*RESTRICTED

TM 9-1727

WAR DEPARTMENT

TECHNICAL MANUAL

ORDNANCE MAINTENANCE

GUIBERSON ENGINE, MODEL T-1020

APRIL 8, 1942

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FOR ORDNANCE PERSONNEL ONLY

ORDNANCE MAINTENANCE

GUIBERSON ENGINE, MODEL T–1020

CHANGES
No. 1

WAR DEPARTMENT,
WASHINGTON, July 16, 1942

TM 9–1727, Ordnance Maintenance, Guiberson Engine, Model T–1020, is changed as follows:

205. Storage protection procedure (fig. 131).—*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 **20 percent oil, lubricating, preservative, light,** and with 100 percent **oil, lubricating, preservative, medium,** circulating through the engine lubricating system.

(2) After shutting down the engine, remove it from the tank (sec. V). It should be thoroughly cleaned with kerosene, brushes, and scrapers over a drip pan and with the aid of compressed air. Slush the portions of the engine interior requiring protection, particularly the combustion chambers. Spray **oil, lubricating, preservative, medium,** on the unpainted portions of the engine exterior.

* * * * * * *

[A. G. 062.11 (7–6–42).] (C 1, July 16, 1942.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

473228°—42

U. S. GOVERNMENT PRINTING OFFICE: 1942

TECHNICAL MANUAL
No. 9-1727

WAR DEPARTMENT,
WASHINGTON, *April 8, 1942.*

ORDNANCE MAINTENANCE
GUIBERSON ENGINE, MODEL T-1020

Prepared under the direction of the
Chief of Ordnance

CONTENTS

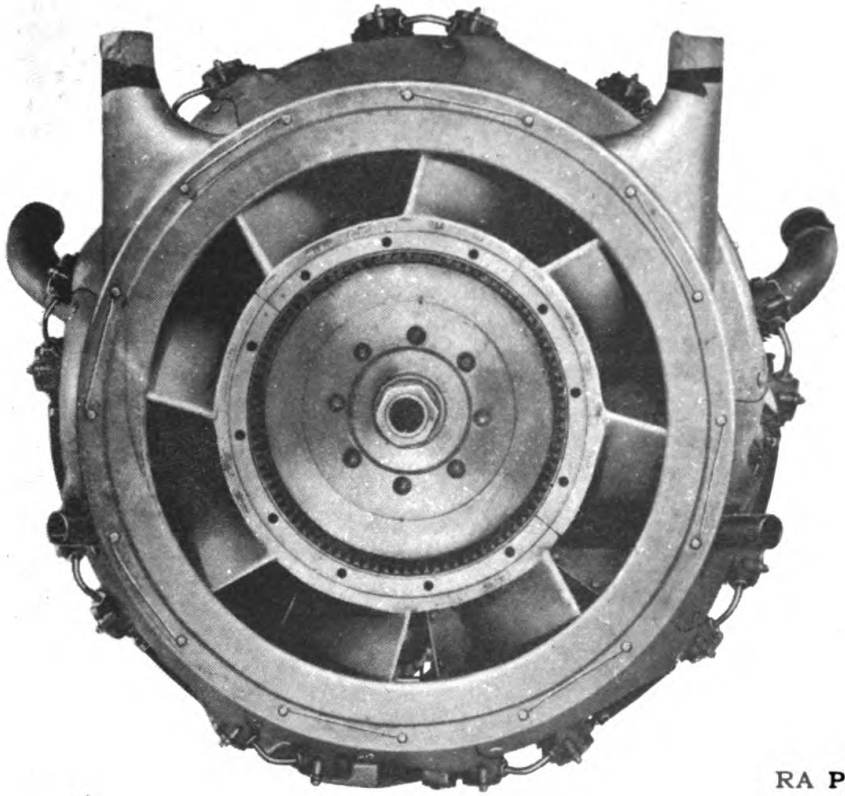
SECTION I

INTRODUCTION

1. Purpose.—This manual is published for the information and guidance of all personnel charged with the maintenance and overhaul of the Guiberson T-1020 tank engine used on light tanks.

2. Scope.—This manual contains information on the detailed construction of the unit, disassembly, and assembly procedure, inspection, maintenance, and repair supplementary to those covered in TM 9-727.

3. References.—Section XVI lists all Technical Manuals, Standard Nomenclature Lists, and other publications relative to the material described herein.



RA PD 6531

FIGURE 1—Front view of engine.

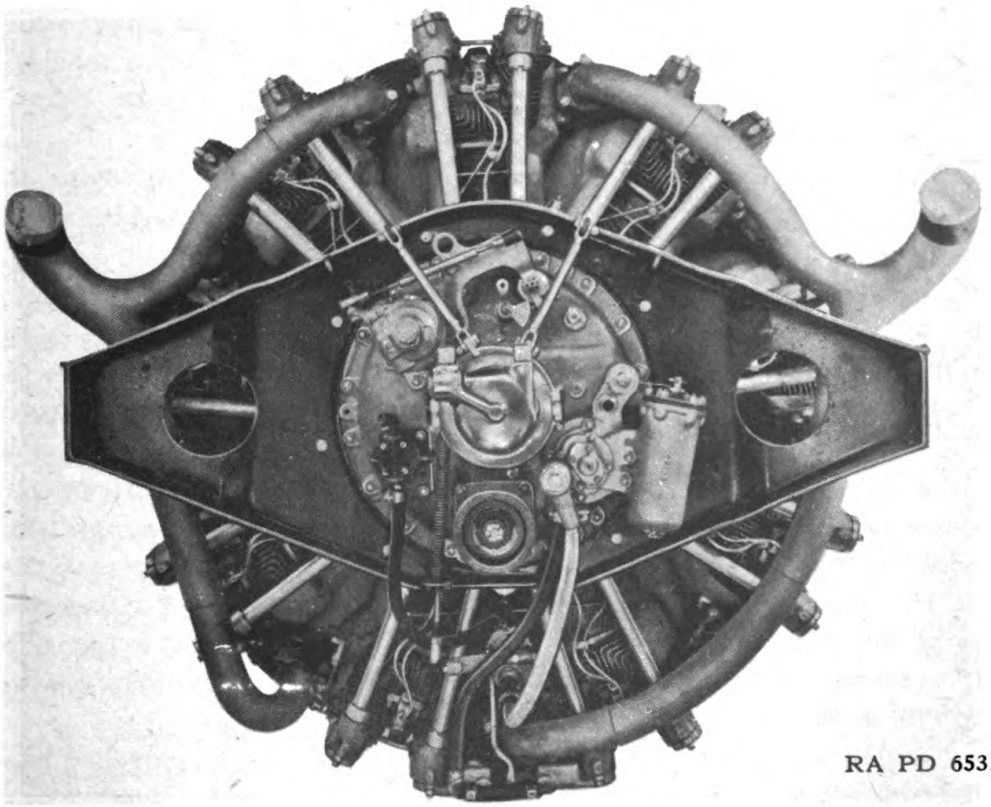


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FIGURE 2—Rear view of engine.

SECTION II

DESCRIPTION AND TABULATED DATA

4. General description.—*a.* The Guiberson Diesel Engine, Model T-1020, 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.

b. The engine is mounted vertically in the tank with the intake manifold and shroud facing the front of the tank; therefore the intake manifold side of the engine is referred to as the front of the engine and the exhaust manifold side of the engine is referred to as the rear.

c. The cylinders fire anticlockwise, facing the front of the engine, the firing order being 1-3-5-7-9-2-4-6-8. Number one cylinder is at the top of the engine.

d. 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 14.5 to 1. This compression raises the temperature of the air sufficiently to ignite the fuel oil which is injected at the proper time.

e. Fuel is pumped to a drilled passage in the crankcase by the fuel supply pump, and thence to each of the individual injection pumps. Individual injection pumps at each cylinder build up the fuel pressure so that the fuel can be injected into the highly compressed air. The injection pump also measures the correct amount of fuel for each injection. The injection of the fuel into the combustion chamber is controlled by a fuel injector at each cylinder.

f. (fig. 4) The action of the fuel injection pumps is controlled by a fuel control plate assembly on the crankshaft. The injection pump plungers ride on levers of the fuel control plate 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 is controlled by the throttle and determines the length of stroke, and amount of fuel injected.

g. (fig. 5) Valve tappets operate on the valve cam. Both the intake and exhaust valve tappets operate over the same cam.

h. (fig. 4) A decompression plate and ring are also parts of the valve cam and fuel control plate assembly. When the throttle is pulled beyond the shut-off position, the exhaust valve tappets rest on the lobes of the decompression ring, and the exhaust valves are held open. The engine is then on decompression. This permits the exhausting of unburned fuel, especially the lubricant.

i. Lubrication of moving parts of the engine is done by oil forced through drilled passages. Oil is drawn from an external tank and circulated through the engine. Before it is returned to the tank, it is passed through filters to remove impurities and through oil coolers to reduce the temperature.

5. Engine characteristics.—a. General specifications.—

Bore	5⅛"
Stroke	5½"
No. Cylinders	9
Cylinder Arrangement	Radial
Total Piston Displacement	1021 cu. in.
Rated Crankshaft rpm	2200
Cooling Media	Air
Cycle	4 stroke
Compression Ratio	14.5 to 1
Fuel Injection	Solid
Rotation (Facing front)	Anticlockwise

b. Performance.—

Maximum rpm	2250
Rated BHP at 2200 rpm	250

c. Fuel consumption with specified fuel: (lbs per BHP per hour). —

at 2200 rpm — Full Power	.415
at 1870 rpm — Full Power	.395
at 1320 rpm — Full Power	.415

d. Lubricating oil consumption: (lbs per BHP per hour). —

at 2200 rpm — Rated Power	.021
at 1870 rpm — Full Power	.023
at 1320 rpm — Full Power	.020

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 (overall).—

Overall diameter	45-$\frac{7}{16}$"
Length with Coffman Starter	36-$\frac{15}{16}$"

g. Center of gravity.—

Horizontal.....Forward of mounting ring by approximately 7".
Vertical..... Crankshaft center.

6. Crankcase.—The crankcase consists of two aluminum alloy castings bolted together on the center line of the cylinders. Hardened bearing liners are pressed into the front and rear portions of the case. Ball or roller bearings fit these liners and furnish support for the crankshaft. Valve tappet guides and the fuel injection pumps are located in the rear case which is provided with mounting bosses. The fuel channel is bored in the rear case between the fuel pump bosses.

7. Cylinders.—Heat-treated aluminum alloy cylinder heads are screwed and shrunk onto forged steel barrels. Cooling fins are provided on the barrels and cylinder heads to provide radiation surface. Cylinder bores are bored 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.

8. Pistons.—Heat-treated aluminum alloy pistons are provided with three compression rings and one oil ring above the piston pin, and one scraper ring in the skirt. The pistons are forged. The full-floating piston pins have aluminum alloy plugs for the piston pin retaining device.

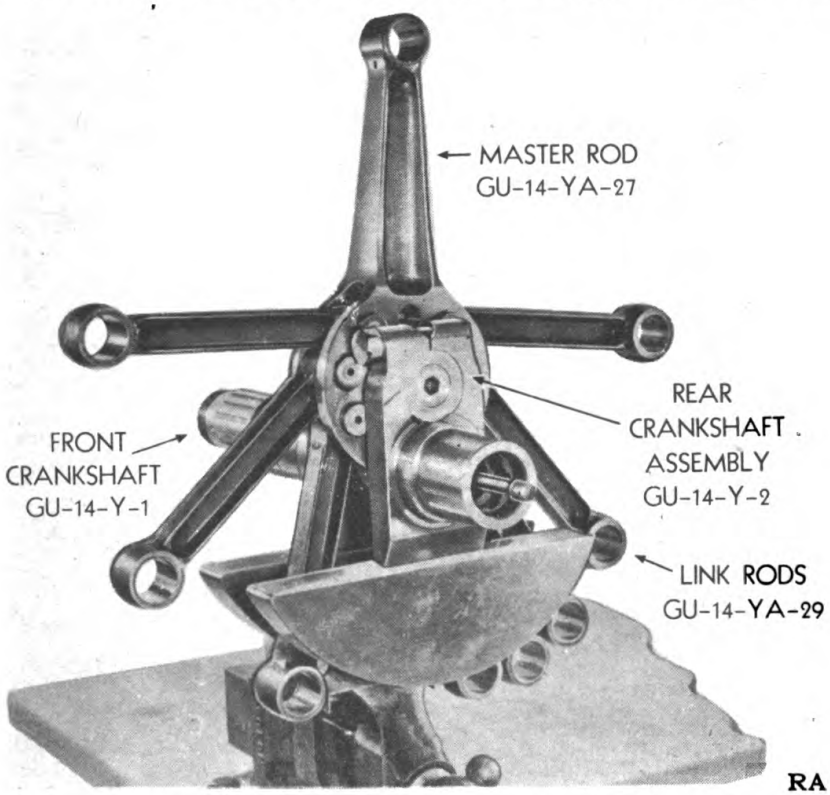


FIGURE 3—Crankshaft, master rod, and link rod assembly.

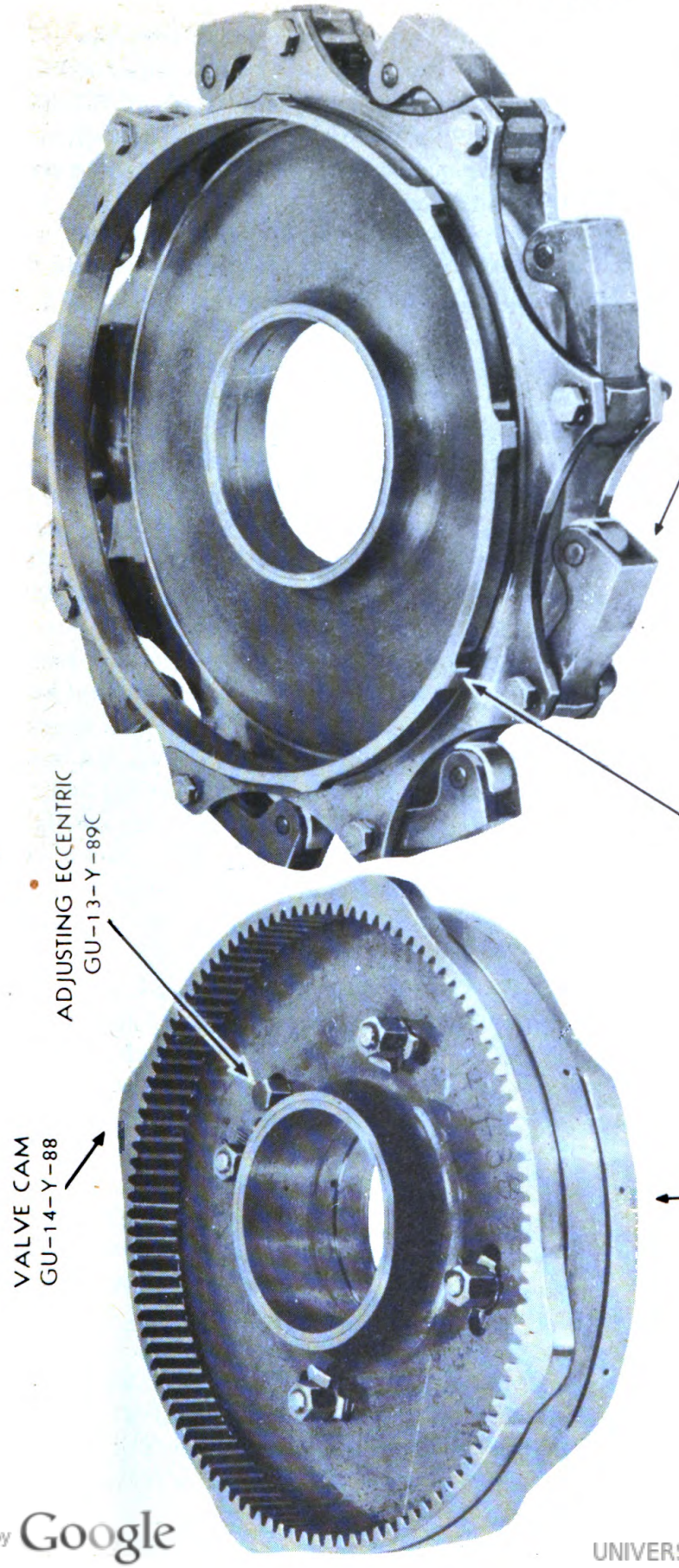


FIGURE 4—Valve cam and fuel control plate assembly.

9. Master and articulated rod assembly.—*a. Master rod.*—The master rod is an "H" section of forged steel, heat-treated, and machined. The crank pin bearing is an integral type, precision-bored, steel-backed, lead-bronze bushing. The link rods operate on knuckle pins secured in the master rod by retaining rings. The master rod is drilled to provide pressure lubrication to the knuckle pin bushings.

b. Link rods. — The link rod is an "H" section with machined ends. Knuckle pin bushings and piston pin bushings are pressed into the link rods. All bearings are jig-bored for alinement and center distance.

10. Crankshaft.—The crankshaft is a two-piece heat-treated steel forging drilled throughout for lightness and plugged to form 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. The shaft is supported by two roller bearings referred to as main bearings and one ball thrust bearing secured in place at the forward end against a spacer sleeve and lock nut. The flywheel end of the shaft is machined with a spline (aeronautic) modified in length for the flywheel hub.

11. Valve cam and fuel control plate assembly.—*a. Valve cam.*—*(fig. 4).* The valve cam is of forged steel, completely machined and hardened. The intake and exhaust lobes are unified so that one lobe operates both the intake and exhaust tappets per cylinder and is known as a monorail cam with four lobes. The valve cam is carried on a bronze bushing. The valve cam drive gear is integral with the cam, turning one-eighth engine speed in the direction opposite to the crankshaft rotation. The valve cam drive gear meshes with the pinion gear which is attached to the intermediate gear. The intermediate gear is driven by the starter jaw crankshaft gear.

b. Fuel cam ring.—(fig. 4). The fuel cam ring is of forged steel, heat-treated and machined all over. The fuel cam ring is secured to the valve cam by four mounting bolts. Slots in the valve cam permit the fuel cam ring to be turned relative to the valve cam for fuel-timing the engine. A fuel cam adjusting eccentric extends through the valve cam for adjusting the fuel cam ring when the securing nuts are loosened.

12. Valve operating mechanism *(fig. 5).*—*a.* The tappets, which operate the valves, have rollers which ride on the valve cam. The tappets fit into aluminum alloy guides which have threaded top sections. The push rod housing nut screws onto this threaded top section of the valve guide, keeps the push rod housing in alinement, and forms an oil-seal.

b. The push rods, which set on the valve tappets and operate the valve rocker arms, 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 an adjustable socket in the rear of the rocker arms. The inner end of the push rod is marked with an arrow. This indicates the end of the

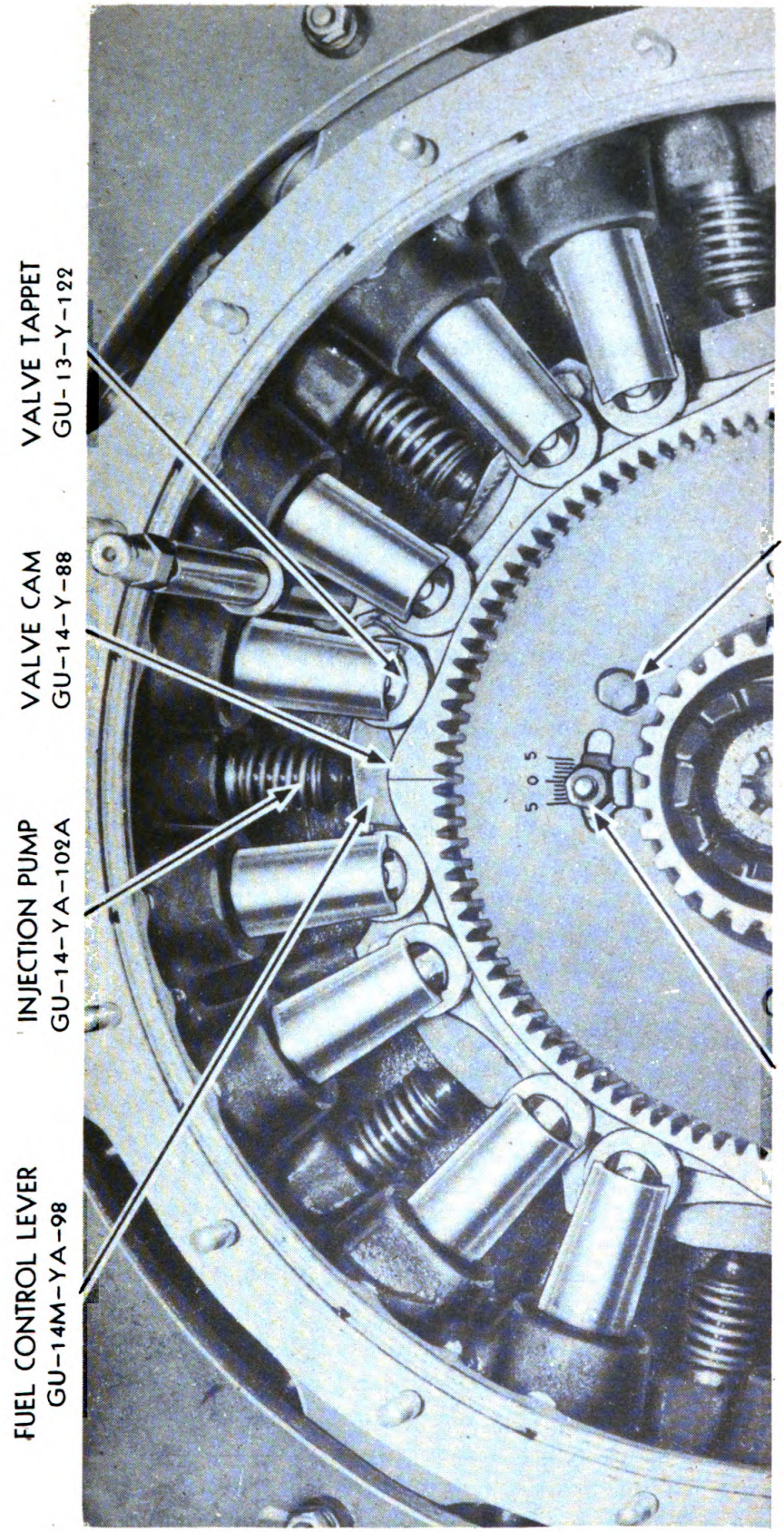


FIGURE 5—Valve tappet roller operation on the valve cam.

push rod which has a ball check valve to let lubricating oil into the push rod, but will not let it drain out. Each rocker arm is mounted on a Timken bearing. The rocker mechanism is enclosed. Push rods may be removed through the rocker arms by removing the adjustable screw socket from the rockers. In case the engine is being disassembled the push rod and housing may be removed by loosening the push rod housing nuts.

c. The push rod housing is a tube, flanged at one end. The push rod housing nipple in the rear of the rocker box receives the straight end of the push rod housing. Push rod housing nuts retain a packing ring which seals securely the push rod housing assembly from dust or oil leaks.

13. Accessory case.—The accessory case which contains the entire gear train is an aluminum alloy casting attached to the rear crankcase. Standard SAE flange mountings are provided for the starter, generator drive, 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. Directly above the starter flange is a small, removable inspection plate which permits the adjusting of the fuel cam ring. Drilled ducts are provided for the oil from the lubricating oil pressure pump to the crankshaft and intermediate gear bushings. A cored duct is incorporated for the by-passed oil and the oil from the scavenging pump.

14. Manifolds.—*a. Intake Manifold (fig. 26).* The intake manifold, an integral part of the fan shrouding, is composed of the intake manifold fan shroud body, intake elbows and flanges, connecting hoses, and clamps. The shroud body is mounted to the engine steady rest tube by means of special fittings. Intake elbows connect the body with each cylinder head.

b. Exhaust Manifold (fig. 30). The exhaust manifold is composed of two halves, one for the right side and one for the left side. Branch pipes which connect the exhaust ports with the exhaust manifold have slip joints.

15. Lubricating oil system.—*a.* It is recommended that the same brand of oil be used exclusively between oil change periods. When it is necessary to change grade or brand, drain the entire oil system including the storage tank, the sump, and the filter. Renew the filter cartridge before refilling the system with the new oil. *Do not mix brands.*

b. The following table should be observed for the operation of the engine.

Above 40° F, use SAE engine oil 60
Below 40° F, use SAE engine oil 50

c. The minimum oil pressure should not be less than 40 pounds per square inch with 160° F oil at 500 rpm and a maximum of 95 pounds per square inch at 2200 rpm. The operating pressure at 2000 rpm should be approximately 85 pounds per square inch.

d. (fig. 7). The lubrication system is made up of a storage tank, oil filters, a combination oil pump, the engine, an oil temperature regulator,

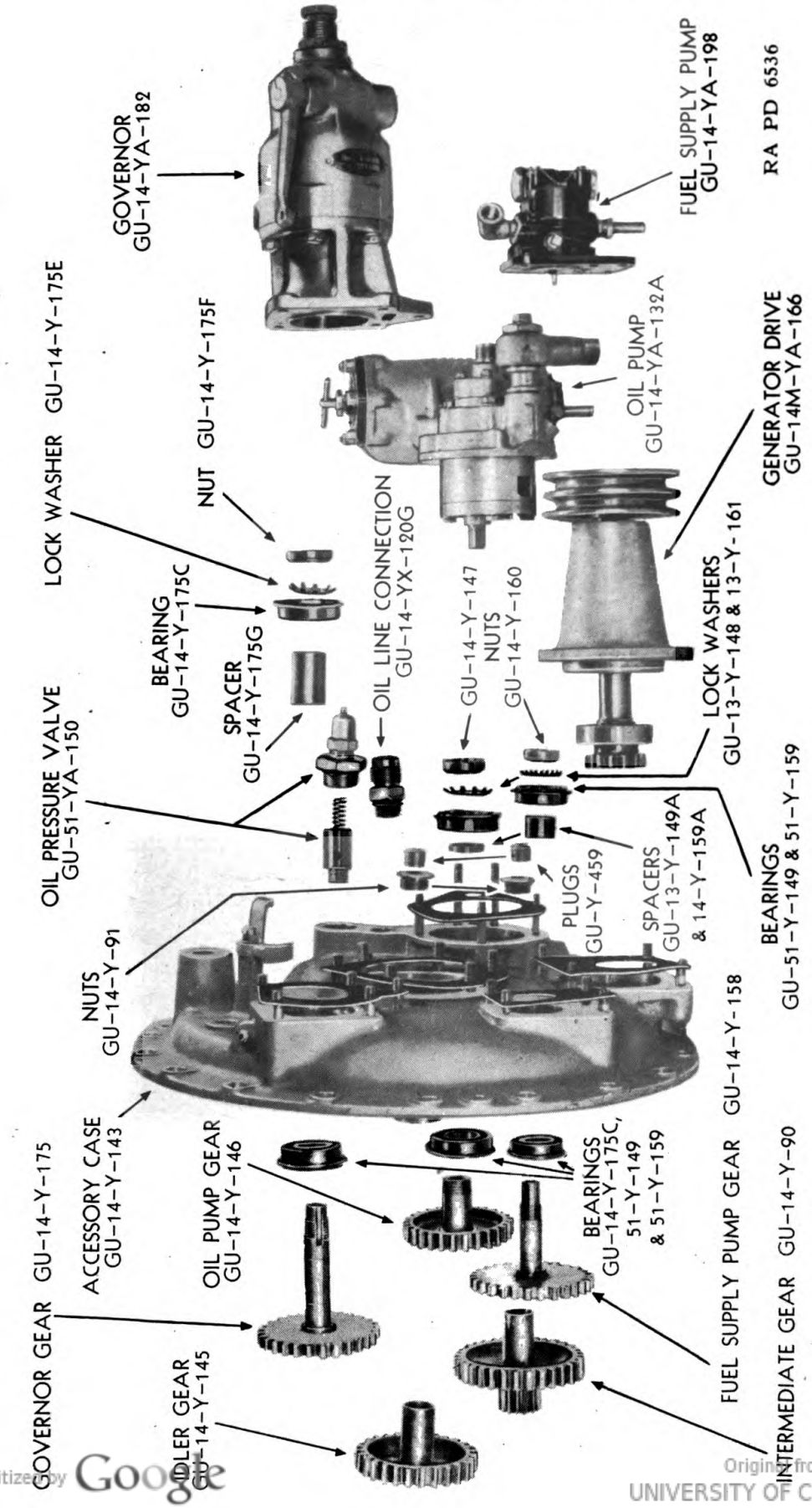
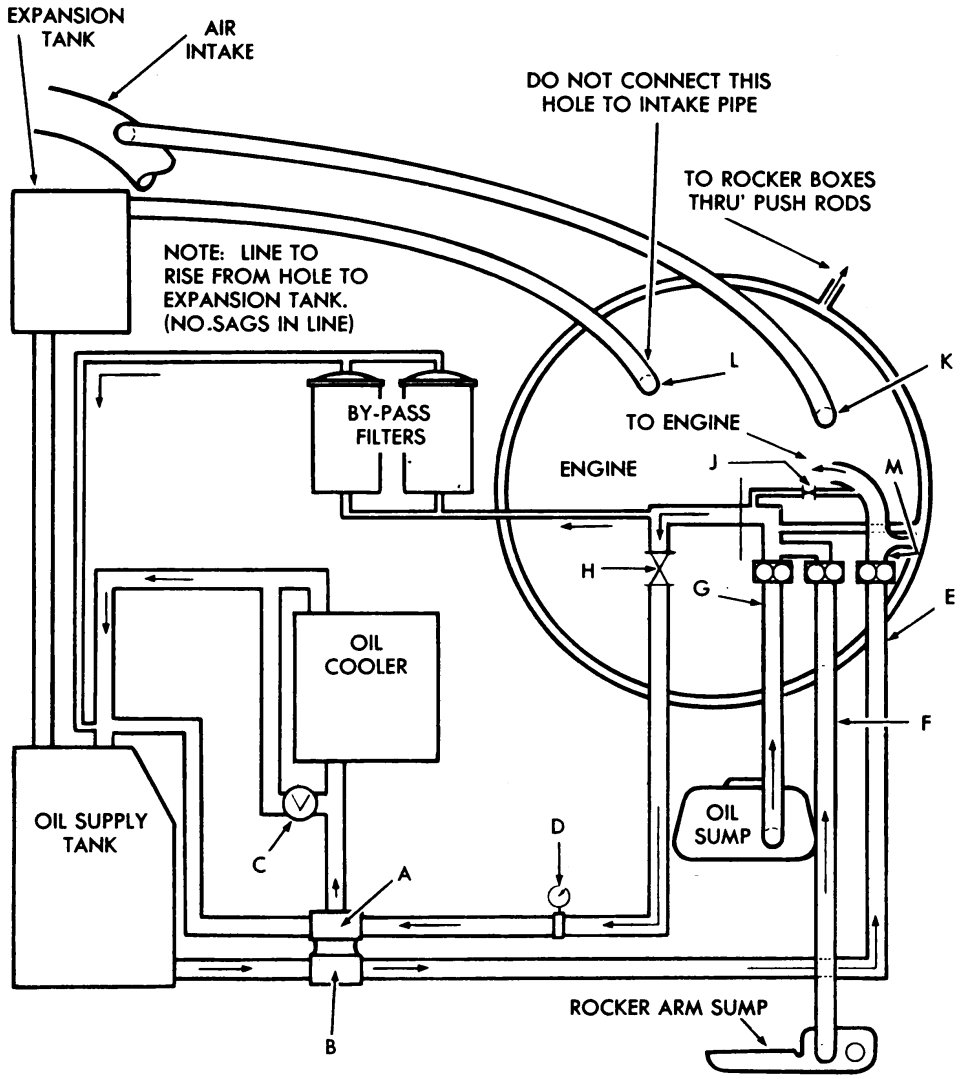


FIGURE 6—The accessory case assembly.



A VALVE SECTION OF TEMPERATURE REGULATOR VALVE
B CONTROL 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
H CRANE VALVE
J OIL PRESSURE RELIEF VALVE
K AIR BREATHER HOLE
L CONNECTION FOR EXPANSION TANK LINE (WET HOLE)
M THE OIL PUMP HAS A BUILT-IN FULL FLOW LUBRICATING OIL FILTER

RA PD 10690

FIGURE 7—Diagrammatic sketch of lubricating oil paths.

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 rocker boxes. The two scavenger pumps are connected on outlet side of the accessory case. A single outlet from the crankcase scavenger pump housing serves as the outlet for both scavenger pumps. See figure 64 for the various parts of the oil pump assembly.

e. 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 housing. Part of the oil is forced 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.

f. Two cartridge-type filters are connected to the pressure side 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.

g. The oil which lubricates the moving parts of the engine leaves the pressure pump and goes from the cored passage through a drilled oil line to a circular groove located in the accessory case 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.

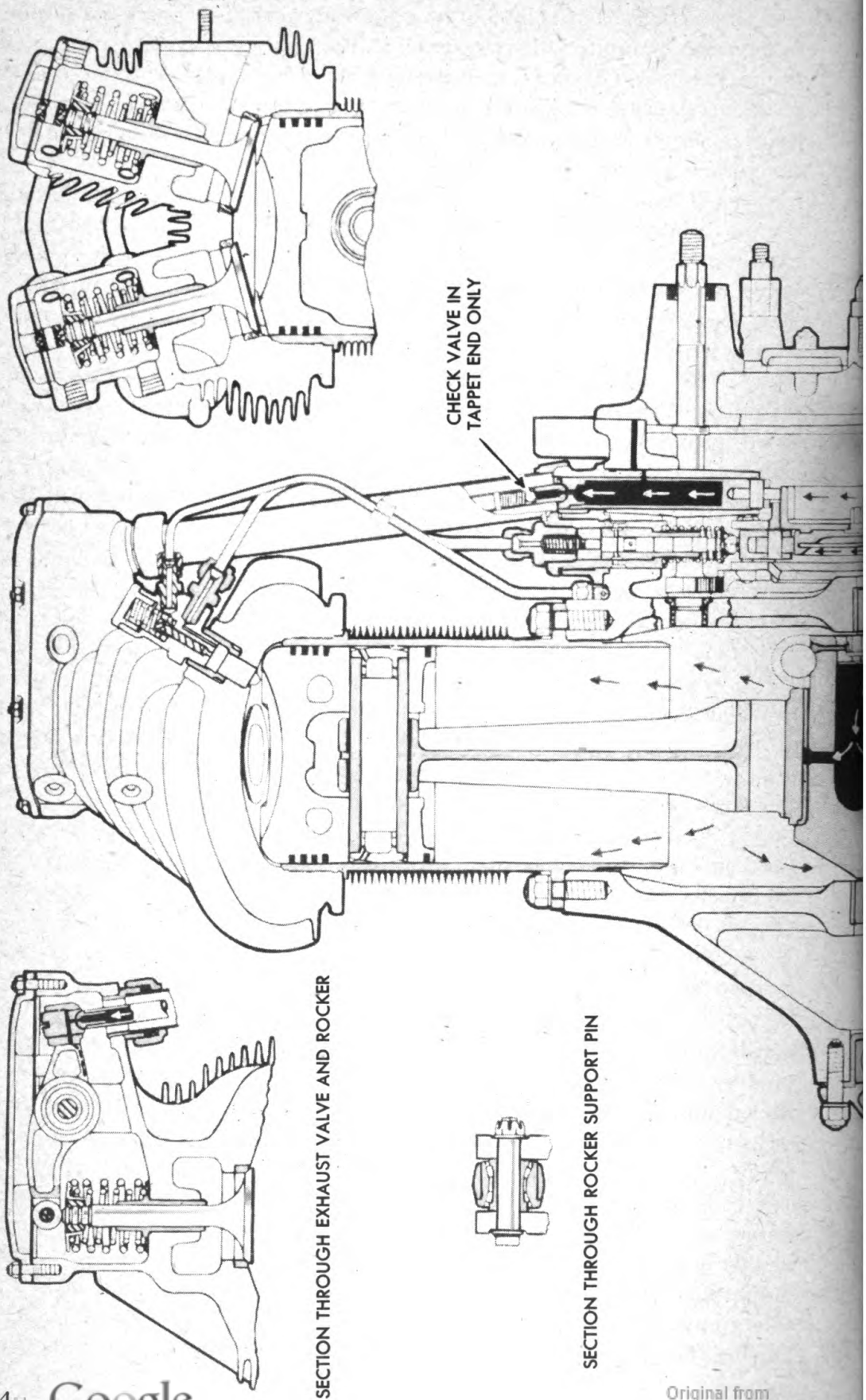
h. The starter jaw bushing is drilled to connect the circular groove in the accessory case with a groove in the starter jaw. Through this path, oil is forced into the center of the crankshaft which is drilled to serve as a gallery line to supply oil to the master rod bearing, the knuckle pin bushings, the valve cam, and the fuel cam.

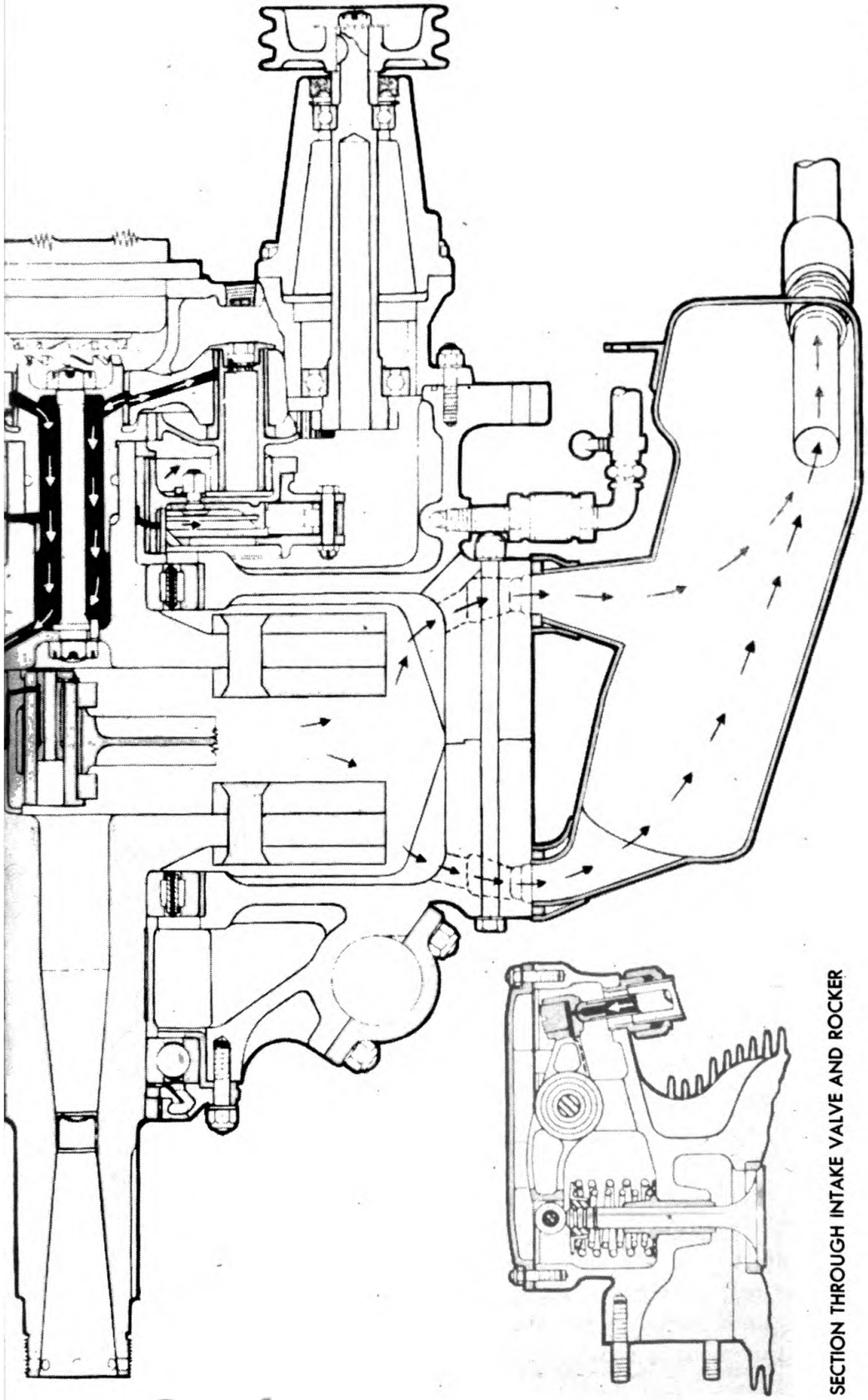
i. Pressure oil from the crankshaft lubricates the valve cam and the fuel control plate bushings. Oil, thrown from the ends of the bushings and the oil holes drilled in the valve cam hub, provides lubrication for the various parts of the fuel control assembly.

j. The gear train is lubricated by the oil from the starter jaw, intermediate gear, and idler gear bushings which receive pressure lubrication.

k. The oil lubricating the parts in the crankcase and accessory case is splashed around by the rotating parts and serves to lubricate the piston pins by splash. 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.

l. The oil which lubricates the push rods, tappets, and rocker arms passes from the pressure pump through a cored passage and through drilled holes in the accessory case, to a circular groove machined in the mounting flange of the rear half of the crankcase. Holes are drilled from this groove to connect with holes drilled in each of the tappet guides. During the operation of the engine, a hole in the tappet body comes in





RA PD 10687

FIGURE 8—The lubrication system.

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 this oil passes by the check ball in the tappet end of the push rod to lubricate the push rod ends before passing on through the rocker arm to lubricate the rocker arm bushing. The oil which collects in the rocker arm boxes drains through a system of inter-cylinder drain tubes to the oil sump rocker box covers of Nos. 5 and 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.

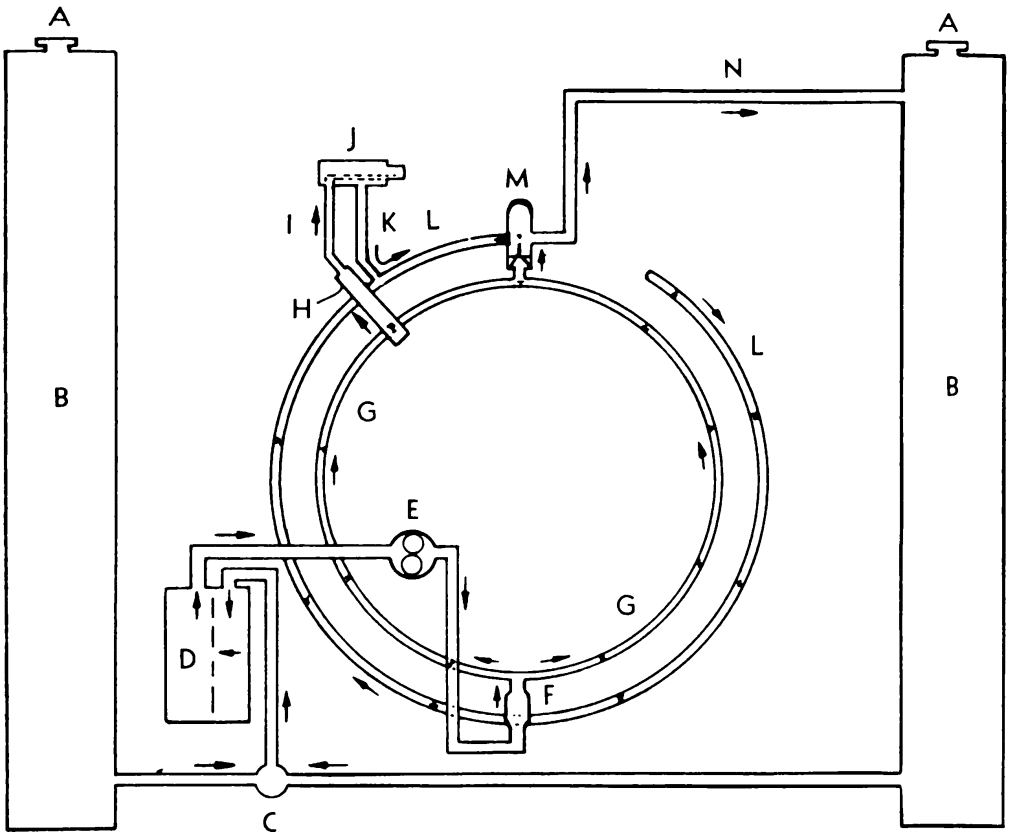
m. In the accessory case are two holes called "Case Breather Connections." One of these holes is connected to the air inlet between the air cleaner and the manifold. The gases which get past the piston rings are removed from the crankcase through this hole, are taken into the intake, and are forced out of the cylinders with the exhaust gas. The other hole is connected to the top of the oil supply tank through two 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. Two inlet connections on the oil tank are used so that the line will not be sealed when the vehicle is operating at an angle. With only one inlet connection, oil would seal the end of the line and prevent a free air path between the case and the oil supply tank.

16. Fuel system.—*a. (fig. 9).* 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 starter jaw gear. The fuel supply pump has a built-in safety by-pass valve to protect the pump in case the flow of fuel should become restricted on the outlet side of the pump. (See Section XI for complete description of the fuel supply pump.)

b. Fuel enters the fuel channel through a one-way check valve located at the bottom of the engine. This check valve allows fuel to enter the fuel channel but the check prevents it from draining back out again.

c. From the check valve the fuel goes to the fuel channel, which is a drilled passage in the rear half of the crankcase connecting the injection pump mounting holes. Fuel is supplied through this channel to each of the fuel injection pumps.

d. (fig. 10). 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 Nos. 1 and 2 fuel injection pumps. 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



KEY

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

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FIGURE 9—Diagrammatic sketch of fuel oil paths.

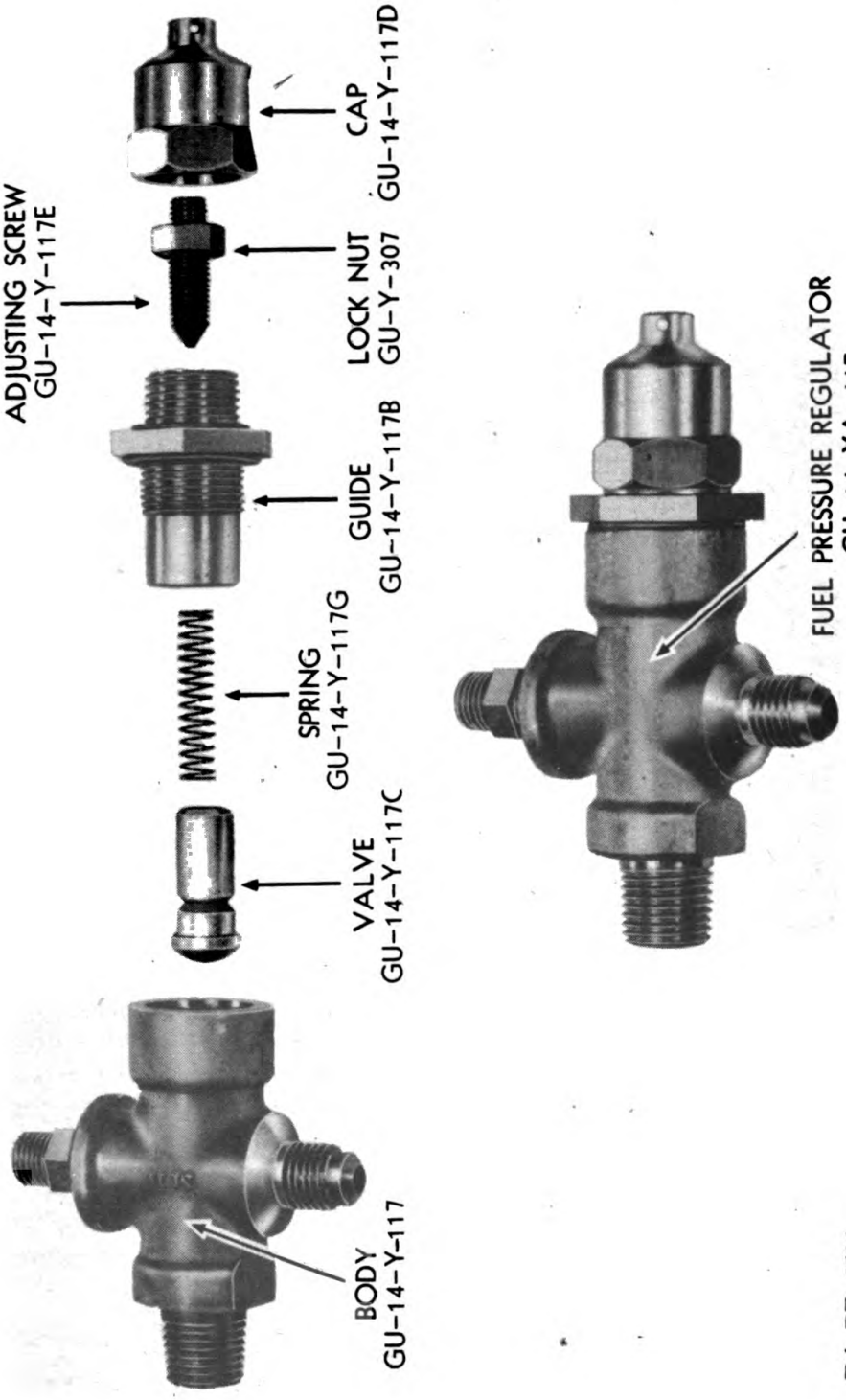


FIGURE 10—The fuel pressure regulator assembly.

nut, and turning the adjusting screw to increase or decrease the spring pressure. This valve is set to open at a pressure of 6 pounds per square inch.

e. (fig. 11). 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 pump is connected to an injector by a heavy wall, high pressure tubing.

f. The plunger of the injection pump rides on a lever on the fuel control plate assembly *(see fig. 5).* The lever, in turn, operates on the fuel cam ring, moving up and down over the lobes of the fuel cam ring and thus moving the injection pump plunger up and down. Operation of the throttle shifts the position of the levers, changing the contact point of the plunger on the lever *(fig. 12).* This changes the length of the plunger stroke, and regulates the amount of fuel injected on each stroke.

g. When the plunger is at the downward end of the stroke, fuel enters the pump through the inlet port above the plunger *(fig. 12).* The fuel pump body has a drilled passage through which the fuel flows on its way to the injector. A one-way check valve seats in the check valve body, allowing fuel to flow through but preventing it from dropping back.

h. With the plunger on the downward part of its stroke, fuel enters from the fuel channel and occupies the space above the plunger. As the plunger moves up, 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.

i. 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 length of the plunger stroke. This is shown in figure 12.

(1) As the throttle lever is moved from the shut-off position to the full load 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 plungers marked "low" in illustration 2 and illustration 1. This low position creates a full opening of the intake port, with the plunger below the 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.

(2) For a wide open throttle, illustration 3 shows an enlarged view with the maximum opening of the inlet port. 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 which time fuel comes through the drilled hole in the center of the

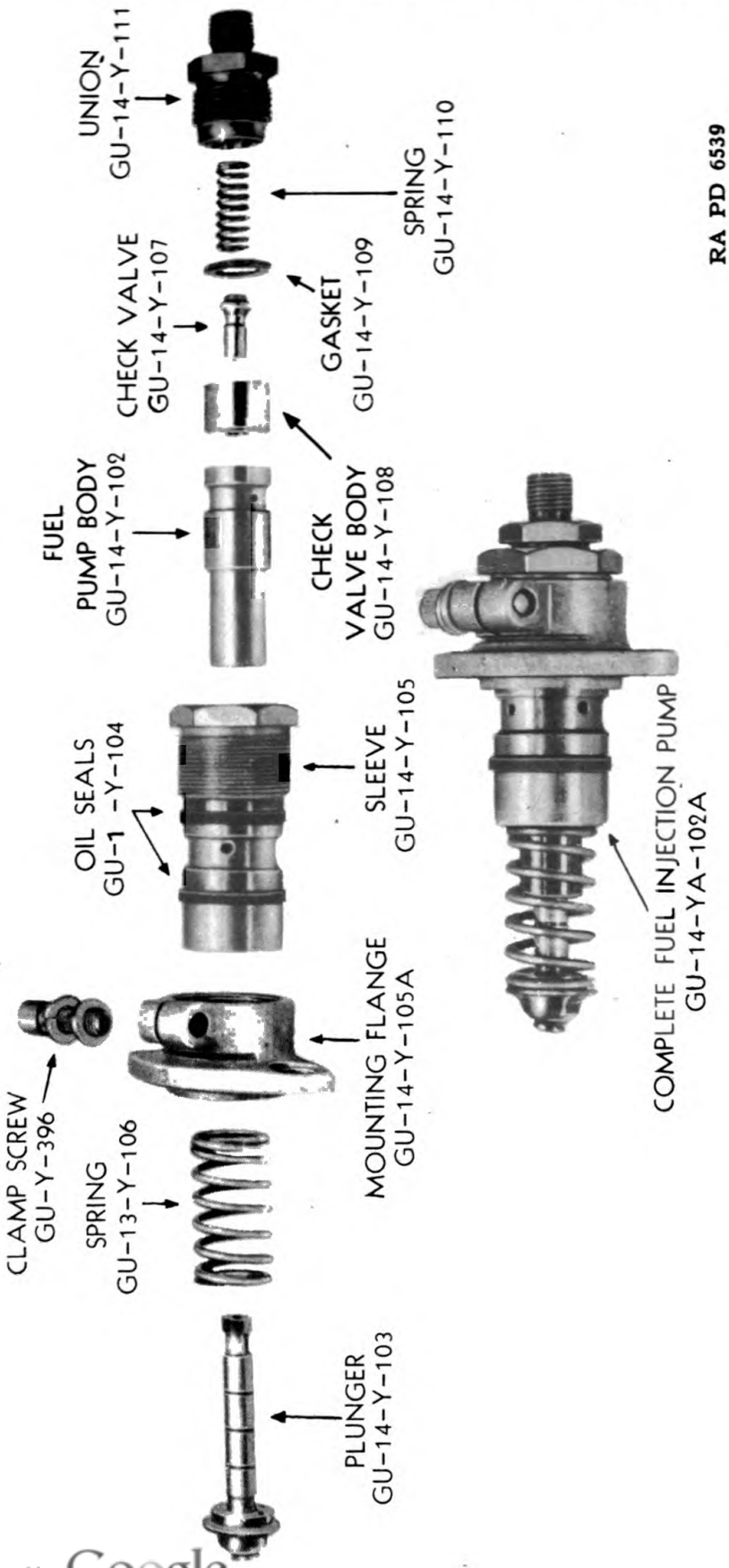
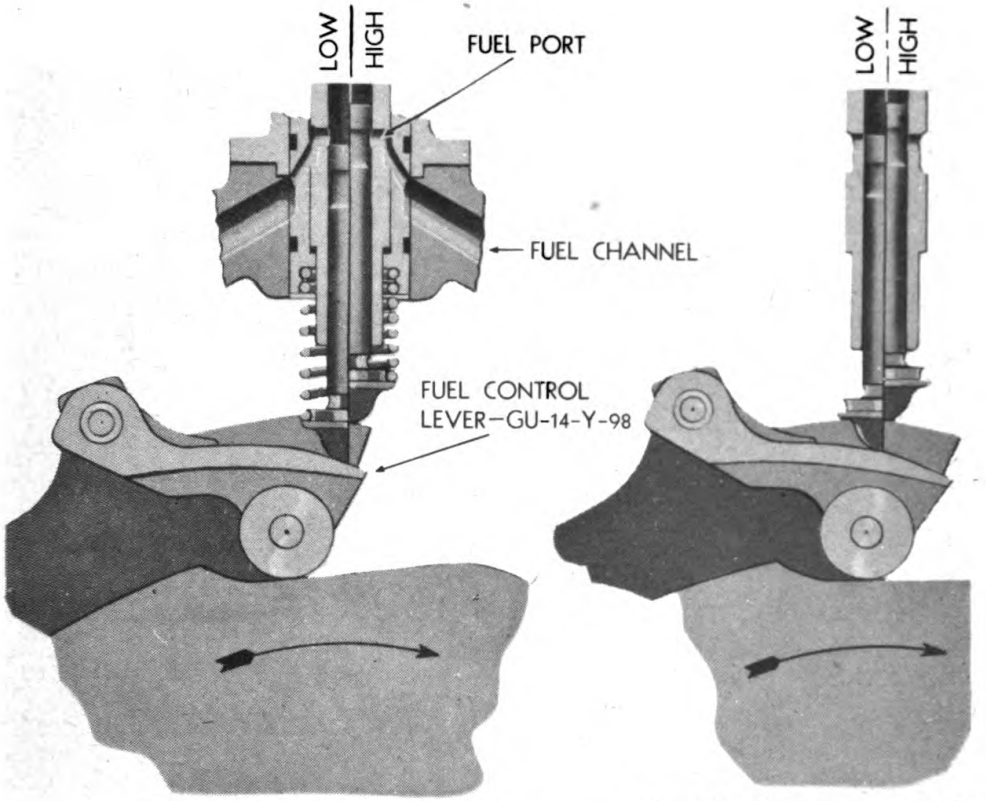


FIGURE 11—The fuel injection pump assembly.

