must be between 0.001 and 0.002-inch.

(11) Place the cover on the gasket with the relief valve disk seat of the cover toward the pump body port which is nearest the short side of the adapter plate.

(12) Using a screwdriver, install six screws attaching the cover to the body assembly.

(13) Remove the pump from the vise and clamp the adapter plate so the relief valve disk seat of the cover is up. Install the disk, spring, gasket and retainer in the above order in the cover. Using a 15/16-inch box wrench, tighten the retainer.

(14) Remove the pump from the vise and clamp the adapter plate so the relief valve ball seat of the cover is up. Install the ball, spring, gasket and retainer, in the above order in the cover. Using a 13/16-inch box wrench, tighten the retainer.

b. Test.

(1) DESCRIPTION OF TEST STAND. A test set-up is required as follows: a reversible, variable speed, driving unit for driving a fuel pump drive shaft adapter. Fuel lines, in which are installed valves to control the fuel flow, run from a fuel tank to the pump adapter stand. Between the control valves in these lines and the pump port connections, are mercury manometer or gage connections, from which pressure readings can be taken. The gages and manometer, required for performance readings, are used on various tests; and these need not be considered as special equipment for a fuel pump overhaul. A flow-meter is also utilized for these tests, if it is available.

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(2) BREAK-IN RUN. Place the pump on the test stand pump adapter, and break-in at 1,750 revolutions per minute for two hours. Use kerosene or Diesel fuel oil. Operate in the same direction of rotation as when on the engine. If the shaft seal leaks after the first hour of operation, dismantle and repair the pump. After the run-in, operate on gasoline for about ten minutes; then dry the pump out by disconnecting the lines and running for about five minutes. Blowing air into the ports by means of the air hose will help to dry the pump.

(3) DRY VACUUM TEST. The dry vacuum readings to be obtained from this test will indicate the condition of the pump, and are more reliable than capacity readings. If the vacuum readings are equal to or greater than the following, the pump is in good condition and is satisfactory for service until the next major overhaul. The reading taken with an accurate vacuum gage, or preferably a mercury manometer, connected to the suction port should be:

7.8 inches of mercury inlet depression at 1,600 revolutions per minute

1.5 inch of mercury inlet depression at 400 revolutions per minute

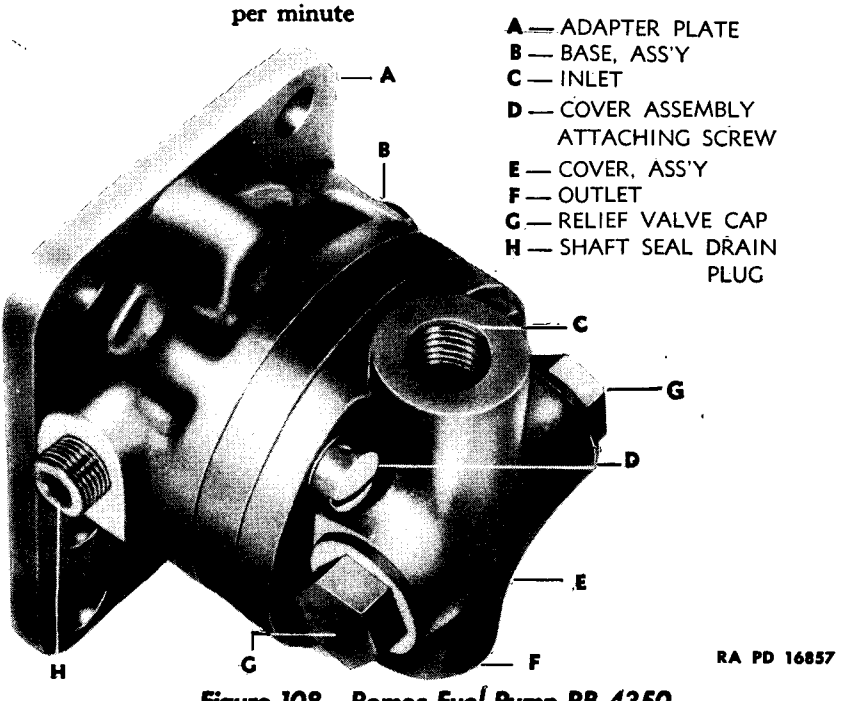


Figure 108—Romec Fuel Pump RB-4350

(4) SHAFT SEAL TEST. Open the lower drain boss in the base section during test. If the leakage is in excess of five drops per minute, remove the seal parts and correct the defective seal. If the seal is satisfactory, install the seal drain plug.

(5) STORAGE. If the pump is to be stored, fill the interior of the pump with lubricating oil and install plugs in all the openings of the pump.

(6) INSTALL LOCKING WIRE. Using pliers and a suitable size and length of locking wire, safety-wire both retainer and the six fillister head screws.

c. Installation in the Vehicle. Use the following procedure to install the fuel pump on the engine:

(1) Using a new gasket 1/64-inch thick, place in position on the engine accessory case.

(2) Place the fuel pump in position on the engine.

(3) Using a ½-inch socket wrench with handle, install four nuts and palnuts on the accessory case studs to secure the pump to the engine.

(4) Using three open-end wrenches of ⅝-inch, 11/16-inch and ¾-inch openings, connect the swivel connector of the inlet fuel line to the inlet side of the pump.

(5) Slip the hose of the pump discharge line over the fitting screwed in the pump discharge. Place the hose clamp in position and use pliers to tighten clamp on the hose.

(6) Remove the shaft seal drain plug.

(7) Open the fuel tank valves and inspect for leaks.

162. ROMEC RB-4350 FUEL PUMP SPECIFICATIONS AND DESCRIPTION (fig 108).

a. Specifications. The Romec RB-4350 fuel supply pump is a rotary vane-type pump with a rated capacity of 75 gallons per hour at 1,750 revolutions per minute at four inches of mercury inlet depression and ten inches of mercury discharge pressure. It rotates at engine crankshaft speed and in a counterclockwise direction when viewed from the drive shaft end of the pump. The pump is attached to the engine accessory case by means of studs and nuts, and is connected to the fuel system by means of flexible lines.

b. Description (fig. 109).

(1) ROTOR. The non-pulsating pump unit consists of a rotor mounted eccentrically within a special shaped recess. The rotor is fitted with two vanes, crossed, that move back and forth in accurately machined, radial slots. The ends of the vanes are grooved to

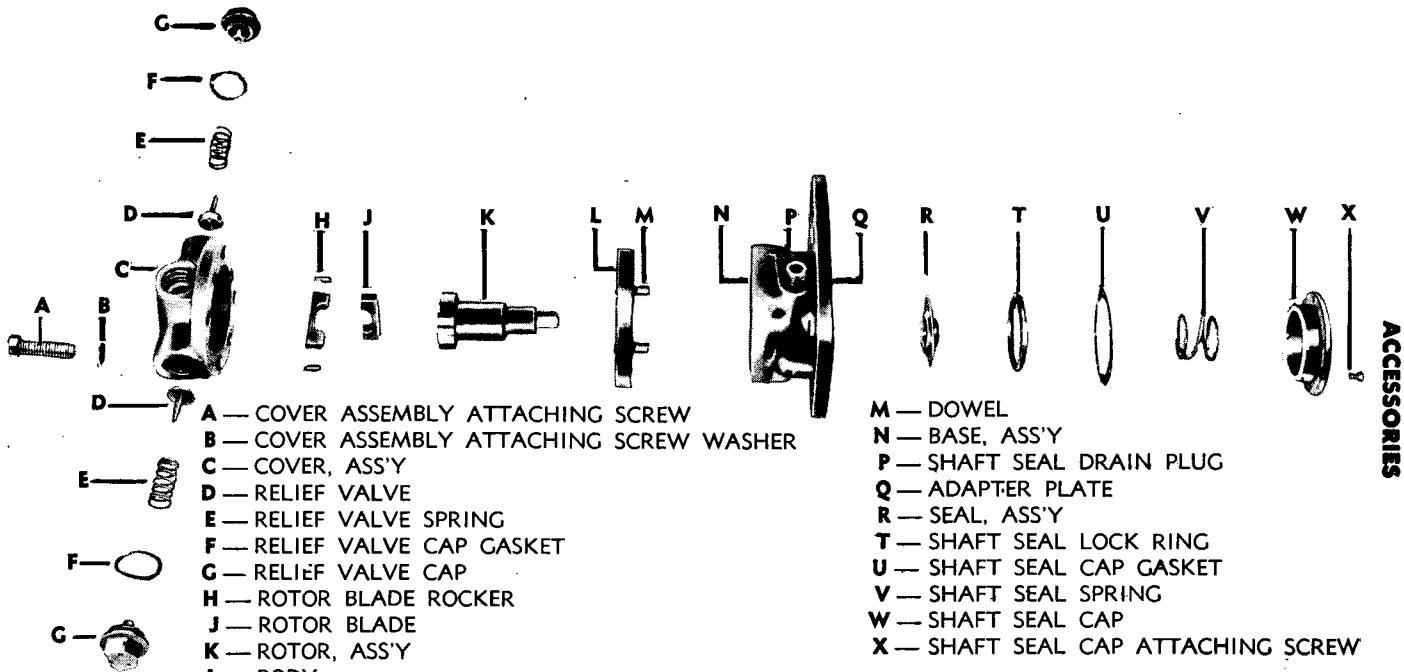


Figure 109—Exploded View—Romec Fuel Pump RB-4350

carry sealing rockers. These maintain a broad contact with the recess wall, regardless of the angle of the vane, at any degree of rotation.

(2) DRIVE SHAFT SEAL. This self-alining seal provides conditions of allowable misalinement between the rotor and the engine driver. Fluid leaking by the clearance area between the rotor shaft and the bearing of the base assembly is retained by means of a sliding collar on the rotor shaft and the diaphragm attached to the sliding collar. This collar remains stationary and its seating face is held against a corresponding face on the rotor shaft by means of a compression spring. These two surfaces are flat and close enough together to prevent a serious fuel leak. The sliding collar is a loose enough fit on the rotor assembly shaft to permit a slightly different axis of rotation between the engine driver and the rotor shaft. The diaphragm is flexible and a leak-proof joint is formed between the sliding collar and the diaphragm by means of the diaphragm lock ring. The shaft seal lock ring exerts sufficient pressure against the outer portion of the diaphragm contacting the base to make a seal and prevent leaking between the diaphragm and the base.

(3) ENGINE OIL SEAL. A synthetic rubber ring fitted in a groove in the seal cap provides a means of keeping the engine oil out of the fuel pump.

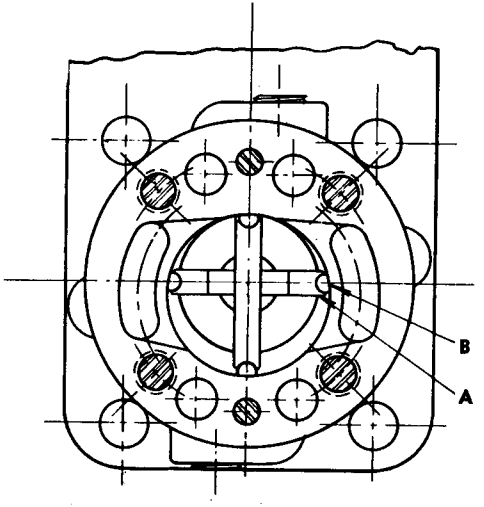
(4) FUEL AND OIL DRAIN. Fuel and engine oil which pass through their respective seals are drained from the base of the pump through a 1/8-inch pipe tapped hole in the base located behind and beneath the pump discharge line. Use an "L" shaped piece of hexagon bar stock 3/16-inch in diameter across the flats to remove this drain plug if it is present. *Do not replace the plug.*

(5) BASE ASSEMBLY. This assembly consists of a housing for the drive coupling and seals, and contains the rotor bearing. The exterior finished face of the housing carries the pilot and means of attaching the adapter plate. The adapter plate is provided with suitable spaced holes to permit the fuel pump to be attached to the engine accessory case. This assembly is lapped and doweled to the body and cover assembly to form a concentric unit.

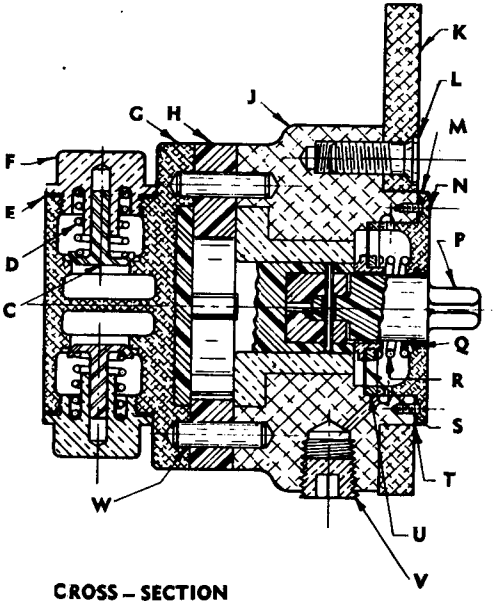
(6) BODY. The body is the center section of the pump and contains the rotor, blades and rockers.

(7) COVER ASSEMBLY. This assembly contains the relief valve assemblies, and the inlet and discharge ports for the pump.

(8) RELIEF OR BYPASS VALVES. These spring-loaded poppet valve assemblies are housed in the cover assembly. Their function is to prevent undue fluid pressure being built up within the pump



COVER - REMOVED



CROSS – SECTION

A — ROTOR BLADE
B — ROTOR ROCKER
C — RELIEF VALVE
D — VALVE SPRING
E — VALVE CAP GASKET
F — VALVE CAP
G — COVER ASSEMBLY
H — BODY
J — BASE ASSEMBLY
K — ADAPTER PLATE
L — ADAPTER PLATE ATTACHING SCREW
M — SHAFT SEAL CAP
N — SHAFT SEAL CAP ATTACHING SCREW
P — ROTOR AND DRIVE ASSEMBLY
Q — SHAFT SEAL CAP OIL SEAL
R — SHAFT SEAL SPRING
S — SHAFT SEAL ASSEMBLY
T — SHAFT SEAL CAP GASKET
U — SHAFT SEAL ASSEMBLY LOCK RING
V — SHAFT SEAL DRAIN PLUG
W — DOWEL PIN

RA PD 16858

Figure 110—Cross-Section of Romec Pump RB-4350

due to operating the pump against a severe restriction or a closed valve on the discharge line. Two valves are provided by the manufacturer, only one of which is operative for a given direction of rotation. When the discharge pressure exerts enough force against the poppet valve, the valve opens, connecting the pump discharge with the suction line, thereby limiting the discharge pressure of the pump.

163. ROMEC RB-4350 FUEL PUMP OPERATION AND INSPECTION ON THE VEHICLE (fig. 110).

a. Operation. Fuel enters through a passage to a depressed portion of the body adjacent to the recess wall. This forms a passage to the rotor and vanes, which carries the fuel around to the outlet side. Due to the eccentric mounting of the rotor and the shape of the recess wall, the passage is restricted here so that the fuel is forced through an outlet passage. A by-pass is provided so that if a restriction should occur on the outlet side of the pump, the fuel will be bypassed to the suction side of the pump. No adjustment is provided for pump pressure. No service is required except inspection for leakage. When leakage occurs or the pump fails to operate efficiently, replace or overhaul the pump.

b. Inspection on the Vehicle. The using arm personnel is responsible for checking the seal of the pump shaft for leaks every 25 hours of tank operation. To check the seal for leaks, proceed as follows:

(1) INSPECTION OF PUMP SHAFT SEAL. Remove the ⅛-inch pipe plug located behind the pump outlet line on the lower side of the base assembly if the plug is present. If fuel continues to drip out of this hole with the fuel tank valves open, the seal is defective and the pump must be replaced. If no leak is present, the seal is serviceable. *Do not* install the ⅛-inch pipe plug.

(2) INSPECTION OF PUMP FLOW AND MECHANICAL CONDITION. The following procedure outlines a method for making a rough check on the ability of the pump to deliver fuel and for determining the pump's mechanical condition without disassembly of the pump:

(a) Open fuel tank valves. (The tank should be ¾ full.)

(b) Disconnect the fuel pump discharge line.

(c) Remove the fuel pump from the engine accessory case.

(d) Facing the drive shaft of the pump, rotate it counterclockwise. If fuel flows and the drive shaft turns easily with no hard spots during its rotation, the pump is satisfactory. If the drive shaft turns hard or offers undue resistance during a portion of a complete revolution of the drive shaft, replace or overhaul the pump.

(e) Reverse the above sequence of operations to install a serviceable pump on the engine. Check the fuel lines for leaks upon completion of the job.

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164. ROMEC RB-4350 FUEL PUMP REMOVAL, DISASSEMBLY AND CLEANING.

a. Removal from Engine. Use the following procedure for removing the fuel pump from the engine:

(1) Close fuel tank valves.

(2) Using pliers, loosen the hose clamp on the discharge side of the pump. Pull the hose away from the pump fitting.

(3) Using three open-end wrenches having 5/8-inch, 11/16-inch and 3/4-inch openings, disconnect the swivel connector of the inlet fuel line of the pump. Use a 1/2-inch socket wrench with handle, and remove the palnuts and nuts from the studs attaching the pump to the engine accessory case. Remove the pump with gasket from the engine.

b. Disassembly (fig. 109). The following list names all the tools necessary to disassemble the pump:

Screwdriver
Vise, soft-jawed
Wrench, box, 9/16-in.