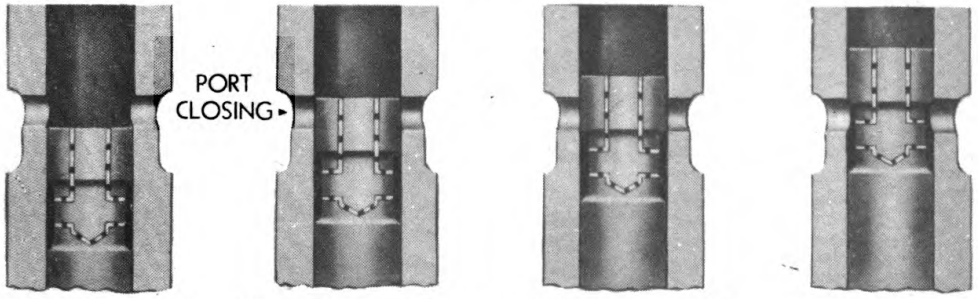


WIDE OPEN THROTTLE POSITION
ILLUSTRATION 1

SHUT-OFF THROTTLE POSITION
ILLUSTRATION 2

4 LOBE CAM
⅛ ENGINE SPEED

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 12—The fuel pump principle.

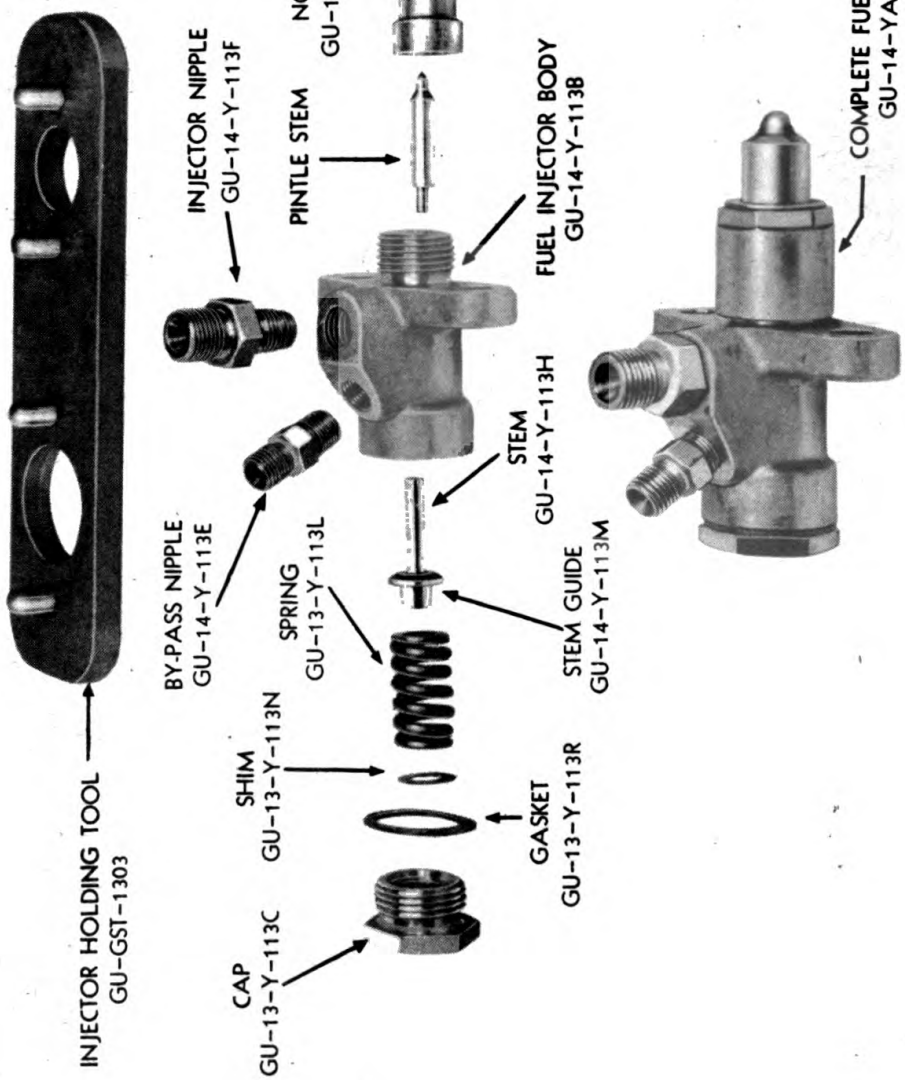


FIGURE 13—The fuel injector assembly.

plunger to the cutaway diameter, and from there out into the fuel channel. After injection is thus ended, the fuel pump plunger continues to rise to the position shown in illustration 6.

j. (fig. 13). The fuel injector injects the charge of fuel from the injection pump into the combustion chamber of the cylinder. The pintle is held against its seat in the nozzle by the stem guide which rests upon a spring. When the fuel pressure from the injection pump overcomes the force of the spring, the pintle moves back out of its seat. Fuel is forced through the nozzle, and is injected into the combustion chamber. After the fuel is injected, the fuel pressure drops until the spring again forces the pintle back against its seat, stopping the injection. Any fuel leaking past the pintle is returned to the fuel tanks through the fuel return ring.

17. Using troop TM reference.—Many second echelon operations described in TM 9-726 are often done by ordnance maintenance personnel; for information on these operations, refer to the using troop TM for information.

SECTION III

ECHELON BREAKDOWN OF MAINTENANCE DUTIES

Paragraph

18. Echelon breakdown of maintenance duties.—*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 adjustment of subassemblies or assemblies and controls.

(2) *Repair.*—Consists of making repairs to, or replacement of, such parts, subassemblies or assemblies as can be accomplished without completely disassembling the subassemblies 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, 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:

	ECHELONS		
	2nd	3rd	4th
(1) *Engine*			
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	—

ECHELON BREAKDOWN OF MAINTENANCE DUTIES

	ECHELONS		
	2nd	3rd	4th
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, cartridge type — CLEAN, SERVICE, REPLACE	X	—	—
Starter, cartridge type — REPAIR	—	X	—
Starter, cartridge type — REBUILD	—	—	X
Starter, breech and tube — CLEAN, SERVICE OR REPLACE	X	—	—
Starter, breech and tube — REPAIR	—	X	—
Starter, breech and tube — 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
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	—	X	—
Baffle, intercylinder — REPAIR AND REPLACE	—	X	—
Cowling — REPLACE	X	—	—
Cowling — REPAIR	—	X	—
Cowling — REPAIR AND REPLACE	—	X	—
Springs, intercylinder baffle — REPLACE	X	—	—
(4) *Fuel System*			
Fuel filter — SERVICE OR REPLACE	X	—	—

	ECHELONS		
	2nd	3rd	4th
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 IV

TROUBLE SHOOTING

19. Shell doesn't fire.—After three attempts to fire the shell, check the wiring in the tank to the starter to make sure that it is in order. Inspect the contact point in the base of the cartridge for dirt or foreign matter.

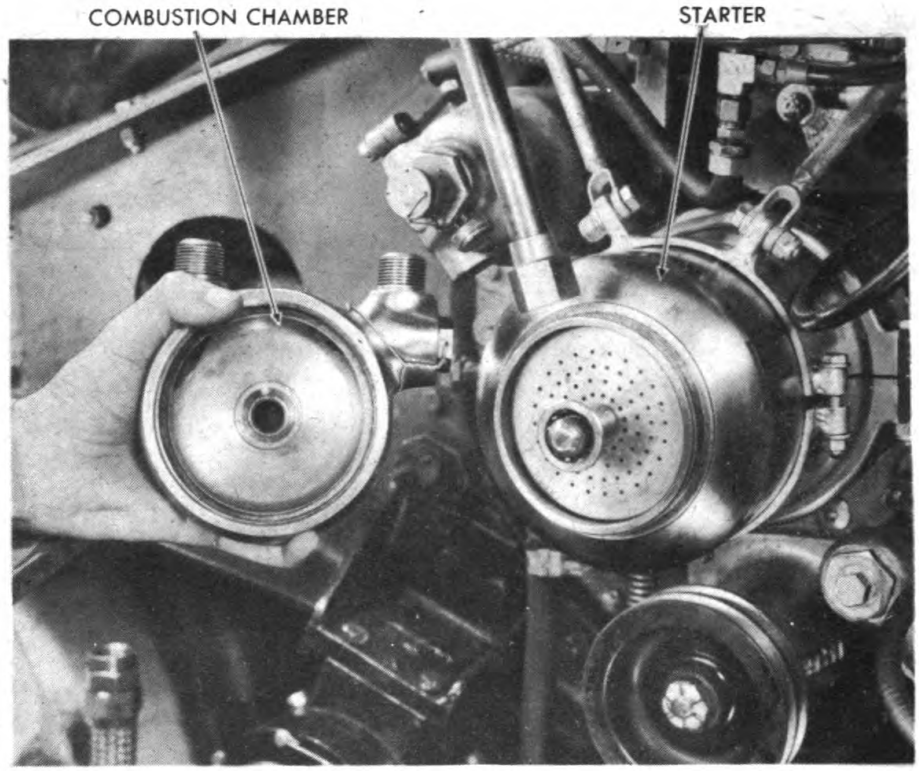
20. Shell fires but engine doesn't turn.—If the shells can be fired but the engine will not turn over, inspect the safety disk. If it is not defective, the trouble will usually be found in the starter. Disassemble the starter (see TM 9-1371).

21. Shells do not fire properly.—Sometimes shells "fizzle" instead of firing. This is usually due to defective shells. After two such occurrences in succession the cap at the back of the starter should be taken off and the unburned powder removed from the combustion chamber to prevent its damaging the starter. Remove the two tubes at the top of the starter, using a 1-inch wrench. Use a soft hammer to drive on the left port to turn the cap and remove it. Wipe the chamber clean. Then replace the cap.

22. Engine turns but doesn't start.—If, after two or three shells have been fired, the engine hasn't started, check the fuel tanks to make sure there is a supply of fuel. Bleed the fuel system (par. 30-*b*. (1)) to remove air and assure fuel reaching the injection pumps. Check the throttle opening to make sure that it is allowing fuel to enter the engine.

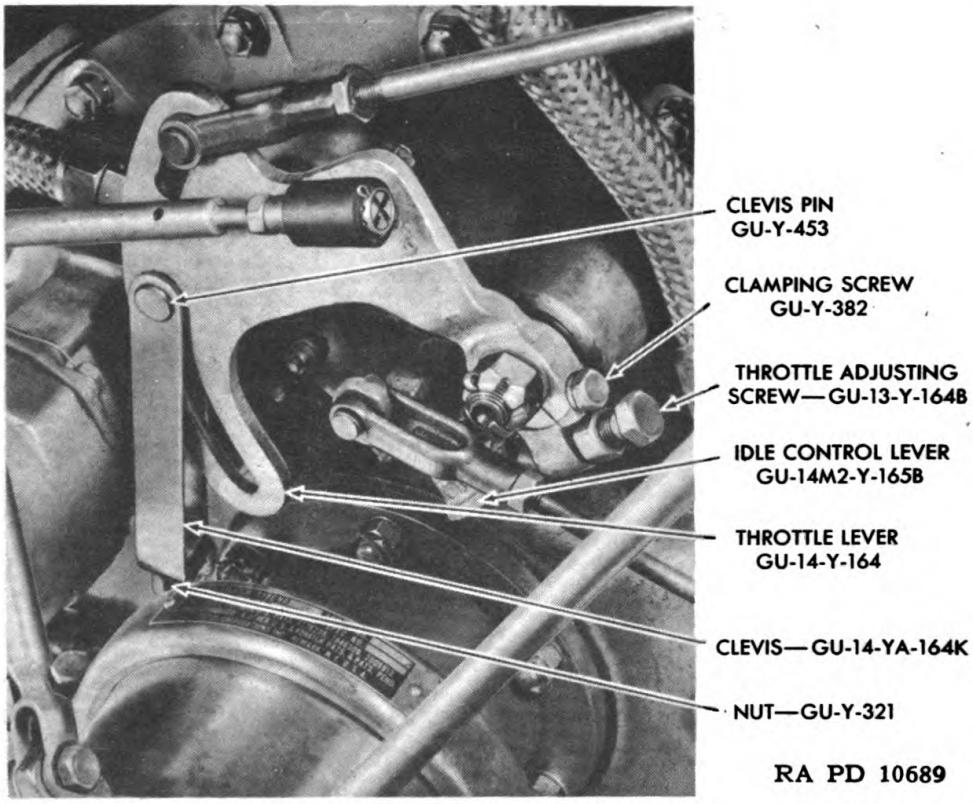
23. Blown safety disk.—A blown safety disk is indicated by a loud report when the shell is fired, and the engine doesn't turn over. Replace the safety disk in the starter, as covered in the "Accessories" section of this manual. Be sure the asbestos side of the safety disk is toward the combustion chamber.

24. Oil pressure drops suddenly.—Examine the oil pressure relief valve. Dirt may have lodged in it, preventing the oil check from closing. In the case of an engine that has seen considerable service, low oil pressure may indicate defective accessory case or crankcase bushings.



RA PD 10688

FIGURE 14—The starter combustion chamber.



RA PD 10689

FIGURE 15—Wide open throttle adjustment.

25. Vibration sets in and white smoke in unusual quantities comes out of the exhaust.—Check the temperature of the exhaust manifolds to make sure all cylinders are firing. Check the compression of each cylinder. Low compression of any cylinder may indicate defective rings. In the case of an engine that has seen considerable service, defective rings should be suspected at once. Remove the injectors (see 27-*b*. (9)), and test them on the injector tester (see par. 104). A sticking pintle valve or a leaky valve seat would cause poor atomization of the fuel.

26. Engine won't reach maximum speed *(fig. 15)*.—Check the throttle to make sure it reaches wide open position. To do this, move the throttle control on the inside of the tank to the wide open position. In this position there should be between $\frac{1}{16}$-inch to $\frac{1}{8}$-inch clearance between the clevis pin in the throttle lever slot and the end of the opening in the lever, as shown in figure 15. Check the governor. With wide open throttle the governor control shaft should have approximately $\frac{1}{4}$-inch of free travel before it affects the throttle. If everything checks all right, and the engine still won't reach maximum speed, turn the adjusting screw in the rear of the governor. Back it out until the governor permits the engine to reach its speed of 2200 rpm under *full* load or approximately 2325 rpm with no load.

27. Inspection of engine in tank.—*a. Equipment.*—

$\frac{7}{16}$-inch wrench	Pliers
$\frac{1}{2}$-inch wrench	1-inch wrench
$\frac{9}{16}$-inch wrench	$1\frac{1}{2}$-inch wrench
$\frac{5}{8}$-inch wrench	Soft hammer
$\frac{3}{4}$-inch wrench	Screwdriver
$\frac{7}{8}$-inch wrench	Valve guide and fuel pump puller (GU-GST-1365)
Feeler gage	

b. Procedure.—

(1) Check intake valve clearance on No. 5 and No. 6 cylinders. Feeler gage

The intake valves on Nos. 5 and 6 cylinders will sometimes lose their adjustment. These two valves are readily accessible for adjustment while the engine is in the tank. Check with a feeler gage and set to .020-inch clearance.

(2) Inspect push rod housing nuts.

Check all push rod housing nuts for tightness, and examine for oil leaks and cracks.

(3) Clean starter combustion chamber. 1-inch wrench
Soft hammer

Clean out the starter combustion chamber. Remove the two tubes at the top of the starter, using a 1-inch wrench. Use a soft

hammer to drive on the left port to turn the cap until it is loose and remove the cap. Wipe the combustion chamber clean. Then screw on the cap.

(4) Adjusting the throttle.

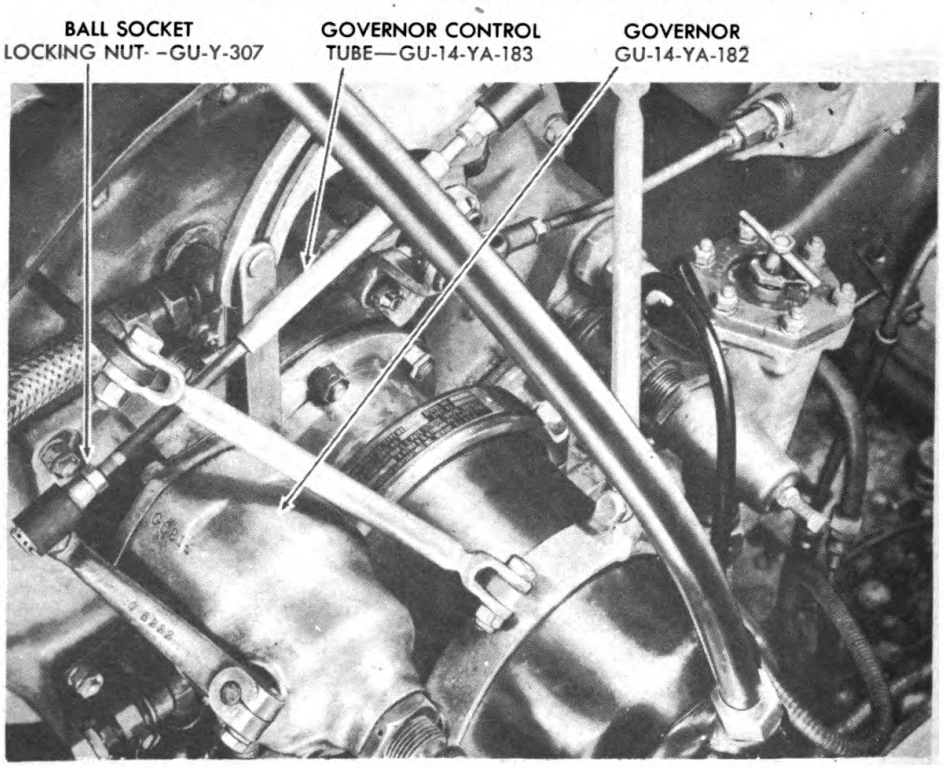
(a) *(fig. 15)*. Before making any adjustments of the throttle, be sure that the throttle shaft lever does not bind against the accessory case. There should be .020-inch clearance between the lever and bushing with throttle shaft pushed all the way in. If the throttle shaft lever binds, loosen the clamp bolt and throttle shaft nut, and adjust to give proper clearance.

(b) With the throttle pressed to the floor, and the throttle shaft lever down in wide open position, there should be $\frac{1}{16}$-inch to $\frac{1}{8}$-inch clearance between the clevis pin and the end of the opening, as shown in figure 15. Adjustment is made by turning the nut at the bottom of the clevis.

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

(d) Set idle adjustment at 500 rpm with the engine thoroughly warm.

(e) Adjust solenoid control rod so that it will pull idle stop out of the way when the engine is on decompression.



RA PD 10693

FIGURE 16—The governor controls.

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

(5) Adjusting the governor. Screwdriver
½-inch wrench

(a) *(fig. 16)*. The engine should not be on decompression when checking the governor linkage.

(b) The governor control shaft should have approximately ¼-inch of free travel before it affects the throttle.

(c) If engine won't reach its speed of 2200 rpm under full load or 2325 rpm with no load, turn the adjusting screw in the rear of the governor until engine reaches desired speed.

(d) 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.

(e) See Section XI for governor disassembly.

(6) Removing fuel supply pump *(fig. 2)*. ½-inch wrench

(a) No adjustment is provided on the fuel supply pump.

(b) To remove the pump, shut off the fuel supply and disconnect the fuel lines at the pump. Remove the four palnuts, nuts and washers from the mounting flange, using a ½-inch wrench. Pull the pump off the studs.

(c) See Section XI for fuel supply pump disassembly.

(7) Removing the starter. ½-inch wrench
$\frac{9}{16}$-inch wrench
$\frac{7}{16}$-inch wrench

(a) See paragraph 27-*b* (3) for cleaning starter combustion chamber.

(b) To remove the starter, use a ½-inch wrench to remove the elastic stop nuts and flat washers which hold the rods of the starter support to the brackets at the top of the engine mounting beam. Disconnect intake tube from starter. Loosen the clamping ring of the support around the starter, using a $\frac{7}{16}$-inch wrench. Slide the support off the starter. Remove the elastic stop nuts and washers from the starter mounting flange, using a $\frac{9}{16}$-inch wrench and pull the starter off the studs on the accessory case.

(c) See TM 9-1731 for the disassembly of the starter.

(8) Removing the oil pump. Pliers
½-inch wrench

(a) To remove the oil pump, disconnect the oil lines, purolator filter line, and the tachometer drive at the oil pump. Cut the safety wire from the packing nut on the oil filter to the oil pressure regulator. Remove the palnuts, nuts and washers from

the oil pump mounting flange, using a ½-inch wrench. Slide the oil pump off the mounting studs.

(b) See Section VII for the disassembly of the oil pump.

(9) Removing fuel injectors *(fig. 13).* ⅝-inch wrench
½-inch wrench

(a) To remove fuel injectors, unfasten the nuts which hold the injection line to the injector and to the injection pump, using a ⅝-inch wrench. Unfasten the nuts which hold the fuel return line to the injector and to the fuel return ring, using a ½-inch wrench. Lift off the lines, taking care not to bend them. Check to make sure lines are numbered as they are removed. Remove the two palnuts, nuts and washers from each injector, using a ½-inch wrench. Lift the injectors from the cylinder heads. 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 fuel lines have been removed.

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

(c) See paragraph 104 for the disassembly of injectors.

(d) See paragraph 104 for testing of injectors.

(10) Removing injection pumps. ½-inch wrench
⅝-inch wrench
Valve guide and fuel pump puller (GU-GST-1365)

(a) To remove injection pumps, disconnect injector line, as in paragraph 27 (9). 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 ½-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.

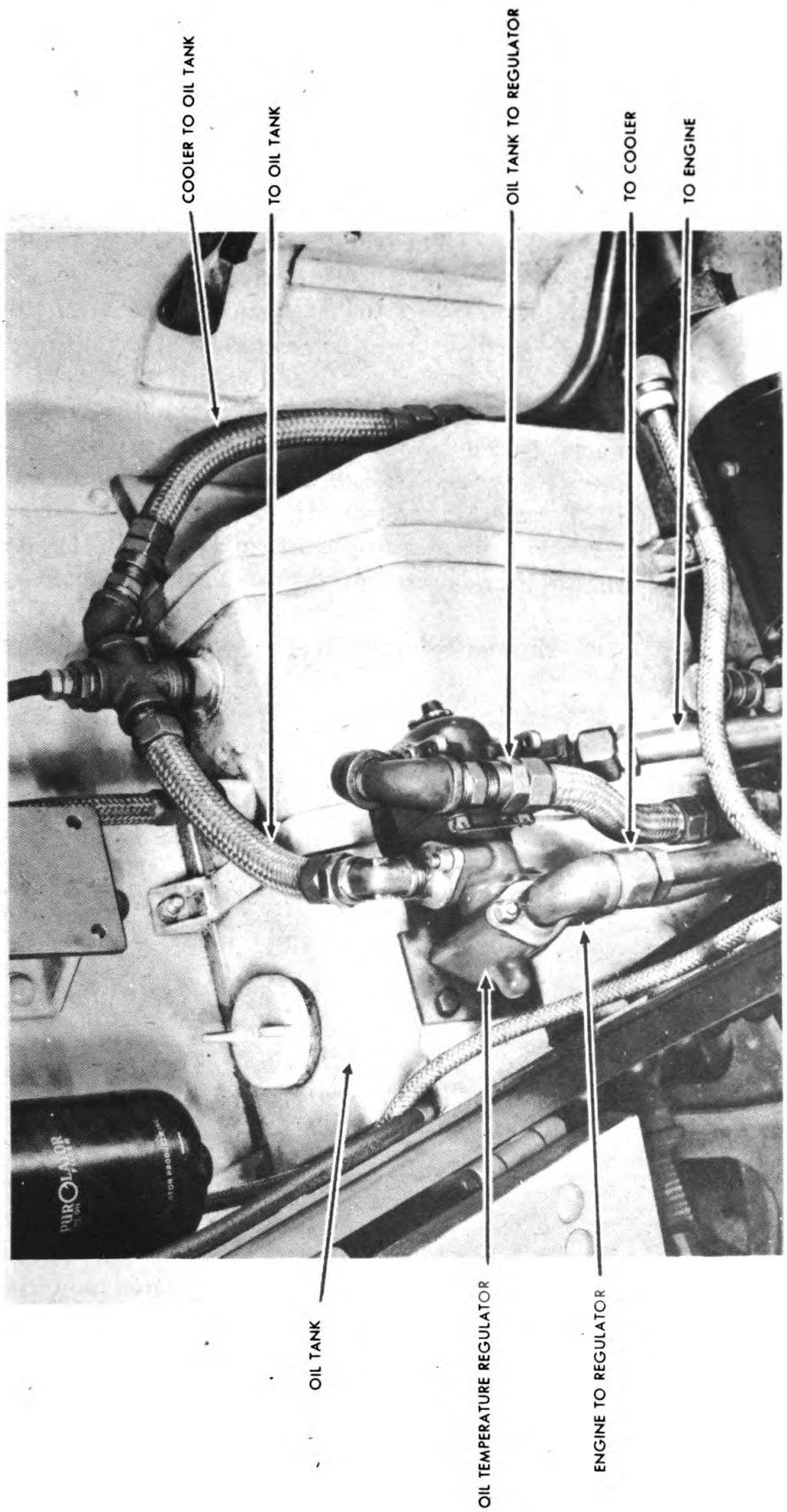
(b) Clean the injection pump of dirt or foreign matter and place it in a bucket of lightweight oil to prevent corrosion.

(c) See paragraph 105 for the disassembly of the injection pump.

(11) Removing the oil sump. ½-inch wrench

(a) Remove the screen periodically and clean.

(b) To remove the oil sump from the engine, disconnect the line at the oil sump. Remove the four nuts which hold the oil sump to the crankcase, using a ½-inch wrench. Lift the baffle bracket off the stud. Remove the oil sump.



RA PD 10694

FIGURE 17—The oil temperature regulator.

(12) Servicing the fuel pressure regulator.

$\frac{7}{16}$-inch wrench
$\frac{3}{4}$-inch wrench

(a) To adjust valve to open at a pressure of 6 pounds per square inch, loosen the lock nut on the adjusting screw, using a $\frac{7}{16}$-inch wrench. Turn the adjusting screw in to increase pressure or out to decrease pressure. Tighten the lock nut.

(b) To remove the fuel pressure regulator, free the connection of the regulator line at the regulator, using a $\frac{7}{16}$-inch wrench. Unscrew the regulator, using a $\frac{3}{4}$-inch wrench.

(c) See paragraph 107 for the disassembly of the regulator.

(13) Oil pressure relief valve.

Screwdriver
$\frac{7}{8}$-inch wrench
$1\frac{1}{2}$-inch wrench

(a) To adjust oil pressures, remove the oil dome from the relief valve, using a $\frac{7}{8}$-inch wrench. Loosen the lock nut. Turn the adjusting screw with a screwdriver.

(b) To remove oil pressure relief valve, use a $1\frac{1}{2}$-inch wrench to unscrew the oil pressure relief valve from the accessory case.

28. Inspection of engine compartment — engine removed. —

a. Equipment. —

$\frac{9}{16}$-inch socket wrench
$1\frac{1}{4}$-inch wrench
$1\frac{1}{2}$-inch wrench
$\frac{1}{2}$-inch wrench
Screwdriver
Pliers

b. Procedure. —

(1) Check oil lines for leaks.

Run the engine at 1600-1800 rpm and inspect all lines and the oil cooler for leaks.

(2) Removing the oil temperature regulator *(fig. 17).*

$\frac{9}{16}$-inch socket wrench
$1\frac{1}{4}$-inch wrench
$\frac{1}{2}$-inch wrench

(a) Remove the generator from its mounting pad, using a $\frac{9}{16}$-inch socket wrench, and rest it on the floor of the engine compartment.

(b) Break the oil line connections at the oil temperature regulator, using a $1\frac{1}{4}$-inch wrench, leaving the elbows on the regulator.

(c) Remove the cap screws from the regulator mounting, using a $\frac{1}{2}$-inch wrench.

(d) Lift out the oil temperature regulator.

(3) Disassembling the oil temperature regulator *(figs. 17 and 18).*

$\frac{1}{2}$-inch wrench
Pliers
Screwdriver

(a) Use a screwdriver to remove the screws and washers

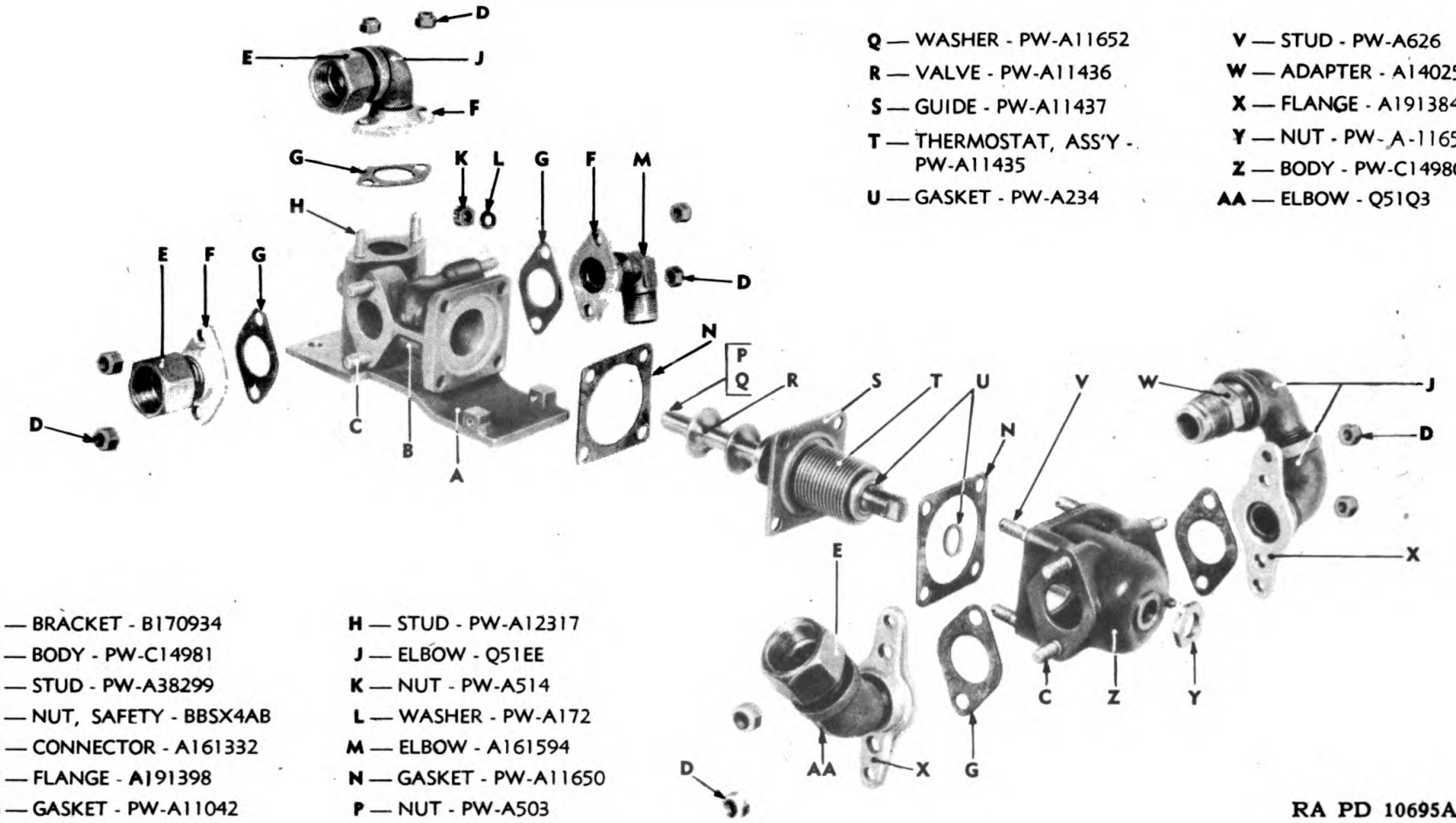


FIGURE 18—The oil temperature regulator disassembled.

that hold the two adapters to the regulator mounting base. One adapter is on the fitting through which oil enters the regulator from the oil tank. The other is on the fitting through which oil passes from the regulator to the engine.

(b) Using a ½-inch wrench, remove the elastic stop nuts from these adapters and lift off the adapters with their elbows, fittings and gaskets.

(c) Cut the safety wire with pliers and remove the nut from the thermostat adjusting screw.

(d) Remove the safety wire from the castellated nuts that hold the valve and control sections of the regulator together.

(e) Using a ½-inch wrench, remove the castellated nuts in step (d).

(f) Separate the valve and control sections of the regulator and remove the thermostat and two square gaskets shown in figure 18.

(g) Using a ½-inch wrench, remove the two elastic stop nuts from the adapter which does not have an elbow (the return line to the regulator). Lift the adapter with its coupling, and the gasket, off the studs of the valve section of the regulator.

(h) Using a ½-inch wrench, remove the two elastic stop nuts from the adapter of the regulator to the cooler line elbow.

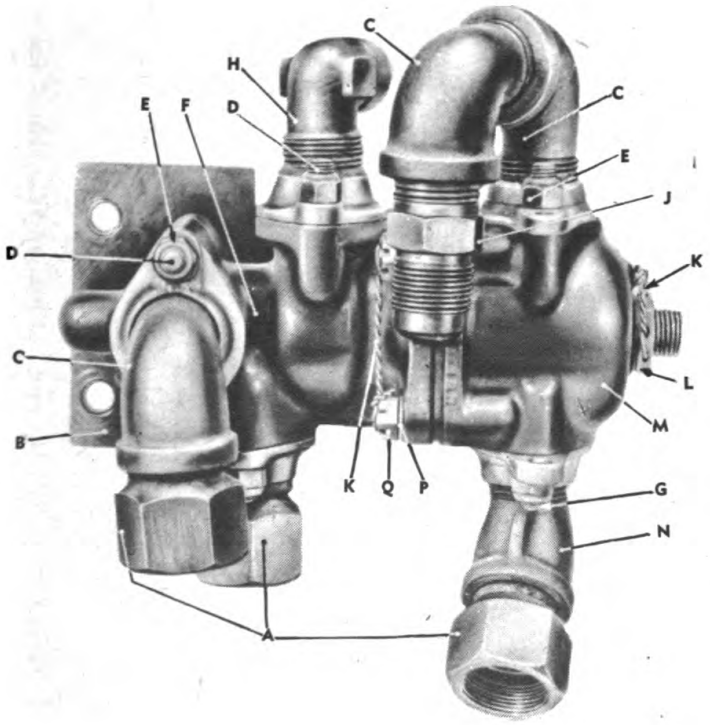


FIGURE 19—The oil temperature regulator assembled.

Lift the adapter with its elbow and coupling, and the gasket, off the studs of the valve section of the regulator.

(i) Using a ½-inch wrench, remove the two elastic stop nuts from the adapter of the regulator to oil tank elbow. Lift the adapter with its elbow, and the gasket, off the studs of the valve section of the regulator.

(4) Inspect the oil temperature regulator.

(a) If engine oil temperature has been too high, and the oil cooler does not become hot during engine operation, the thermostat is probably not opening to permit oil to circulate through the cooler and should be replaced with a new thermostat.

(b) Examine couplings and elbows for cracks and defective threads. Replace defective couplings and elbows.

(c) Adjustment of the regulator is made by turning the adjusting screw at the control end of the regulator. Loosen the lock nut and screw the adjusting screw in or out.

(5) Assemble the oil temperature regulator *(figs. 17, 18 and 19).*

½-inch wrench
Screwdriver
Pliers

(a) Use new gaskets and coat with gasket cement.

(b) Install a new gasket on the four studs of the control section and place the thermostat and valve unit in position, with the thermostat end in the control section, and the adjusting screw extending through the opening.

(c) Install another square gasket on the studs over the thermostat mounting flange.

(d) Place the control and valve sections together, with the valve end of the thermostat unit in the valve section. Install the washers and castellated nuts on the studs, using a ½-inch wrench. Safetywire the castellated nuts. Install the lock nut on the adjusting screw at the control end of the regulator. If the adjusting screw setting has been changed, do not safetywire the lock nut until the regulator has been readjusted.

(e) Install a new gasket on the studs of the control section of the regulator and install the outlet to the engine adapter with its elbow and coupling, using a ½-inch wrench to screw on the elastic stop nuts.

(f) Install a gasket on the oposite studs and install the inlet to the regulator adapter with its elbows and coupling, using a ½-inch wrench on the elastic stop nuts.

(g) Use a screwdriver to screw the adapters on the control section to the mounting base, installing washers first.

(h) Install the return line to the regulator adapter and

coupling, using a new gasket. Use a ½-inch wrench to screw on the elastic stop nuts.

(i) Use a new gasket and install the regulator to cooler line adapter with its elbow and coupling, using a ½-inch wrench on the elastic stop nuts.

(j) Use a new gasket and install the regulator to oil tank line adapter, with its elbow, using a ½-inch wrench on the elastic stop nuts.

(6) Install the oil temperature regulator in the engine compartment. ½-inch wrench, 1¼-inch wrench

(a) Place the regulator in its position in the engine compartment as shown in figure 17, and use a ½-inch wrench to tighten the cap screws on the regulator mounting base.

(b) Attach the oil lines to the couplings of the regulator, using a 1¼-inch open-end wrench to tighten the couplings, connecting the lines as shown in figure 17.

(7) Check the fuel lines for leaks.

(8) Examine the engine mounting beam pads for cracks.

(9) Inspect the clutch release bearing.

29. Cardinal operating rules.—*a. Turn the engine two revolutions on decompression before starting.* WARNING: Do not operate the starter when the engine is on decompression.

(1) If the engine has been allowed to stand, turn the flywheel and the engine two or more revolutions on decompression before firing the starting shell. Observe the following:

(a) Set the lever on decompression.

(b) Turn the engine flywheel two revolutions or more.

(c) Set the throttle in the starting position.

(2) Do not have the engine throttle lever 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 1000 rpm for 2 minutes.
at 1200 rpm for 2 minutes.
at 1400 rpm for 2 minutes.

Below 30° F.
Operate engine at 1000 rpm for 5 minutes.
at 1200 rpm for 5 minutes.
at 1400 rpm for 5 minutes.

c. Operate engine between 1600 and 2000 rpm after warm-up.—Avoid continued low speed operation by shifting gears to maintain an engine speed above 1600 rpm. The maximum speed of the engine under load should not exceed 2200 rpm. For long continued operation, it is recommended that the engine speed be less than 2000 rpm.

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	Grade	SAE
Below 40° F	100°	180°	100	50
Above 40° F	100°	180°	120	60

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 1200 rpm for 4 minutes, then at 1000 rpm for 2 minutes, then at 500 rpm for 2 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.

g. Keep all connections tight.—Difficulty from leaking lines or connections should be prevented by frequent regular inspection.

h. Check the injector nozzles periodically.—(1) The injector nozzles should be maintained in good condition to obtain the proper power and balance of the engine.

(2) The injectors should be set for 2500 pounds pressure per square inch on an injector test unit.

(3) The angle of the spray should be adjusted so that the spray is directed parallel to the top of the piston. This is very important.

30. Testing and running-in of the engine after a major overhaul.

a. Equipment.—
3/10-inch Allen wrench
Injection pump balancing wrench (GU-GST-1419)

b. Procedure.—The engine should be tested and run-in on a dynamometer. 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) Place the engine on decompression.

(b) Open the bleeder valves on the fuel filter, and the pipe plug between Nos. 1 and 9 cylinders. (Loosen only enough to allow air to escape, or pressure will be lost.)

(c) 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 necessary to use two or three pounds of air pressure to force the fuel through the fuel supply pump.

(d) 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 injection nozzle.

(b) Locate the cylinder and mark the fan blade at that cylinder.

(c) 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.

(d) Continue this operation with all cylinders in their firing order.

(e) Repeat this procedure until the engine has made at least four complete revolutions, or five different injectors have been made to squeal.

(3) Starting the engine.

(a) Place a cartridge in the starter breech.

(b) In cold weather the throttle should be wide open when starting; semifull 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 throttle for warm-up speed.

(4) Balance the cylinders. Injection pump balancing wrench (GU-GST-1419)

(a) Operate the engine until the normal temperature is reached. Set the idling screw in the throttle arm to idle the engine at 500 rpm. Idle the engine at this speed several minutes to allow the temperatures to become stabilized.

(b) 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.

(c) The fuel is cut down by turning the adjusting sleeve at the fuel pump clockwise, using an injection pump balancing wrench (GU-GST-1419). 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.

(d) 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 anticlockwise. 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.

(5) Engine run-in.

(a) Operate the engine under light load at 1200 rpm for one hour.

(b) Increase the speed to 1800 rpm and operate for one hour with ¾-load.

(c) Idle the engine at 500 rpm with no load and check the balancing of the injection pumps by the heat of the exhaust manifolds.

(d) Operate the engine at 2000 rpm 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 and set at 6 pounds by adjusting the fuel pressure regulator at the fuel supply pump.

(7) With an oil temperature of 160°, set the oil pressure at approximately 85 pounds at 2000 rpm 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° temperature.

(8) Check the scavenging oil temperature and do not permit it to run higher than 180°.

(9) Check the compression of each cylinder.

(10) Set the governor by means of the adjusting screw at the back to a maximum speed of 2200 rpm under full load or approximately 2325 rpm under no load.

(11) If a dynamometer is not available, the engine must be tested and run-in after installing it in the tank. With the engine installed, operate at 1200 rpm in 4th gear for one hour, then operate at 1800 rpm in 4th gear for one hour. Then proceed with the checking as outlined above.

SECTION V

REMOVAL OF ENGINE FROM VEHICLE

31. Preliminary procedure. — *a. Equipment.* —

3/4-inch socket wrench	Screwdriver
7/16-inch socket wrench	Hoist
9/16-inch socket wrench	Three chains and spacer

b. Procedure. —

(1) Preliminary precaution. — Before starting to remove the engine from the tank, be sure that the battery switch is turned off, the engine is on decompression, and that the fuel supply is turned off.

(2) Remove the tool boxes. — *(a)* Remove the tool BOX from the top of each rear FENDER, as shown in figure 20.

(b) Remove the STRAPS that hold each tool box to the fender.

(c) Lift the tool boxes off the fenders.

(3) Remove the guard. 3/4-inch socket wrench

(a) Use a 3/4-inch socket or box wrench to unscrew the BOLTS which hold the GUARD or screen to the HOOD.

(b) Lift off the guard.

(4) Remove the tail lights 7/16-inch open-end wrench *(fig. 20).*

(a) Remove the NUT on each side of the TAIL LIGHT, using a 7/16-inch socket wrench.

(b) Remove the lights.

(5) Open the engine compartment doors. 3/4-inch socket wrench

(a) Remove the four bolts which hold the DOORS shut, using a 3/4-inch socket wrench.

(b) Open the doors.

(6) Free the oil expansion tank. 9/16-inch socket wrench

(a) Remove the four nuts on top of the top armor plate at the left side, using a 9/16-inch socket wrench.

(b) Remove the oil expansion tank HANGER from underneath the top armor plate.

(c) Leave the oil expansion TANK suspended in the engine compartment.

(7) Remove the flywheel compartment guard. 9/16-inch socket wrench

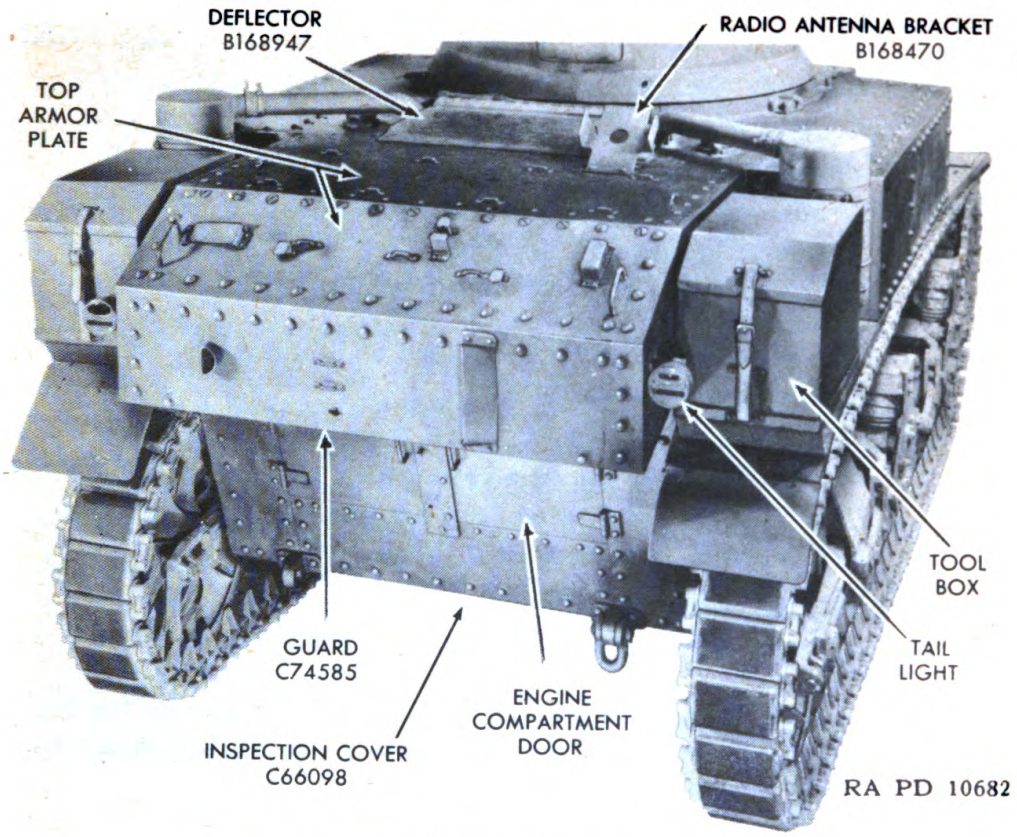


FIGURE 20—Rear view of tank.

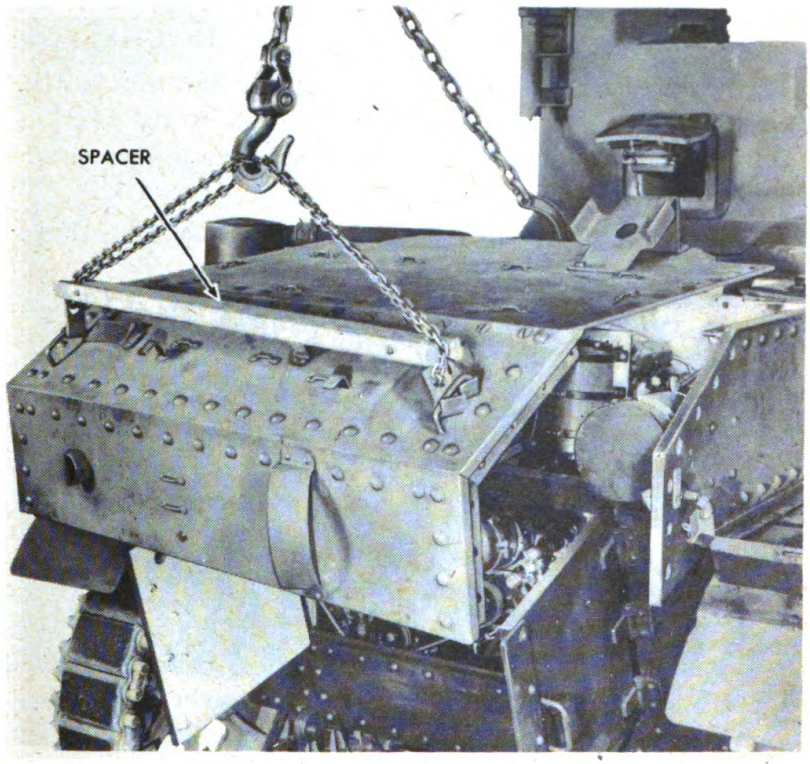


FIGURE 21—Removing the top armor plate.

(a) Remove the four bolts and washers from the **GUARD**, with a $\frac{9}{16}$-inch socket wrench.

(b) Lift off the guard.

(8) Loosen the radio antenna bracket. — $\frac{3}{4}$-inch socket wrench

(a) Remove three of the bolts that hold the **BRACKET** (B168470) in place, and loosen the fourth, using a $\frac{3}{4}$-inch socket wrench.

(b) Swing the bracket around so that the oval head screws underneath are accessible.

(9) Remove the deflector. — Screwdriver

(a) Unscrew the nine bolts which hold the **DEFLECTOR** (B168947) at the flywheel compartment to the armor plate.

(b) Lift off the deflector.

(10) Remove the armor plate. — Screwdriver
Three chains and spacer
Hoist

(a) Unscrew the seven bolts down each side on the top of the top armor plate that hold the top armor plate to the angle of the side armor plate.

(b) Unscrew the four bolts at the front of the top armor plate.

(c) Unscrew the four bolts on the diagonal section of the side armor plate and the three bolts on the vertical section that attach the angle of the top armor plate to the side armor plate.

(d) Attach two chains from a hoist to the handles on each side of the top armor plate. A spacer should be used between these chains, as shown in figure 21.

(e) Attach a third chain from the hoist so that the hook supports the front of the top armor plate.

(f) Raise the top armor plate off the tank and set it to one side.

32. Procedure for removal of engine. — *a. Equipment.* —

$\frac{5}{8}$-inch socket wrench
$\frac{1}{2}$-inch socket wrench
$\frac{15}{16}$-inch socket wrench
$1\frac{1}{4}$-inch open-end wrench
$\frac{3}{4}$-inch open-end wrench
$\frac{3}{4}$-inch socket wrench
$\frac{9}{16}$-inch open-end wrench
$\frac{9}{16}$-inch socket wrench
$\frac{1}{2}$-inch open-end wrench
Engine mounting stand
1-inch open-end wrench
$\frac{7}{8}$-inch open-end wrench
$\frac{3}{8}$-inch open-end wrench
$\frac{7}{16}$-inch open-end wrench
(2) 15-inch wrench extensions on a hinge handle
Engine lifting sling or rope
Screwdriver
Pliers
Plugs for fuel and oil lines
Hoist

b. Procedure.—

(1) Free the propeller shaft. ¾-inch open-end wrench; ⅝-inch socket wrench

(a) Remove the propeller shaft tunnel **COVER** inside the tank by removing the eight nuts, using a ⅝-inch socket wrench.

(b) Free the propeller shaft companion **FLANGE** by removing the nuts with a ¾-inch open-end wrench.

(2) Remove the inspection cover. 9/16-inch socket wrench

(a) Remove the inspection **COVER** (C66098) and **GASKET** underneath the rear of the engine compartment by removing the 14 screws with a 9/16-inch socket wrench.

(3) Remove the mufflers *(fig. 22).* 9/16-inch socket wrench

(a) Using a 9/16-inch socket wrench remove the castellated nuts that hold the muffler support **BRACKETS** around each **MUFFLER.**

(b) Pull the mufflers back free of the exhaust manifolds and remove them.

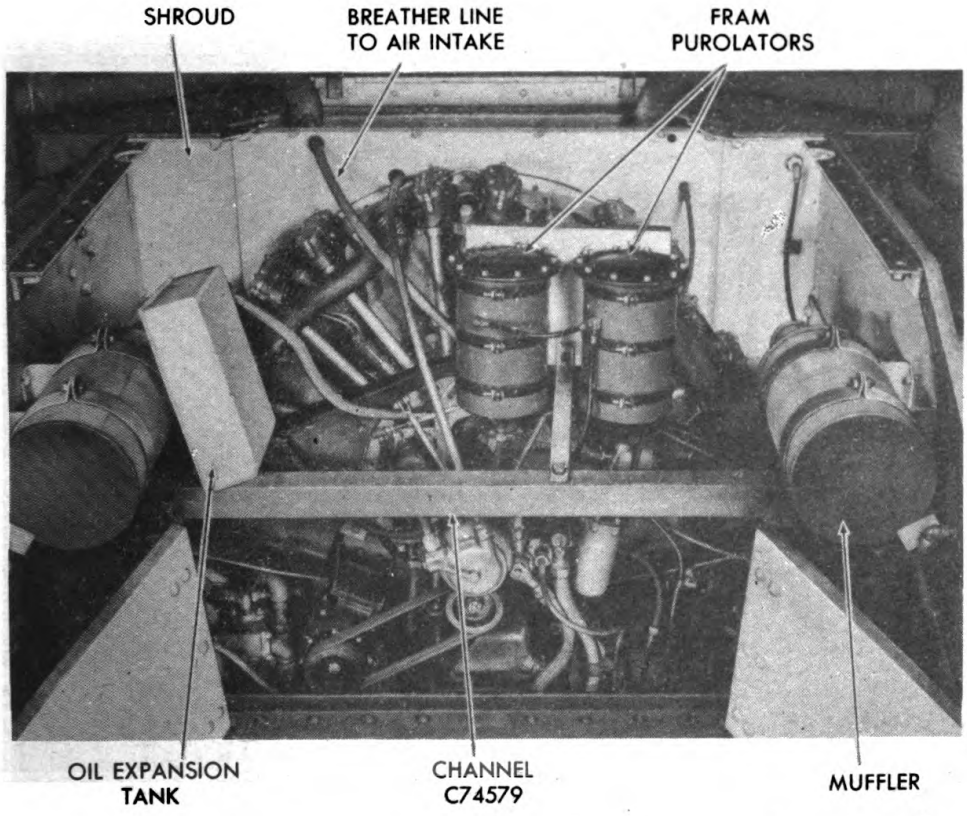


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FIGURE 22—Engine compartment.

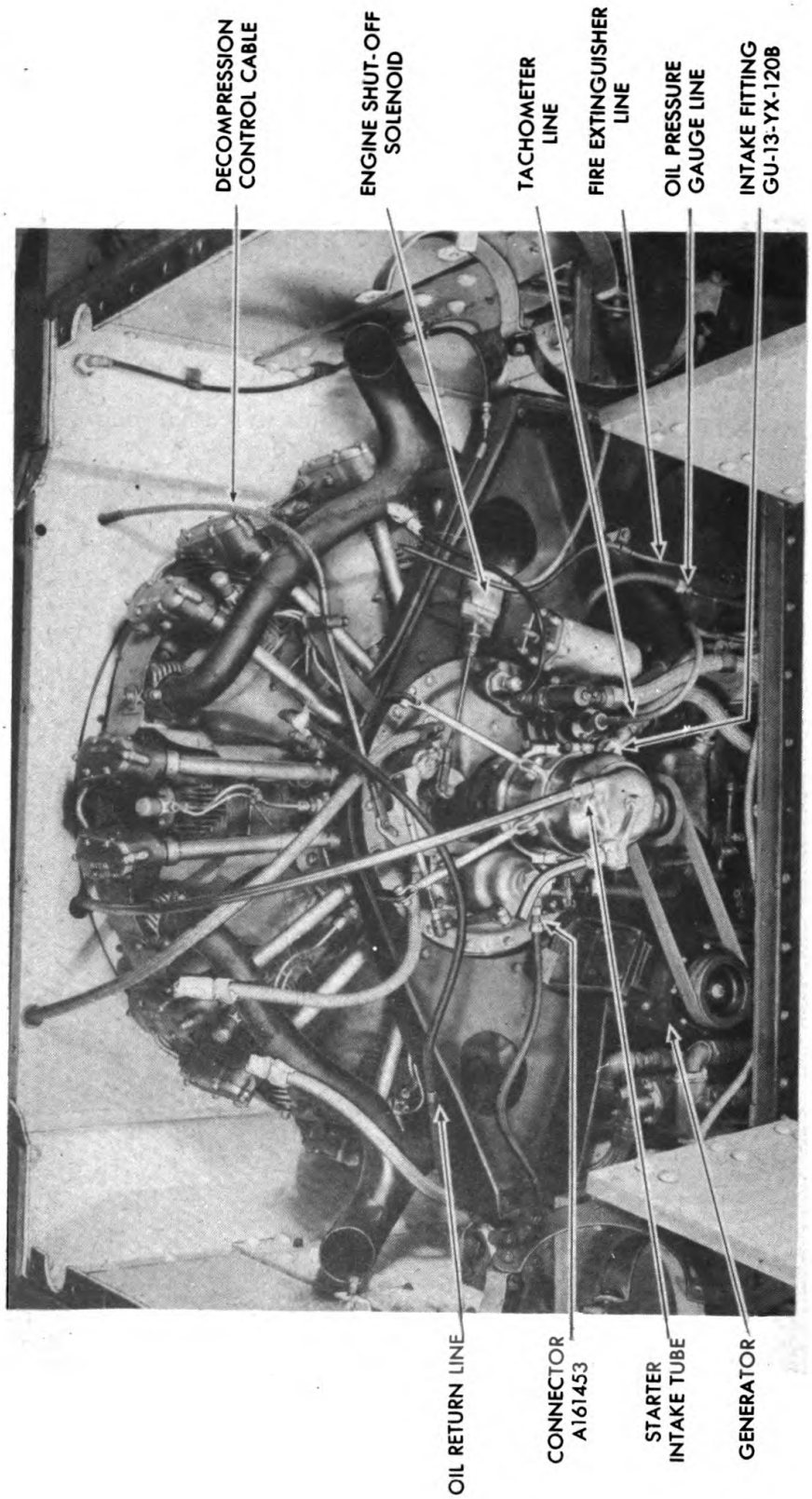

FIGURE 23—The engine compartment.

(4) Remove the Fram purolators *(fig. 22).*

½-inch open-end wrench
Plugs for lines
$\frac{9}{16}$-inch socket wrench
¾-inch socket wrench

(a) Unscrew the COUPLING on the outlet LINE underneath the FILTER at the left, using a ½-inch open-end wrench.

(b) Unscrew the coupling on the inlet line underneath the filter at the right, using a ½-inch open-end wrench.

(c) Plug or wrap cloth around the inlet and outlet line openings to keep out foreign matter.

(d) Disconnect the outlet line from the engine mounting beam, using a $\frac{9}{16}$-inch socket wrench.

(e) Remove the bolt and nut which holds the supporting bracket of the PUROLATOR SUPPORT to the CHANNEL (C74579), using a ¾-inch socket wrench.

(f) Lift off the two filters and support.

(5) Remove the oil expansion tank *(fig. 22).*

⅞-inch open-end wrench
Plugs for lines

(a) Free the connections on the two lines at the oil expansion tank.

(b) Lift off the oil expansion tank.

(c) Plug or wrap cloth around the lines to keep out foreign matter.

(6) Remove the channel *(fig. 22)*

$\frac{5}{16}$-inch socket wrench
¾-inch socket wrench
Screwdriver

(a) Remove the two bolts at the rear at each side that hold the channel to the rear armor plate, using a $\frac{5}{16}$-inch socket wrench.

Remove the two bolts (with a ¾-inch socket wrench) on the bracket at each end of the channel.

(c) Remove the tail light cable CLIPS from the channel by removing the screws.

(d) Remove the channel. Clamp a wrench to the channel and turn the channel sideways to remove the channel between the brackets and the top of the rear armor plate.

(7) Oil pump lines *(fig. 23).*

1¼-inch open-end wrench
Pliers
Plugs for lines
½-inch open-end wrench
$\frac{9}{16}$-inch open-end wrench

(a) Disconnect the oil return line from the filters on top of the engine mounting beam, using ½-inch and $\frac{9}{16}$-inch open-end wrenches.

(b) Disconnect the oil line at the intake FITTING (GU-13-YX-120B) and the oil line at the VALVE assembly (GU-51-YA-150) of the oil pump, using a 1¼-inch open-end wrench.

(c) Plug or wrap cloth around the ends of the lines.

(d) Disconnect the tachometer drive line at the oil pump by loosening the knurled nut.

(8) Free the generator *(fig. 23).* — $\frac{9}{16}$-inch socket wrench

(a) Using a $\frac{9}{16}$-inch socket wrench, remove the four cap screws that hold the GENERATOR to its mounting pad on the engine mounting beam.

(b) Rest the generator on the floor of the engine compartment.

(9) Free the oil pressure gage line *(fig. 23).* — $\frac{9}{16}$-inch open-end wrench; ¾-inch open-end wrench

Use $\frac{9}{16}$-inch and ¾-inch open-end wrenches to free the oil pressure gage line CONNECTION.

(10) Free the fire extinguisher line *(fig. 23).* — ¾-inch open-end wrench

Use a ¾-inch open-end wrench to break the connection on the fire extinguisher line. Leave the line clamped to the engine mounting beam.

(11) Disconnect the fuel lines *(fig. 23).* — ½-inch open-end wrench; ¾-inch open-end wrench

Disconnect the swivel CONNECTOR (A161453) on the tube at the top of the fuel supply pump which extends from the fuel filter, using ½-inch and ¾-inch open-end wrenches.

(12) Free the engine shut-off solenoid *(fig. 23).* — Screwdriver; ½-inch open-end wrench

Free the wire from the SOLENOID and the bracket beneath it, using a screwdriver and a ½-inch open-end wrench.

(13) Free the decompression control cable *(fig. 23).* — Pliers; ½-inch open-end wrench; $\frac{9}{16}$-inch open-end wrench

(a) Remove the cotter pin from the clevis pin and remove the clevis pin.

(b) Using a ½-inch open-end wrench, remove the clamp bolt that holds the decompression control CABLE to the bracket on the engine mounting beam.

(c) Remove the clevis from the end of the cable, using a $\frac{9}{16}$-inch open-end wrench.

(d) Pull the cable out of the clamp.

(e) Replace the clevis temporarily on the cable.

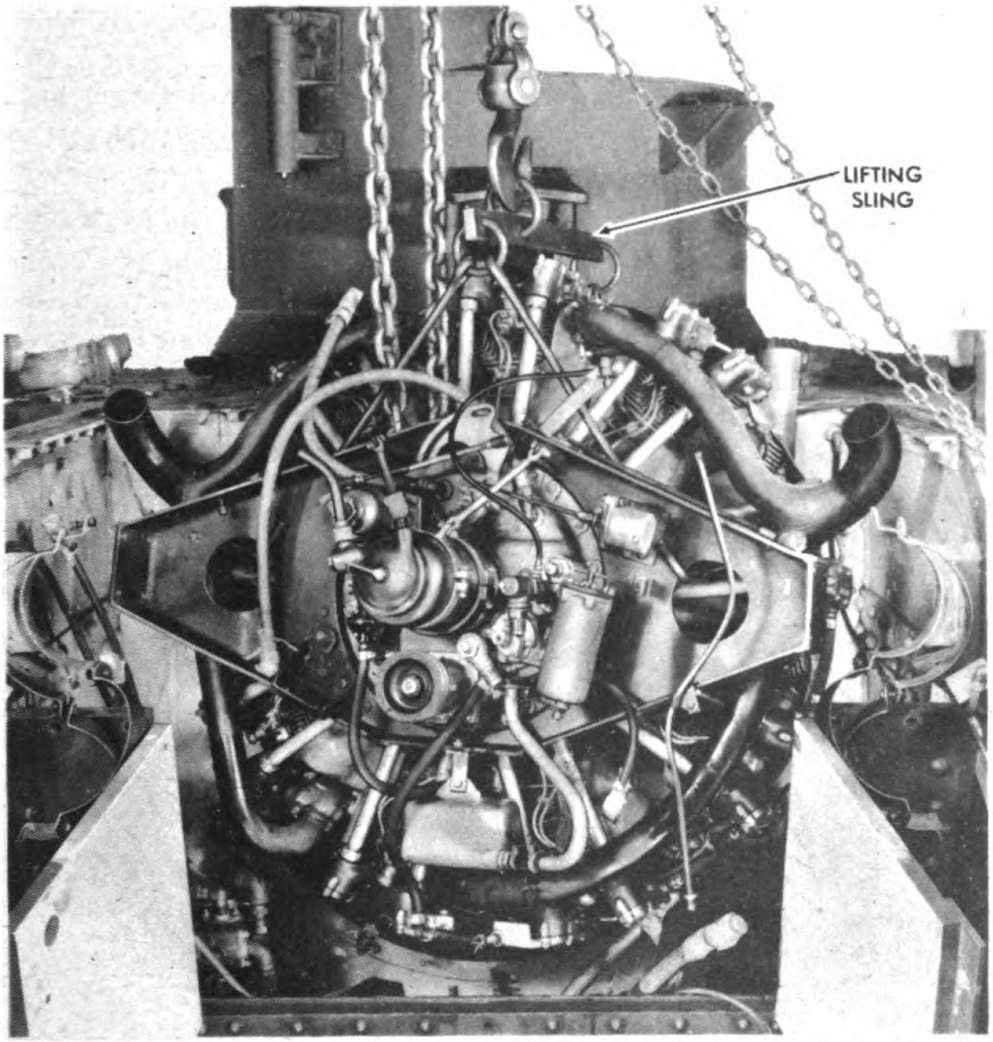

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FIGURE 24—Removing the engine.

(14) Remove the starter intake tube *(fig. 23).* — 1-inch open-end wrench

(a) Using a 1-inch open-end wrench, free the starter intake TUBE at the STARTER and at the BREECH inside the tank.

(b) Pull out the starter intake tube and set to one side.

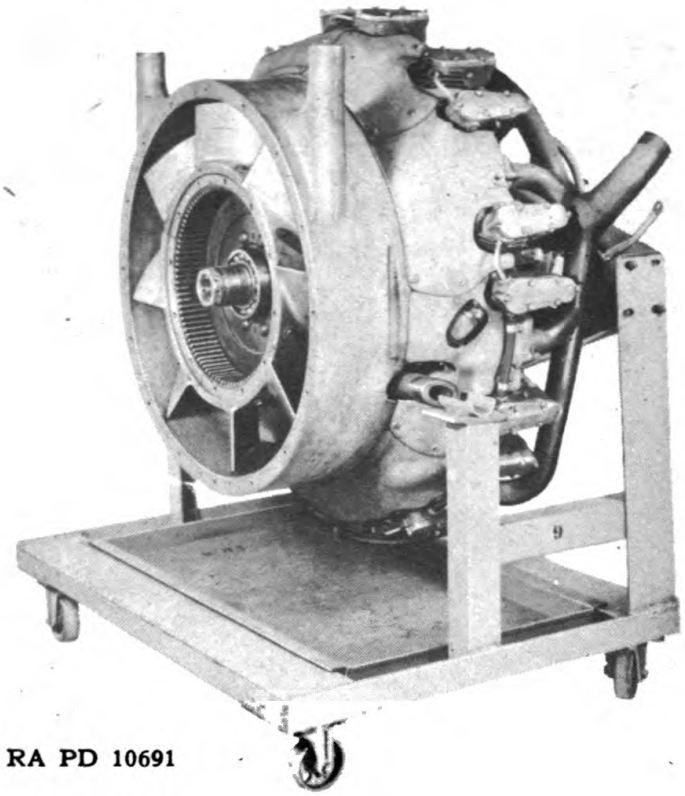
(15) Disconnect the throttle control *(fig. 15).* — Pliers; $\frac{9}{16}$-inch open-end wrench (2)

(a) Remove the cotter pin from the clevis PIN (GU-Y-453) and remove the clevis pin.

(b) Remove the LUG that holds the throttle SPRING to the lower side of the engine mounting beam, using two $\frac{9}{16}$-inch open-end wrenches. The throttle control spring and cable will remain in the engine compartment when the engine is removed.

(16) Disconnect the breather line to air intake *(fig. 22).* — $\frac{7}{8}$-inch open-end wrench

Disconnect the breather LINE at the air intake, using a $\frac{7}{8}$-inch open-end wrench. The breather line will remain with the engine when it is removed.



RA PD 10691

FIGURE 25—Engine on mounting stand.

(17) Remove the shroud *(fig. 22).*

3/8-inch open-end wrench
7/16-inch open-end wrench

(a) Remove the bolt and nut on each side that holds the SHROUD. Use a 3/8-inch open-end wrench on the bolt and 7/16-inch open-end wrench on the nut.

(b) Lift out the shroud.

(18) Remove the air intake tubes.

(a) Loosen the hose clamps on the air intake TUBES in the flywheel compartment.

(b) Remove the tubes from the intake MANIFOLD.

(19) Remove the steady rest clamp.

3/4-inch socket wrench with two 15-inch extensions on a hinge handle

Remove the two bolts on each side that hold the steady rest CLAMP. Use a 3/4-inch socket wrench with two 15-inch extensions on a hinge handle.

(20) Free the engine mounting beam.

9/16-inch socket wrench

Remove the four bolts at each end of the engine mounting beam, using a 9/16-inch socket wrench.

(21) Disconnect the ground wire cable.

9/16-inch open-end wrench

Use a 9/16-inch open-end wrench to remove the ground wire cable from the left side of the engine mounting beam.

(22) Remove engine from tank *(fig. 24).*

Hoist
Engine mounting stand
Engine lifting sling or rope

(a) Attach a lifting sling to the openings in the engine mounting beam and with a chain around the hub of the clutch pressure plate, as shown in figure 24. If a lifting sling is not available, a rope can be used, which is passed under the rocker boxes of No. 1 cylinder.

(b) Hoist the engine out of the engine compartment. The engine will have to be turned diagonally as it is raised, to permit the intake manifolds to clear.

(c) Support the engine on a mounting stand, as shown in figure 25.

SECTION VI

DISASSEMBLY OF ENGINE

(Guide to Complete Tear Down for Inspections Covered in Section VII.)

33. General precautions. — *a.* Before removing parts from the engine, check them for numbering where it is necessary to reinstall them at the proper cylinder.

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

c. Parts should be placed in storage bins as they are removed.

34. Remove the intake manifold front plate *(fig. 26).* — *a. Equipment.* —

$\frac{7}{16}$-inch socket wrench
Pliers

b. Procedure. —

Cut the safety wire with pliers, then remove the cap SCREWS and flat WASHERS, using a $\frac{7}{16}$-inch socket wrench. Lift off the intake manifold front PLATE (GU-13-YX-102E).

35. Remove the flywheel *(fig. 27).* — *a. Equipment.* —

$2\frac{5}{16}$-inch box wrench
Pliers

b. Procedure. —

(1) With the engine in a vertical position, remove the cotter pin and the flywheel hub nut lock PIN. Then remove the flywheel hub NUT using a $2\frac{5}{16}$-inch box wrench. Remove the front CONE.

(2) The front cone is in two halves. These 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.

(3) After the nut is removed, lift the FLYWHEEL off the front crankshaft. This can be done by two men, with the engine in a vertical position, or the engine can be turned horizontally and a hoist used to raise the flywheel. Then remove the rear cone from the CRANKSHAFT.

36. Remove the starter support *(fig. 28).* — *a. Equipment.* —

$\frac{7}{16}$-inch open-end wrench
$\frac{1}{2}$-inch open-end wrench

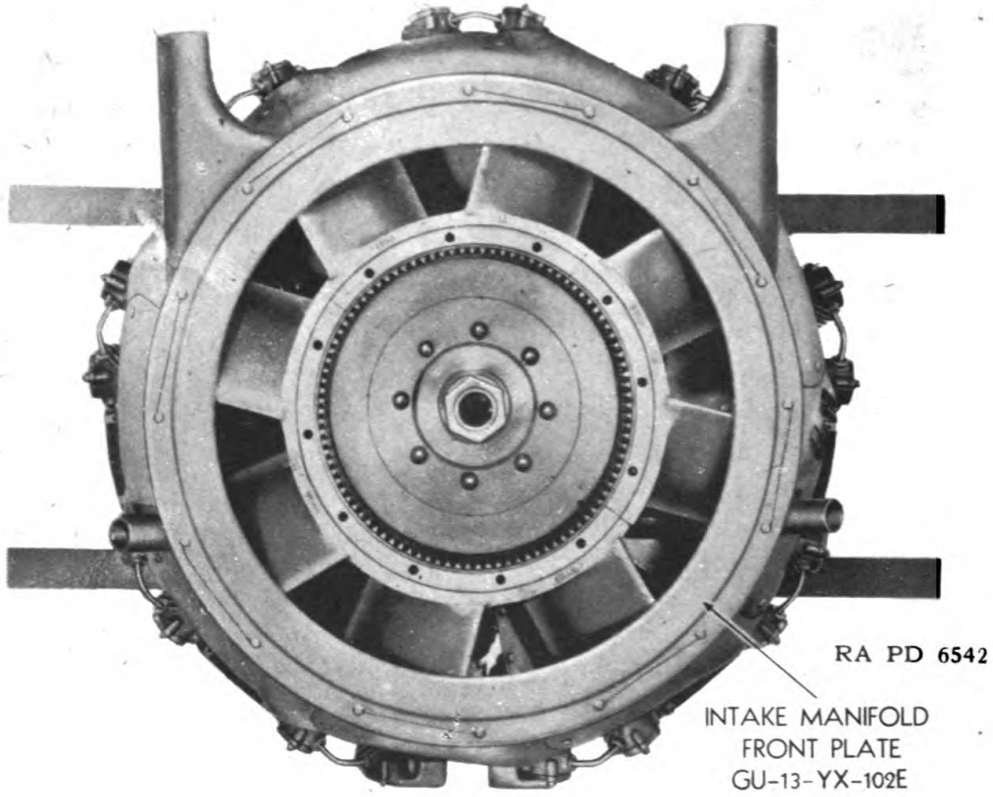


FIGURE 26—The intake manifold front plate.

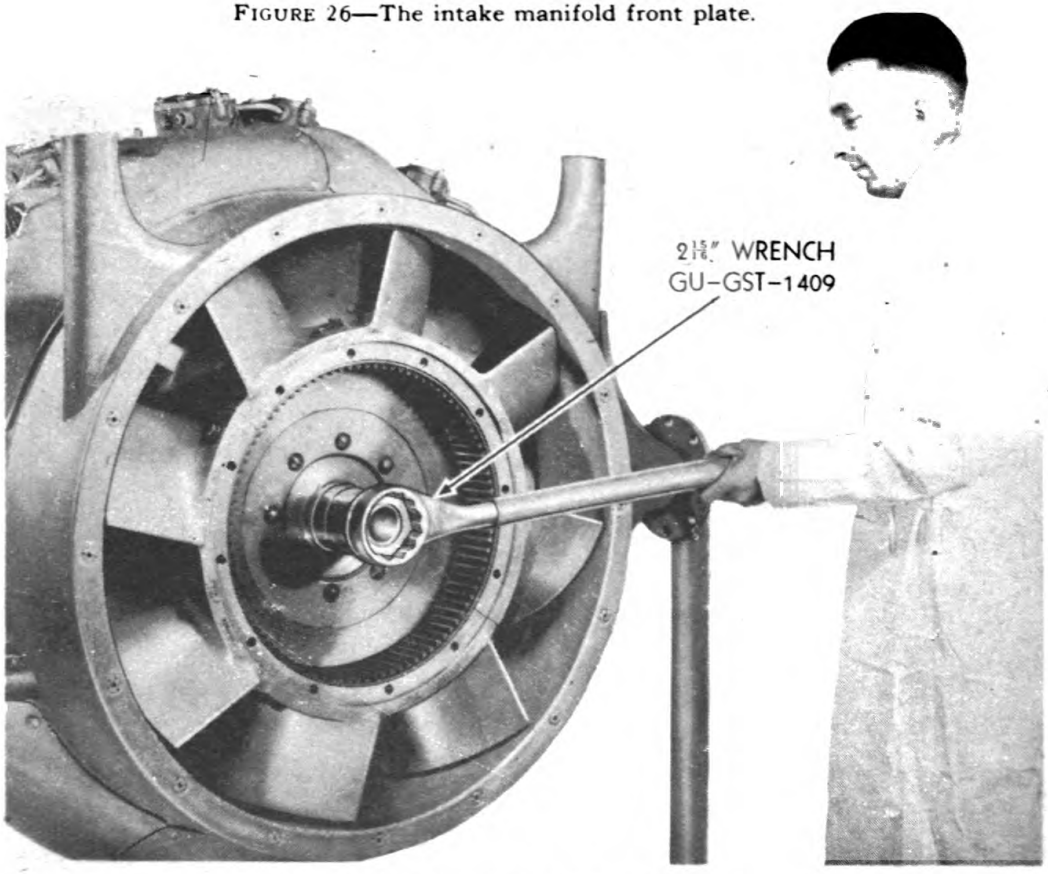


FIGURE 27—Removing the flywheel nut.

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b. Procedure.—

Remove the elastic stop **NUTS** (½-inch open-end wrench) and flat **WASHERS** which hold the tie **RODS (GU-14-YX-108G)** of the starter **SUPPORT (GU-14-YX-168)** to the braces at the top of the engine mounting **BEAM.** Loosen the clamping **RING (GU-14-YX-108F)** of the support around the **STARTER (GU-14-YX-130)**, using a $\frac{7}{16}$-inch open-end wrench. Then slide the support off the starter.

37. Remove the rocker box sumps to oil pump line *(fig. 28).* —

a. Equipment. — Pliers

b. Procedure.—

Loosen the hose **CLAMPS** at the rocker box sumps nipple and at the oil **PUMP (GU-14-YA-132A)**, and remove the **LINE.**

38. Remove the engine scavenger line *(fig. 28).* — *a. Equipment.*

½-inch open-end wrench Pliers

b. Procedure.—

Remove the **PALNUTS, NUTS** and flat **WASHERS** which hold the mounting flange of the scavenger **LINE (GU-14M-Y-191)** to the oil pump. The scavenger line is a curved metal tubing attached to the oil pump. A short section of hose is used at the other end of the scavenger line to connect it to the oil **SUMP (GU-14M3-YA-131).** Inside this hose is a brass **LINER** which fits into the oil sump passage to prevent oil leakage and kinking of the hose. Loosen the hose clamps on the oil sump and

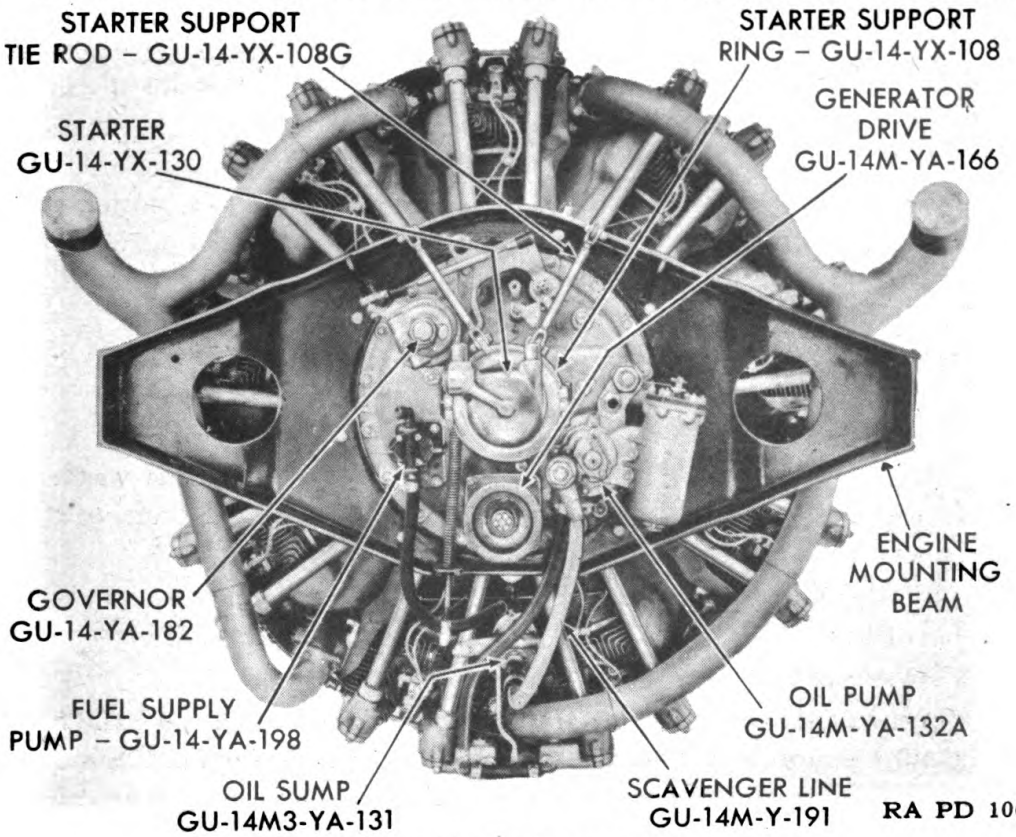

FIGURE 28—Engine accessories.

scavenger line, and pull out the scavenger line. Then remove the hose and if the hose needs replacement, force out the brass liner and save for use in the new hose.

39. Remove fuel supply pump line *(fig. 28).* — *a. Equipment.* —
Pliers

b. Procedure. —

Fuel is carried through a line from the fuel supply **PUMP (GU-14-YA-198)** 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 and remove the hose from the nipples.

40. Remove the throttle controls *(fig. 29).* — *a. Equipment.* —
Pliers
¾-inch open-end wrench
$\frac{7}{16}$-inch open-end wrench
$\frac{9}{16}$-inch open-end wrench

b. Procedure. —

(1) Remove the cotter pin from the clevis **PIN** at the upper end of the vertical tie **ROD (GU-14-Y-164C)** and remove the clevis pin.

(2) Using a $\frac{9}{16}$-inch open-end wrench, remove the nut that holds the ball socket joint at the lower end of the vertical tie rod to the **BELL-CRANK (GU-14-Y-164F)** on the oil sump, and slide the joint **BOLT** out of the bell-crank. The vertical tie rod (GU-14-Y-164C) and throttle **SPRING (GU-14-Y-164M)** can now be lifted out of the spring **SUPPORT (GU-14-Y-164L)**.

(3) Remove the governor **CONTROL (GU-14-YA-183)** using a $\frac{7}{16}$-inch open-end wrench to remove the nut and washer that holds the ball socket joints at each end of the governor control.

(4) Using a $\frac{7}{16}$-inch open-end wrench, loosen the clamping **SCREW** on the control shaft **LEVER (GU-14-Y-164)**. Remove the cotter pin from the nut on the throttle control shaft and remove the control lever nut and washer, using a ¾-inch open-end wrench. Then slide the control lever off the shaft.

41. Remove the starter *(fig. 28).* — *a. Equipment.* —
$\frac{9}{16}$-inch socket wrench

b. Procedure. —

Using a $\frac{9}{16}$-inch socket wrench, remove the palnuts, nuts and washers from the starter mounting flange and pull the starter off the studs of the accessory case.

42. Remove the oil pump *(fig. 28).* — *a. Equipment.* —
Pliers
½-inch socket wrench

b. Procedure. —

Cut the safety wire that runs from the packing nut on the oil **FILTER** to the oil pressure relief **VALVE**. Using a ½-inch socket wrench, remove the palnuts, nuts and washers from the oil pump mounting flange, and slide the oil pump out of the accessory **CASE**.

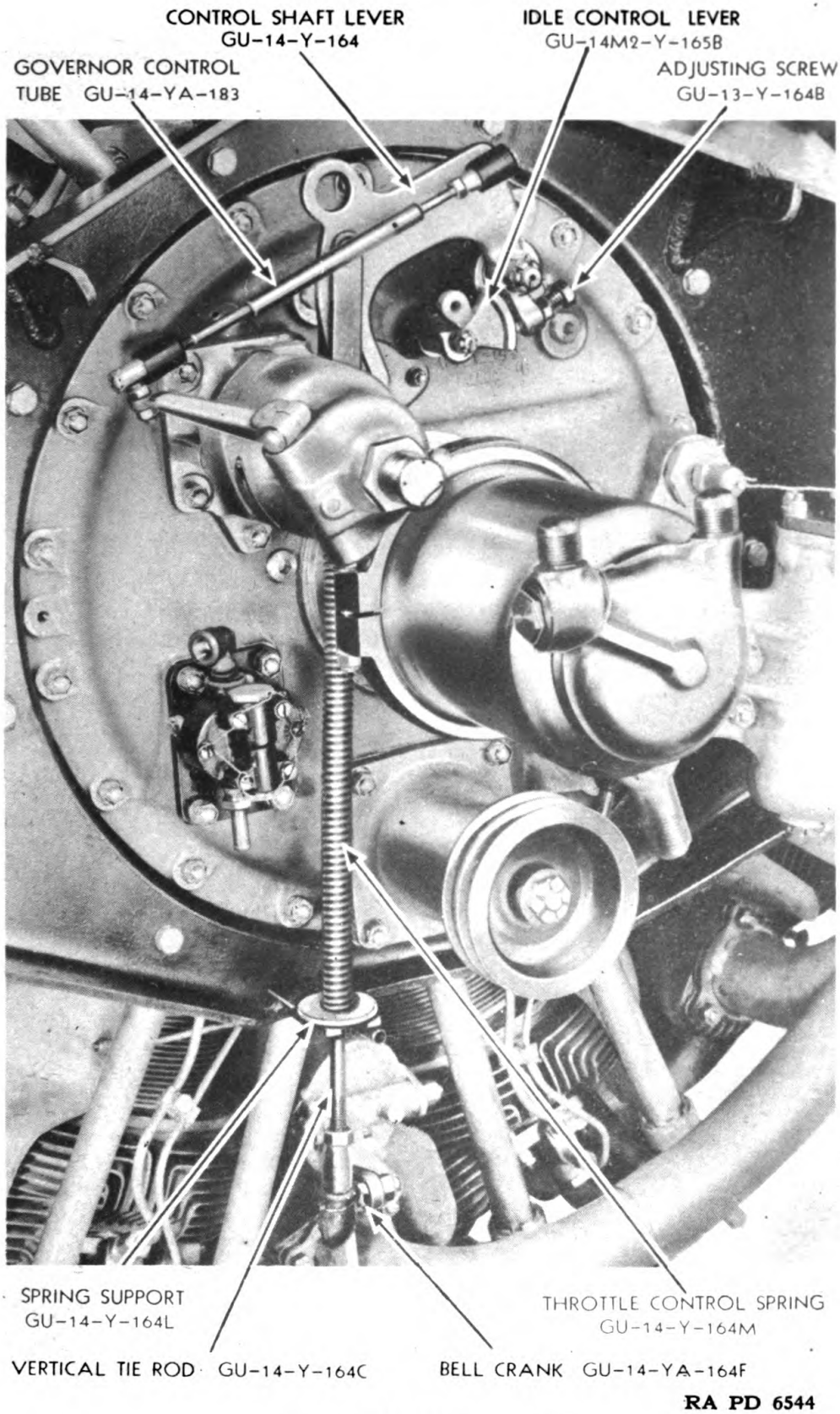

FIGURE 29—The throttle controls.

43. Remove the engine mounting beam. — *a. Equipment.* —

Pliers — Hoist
Engine lifting eye GU-GST-1308 — $\frac{9}{16}$-inch socket wrench

b. Procedure. —

With the front of the engine facing upward, remove the cotter pins from the nuts on the engine mounting flange and remove the nuts ($\frac{9}{16}$-inch socket wrench), washers and bolts. Screw the engine lifting eye (GU-GST-1308) on the front crankshaft and, with a hoist, lift the engine out of the engine mounting beam.

44. Remove the exhaust manifolds *(fig. 30).* — *a. Equipment.* —

$\frac{1}{2}$-inch box wrench

b. Procedure. —

The exhaust MANIFOLDS are removed after the engine is lifted out of the engine mounting beam (while still on hoist), but before the engine is placed on the engine mounting stand.

(1) Use a $\frac{1}{2}$-inch box wrench to remove the brass nuts and lock washers from the exhaust manifold mounting flanges at all cylinders. NOTE: It will help in reassembling the manifold to number each section of the manifold to show the cylinder to which it belongs.

(2) When the nuts have been removed, lift each manifold off the studs as a unit.

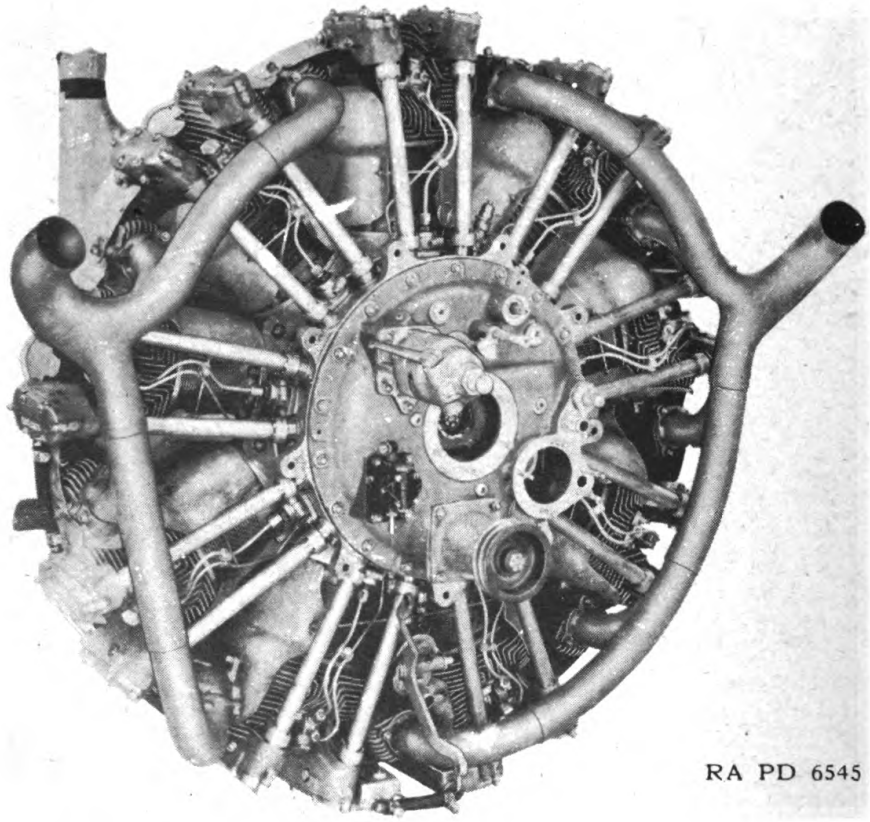

FIGURE 30—Rear of engine showing the exhaust manifolds.

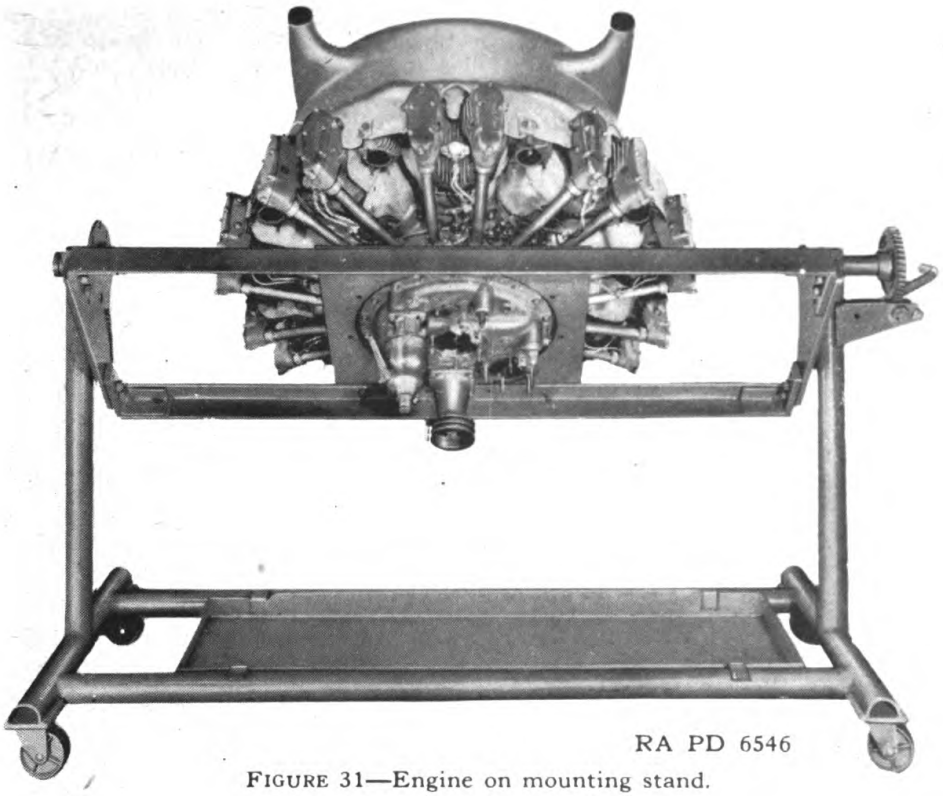

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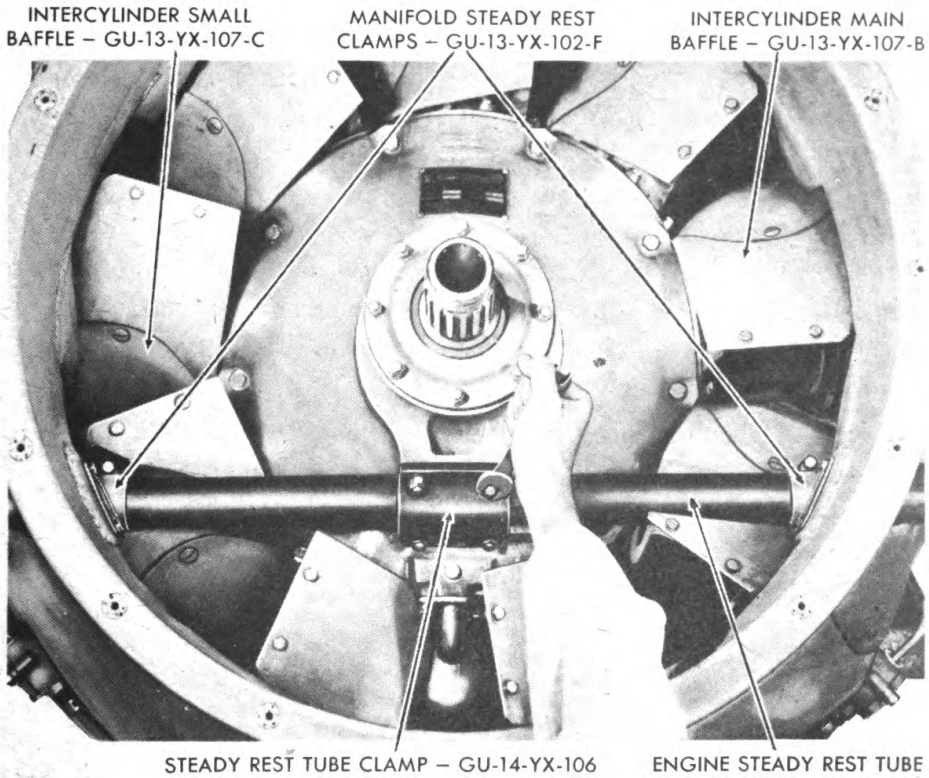
FIGURE 31—Engine on mounting stand.



RA PD 6547

FIGURE 32—Removing the steady-rest tube.

45. Mount engine on engine mounting stand. — *a. Equipment.* —

$\frac{9}{16}$-inch socket wrench

b. Procedure. — NOTE: The engine should be mounted on an engine mounting stand, before proceeding with further disassembling operations, to facilitate working on it. The type of stand shown in figure 31 is recommended.

(1) Mount the engine so that the rear of the engine projects through the circular opening in the platform of the stand.

(2) Bolt the engine in place through the flange of the crankcase, using a $\frac{9}{16}$-inch socket wrench.

46. Remove steady-rest tube *(fig. 32).* — *a. Equipment.*—

$\frac{5}{8}$-inch socket wrench
$\frac{7}{16}$-inch open-end wrench

b. Procedure. —

(1) Remove the four palnuts, nuts and washers from the engine steady-rest studs on the crankcase. Either a $\frac{5}{8}$-inch open-end or socket wrench can be used on the upper nuts, but a $\frac{5}{8}$-inch socket wrench will be necessary on the lower nuts.

(2) Lift off the steady-rest tube CLAMP (GU-14-YX-106). Loosen one nut on the manifold steady-rest CLAMP (GU-13-YX-102F) on each side, using a $\frac{7}{16}$-inch open-end wrench.

(3) Slide the steady-rest tube out of the assembly.

47. Remove the outer cylinder cowling *(fig. 33).* — *a. Equipment.* —

Screwdriver
$\frac{1}{2}$-inch socket wrench

b. Procedure. —

(1) Remove the NUTS (GU-YX-311) on the outer cylinder cowling mounting exhaust elbow studs, using a $\frac{1}{2}$-inch socket wrench. There are nine of these nuts to be removed—one for each cylinder.

(2) Free the Dzus FASTENERS on the outer cylinder COWLING (GU-13-YX-107-A5) by turning them with a screwdriver. There are eighteen of these fasteners to be loosened. Then lift off the sections of outer cylinder cowling.

48. Detach intercylinder drain lines *(fig. 34).* — *a. Equipment.* —

Pliers

b. Procedure. —

Use pliers to loosen the CLAMPS (GU-Y-449) on the intercylinder drain LINES (GU-13M-Y-197B1) and remove the LINES on all cylinders.

49. Free the intake elbow hoses *(fig. 34).* — *a. Equipment.* —

Pliers

b. Procedure. —

Loosen the two intake elbow hose CLAMPS (GU-13-YX-102D) on the hose sections of all cylinders.

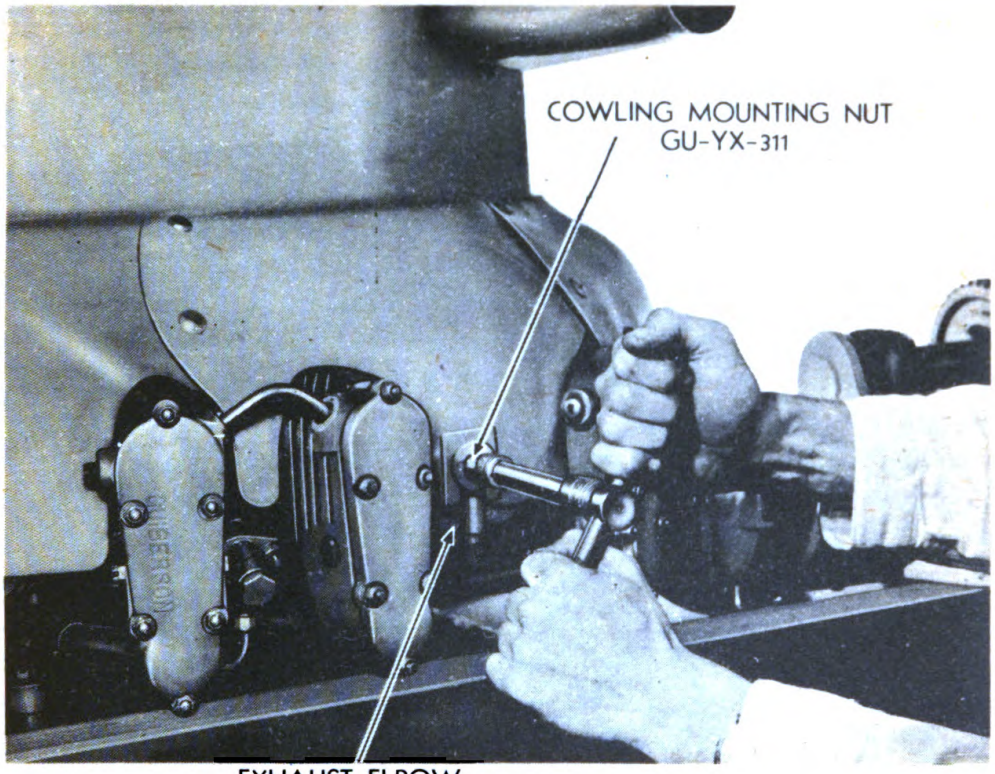


FIGURE 33—Removing the outer cylinder cowling.

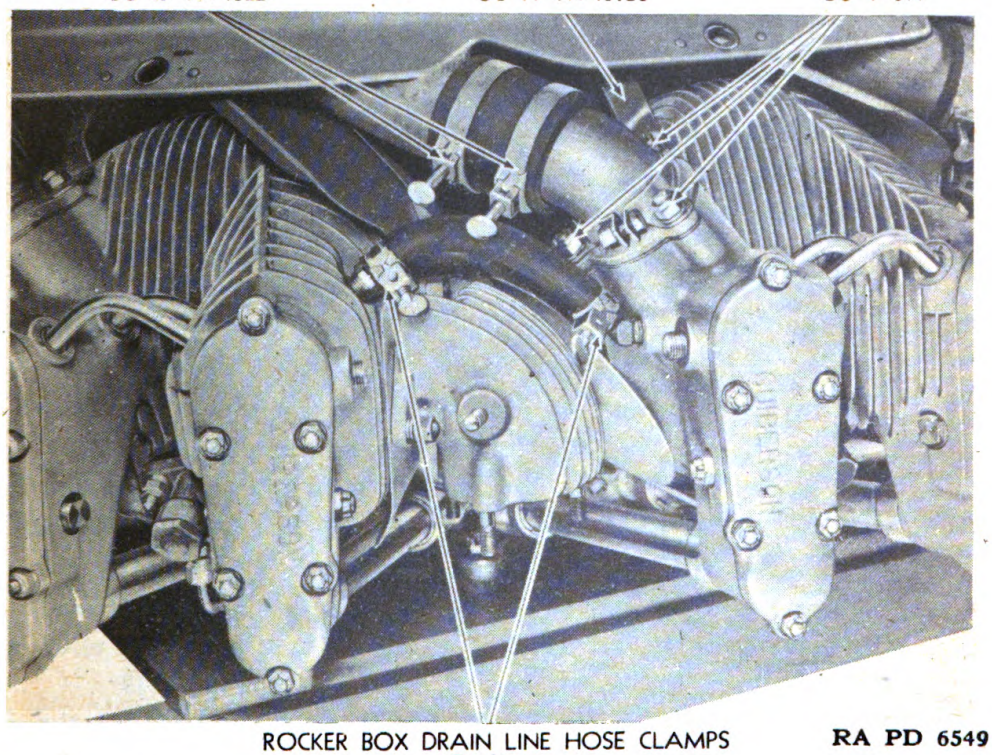


FIGURE 34—The intake elbow and drain lines.

50. Free the intake elbows *(fig. 34).* — *a. Equipment.* —

Screwdriver
½-inch open-end wrench

b. Procedure. — Using a ½-inch open-end wrench, remove the three intake elbow palnuts, NUTS (GU-Y-314) and washers from each of the nine intake ELBOWS.

51. Lift support brackets off the studs *(fig. 34).* — Lift the main baffle support BRACKETS (GU-14-YX-107B5) off the intake elbow studs. There are nine of these brackets to be removed. It may be necessary to pry them up with a screwdriver in order to remove them.

52. Remove the intake manifold and fan shroud. — With a man on each side, lift the intake manifold and fan SHROUD, turning it to the left to pull the hoses off the intake elbows as the manifold is raised.

53. Remove the intake elbows. — Lift the intake elbows and gaskets off at each cylinder.

54. Remove the intercylinder baffle tie bolts *(fig. 35).* — *a. Equipment.* —

⅜-inch box or open-end wrench

b. Procedure. — (1) Turn the platform of the engine mounting stand so that the rear of the engine is facing upward. The intercylinder baffles are held by a tie bolt (GU-YX-372) behind each cylinder.

(2) Using a ⅜-inch box or open-end wrench, remove the elastic stop nuts from each tie bolt and take out the bolts and washers. There are eight of these bolts.

(3) The oil sump is located between Nos. 5 and 6 cylinders and no intercylinder baffles are used at this point. A long tie ROD connects the baffles on the outside of these cylinders. Using a ⅜-inch wrench remove the nut and washer and pull out the rod.

55. Remove the small intercylinder baffles *(fig. 32).* — *a. Equipment.* —

Screwdriver

b. Procedure. — (1) Turn the platform of the engine mounting stand so that the front of the engine is once more facing upward.

(2) Using a screwdriver, loosen the Dzus fasteners that hold the small and main intercylinder baffles together and lift out the small intercylinder BAFFLES (GU-13-YX-107-C1).

56. Remove rocker box covers. — *a. Equipment.* —

$\frac{7}{16}$-inch box wrench

b. Procedure. — Use a $\frac{7}{16}$-inch box wrench to unscrew the nuts on the faces of the rocker box COVERS (GU-14-Y-68) and remove the nuts, washers and covers.

57. Remove the exhaust elbows *(fig. 35).* — *a. Equipment.* —

½-inch open-end wrench
90° ½-inch open-end wrench No. GU-GST-1449

b. Procedure. — Using a ½-inch open-end wrench, remove the three nuts and lock washers from each exhaust ELBOW (GU-13-YX-101D).