(1) REMOVE SHAFT SEAL ASSEMBLY FROM THE BASE ASSEMBLY.
Screwdriver

Clamp the adapter plate of the pump in a soft-jawed vise, with the drive shaft end up. Using a screwdriver, remove six seal cap-to-base attaching screws. Remove shaft seal cap and gasket from base. Remove the shaft seal spring from the rotor and drive group assembly. Using a small screwdriver, remove the shaft seal lock ring from the base, taking care not to injure the diaphragm of the shaft seal. Remove the shaft seal from the base.

(2) REMOVE BYPASS VALVES.
Wrench, box, 9/16-in.

Clamp the pump in a vise, equipped with soft jaws, cover side up. Using a 9/16-inch box wrench, remove two relief valve caps and gaskets from the cover. Remove two relief valve springs and valves from the cover assembly.

(3) REMOVE THE COVER ASSEMBLY.
Screwdriver

Mark the cover, body and base beside the relief valve, so that these parts may be assembled in their original position. Using screwdriver, remove the four fillister head screws with washers, the cover and body to the base. Using a soft hammer, tap lightly to separate the cover and body from the base. These three parts are doweled together, and extreme care must be taken to avoid damaging their lapped surfaces. When secured together, these surfaces are sufficiently flat and smooth to retain

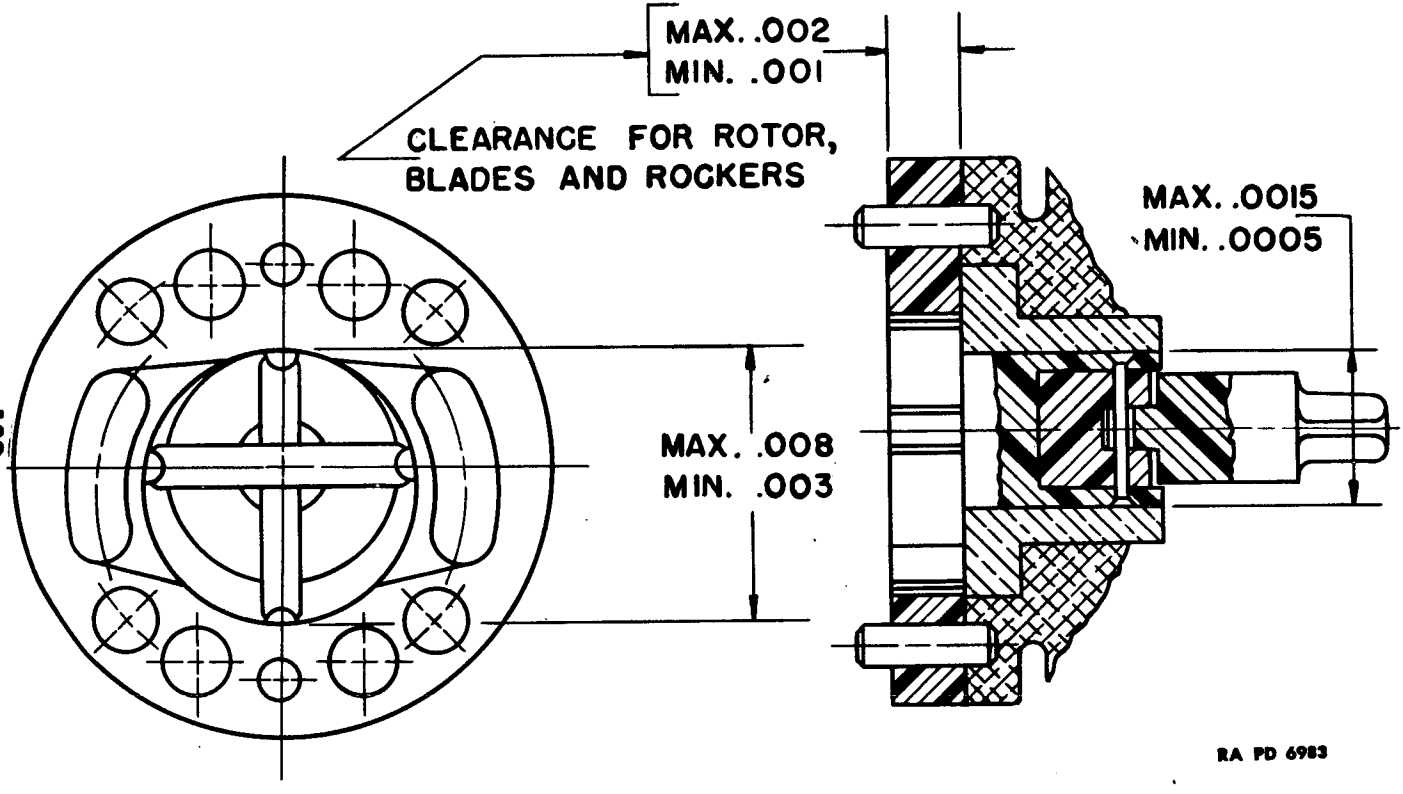


Figure 111—Clearance Diagram for Romec Fuel Pump RB-4350

fluid under pressure. Remove four rockers from the rotor and drive group assembly. Remove the dowel pins.

c. **Cleaning.** Using SOLVENT, dry-cleaning, clean and dry all the pump parts. Observing the caution note below, remove all burs that were caused in the process of disassembly. Remove all of the sealing cement from the lapped surfaces. CAUTION: The removal of any sharp corners from the internal parts of the pump will result in a loss of pump efficiency.

165. ROMEC RB-4350 FUEL PUMP INSPECTION AND REPAIR.

a. Replace the diaphragm if it is not fuel tight or if it has check marks on either side.

b. Replace the synthetic rubber oil seal in the seal cap.

c. Replace both the rotor and base if the clearance between the shaft of the rotor and the bearing of the base is greater than 0.0015-inch (fig. 113).

d. Replace the rotor if the sealing face (the surface that bears against the face of the shaft seal assembly) is excessively worn. If this sealing surface is only slightly worn, refinish it as follows:

(1) Clamp a piece of cast-iron stock one inch in diameter in the lathe chuck.

(2) Face off the end of the cast-iron piece to make a smooth flat surface that is square (90 degrees) with the axis of rotation of the chuck.

(3) Drill a hole through the stock approximately 0.010-inch larger than the drive shaft.

(4) Lap until smooth, using a very fine lapping compound.

(5) Add kerosene to the lap to polish.

(6) Wash the lap and finish with kerosene; then wash the parts with cleaning solvent to thoroughly remove every trace of the compound.

(7) If more than one rotor is to be lapped, repeat the facing operation on the cast-iron stock for each rotor.

e. **The Shaft Seal Assembly.** If the sealing face of this assembly is badly worn, replace it with a new one. If this sealing face is only slightly worn, use either of the following methods to refinish it:

(1) HOME METHOD.

(a) Mount a fine hone in the chuck of a lathe, with the flat surface of the stone perpendicular to the axis of rotation of the chuck.

(b) Rotate the stone with the engine of the lathe. Hold the sealing surface of the shaft seal against the stone, keeping the

flat surface of the stone lubricated with light oil. If the sealing surface of the shaft seal does not clean up in one minute, use the lapping procedure outlined in (3) below, to procure the desired sealing surface.

(2) NON-CHARGING LAPPING COMPOUND METHOD.

(a) Using grade H-41 fine non-charging Carborundum lapping compound, lap the sealing surface on a flat cast-iron plate. If the sealing surface does not "clean-up" in three minutes, wash the seal and the plate with SOLVENT, dry-cleaning and refinish the sealing surface on a lathe as outlined in (3) before proceeding with the lapping operations. The sealing surface must clean up before proceeding with the next step. If the sealing surface has cleaned up, wash the plate and seal with SOLVENT, dry-cleaning.

(b) Using the flat cast-iron plate, dry-lap the sealing surface until a high finish is obtained all the way over the entire sealing surface. Using SOLVENT, dry-cleaning, wash the plate and seal to remove all traces of the lapping compound. The seal is now ready for use.

(3) PREPARING SHAFT SEAL FOR LAPPING OR HONING.

(a) Clamp a short length of 9/16-inch brass rod in the chuck of a lathe, leaving about one inch projecting from the end of the jaws.

(b) Face off the end of the rod square with the axis of rotation of the chuck.

(c) Turn down the exposed portion of the rod until the seat with the sealing surface away from the chuck, can be forced on the rod by hand.

(d) Take a light cut across the sealing surface of the shaft seal of sufficient depth to clean up the surface.

(e) Remove the shaft seal from the shaft in the chuck, and repeat the honing procedure described under paragraph 165 e (1).

(f) The permissible tolerance between rotor blade rockers and the pump body is shown in figure 111. Use the following procedure to make this measurement:

1 Using a soft-jawed vise, clamp the mounting plate adapter in the vise with the base up.

2 Place the body on the base with the dowel pin holes and reference marks lined up correctly. Install the dowel pins, rotor, blades and rockers in the order mentioned. Using a feeler gage, measure the clearance between the bore of the body and the rockers of each blade with each blade in position as shown in the diagram. If the clearance is greater than 0.008-inch replace both the body and the four rockers. Use a depth micrometer to

measure the distance between the blades, rockers, and rotor and the face of the body that contacts the cover. If the distance is greater than 0.002-inch, replace the worn parts with new ones.

(g) The Cover Assembly Bearing. This bearing takes the end thrust of the rotor, blades and rockers. Replace the cover if it is worn more than 0.015-inch. If the bearing is worn more than 0.001-inch and less than 0.015-inch in depth measured with a depth micrometer from the face of the cover contacting the body, use the following procedure to refinish the contact face:

1 Using a surface grinder, take a cut of sufficient depth to clean up the bearing surface and make the face flat.

2 Use a cast-iron surface plate and a fine grade of lapping compound to hand-lap the surface. NOTE: This surface must be flat.

(4) RELIEF VALVES. The relief valve seating on the suction side of the pump should show no wear. If either relief valve leaks, replace the cover assembly and install new valves, springs and valve caps in the cover assembly.

166. ROMEC RB-4350 FUEL PUMP ASSEMBLY, TEST AND INSTALLATION.

a. Assembly. The following list mentions all of the tools necessary for this operation:

Pliers
Screwdriver
Wrench, box, 9/16-in.

(1) INSTALL COVER ASSEMBLY ON BODY AND THE BASE ASSEMBLY.

Pliers
Screwdriver
Wrench, box, 9/16-in.

Clamp the adapter plate of the pump in a soft-jawed vise, with the base up. Coat the lapped surfaces of the body with a very thin coating of shellac. NOTE: Assemble immediately after applying the shellac. Place body on the lapped surface of the base with the reference marks and dowel pin holes correctly lined up. CAUTION: In using the shellac do not permit any shellac to enter the pumping chamber. Lubricate the rotor, blades and rockers with engine oil. Install the dowel pins, rotor, blades and rockers in the body in the order mentioned. Place the cover on the body with the dowel pin holes and reference marks lined up correctly. Using a screwdriver, install the four fillister head screws with washers under their heads, attaching the body and cover to the base. Using pliers, safety-wire the four cover attaching screws in place. Install the relief valves and spring in the cover. Using a 9/16-inch box wrench, install the valve caps. Using pliers, safety-wire the valve caps.

(2) INSTALL SHAFT SEAL ASSEMBLY IN THE BASE ASSEMBLY. Screwdriver

Clamp the adapter plate in a soft-jawed vise, with the drive shaft end up. Place the shaft seal in the base with the sealing surface toward the rotor. Use a screwdriver to install the shaft seal lock ring in position in the base, being careful not to injure the diaphragm. Install the shaft seal spring in position. Use a new gasket and place the seal cap in position. Using a screwdriver, install the six screws attaching the seal cap to the base. If the pump rotor does not turn easily by hand or if there are any pronounced tight spots, disassemble the pump and correct the difficulty. Remove the shaft seal drain plug if it is present.

b. Test.

(1) DESCRIPTION OF TEST STAND. A test set-up is required as follows: a reversible, variable speed, driving unit for driving a fuel pump adapter. Fuel lines, in which are installed valves to control the fuel flow, run from a fuel tank to the pump adapter stand. Between the control valves in these lines and the pump port connections, are mercury manometer or gage connections; from which pressure readings can be taken. The gages and manometer, required for performance readings, are used on various tests; and these need not be considered as special equipment for a fuel pump overhaul. A flow-meter is also utilized for the tests, if it is available.

(2) BREAK-IN RUN. Place the pump on the test stand pump adapter, and break-in at 1,750 revolutions per minute for two hours. Use kerosene or Diesel fuel oil. Operate in the same direction of rotation as when on the engine. If the shaft seal leaks after the first hour of operation, dismantle and repair the pump. After the run-in, operate on gasoline for about ten minutes; then dry the pump out by disconnecting the lines and running for about five minutes. Blowing air into the ports by means of the air hose will help to dry the pump.

(3) DRY VACUUM TEST. The dry vacuum readings to be obtained from this test will indicate the condition of the pump, and are more reliable than capacity readings. If the vacuum readings are equal to or greater than the following, the pump is in good condition and is satisfactory for service until the next major overhaul; the reading taken with an accurate vacuum gage, or preferably a mercury manometer, connected to the suction port should be:

$3\frac{1}{2}$-inch of mercury inlet depression at 1,600 revolutions per minute.

$1\frac{1}{2}$-inch of mercury inlet depression at 400 revolutions per minute.

(4) SHAFT SEAL TEST. Open the lower drain boss in the base section during test. If the leakage is in excess of five drops per minute, remove the seal parts and correct the defective seal. If the seal is satisfactory, install the seal drain plug.

(5) STORAGE. If the pump is to be stored, fill the interior of the pump with lubricating oil and install plugs in all the openings of the pump.

(6) INSTALL LOCKING WIRE. Using pliers and a suitable size and length of locking wire, safety-wire both retainers and the six fillister head screws.

c. Installation in the Vehicle. Use the following procedure to install the fuel pump on the engine:

(1) Using a new gasket 1/64-inch thick, place in position on the engine accessory case.

(2) Place the fuel pump in position on the engine.

(3) Using a ½-inch socket wrench with handle, install four nuts and palnuts on the accessory case studs to secure the pump to the engine.

(4) Using three open-end wrenches of ⅝-inch, 11/16-inch and ¾-inch openings, connect the swivel connector of the inlet fuel line to the inlet side of the pump.

(5) Slip the hose of the pump discharge line over the fitting screwed in the pump discharge. Place the hose clamp in position and use pliers to tighten clamp on the hose.

(6) Remove the shaft seal drain plug.

(7) Open fuel tank valves and inspect for leaks.

167. GENERAL DESCRIPTION OF GOVERNOR.

a. The engine driven governor on the Guiberson T-1020 engine is a protective overspeed control device which prevents the engine from being operated above the top speed for which the governor has been set. It protects the engine from damaging or destructive overspeeds. An adjusting screw regulates the maximum speed at which the engine can be run by making it possible to change the speed at which the governor goes into operation.

b. Construction (figs. 112 and 113). The governor mechanism is enclosed in an aluminum housing which is divided into two parts, the governor bearing housing and the governor body. The action of the governor depends upon the position of two centrifugal weights fastened by means of a spider to the main or spider shaft. A thrust sleeve and thrust collar transfer the action of the weights to a yoke on the rocker shaft. On the serrated end of the rocker shaft is clamped a throttle lever. A spring opposes the action of the weights and thrust sleeve and collar, and the amount of this opposition is increased or decreased by turning the governor adjusting screw located at the end of the governor