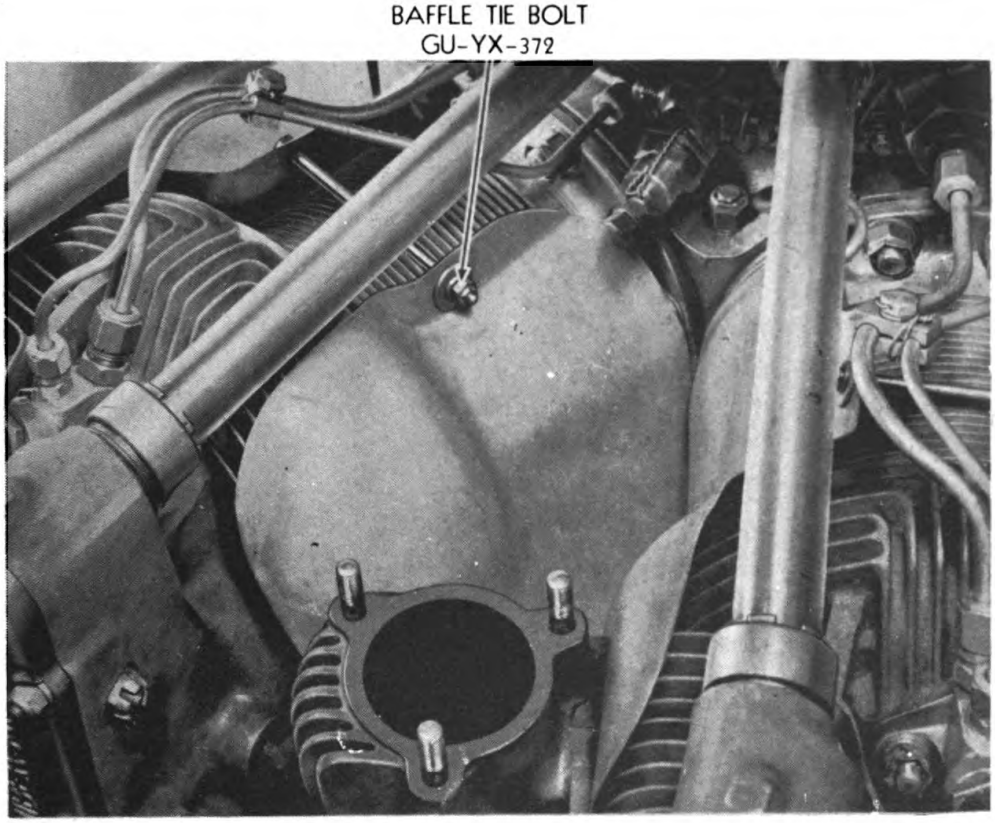


FIGURE 35—Intercylinder baffle tie bolt. RA PD 6550

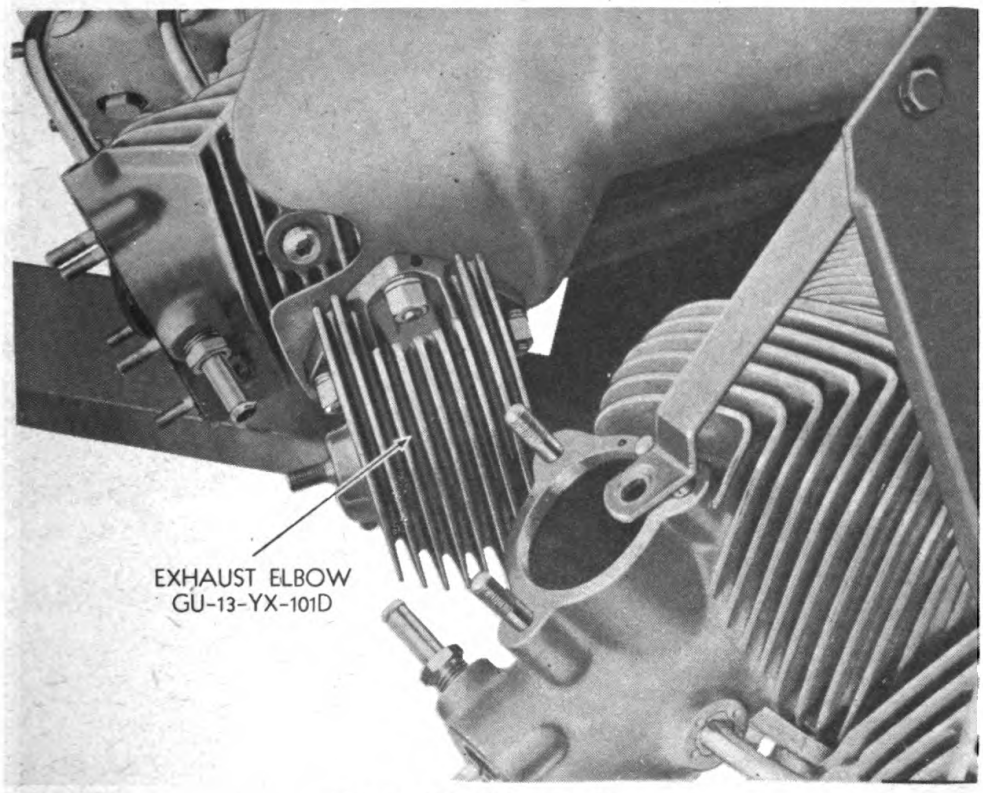


FIGURE 36—Exhaust elbow. RA PD 6551

A straight open-end wrench can be used on all nuts except the inner nut on number five cylinder. A 90° open-end wrench is necessary to reach this nut.

58. Remove the main intercylinder baffles *(fig. 32).* — *a. Equipment.* —

½-inch open-end wrench
⅝-inch open-end wrench

b. Procedure. — Using a ⅝-inch open-end wrench, remove the nut that holds each main intercylinder baffle support bracket to the cylinder base (except on number six cylinder). On number six cylinder use a ½-inch open-end wrench to remove the nut which holds the main intercylinder baffle support bracket to the oil sump. Lift off the main intercylinder **BAFFLES (GU-13-YX-107-B1)** with their support brackets.

59. Remove the injection lines *(fig. 37).* —*a. Equipment.* —

½-inch open-end wrench ⅝-inch open-end wrench

b. Procedure. — (1) Turn the platform of the engine mounting stand so that the rear of the engine is facing upward. Using a ⅝-inch open-end wrench, unscrew the nuts which hold the injection **LINE (GU-14M-Y-112)** to the **INJECTOR (GU-14-YA-113A)** and to the injection **PUMP (GU-14-YA-102A).**

(2) Use a ½-inch open-end wrench to unscrew the nuts which hold the fuel return line to the injector and to the fuel return **RING.** Lift off the two lines as an assembly.

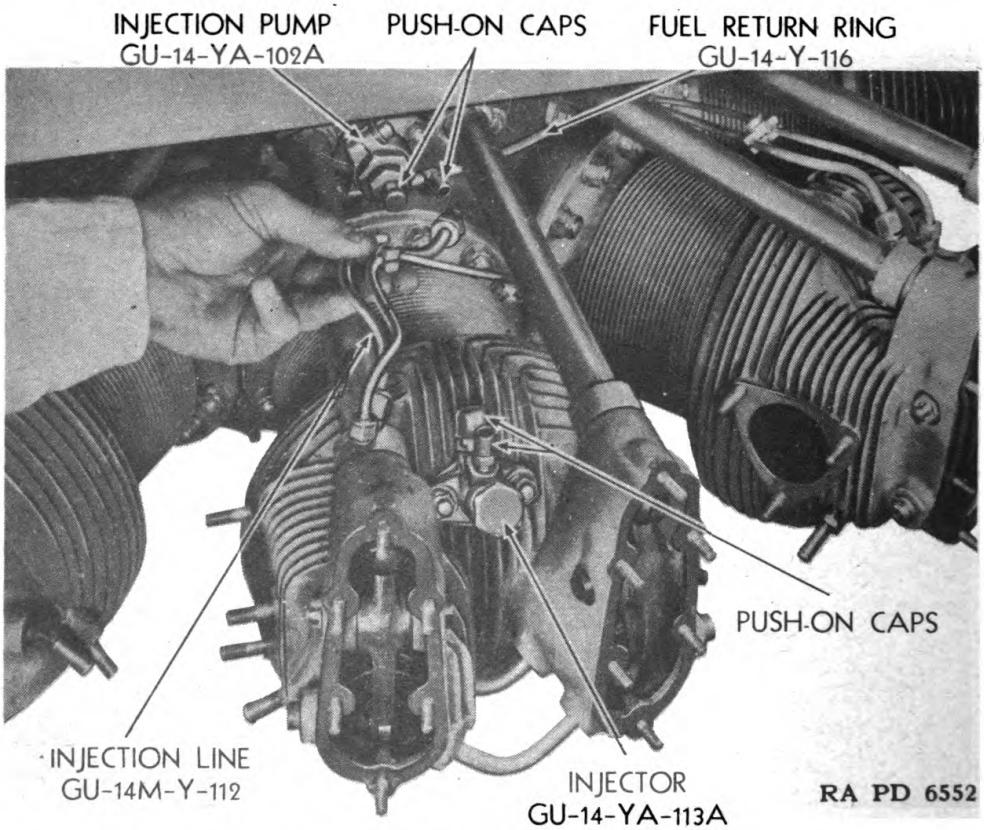


FIGURE 37—Fuel injector and lines.

(3) Repeat on all cylinders. *Do not bend these lines.* Number the lines as they are removed so that they can be reinstalled at the correct cylinder.

(4) To prevent dirt and foreign material from entering and causing damage, cover the openings with push-on caps as soon as the lines have been removed. Line the cap with a piece of paper to prevent damage to the threads.

60. Remove the fuel injectors *(fig. 37).* —*a. Equipment.* — ½-inch open-end wrench

b. Procedure. — Use a ½-inch open-end wrench to remove the two **PALNUTS, NUTS** and **WASHERS** from each injector and lift the injectors from the cylinder heads. 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 cleaned of any dirt or grit, and placed in lightweight oil, flushing oil, or fuel oil, to prevent possibility of corrosion.

61. Remove the push rods and push rod housings *(figs. 38 and 39).* —*a. Equipment.* —

Engine turning bar No. GU-GST-1344
Push rod housing nut wrench No. GU-GST-1306
Push rod remover No. GU-GST-1304

b. Procedure. — (1) The **NUTS** (GU-13-Y-128B) on the push rod **HOUSINGS** (GU-13-Y-128) must be loosened and the push **RODS** must be removed one at a time.

(2) Install the engine turning bar (GU-GST-1344) over the splined end of the crankshaft, to help in turning the engine, and hold it on by means of the flywheel nut.

(3) Before the push rods can be removed, the piston must be approximately 80° beyond top center to allow clearance for the valve above the piston when the valve is forced down in removing the push rod. Note that 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. Since the angle between each two cylinders is 40°, the wide spline of the crankshaft should face the second cylinder beyond the cylinder on which the push rods are being removed. With the piston in this position, move the rocker arms of the cylinder 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.

(4) With the rocker arms free and the piston 80° beyond top center, loosen the round nuts at each end of both push rod housings, using the push rod housing nut wrench (GU-GST-1306).

CAUTION: Loosen the push rod housing nuts on only one cylinder at a time. Loosening the nuts allows the push rod housing to move out of position and the valve tappets might be damaged when turning the engine.

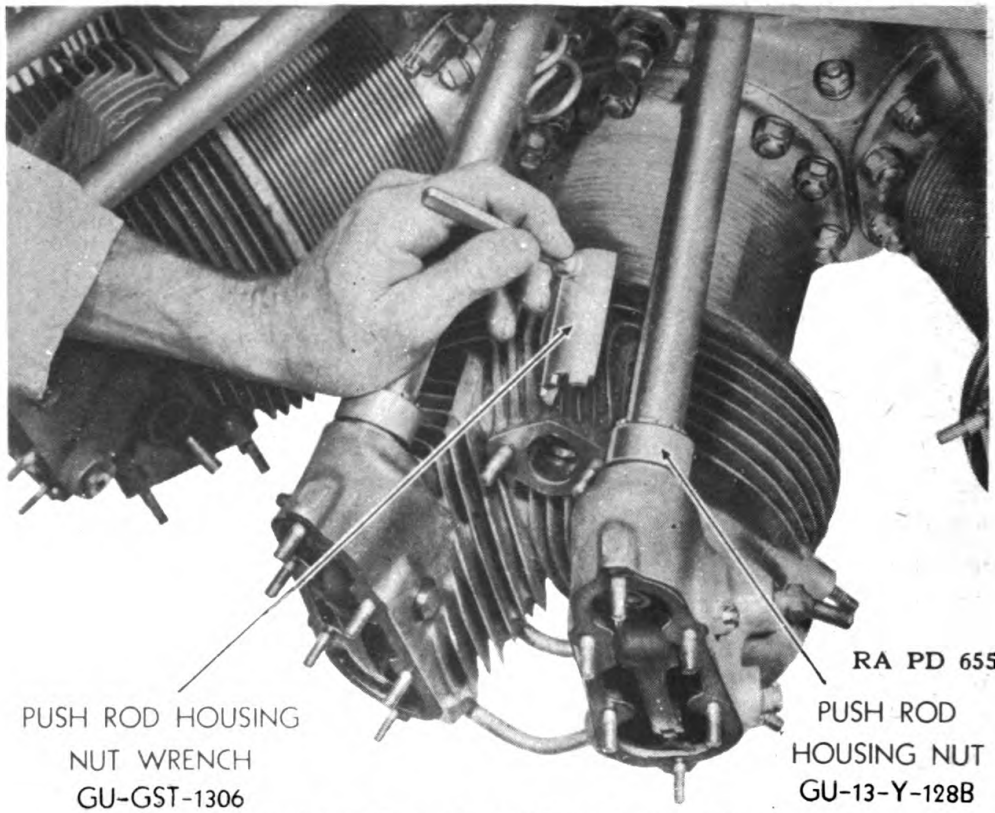


FIGURE 38—Removing push rod housing nut.

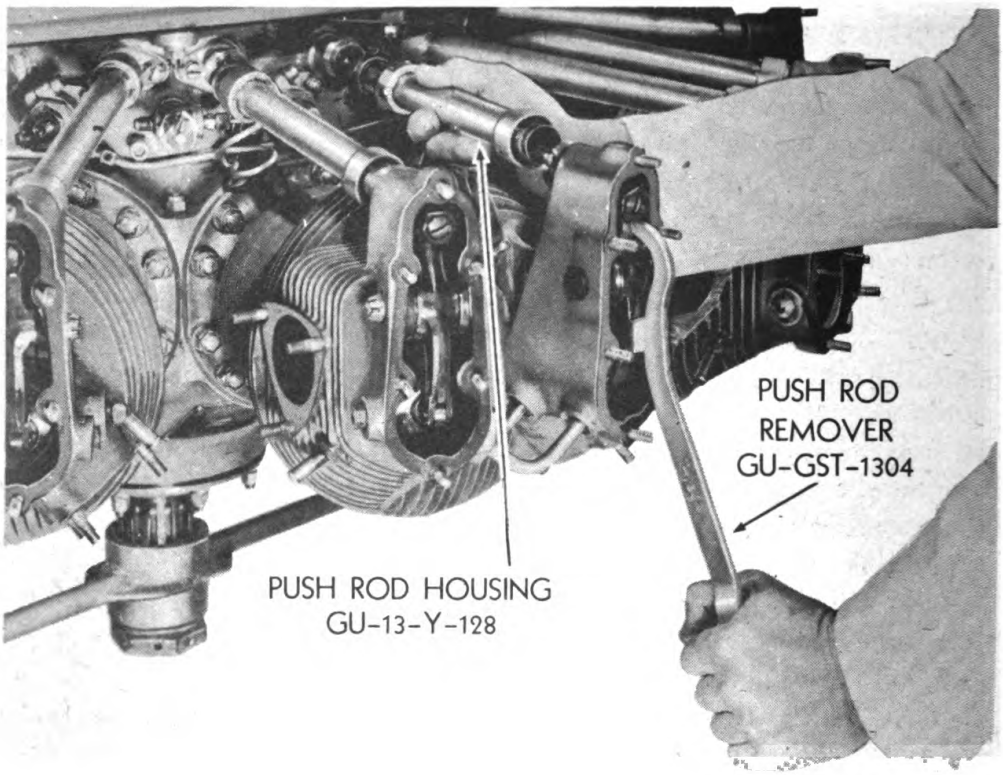


FIGURE 39—Removing push rod and housing.

(5) Fit the push rod remover (GU-GST-1304) to a ROCKER of the cylinder 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 push rod, so that the push rod and housing will lift out. Remove the other push rod and housing on the cylinder in the same way.

(6) This same procedure can be followed to remove the push rods and housings from the other eight cylinders.

62. Remove the oil sump *(fig. 40).* —*a. Equipment.* —

½-inch open-end wrench

b. Procedure. — Turn the platform of the engine mounting stand so that the front of the engine faces upward. Using a ½-inch open-end wrench, remove the three nuts which hold the oil sump (GU-14M2-YA-131) to the crankcase. (The other nut at the top was removed in taking off the main baffle.) Then lift off the oil sump.

63. Remove the cylinders from the crankcase *(figs. 41 and 42).* — *a. Equipment.* —

Cylinder hold-down nut wrench GU-GST-1432 with ½-inch drive

b. Procedure. — (1) The cylinder BARREL (GU-14-Y-66), cylinder HEAD and rocker arm ASSEMBLY are lifted off as a unit. In removing the cylinders, start with number eight cylinder, then remove number nine, and the others in order. This is done because the master connecting rod is in number seven cylinder, and this should be the last to be removed so that it can hold the others in position.

(2) The PISTON (GU-14M-Y-37) should be on top dead center as shown by the wide spline of the crankshaft facing the cylinder, as the cylinder is removed, otherwise the lower piston RING might not extend beyond the crankcase, and be damaged when turning the crankshaft to remove the other pistons.

(3) To remove each cylinder, remove the palnuts, nuts and washers from the studs that encircle the cylinder barrel. A special wrench (GU-GST-1432) is used to remove these nuts, with a ½-inch drive to provide leverage. Then pull the cylinder back off the studs and remove it from the piston assembly.

64. Remove the piston assemblies *(fig. 43).* — *a. Equipment.* —

Piston pin driver No. GU-GST-1345

b. Procedure. — (1) With the cylinder removed, the next step is to remove the piston PINS so that the pistons can be removed. A PLUG fits over each end of the piston pin. These can be lifted out by inserting a nail or similar pointed object into the hole in the plug and lifting up. Hold a hand under the piston pin, in case it might be free enough to fall out. With the plugs removed, use the special piston pin driver to drive the

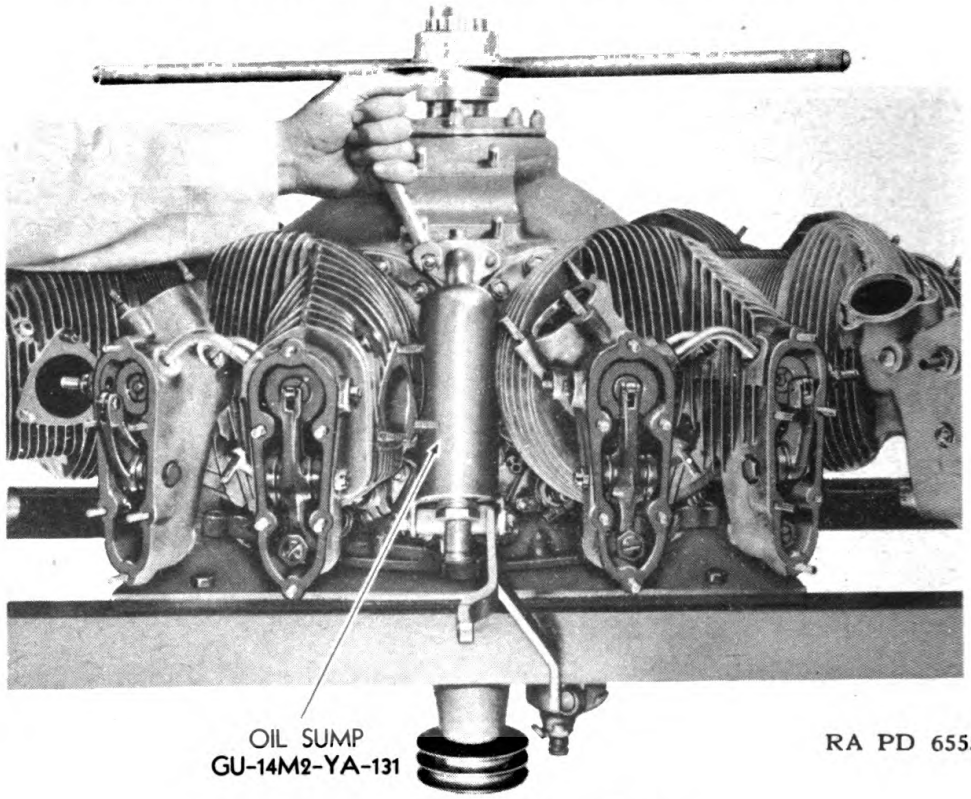


FIGURE 40—Removing the oil sump.

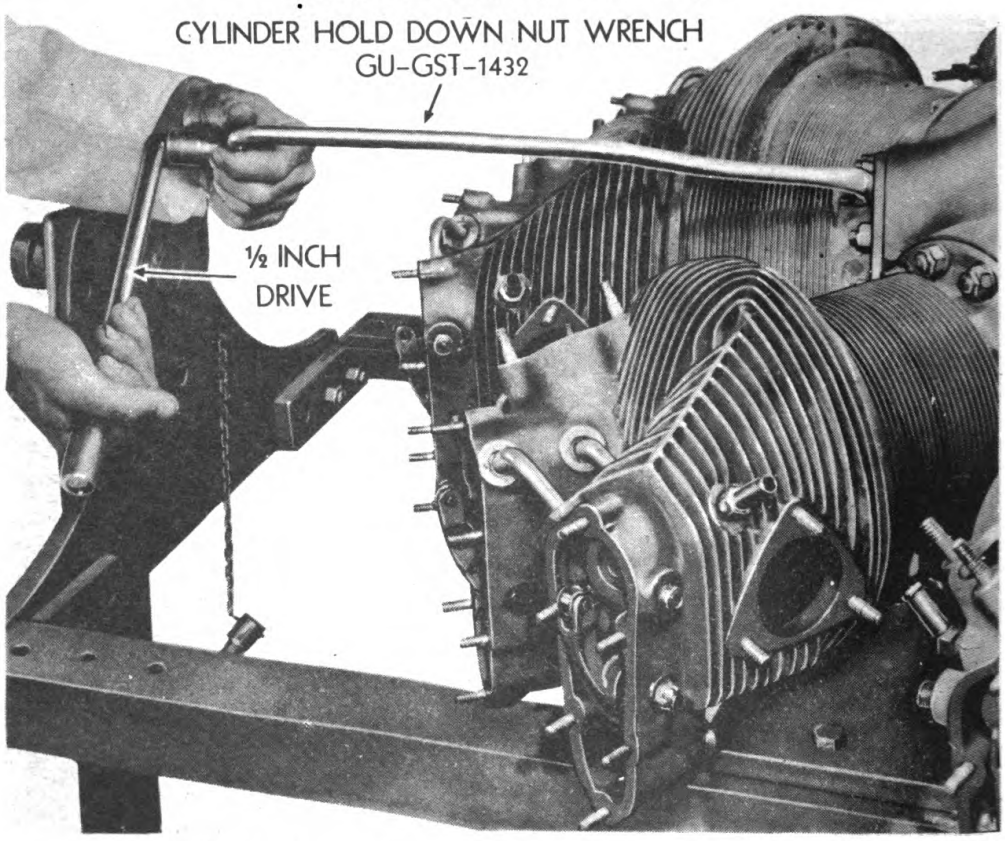
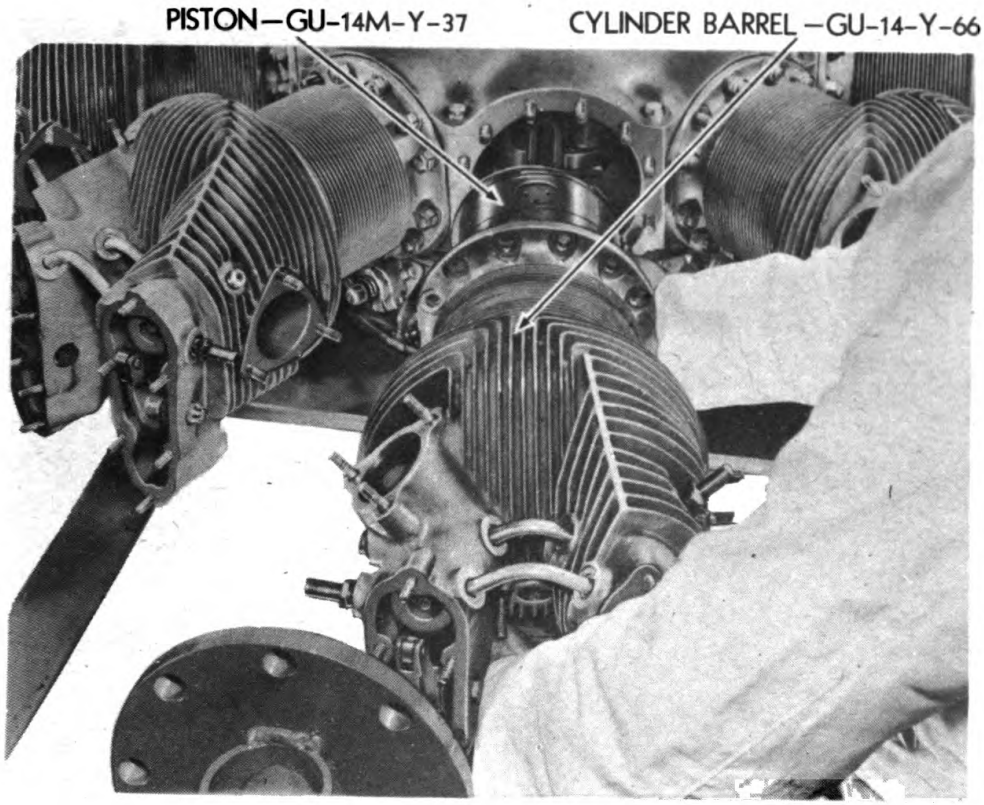
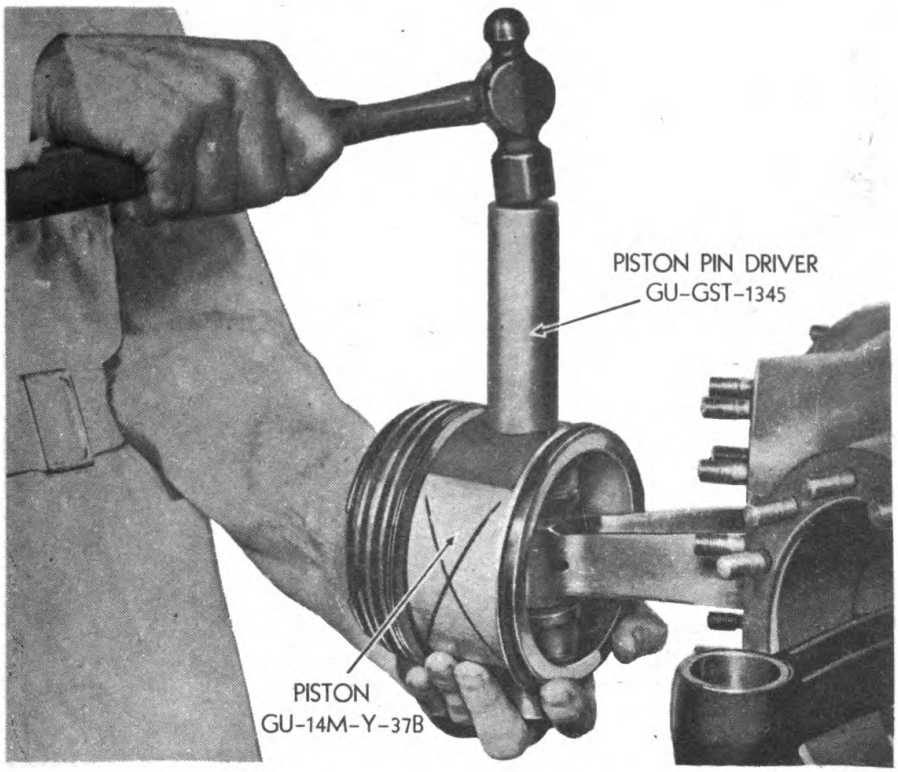


FIGURE 41—Removing cylinder hold-down nuts



RA PD 6557

FIGURE 42—Lifting off the cylinder.



RA PD 6558

FIGURE 43—Removing the piston (master rod piston shown).

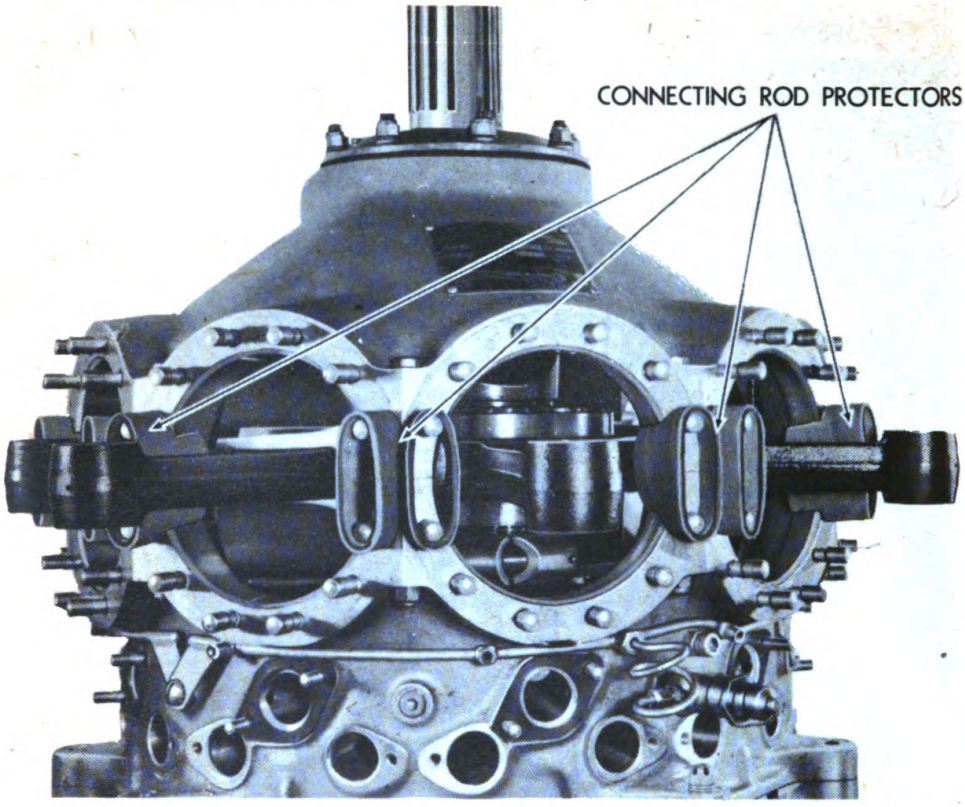


FIGURE 44—Connecting rod protectors. RA PD 6559

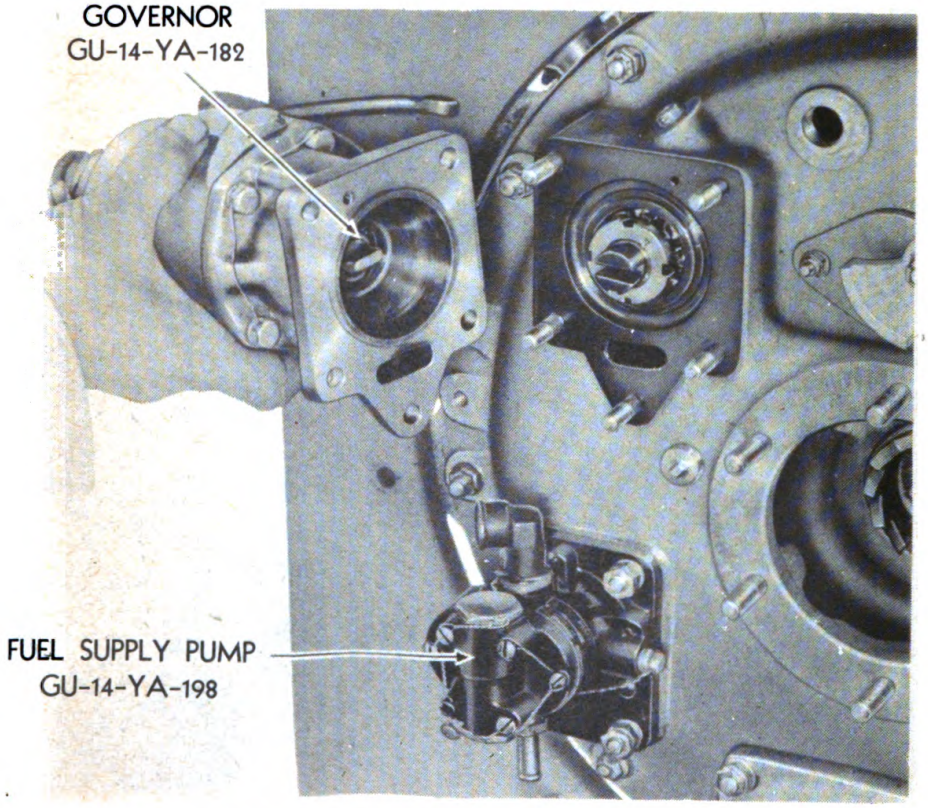


FIGURE 15—Governor and fuel supply pumps. RA PD 6560

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

(2) Pull the piston off the link rod.

(3) Repeat this operation on the other eight cylinders, turning each piston to top center before the cylinder is removed. **NOTE:** The cylinder barrels, pistons, piston pins and plugs are all numbered to indicate the cylinder. Check to make sure numbers are legible.

65. Insert rubber protectors over cylinder hold-down studs *(fig. 44).* — When the cylinder barrels and piston assemblies have been removed, the link rods are free to move back and forth in the cylinder openings, and they might damage the threads of the cylinder barrel hold-down studs. 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 long flap should be left in the hose to extend down into the cylinder opening. Install these protectors as each cylinder barrel is removed.

66. Remove the governor *(fig. 45).* — *a. Equipment.* —

½-inch socket wrench

b. Procedure. — Turn the engine so that the rear is facing upward. Using a ½-inch socket wrench, remove the five palnuts, nuts and washers from the governor mounting flange and remove the **GOVERNOR (GU-14-YA-182)** from the crankcase.

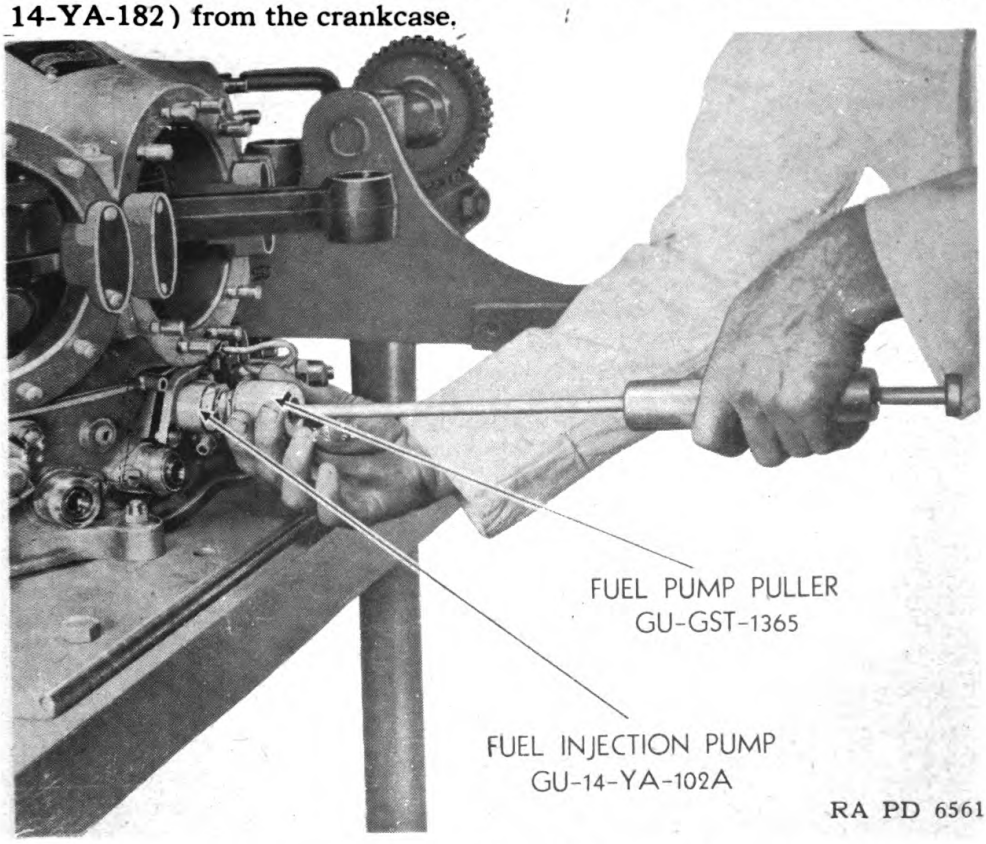


FIGURE 46—Removing the fuel injection pump.

67. Remove the fuel supply pump *(fig. 45).* — *a. Equipment.* —
½-inch socket wrench

b. Procedure. — Using a ½-inch socket wrench, remove the four palnuts, nuts and washers from the fuel supply pump mounting flange and remove the fuel supply PUMP (GU-14-YA-198) or (GU-14M-YA-198) from the accessory case.

68. Remove fuel injection pumps *(fig. 46).* — *a. Equipment.* —
Fuel pump puller
No. GU-GST-1365 ½-inch open-end wrench

b. Procedure. — (1) Be sure each pump is numbered to indicate the cylinder in which it belongs.

(2) Using a ½-inch open-end wrench, remove the palnuts, nuts and washers on each side of the injection pump.

(3) Thread the fuel pump adapter of the fuel pump puller (GU-GST-1365) shown in figure 46, over the nipple of the injection pump. Operate the sliding hammer of the puller, striking it forcibly back against the flange of the rod, until the injection pump is pulled out. Remove the injection pump.

(4) Repeat this operation to remove the injection pumps at all cylinders.

(5) The injection pump should be thoroughly cleaned of dirt or foreign matter, and placed in a bucket of light oil or fuel oil to prevent corrosion.

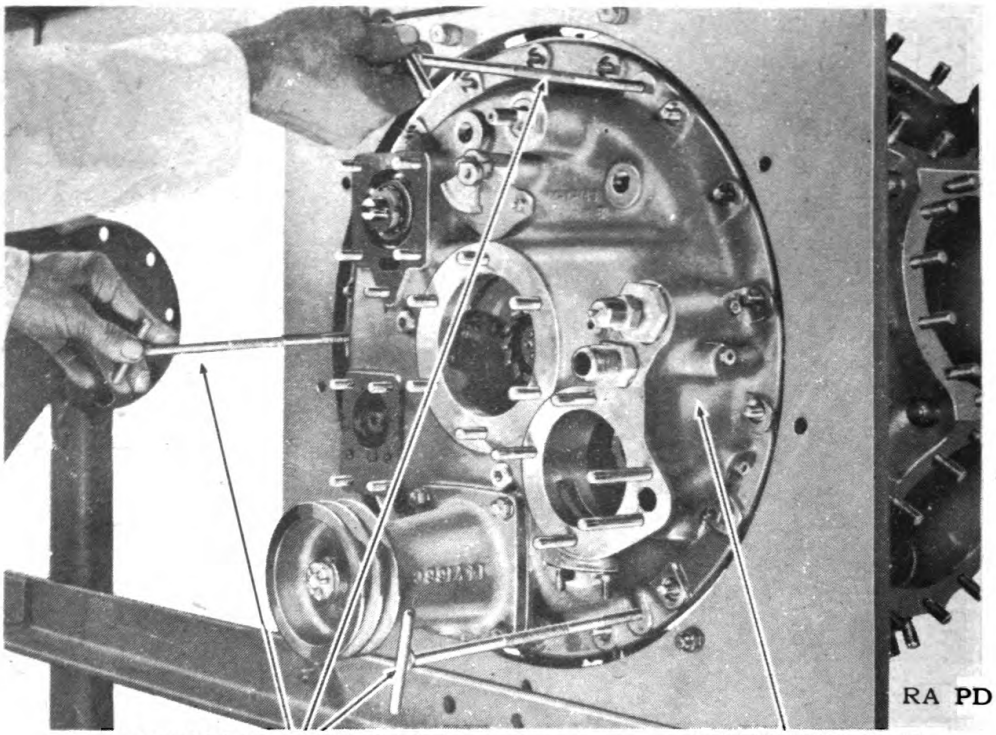


FIGURE 47—Removing the accessory case from the crankcase.

69. Remove the accessory case *(fig. 47).* — *a. Equipment.* —

½-inch socket wrench
Accessory case pullers, (3) GU-GST-1360

b. Procedure. — (1) The accessory **CASE (GU-14-Y-143)** is held to the crankcase by eighteen nuts, which encircle the accessory case. Using a ½-inch socket wrench, remove the palnuts, nuts and washers from the accessory case mounting studs. There may not be sufficient clearance to remove the nut which is directly under the oil inlet to the accessory case. In that event, turn the nut back as far as possible. It can be removed as the accessory case is taken off.

(2) Before removing the accessory case, be sure that there are no burs on the throttle shaft hex 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.

(3) 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 rear **CRANKCASE (GU-Y-56)**, 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.

(4) When the accessory case is free. lift it off the studs.

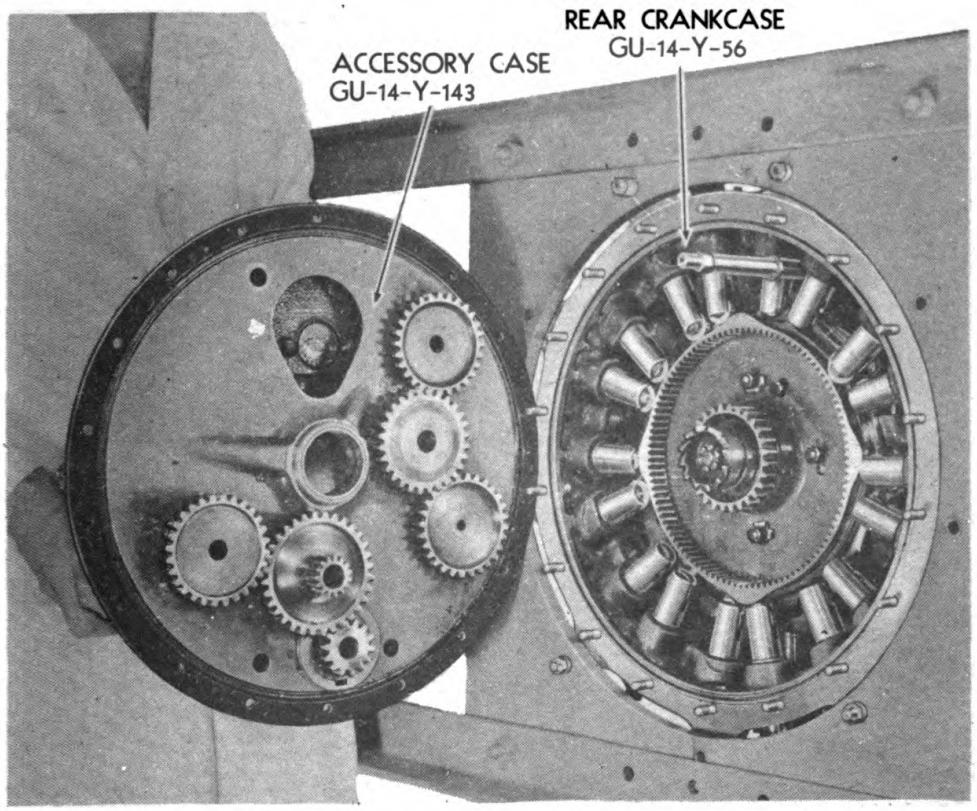


FIGURE 48—The accessory case removed from the crankcase. RA PD 6563

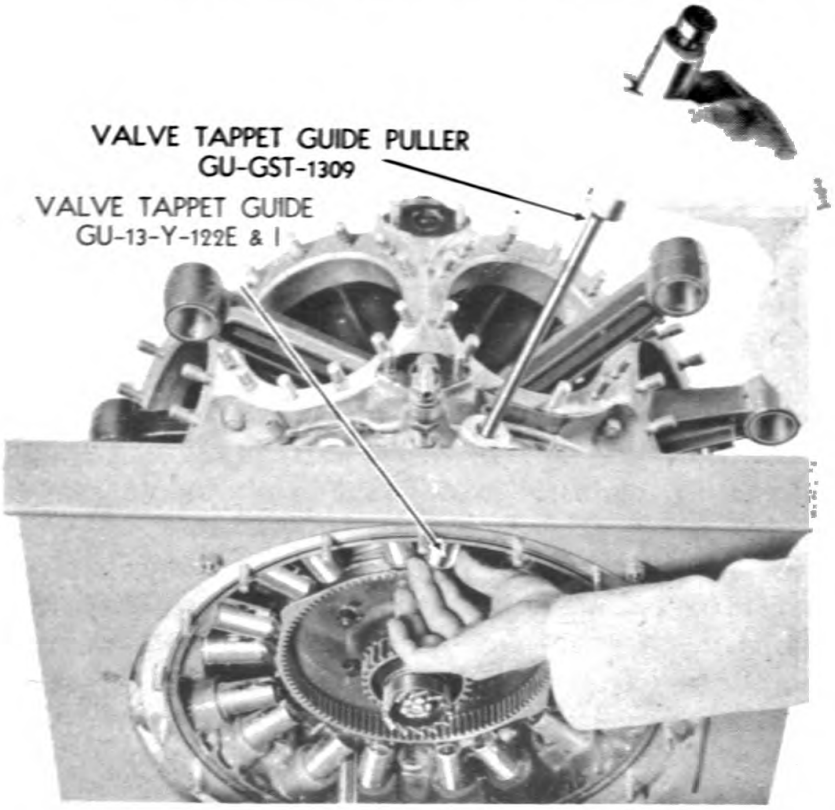
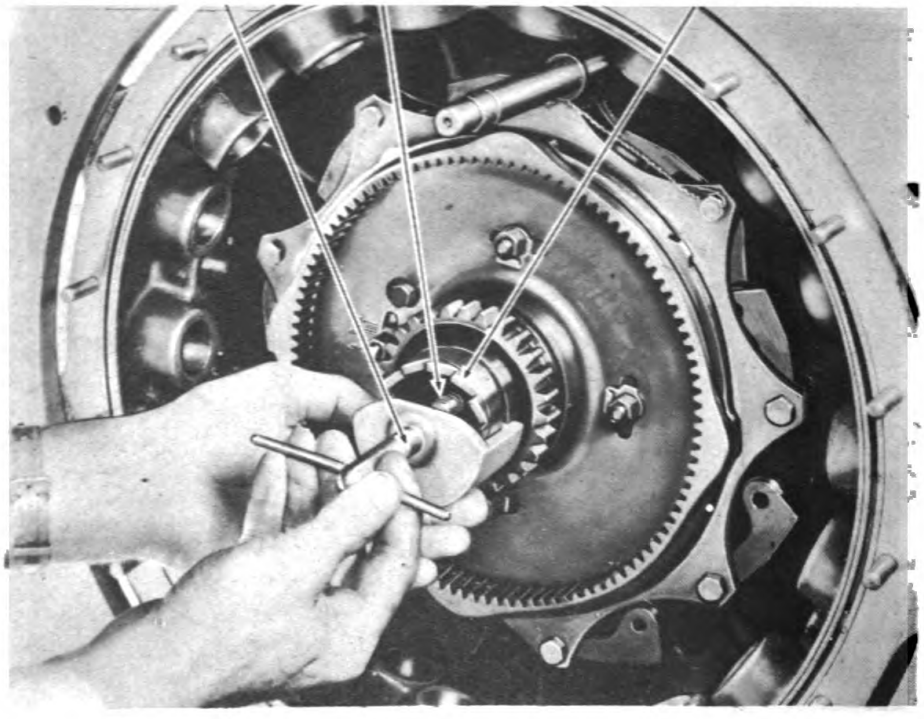


FIGURE 49—Removing valve tappet and guide. RA PD 6564



RA PD 6565

FIGURE 50—Removing the starter jaw.

70. Remove the valve tappets and guides *(fig. 49).* — *a. Equipment.* —

Valve tappet guide puller No. GU-GST-1309	Pliers
	Screwdriver

b. Procedure. — (1) Check to make sure the tappets and guides are marked to indicate "Intake" or "Exhaust."

(2) Cut the safety wire with pliers and use a screwdriver to take out the screws. Be careful that the screwdriver does not scrape the valve tappet guide and damage it.

(3) When removing **TAPPET** and **GUIDE**, the tappet must not be on the high lobe of the cam, or it will protrude too far through the guide to permit the use of the puller. Screw the valve guide puller (**GU-GST-1309**) onto the valve tappet. Striking the hammer of the guide puller forcibly back against the flange will pull the guide out of the case.

(4) The tappet **BODY** and **ROLLER** are removed from underneath the crankcase at the same time that the valve guide is removed. As the valve guide puller is operated, reach under the crankcase and hold the tappet or it will come apart. Pull the tappet toward the crankshaft as the guide is removed, and lift it out, then replace it immediately in the valve guide.

(5) Notice the two holes in one side of the valve tappet. The tappet should be replaced in the guide so that these holes are at the same side

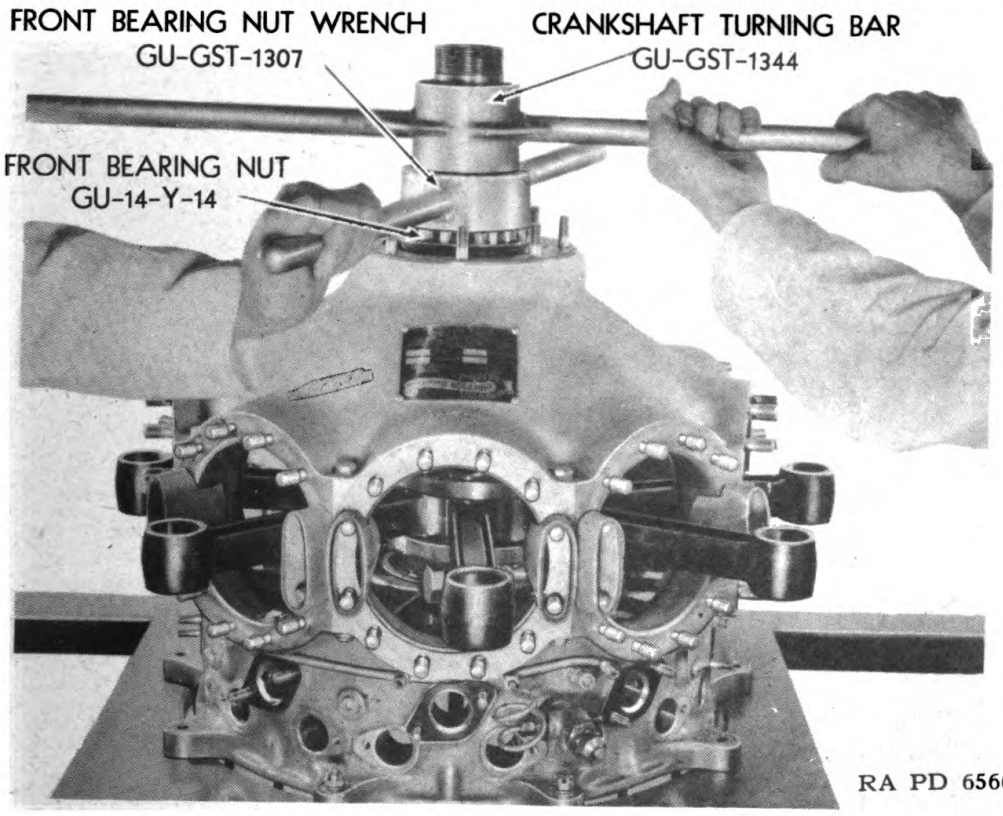


FIGURE 51—Removing the crankshaft front bearing nut.

of the guide as when the tappet was removed. The tappet and guide should be kept together as a unit, since the fit is very close, and once a bearing surface has been obtained, the parts should remain together.

71. Remove the valve cam and fuel control plate assemblies *(fig. 50).* — *a. Equipment.* —

	Starter jaw gear puller
7/8-inch socket wrench	No. GU-GST-1301

b. Procedure. — (1) The starter **JAW (GU-32-Y-21)** must be removed before the valve **CAM** and fuel control **PLATE** assembly can be taken off.

(a) Pull the cotter pin out of the nut, and use a 7/8-inch socket wrench to remove the nut from the starter jaw tie **BOLT (GU-13-Y-22).**

(b) Fit the starter jaw gear **PULLER (GU-GST-1301)** to the starter jaw, so that the ridge in the puller is behind the jaw. Turning the center bolt of the puller will bear against the tie bolt, pulling the jaw out. The gear will come off with the jaw.

(2) With the starter jaw removed, the valve and fuel cam and fuel control plate assemblies, and the rear crankshaft **SPACER** can be removed.

72. Remove the throttle shaft. — The throttle shaft can be removed by pulling it straight out of the crankcase.

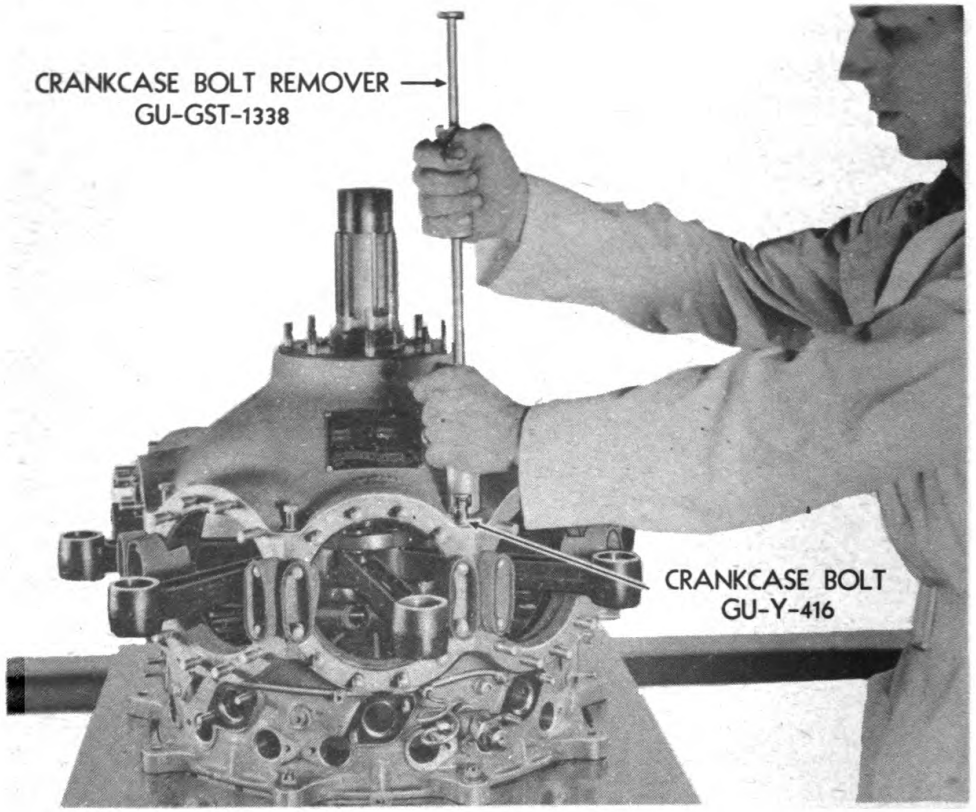
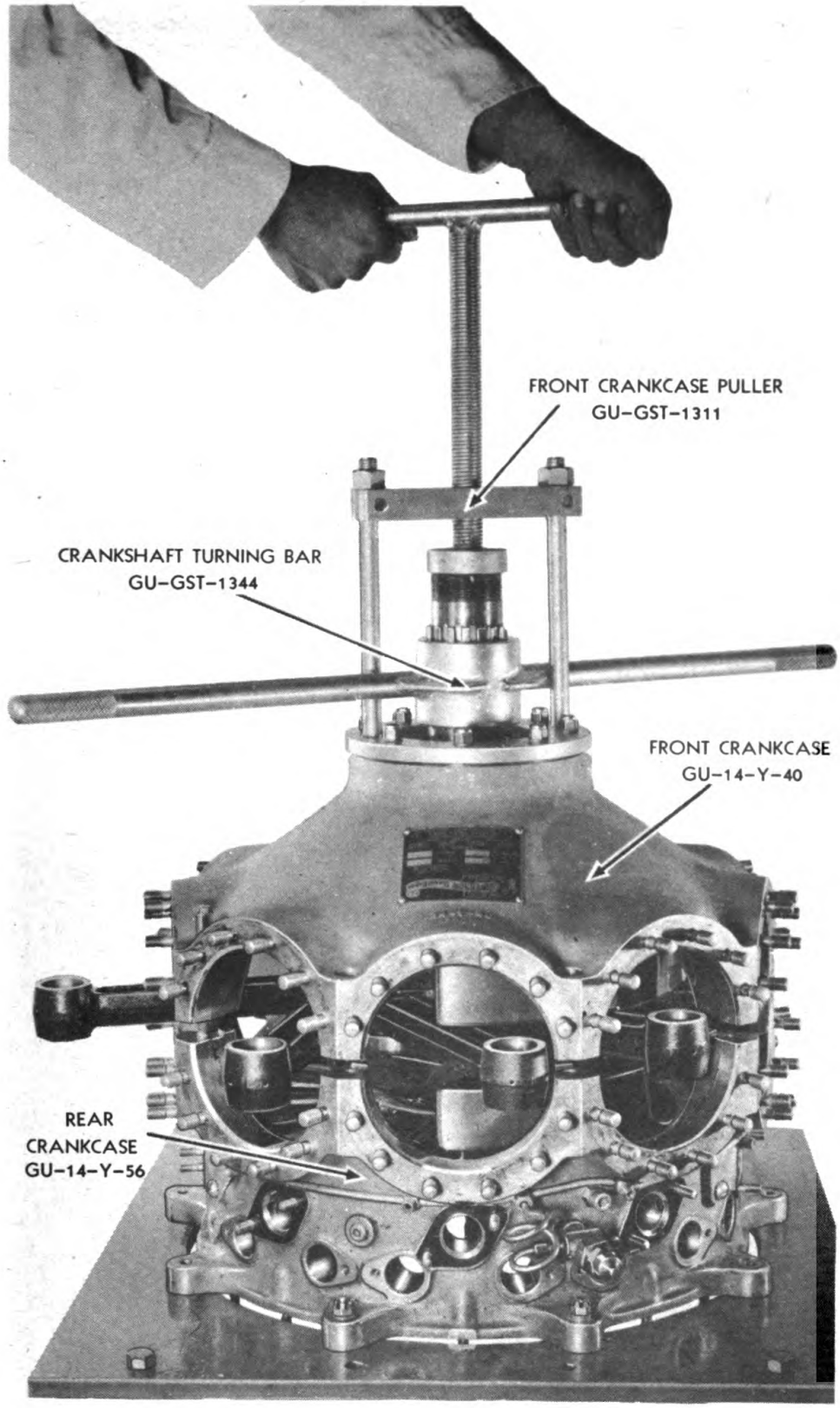


FIGURE 52—Removing crankcase assembly bolts.



RA PD 6568

FIGURE 53—Removing front half of crankcase.

73. Remove the crankshaft from the crankcase. — *a. Equipment.* —

Front bearing nut wrench No. GU-GST-1307	Engine lifting eye No. GU-GST-1308
Crankcase bolt remover No. GU-GST-1338	Crankshaft turning bar No. GU-GST-1344
Crankcase puller No. GU-GST-1311	Brass rod
$\frac{9}{16}$-inch socket wrench	Hammer
	Hoist

b. Procedure. — (1) Turn the engine mounting stand so that the front of the engine is facing upward.

(2) Use a $\frac{9}{16}$-inch socket wrench to remove the palnuts, nuts and washers on the front bearing **PLATE** and remove the plate.

(3) *(fig. 51)* Place the front bearing nut wrench (GU-GST-1307) over the crankshaft, fitting the prongs of the wrench into the grooves of the front bearing **NUT** (GU-14-Y-14). Place the crankshaft turning bar (GU-GST-1344) on the crankshaft over the wrench, and with one man holding it to keep the crankshaft from turning, unscrew the front bearing nut from the crankshaft.

(4) Lift off the **SPACER** and oil **THROWER**.

(5) *(fig. 52)* Using a $\frac{9}{16}$-inch socket wrench, remove the nuts from the crankcase assembly **BOLTS** (GU-Y-416). Turn all the bolts up to

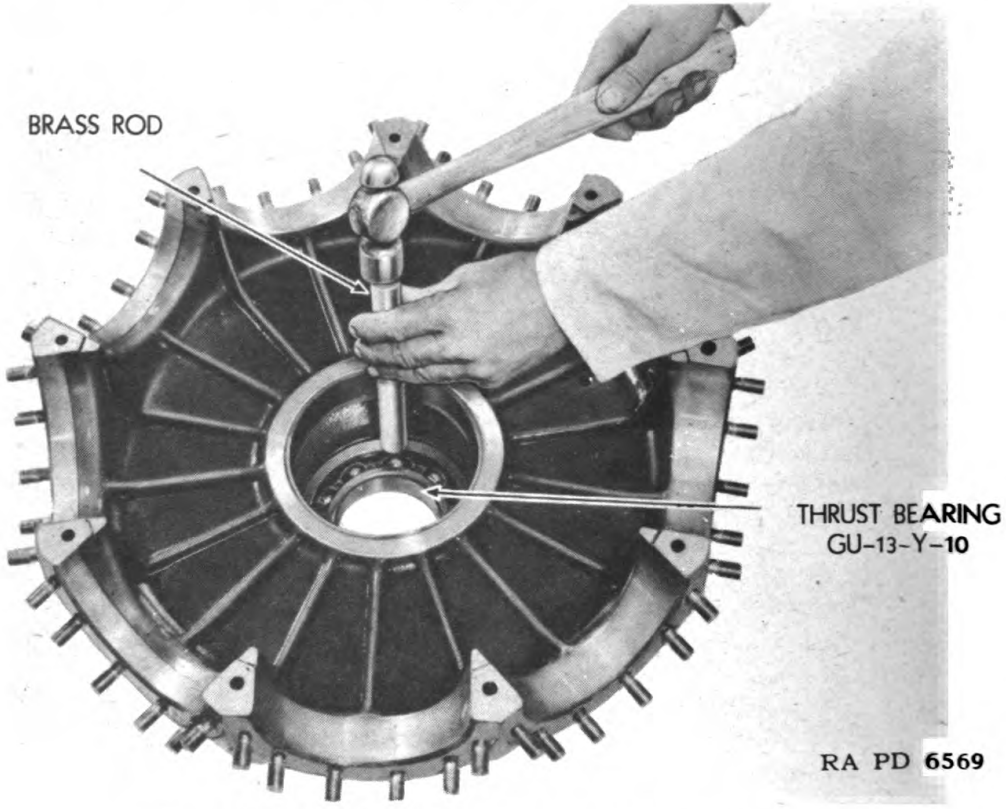


FIGURE 54—Removing the bearing from the front crankcase.

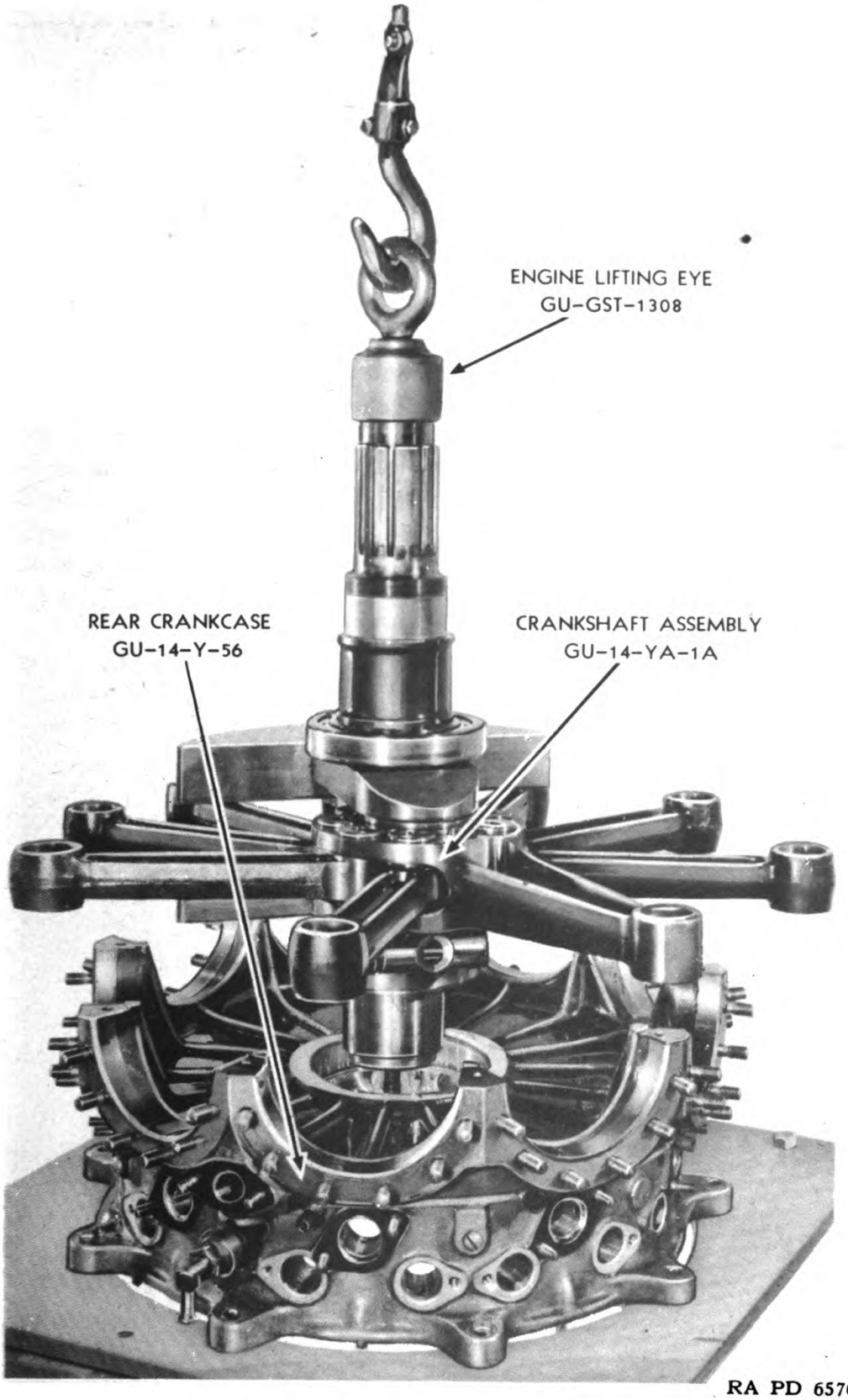


FIGURE 55—Lifting the crankshaft out of the rear crankcase.

give sufficient clearance to attach the crankcase bolt remover (GU-GST-1338). Attach the remover as shown in figure 52 and remove the bolts by striking the sliding hammer of the remover against the flange. Two bolts are left on opposite sides of the crankcase to maintain alinement as the front crankcase is removed.

(6) *(fig. 53)* Install the front crankcase puller (GU-GST-1311) on the thrust plate studs, as shown in figure 53. The crankshaft turning bar (GU-GST-1344) is used to keep the crankshaft from turning. Turning the center bolt of the puller down on the crankshaft will lift the front CRANKCASE (GU-14-Y-40). Then remove the two crankcase assembly bolts, which had been left in position to maintain alinement.

(7) Set the front crankcase on a bench and remove the crankcase puller.

(8) *(fig. 54)* Turn the front crankcase face down and with a brass rod, drive the BEARING (GU-13-Y-10) out of the case, being sure to drive only on the outer race of the bearing and not on the bearing itself.

(9) *(fig. 55)* Thread the engine lifting eye (GU-GST-1308) on to the end of the crankshaft. Using a hoist, lift the CRANKSHAFT assembly (GU-14-YA-1A) out of the rear CRANKCASE (GU-14-Y-56), as shown in figure 55.

74. Remove fuel pressure regulator. — *a. Equipment.* —

$\frac{7}{16}$-inch open-end wrench
$\frac{3}{4}$-inch open-end wrench
$\frac{1}{2}$-inch open-end wrench

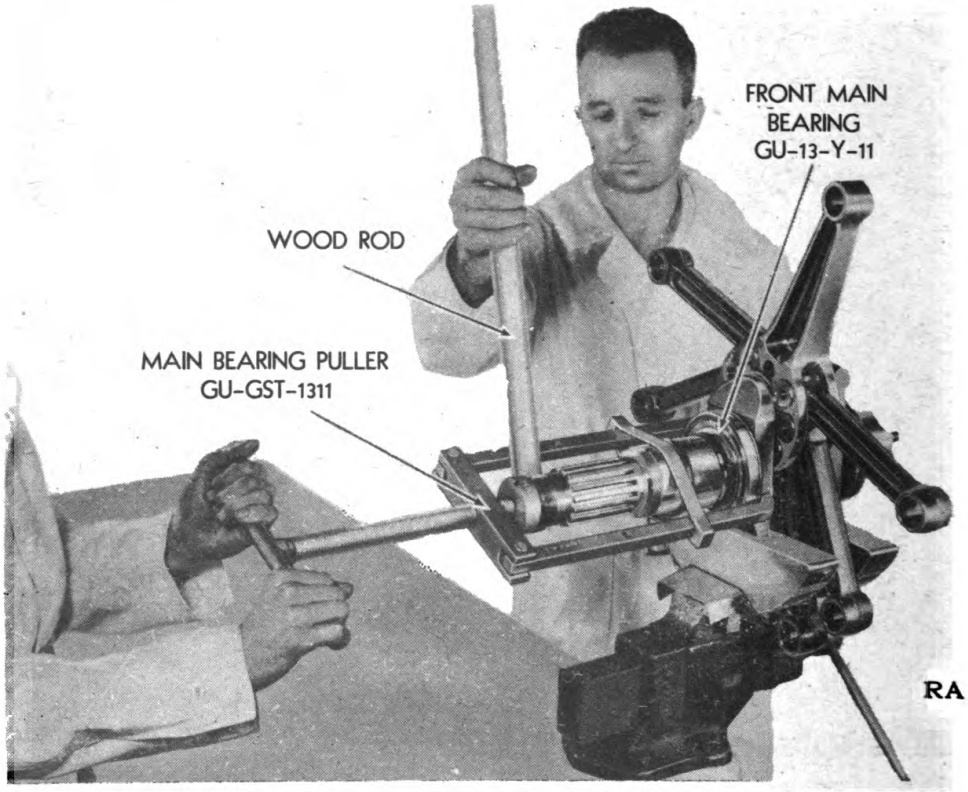


FIGURE 56—Removing the crankshaft main bearings.

b. Procedure. — (1) The fuel pressure **REGULATOR** is located at the top of the engine, and is connected to the fuel channel between Nos. 1 and 2 pressure pumps. A short fuel pressure regulator line connects the fuel pressure regulator to the fuel return ring.

(2) Using a $\frac{7}{16}$-inch open-end wrench, loosen the fitting of the regulator line at the regulator, and use a ½-inch open-end wrench to unscrew the nut at the fuel return ring and remove the regulator line.

(3) Then unscrew the fuel pressure regulator with a ¾-inch open-end wrench.

75. Remove the check valve. — *a. Equipment.* —

⅞-inch open-end wrench

b. Procedure. — The check valve is located at the bottom of the engine between the fuel supply pump and the fuel channel. Use a ⅞-inch open-end wrench to unscrew it.

76. Remove the fuel return ring. — *a. Equipment.* —

Screwdriver

b. Procedure. — The fuel return ring does not need to be removed unless it is broken or damaged. To remove it, take out the 4 screws that hold the return ring to the crankcase. Disconnect the ends of the ring at the connector between Nos. 3 and 4 mounting pads, and lift the ring off the crankcase.

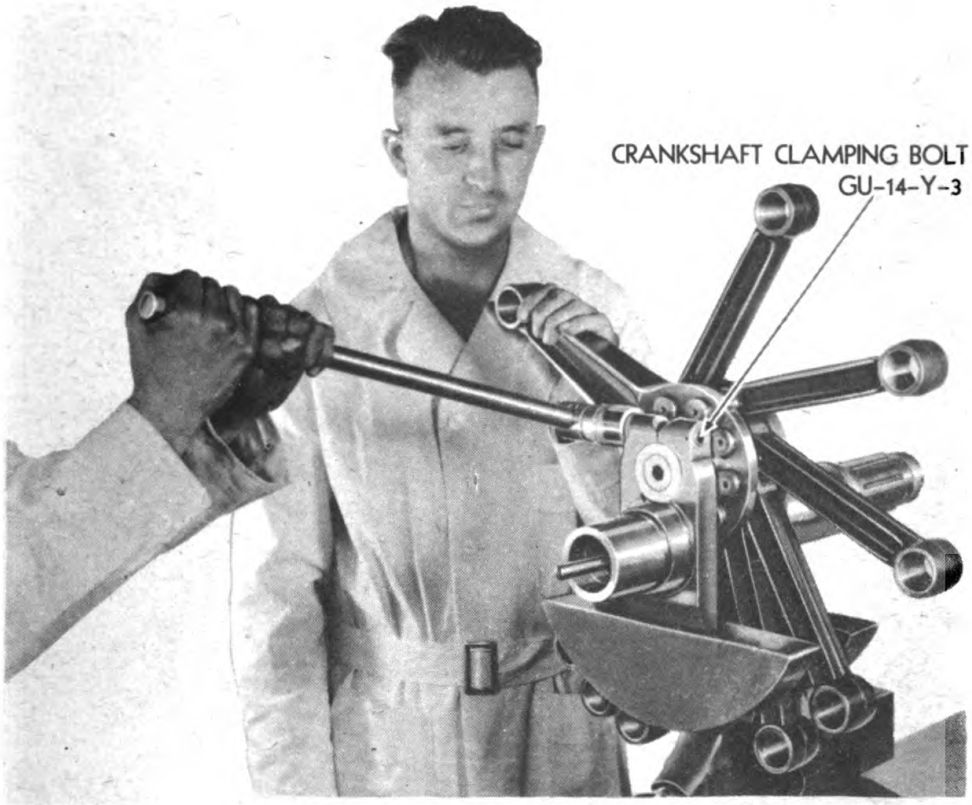


FIGURE 57—Removing crankshaft clamping bolt. RA PD 6572

77. Remove crankshaft main bearings *(fig. 56).* — *a. Equipment.* —

Front crankcase and main bearing puller No. GU-GST-1311
Wood bar

b. Procedure. — (1) Clamp the outer crankshaft **COUNTERWEIGHT (GU-14-Y-7)** in a soft-jawed vise. The master connecting rod and three of the link rods should be on one side, and the other five link rods on the other, as shown in figure 56.

(2) Use the necessary parts of the front crankcase and main bearing puller (GU-GST-1311), and clamp the fingers of the puller behind the front main **BEARING (GU-13-Y-11)**, as shown in figure 56. A short adapter is used on the crankshaft under the center bolt of the puller in removing the front main bearing, and the ends of the fingers of the puller are attached to the cross bar, as shown in the illustration.

(3) Turn the center bolt of the puller against the adapter and crankshaft to pull the front main bearing and sleeve off the shaft.

(4) The same procedure is followed in removing the rear crankshaft bearing except that a longer adapter is used on the crankshaft, and the crossbar of the puller is attached at the centers of the puller fingers.

(5) A wood bar should be inserted between the puller and the crankshaft to keep the crankshaft from turning while the puller is being used.

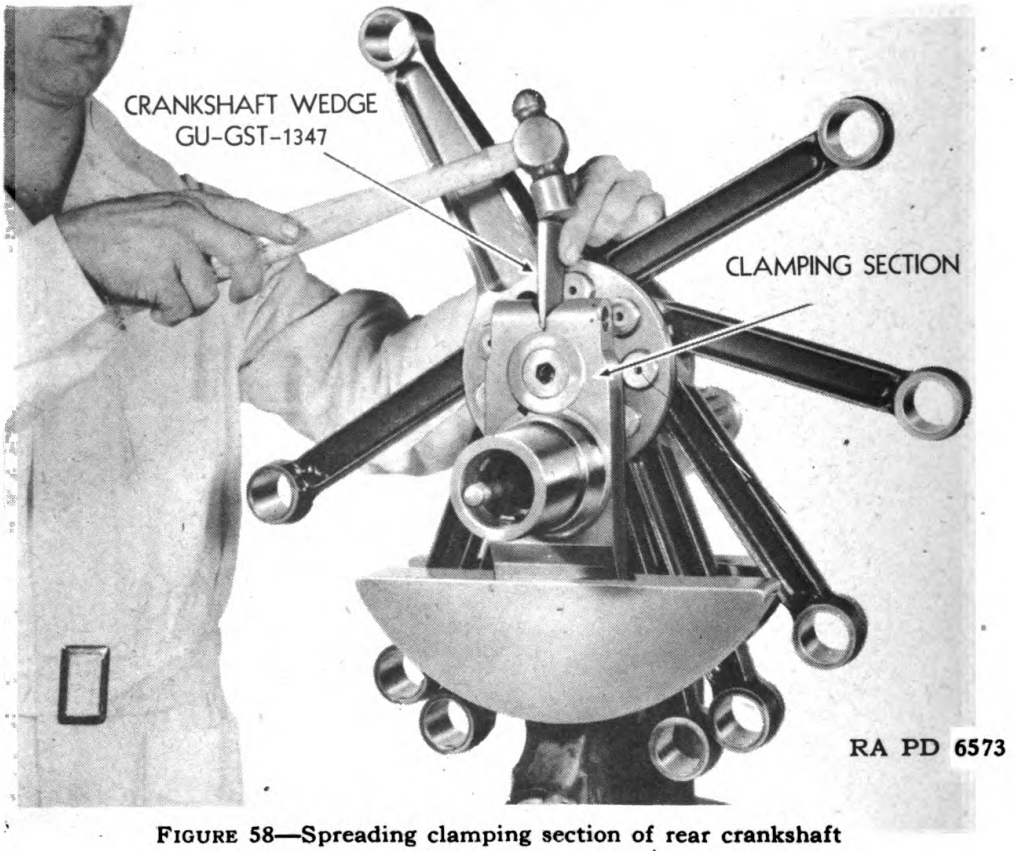


FIGURE 58—Spreading clamping section of rear crankshaft

Be careful not to let the puller fingers ride against the crankshaft counterweights or it might damage them.

78. Remove crankshaft clamping bolt *(fig. 57).* — *a. Equipment.* —

Pliers
1⅛-inch socket wrench

b. Procedure. — The crankshaft clamping BOLT (GU-14-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 on the master rod assembly which will allow sufficient clearance to fit a wrench over the bolt. Remove the cotter pin from the bolt, and with one man holding the master connecting rod in place, screw out the bolt, using a 1⅛-inch socket wrench.

79. Removing rear crankshaft *(fig. 58).* — *a. Equipment.* —

Crankshaft wedge
No. GU-GST-1347
Soft hammer

b. Procedure. — Drive the crankshaft wedge (GU-GST-1347) down into the "V" opening in the rear crankshaft clamping section, as shown in figure 58, being careful not to drive the wedge down far enough to damage the front crankshaft journal. Do not spread the rear crankshaft over a maximum of .004 inch as it might split the crankshaft. With the clamping section spread, drive the rear CRANKSHAFT assembly (GU-14-Y-2) off

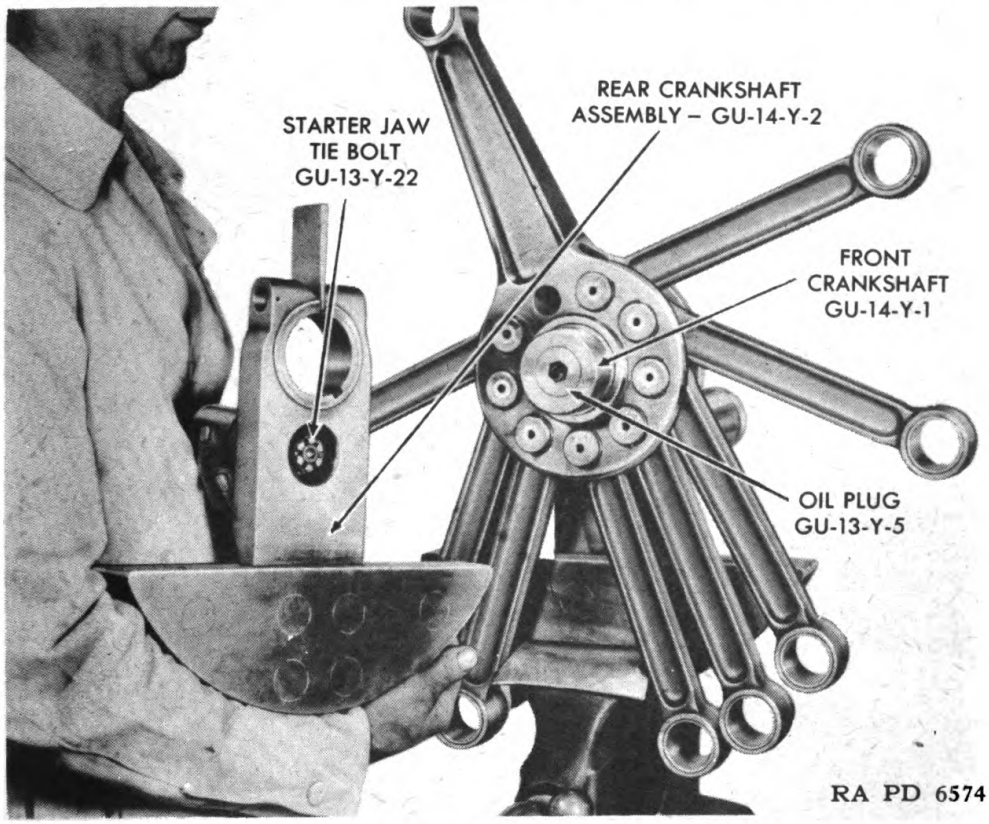


FIGURE 59—Removing rear crankshaft assembly.

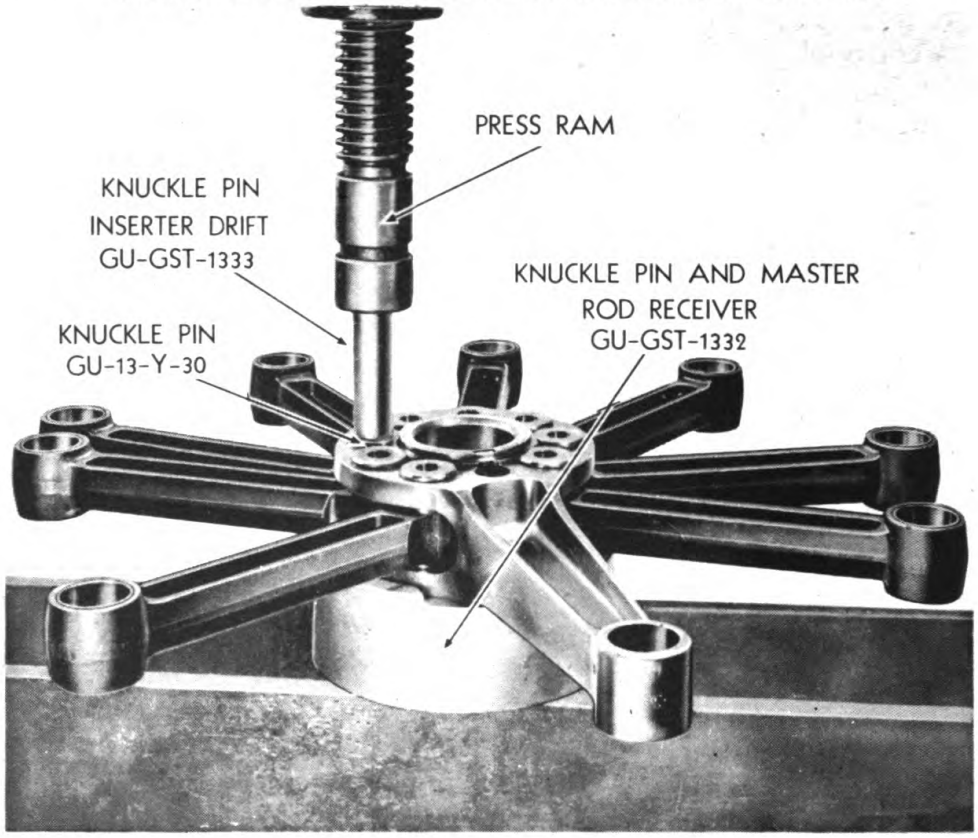


FIGURE 60—Removing the knuckle pins. RA PD 6575

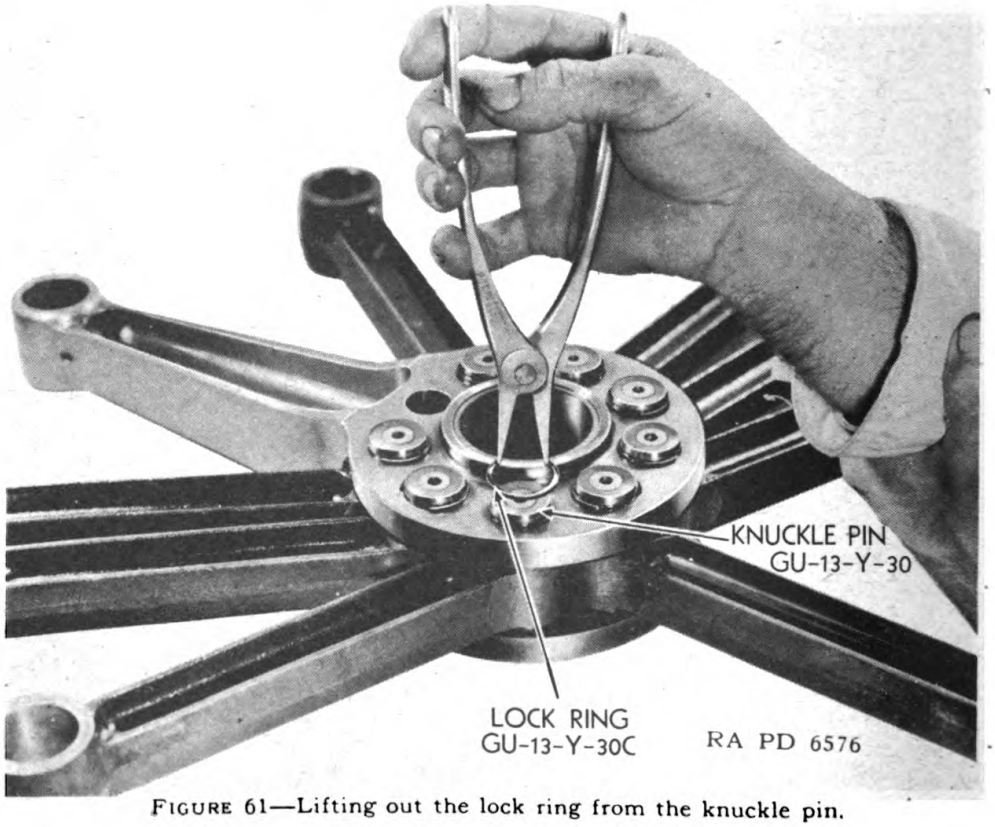


FIGURE 61—Lifting out the lock ring from the knuckle pin.

the front crankshaft journal, using a soft hammer. If an alining key was used to maintain alinement of the rear crankshaft, remove the key.

80. Remove master 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 assembly (GU-14-YA-27) off the front crankshaft journal.

81. Remove oil channel plug *(fig. 59).* — *a. Equipment.* —

$\frac{9}{16}$-inch Allen wrench
Pliers

b. Procedure. — Remove the cotter pin from the front crankshaft journal, then use a $\frac{9}{16}$-inch Allen wrench to remove the oil channel PLUG (GU-13-Y-5). Be careful not to mar the crankshaft.

82. Remove the starter jaw tie bolt *(fig. 59).* — *a. Equipment.* —

Pliers
$\frac{7}{8}$-inch socket wrench

b. Procedure. — Remove the cotter pin from the front end of the starter jaw tie BOLT (GU-13-Y-22). Use a $\frac{7}{8}$-inch socket wrench to remove the nut and slide out the bolt.

83. Remove the knuckle pins. — *a. Equipment.* —

Press
Knuckle pin remover No. GU-GST-1331
Knuckle pin and master rod receiver No. GU-GST-1322
Ring splitter

b. Procedure. — (1) Check to make sure that the knuckle PINS (GU-13-Y-30) and link rods are numbered.

(2) Notice that each knuckle pin has a flange at one end. A lock RING (GU-13-Y-30C) is used at the other end of the knuckle pin, to hold it in place.

(3) *(fig. 60)* To remove the knuckle pins, place the knuckle pin and master rod receiver (GU-GST-1332) on a press. Install the master rod assembly on the receiver with the master rod in the offset in the receiver as shown in figure 60. The flanged side of the knuckle pins on the opposite end from the lock ring end should face upward.

(4) Place the knuckle pin remover (GU-GST-1331) or a knuckle pin inserter drift (GU-GST-1333) on a knuckle pin and use a press to force the pin down to free the lock ring on the other side so that it can be lifted out.

(5) Repeat this operation on all the knuckle pins.

(6) Remove the master rod assembly and turn it over.

(7) *(fig. 61)* Turn the lock rings so that the gap in the ring is toward the master rod bushing. This will allow clearance in removing the ring. Insert the prongs of a lock ring remover or ring splitter between the ends of the lock ring and expand it so that it clears the groove in which it sets, then lift it out as shown in figure 61.

(8) When all the lock rings have been removed, place the assembly on the receiver on the press with the flange side of the knuckle pins down, and the side from which the lock rings were removed facing upward. Place the remover on the knuckle pins and press out.

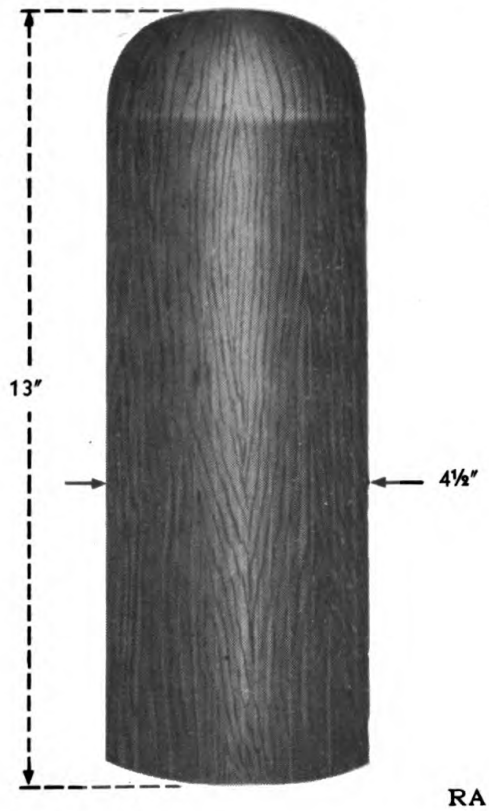


FIGURE 62—Cylinder mounting block.

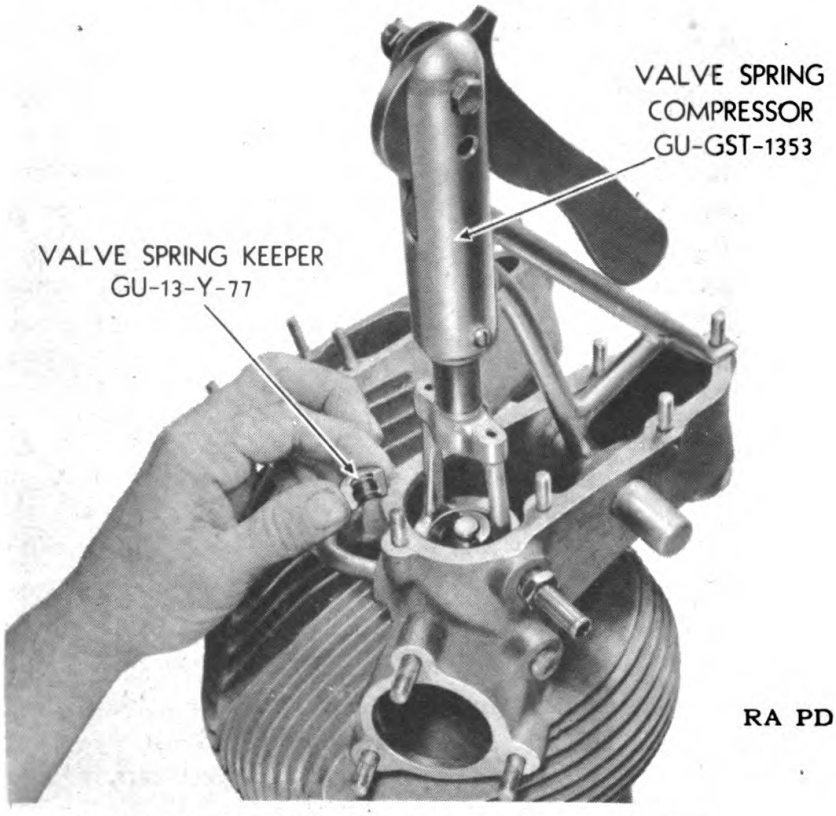


FIGURE 63—Removing the valve operating mechanism.

(9) Remove the link rods as the knuckle pins are removed.

84. Dismantle the cylinders. — *a. Equipment.* —

Cylinder mounting block	$\frac{9}{16}$-inch open-end wrench
Valve spring compressor	Screwdriver
No. GU-GST-1353	Brass drift pin

b. Procedure. — (1) *(fig. 62)* 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, as shown in figure 62, will serve for this purpose.

(2) Check to make sure that the rocker arms are numbered to indicate the cylinder to which they belong, and also that they are marked "Intake" or "Exhaust."

(3) Remove the cotter pin from the rocker shaft and use a $\frac{9}{16}$-inch open-end wrench to remove the nut. Lift off the washer. Use a brass drift pin to drive out the shaft. Lift out the rocker assembly.

(4) Before attempting to remove the valve springs, use a brass drift pin and tap the washer above the spring lightly. Otherwise, the spring may stick when it is compressed.

(5) *(fig. 63)* Place the valve spring compressor (GU-GST-1353) in position over the valve spring as shown in figure 63. Pressing down the handle of the compressor to lock position will compress the valve spring.

(6) Remove the two halves of the valve spring KEEPER (GU-13-Y-77). Remove the compressor, then lift out the inner SPRING and outer SPRINGS and the upper and lower washers. Use a screwdriver to remove the valve safety lock ring from the valve stem just below the valve keeper position.

(7) Inspect the valve stem for burs which might damage the valve guides. Remove the mounting block through the cylinder barrel opening.

(8) 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.

(9) Repeat this operation to remove the valve operating mechanism from all cylinders.

85. Remove the oil pressure relief valve. — *a. Equipment.* —

Screwdriver	Oil pressure relief valve seat
1½-inch open-end wrench	plate wrench
⅞-inch open-end wrench	No. GU-GST-1350

b. Procedure. — With a 1½-inch open-end wrench remove the oil pressure relief valve and spring. Use a ⅞-inch open-end wrench to remove the cap from the oil pressure relief valve. Adjustment of the oil pressure is made by loosening the locking nut and turning the adjusting screw with a screwdriver. To remove the oil pressure relief valve seat, insert the plate wrench (GU-GST-1350) which is a piece of metal 7/64-inch thick, into the slot in the seat and screw the seat out.

SECTION VII

THE INSPECTION

86. General. — *a.* When the engine is completely disassembled, all parts should be properly cleaned and thoroughly inspected. A careful inspection will lengthen the time interval 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 fits and clearances. Fits and clearances of various parts are shown in this section of the manual when the inspection of those parts is described. 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.

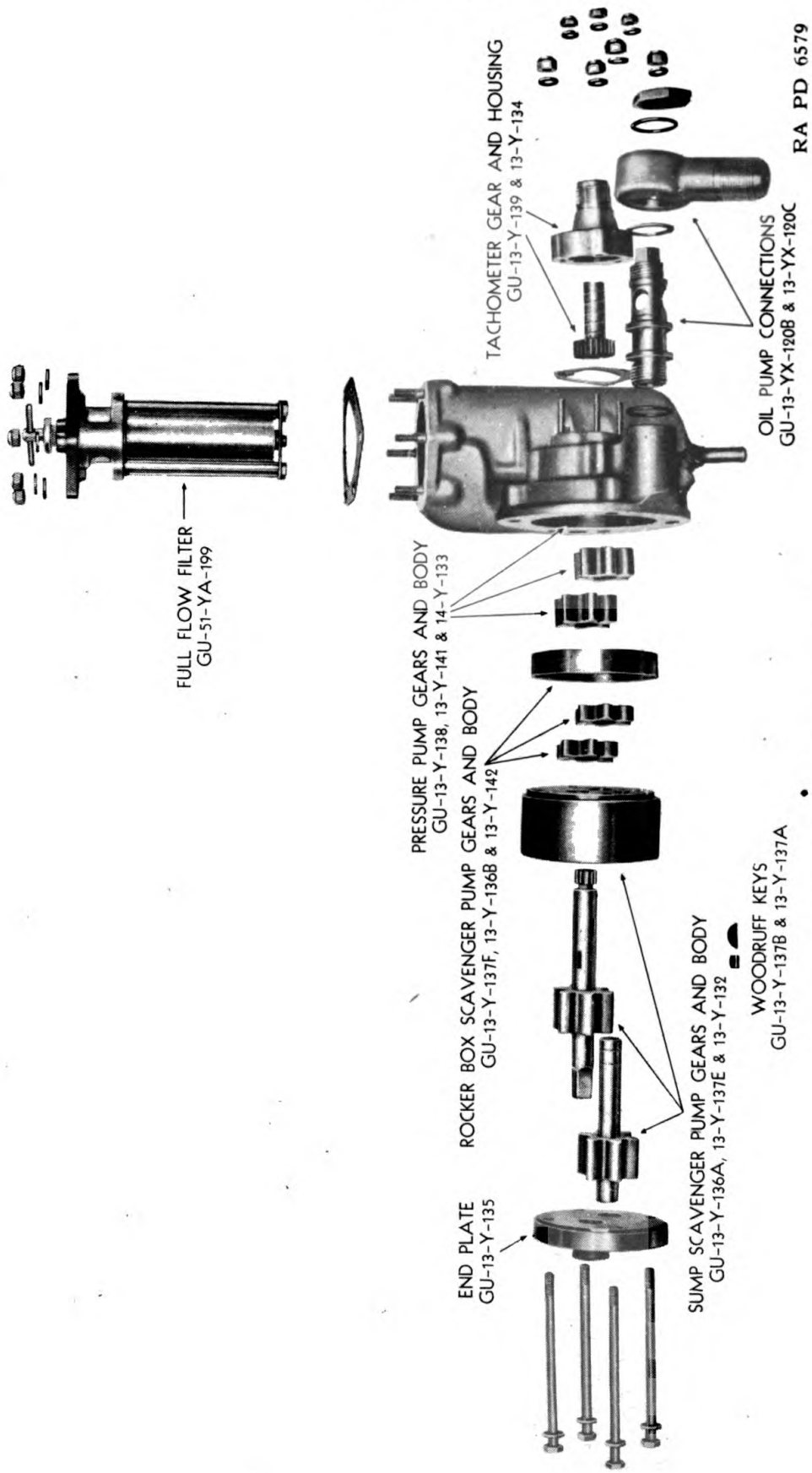


FIGURE 64—The oil pump assembly.

d. Cleaning facilities for thoroughly cleaning engine parts should be provided.

(1) Only approved cleaning fluids that are known not to be injurious to steel and aluminum should be used.

(2) A separate vat for cleaning bearings, in which no other parts are cleaned, should be available.

(3) Oil bearings immediately after cleaning, cover, and place in a dust-tight container, or submerge in clean oil in a covered container.

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

f. 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.

87. The oil pump. — *a. Equipment.* —

$\frac{7}{16}$-inch open end wrench	$\frac{3}{8}$-inch open-end wrench
Soft-jawed vise	Depth micrometer
Feeler gage	Soft drift

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 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. One gear in each unit is keyed to the shaft. Each set of gears is enclosed in its own housing. The procedure for disassembling the oil pump is as follows:

c. *Disassembly procedure (figs. 64 and 65).* —

$\frac{7}{16}$-inch open-end wrench	$\frac{3}{8}$-inch open-end wrench
Soft-jawed vise	Soft drift

(1) Using a $\frac{7}{16}$-inch open-end wrench, remove the six elastic stop nuts and washers which hold the oil filter in the pump, and lift out the oil filter.

(2) Using a $\frac{3}{8}$-inch open-end wrench, remove the three nuts and washers which hold the tachometer CAP or housing (GU-13-Y-134) to the oil pump assembly or housing, and lift out the tachometer GEAR (GU-13-Y-139).

(3) Remove the four bolts, with washers at each end, which extend through the oil pump, and the elastic stop nuts, using a $\frac{7}{16}$-inch open-end wrench for nuts and bolts.

(4) Remove the end PLATE (GU-13-Y-135) exposing the sump scavenger GEARS (GU-13-Y-136A and GU-13-Y-137E).

(5) Lift the oil pump gears and plates or bodies from the oil pump assembly.

(6) The gears on the shaft which drives the tachometer gear are all keyed to the shaft. To disassemble the gears, lift out the sump

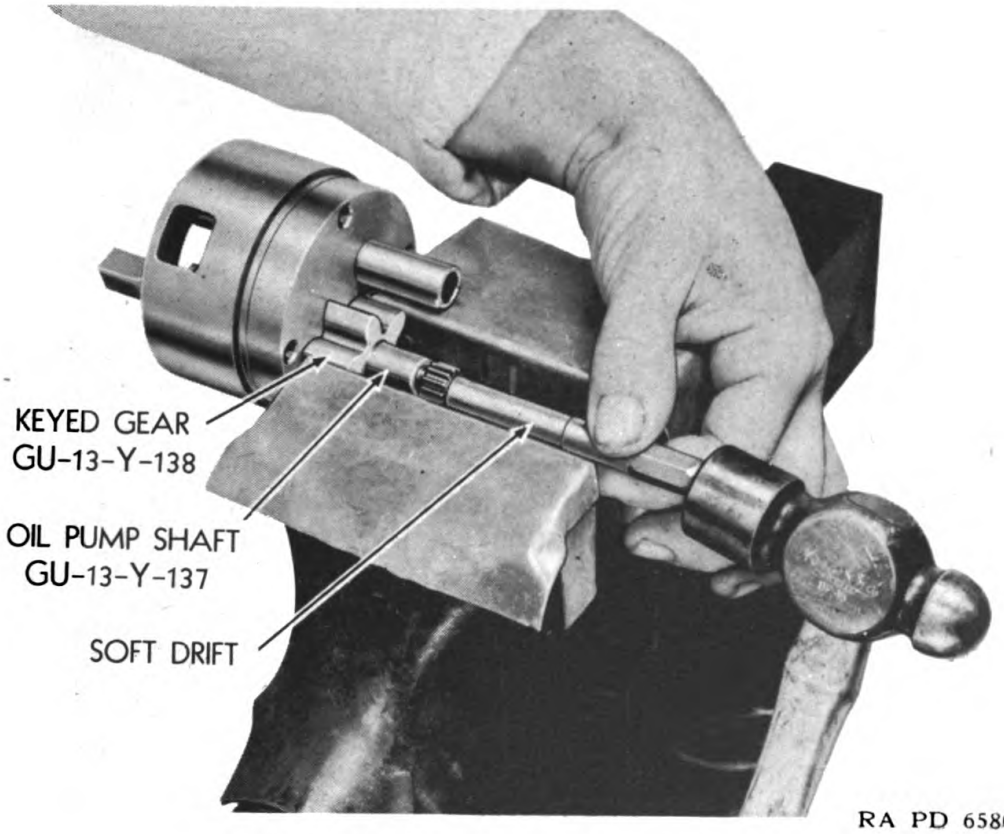


FIGURE 65—Disassembling the oil pump.

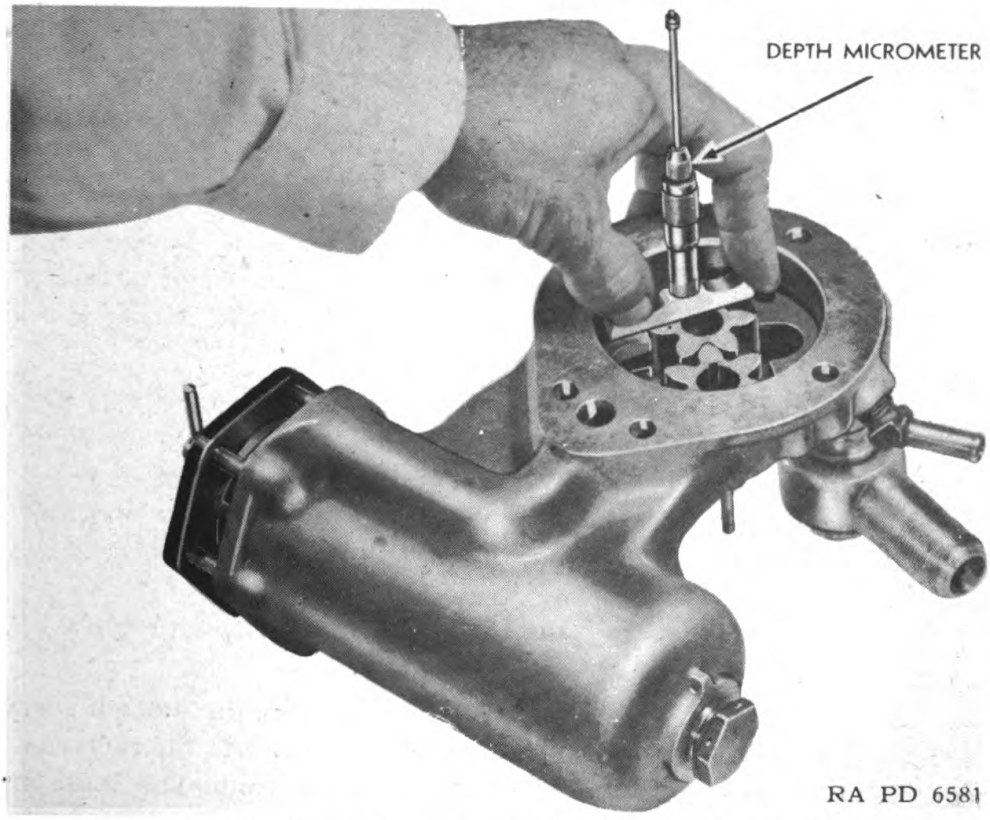


FIGURE 66—Checking oil pump gear side play with depth micrometer.

scavenger gear and oil pressure idler gear. Clamp the oil pressure drive GEAR (GU-13-Y-138) in a soft-jawed vise as shown in figure 65. Drive on the shaft with a soft drift, being sure that the gear plates move back with the shaft. When the shaft has been driven out of the pressure gear, the KEY (GU 13-Y-137A) is removed and the body lifted off. The rocker box scavenger GEAR (GU-13-Y-137F) and KEY (GU-13-Y-137B) can then be removed to complete the disassembly.

d. Inspection procedure (figs. 66 and 67). —

Feeler gage Depth micrometer

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

(2) Place the gears in their respective bodies. Lay a depth micrometer over the rim of the body and measure the clearance between the gears and the rim, as shown in figure 66. This clearance should be .001-inch — .004-inch.

(3) 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, as shown in figure 67. This clearance should be .0035-inch — .0065-inch.