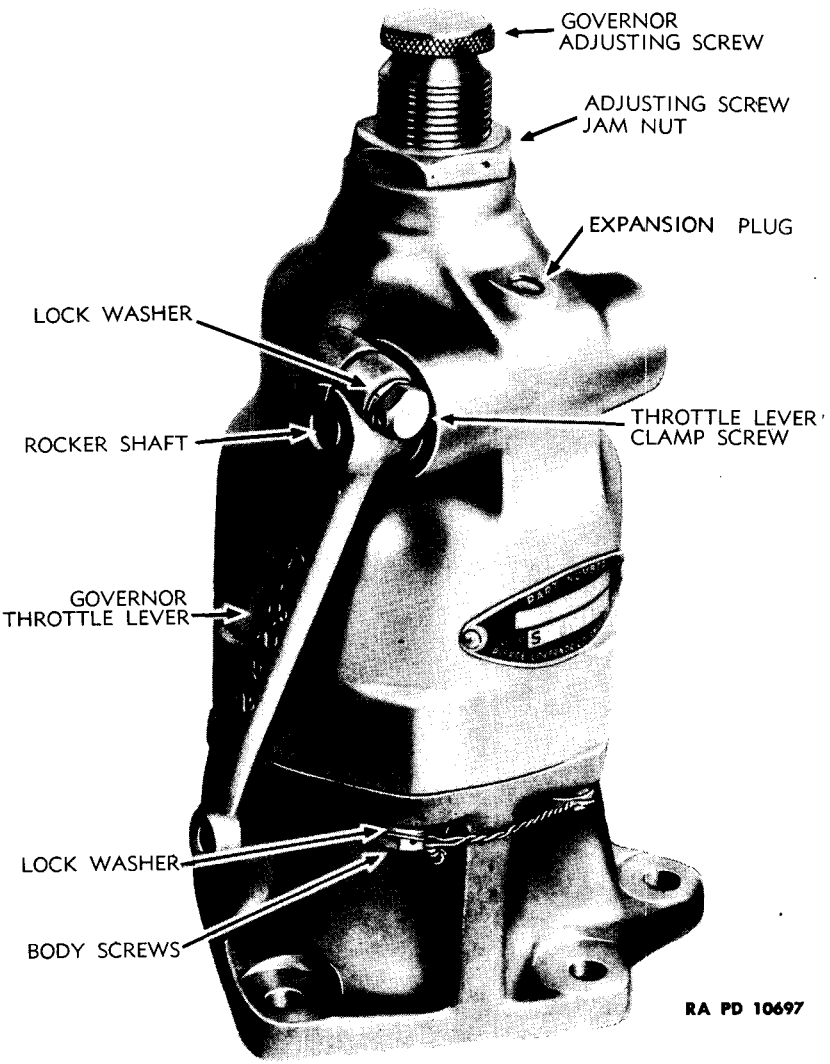


Figure 112—The Governor Assembled

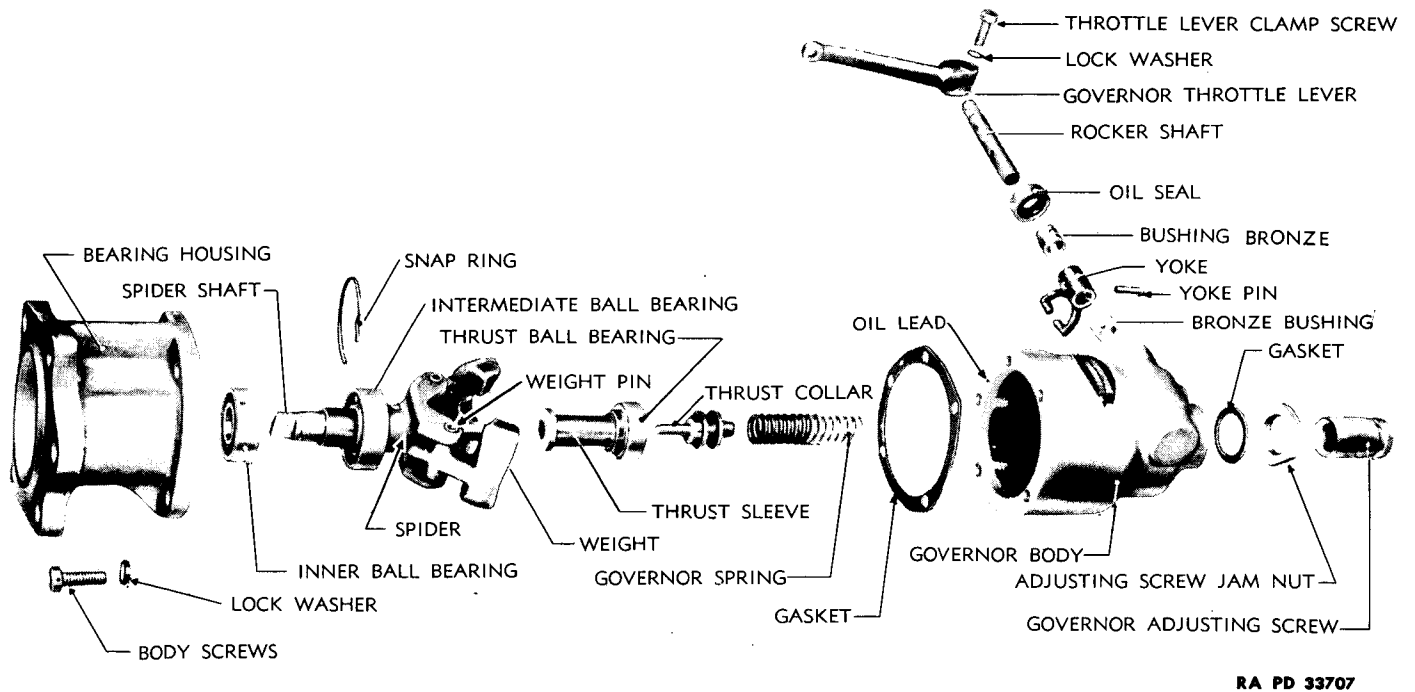


Figure 113—The Governor Disassembled

body. Two ball bearings support the shaft and sleeve mechanism, one at the inner end of the spider shaft, and an intermediate bearing on the inner end of the spider. A thrust ball bearing is pressed on the end of the thrust sleeve. Two bronze bushings provide bearings for the rocker shaft. An oil seal is provided in the rocker shaft hole in the governor body section. The governor is pressure lubricated from the engine, with oil entering through oil leads in the housing and body sections and returning through an oil port at the bottom of the housing section.

c. **Operation.** When the engine is being operated below the speed for which the governor is set, the centrifugal weights are not thrown outward with enough force to counteract the action of the governor spring. Thus the throttle lever is not moved, and manual regulation of the engine speed is unaffected. As the engine speed is increased, however, the outward thrust of the weights pushes the weight noses against the thrust sleeve with greater and greater force until the resistance of the spring is overcome. The weights can then swing farther outward as the weight noses push the thrust sleeve and the thrust collar toward the outer end of the governor. Since the end of the yoke on the rocker shaft rides in the thrust collar, it is also moved back, turning the shaft, and thus moving the governor throttle lever. A governor control rod transmits the governor action to the throttle linkage and prevents any further increase of engine speed regardless of any further advance of the manual throttle. A slip joint in the governor control rod permits independent movement of the manual throttle control at any engine speeds below the top governed speed, giving the governor an overspeed control only. Reduction in engine speed decreases the centrifugal force of the weights and causes them to swing inward. This moves the governor throttle lever and control rod, permitting the engine throttle to be opened further by the manual control. Since the action of the governor depends upon the ability of the centrifugal weights to overcome the resistance of the governor spring, the more compression on the spring, the faster the engine will be allowed to go. The adjusting screw increases or decreases spring compression and thus accurately regulates the speed by which the governor limits the engine revolutions per minute.

168. ADJUSTMENTS OF GOVERNOR ON ENGINE.

Ordnance personnel is responsible for engine driven governors. The required setting for the governor adjusting screw must be made with the engine running. With the adjusting screw jam nut loosened, the adjusting screw is turned clockwise to increase the governed engine speed, and turned counterclockwise to reduce it. After the screw is turned to produce the desired tachometer reading *at full throttle,* the jam nut is tightened and the locking wire put into place and sealed. Before setting the governor adjusting screw, the governor control rod should be checked for free play. There should be approximately ¼-inch free play in the slip joint to prevent governor interference with manual engine speed regulation below the top governed speed. Free play can

be increased or decreased by turning the threaded ends of the rod in or out of the ball and socket connectors at either end. Safety-wire adjusting screw.

169. TROUBLE SHOOTING OF GOVERNOR ON VEHICLE.

If the governor fails to hold the engine speed to the desired revolutions per minute, check the linkage for any obstructions or connections that bind. Check the governor control rod for excessive free play. Check adjusting screw to see if the jam nut has become loose, thus allowing the adjustment to become changed. If governor cuts in too early, check governor control rod for lack of free play. Disconnect control rod and test governor throttle lever action. Lack of resistance will indicate a weak or broken spring. NOTE: If engine cannot be started in cold weather, it may be due to the governor control rod being frozen in decompression position. This can happen only if control rod has been installed with the tube at the bottom. Remove the control rod, free it, and install in the proper position, with the tube at the top.

170. REMOVAL OF GOVERNOR FROM ENGINE.

See Paragraph 50.

171. DISASSEMBLY OF GOVERNOR.

a. Equipment.

Block, wooden, 1-in. x 1-in. x 2-in.
Block, wooden, 1¾-in. x 1¾-in. x 4-in. with a ½-in. diameter hole bored through one of the 1¾-in. faces
Blocks, wooden, each 1¾-in. x 8-in. x 8-in., two
Chisel, cold, small
Cylinder, thrust sleeve support
Drift
Drift, aluminum
Drill
GREASE, general purpose, seasonal grade
Hammer
Pliers, cutting
Press, arbor
Press, drill
Punch, pin
Screwdriver
SOLVENT, dry-cleaning
Spacer
Wedge
Wheel, grinding
Wrench, open-end, 7/16-in.
Wrench, open-end, 1⅜-in.

b. Procedure.

(1) REMOVING GOVERNOR SPRING.

Wrench, open-end, 1⅜-in.

Set the governor on the bench, bearing housing down. Loosen the adjusting screw jam nut at the end of the governor body. Then unscrew and remove the adjusting screw and the nut. Lift out the governor spring.

(2) SEPARATE GOVERNOR HOUSING AND BEARING HOUSING.

Pliers, cutting
Wrench, open-end, 7/16-in.

Remove the safety wire from the five governor body cap screws (cutting pliers). With a 7/16-inch open-end wrench, un-

screw the five cap screws and remove them along with the lock washers under their heads. Lift off the governor housing and remove the gasket.

(3) REMOVE SPIDER AND SHAFT ASSEMBLY FROM LOWER BODY SECTION.

Block, wooden, 1-in. x 1-in. x 2-in.
Blocks, wooden, each 1¾-in. x 8-in x 8-in., two
Hammer
Screwdriver

Removing the governor body exposes the spider and shaft assembly which is held in place in the bearing housing by a snap ring (locking ring) in a groove in the bearing housing above the top of the intermediate ball bearing. Lift off the thrust collar and thrust sleeve with thrust bearing. With a screwdriver, pry the snap ring out of its slot in the bearing housing. Invert the bearing housing and place it on two wooden blocks each 8 inches high. Then with a wooden block (dimensions 1-in. x 1-in. x 2-in.) and a hammer, drive the spider and shaft assembly out of the bearing housing along with the inner ball bearing and the intermediate ball bearing. Slip the inner ball bearing off the spider shaft.

(4) CLEANING. Wash all parts with SOLVENT, dry-cleaning.

(5) REMOVE GOVERNOR WEIGHTS FROM YOKE.

Block, wood, 1¾-in. x 1¾-in. x 4-in. with a ½-in. diameter hole bored through one of the 1¾-in. faces.
GREASE, general purpose, seasonal grade
Hammer
Punch, pin
Wheel, grinding

Do not remove the governor weights except to replace weight pins or weights. If an excessive amount of play is evident between the weights and pins, replace both. When removing the weights, be sure to cover both faces of the intermediate ball bearing with grease to prevent dirt and particles of abrasive from getting into the bearing. Then grind off the ends of the weight pins on a grinder wheel. (Be careful not to damage the assembly with the grinder.) Place the spider on a block of wood, the weight pin directly over the hole in the block (dimensions 1¾-in. x 1¾-in. x 4-in. with a ½-in. hole bored through one of the 1¾-in. faces). With a pin punch and a hammer, drive each of the two weight pins down through the hole in the block of wood and out of the spider. This releases the weights which can be removed.

(6) REMOVE ROCKER SHAFT.

Drift, aluminum
Hammer
Punch, pin

Inspect the contact points of the rocker yoke and the amount of play between the rocker shaft and bushings. Do not remove the rocker shaft from the governor body except for one of the

following reasons: Worn contact points of the rocker yoke, leaking oil seal, excessive play between the rocker shaft and bushings, damaged rocker shaft or rocker yoke. Using pin punch, punch through the large opening of the governor body, drive out the tapered pin that fastens the rocker yoke to the rocker shaft. This pin will push the expansion plug (fig. 112) out of the way and may be removed through the hole thus exposed. Tap the rocker shaft out of its bearings by tapping against the throttle lever as close to the shaft as possible. Use an aluminum drift and a hammer. Then reach inside the governor body and remove the rocker yoke.

(7) REMOVE OIL SEAL AND ROCKER SHAFT BRONZE BUSHINGS.

Chisel, cold, small	Hammer
Drift	Press, drill
Drill	Screwdriver

If the rocker shaft bronze bushings are worn, they should be removed as follows: Pry out the oil seal and, with a drift or driving tool, drive the outer bronze bushing down through the rocker shaft hole and into the inside of the governor body. Remove the bushing from the body. Drill out the inner bushing, being careful not to remove any of the aluminum casting (drill, drill press). Collapse the bushing with a hammer and small chisel and remove it from the body.

(8) REMOVE THROTTLE LEVER.

Pliers, cutting	Wrench, open-end, 7/16-in.
Wedge	

If it is necessary to install a new rocker shaft, the throttle lever can be removed from the shaft by removing the locking wire from the clamp screw and using a 7/16-inch open-end wrench to loosen and remove the screw and lock washer. The shaft can now be driven out of the lever, or it can be released by forcing open the jaws of the lever with a wedge. As soon as the governor is completely disassembled, wash all parts with clean SOLVENT, dry-cleaning. After washing, dry with compressed air. Clean the oil leads in both aluminum castings with compressed air.

172. INSPECTION AND REPAIR OF GOVERNOR.

a. General. All defective parts on the governor are replaced by new or serviceable parts.

b. Shaft with Spider Assembly. If the intermediate bearing or any part of this assembly is defective, use a new assembly consisting of the bearing, governor spider shaft, and spider.

c. Thrust Collar. Examine the groove of the thrust collar in which the contact points of the rocker yoke operate. The surface of this groove is case-hardened to a depth of 0.010-inch. If this surface is appreciably

worn at the places in which the rocker yoke operates, replace the defective thrust collar with a new one.

d. Rocker Yoke. The points of the rocker yoke which fit in the groove of the thrust collar are cyanided for hardness. Replace the rocker yoke before the hard shell of the metal is worn through.

e. Governor Body and Housing. Examine these aluminum castings for cracks and defective threads. If these castings are defective, replace them with serviceable ones.

f. Oil Seal. Always use a new oil seal if the rocker shaft has been removed.

g. Rocker Shaft and Bushings. Replace all of these parts if any are defective.

h. Governor Spring. If the governor spring is broken, distorted, or has taken a "set," replace it with a new spring.

i. Ball Bearings. Clean and lubricate each ball bearing. Spin each bearing to determine whether it runs smoothly or roughly. Do not spin by applying compressed air to the bearing. With the fingers, press the races of each of the spider shaft bearings in opposite directions to determine the amount of end play in the bearings. If any bearing is rough-running or the spider shaft bearing has an exceptional amount of end play, replace the defective bearing with a new one.

173. ASSEMBLY AND INSTALLATION OF GOVERNOR.

a. Assembly. The following list names the tools necessary to assemble the governor:

Block or anvil, riveting	Punch, pin
Drill, No. 27	Reamer, straight, 7/16-in.
Driver, bearing	Reamer, taper, No. 1
Driver, special bearing	Screwdriver
Hammer	Scriber
Hammer, ball peen	Spacer
Hammer, fiber	Tool, expansion plug seating
Pliers	Wedge
Press, arbor	Wrench, open-end, 7/16-in.
Press, drill	Wrench, open-end, 1⅜-in.

(1) INSTALL NEW ROCKER SHAFT BRONZE BUSHINGS.

Press, arbor
Reamer, straight, 7/16-in.
Spacer

If the rocker shaft bronze bushings have been removed, install new bushings. With an arbor press, press a new inner rocker shaft bronze bushing into place. Insert a steel spacer over the exposed end of the inner bushing, which is 1/32-inch wider than the width of the part of the yoke through which the rocker shaft passes. Press a new outer bushing in place (contacting

the spacer). Remove the spacer. Check the alinement of the bushings by inserting the rocker yoke in place, and adjusting the bushings so the contact points of the rocker yoke are equidistant from the axis of rotation of the thrust collar. Line-ream both bushings (7/16-in. straight reamer). Make the clearance between the rocker shaft and bushings. Install the oil seal (arbor press). If a new rocker shaft is used, proceed with step (2) and omit step (3).

(2) INSTALL NEW ROCKER SHAFT.

Drill, No. 27	Punch, pin
Hammer	Reamer, taper, No. 1
Hammer, fiber	Scriber
Press, drill	Tool, expansion plug seating

Scribe a line around the rocker shaft 31/32-inch from the plain end of the shaft (scriber). Insert the rocker shaft, plain end first, into the outer bronze bushing of the governor body and line up the shaft hole of the yoke with the shaft. Tap the shaft into position (fiber hammer). Rotate the rocker yoke until the drilled hole in the yoke for the tapered pin is visible from the expansion plug hole in the governor body. Adjust the rocker shaft on the rocker yoke until the scribed line on the shaft is in the middle of the tapered pin hole of the rocker yoke. Drill a hole through the shaft and opposite side of the rocker yoke (drill press, No. 27 drill). Ream this hole (No. 0 taper reamer). Remove chips (compressed air). Install a new No. 0 taper pin (hammer, pin punch). Install a new expansion plug in the governor body (expansion plug seating tool, hammer). Omit step (3). NOTE: The rocker shaft must turn freely.

(3) INSTALL ORIGINAL ROCKER SHAFT IN GOVERNOR BODY.

Hammer	Punch, pin
Hammer, fiber	Tool, expansion plug seating

Insert the rocker shaft, plain end first, into the outer bronze bushing of the governor body. Insert the rocker yoke into the body and line up the shaft hole of the yoke with the shaft. Tap the shaft into position (fiber hammer). Rotate the rocker yoke until the larger drilled hole in the yoke is visible from the expansion plug hole in the governor body. Adjust the rocker shaft so the hole in the shaft is in alinement with the holes in the rocker yoke. Install a new No. 1 taper pin in this hole (pin punch, hammer). Install a new expansion plug in the governor body (hammer, expansion plug seating tool). NOTE: The rocker shaft must turn freely.

(4) ATTACH GOVERNOR WEIGHTS ONTO SPIDER.

Block or anvil, riveting	Hammer, ball peen

Install one of the weights in position in the spider and insert a new weight pin through the spider and weight. Support one end of the pin on a riveting block or anvil and flare the exposed

end of the pin (ball peen hammer). Repeat this process for the opposite end of the pin. NOTE: The weights must move freely.