(4) The oil filter is made up of a deep layer of metal disks. It is cleaned by turning the handle at the top. As the handle is turned the disks revolve against the stationary cleaner blades which project into each slot and remove any 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 (figs. 64 and 68). —

$\frac{3}{8}$-inch open-end wrench $1\frac{7}{16}$-inch open-end wrench

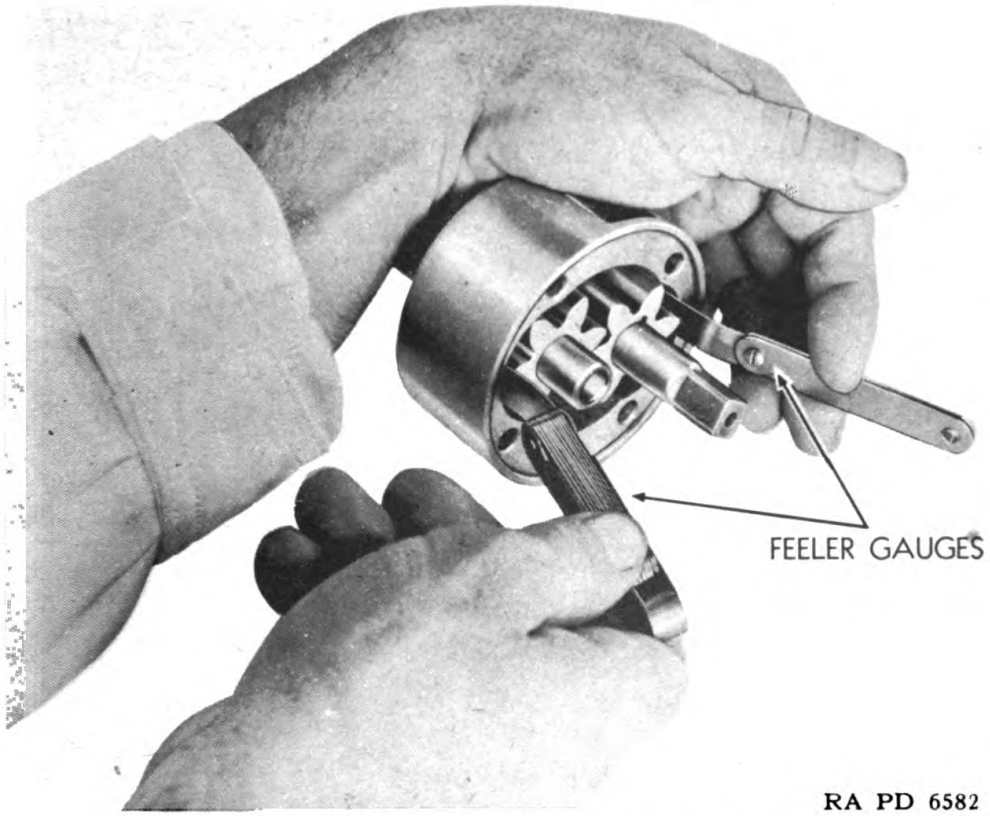
(1) Hold the sump scavenger pump housing (the large housing) with the port down, and insert the shaft which drives the tachometer, from the inside of the housing through the hole at the left. Insert the idler shaft through the other hole.

(2) 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 shaft that drives the tachometer gear, and with the key in place.

(3) Slide the rocker box scavenger pump body on the shafts *with the port at the opposite side from the port in the larger body,* as shown in figure 68.

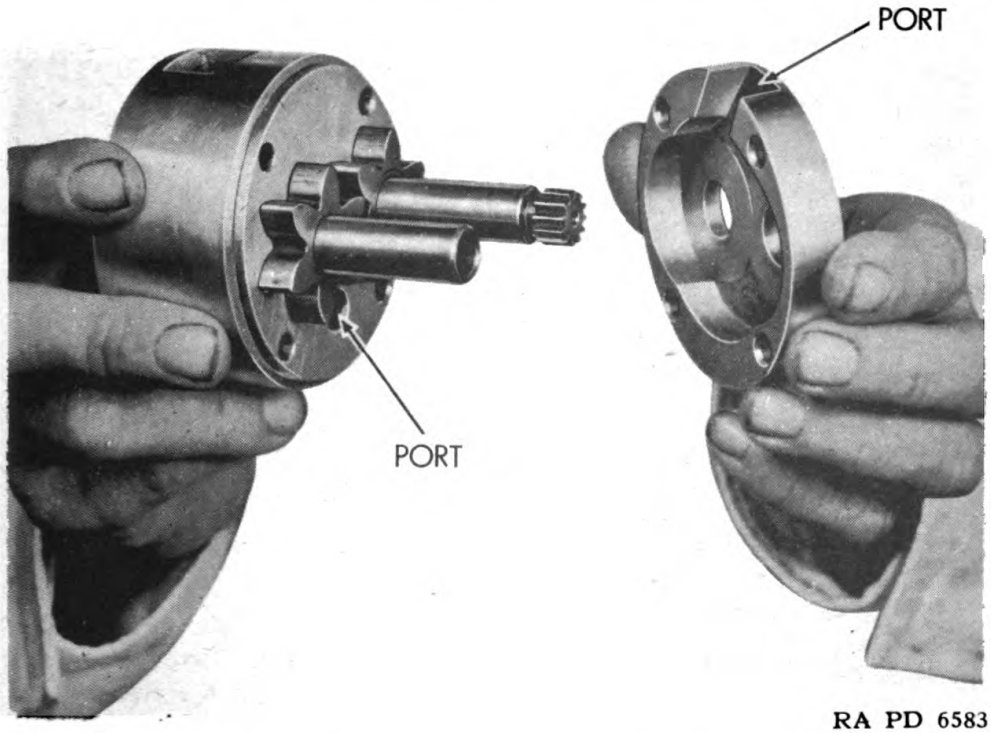
(4) Install the pressure pump gears on the shaft, with the key in the drive shaft.

(5) Install the end plate over the other end of the assembly with the high shoulder of the plate over the shaft that drives the tachometer gear. Insert the gear assembly in the oil pump housing. The shaft that drives the tachometer gear goes through the opening nearest the oil filter.



RA PD 6582

FIGURE 67—Checking clearance between gear teeth and housing.



RA PD 6583

FIGURE 68—Assembling the oil pump gears.

(6) Install the housing bolts, with a washer at both the bolt head and nut, and screw on the elastic nuts, using a $\frac{7}{16}$-inch open-end wrench.

(7) Install a new tachometer gasket, and the gear and housing. Place washers on the studs and install the elastic stop nuts, using a $\frac{3}{8}$-inch open-end or box wrench.

(8) Install the washers, connections and nut in the order shown in figure 64.

(9) Place a new oil filter gasket on the studs of the oil filter.

(10) Install the oil filter, with its washers and nuts, using a $\frac{7}{16}$-inch open-end wrench.

88. **Inspect link rods** *(figs. 69 and 70).* — *a. Equipment.* —

Knuckle pin aliner GU-GST-1335
Snap gage
Micrometer

b. Procedure. —

(1) **Check alinement.** Knuckle pin aliner GU-GST-1335

Place the link rod over the knuckle pin aliner (GU-GST-1335). 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 on the fixtures, cover them with light oil, and slip the rod down on the tool with the bushings over the fixtures. The rod bushings should slide over the upright prongs or fixtures by hand pressure. If it does not fit over the fixtures, 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.

(3) **Bushings.** Snap gage
Micrometer

Using a snap gage, measure the bushings at both sides of the bushings, and in line with the rod and across the rod. Use a micrometer on the snap gage to get the measurements. Mark these down for use in assembling the master rod.

89. **Inspect the master rod.** — *a. Equipment.* —

Snap gages
Micrometer

b. Procedure. — The master rod is inspected in the same way as the other rods as covered in paragraph 88. In addition, inspect the pin at the top which holds the piston pin bushing, to make sure it is tight.

90. **Inspect the knuckle pins.** — *a. Equipment.* —

Micrometer

b. Procedure. —

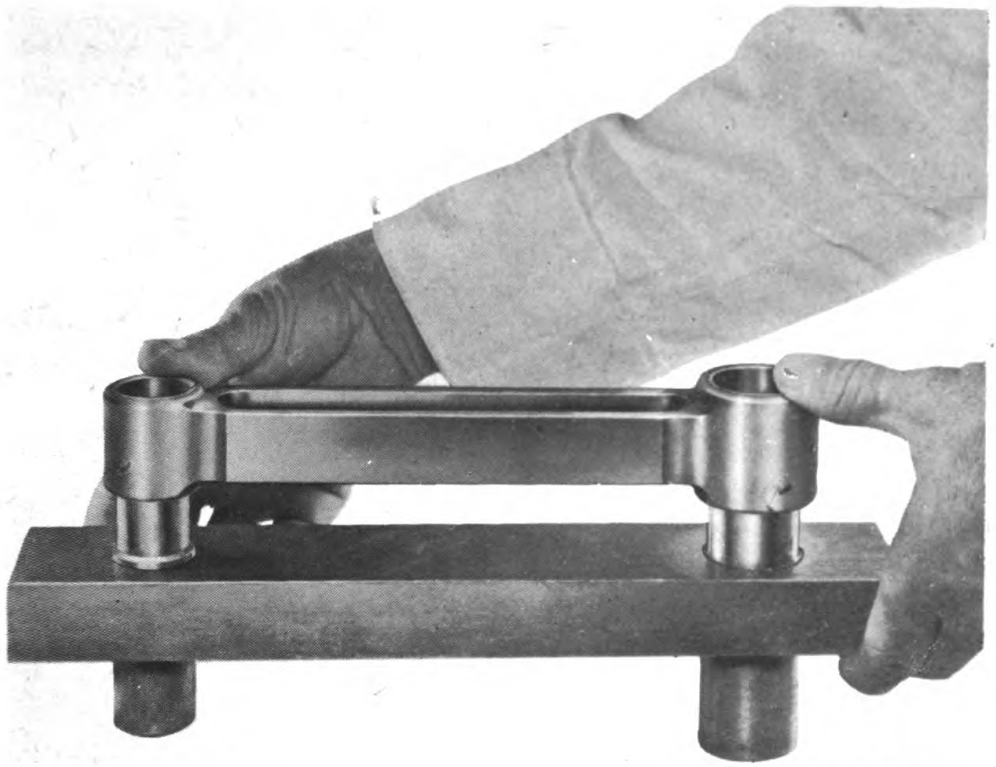


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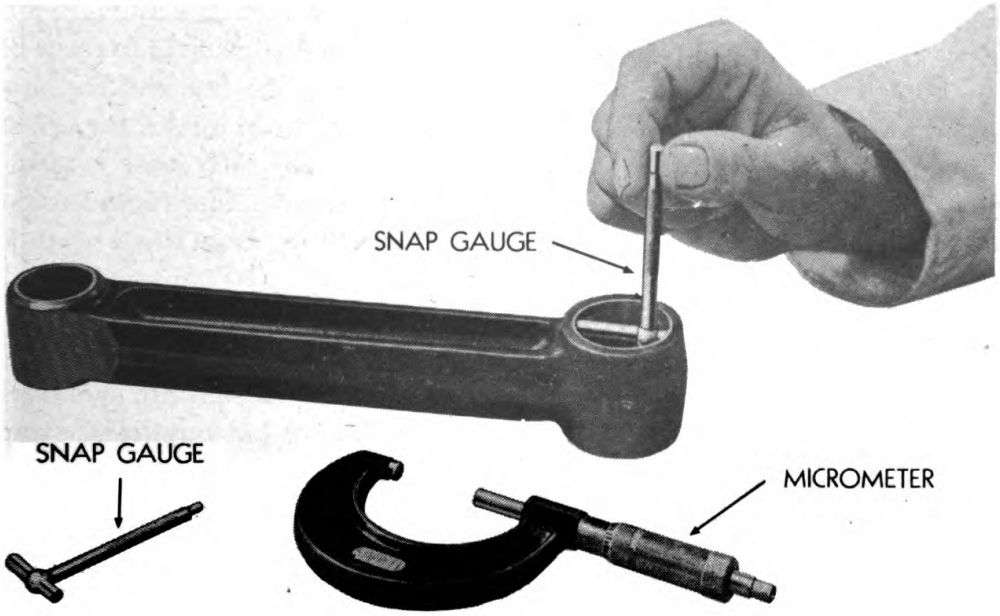
FIGURE 69—Checking link rod alinement.



RA PD 6585

FIGURE 70—Checking link rod bushing with snap gage.

(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.

(2) Miking. Micrometer

Since the pin is clamped at each end in the master rod, there can be no wear there and 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. These measurements should be marked down for use in assembling the master connecting rod.

91. Assemble master rod assembly *(figs. 71 and 72). — a. Equipment. —*

Feeler gage
Press
Knuckle pin inserter drift No. GU-GST-1333
Soft hammer
Knuckle pin and master rod receiver No. GU-GST-1332
Ring splitter

b. Inspection procedure. —

Feeler gage

(1) Lay the master rod on a bench with the wide 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.

(2) 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 .007-inch loose to .016-inch loose when new, and has limit of .030-inch loose before replacement is necessary. Use a feeler gage all around the bushing, since there may be some variation.

(3) If the clearance exceeds the limits, the bushing should be replaced, as described in Section VIII of this manual.

(4) 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*.

(5) The link rod bushings and knuckle pins were gaged in paragraphs 89 and 90. The knuckle pins must fit in the bushings with proper clearance. This clearance is set at .0015-inch loose to .003-inch loose when new, and has a limit of .005-inch loose.

(6) 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).

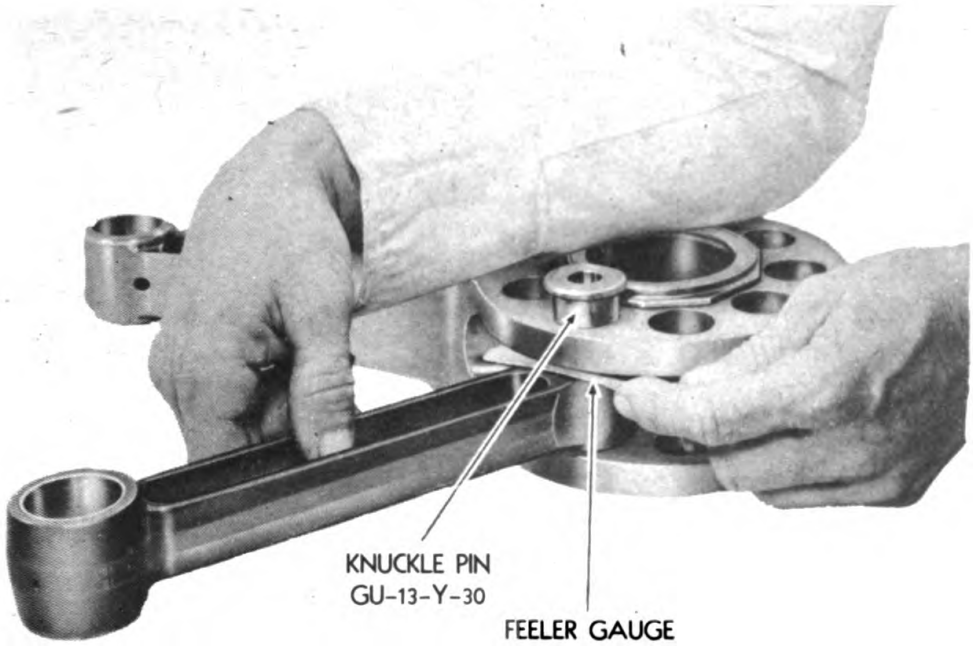


FIGURE 71—Checking link rod side clearance.

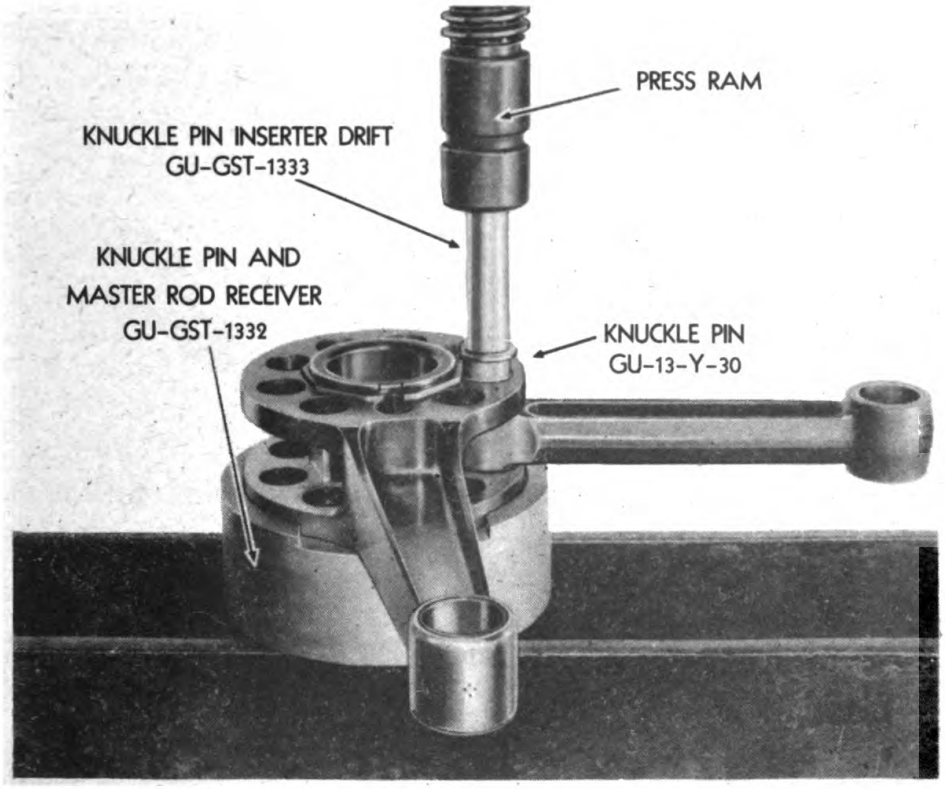


FIGURE 72—Pressing knuckle pins into the master rod.

(7) If the clearance is within the limit, the pin is ready to be inserted.

(8) If the clearance exceeds the limit, the bushing should be replaced, as described in Section VIII of this manual.

c. Assembly procedure. —

Press	Lubricant
Knuckle pin and master rod receiver No. GU-GST-1332	Ring splitter
Soft hammer	Knuckle pin inserter drift No. GU-GST-1333

(1) Coat the pin and bushing surfaces with Lubriplate, or a similar lubricant, and insert the link rod at the proper master rod opening, as indicated by the cylinder number.

(2) Line the pin up carefully, with the flat side of the pin flange parallel with a side of the hex on the master rod. Tap the pin lightly with a soft hammer to hold it in position.

(3) Place the master rod on a press, using a master rod receiver (GU-GST-1332) to support it, as shown in figure 72.

(4) Place the inserter drift (GU-GST-1333) on the pin, and press the pin into position, watching it carefully to make sure the flange of the pin is not pressed against the hex on the master rod.

(5) When all pins have been inserted in this manner, remove the master rod assembly from the press and turn it over.

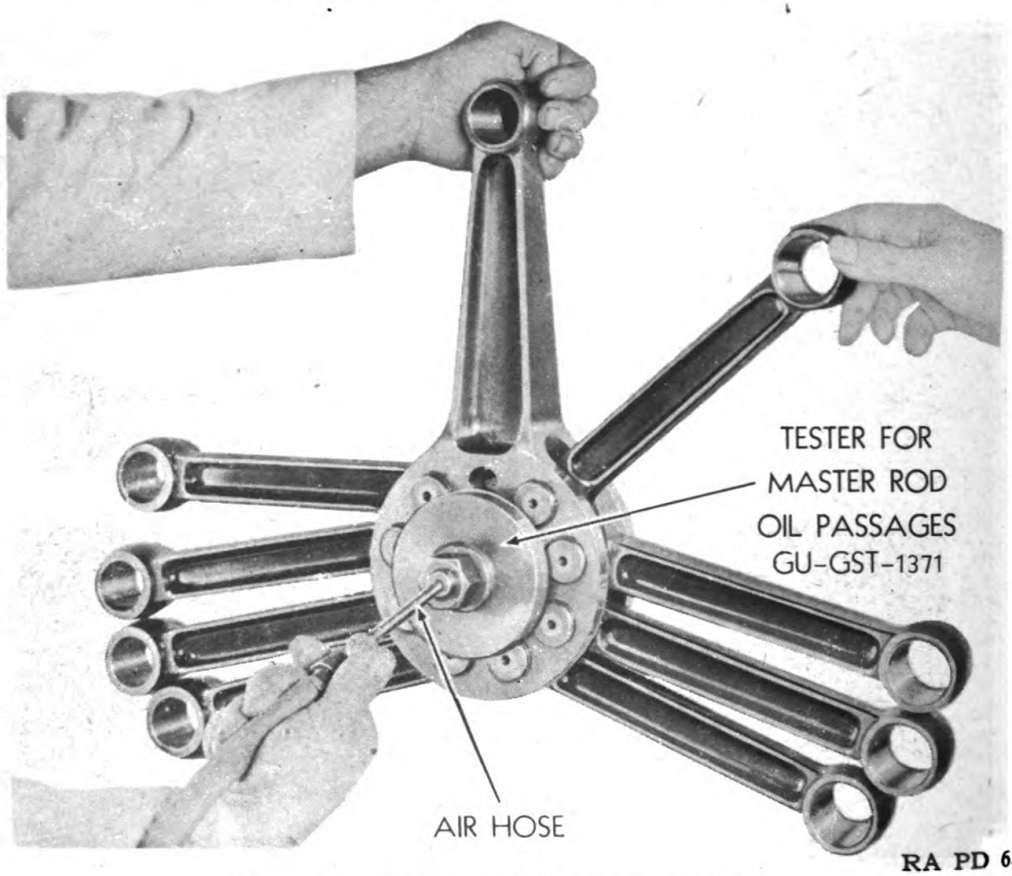


FIGURE 73—Testing master rod oil passages.

(6) Install the lock rings in the grooves in the pins, using a lock ring splitter to spread the rings, and with the opening in the ring toward the master rod bushings.

(7) When the ring is in position in the pin groove, turn the opening to the side away from the master rod bushing.

(8) Repeat this procedure to assemble the other link rods in the master rod.

92. Test the oil passages in the master rod assembly *(fig. 73).* —

a. Equipment. —

Compressed air and air hose

Tester for master rod assembly oil passages No. GU-GST-1371

b. Procedure. — (1) 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 for master rod assembly oil passages (GU-GST-1371), as shown in figure 73.

(2) A washer and plate of the tester are placed underneath one side of the master connecting rod bushing and the bushing filled with SAE No. 30 oil. The top plate is then put on and bolted down.

(3) 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.

93. Check the crankshaft. — *a. Equipment.* —

Soft hammer

Micrometer

b. Procedure. — (1) Make a visual inspection of the crankshaft for scoring or defects.

(2) Check the oil passages to make sure that they are clear, and examine the shaft for burs.

(3) The crankshaft counterweights are riveted together, six rivets being used in each counterweight. 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 the rivets are loose they will be satisfactory.

(4) Use a micrometer to measure the front and rear crankshaft journals. Measure at each end of the journals and two ways across the shaft. Mark these measurements down for use when the crankshaft is installed.

94. Inspect the pistons *(figs. 74 and 75).* — *a. Equipment.* —

Feeler gage

Micrometer

Ring splitter

b. Procedure. —

(1) Inspect piston pins.

Micrometer

(a) Inspect the piston pin caps for surface nicks or damages.

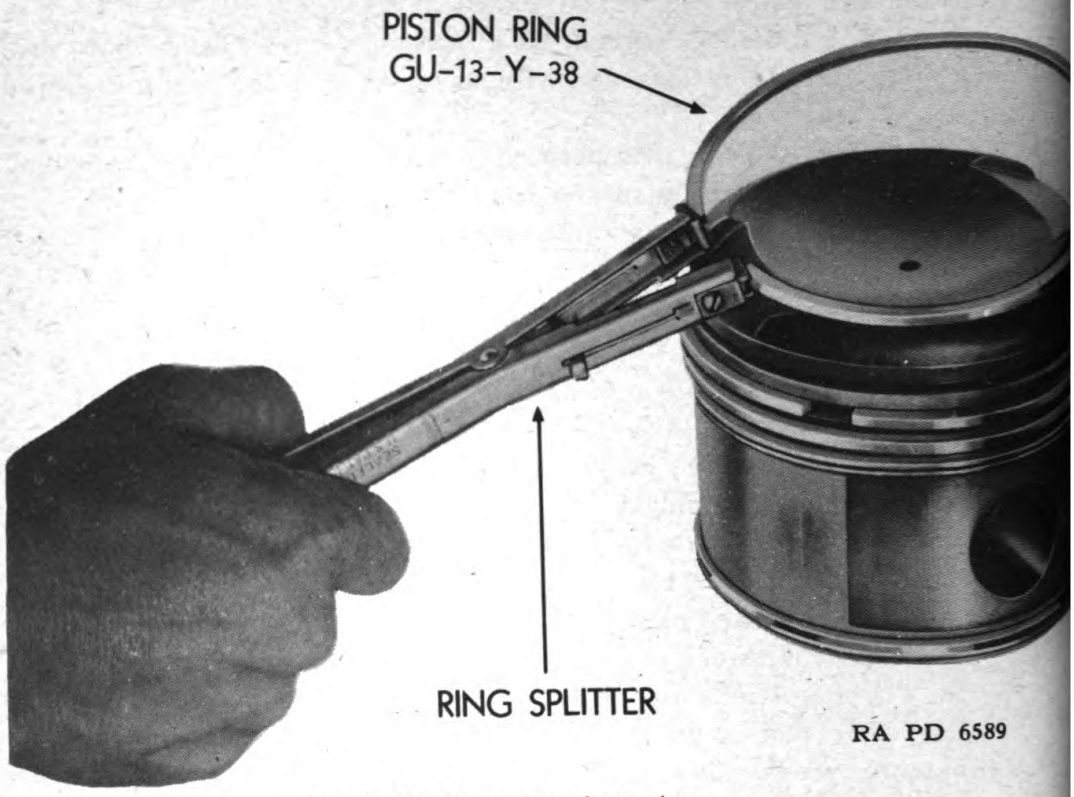


FIGURE 74—Removing piston rings.

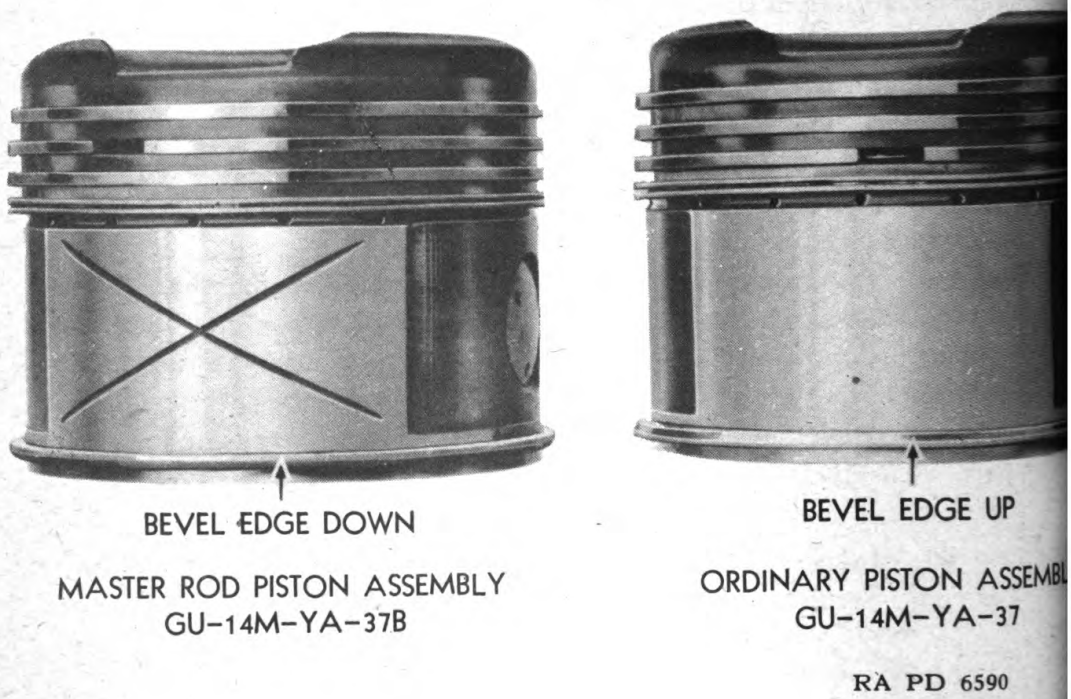


FIGURE 75—Two types of pistons used.

(b) Inspect the piston pins for scoring or scratches.

(c) Roll the piston pins on a flat surface, such as a metal sheet, and inspect for straightness.

(d) 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.

(e) Use a micrometer to measure the piston pins. Measure at each end and at the center and at two diameters of the pin at each point.

(2) Inspect pistons. Ring splitter

(a) Carefully remove carbon from the pistons.

(b) Inspect the pistons for scoring and defects, paying particular attention to the ring grooves for burned sections.

(c) To remove the rings, 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, as shown in figure 74.

(3) Install piston rings. Feeler gage

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

(b) Install new rings and use a feeler gage to measure the clearance above them in the ring grooves. Clearances are shown in the chart in Section X.

(c) Piston ring end clearance must be measured also to make sure that they will have the right amount of tension in the cylinder barrel. To measure this clearance, insert the piston ring in the cylinder barrel, and place at the cylinder mounting flange. Use a feeler gage to measure the distance between the ends of the rings. These clearances are also shown in the clearance chart. If the clearance is too small, the ring can be clamped in a vise and the ends of the ring lightly filed. If the clearance is too great, oversize rings should be used.

(d) On No. 7 piston (the piston on the master 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, as shown in figure 75. This piston takes the thrust, and a cushion of oil is necessary to prevent scoring. On all other pistons this ring is placed with the bevel side up, and acts as an oil scraper ring.

95. Inspect the cylinders *(fig. 76).* — *a. Equipment.* —
Snap gage Micrometer

b. Procedure. —

(1) Cylinder barrels.

(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.

(b) Use an inside micrometer to check the cylinder barrel for taper and for out of round, as shown in figure 76. Cylinder barrels have a converging taper in the cylinder head of minus .007-inch to .012-inch. Taper starts at the second fin from the cylinder head. The maximum worn diameter of the cylinder is 5.137-inches at ¾-inch from the top of the barrel. Cylinder barrels that are tapered or out of round more than .012-inch or that exceed the diameter of 5.137-inches, should be discarded.

(2) Valve guides and seats.

Micrometer
Snap gage

(a) Examine the valve seats for pitting. If necessary, they should be ground smooth.

(b) Examine the valve guides for galling. If galled, replace.

(c) Use a snap gage to measure the inside diameter of the valve guides, and use a micrometer to get a reading from the snap gage. Mark down the reading for reference in assembling the engine.

96. Inspect the valve cam and fuel cam ring, and the fuel control and decompression plate assemblies. — *a. Equipment.* —

½-inch socket wrench
Micrometer
$\frac{7}{16}$-inch open-end wrench
Feeler gage

b. Procedure. — NOTE: The valve cam and fuel cam ring set inside of the fuel control and decompression plate assembly, and can be lifted

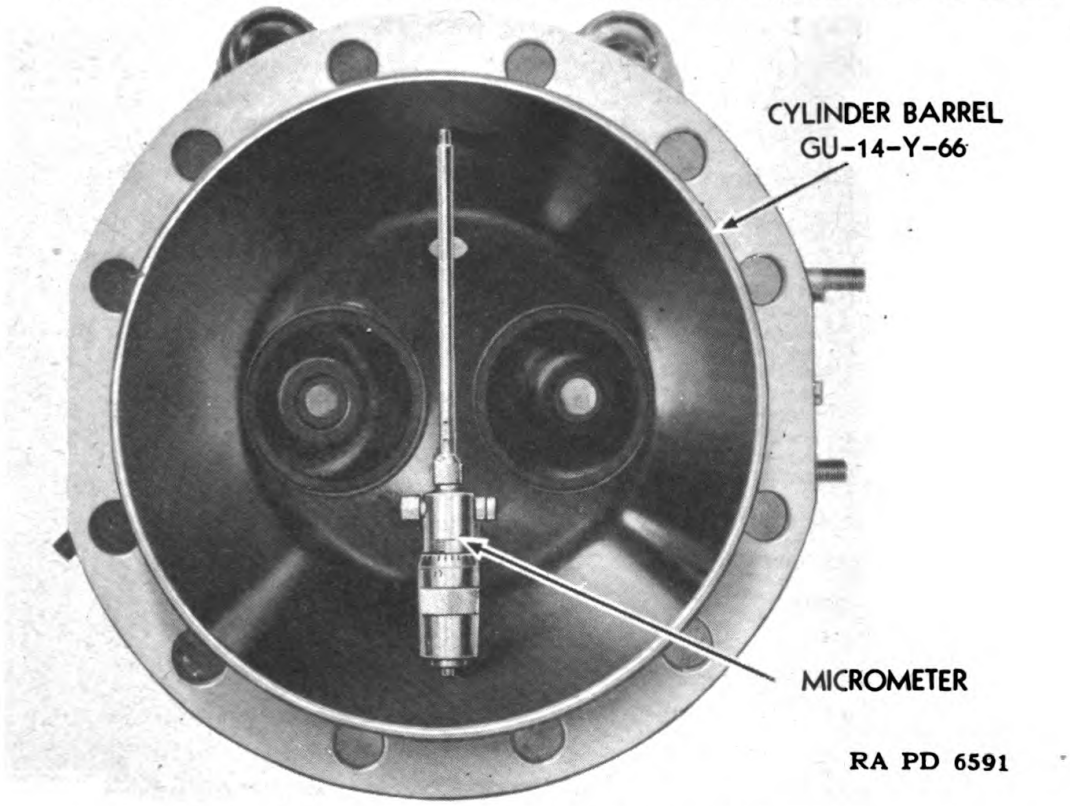


FIGURE 76—Measuring the cylinder barrel with a micrometer.

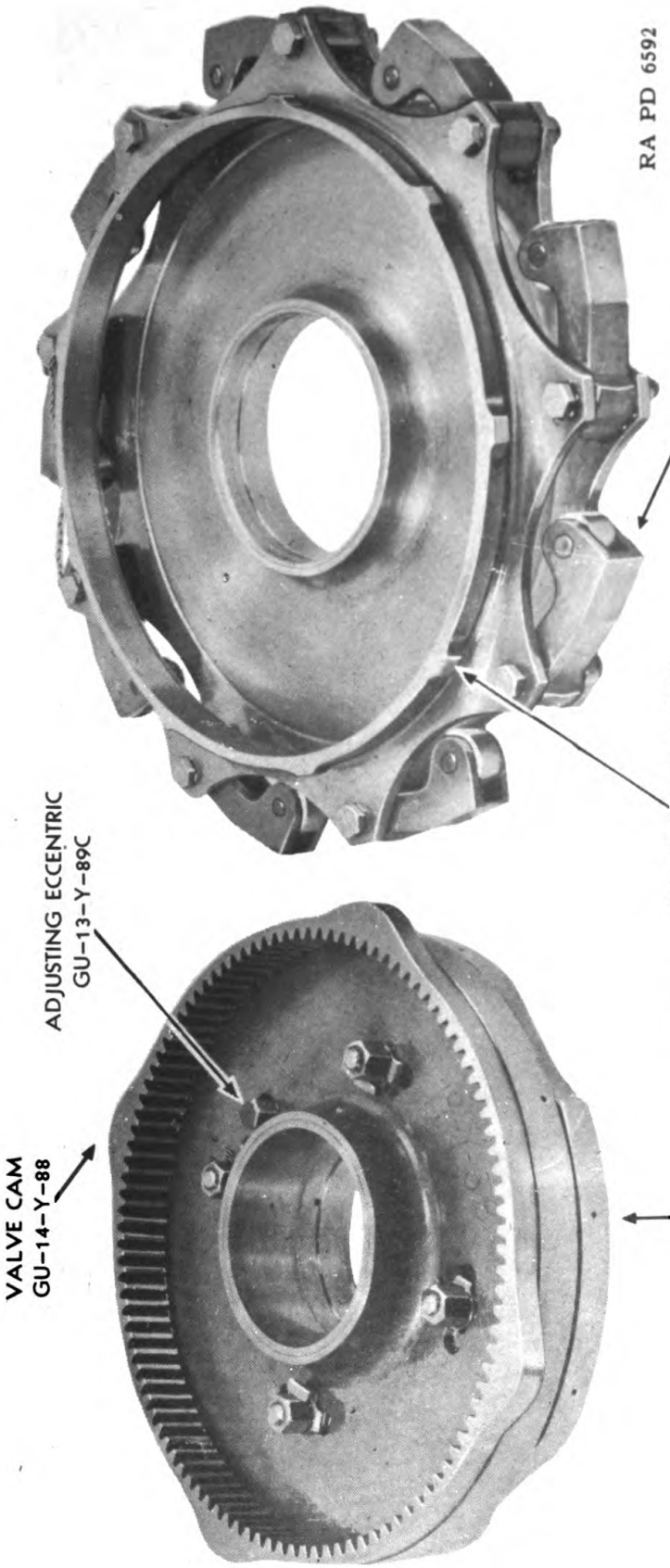


FIGURE 77—The valve cam, decompression and fuel control assemblies.

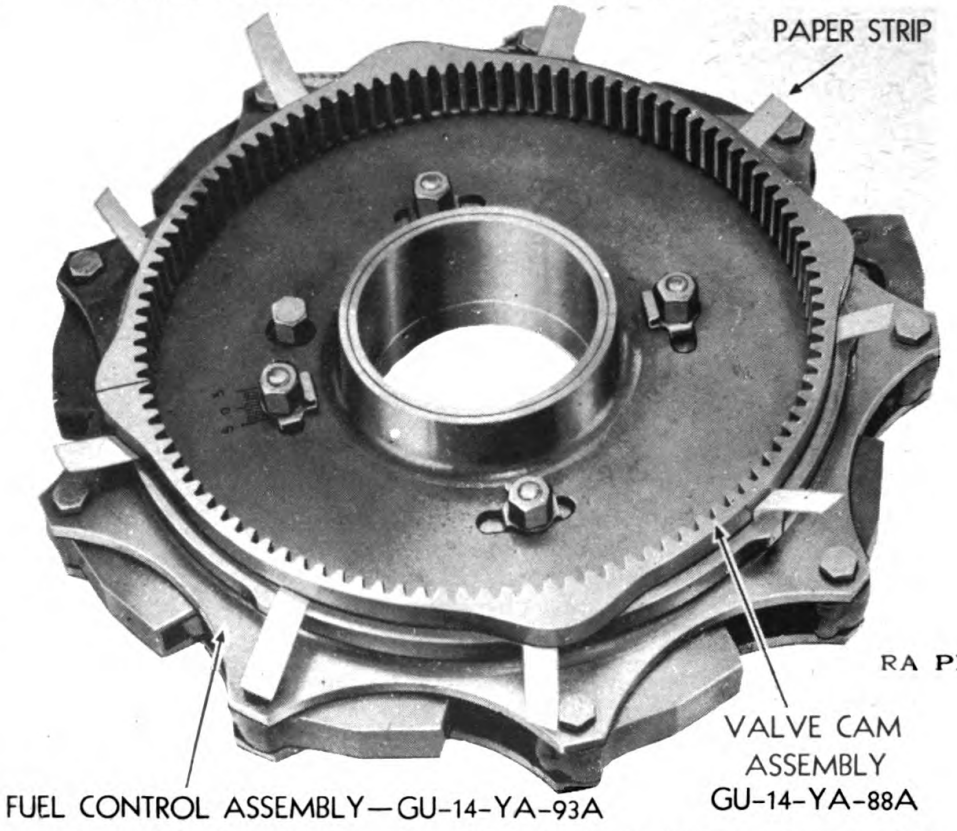


FIGURE 78—Centering the valve and fuel cams in the decompression plate and fuel control assembly.

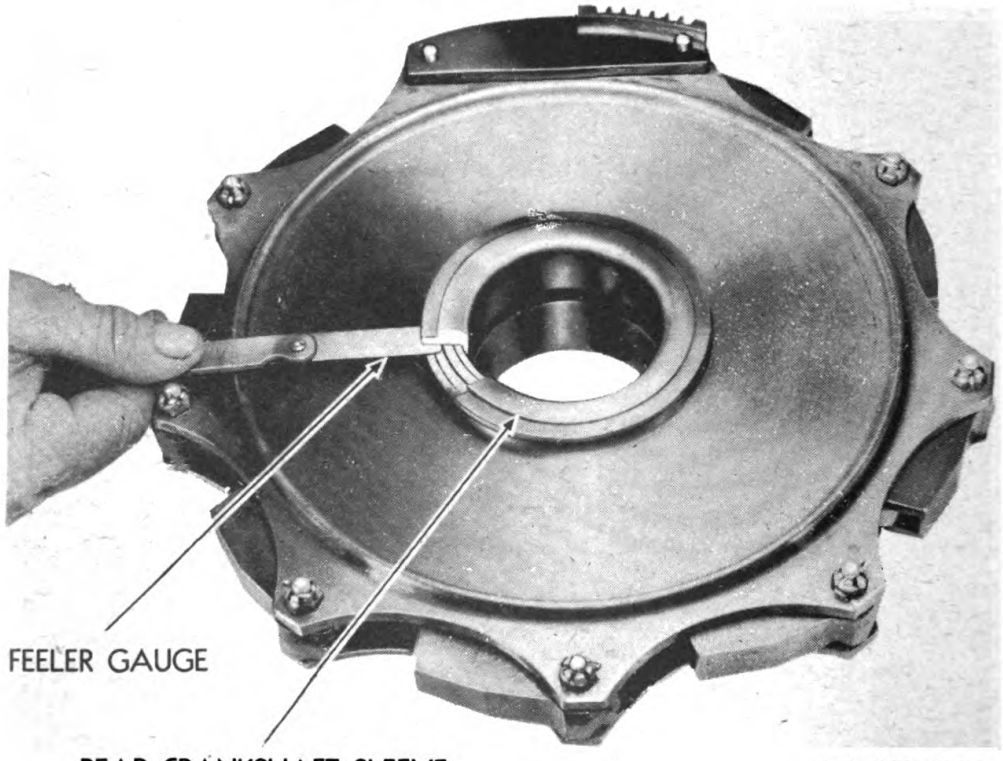


FIGURE 79—Checking clearance between fuel control ring and spacer.

out *(fig. 77)*. The valve cam and fuel cam ring are held together by four mounting bolts. Slots in the valve cam where these bolts enter permit the fuel cam ring to be turned by means of an adjusting eccentric. This setting should not be disturbed unless it is necessary to replace one of the parts, or the injection timing will have to be reset.

(1) Disassembling the valve cam. ½-inch socket wrench

Should it be necessary, the four nuts can be removed (½-inch socket wrench) and the fuel cam ring and valve cam dismantled. In assembling, the metal flange of the washers should be on the inside, toward the hub, or the gears will shear them.

(2) Disassembling the fuel control and decompression plate assembly. $\frac{7}{16}$-inch open-end wrench

The fuel control and decompression plate assembly should also be kept intact unless it is necessary to dismantle it to replace any parts. If necessary, the fuel control lever nuts may be removed ($\frac{7}{16}$-inch open-end wrench) and the levers replaced or the assembly dismantled.

(3) Inspection. Inside micrometer
Feeler gage

(a) Examine the teeth on the valve cam for chipping or excessive wear. Inspect the surfaces of the valve cam and fuel cam ring for defects. Inspect the valve cam bushing for roughness.

(b) Check the valve cam external hub, which carries the fuel control plate assembly bushing, for roughness. Carefully stone out marks. Blow out oil holes.

(c) Check the surfaces of the fuel control levers for defects, and examine to make sure they operate freely. Inspect the rollers for flat surfaces. Check the fuel control plate assembly bushing for roughness.

(d) With an inside micrometer, measure the diameter of the bushings in the valve cam hub and in the decompression plate and fuel control assembly. Make a notation of them for reference in assembling.

(e) *(fig. 78)* If the decompression plate and fuel control assembly has been dismantled, it will have to be assembled so that there is an equal clearance all around the valve cam assembly. To do this, place the fuel control levers in position and bolt the decompression plate and fuel control assembly loosely together. Place strips of paper .003-inch thickness (light wrapping paper) at each fuel control lever bolt. Place the valve cam assembly in position inside the decompression plate, as shown

in figure 78, then tighten the fuel control lever bolts. Remove the paper strips.

(f) The valve cam hub revolves, while the fuel control and decompression plate assembly, which is mounted on the valve cam hub, remains stationary. There must be clearance between the two. This is checked by means of a feeler gage. Place the valve cam assembly in the fuel control and decompression plate assembly, and turn so that the decompression plate is up. Place the rear crankshaft spacer over the decompression plate bushing and insert the rear crankshaft sleeve. Use a feeler gage to measure the clearance between the fuel control and decompression plate bushing and the rear crankshaft spacer, making sure that the feeler gage is inserted only over the bushing, as shown in figure 79, and not over the valve cam hub. This will give the clearance between the decompression plate bushing and the valve cam when they are mounted in place on the crankshaft. The clearance limit is .008 inch loose minimum make-up side clearance.

(g) Side clearance must also be provided between the decompression ring and the valve cam. This is measured with a feeler gage, as shown in figure 80, with the decompression plate face up and the feeler gage inserted between the decompression ring and the valve cam. Clearance should be .005-inch minimum.

97. Inspect the push rods. — Make a visual inspection of each push rod for defects. Roll the push rod on a flat surface, such as a smooth sheet of metal, to make sure that the rods are not bent. Make an inspection of each push rod housing for defects and to make sure that the housing is not sprung out of shape.

98. Inspect the valve tappets and guides. — Make a visual inspection of each valve tappet and guide, watching for damaged threads, and defects in the surfaces of the tappets or guides. See that the tappet rollers operate freely, and that there are no flat surfaces on the rollers.

99. Inspect the valve springs. — Line the valve springs up and examine to make sure that all of them are approximately the same height.

100. Inspect the rocker arms. — 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.

101. Valve inspection. — Make a visual inspection of the valves for pitting and scoring.

102. Inspect crankshaft main and front bearings. — Make a visual inspection of the crankshaft bearings, checking to make sure that the bearings roll freely and that there are no flat surfaces.

103. The fuel injection lines. — Examine the fuel injection lines for cracks or defects. Blow through them to make sure they are clear.

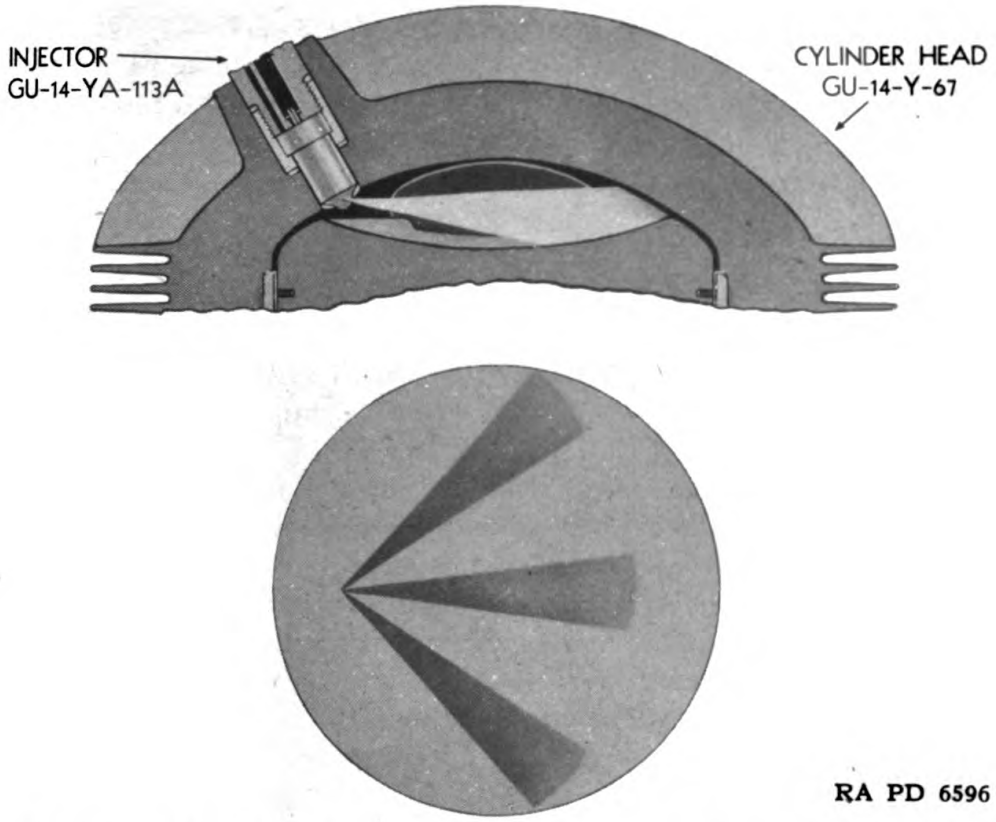


FIGURE 80—Measuring side clearance between decompression ring and valve cam.

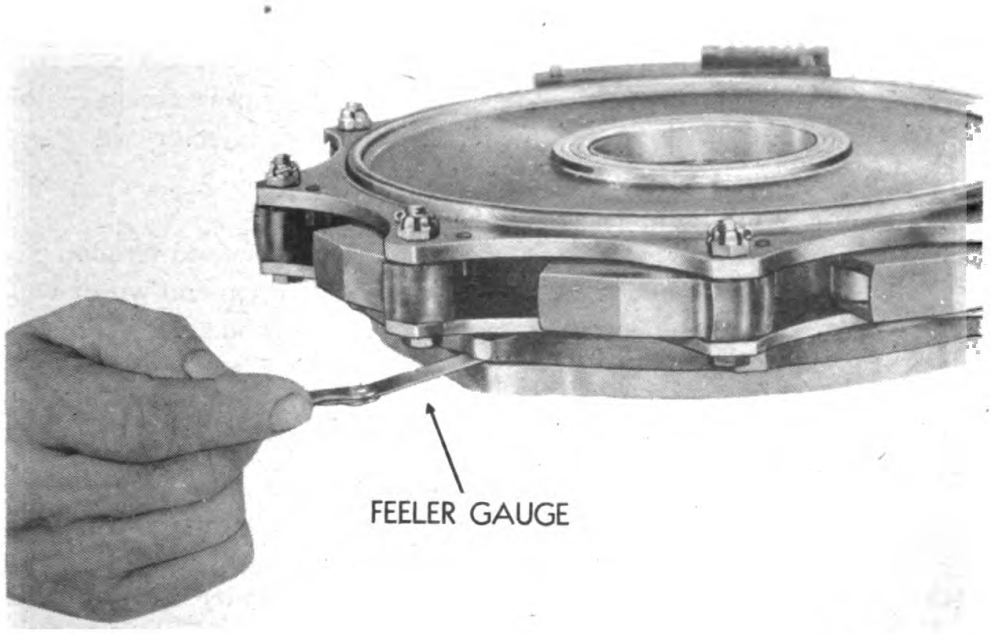


FIGURE 81—The injector spray pattern.

104. Inspect the fuel injectors. — *a. Equipment.* —

Fuel injector test unit No. GU-GST-1351	Injector holding bar No. GU-GST-1303
$\frac{5}{8}$-inch open-end wrench	Vise
$\frac{13}{16}$-inch open-end wrench	1-inch open-end wrench
Soft wire brush	$\frac{7}{16}$-inch open-end wrench
	Orangewood stick

b. Cleaning procedure. — Soft wire brush

Clean the carbon from the external parts of the injector. Use a soft wire brush which will not injure the three small holes in the valve body.

c. Testing procedure. — Fuel injector test unit No. GU-GST-1351

(1) Attach the assembly to the fuel injector test unit and test the injection pressure and atomization. The desired pressure required to break or open the nozzle spray valve is 2500 pounds.

(2) *(fig. 81)* The nozzle has three spray holes, which should release an evenly distributed fan-shaped spray pattern, as shown in figure 81.

(3) The valve should break sharp and clean, without leaking or dripping either before or after the injection occurs.

d. Adjustment procedure. — Injector holding bar No. GU-GST-1303
1-inch open-end wrench
Vise

(1) To adjust the injection pressure to 2500 pounds minimum and 2550 pounds maximum, place the injector in the holding bar (GU-GST-1303) with the flange mounting holes over the prongs of the holding bar.

(2) Clamp the holding bar in a vise and remove the fuel injector cap (1-inch open-end wrench).

(3) Adjust the shims by adding shims to increase pressure and taking out shims to decrease pressure. Then replace the fuel injector cap.

e. Disassembly procedure (fig. 82). —

Injector holding bar No. GU-GST-1303	Vise
$\frac{5}{8}$-inch open-end wrench	1-inch open-end wrench
$\frac{13}{16}$-inch open-end wrench	$\frac{7}{16}$-inch open-end wrench
	Orangewood stick

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.

(1) The injector is placed in an injector holding bar in disassembling it. This holding bar is also used in disassembling the inspection 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.

(2) Remove the fuel injector cap with a 1-inch open-end wrench. Remove the injector nipple with a $\frac{5}{8}$-inch open-end wrench, and the by-

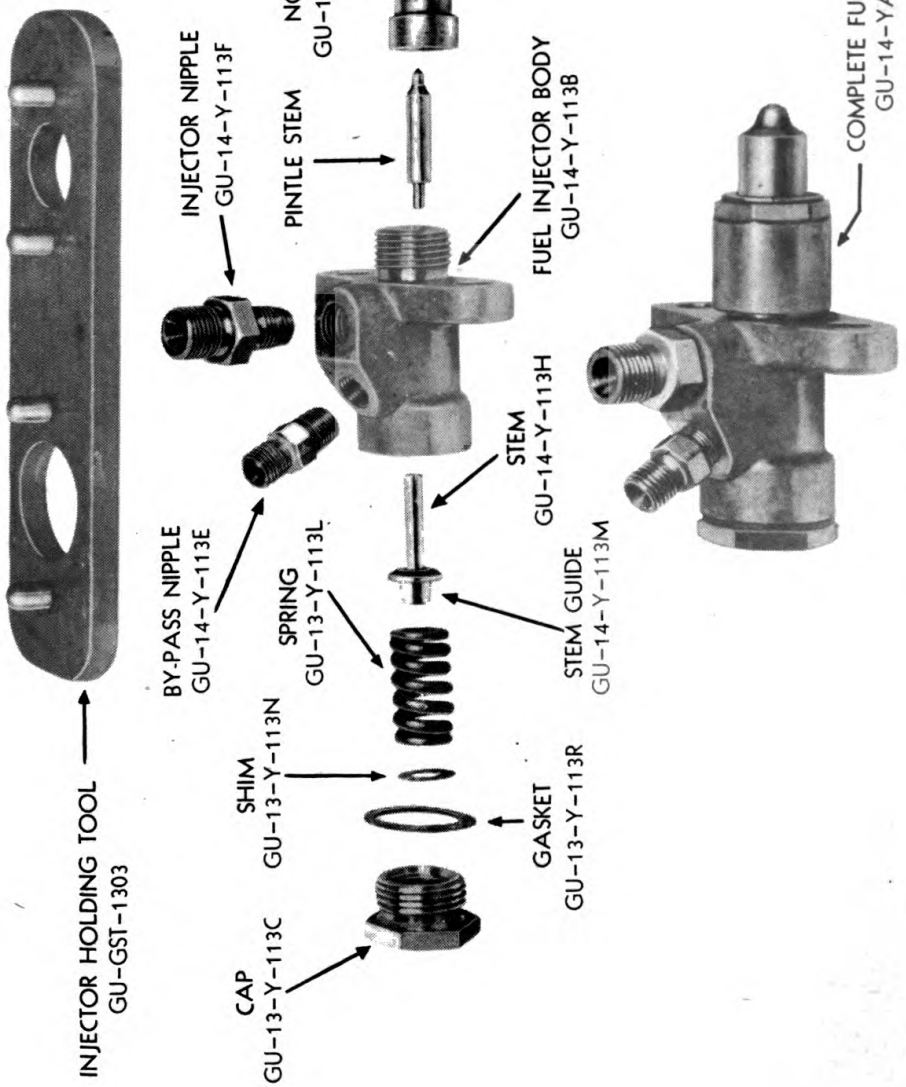


FIGURE 82—The fuel injector assembly.

pass nipple with a $\frac{7}{16}$-inch open-end wrench from the injector body. Remove the gasket and lift out the shims, spring, and stem guide. Remove the injector from the holding bar. Turn the hex on the nozzle holder using a $\frac{3}{4}$-inch open-end wrench and remove the nozzle holder. Lift out the nozzle and pintle stem. **NOTE:** ***Do not touch the large diameter of the nozzle pintle with the hand.*** Hold the pintle by the small diameter on the end next to the body. The pintle is made of special alloy. Perspiration from the fingers might start corrosion.

(3) Wash the pintle valve and nozzle in clean fuel oil by swashing and brushing with a soft orangewood stick or any soft piece of wood. Cloth or paper might leave lint on the pintle.

(4) Lap the pintle in the nozzle and on the seat, using fuel oil for lubricant. Time and patience are often required in removing particles of dirt. No abrasive should be used in lapping the pintle in the nozzle as the clearance is approximately .00015-inch. This is much less than the diameter of particles of any commercial compound.

(5) To assemble the injector, place the pintle in the nozzle, and insert the nozzle into the nozzle holder, then screw the holder onto the body, but do not tighten. Drop the stem guide into the other side of the body, over the end of the pintle. Insert the spring, and place the shims on top of the spring. Replace the gasket and screw on the cap. Replace the injector nipple and the by-pass nipple.

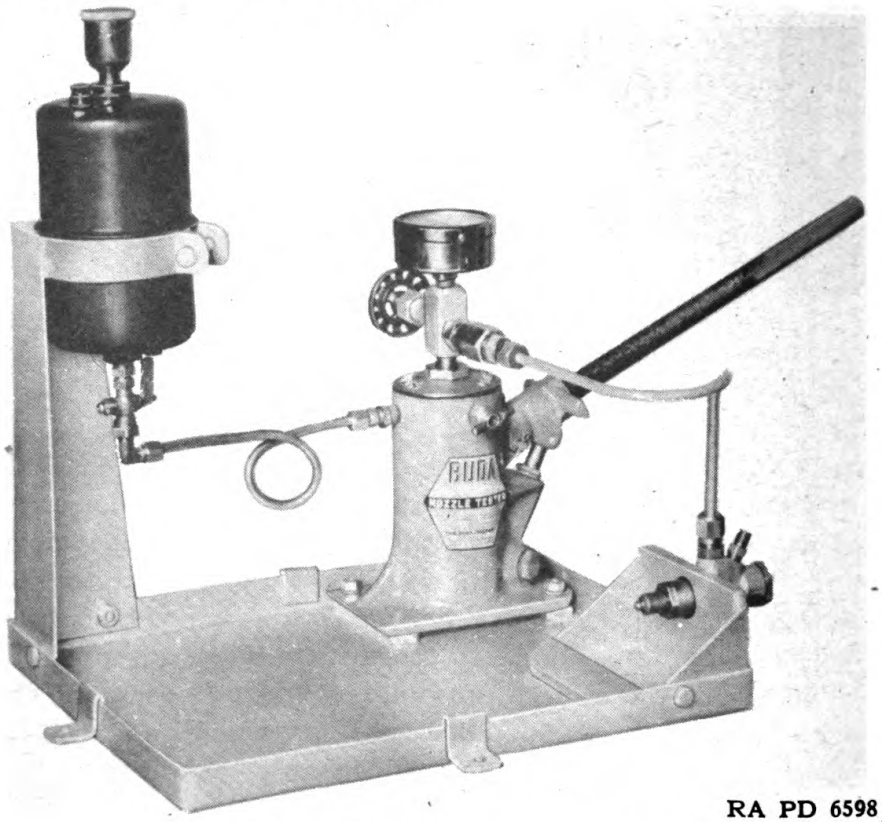


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FIGURE 83—Injector testing equipment.

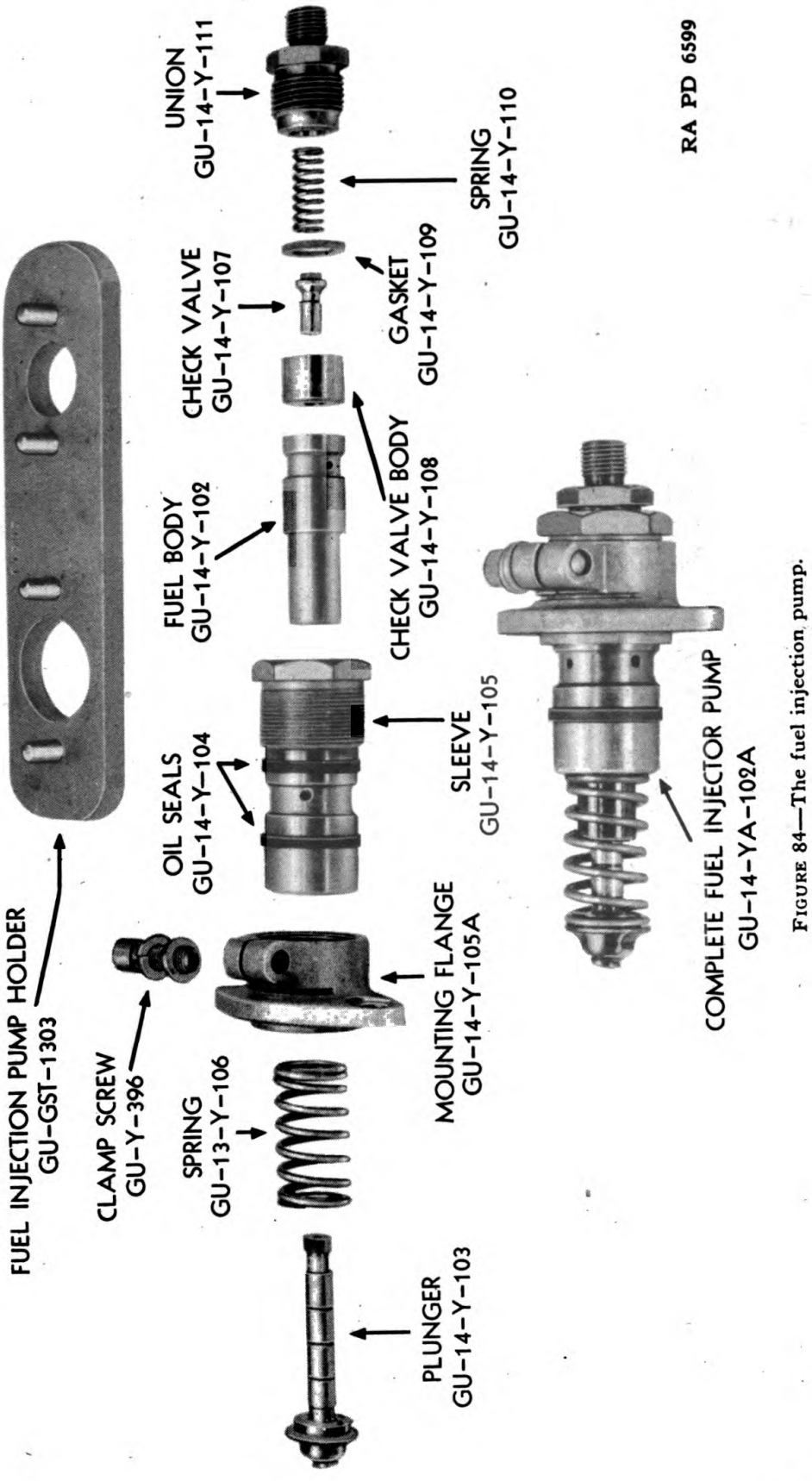


FIGURE 84—The fuel injection pump.

(6) When the assembly is completed, find the chisel mark on the injection nozzle which indicates the center spray hole. The nozzle must be assembled to the body with the center line through the body so the spray pattern will be directed squarely across the combustion chamber *(fig. 81)*. If the center spray hole is turned to either the right or left of the center line through the injector, the spray will impinge upon the head or piston. The side sprays must also be directed parallel to the top of the piston. When this chisel mark is centered, tighten the nozzle holder, making sure that the mark didn't change position.

(7) Retest the injector for pressure and operation *(fig. 83)*. The tester recommended in the equipment column includes a holding fixture with a horizontal line for locating the correct angle of the spray pattern and also includes a vertical line for locating the center spray. The unit has a spray locating fixture, a filter, and a hydraulic unit designed especially for the work. With this tester the correct location of the spray pattern is easy to obtain and verify. An injector which does not operate properly after having been thoroughly cleaned, should be replaced as a unit.

105. Inspect the fuel injection pumps *(figs. 84 and 85)*. — *a. Equipment.* —

Injection pump holding bar No. GU-GST-1303	7/8-inch open-end wrench
3 7/2-inch Allen wrench	Pliers
	1 1/4-inch open-end wrench

b. Procedure. — **NOTE**: 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.

(1) Disassembly *(fig. 84)*.

7/8-inch open-end wrench	Injection pump holding bar No. GU-GST-1303
Pliers	3 7/2-inch Allen wrench
	1 1/4-inch open-end wrench

(a) The plunger and spring are removed together. The end of the spring is turned into a groove in the pump sleeve. Holding the pump mounting flange in one hand, twist the spring to free it from the retaining groove.

(b) Lift the spring and plunger straight up, and out of the fuel pump body *(fig. 85)*. Be careful not to lock 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.

(c) 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.

(d) With the plunger and spring removed, clamp the fuel

injection pump holding bar horizontally in a vise, and place the injection pump in the larger of the two openings, with the union end up. Turn the union hex, using a 7/8-inch open-end wrench to remove the union from the injection pump. Use small pliers to lift out the spring and check valve.

(e) Remove the sleeve from the mounting flange by loosening the clamp on the mounting flange (using a 7/32-inch Allen wrench) and turning the hex nut on the end of the sleeve with a 1 1/4-inch open-end wrench until the sleeve can be lifted out of the mounting flange.

(f) The two sections of the fuel pump body, the check valve and the washer are within the sleeve and can now be removed. **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.

(2) Inspection.

(a) Clean all the parts of the fuel injection pump, and examine the surfaces 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. The two rubber oil seals on the sleeve of the fuel injection pump should be replaced whenever the fuel pump has been removed.

(b) 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 with new pairs of parts.

(d) In testing the plunger spring for compression, the springs when compressed to 1 1/2-inches should produce a force of 18-pounds, plus or minus one pound, and when compressed to one inch should produce a force of 52-pounds, plus or minus 2 1/2-pounds.

CAUTION: Handle fuel pump bodies and plungers with clean hands and tools. Keep submerged in oil at all times when disassembled.

(3) Assembly.

Injection pump holding bar No. GU-GST-1303

1 1/4-inch open-end wrench
7/8-inch open-end wrench
7/32-inch Allen wrench

(a) To assemble the injection pump, place the mounting flange over the two prongs at the largest opening in the fuel injection pump holding bar.

(b) Insert the sleeve into the flange and screw it down until the threads are about even with the top of the flange.

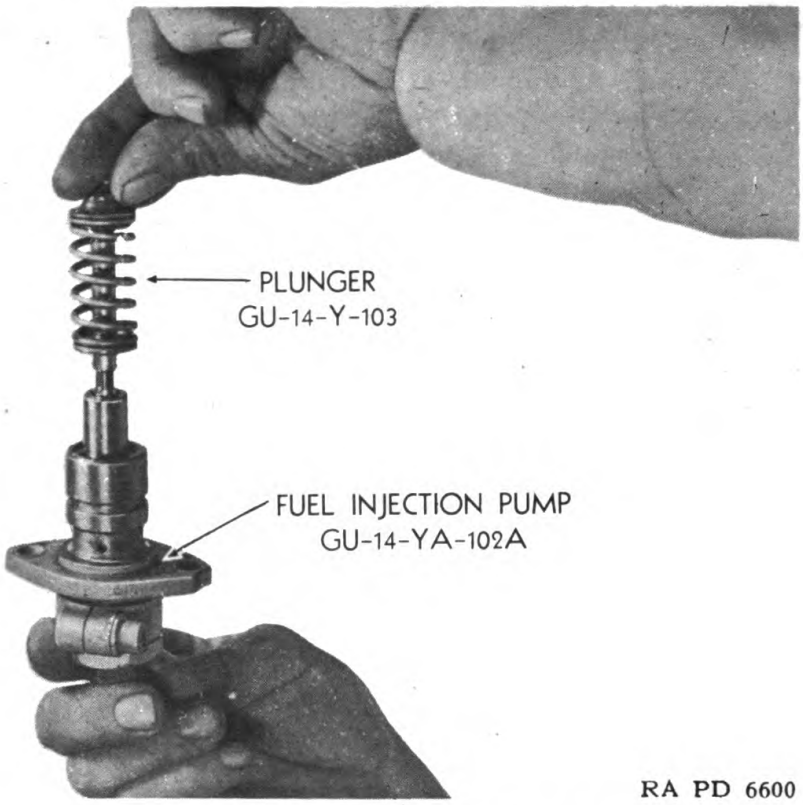


FIGURE 85—Inserting the plunger into the injector body.

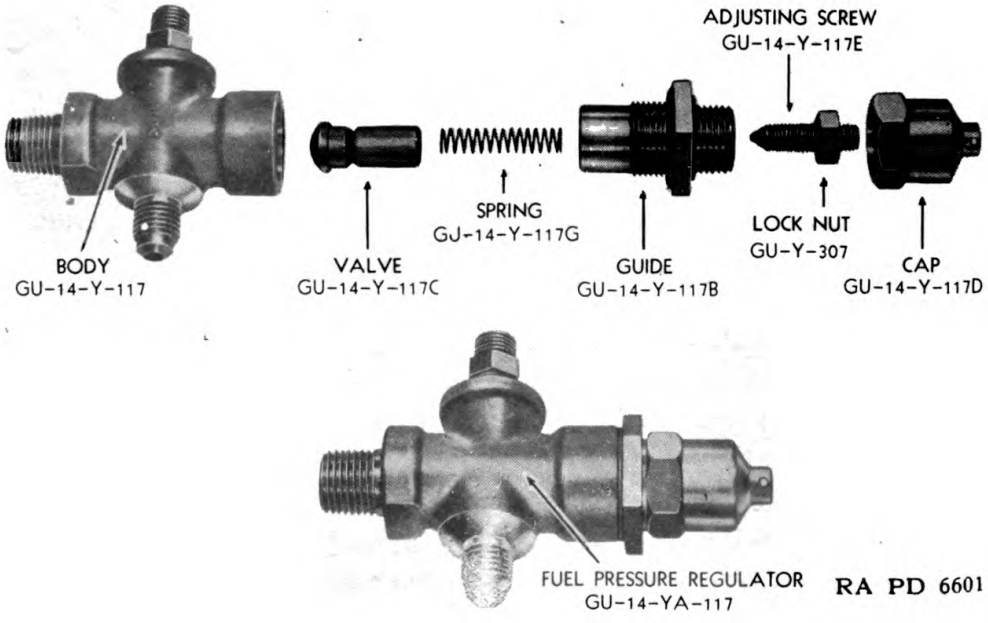


FIGURE 86—The fuel pressure regulator assembly.

(c) Insert the fuel pump body and note the slight bevel around the opening 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.

(d) Insert the check valve stem into this fuel passage and place the washer around it. The center of the washer will have been depressed by the union, and it should go back in the same position from which it was removed, so that the union will form a bond with it. Place the spring on top of the washer. Make sure that the washer is in position, and then replace the union. Remove the union and inspect the washer to make sure the union is bearing on it evenly, then tighten the union down again.

(e) Insert the plunger into the lighter or open 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 heavy end of the spring into the body. Be sure to drop it straight in, as shown in figure 85, to prevent damaging the edge of the injector head. Then twist the spring to lock it in place. *Do not force the plunger into the body under any condition.*

106. 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. The only inspection of the fuel check valve is to suck on the nipple. If the check is in good condition, a vacuum will form which will make the nipple cling to the tongue. If the check valve is defective, it should be replaced.

107. Inspect the fuel pressure regulator *(fig. 86).* — *a. Equipment.* —

¾-inch open-end wrench
1-inch open-end wrench

b. Procedure. —

(1) Disassembly.

¾-inch open-end wrench
1-inch open-end wrench

Turn the hex with a ¾-inch open-end wrench to remove the dome cap from the fuel pressure regulator. Unscrew the nut below the dome cap with a 1-inch open-end wrench and remove the guide. The spring and valve can then be lifted out of the body.

(2) Inspection.

Give all parts a visual inspection for defects.

(3) Assembly.

¾-inch open-end wrench
1-inch open-end wrench

To assemble the fuel pressure regulator, drop the valve into the body and insert the spring over it. Screw the guide down tight and replace the adjusting screw. Tighten the lock nut and replace the dome cap.

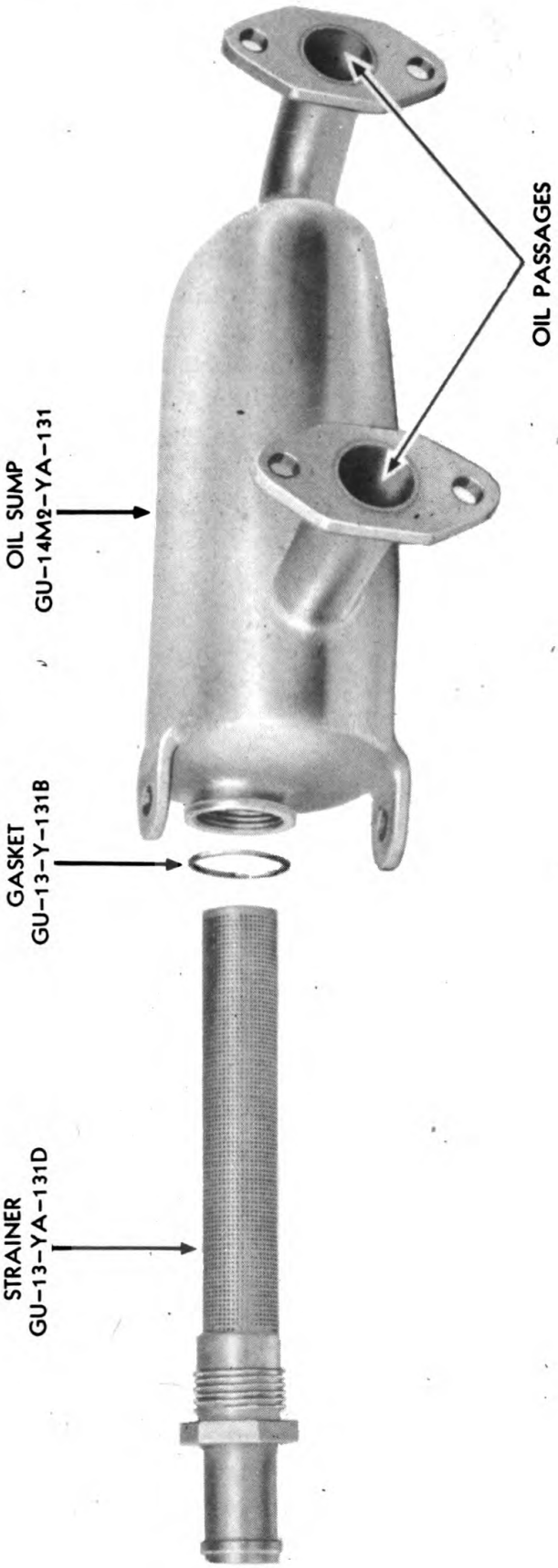


FIGURE 87—The oil sump.

108. Inspect the oil sump *(fig. 87).* — *a. Equipment.* —

1¼-inch open-end wrench

b. Procedure. — Remove the oil strainer by screwing it out with a 1¼-inch open-end wrench. The strainer should be washed and the oil sump flushed out. Inspect the sump housing for cracks. This is the only servicing that the oil sump requires. To assemble the oil sump, renew the gasket on the strainer. Screw the strainer into the sump.

109. Inspect the accessory case. — *a. Equipment.* —

Governor drive gear nut wrench No. GU-GST-1325
Intermediate and idler gear nut wrench No. GU-GST-1349
Backlash gage
Soft hammer
Oil pump bearing driver No. GU-GST-1368
Governor bearing driver No. GU-GST-1370
Accessory case bearing puller and adapters No. GU-GST-1367
Fuel supply pump gear nut wrench No. GU-GST-1322
$\frac{5}{16}$-inch Allen wrench
Fuel supply pump and idler gears holder No. GU-GST-1312
Plate Wrench No. GU-GST-1350
Fuel supply pump bearing driver No. GU-GST-1369
Screwdriver
½-inch socket wrench
Oil pump drive gear nut wrench No. GU-GST-1324
Soft-jawed vise
Soft drift

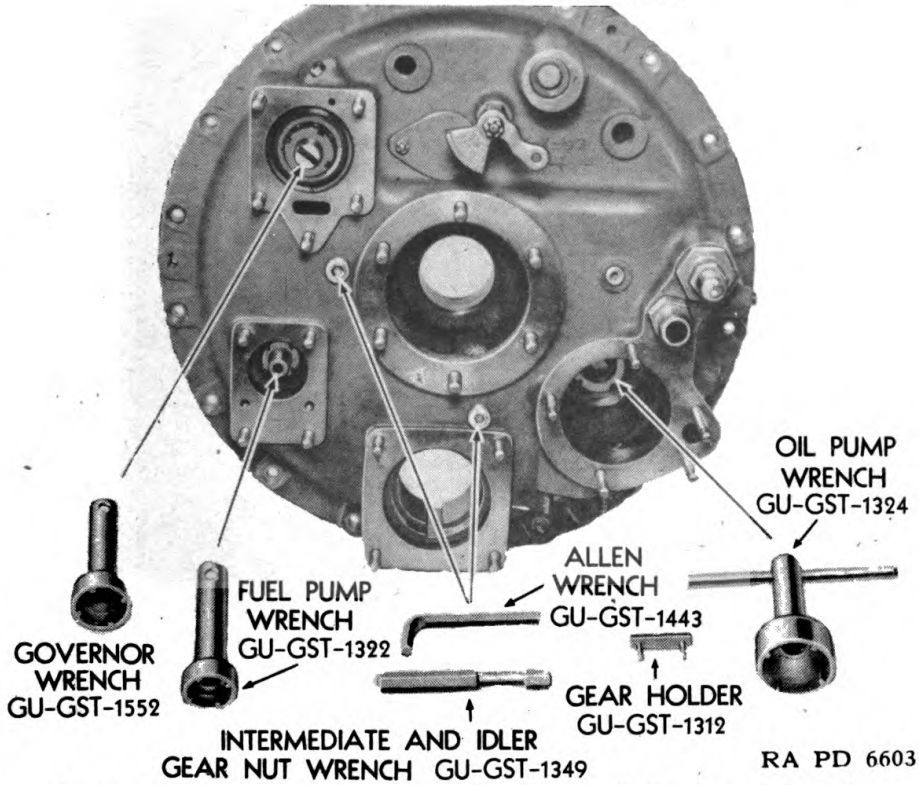


FIGURE 88—The accessory case and special tools for dismantling it.

b. Procedure. —

(1) Disassembly *(figs. 88 and 89).*

½-inch socket wrench
Soft-jawed vise
Screwdriver
Gear holder (GU-GST-1312)
Intermediate and idler gear nut wrench (GU-GST-1349)
Oil pump drive gear nut wrench (GU-GST-1324)
$\frac{5}{16}$-inch Allen wrench
Fuel supply pump gear nut wrench (GU-GST-1322)
Accessory case bearing puller (GU-GST-1367)

(a) To dismantle the accessory case, place the accessory case on a bench with the gear side down. Remove the 4 palnuts, nuts, and washers from the generator drive mounting using a ½-inch socket wrench and slide the generator drive out of the case. It may be necessary to drive the assembly out with a soft mallet.

(b) Turn the accessory case so that it stands vertically and clamp in a soft-jawed vise. Use a screwdriver to bend the locking washer clips out of the nuts on the oil pump drive gear, the fuel supply pump drive gear and the governor drive gear.

(c) Remove the plugs from behind the cam intermediate and idler gears, using a $\frac{5}{16}$-inch Allen wrench. With the gear

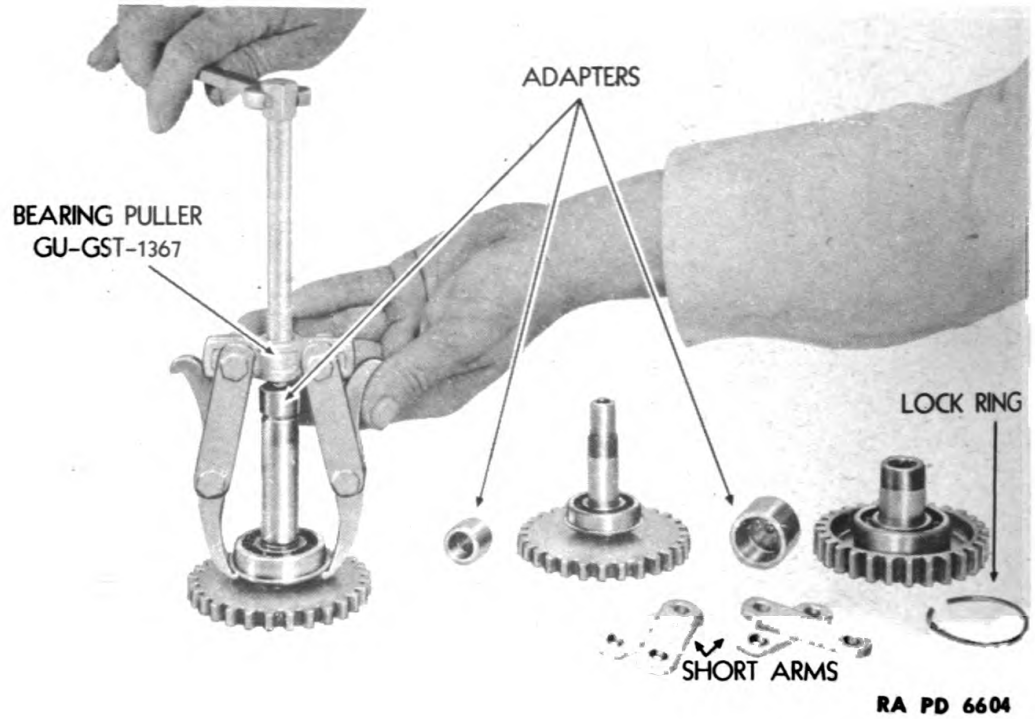


FIGURE 89—Removing accessory case gear bearings.

holder (GU-GST-1312) placed between the teeth of the cam intermediate and the oil pump drive gears, enter the special wrench No. GU-GST-1349 into the opening where the plug was removed, and into the nut of the cam intermediate gear, and turn the nut. This will shear off the cotter pin on this nut. Be careful that the pieces of the cotter pin do not fall into the recesses of the accessory case, as they will be difficult to remove. Remove the intermediate gear nut. This is too large to come out through the plug opening, but must be removed through the starter opening. Leave the gear in its bushing for use in locking the idler gear.

(d) With the gear holder still in place, unscrew the nut on the oil pump gear with the special wrench (GU-GST-1324) *(left-hand thread)*.

(e) Place the gear holder between the teeth of the fuel supply pump gear and the idler gear and unscrew the idler gear nut through the opening where the pipe plug was removed. Remove the nut from the inside recess of the accessory case through the starter drive opening.

(f) Remove the fuel supply pump gear nut *(left-hand thread)* using the special wrench (GU-GST-1322).

(g) Slide the intermediate and idler gears out of their bushings.

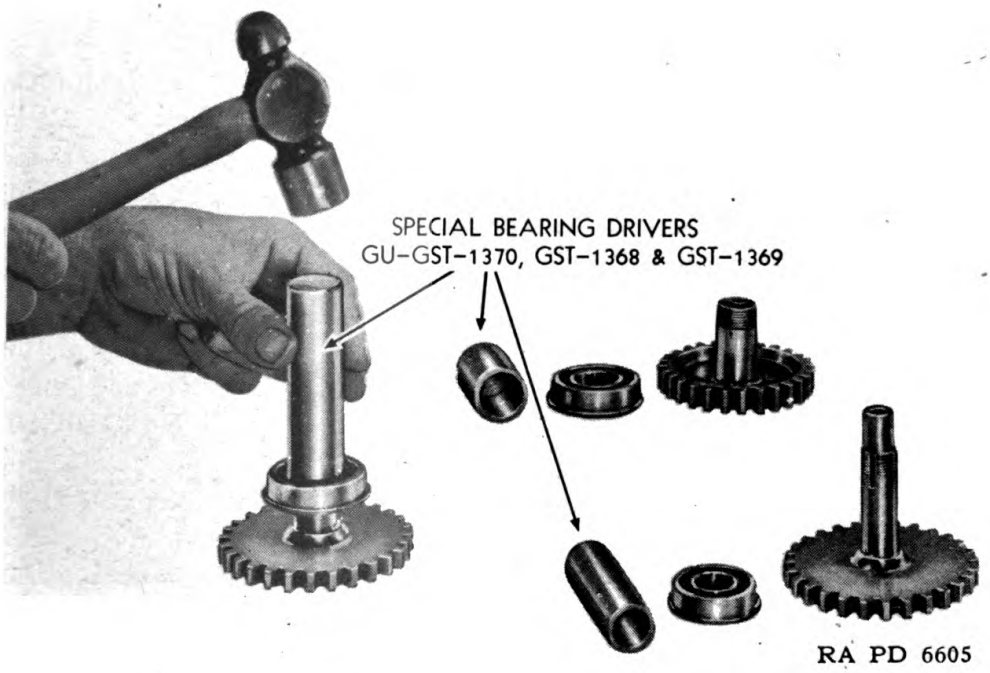


FIGURE 90—Replacing accessory case gear bearings.

(h) With a soft drift drive the oil pump, fuel supply pump and governor drive gears out of the accessory case.

(i) One bearing is used on each side, with a spacer between them. These bearings have lock rings, so that they cannot be driven through the accessory case. The front bearings will come out when the oil pump, fuel supply pump and governor drive gears and shafts are driven out. The rear bearing can then be driven out from the front or gear side of the case.

(j) *(Fig. 89.)* An accessory case bearing puller (GU-GST-1367) is used to remove the front bearings from the fuel supply pump, oil pump, and governor drive gear shafts. An adapter is placed over the shaft to provide a surface on which the bolt 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 sufficent clearance to attach the puller fingers under the bearing.

(k) Three adapters are provided — one for each shaft. Two sets of arms for the puller are also provided. The long arms are used in removing the governor gear bearing. The short arms are used for removing the oil pump and fuel supply pump bearings.

(2) Inspection.

Micrometer

(a) Give all gears a visual inspection for scoring, chipped teeth, etc.

(b) Inspect bearings to make sure they roll freely, and that there are no flat surfaces.

(c) Use a micrometer on the intermediate and idler shafts and on the bushings in which they fit to determine the clearance. This was from .0015-inch loose to .0035-inch loose when new, and has a limit of .008-inch loose before the bushing must be replaced.

(3) Assembly.

Governor drive gear nut wrench No. GU-GST-1325
Intermediate and idler gear nut wrench No. GU-GST-1349
Backlash gage
Soft hammer
Oil pump bearing driver No. GU-GST-1368
Screwdriver
Soft drift
Fuel supply pump gear nut wrench No. GU-GST-1322
$\frac{5}{16}$-inch Allen wrench
Fuel supply pump and idler gears holder No. GU-GST-1312
Plate wrench No. GU-GST-1350
Governor bearing driver No. GU-GST-1370
Fuel supply pump bearing driver No. GU-GST-1369
Oil pump drive gear nut wrench No. GU-GST-1324

(a) Oil the bearings and replace them on the governor, fuel supply pump and oil pump gear shafts by laying the gears face down on a bench and driving the bearings on with the special bearing drivers (GU-GST-1368-1369-1370). Drive only on the inner race of the bearings. Make sure that bearings are driven down to the shoulders of the gears, and that they turn freely after they are driven on. Replace the lock ring in the oil pump gear bearing.

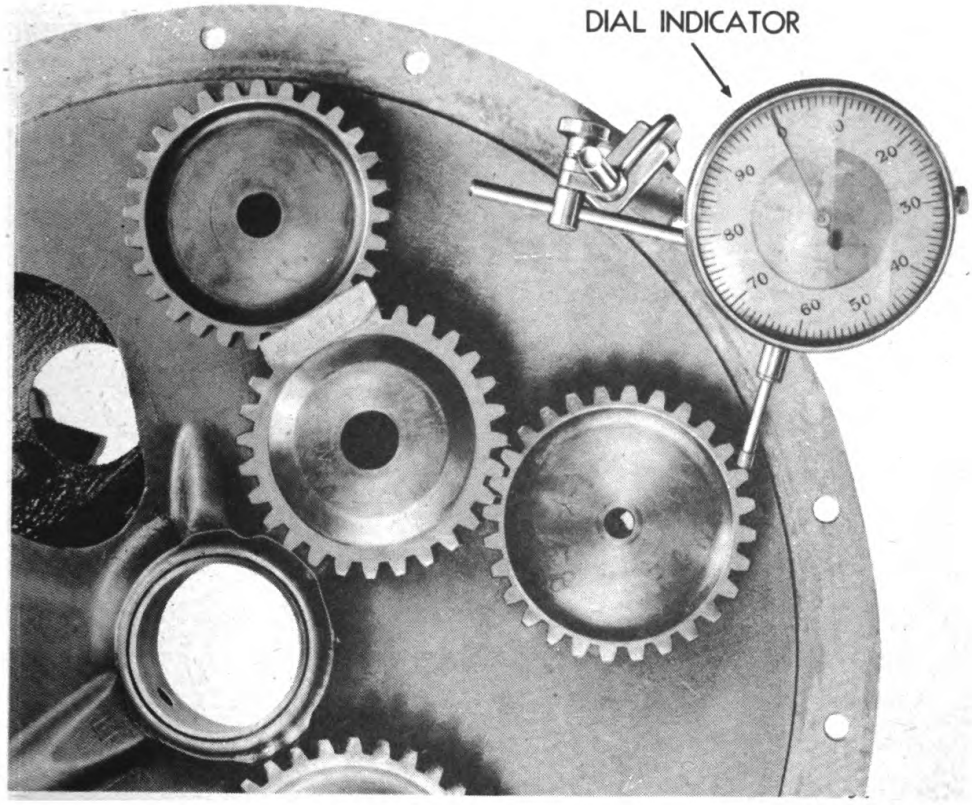
(b) Replace the gears and bearings in their position in the case, driving them in with a soft hammer.

(c) Replace the spacers on the shafts from the rear of the case.

(d) Oil and replace the rear bearings, driving them in with the same bearing drivers that were used to install the front bearings. Drive only on the outer race where possible.

(e) Replace the lock washers with the prongs out and the tip on the inside of the washer in the groove in the shaft.

(f) Screw on the nuts with the bevel side down toward the washer, using the special wrenches which were used in removing those nuts and which are shown in figure 86. **NOTE**: *The oil pump, fuel supply pump and governor nuts are all left-hand threads.*



RA PD 6606

FIGURE 91—Checking gear tooth play with dial gage.

(g) Install the idler gear and intermediate gears in position. Insert the nuts for the intermediate and idler gears through the opening inside the accessory case and screw onto the gear shafts. The holes in the nuts should line up with those on the gear shafts. Insert a cotter pin from the nut side and bend over on the gear face. Then replace the pipe plugs over the nuts, using a $\frac{5}{16}$-inch Allen wrench.

(h) Determine the side play of the idler and intermediate gears. This is done by measuring with a feeler gage, through the opening in the accessory case, the clearance between the flange of the nut and the rear of the case. The original side play was from .003-inch loose to .017-inch loose, and has a limit of .050-inch loose.

(i) The side play on the governor, fuel supply pump, 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	—.0004″L—.0444″L
Fuel supply pump drive gear	—.0008″L—.0448″L
Oil pump drive gear	—.0002″L—.0442″L

(j) *(Fig. 91.)* Next check the play between the teeth of the gears. This is done with a dial gage. The gage is attached to the accessory case, with the needle of the gage resting on a gear tooth, as shown in figure 91. Lock the two other gears of the train with gear holder. Move the first gear as far as it will turn in one 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.

BACKLASH ON GEARS
T-1020 ENGINE
SERIES 4

Gear Combination	Backlash
1. Starter Shaft Gear & Intermediate Gear	.006″ — .010″
2. Starter Shaft Gear & Idler Gear	.006″ — .010″
3. Intermediate Gear & Oil Pump Drive Gear	.004″ — .008″
4. Intermediate Gear & Generator Drive Gear	.004″ — .008″
5. Intermediate Pinion & Valve Cam Gear	.008″ — .012″
6. Idler Gear & Governor Drive Gear	.004″ — .008″
7. Idler Gear & Fuel Supply Pump Gear	.004″ — .008″

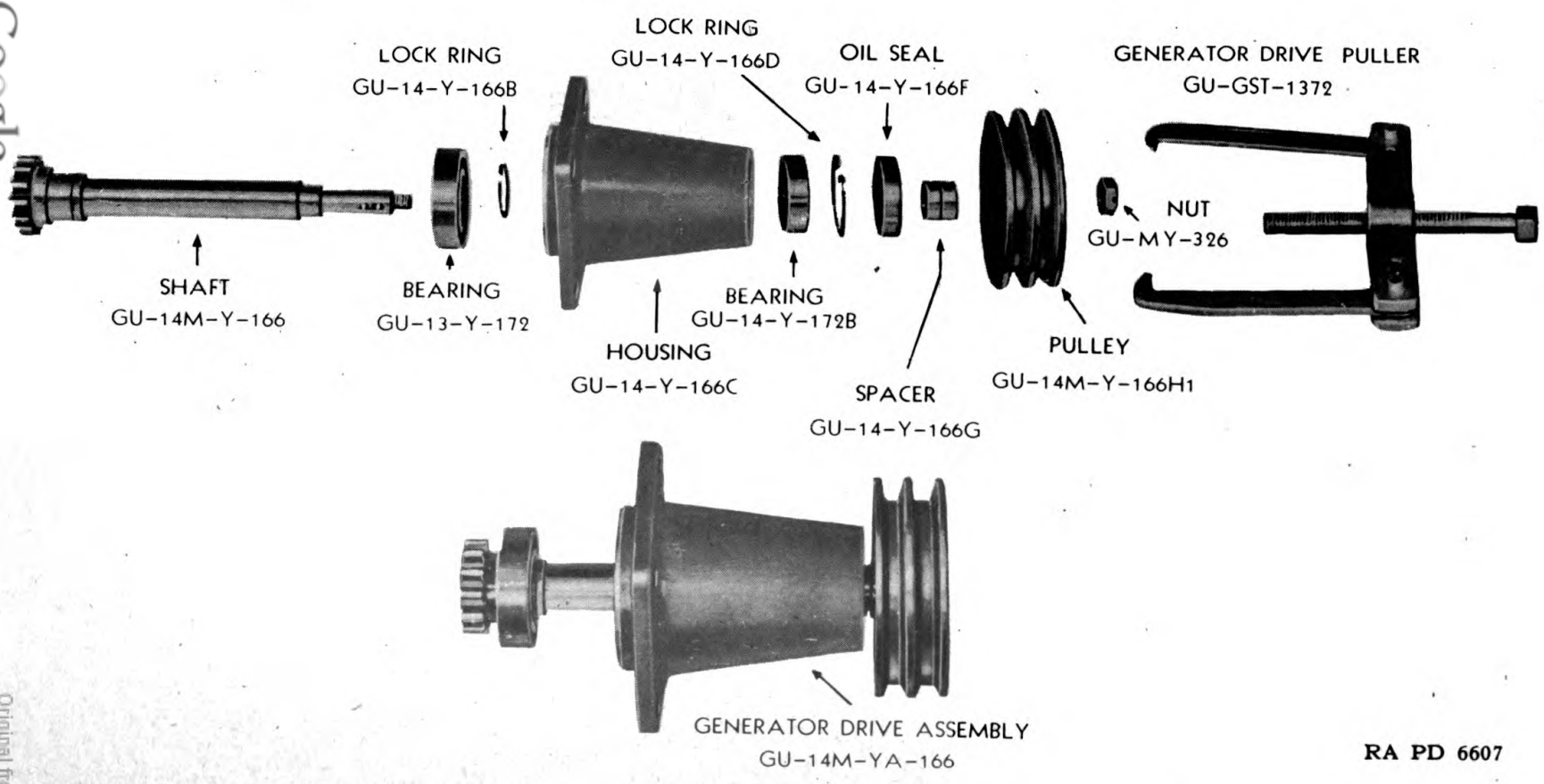


FIGURE 92—The generator drive assembly.

(k) Insert the seat of the oil pressure regulator valve in the accessory case and tighten it by inserting the plate wrench into the groove in the seat. Oil the valve with light oil and drop it into the seat. Replace the spring over the valve, and then tighten down the cover.

110. Inspect the generator drive assembly *(fig. 92).* — *a. Equipment.* —

	Ring splitter
Pliers	7/8-inch socket wrench
Generator drive pulley	Vise
puller No. GU-GST-1372	Screwdriver
Soft drift	Press

b. Procedure. —

(1) Disassembly *(fig. 92).*

	Ring splitter
Pliers	7/8-inch socket wrench
Generator drive pulley	Vise
puller No. GU-GST-1372	Screwdriver
Soft drift	Press

(a) To disassemble the generator drive assembly, remove the cotter pin from the nut at the pulley end. Clamp the generator drive gear in a soft-jawed vise and remove the nut from the shaft, using a 7/8-inch socket wrench.

(b) Turn the generator drive horizontally in the vise, clamping it at the flange.

(c) Fasten the fingers of the generator drive pulley puller (GU-GST-1372) behind the pulley. Place the center bolt of the puller over the shaft of the generator drive and screw down the center bolt of the puller. This will remove the pulley from the shaft. Remove the Woodruff key which was under the pulley.

(d) Drive the shaft and outer bearing out of the housing with a soft drift.

(e) Lift the spacer out of the oil seal. NOTE: A lock ring fits into a groove in the housing between the inner bearing and oil seal. This lock ring must be removed before the inner bearing can be removed. Do not try to drive the bearing out with this lock ring in position or it may split the housing.

(f) Using a pair of needle-nosed pliers, reach in through the oil seal opening and compress the ears of the lock ring. Lift the ends of the ring out of the groove, and then pry the rest of the ring out of the groove with a screw driver. With the ring out of the groove, drive the bearing and oil seal out with a soft drift.

(g) Remove the lock ring that holds the outer bearing on the shaft by spreading the ends out with a ring splitter and lifting off with a screwdriver. Set the shaft upright in a press.

with a support under the bearing on each side of the gear, and press the shaft down and out of the bearing.

(2) Inspection.

Give bearings a visual inspection for defects. Make sure that bearings roll freely and with no flat surfaces. Examine the gear for chipped teeth. Inspect the shaft for defects. Examine the housing for cracks.

(3) Assembly

Pliers	Ring splitter
Generator drive pulley puller No. GU-GST-1372	7/8-inch socket wrench
Soft drift	Vise
	Screwdriver
	Press

(a) To reassemble the generator drive, oil the larger bearing and drop it on the shaft as far as it will go. Place the bearing on a press and press the shaft down into the bearing up to the shoulder of the drive gear.

(b) Use a ring splitter to spread the ends of the locking ring apart, and drop it over the shaft and fit it into the groove next to the bearing.

(c) Set the generator drive housing, with the flange down, on a bench. Oil the smaller bearing, and drop it into the housing with the enclosed side up to permit oil reaching the bearing, and drive into place with a soft drift. Compress the ends of the lock ring with pliers and insert it into the groove in the housing, above the bearing. Replace the oil seal. Place a block of wood over it and drive the seal down flush with the end of the housing.

(d) Insert the shaft through the bearing and oil seal in the housing. Support the housing on a press and press the shaft down into the bearing. Replace the spacer inside the oil seal and over the shaft. Replace the Woodruff key in the shaft. Drop the pulley over the shaft with the flat side of the pulley next to the housing. Line up the groove in the pulley with the key and press the pulley on.

(e) Screw on the nut and replace the cotter key.

(f) Make sure that the pulley rotates freely after it is installed.

SECTION VIII

REPAIR OF ENGINE

111. General. — *a.* Due to the 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. However, a few repairs can be made and most bushings can be replaced. These subjects are covered in this section.

b. 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 the replacement of parts, refer to the Disassembly, Inspection, and Assembly Sections of this manual for the correct procedure.

c. The servicing of accessories is covered in the Accessories Section of this manual.

112. To replace decompression plate bushing or valve cam bushing. — *a. Equipment.* —

Alcohol and dry ice
Lathe
Press

b. Procedure. — (1) Bore the old bushing out to a wall diameter of $\frac{1}{32}$-inch, leaving a shoulder of about $\frac{1}{8}$-inch depth at the bottom of the bushing to serve as a base in removing the bushing. Remove the decompression plate or valve cam from the lathe and center it in a press. Press out the remaining shell of the bushing.

(2) To insert a new bushing, place the bushing in an alcohol and dry ice solution for about ten minutes. Place the decompression plate or valve cam on a surface plate on a press. Center the bushing over the hub of the plate and press inward, taking care to keep the bushing straight in the hub bore. Finish-bore with a Carboloy tool.

113. To replace the master rod bushing *(fig. 93).* — *a. Equipment.* —

Press
Lathe
Key alining tool

b. Procedure. — (1) Bore the old bushing out to a shell of $3\frac{1}{2}$-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) The bushing is keyed in the master rod and is very difficult to install since it must be perfectly alined with the key and the operation of installing the bushing performed quickly. A simple device for alining the bushing with the key is shown in figure 93. 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 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 on the master rod key.

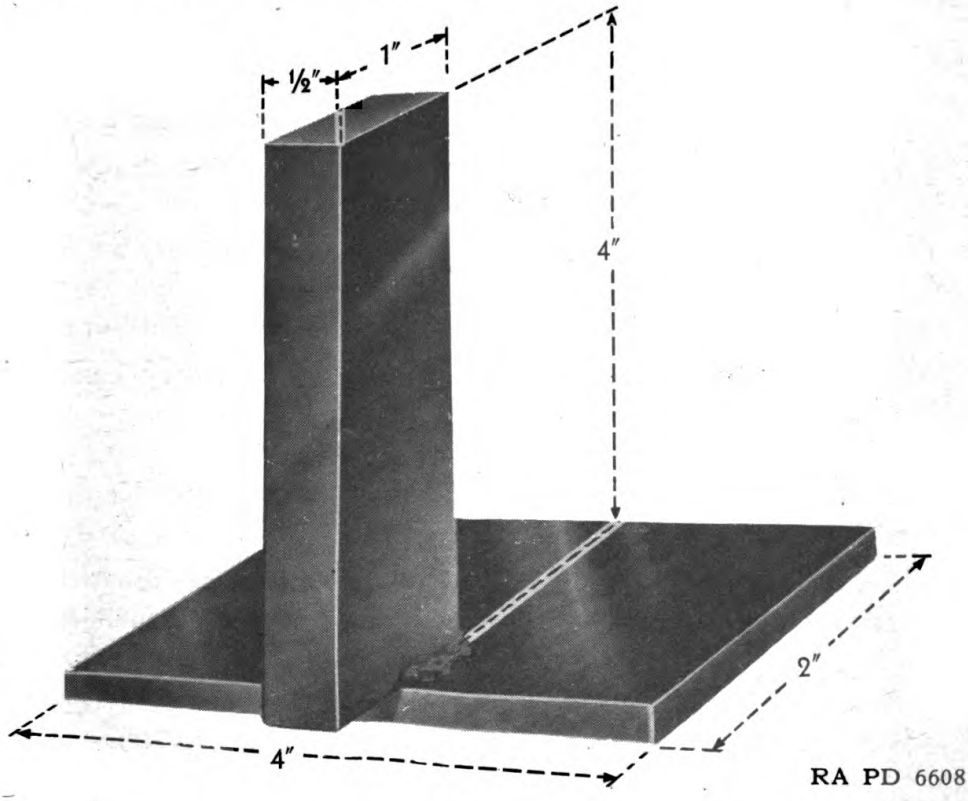


FIGURE 93—Tool for alining master rod bushing.

(3) Heat the end of the master rod in oil until the bore is from .004-inch to .006-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 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. When the rod and bushing have cooled, finish-bore the bushing with a Carboloy tool.

114. To replace the master rod piston pin bushing. — *a. Equipment.* —

Punch	Lathe
Press	Alcohol and dry ice

b. Procedure. —

(1) This bushing is doweled through the master rod. Punch out the dowel pin. Bore the old bushing down to a $\frac{1}{32}$-inch shell, with a shoulder $\frac{1}{8}$-inch deep at the bottom. Remove from the lathe and press the shell out.

(2) Put a new bushing in a solution of 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 counterpunch the metal around the edges to hold it in place. Then finish-bore the bushing with a Carboloy tool.

115. To replace the link rod bushings. — *a. Equipment.* —

Alcohol and dry ice	Lathe
	Press

b. Procedure. —

(1) Bore out the old bushing to a $\frac{1}{32}$-inch shell, leaving a $\frac{1}{8}$-inch shoulder at the bottom. Remove the link rod from the lathe and press out the shell.

(2) Place a new bushing in a solution of alcohol and dry ice for ten minutes. Place the link rod on a surface plate on a press, and press the bushing into position. Finish-bore the bushing with a Carboloy tool.

116. To replace starter shaft bushing in accessory case. — *a. Equipment.* —

Punch	Lathe
Press	Alcohol and dry ice

b. Procedure. —

(1) This bushing is doweled to the case with three brass screws. Punch out the dowels. Bore the bushing down to a $\frac{1}{32}$-inch shell, leaving a $\frac{1}{8}$-inch shoulder at the bottom. Remove the accessory case from the lathe and press the bushing out.

(2) Place a new bushing in alcohol and dry ice for ten minutes. Aline the accessory case on a press, then press the bushing into place, taking care to keep it straight. Finish-bore the bushing with a Carboloy tool. Replace the dowels to hold this bushing in the accessory case.

117. To replace the intermediate gear and idler gear bushings in the accessory case. — *a. Equipment.* —

Punch
1¼-inch button with a 1-inch pilot
Press
Lathe
Rod
Alcohol and dry ice

b. Procedure. —

(1) These bushings are doweled to the case with two dowel pins on the outside of the case. Punch out these dowel pins. The bushings must be forced through the front, or gear side of the accessory case. Bore the bushings down to a $\frac{1}{32}$-inch shell with a ⅛-inch shoulder at the bottom. Use a 1¼-inch button that is undersized .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 basing it on the button.

(2) A new bushing is placed in a solution of alcohol and dry ice for ten minutes and pressed in from the outside or front of the accessory case. Finish-boring is also done from the front. Bevel the shoulder of the bushing to form a radius for the gear.

118. To replace the throttle shaft bushing in the rear crankcase. — *a. Equipment.* —

Press
Hammer
Punch
Lathe
Alcohol and dry ice

b. Procedure. —

(1) Drive the bushing out with a punch and hammer.

(2) Place the new bushing in a solution of alcohol and dry ice for ten minutes and press into place. Finish-bore with a Carboloy tool.

119. To replace valve guides. — *a. Equipment.* —

Press
Support for guide boss
Rod for removing guide
Cylinder mounting fixture

b. Procedure. —

(1) To remove the guides, a long tool is used with a pilot that fits into the valve guide. The shoulder of the tool rests against the guide. Install in a press, with the barrel resting on the rocker box, lining the cylinder barrel up so that the tool is straight and the guide will be pressed straight down. A support should be used under the guide boss. Press out the guides.

(2) To replace the guides, set the cylinder barrel in a press with the rocker boxes up. A fixture should be used inside the barrel to brace the head, with an opening that surrounds the guide. Line the barrel so that the guide will be pressed straight down. Install a rod over the guide and press the guide into place. Finish-ream to size for proper clearance.