(5) INSTALL SHAFT WITH SPIDER ASSEMBLY IN BEARING HOUSING.

Driver, bearing	Hammer
Driver, special bearing	Screwdriver

Place the bearing housing on the bench, mounting flange down. The maker's name of the bearing is installed towards the mounting flange of the bearing housing. Install the inner bearing (bearing driver and hammer). It may be necessary to make a cylinder of steel of the following dimensions: 0.375-inch I.D., ½-inch O.D., 3 inches long and square on the ends. Insert this tool over the governor spider shaft, place shaft in position, and install shaft in bearing housing (hammer and special driver). Install the snap ring in its groove in the bearing housing (screwdriver). Remove the special bearing driver.

(6) JOIN BEARING HOUSING TO GOVERNOR BODY.

Pliers	Wrench, open-end, 7/16-in.

Examine the oil lead in the bearing housing to make sure that it is clear. Place a gasket on the flange of the bearing housing that attaches to the governor housing, being sure that the screw holes and oil lead in the gasket are in alinement with those in the housing. Slip the thrust sleeve in position on the governor shaft, ball bearing end away from the spider and plain end resting against the weight pads. Then slip the small end of the thrust collar into the hole in the outer end of the thrust sleeve. Examine the oil lead in the governor housing to be sure the opening is clear. Assemble the governor body to the bearing housing, tilting the governor housing and manipulating the end of the rocker shaft so that the fork of the rocker shaft yoke enters the groove of the thrust collar. Position the two castings so that the oil hole in each housing and the oil hole in the gasket are all in alinement. Put a lock washer on each of the five body cap screws; screw them into place and tighten (7/16-in. open-end wrench). Secure the heads of the body cap screws with safety wire (pliers).

(7) INSTALL GOVERNOR SPRING IN GOVERNOR BODY.

Wrench, open-end, 1⅜-in.

Slip the governor spring through the opening on the end of the governor body and into position on the end of the thrust collar. Install lock nut and gasket in place on the spring adjusting screw and turn the screw into place with the fingers. Screw down the locking nut with the fingers and tighten it with a 1⅜-inch open-end wrench.

(8) INSTALL GOVERNOR THROTTLE LEVER ON ROCKER SHAFT.

Hammer	Wedge
Pliers	Wrench, open-end, 7/16-in.

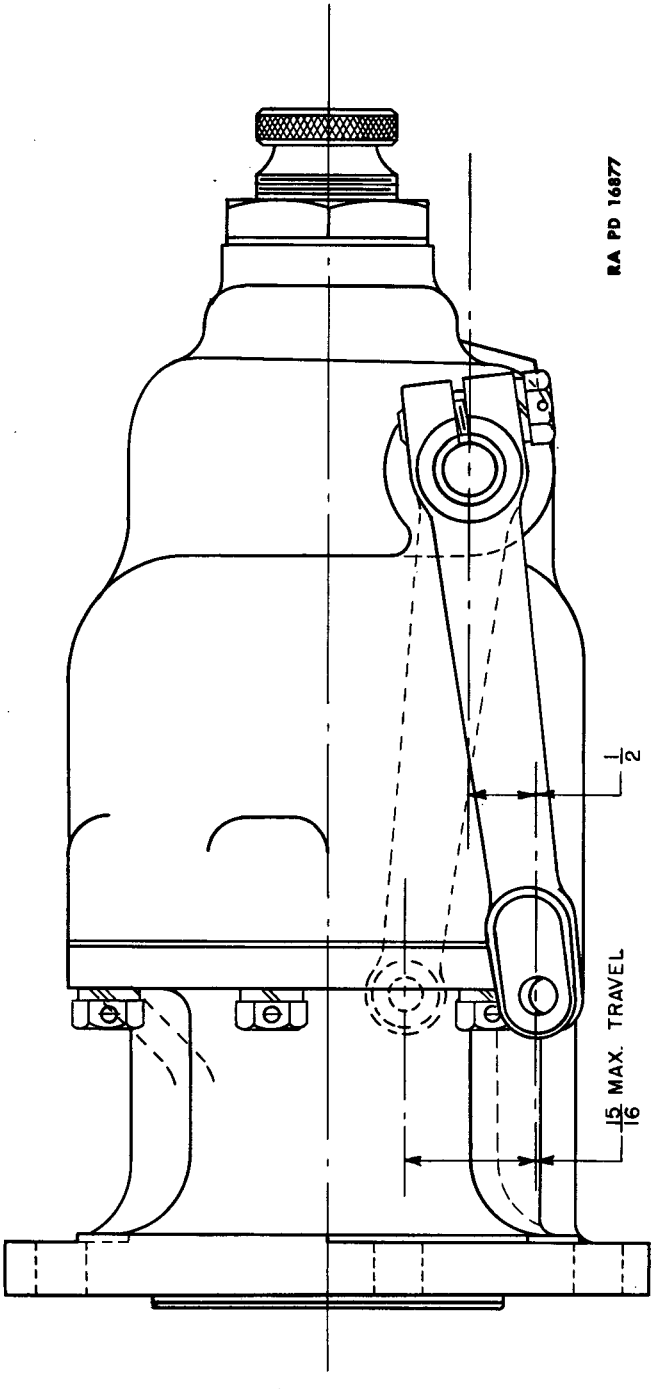


Figure 114—Position of Governor Throttle Lever

Place the governor on the bench, mounting flange of bearing housing down. Spread the jaws of the throttle lever clamp far enough for it to slip onto the serrated end of the rocker shaft (hammer, wedge). Install the lever on the rocker shaft (fig. 114). Remove the wedge, install and tighten clamp screw, install safety wire (7/16-in. open-end wrench, pliers).

b. **Installation.** Refer to paragraph 147.

174. INSTALLATION OF THROTTLE CONTROLS.

Refer to paragraph 144.

175. GENERATOR.

Refer to TM 9-1750D.

176. STARTER.

Refer to TM 9-1726E.

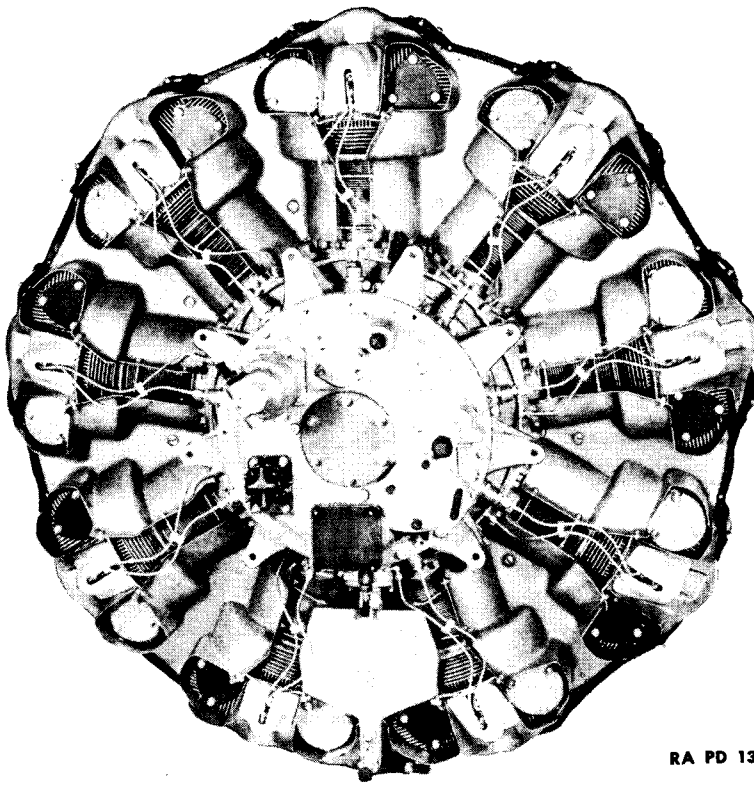
Section VIII

PREPARING THE ENGINE FOR STORAGE

177. STORAGE PROTECTION PROCEDURE (fig. 117).

a. Rust Preventive.

(1) To maintain the engine in good condition, and to guard against corrosion, an engine should be properly prepared before it is placed in storage. If the engine is not to be overhauled before it is stored, it should be operated for 15 minutes on fuel containing ten percent OIL, lubricating, preservative, medium, and with 100 percent OIL, lubricating, preservative, medium, circulating through the engine lubricating system.



RA PD 13276

Figure 115—All Openings and Ports Should be Plugged

(2) After shutting down the engine, remove it from the tank. All openings and ports in the engine should be covered with plugs, as shown in figure 115, to prevent dirt or foreign materials from

entering the engine. It should be thoroughly cleaned with SOLVENT, dry-cleaning, brushes, and soft point scrapers over a drip pan and with the aid of compressed air. Remove the injectors and pour OIL, lubricating, preservative, medium, into the combustion chambers, and crank the engine two or three times. Spray OIL, lubricating, preservative, medium, on the unpainted portions of the engine exterior.

b. Accessories. The engine accessories should be removed from the engine and given a rustproofing treatment, then stored separately.

c. When Engine is to be Overhauled. If the engine is to be overhauled before placing in storage, follow the procedure given in sections III, IV, V and VI of this manual. When the engine is reassembled, the precautions against corrosion given above should be followed.

d. Storage.

(1) The engine should be supported by the engine mounting beam or blocked on wood in closed storage where it will not be damaged.

(2) The engine should be inspected every two or three months, and if necessary should be reslushed to protect against corrosion.

(3) Each engine should carry a tag on which is entered any important information suggested by the following:

(a) Name of vehicle from which engine was removed or for which it was built.

(b) Name of manufacturer of engine.

(c) Bore and stroke.

(d) Manufacturer's type or model symbol.

(e) Manufacturer's serial number.

(f) Government purchase number if purchased as a separate unit and not removed from a complete vehicle.

(g) United States number of vehicle from which removed.

(h) Date placed in storage.

(i) Conditions—as new stock, rebuilt, overhauled, needs overhaul, needs repairs of_____parts; robbed of_____ parts.

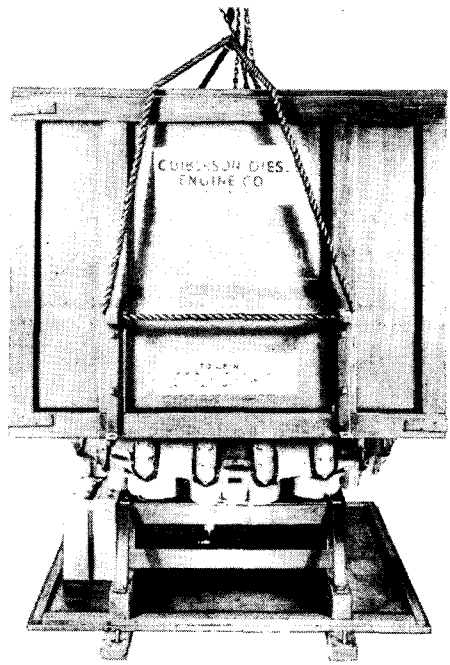
(j) If O.K. (as new or rebuilt), initials of inspector and date.

(k) Dates of subsequent periodical inspections and initials of inspectors.

(l) Any other information likely to be desired.

Section IX

REMOVAL OF ENGINE FROM SHIPPING CRATE



RA PD 13277

Figure 116—Removing the Shipping Crate Cover

178. REMOVING THE SHIPPING CRATE (figs. 116, 117, and 118).

a. Equipment.

Eye, lifting, GU-GST-1550 Pliers
Hoist

b. Procedure. NOTE: The engine is shipped from the factory in a shipping crate. Accessories are packed separately and must be installed after the engine is removed from the crate.

(1) REMOVE THE COVER.
Hoist

The engine is bolted to a platform which is attached to the bottom of the shipping crate. To remove the engine, first lift off the cover. This consists of all the sides and the top, which make up a unit. The cover can be lifted off by a man at each corner, or with a hoist. Remove the two bolts and nuts at each end which hold the cover to the base of the shipping crate. If

a hoist is used, pass a rope under the lifting hooks at each end and form a sling, as shown in figure 116. Raise the cover straight up until the engine is cleared.

(2) REMOVE ENGINE FROM CRATE PLATFORM.

Eye, engine lifting, GU-GST-1550 Pliers
Hoist

(a) The engine is bolted to the platform through the engine mounting flange. Remove these bolts.

FLYWHEEL NUT TAPED RA PD 13278

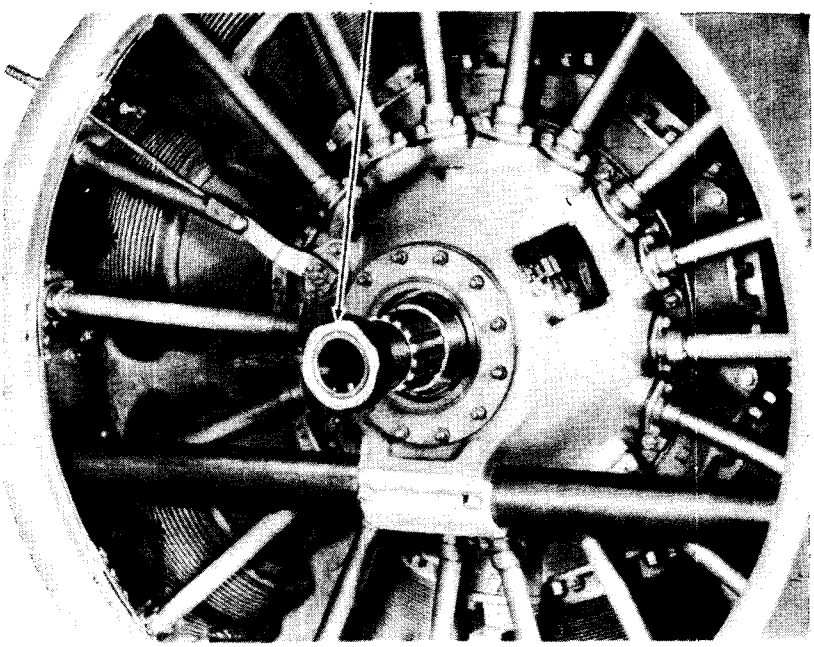
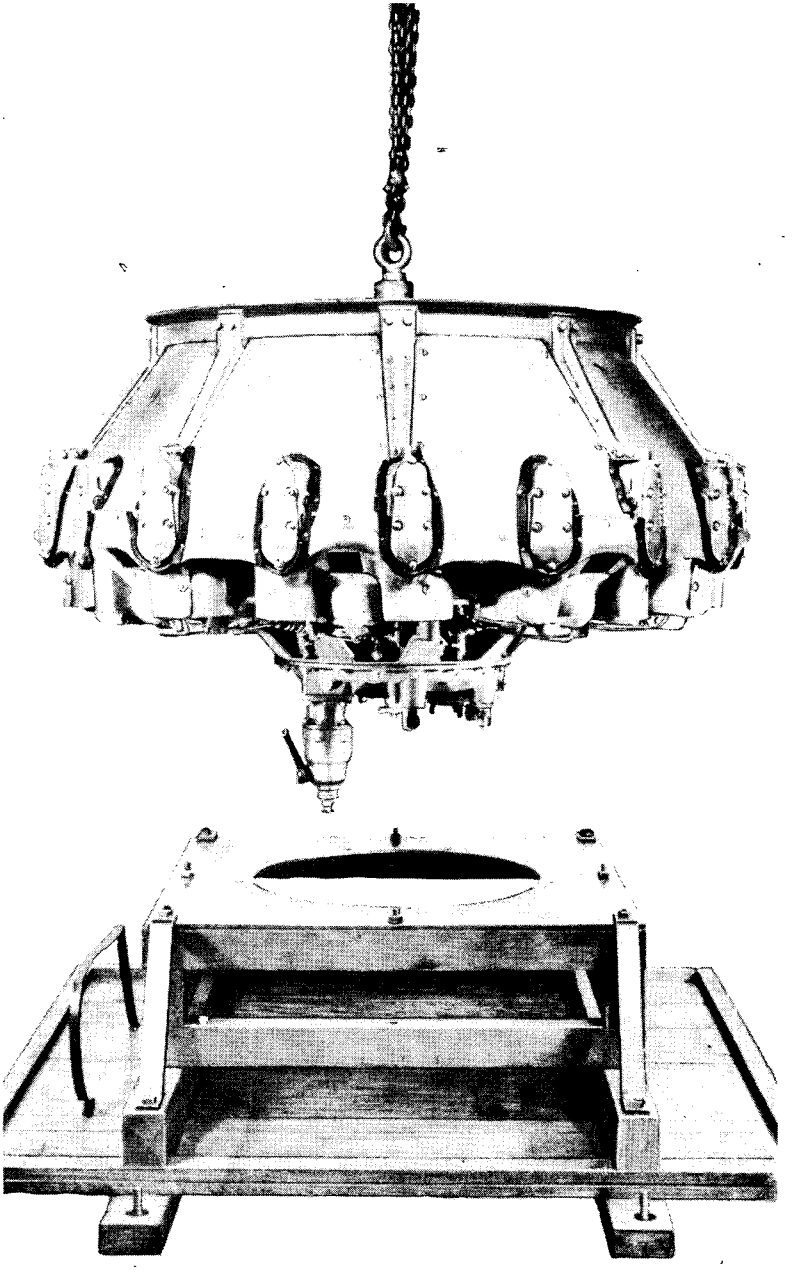


Figure 117—Flywheel Nut and Cone Are Taped to Crankshaft

(b) The engine is shipped with the flywheel nut and cone installed on the crankshaft, taped to hold the cone in place. Remove the tape and lift out the two halves of the front cone. Cut the safety wire from the lock pin through the nut and lift out the lock pin. Remove the flywheel nut and install a lifting eye GU-GST-1550 on the front crankshaft. Lift the engine off the platform with a hoist, being careful that all parts of the accessory case clear the platform.

REMOVAL OF ENGINE FROM SHIPPING CRATE



RA PD 13279

Figure 118—Lifting the Engine from the Shipping Crate

179. ASSEMBLING THE ENGINE.

a. Equipment.

Hoist	Wrench, open-end, 1/2-in.
Pliers	Wrench, open-end, 9/16-in.
Stand, banjo mounting	Wrench, open-end, 5/8-in.
Wrench, flywheel hub nut, GU-GST-1554	Wrench, open-end, 3/4-in.
Wrench, open-end, 7/16-in.	Wrench, socket, 7/16-in.
	Wrench, socket, 1/2-in.

b. Procedure.

(1) INSTALL THE EXHAUST MANIFOLDS.

Wrench, open-end, 1/2-in.

The exhaust manifolds must be replaced before the banjo is installed. Place a new exhaust manifold gasket over the studs of each exhaust elbow. The sections of the exhaust manifolds are of different shapes and each section must be installed at the proper cylinder. Place all of the sections together before bolting any of them to the exhaust elbows. When all of the sections are together and on the exhaust elbows, bolt down with lock washers and brass nuts. Attach a paper with adhesive tape over the ends of the manifold to prevent anything from falling in.

(2) PLACE THE ENGINE ON THE BANJO MOUNTING STAND.

Hoist	Stand, banjo mounting
Pliers	Wrench, open-end, 5/8-in.

Lower the engine onto the engine mounting beam in the stand, with the flat side of the engine mounting beam up toward the engine. Lower the accessory case of the engine through the beam opening. Push the bolts through the bolt holes in the engine mounting flange and beam, using a flat washer at both the bolt head and nut. Tighten the nuts securely, using a 5/8-inch open-end wrench. Line the cotter pin openings in the bolt and nut, and insert them. Remove the plugs and tape from all the openings in the engine.

(3) INSTALL THE FLYWHEEL (fig. 119).

Pliers	Wrench, flywheel hub nut, GU-GST-1554

NOTE: Before installing the flywheel be sure that the cones on each side of the hub are perfectly smooth and free from rust. Also be sure that the front crankshaft is clean and smooth.

(a) Coat the inside of the brass cone with GREASE, general purpose, seasonal grade, and slide it on the front crankshaft with the tapered side out.

(b) The flywheel can be installed with the front of the engine facing upward, as shown in figure 119, or with the engine in a vertical position. Slide the flywheel onto the front crankshaft.

REMOVAL OF ENGINE FROM SHIPPING CRATE

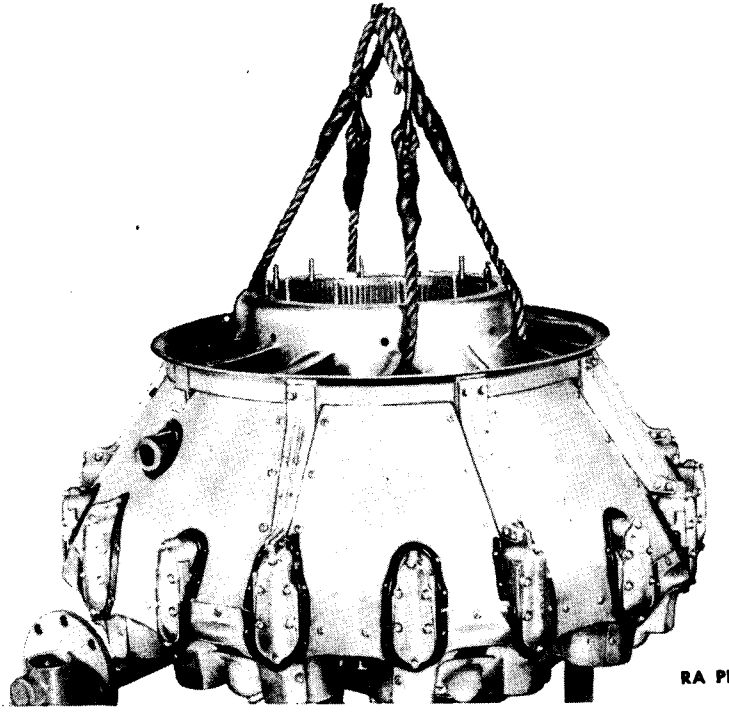


Figure 119—Installing the Flywheel

(c) Place the two halves of the front cone in the flywheel nut, so that the tongue in the cone is inserted into the groove in the nut. Hold them in this position until the nut is turned in far enough for the flywheel hub to support them. Then tighten the nut using the flywheel hub wrench GU-GST-1554.

(d) The flywheel should be centered in the fan shroud assembly. If it is not, the fan shroud will have to be shifted to provide equal clearance.

(e) Insert the locking pin through the holes in the nut and the front crankshaft from the inside, and safety-wire it in position, wrapping the wire around the groove in the nut.

(4) INSTALL THE THROTTLE CONTROLS.

Pliers	Wrench, open-end, 9/16-in.
Wrench, open-end, 7/16-in.	Wrench, open-end, 3/4-in.

Slide the throttle control shaft lever over the throttle shaft and install the washer and nut (3/4-in. open-end wrench). Insert a cotter pin to lock the nut. Tighten the clamp bolt (7/16-in. open-end wrench) with a flat washer and lock washer underneath. Using a 9/16-inch open-end wrench, tighten the throttle control shaft adjusting screw to rest on the idle control lever. Use a 7/16-inch open-end wrench to install the governor control

tube. One end is attached to the throttle control lever and the other to the governor.

(5) INSTALL THE FUEL PRESSURE REGULATOR.

Wrench, open-end, 7/16-in. Wrench, socket, ½-in.
Wrench, open-end, ½-in.

The fuel pressure regulator is connected to a short section of hose above the accessory case, and is attached to the engine mounting beam by means of a clamp and two bolts (½-in. socket wrench). A fitting is used to connect the hose to the clamp, in which the regulator is installed. The fuel pressure regulator line extends from the regulator to the fuel return ring and is held in place by nuts (7/16-in. open-end wrench) at regulator end and (½-in. open-end wrench) at return line.

(6) INSTALL THE FUEL SUPPLY PUMP.

Wrench, socket, ½-in.

Turn the engine perpendicularly. Use a new gasket and place the fuel supply pump on the mounting studs of the accessory case and replace washers, nuts and palnuts.

(7) INSTALL THE GOVERNOR.

Wrench, socket, ½-in.

Use a new gasket and place the governor in position on the studs of the accessory case. Replace the flat washers, nuts and palnuts.

(8) INSTALL THE OIL PUMP.

Pliers Wrench, socket, ½-in.

Place the oil pump on the mounting studs and install washers, nuts and palnuts (½-in. socket wrench). Safety-wire through the dome of the oil pressure regulator and one of the holes of the packing nut of the oil filter.

(9) INSTALL THE STARTER.

Wrench, open-end, 9/16-in.

Use a new gasket and install the starter on the mounting studs with the ports up. Replace washers and elastic stop nuts.

(10) INSTALL THE GENERATOR.

Pliers Wrench, socket, 7/16-in.
Wrench, open-end, ½-in. Wrench, socket, ½-in.
Wrench, open-end, ⅝-in.

(a) Install the generator on the mounting studs, using flat washers, nuts and palnuts (½-in. open-end wrench).

(b) The generator is braced by a clamp around it, which is attached to the engine mounting beam by two arms. Remove the window strap from the generator and install the two halves of the clamp just in back of the strap position, with the brackets

up. Use flat washers at both bolt head and elastic stop nut (7/16-in. socket wrench).

(c) Install the long tie rods, with the clevis at the lower ends straddling the brackets on the clamp. The flat strap that encircles the starter is placed next to the clevis, on the inside. Then insert the bolt and install the elastic nut (½-in. socket wrench) with a flat washer at both the bolt head and nut.

(d) Install the upper ends of the tie rods in the engine mounting beam. A clevis at the upper end of the support rod straddles a flat-headed mounting stud. Install a flat washer on each side of the clevis, insert the bolt and tighten the elastic nut (½-in. open-end wrench).

(e) Insert the mounting stud through an opening in the engine mounting beam and install a flat washer, lock washer, and plain nut (⅝-in. open-end wrench).

(f) Clamp the flat straps at the lower end of the support rod around the starter and bolt them together, with a flat washer at the bolt head and elastic nut (7/16-in. socket wrench).

(g) Screw up the bolt in the center of the brace around the generator, to support the starter (½-in. open-end wrench).

(h) Install the window strap around the generator opening, tightening the wing nut with pliers.

(11) CONNECT THE OIL SUMP TO THE OIL PUMP.

Pliers — Wrench, open-end, ½-in.

A brass liner fits into the oil sump and the scavenger line to prevent collapsing of the line. Insert the end of the scavenger line into a short piece of hose and push the hose back so that the line projects through it. Insert the liner into the oil sump opening and place the line over the other end of the liner. Slide the hose up over the liner and tighten the hose clamps on the oil sump and scavenger line. The flanged end of the scavenger line bolts to the bottom of the oil pump. Use a new gasket and bolt in place, using a flat washer, a nut and palnut (½-in. open-end wrench).

(12) INSTALL THE INTAKE MANIFOLD.

Wrench, open-end, 9/16-in. — Wrench, socket, ½-in.

(a) If the elbows were not removed from the manifold, the entire assembly may be installed as a unit. Place the elbows on the mounting studs at the intake ports in the position shown in figure 103. Install the nuts and palnuts (½-in. socket wrench). Tighten all the hose clamps. CAUTION: The inlet ports should be covered to be sure that nothing can drop into the manifold and engine.

(b) Install the four braces on the intake manifold and the inner circle of the engine mounting beam. A flat washer is used at both the bolt head and nut (9/16-in. open-end wrench).

(13) INSTALL THE EXHAUST MANIFOLD.

Wrench, socket, ½-in.

NOTE: If the exhaust manifolds were not disassembled, they can be installed in two sections. If they have been dismantled, assemble them as shown in figure 104, installing the clamps at each connection. Install each section at the exhaust ports with new gaskets. Install lock washers and brass nuts. Attach a paper over the ends of the manifold to prevent anything from falling in.

(14) REPLACE FUEL SUPPLY PUMP HOSE.

Pliers

Run a hose from the lower connection of the fuel supply pump down to the fuel check valve nipple. Tighten it on with thumbscrews.

(15) ATTACH THE ROCKER BOX SCAVENGER HOSE.

Pliers

Connect a hose from the nipple on the rocker box scavenger to the nipple on the oil pump, tightening the clamp at each end by means of the thumbscrew.

Section X

FITS AND CLEARANCES

180. ENGINE PARTS.

The following table gives the minimum and maximum limits for the wearing parts of the engine The column at the extreme right shows the limit beyond which replacement is necessary. Tight fits with no limits will be replaced when any looseness is found. The numbers in the table refer to the arrows on figure 120.

Clearance between:

1. Rocker support pin and rocker box 0.000L–0.0015L *0.004L
2. Rocker support pin and rocker bearing .. 0.0005T–0.0005L *0.002L
3. Rocker bearing and rocker box ..... Clamp tight
4. Rocker bearing and rocker 0.0007T–0.0017T *0.001L
5. Spring, cylinder valve outer ..... 98lb min. new at 1½-in. *94 lb
6. Cylinder valve inner spring ..... 88 lb min. new at 1½-in. *84 lb
7. Valve, cylinder intake and guide, cylinder intake valve 0.002L–0.004L
8. Valve, cylinder intake and guide, cylinder intake valve ..... *0.012L at ends
9. Valve, cylinder intake and guide, cylinder intake valve ..... *0.008L at center
10. Guide, cylinder intake valve and cylinder head 0.002T–0.004T
11. Rocker, intake and rocker socket 0.0000–0.0015T
12. Insert, intake valve seat and cylinder head 0.009T–0.011T
13. Spring, cylinder valve outer ..... 98 lb min. new at 1½-in. *94 lb
14. Cylinder valve inner spring ..... 88 lb min. new at 1½-in. *84 lb
15. Valve, cylinder exhaust and guide, cylinder exhaust valve 0.005L–0.007L
16. Valve, cylinder exhaust and guide, cylinder exhaust valve ..... *0.012L at ends
17. Valve, cylinder exhaust and guide, cylinder exhaust valve ..... *0.010L at center
18. Guide, cylinder exhaust valve and cylinder head ... 0.003T–0.005T
19. Rocker, exhaust and rocker socket 0.0000–0.0015T
20. Insert, exhaust valve seat and cylinder head 0.009T–0.011T
21. See chart (fig. 120) ..... *5.762 in. maximum worn inside dia. of barrel at ¾ in. from top
22. Plug, piston pin and cylinder barrel ..... 0.031L–0.093L (side) at bottom of barrel
23. Plug, piston pin and piston pin 0.001L–0.004L
24. Piston pin and piston 0.0002T–0.0008L *0.004L
25. Skirt, piston and cylinder barrel 0.0225L–0.0255L

*Limit before replacement T—tight L—loose

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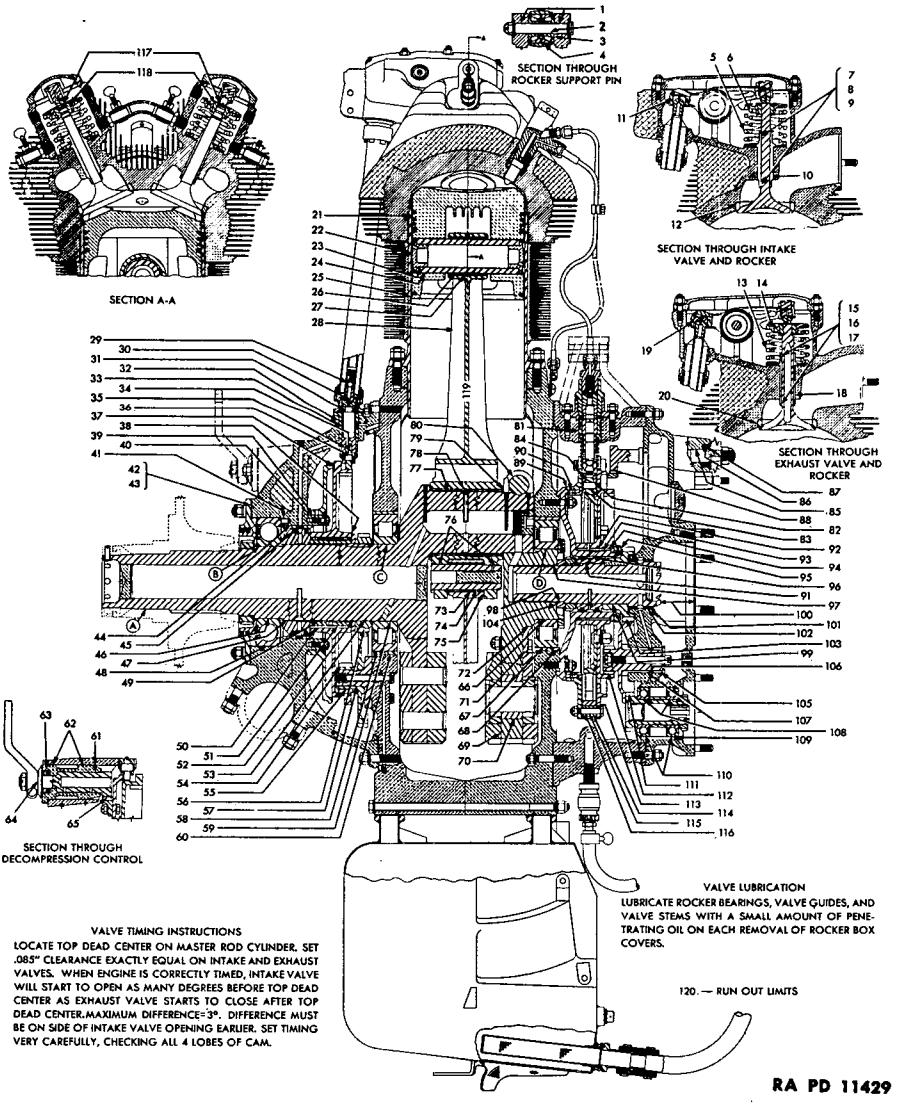

Figure 120—Clearances and Tolerances Chart

FITS AND CLEARANCES

26. Piston pin and bushing, piston pin 0.0015L–0.003L *0.006L
27. Bushing, piston pin and link rod 0.003T–0.005T
28. See chart (fig. 120) ..... Space master rod 0.005 front to 0.010 rear of center line
29. See chart (fig. 120) ..... Check valve in tappet end only
30. Ball end, push rod and socket, valve tappet ..... *Worn 0.032 in., rough or uneven
31. Socket, valve tappet and tappet, valve 0.001T–0.0025T
32. Guide, valve tappet and crankcase, front section ... 0.0000–0.001L
33. Tappet, valve and guide, valve tappet ... 0.0008L–0.0018L *0.003L
34. Pin, valve tappet roller and roller, valve tappet 0.0005L–0.002L *0.005L
35. Roller, valve tappet and tappet, valve ..... 0.002L–0.007L (side)
36. Pin, valve tappet roller and tappet, valve 0.0005L–0.002L *0.005L
37. Plate, decompression and cam valve 0.003L–0.055L
38. Cam, valve and spacer, crankshaft 0.007L–0.012L *0.020L
39. Crankcase front section and plate, decompression .. 0.008L–0.012L
40. Crankcase front section and plate, decompression .. 0.005L–0.016L
41. See chart (fig. 120) .... Install dowel pin so that it is 0.010 in. under bushing flange surface as a minimum
42. See chart (fig. 120) ..... 0.002–0.009 pinch on bearing with gasket compressed to 0.022. Gap = 0.024–0.031 without gasket
43. See chart (fig. 120) ..... Overhaul note: Lathe cut face of thrust plate to restore gap to required clearance
44. Bushing, front crankcase oil seal and crankcase front section 0.004T–0.006T
45. Spacer, front bearing seal ring and ring; front crankshaft bearing seal ..... 0.0046L–0.0081L (side)
46. Crankshaft, front and bearing front thrust ball ... 0.0005T–0.0019T
47. Crankshaft, front and spacer, front bearing seal ring 0.0015L–0.0035L
48. Bearing, front thrust ball and crankcase, front section 0.0008T–0.0012L *0.003L
49. Crankshaft, front and spacer, front crankshaft bearing 0.0005L–0.002L
50. Bushing, valve cam and cam, valve 0.0035T–0.005T
51. Spacer, front crankshaft bearing and bushing, valve cam 0.004L–0.006L *0.009L
52. Crankshaft, front and spacer, crankshaft 0.0095L–0.0155L
53. Crankshaft, front and gear, crankshaft 0.0005L–0.001T
54. Gear, valve cam intermediate and lock nut, intermediate gear spindle ..... 0.006L–0.014L (side)
55. Pinion, valve cam intermediate and cam, valve ..... 0.007–0.012 backlash
56. Gear, crankshaft and gear, valve cam intermediate ..... 0.007–0.011 backlash

*Limit before replacement T—tight L—loose

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GUIBERSON DIESEL T1400 ENGINE, SERIES 3

57. Spindle, valve cam intermediate gear and gear, valve cam intermediate 0.001L–0.0025L *0.009L
58. Bearing, front main roller and lever, front center section bearing 0.0003T–0.0017L *0.003L
59. Crankshaft, front and bearing front, main roller .. 0.0005T–0.0017T
60. Liner, front center section bearing and crankcase, front center section 0.0065T–0.0085T
61. Shaft, decompression control and guide, decompression control shaft 0.001L–0.003L
62. Guide, decompression control shaft and crankcase, front section 0.001L–0.003L
63. Oil seal, decompression control shaft and guide, decompression control shaft 0.002T–0.007T
64. See chart (fig. 120) ..... Set clearance to 0.020 min.–0.040 max.
65. Shaft, decompression control and gear, decompression control segment ..... 0.004–0.008 backlash
66. Crankshaft, rear and bearing, rear main roller .. 0.0005T–0.0019T
67. Bearing, rear main roller and liner, rear center section bearing 0.0003T–0.0017L *0.003L
68. Liner, rear center section bearing and crankcase, rear center section 0.006T–0.008T
69. Crankcase rear and counterweight, rear floating ..... 0.010L–0.016L (side)
70. Bushing, rear crankshaft and crankshaft, rear 0.0015T–0.0035T
71. Stop, rear crankshaft counterweight and counterweight, rear floating ..... Set clearance to 0.027 min.–0.040 max.
72. Crankshaft rear and stop, rear crankshaft counterweight ..... Zero clearance
73. Bushing, knuckle pin and link rod 0.003T–0.005T
74. Knuckle pin and bushing, knuckle pin .. 0.0015L–0.0032L *0.005L
75. Master rod and link rod 0.012L–0.021L *0.030L
76. Knuckle pin and master rod ..... 0.0005T–0.0015T always drive fit
77. Crankshaft front and bushing, master rod .. 0.003L–0.005L *0.008L
78. Bushing, master rod and master rod 0.003T–0.005T
79. Master rod and crankshaft rear 0.015L–0.025L
80. Bolt, crankshaft clamp ..... Bolt stretch 0.0065–0.0075
81. Sleeve, fuel pump and crankcase, rear mounting section 0.0025L–0.0045L
82. Pin, fuel control lever and lever, fuel control ..... 0.0005 minimum selective fit
83. Pin, fuel control lever and roller, fuel control lever 0.0015L–0.0025L *0.005L
84 See chart (fig. 120) ..... Set for 0.003 loose
85. Shaft, throttle control and accessory case .. 0.000L–0.002L *0.012L
86. Seal, throttle control shaft oil and accessory case .. 0.001T–0.007T
87. See chart (fig. 120) ..... Set clearance to 0.015 min.–0.060 max.

*Limit before replacement T—tight L—loose

FITS AND CLEARANCES

88. Shaft, throttle control and gear throttle control segment ..... 0.002–0.004 backlash
89. Plate, fuel cam mounting and plate, fuel control lever mounting ..... 0.005L–0.023L (side)
90. Plate, fuel cam mounting and plate, fuel control lever mounting 0.004L–0.007L
91. Starter shaft and sleeve, oil seal rear spacer 0.0008L–0.0023L
92. Bushing, fuel cam drive and gear, fuel cam drive .. 0.0035T–0.005T
93. Plate, fuel cam mounting and bushing, fuel cam drive 0.0025L–0.0045L *0.009L
94. Bushing, fuel cam drive and spacer, fuel cam mounting plate ..... 0.008L–0.017L (side) *0.025L
95. Lock nut, fuel cam mounting plate and gear, starter shaft accessory drive ..... 1/16 in. L average ref.
96. Sleeve, oil seal rear spacer and seal ring, oil seal rear spacer ..... 0.0036L–0.0086L (side)
97. Starter shaft and crankshaft, rear 0.0005L–0.0025L
98. Starter shaft and spacer, starter shaft 0.0025L–0.0055L
99. Starter shaft and gear, starter shaft accessory drive 0.0005T–0.0005L
100. Starter shaft and accessory case ..... If this dimension is 1-21/32 in. to 1-11/16 in., use 1/32 in. gasket part No. 13-Y-465. If this dimension is 1-11/16 in. to 1-23/32 in., use 1/64 in. gasket part No. 14-Y-465
101. Starter shaft and bushing, starter shaft ..... 0.0010L–0.0035L *0.008L (important)
102. Bushing, starter shaft and accessory case 0.003T–0.0045T
103. Gear, starter shaft accessory drive gear, accessory case intermediate ..... 0.006–0.010 backlash
104. Crankshaft, rear and spacer, starter shaft 0.012L–0.081L
105. Washer, intermediate gear bolt and bushing, intermediate and idler gear ..... 0.003L–0.017L (side) *0.050L
106. Gear, accessory case intermediate and bushing, intermediate and idler gear 0.0015L–0.0035L *0.008L
107. Bushing, intermediate and idler gear and accessory case 0.0015T–0.0035T
108. Gear, generator drive and bearing, generator drive gear 0.0002T–0.0012T
109. Snap ring, generator drive gear bearing and accessory case ..... 0.0002T–0.044L (side)
110. Bearing, generator drive gear and accessory case .. 0.0006T-0.001L
111. Gear, generator drive and gear accessory case intermediate ..... 0.004–0.008 backlash
112. Pinion, accessory case intermediate and gear, fuel cam drive ..... 0.008–0.012 backlash

*Limit before replacement T—tight L—loose

113. Lever, fuel control and ring, fuel control lever mounting ..... 0.017L–0.039L (side)
114. Bushing, fuel control lever and lever, fuel control ..... 0.001L–0.0025L *0.005L—out-of-round
115. Bolt, fuel control lever assembly and bushing, fuel control lever 0.0005L–0.0045L
116. Bushing, fuel control lever and plate, fuel control lever mounting ..... Clamp tight
117. Ball end, rocker adjusting and valve, cylinder ..... 0.019–0.021 cold (see valve timing note)
118. See chart (fig. 120) ..... Keeper must not wedge in groove
119. See chart (fig. 120) ..... Install master rod in No. 7 cylinder
120. Run-out limits. With shaft supported at "C" and "D," with clamping bolt set loosely, and with all slack taken up from keyway in both directions (2 trials), allowable run-out limits at "A" = 0.005-inch maximum total indicator reading. Assemble front and rear crankshaft with master rod and 0.017-inch master rod side clearance. Set clamping bolt to 0.0065–0.0075 bolt stretch. With crankshaft supported at "C" and "D," allowable run-out at "A" = 0.005-inch maximum total indicator. (Set to minimum run-out obtainable by trial.) With crankshaft supported at "C" and "D" in crankcase final assembly for both test and shipment, journal "B" before installing thrust bearing, must be centrally located to crankcase bore within 0.004-inch maximum micrometer difference. Check four points at 90-degree intervals on crankcase with stationary crankshaft. Check position of end of starter jaw as shown.

181. ACCESSORY CASE (fig. 121).

The following table shows the minimum and maximum limits and the limit beyond which the units on the accessory case must be replaced. Tight fits with no limits will be replaced when any looseness is found.

Clearance between:

1. Bearing, governor drive gear and accessory case 0.0004T–0.0009L
2. Snap ring, bearing governor drive gear and accessory case ..... 0.0004L–0.0444L (side)
3. Gear, governor drive and spacer, governor drive gear bearing 0.0018L–0.0084L
4. Bearing, governor drive gear and gear, governor drive 0.0002T–0.0012T
5. See chart (fig. 121) ..... Clamp tight
6. Bushing, intermediate and idler gear, and accessory case 0.0015T–0.0035T
7. Gear, idler and bushing intermediate and idler gear 0.0015L–0.0035L *0.008L
8. Bushing, intermediate and idler gear and washer, idler gear bolt ..... 0.003L–0.017L (side) *0.050L

*Limit before replacement T—tight L—loose

FITS AND CLEARANCES

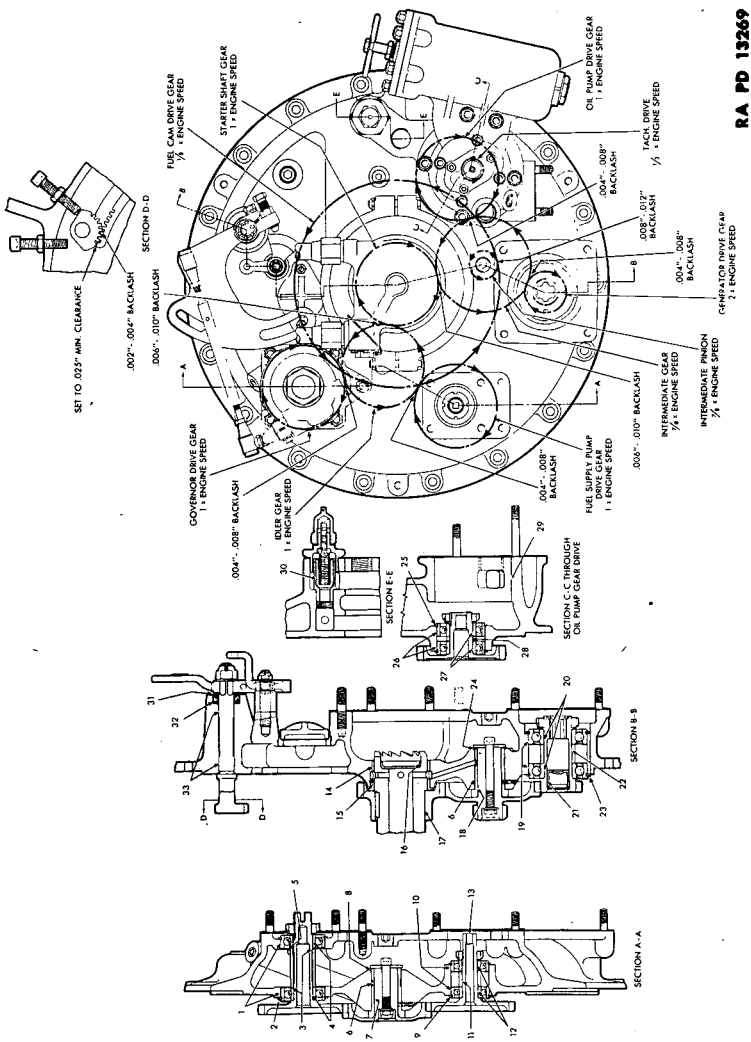

Figure 121—Clearances and Tolerances Chart—Accessory Case

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

9. Snap ring, fuel supply pump drive gear bearing and accessory case ..... 0.0008L–0.0448L (side)
10. Bearing, fuel supply pump drive gear and accessory case 0.0005T–0.0009L
11. Gear, fuel supply pump drive and spacer, fuel supply pump drive bearing 0.0012L–0.0077L
12. Gear, fuel supply pump drive and bearing, fuel supply pump drive gear 0.0008T–0.0001L
13. Fuel pump drive 0.008–0.012
14. Bushing, starter shaft and accessory case 0.0030T–0.0045T
15. Starter, shaft and bushing, starter shaft ..... 0.0010L–0.0035L *0.008L (important)
16. Oil plug, starter shaft and starter shaft 0.0065T–0.0185T
17. Starter shaft and gear, starter shaft accessory drive 0.0005T–0.0005L
18. Gear, accessory case intermediate and bushing, intermediate and idler gear 0.0015L–0.0035L *0.008L
19. Bearing, generator drive gear and accessory case 0.0006T–0.0010L
20. Gear, generator drive and bearing, generator drive gear 0.0002T–0.0012T
21. Plug, expansion and gear, generator drive 0.004T–0.016T
22. Gear, generator drive and spacer, generator drive gear bearing 0.0011L–0.0037L
23. Snap ring, generator drive gear bearing and accessory case ..... 0.0002T–0.044L (side)
24. Bushing, intermediate and idler gear and washer, intermediate gear bolt ..... 0.003L–0.017L (side) *0.050L
25. Snap ring, oil pump drive gear bearing and accessory case ..... (side) 0.0002L–0.0442L
26. Bearing, oil pump drive gear and accessory case 0.0006T–0.0011L
27. Gear, oil pump drive and bearing, oil pump drive gear 0.0002T–0.0012T
28. Gear, oil pump drive and spacer, oil pump drive gear bearing 0.0019L–0.0085L
29. Oil pump body in position 0.0015L–0.0035L
30. Valve, oil pressure relief and seat, oil pressure relief valve 0.003L–0.006L
31. Lever, throttle control shaft, and accessory case ..... 0.015L–0.060L (side)
32. Seal, throttle control shaft oil, and accessory case 0.001T–0.007T
33. Shaft, throttle control and accessory case 0.000L–0.002L *0.012L

*Limit before replacement T—tight L—loose

Section XI

SERVICE ASSEMBLY AND OVERHAUL TOOLS

182. TOOL LIST.

This is a list of the tools used in servicing, assembling, and overhauling T-1400 Engine, Series 3. Numbers under the heading "Tool No." are of the complete tool. Numbers under the heading "Part No." are of individual parts that make up the complete tool. These can be supplied separately.

TOOL NO.	PART NO.	NAME
GU-GST-1518		Puller, crankshaft gear and front bearing
	GU-GST-1518B	Cross-arm, crankshaft gear and front bearing puller
	GU-GST-1518C	Screw, crankshaft gear and front bearing puller
	GU-GST-1518D	T-rod, crankshaft gear and front bearing puller
	GU-GST-1518E	Stud, crankshaft gear and front bearing puller
	GU-GST-1518F	Nut, crankshaft gear and front bearing puller
GU-GST-1507		Puller, rear crankshaft bearing
	GU-GST-1517B	Ring, clamp
	GU-GST-1517C	Split clamp
GU-GST-1516		Collar, front crankshaft bearing puller
GU-GST-1528		Wrench, rear crankshaft bearing nut
	GU-GST-1519C	Spacer
GU-GST-1503		Plug, rear crankshaft bearing puller
GU-GST-1347		Wedge, crankshaft
GU-GST-1521		Driver, front crankshaft bearing

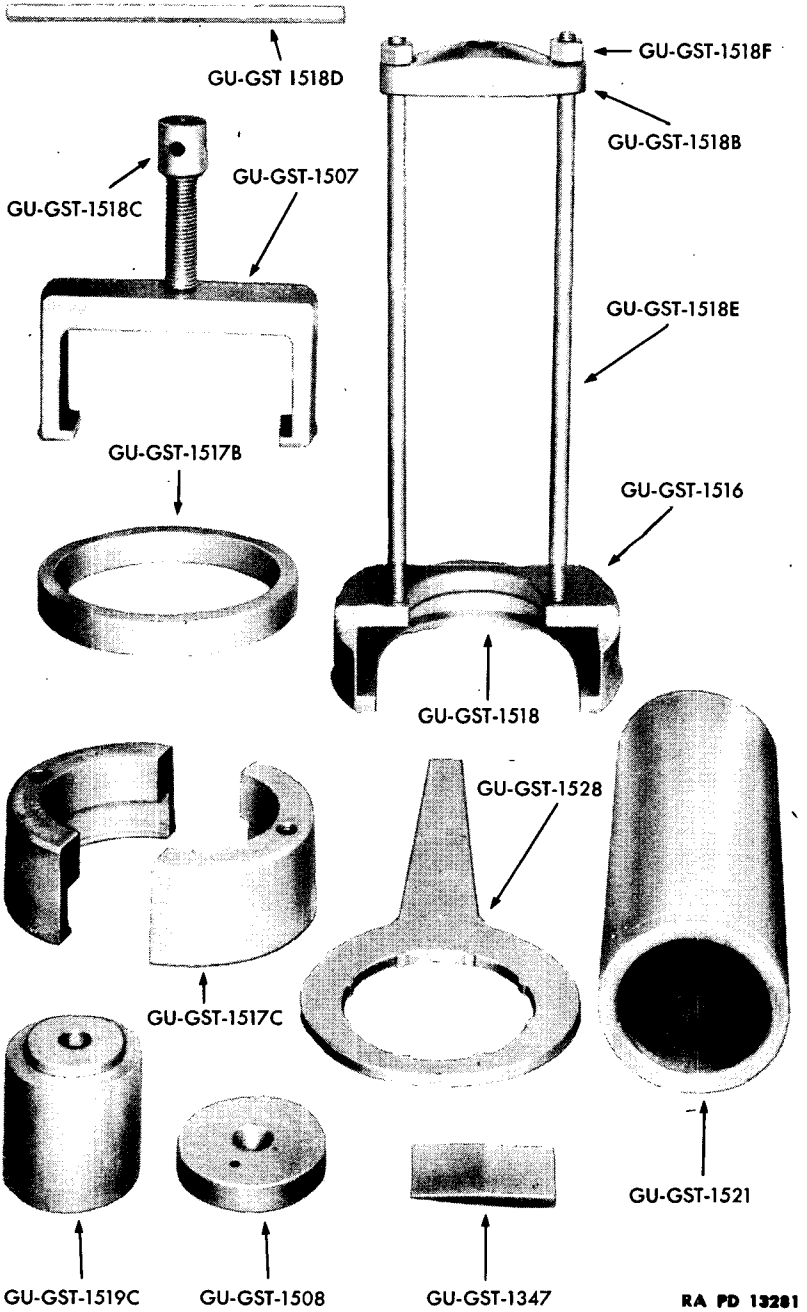

Figure 122—Special Tools

SERVICE ASSEMBLY AND OVERHAUL TOOLS

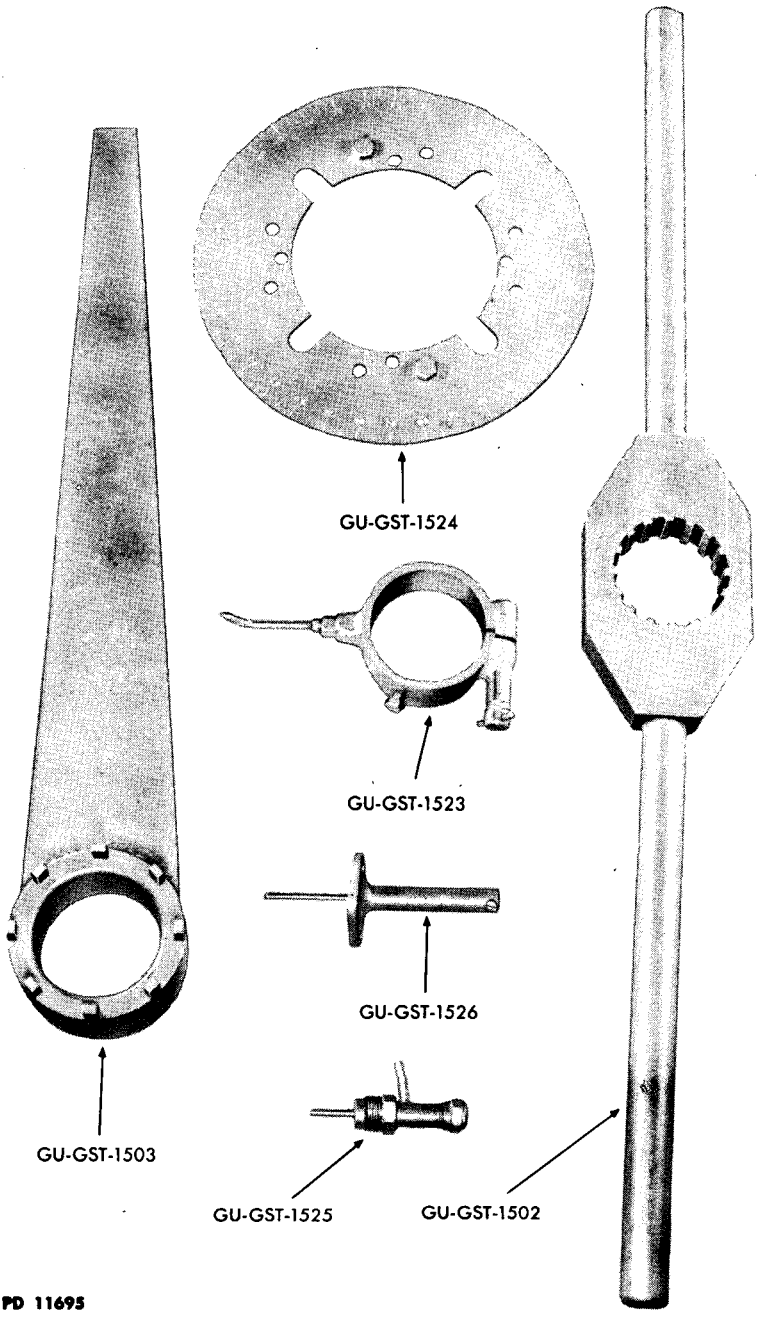

Figure 123—Special Tools

ORDNANCE MAINTENANCE
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TOOL NO.	PART NO.	NAME
GU-GST-1502		Turner, crankshaft
GU-GST-1503		Wrench, front bearing nut
GU-GST-1523		Timing pointer
GU-GST-1524		Timing disk
GU-GST-1525		Holder, fuel pump indicator
GU-GST-1526		Holder, top center indicator
GU-GST-1511		Balls and holder, crankshaft clamp bolt stretch measuring
GU-GST-1530		Drift, knuckle pin inserting
GU-GST-1531		Remover, knuckle pin
GU-GST-1532		Receiver, knuckle pin and master rod
GU-GST-1550		Engine lifting eye
GU-GST-1556		Support, master rod web
GU-GST-1371		Tester for master rod oil passages
Fixture at bottom		Aliner, link rod
GU-GST-1501		Front crankcase puller
	GU-GST-1501B	Plate, front crankcase puller
	GU-GST-1501C	Cross bar, front crankcase puller
	GU-GST-1501D	Nut, front crankcase puller
GU-GST-1365		Puller, valve tappet guide and fuel pump
	GU-GST-1309A	Tie bolt, valve tappet guide puller
	GU-GST-1309D	Connector, valve tappet guide puller
	GU-GST-1309E	Hammer, valve tappet guide puller
	GU-GST-1365B	Adapter, fuel pump puller
GU-GST-1510		Driver, piston pin
	GU-GST-1519C	Spacer
GU-GST-1522		Compressor, piston ring
GU-GST-1529		Wrench, starter shaft lock nut
GU-GST-1338		Remover, crankcase bolt
	GU-GST-1338A	Weight, crankcase bolt remover
	GU-GST-1338B	Head, crankcase bolt remover
	GU-GST-1338C	Shaft, crankcase bolt remover
GU-GST-1444		Valve adjusting wrench
	GU-GST-1444A	Driver, valve adjusting wrench
	GU-GST-1444B	Socket, valve adjusting wrench
GU-GST-1533		Inserter, rocker bearing
	GU-GST-1533B	Driver, rocker bearing inserter
	GU-GST-1533C	Anvil, rocker bearing inserter
GU-GST-1534		Remover, rocker bearing
	GU-GST-1534B	Driver, rocker bearing remover
	GU-GST-1534C	Receiver, rocker bearing remover

SERVICE ASSEMBLY AND OVERHAUL TOOLS

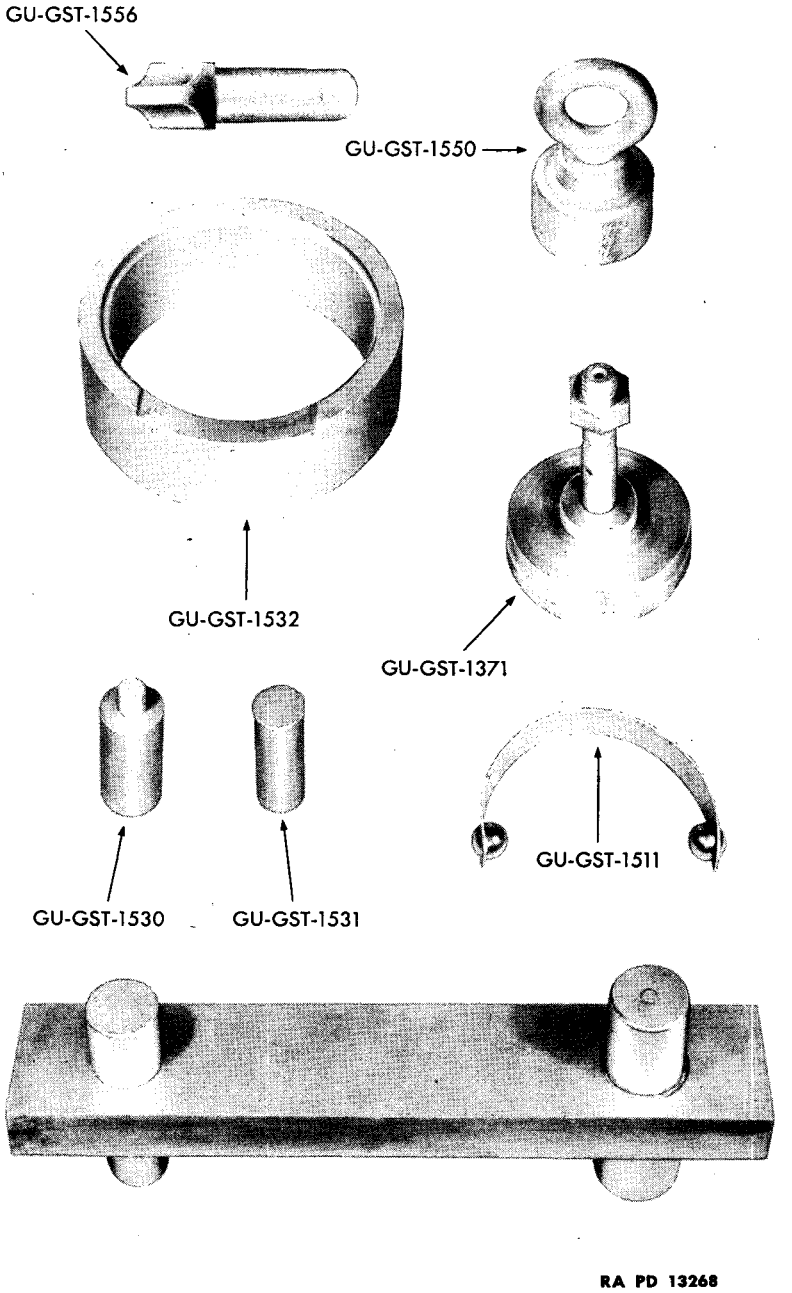

Figure 124—Special Tools

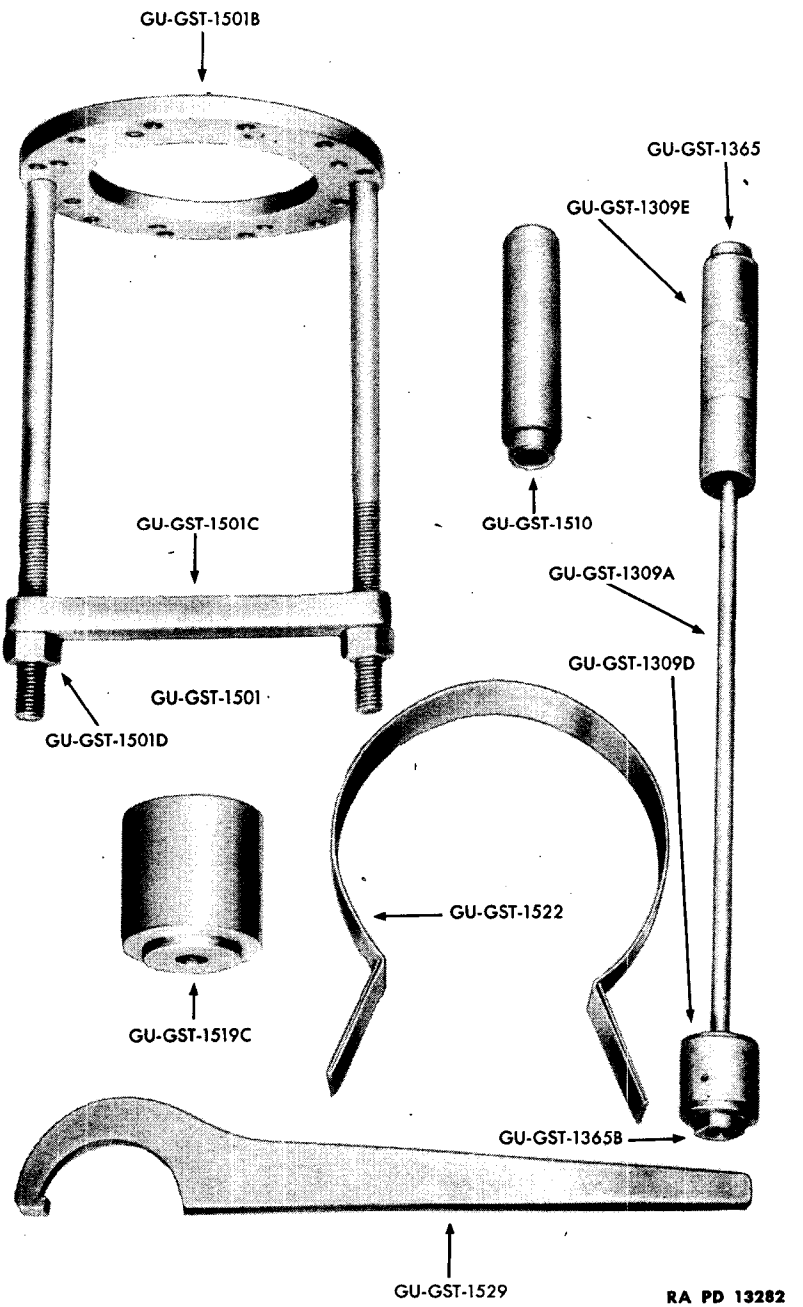

Figure 125—Special Tools

SERVICE ASSEMBLY AND OVERHAUL TOOLS

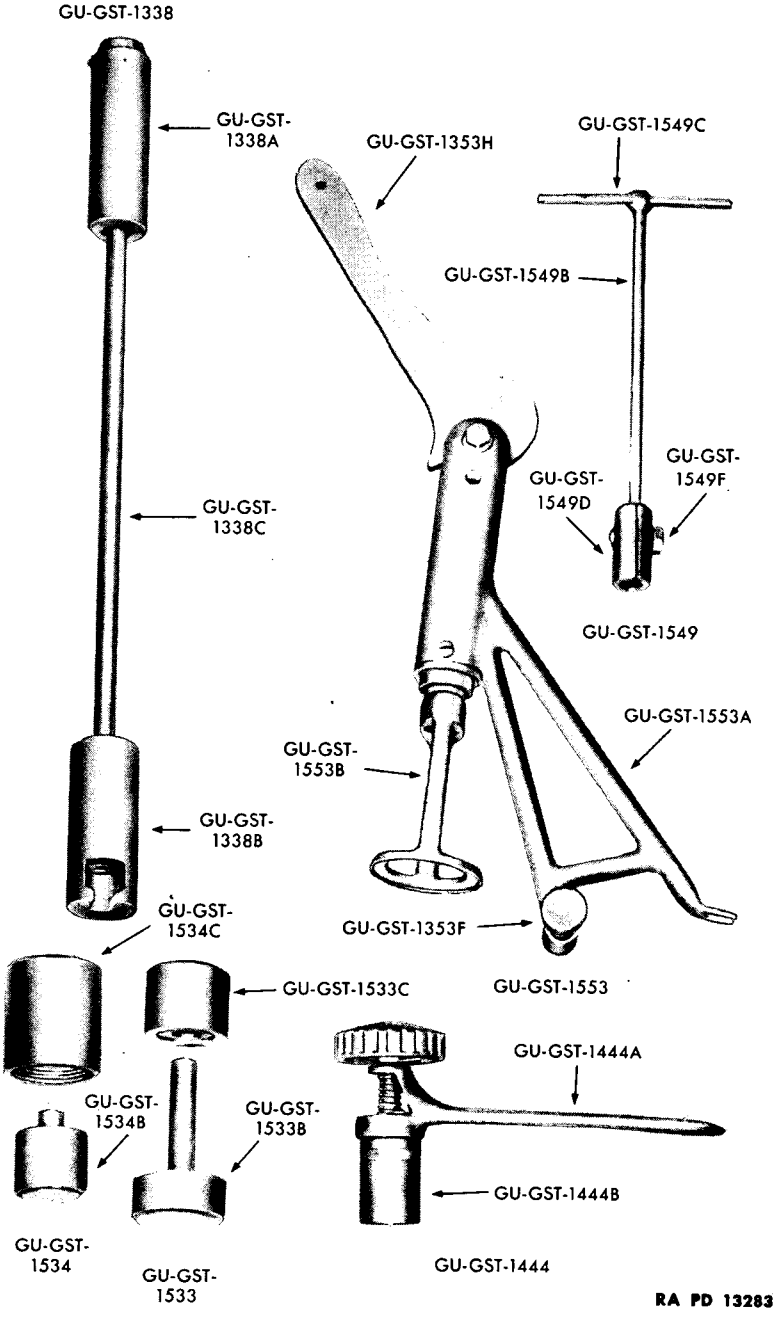

Figure 126—Special Tools

ORDNANCE MAINTENANCE
GUIBERSON DIESEL T1400 ENGINE, SERIES 3

TOOL NO.	PART NO.	NAME
GU-GST-1553		Compressor, valve spring
	GU-GST-1553A	Body, valve spring compressor
	GU-GST-1553B	Plunger, valve spring compressor
	GU-GST-1553F	Pin, valve spring compressor
	GU-GST-1553H	Handle, valve spring compressor
GU-GST-1549		Valve grinder
	GU-GST-1549B	Handle, valve grinder
	GU-GST-1549C	T-rod, valve grinder
	GU-GST-1549D	Body, valve grinder
	GU-GST-1549F	Bolt, valve grinder
GU-GST-1302		Wrench, timing
GU-GST-1303		Holding bar, fuel pump and fuel injector
GU-GST-1306		Wrench, push rod housing nut
GU-GST-1419		Wrench, fuel pump adjusting
GU-GST-1545		Remover, push rod
GU-GST-1547		Wrench, cylinder hold-down nut
GU-GST-1551		Wrench, fuel cam mounting plate lock nut
	GU-GST-1551B	Socket, fuel cam mounting plate lock nut wrench
	GU-GST-1551C	Handle, fuel cam mounting plate lock nut wrench
GU-GST-1554		Wrench, flywheel hub nut
Illustration No. 3		
GU-GST-1539		Driver, intake valve guide
GU-GST-1540		Driver, exhaust valve guide
Illustration No. 2		
GU-GST-1541		Puller, valve guides
	GU-GST-1541B	Bolt, valve guide puller
	GU-GST-1541C	Nut, valve guide puller
	GU-GST-1541D	Pin, valve guide puller
	GU-GST-1541E	Pin adapter, valve guide puller
	GU-GST-1541F	Sleeve, valve guide puller
Illustration No. 1 at top		Cylinder head support
GU-GST-1312		Holder, fuel supply pump and idler gears
GU-GST-1322		Wrench, fuel supply pump gear nut
GU-GST-1324		Wrench, oil pump drive gear nut
GU-GST-1325		Wrench, generator drive gear nut
GU-GST-1349		Wrench, intermediate and idler gear nut

SERVICE ASSEMBLY AND OVERHAUL TOOLS

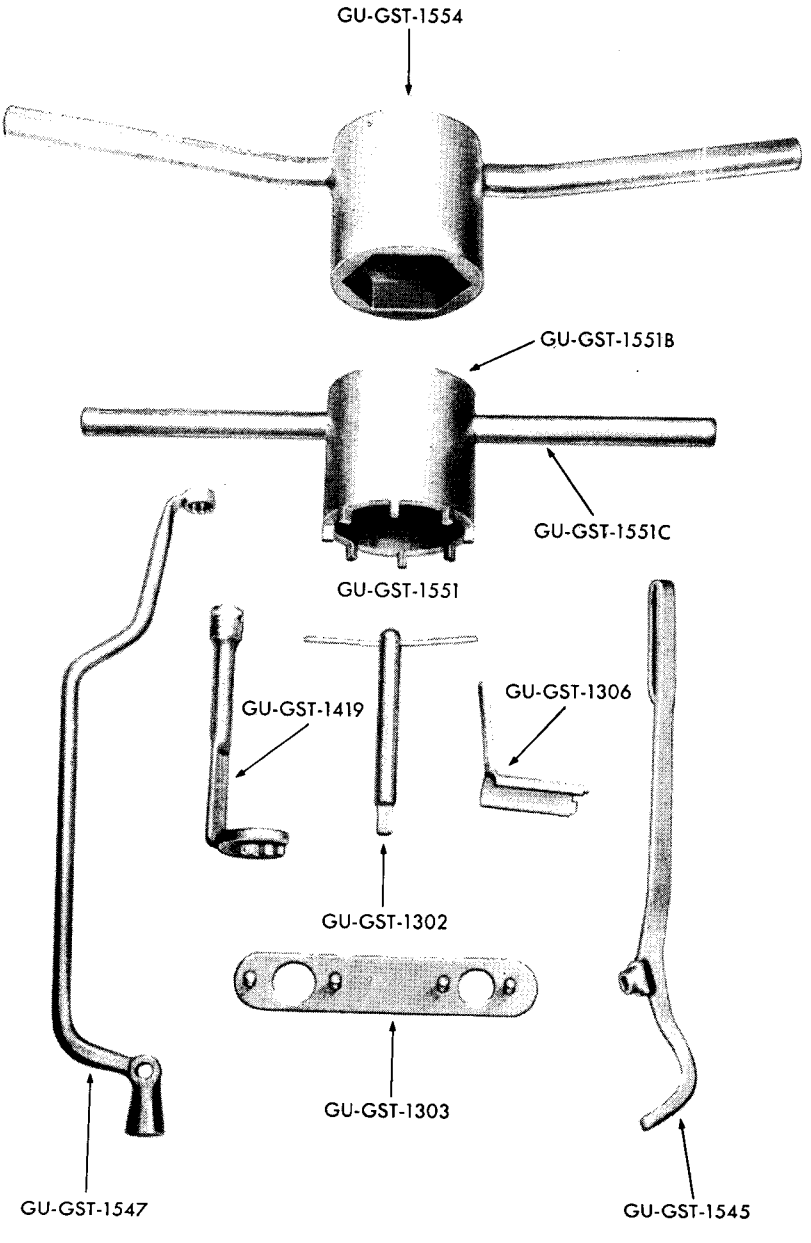

Figure 127—Special Tools

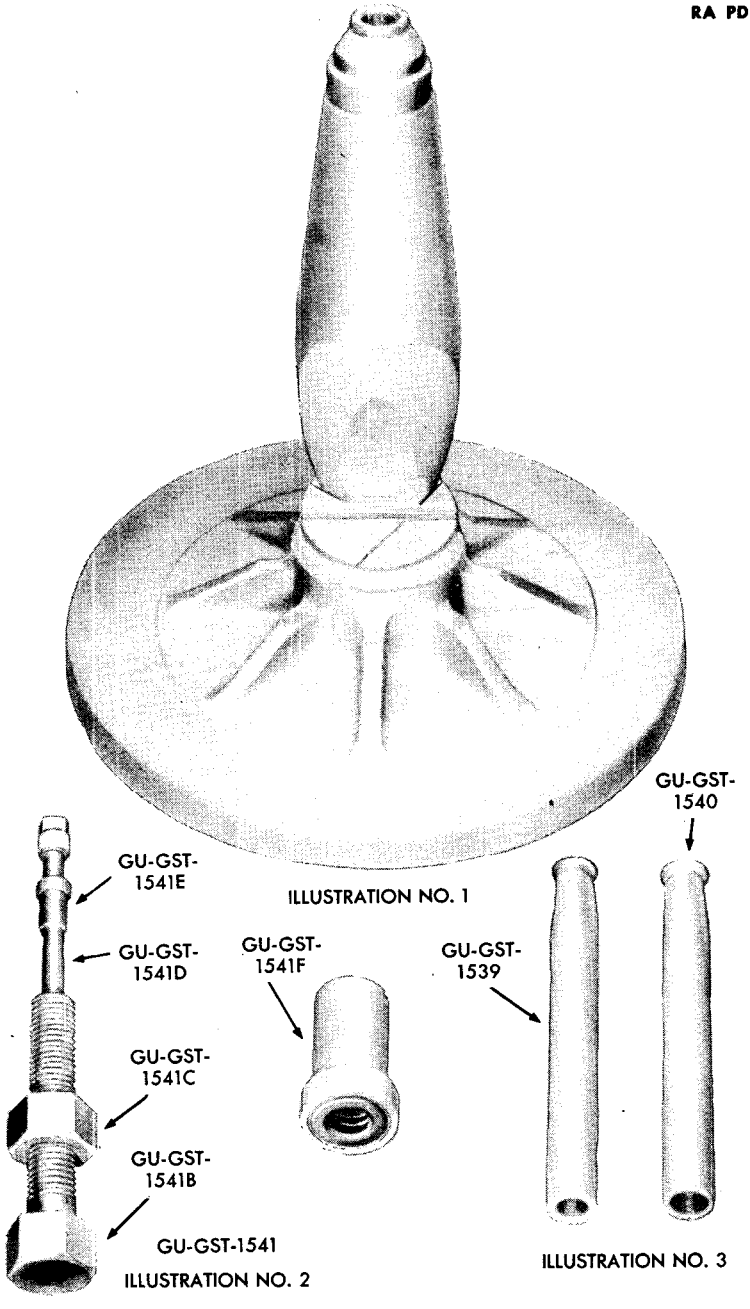

Figure 128—Special Tools

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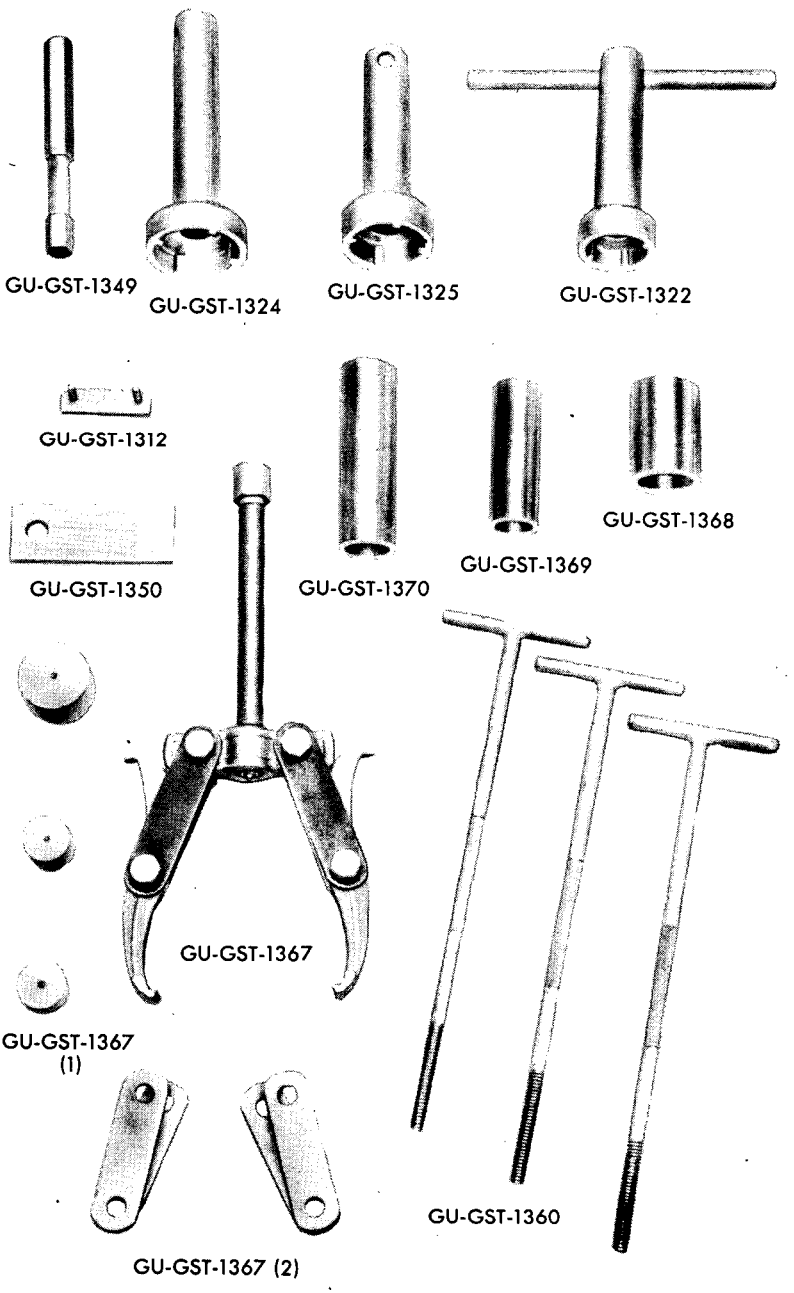

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Figure 129—Special Tools

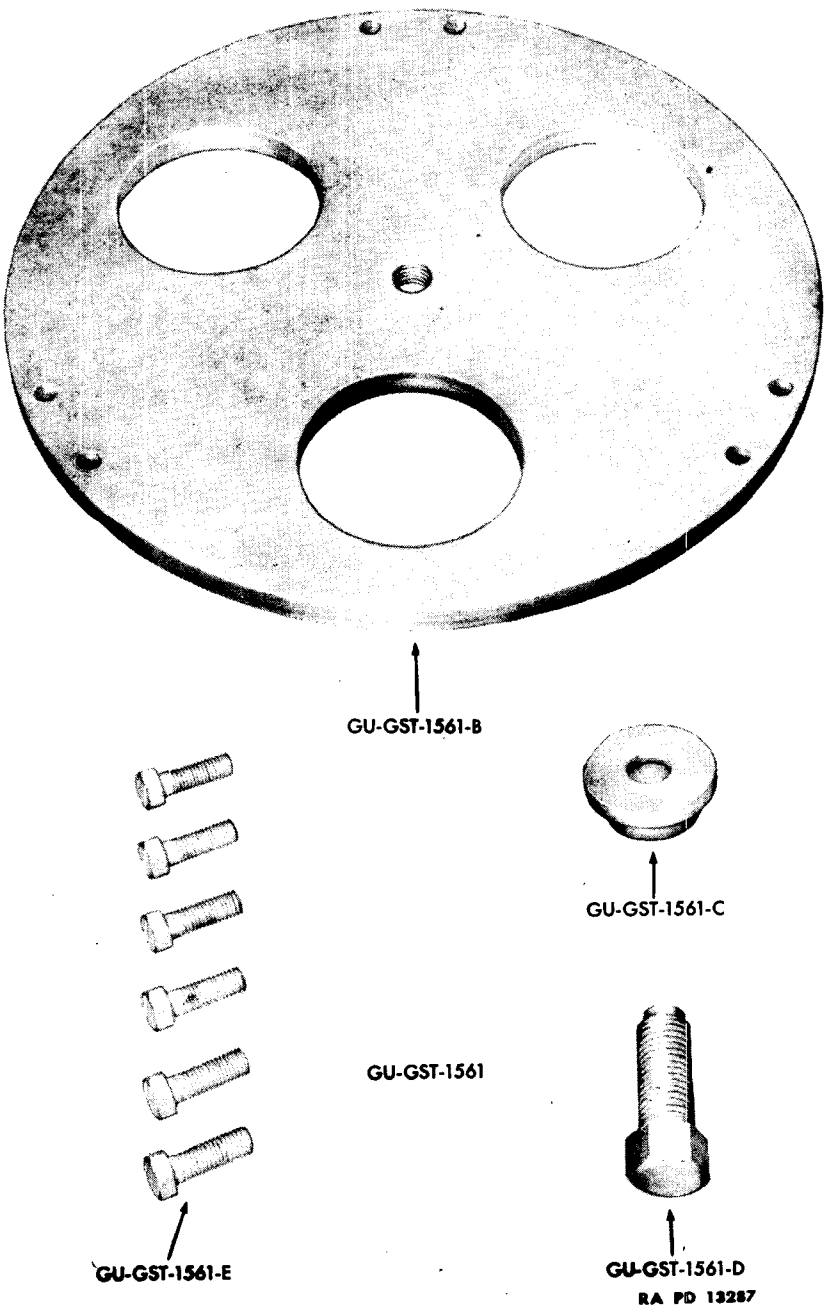

Figure 130—Special Tools

SERVICE ASSEMBLY AND OVERHAUL TOOLS

TOOL NO.	PART NO.	NAME
GU-GST-1350		Plate wrench, oil pressure relief valve seat
GU-GST-1360		Puller, accessory case
GU-GST-1360		Puller, accessory case gear bearings
	GU-GST-1367(1)	Adapters, accessory case bearing puller
	GU-GST-1367(2)	Arms, short, accessory case bearing puller
GU-GST-1368		Driver, oil pump gear
GU-GST-1369		Driver, fuel supply pump gear
GU-GST-1370		Driver, governor gear
GU-GST-1561		Flywheel puller
	GU-GST-1561B	Plate, flywheel puller
	GU-GST-1561C	Guide, flywheel puller
	GU-GST-1561D	Screw, flywheel puller
	GU-GST-1561E	½-in. by 1½-in. cap screw, (13-thread), flywheel puller

Section XII

REFERENCES

183. STANDARD NOMENCLATURE LISTS.

a. Cleaning, preserving, and lubricating materials ..... SNL K-1

b. Medium tanks ..... SNL G-104

Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publications for Supply Index" ..... OPSI

184. EXPLANATORY PUBLICATIONS.

a. Cleaning, preserving, and lubricating materials ..... TM 9-850

b. Medium tanks M3, M3A1, and M3A2 ..... TM 9-750

c. Ordnance maintenance, Breeze cartridge starter for radial Diesel engines ..... TM 9-1726G

d. Diesel engines and fuels ..... TM 10-575

e. Cold weather operation of automotive equipment ..... OFSB 6-G-3

f. **Radial Engines.**

Aircraft engines ..... TM 1-405
Aircraft induction, fuel and oil systems ..... TM 1-407
Aircraft engine operation and test ..... TM 1-408

185. TRAINING FILMS AND FILM STRIPS.

a. Lubrication ..... FS 10-39

b. Hand, measuring, and power tools ..... FS 10-40

c. Diesel engines ..... TF 10-158

d. Diesel engine and fuels ..... FS 10-37

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(For explanation of symbols, see FM 21-6)

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