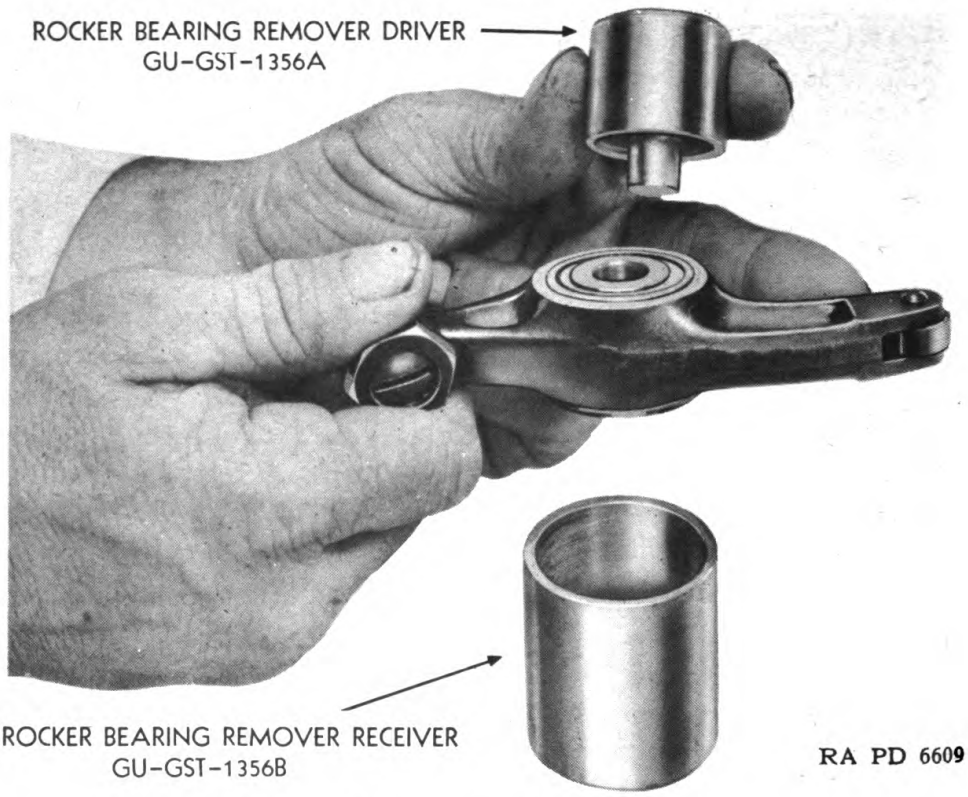


FIGURE 94—Removing rocker arm bearing.

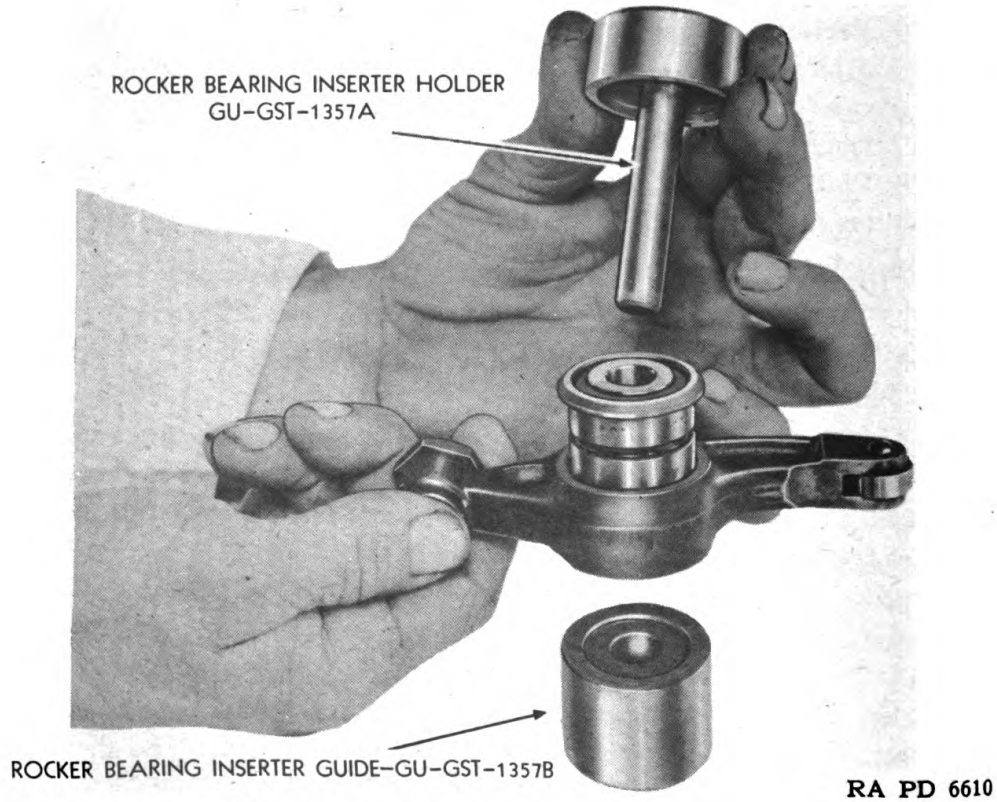


FIGURE 95—Installing rocker arm bearing.

120. To replace rocker arm bearing *(figs. 94 and 95).* — *a. Equipment.* —

Rocker bearing remover GU-GST-1356
Hammer
Rocker bearing inserter GU-GST-1357

b. Procedure. —

(1) To remove the bearing use the special rocker bearing remover (GU-GST-1356). Place the rocker arm on the receiver part of the tool, with the flanged side of the bearing down. Place the driving part of the tool on the bearing. Hammer on the driver to force the bearing out.

(2) Before installing a new rocker arm bearing, oil the bearing. Using the special rocker bearing inserter (GU-GST-1357), place the rocker arm on the holder part of the tool with the narrow shoulder of the rocker arm upward. Place the bearing in position with the flanged side of the bearing upward. Use the bearing inserter guide part of the tool, placing the inserter guide through the bearing. Hammer down on the head of the inserter to drive the bearing into place.

121. To replace inter-rocker box oil drain lines *(fig. 96).* — *a. Equipment.* —

Drift
Punch
Hack saw
Rocker box drain lines installation tool (GU-GST-1363)

b. Procedure. —

(1) To remove damaged tubing, cut the tubing with a hack saw at the side of the rocker box. Then use a drift to drive the rubber gasket and washers out through the rocker box.

(2) There is a thick metal washer, a rubber washer, and a thinner metal washer at each end of the tube. Inspect the openings and remove any roughness, then insert the ends of the tube into the openings in the rocker boxes.

(3) Slide the washers up to the opening and install the inter-rocker box drain lines installation tool (GU-GST-1363), so that the prongs of one lever are against the washer on the outside of the rocker box, and the smooth fingers of the tool grip the inside of the rocker box as shown in figure 96. Turn the handle of the tool to force the washers into the opening for an oil-tight fit.

(4) Use a punch to bind the metal of the rocker box, to hold the washer in place.

122. To grind valve seats *(fig. 97).* — *a. Equipment.* —

Cork for injector opening
Gasoline
Vacuum valve grinder GU-GST-1423
Grinding compound

b. Procedure. —

(1) The cylinder barrels must be removed from the engine to grin

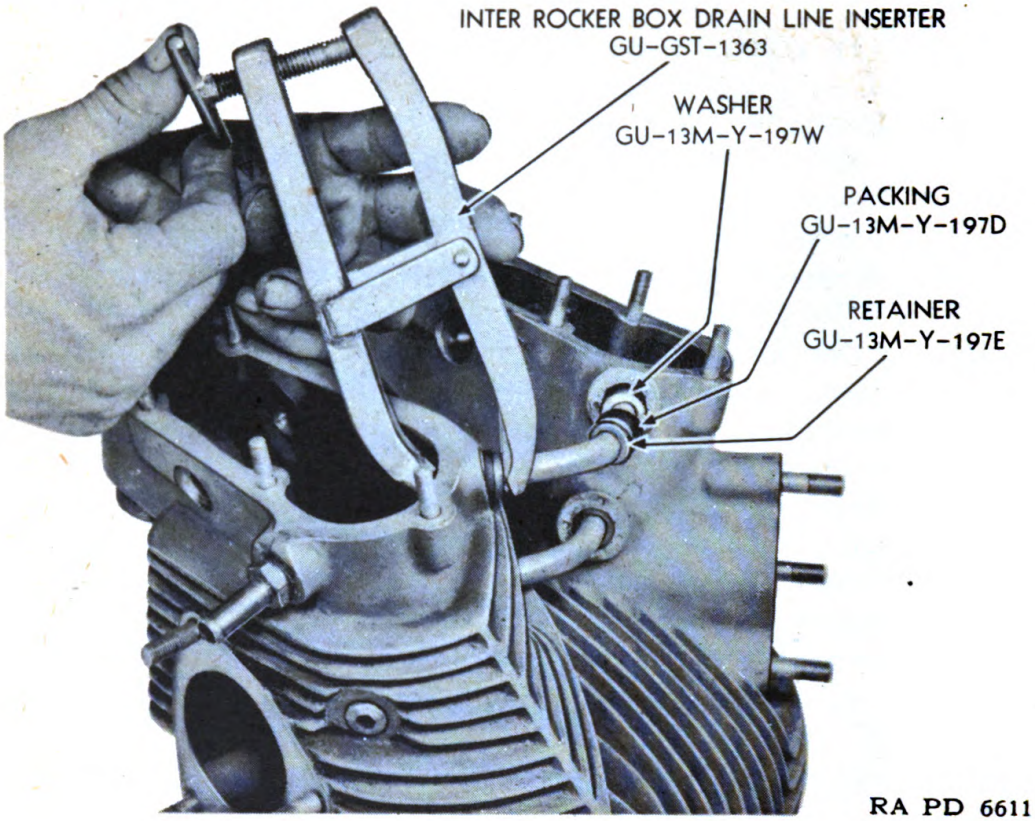


FIGURE 96—Replacing inter-rocker box oil drain lines.

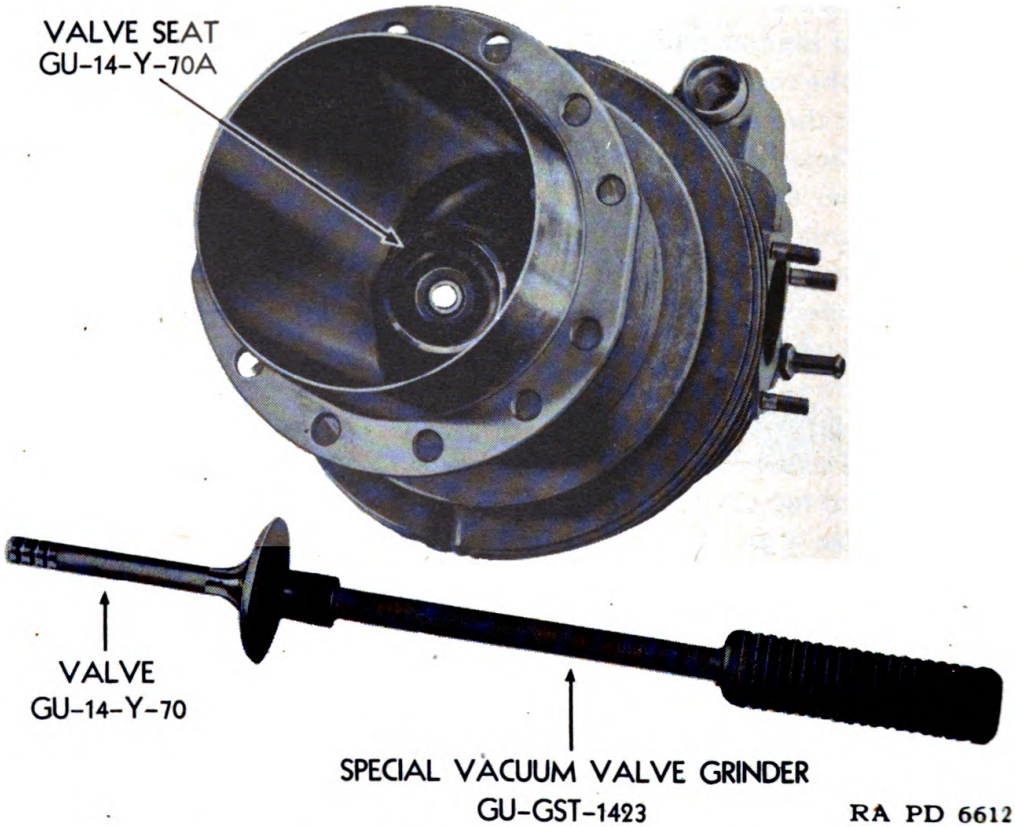


FIGURE 97—Valve grinding.

the valve seats, so this operation is performed only at the time of a major overhaul (see Section VI for disassembly of the engine). With the cylinder barrel off the crankcase and the valve operating mechanism removed, turn the cylinder barrel on its side.

(2) Attach the suction cup of the vacuum valve grinder (GU-GST-1423) to the valve head, as shown in figure 97. Coat the valve seat with grinding compound and insert the valve stem through the guide until the head of the valve bears against the seat. Twirl the valve back and forth to grind the seat.

(3) To test the fit of the valves in the seats, insert a cork in the injector opening. Insert the valve stems into the guides and cover the valve heads with gasoline. Look through the valve ports to see if any of the gasoline seeps through around the valve heads. If it does, the valves and seats will require further grinding until a tight, test-proof fit is obtained.

123. The fuel injectors. — See Inspection Section No. VII for complete operation for testing and repairing the fuel injectors.

124. The fuel injection pumps. — See Inspection Section No. VII for complete operation for testing and repairing the fuel injection pumps.

125. 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 disks 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. The filtering unit is removed and washed, and the housing flushed periodically.

126. Timing — valve and fuel — See Section IX of this Manual.

127. Bleeding fuel lines. — See Section IV of this Manual.

128. Balancing the cylinders. — See Section IV of this Manual.

SECTION IX

ASSEMBLY OF ENGINE

129. Facilities needed. — *a.* In assembling the engine, it will be necessary to have cleaning facilities available, such as cloths and cleaning fluid, to make sure that all parts are thoroughly clean before assembly.

b. An engine mounting stand must be provided on which to mount the engine as it is assembled.

c. Standard and special tools are listed for each operation.

130. New parts which must always be used. — *a.* In assembling the engine, new gaskets must always be used throughout.

b. New safety wire must always be used where parts are safety-wired together.

131. Inspection of components. — *a.* Before assembling any components into the engine, they should be given a careful, final inspection.

b. Close attention must be paid to fits and tolerances in the assembly. Measurements were taken at the time the inspections were made, as outlined in Section VII. When assembling the various parts, the measurements of mating parts must be compared to determine the clearances. In Section X, a table of clearances is given and should be referred to during the assembly operations.

132. Lubrication of components. — All moving parts must be lubricated with oil or grease as indicated in the description of the assembly operation.

133. Assembling the crankshaft *(fig. 59).* — *a. Equipment.*

Vise	$\frac{9}{16}$-inch Allen wrench
Pliers	Micrometer
Feeler gage	$\frac{7}{8}$-inch straight edge socket wrench

b. Procedure. — (1) Clamp the counterweight of the front crankshaft in a soft-jawed vise. Replace the plug in the end of the crankshaft journal, using a $\frac{9}{16}$-inch Allen wrench, and tighten. If the cotter key hole in the crankshaft does not line up with the hole in the plug, use the crankshaft hole as a guide in drilling a new hole in the plug. Ther

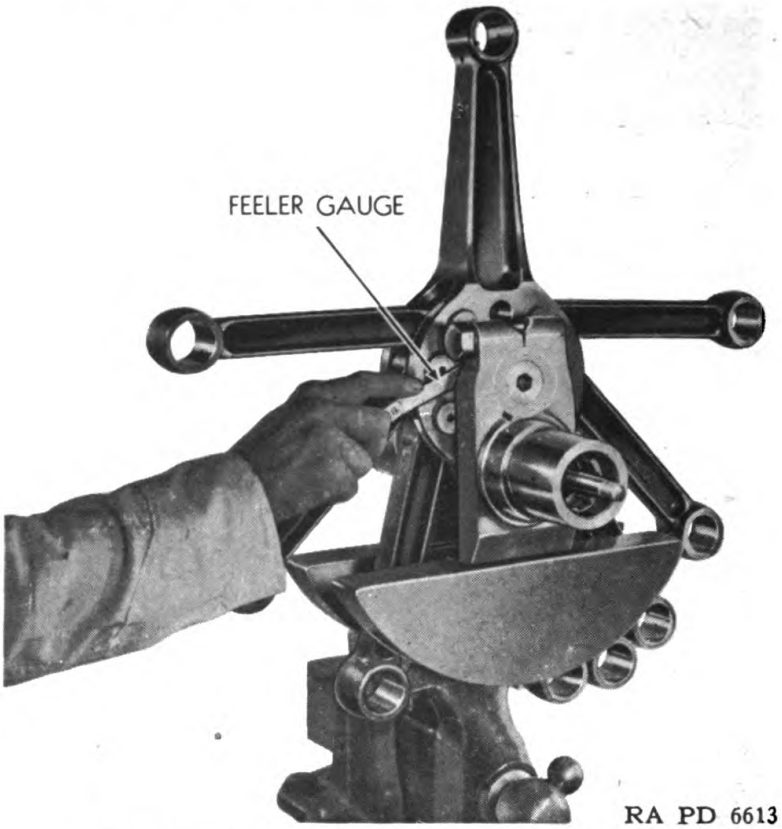


FIGURE 98—Checking rear crankshaft clearance.

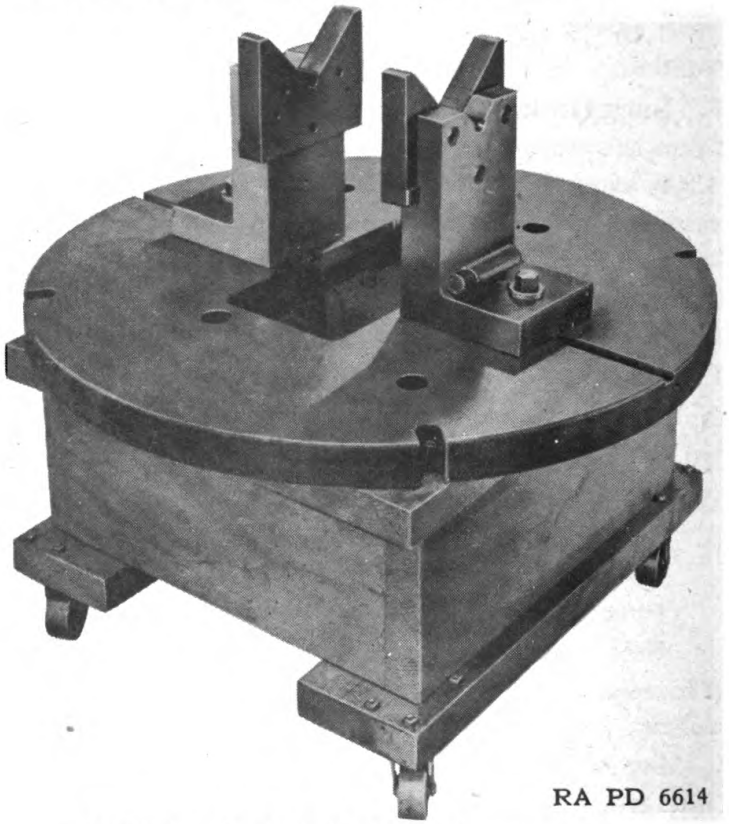


FIGURE 99—Crankshaft "V" block support.

replace the cotter key, being sure that the head is sunk below the surface of the shaft.

(2) Install the starter jaw tie bolt in the rear crankshaft. The tie bolt is inserted through the front end of the rear shaft, with the notch in the flange above the opening. A pin is placed in this opening to prevent the tie rod from turning. Then replace the starter jaw nut, using a 7/8-inch socket wrench, and install the cotter pin.

(3) Slide the master rod assembly onto the crankshaft. The crankshaft must be free of grease and be powder dry.

(4) Install the rear crankshaft. Wipe off the end of the crankshaft with a gasoline cloth, and also the bore in the rear crankshaft. Then slide the rear crankshaft onto the front shaft.

(5) Install the clamping bolt. NOTE: The clamping bolt passes through the clamping sections of the rear crankshaft and binds them to the front cranshaft. To provide an extremely tight connection, the bolt is streched while it is installed. The bolt passes through a groove in the front crankshaft. To pass through the groove the rear crankshaft should be flush with the end of the front crankshaft.

(a) Measure the length of the clamping bolt with a micrometer before installing, placing a ball at one end to provide a surface. Make a note of the dimension, to determine the stretch later on.

(b) Coat the clamping bolt with Lubriplate or similar lubricant and install it. Lay a straight edge across the two counterweights to line them up as evenly as possible. Do not tighten the clamping bolt too tight at this point.

(6) Use a feeler gage to check the clearance between the master rod and the rear crankshaft, as shown in figure 98. Clearances should be .012-inch — .018-inch.

134. Check the crankshaft for run-out *(figs. 99 and 100). — a. Equipment. —*

"V" blocks Dial indicator

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 master connecting rod assembly turns. "V" blocks are used to support the crankshaft.

(1) Before placing the crankshaft assembly in the "V" blocks, coat the journals of the crankshaft and the jaws of the fixture with Lubriplate or other lubricant to reduce friction and prevent scoring the journals. Then mount the crankshaft in the jaws, supporting it at the main bearing journals. Replace the starter jaw on the rear crankshaft. Use a dial indicator to measure the run-out, as shown in figure 100, 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 knocking together.

(2) Turn the master rod one complete revolution. If the run-out

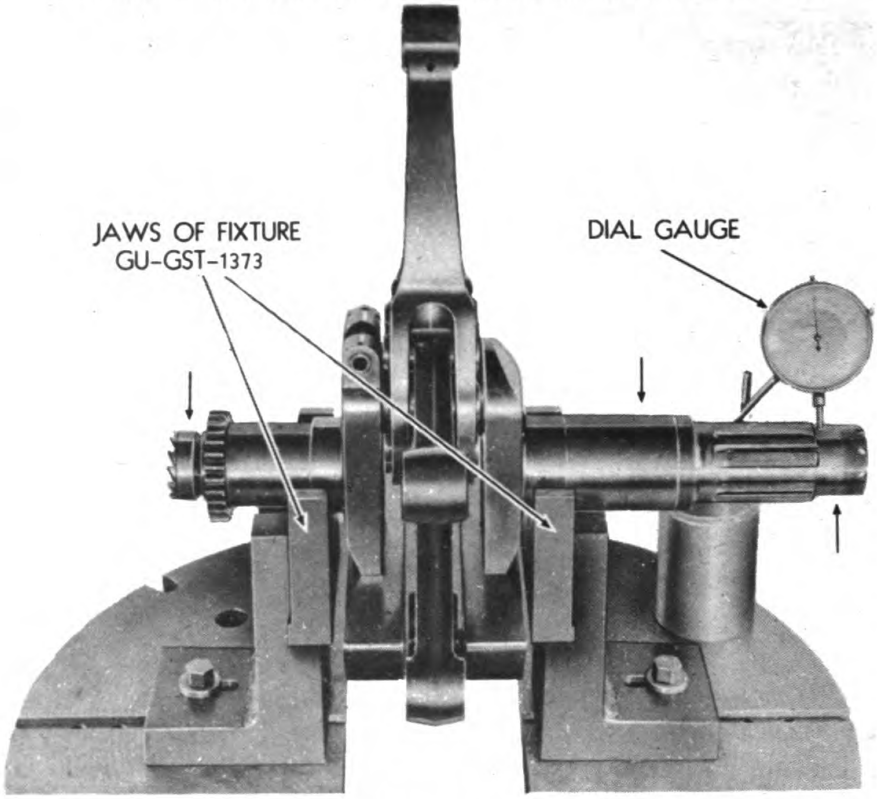


FIGURE 100—Checking crankshaft run-out. RA PD 6615

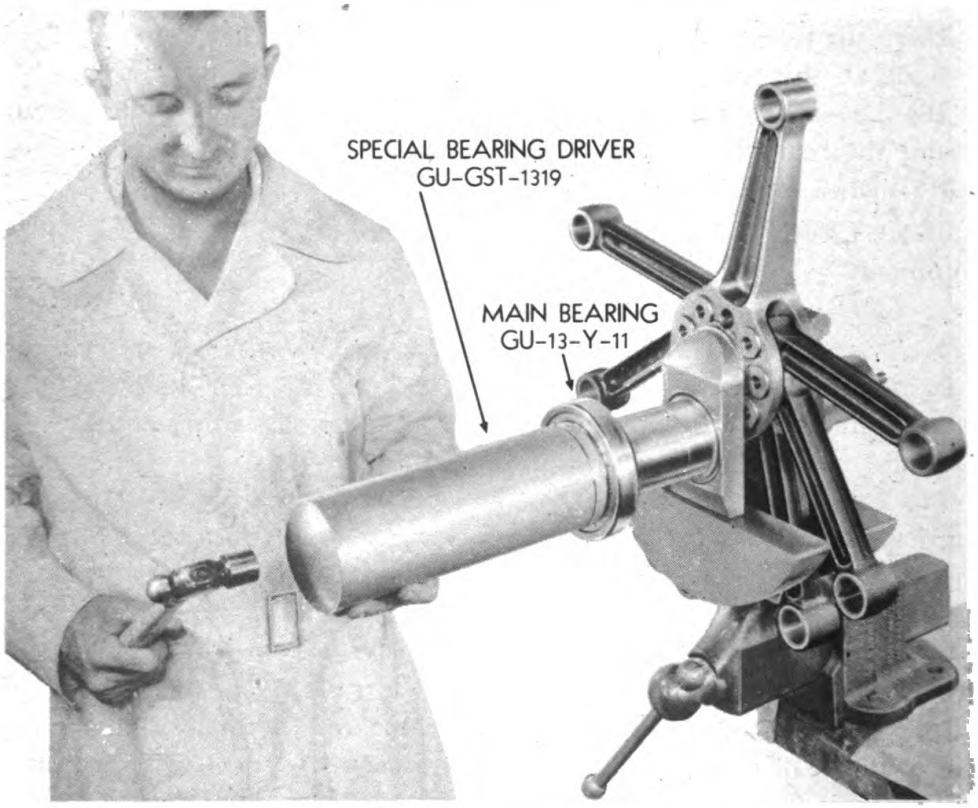


FIGURE 101—Driving main bearings onto the crankshaft. RA PD 6616

is greater than the limits shown in the chart below, tap the rear crankshaft slightly, to change the position of the counterweight, until the correct reading is obtained.

Run-Out Limits

At front end of shaft	.010"
At front bearing journal	.004"
At starter jaw	.003"

(3) 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 .005-inch to .006-inch over its original dimension. Then 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.

135. Install crankshaft main bearings *(fig. 101).* — *a. Equipment.* —

Micrometer	Crankshaft bearing driver GU-GST-1319

b. Procedure. — (1) The crankshaft main bearings are shrunk on the crankshaft to a fit of .0001-inch tight to .0011-inch tight. Use a micrometer on the crankshaft journals and on the inside of the bearings to make sure the fit will be within those limits. Then place the bearings in oil and heat until the oil reaches a temperature of 150°. This will expand the bearings so that they can be driven on the shaft.

(2) Clamp the crankshaft in a soft-jawed vise and as soon as the bearings are heated sufficiently, place the bearings on the shaft immediately, with the numbers on the bearing on the outside. Place the crankshaft bearing driver (GU-GST-1319) over the bearing, as shown in figure 101, and drive the bearings onto the shaft.

136. Install the crankshaft in the crankcase *(figs. 55 and 102).*

a. Equipment. —

Hoist	Front bearing nut wrench GU-GST-1307
Micrometer	Engine lifting eye GU-GST-1308
Crankshaft turning bar GU-GST-1344	Crankshaft bearing driver GU-GST-1319
$\frac{9}{16}$-inch socket wrench	
Compressed air	

b. Procedure. — (1) Place the rear crankcase on the engine mounting stand and bolt it through the engine mounting flange. Clean the crankcase thoroughly. Use an air hose to blow out all the oil passages. Inspect the throttle shaft bushing to make sure it is in good condition. Use a snap gage and micrometer to measure the diameter of the throttle shaft bushing for reference when the throttle shaft is inserted. Inspect the two passages for the oil sump to make sure they are clear.

(2) Attach the engine lifting eye (GU-GST-1308) to the front crankshaft and raise the crankshaft on a hoist, then lower it into the

crankcase, with the master connecting rod in No. 7 cylinder. (No. 1 cylinder is opposite the oil sump openings; number anticlockwise to No. 7).

(3) Clean the front crankcase and lower it over the rear crankcase, with the oil sump drain and steady rest tube clamp opposite No. 1 cylinder.

(4) Bolt the two halves of the crankcase together, with a washer at both the bolthead and nut. The bolthead is at the front crankcase. The long bolt goes at the oil sump openings. Use a soft hammer to drive the bolts through. Then install washers and screw on the elastic stop nuts, using a $\frac{9}{16}$-inch socket wrench. Put the connecting rod protectors over the cylinder hold down studs between each pair of cylinders. Place the front crankshaft sleeve over the front crankshaft.

(5) Heat the front crankshaft bearing in oil until the oil reaches a temperature of 150°, then place the bearing on the crankshaft immediately, with the open side of the bearing toward the engine. Use the bearing driver to force it down on the crankshaft and countersink the bearing so that it rests on the shoulder of the crankcase. Install the oil slinger with the tapered end down, and install the spacing washer. Then screw on the front bearing nut, with the side up that was in that position when the nut was removed. This can usually be told by marks made by the flywheel spacer. Use the front bearing nut wrench

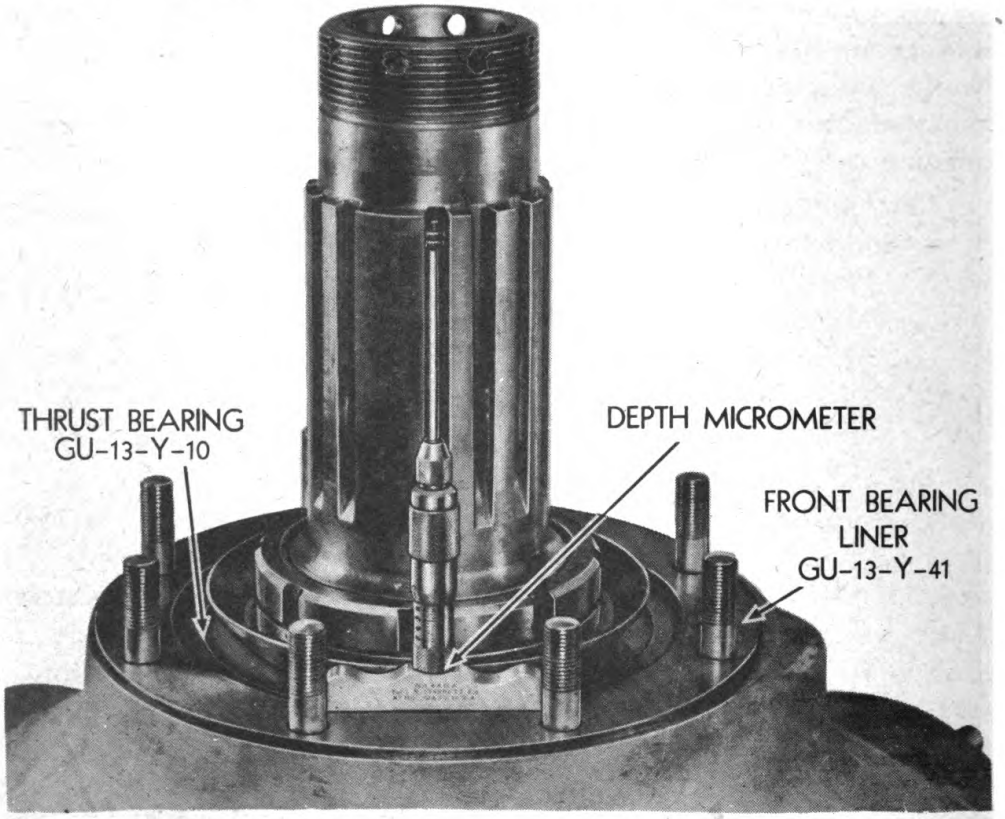


FIGURE 102—Measuring front bearing pinch. RA PD 6617

(GU-GST-1307) to draw the nut up as tight as possible, holding the crankshaft from turning by means of the crankshaft turning bar (GU-GST-1344).

(6) The front bearing plate is installed over the studs around the crankshaft, and must put a pinch of from .004-inch to .006-inch on the front bearing race. Use a depth micrometer to measure the distance from the front bearing liner to the bearing race, as shown in figure 102. Also measure the flange depth on the front bearing plate. These should total from .026-inch to .030-inch. Since the gasket will compress to .022-inch, this clearance will give the right amount of pinch. If the clearance is too great, grind down the flange of the front bearing plate to give this clearance.

(7) When a clearance of .026-inch to .030-inch is obtained, place a new gasket over the studs, being sure that the small holes in the gasket line up with the drain holes in the crankcase. Replace the front bearing plate, with the drain holes also lined up with those in the case. Replace the washers, nuts and palnuts using a $\frac{9}{16}$-inch socket wrench.

137. Install the valve cam and the decompression plate and fuel control assemblies *(fig. 103).* — *a. Equipment.* —

Narrow feeler gage	Depth micrometer
Pliers	$\frac{7}{8}$-inch socket wrench

b. Procedure. — (1) Turn the motor to a vertical position. Oil the rear crankshaft sleeve and place it on the crankshaft with the flange on the inside. If it is started straight it will push on by hand pressure.

(2) Place the valve cam and the decompression plate and fuel control assemblies on the sleeve, with the fuel control levers toward the engine and the valve cam out. The throttle segment should be between Nos. 1 and 2 cylinders.

(3) Insert the throttle shaft into its bushing in the rear crankcase, and mesh the teeth with those on the throttle segment. The throttle shaft teeth should be located to give the maximum amount of roll as the shaft is turned, and so that the end tooth rides on the end tooth of the throttle segment.

(4) Use a narrow feeler gage to measure the backlash between the throttle shaft teeth and segment teeth. This should be from .002-inch to .004-inch. With wide open throttle, the clearance between the last throttle tooth and the base of the segment should be .020-inch. Adjustment is made by the adjusting bolt which rests on the throttle shaft gear.

(5) If a new front crankshaft sleeve has been used, it will be necessary to make sure that there will be sufficient clearance between the bolts on the decompression plate and fuel control assembly and the valve tappets. Insert a valve tappet and guide into position and use a feeler gage to measure the clearance. If it is less than .015-inch, remove

the front bearing plate and front bearing, and replace the front crankshaft sleeve with a longer sleeve.

(6) With the valve tappet still in position, use a depth micrometer to measure the distance from the side of the valve tappet roller to the edge of the valve cam. This should be .020-inch to .040-inch to make sure that the rollers are centered on the valve cam.

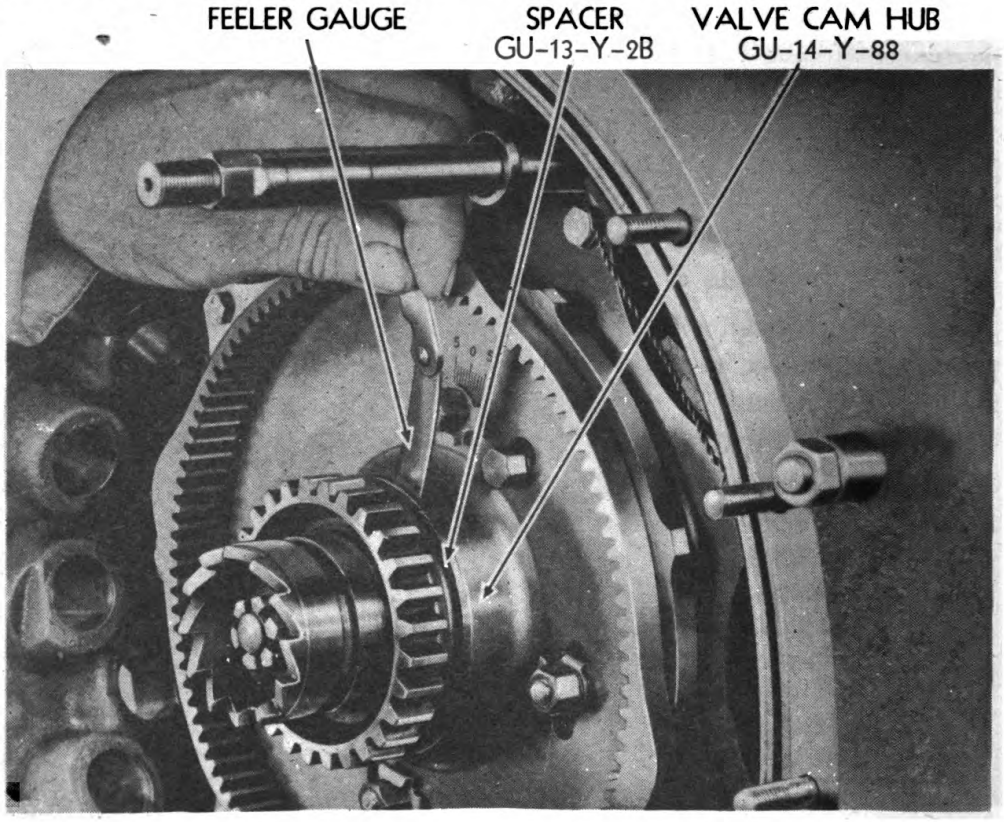
(7) Install the rear crankshaft spacer on the rear crankshaft. Install the starter jaw and the nut using a 7/8-inch socket wrench. With a feeler gage measure the clearance between the spacer and the valve cam hub. This was originally .006-inch loose to .015-inch loose, and has a limit of .025-inch loose. If the clearance is not sufficient, grind the cam hub down to give the required clearance. With the correct clearance, insert the cotter pin in the starter jaw nut.

138. Install the fuel pressure regulator. — *a. Equipment.* —
3/4-inch open-end wrench

b. Procedure. — Screw the fuel pressure regulator into the opening at the top of the engine, using a 3/4-inch open-end wrench.

139. Install the fuel check valve. — *a. Equipment.* —
7/8-inch open-end wrench

b. Procedure. — Screw the fuel check valve into the opening at the bottom of the engine, using a 7/8-inch open-end wrench.



RA PD 6618

FIGURE 103—Measuring clearance between spacer and valve cam hub.

140. Install the fuel injection pumps *(fig. 46).* — *a. Equipment.* —

Injection pump puller GU-GST-1365
½-inch open-end wrench

b. Procedure. — **NOTE:** When installing the fuel injection pumps, it is important to make sure that the small flat rider on the end of the plunger is at the same angle as the fuel control lever on which it operates.

(1) 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.

(2) Screw the adapter of the fuel pump puller (GU-GST-1365) on the nipple of the fuel pump, then push the fuel pump into the crankcase, with the small cut-out section of the flange next to the valve guide opening to allow clearance for the guide. Install the washers and nuts, using a ½-inch open-end wrench, but not the palnuts. **NOTE:** The oil seal should be oiled and the fuel pumps installed one at a time. The oil causes the seal to swell, and unless it is inserted immediately, the seal will not pass through the opening. If the oil seal seems to catch when the pump is forced in, remove the pump and replace the oil seal. Be sure to remove any pieces of the seal from the opening.

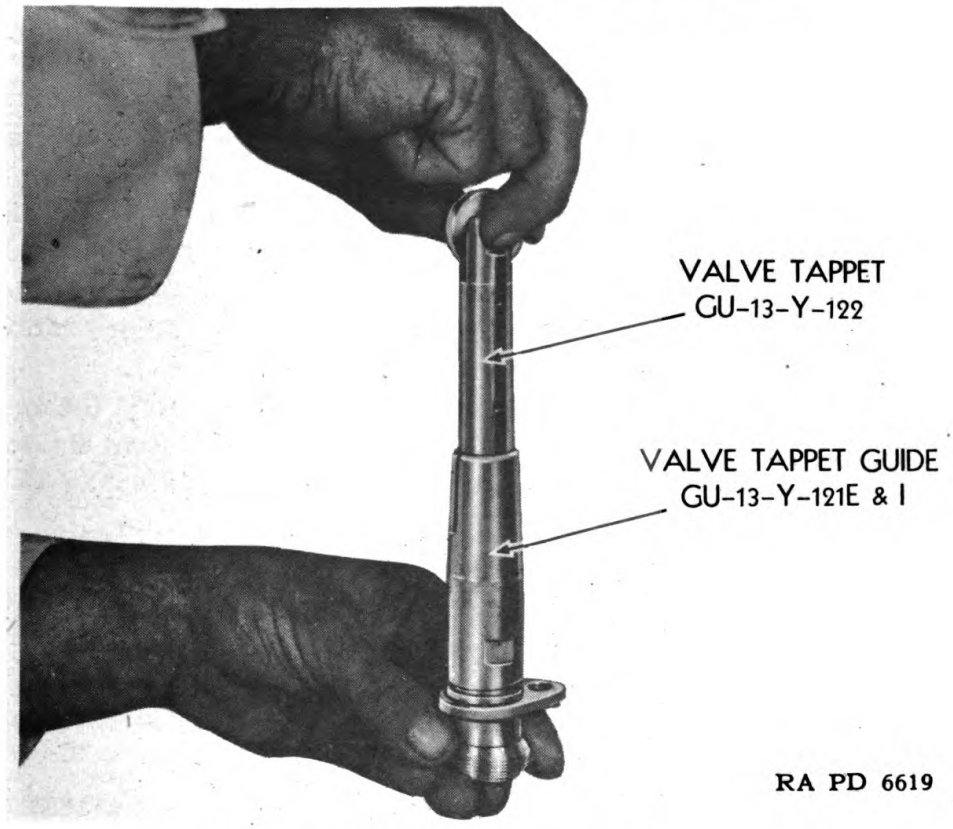


FIGURE 104—Valve tappet and guide.

141. Test the fuel pumps. — *a. Equipment.* —

Fuel supply hose

b. Procedure. — (1) When all of the fuel injection pumps have been installed, they should be tested for leaks. Cover the nipples of the fuel pressure regulator with caps. Attach a fuel supply hose to the check valve and allow the fuel to enter.

(2) If the fuel comes out of any injection pump in quantity, remove the pump and replace the rubber seal. Be sure to remove any pieces of rubber that may have been sheered from the rubber seal.

(3) Some fuel may dribble from some of the injection pumps. In that event, allow the fuel to remain until the rubber oil seal has had a chance to swell. If fuel still leaks, pull the injection pump and replace the rubber oil seal.

(4) When all the injection pumps are tight and leakproof, install the palnuts on the fuel pump mounting studs.

142. Install the valve tappets and guides *(figs. 49 and 104).* — *a. Equipment.* —

Valve tappet guide puller GU-GST-1358	Accessory case puller GU-GST-1360
Screwdriver	Pliers

b. Procedure. — NOTE: Turn the engine mounting stand so that the rear of the engine is facing upward. Before the tappets are installed, the graduated marking on the valve cam should be lined straight with No. 1 cylinder. The valve guides are marked "intake" and "exhaust." The exhaust opening is the right of each of the series of two openings, and the intake the left.

(1) Remove the valve tappet from the guide, holding the pin to prevent the pin and roller from dropping out. Note the oil holes on one side of the tappet, and the air vent in the guide. The tappet should be replaced in the guide with the oil holes on the same side in relation to the air vent as when it was removed. Oil the tappet.

(2) Insert the valve guide into the proper opening from the outside of the crankcase, and slide the tappet into the guide from inside the crankcase. Use the valve tappet guide puller (GU-GST-1358) *(fig. 49),* to push the guide up into position.

(3) Screw the T-shaped accessory case puller (GU-GST-1360) into the flange of the guide and into the bolt hole in the crankcase to aline them. Withdraw the tool and install the washers and cap screws with a screwdriver. Safety-wire the cap screws together by pairs.

(4) When the tappets and guides are installed, move the tappets and rollers to be sure they operate freely.

143. Check starter jaw run-out *(fig. 105).* — *a. Equipment.* —

Crankshaft turning bar GU-GST-1344	Dial gage

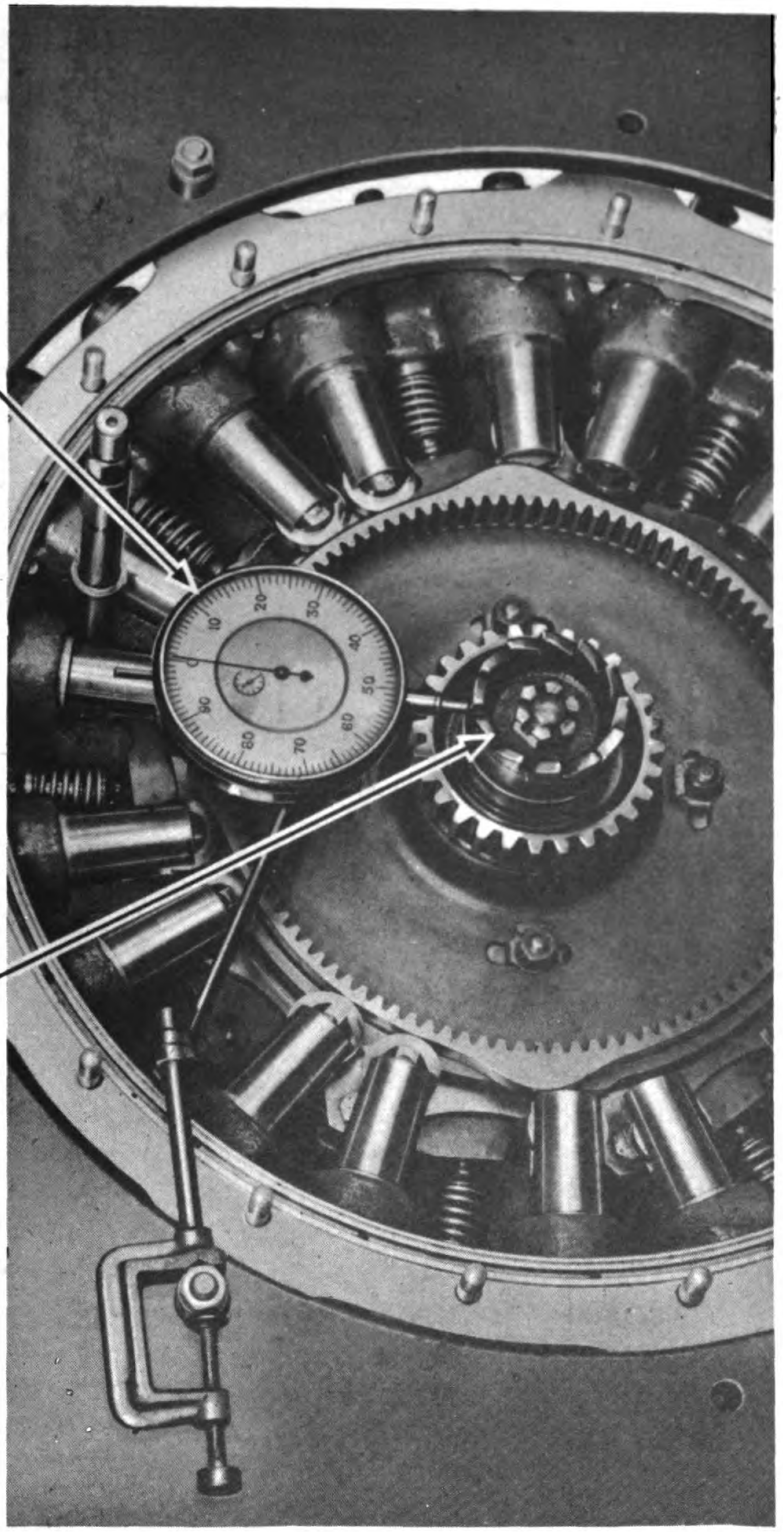


FIGURE 105—Checking starter jaw run-out.

b. Procedure. — Turn the engine perpendicularly. Clamp a dial indicator to one of the nuts on the engine mounting stand, or any convenient support. Rest the stem of the dial indicator on the starter jaw, as shown in figure 105. Set the dial at zero. Install the crankshaft turning bar (GU-GST-1344) on the front crankshaft and turn the crankshaft, taking a reading on the dial indicator. Run-out should be .003-inch limit. If run-out is not within the limits, remove the starter jaw nut and starter jaw. Turn the starter jaw to a different position and check again. Repeat until the run-out is within the limit. Turn the crankshaft slowly, as jarring of the rods might affect the reading of the dial indicator.

144. Install the valve assemblies *(figs. 62 and 63).* — *a. Equipment.* —

Cylinder mounting block	$\frac{9}{16}$-inch open-end wrench
Valve spring compressor GU-GST-1353	Pliers
Soft hammer	Rocker support pin aliner GU-GST-1336
	Soft drift

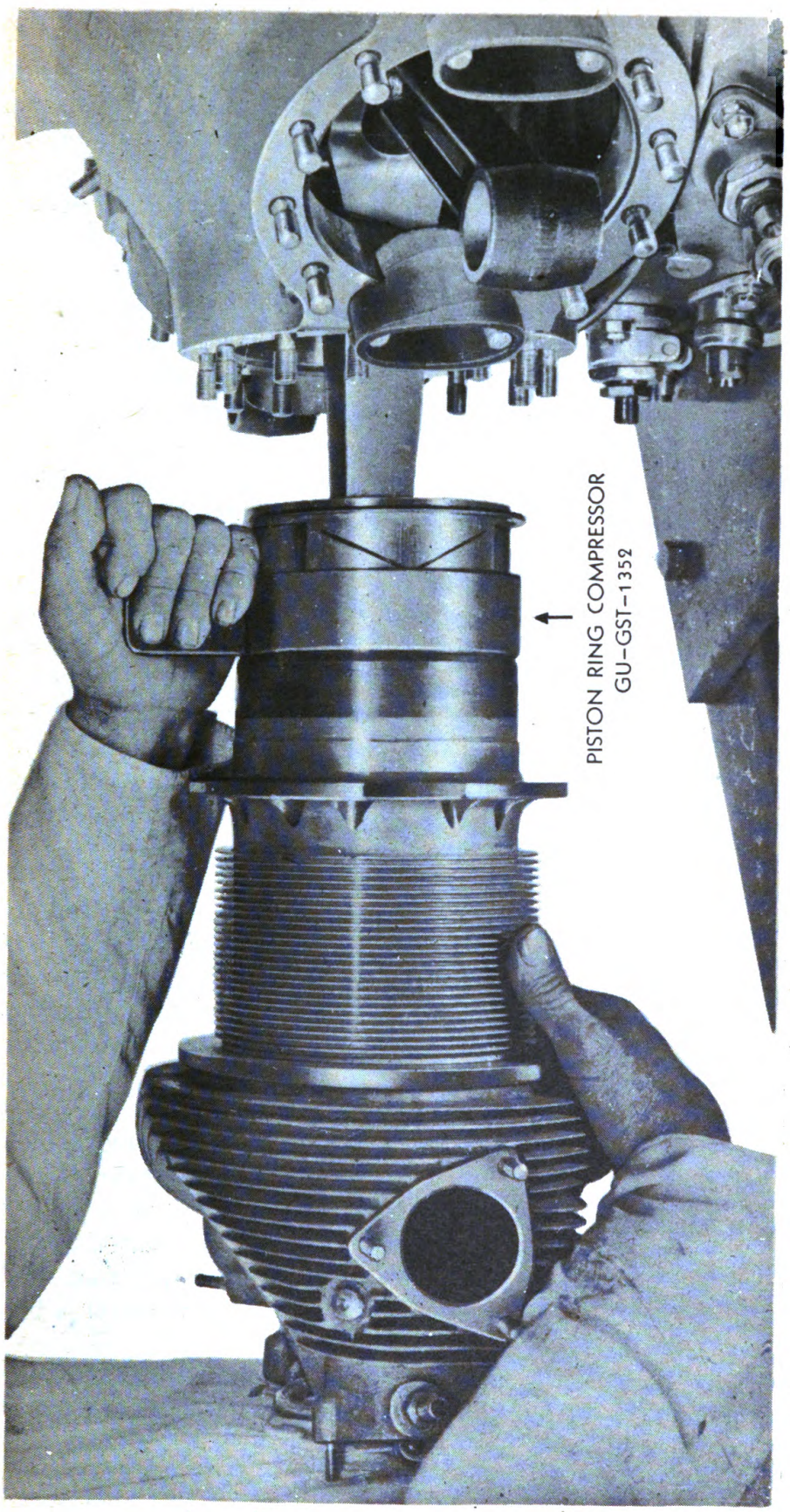
b. Procedure. — (1) Oil the valve stems and insert them into the valve guides from the inside of the cylinder. The intake and exhaust valves and guides are different sizes, so it will be impossible to get the valves into the wrong guides. Place the cylinder barrel over the cylinder barrel mounting block *(fig. 62)*. This block will hold the valves in position.

(2) 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 with pliers, making sure that none of the ring projects beyond the surface of the stem.

(3) Drop the lower valve spring retaining 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.

(4) Install the valve spring compressor (GU-GST-1353) on the rocker box, with the rocker support pin aliner (GU-GST-1336) through the rocker shaft opening and the inner brace of the compressor *(refer to fig. 63)*. Push the handle of the compressor down 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.

(5) Remove the valve spring compressor and take the cylinder off the mounting block. Tap the valve with a soft hammer to seat the keepers.



RA PD 6621

FIGURE 106—Installing a cylinder barrel.

(6) 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, using a $\frac{9}{16}$-inch open-end wrench, and insert a cotter pin.

(7) Repeat this operation to install the valves and rocker arms on all cylinders. Check the rocker arms after they are installed to make sure they work freely.

145. Install pistons and cylinder barrels *(figs. 106 and 107).* — *a. Equipment.* —

Piston ring compressor GU-GST-1352	Crankshaft turning bar GU-GST-1344
Torque wrench	Cylinder hold-down nut wrench GU-GST-1432

b. Procedure. — NOTE: Turn the motor horizontally and with the front facing upward. Always start on No. 7 cylinder, which has the master connecting rod. No. 7 piston has an "X" groove in the skirt of the piston. As each piston and cylinder barrel is installed, turn the motor with the crankshaft turning bar (GU-GST-1344) until the connecting rod is in its furthest out position. This can be told by the wide spline on the crankshaft, which faces the cylinder when the piston is at the top of its stroke. Remove the connecting rod protectors from each cylinder as the piston and cylinder barrel are installed.

(1) Install the piston on the rod so that the piston number is up. The piston pin is also inserted with the number up. Oil the piston pin and press it through the piston pin bushing and connecting rod bushing. Replace the caps at each end of the piston pin.

(2) Slide the piston rings so that all gaps are up and in line, and 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 up against the mounting flange to act as an oil seal. Oil the cylinder barrel, spreading it evenly over the barrel surface by hand.

(3) A piston ring compressor (GU-GST-1352) is used to hold the piston rings while the barrel is installed, as shown in figure 106. Holding the cylinder barrel so that the push rod openings are down, 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.

(4) Move the barrel up on the mounting studs. Install the washers and nuts around the barrel, using the cylinder hold-down nut wrench, but do not install the palnuts. Nuts should be installed at 180° intervals around the cylinder barrel, and then tightened evenly in the same way.

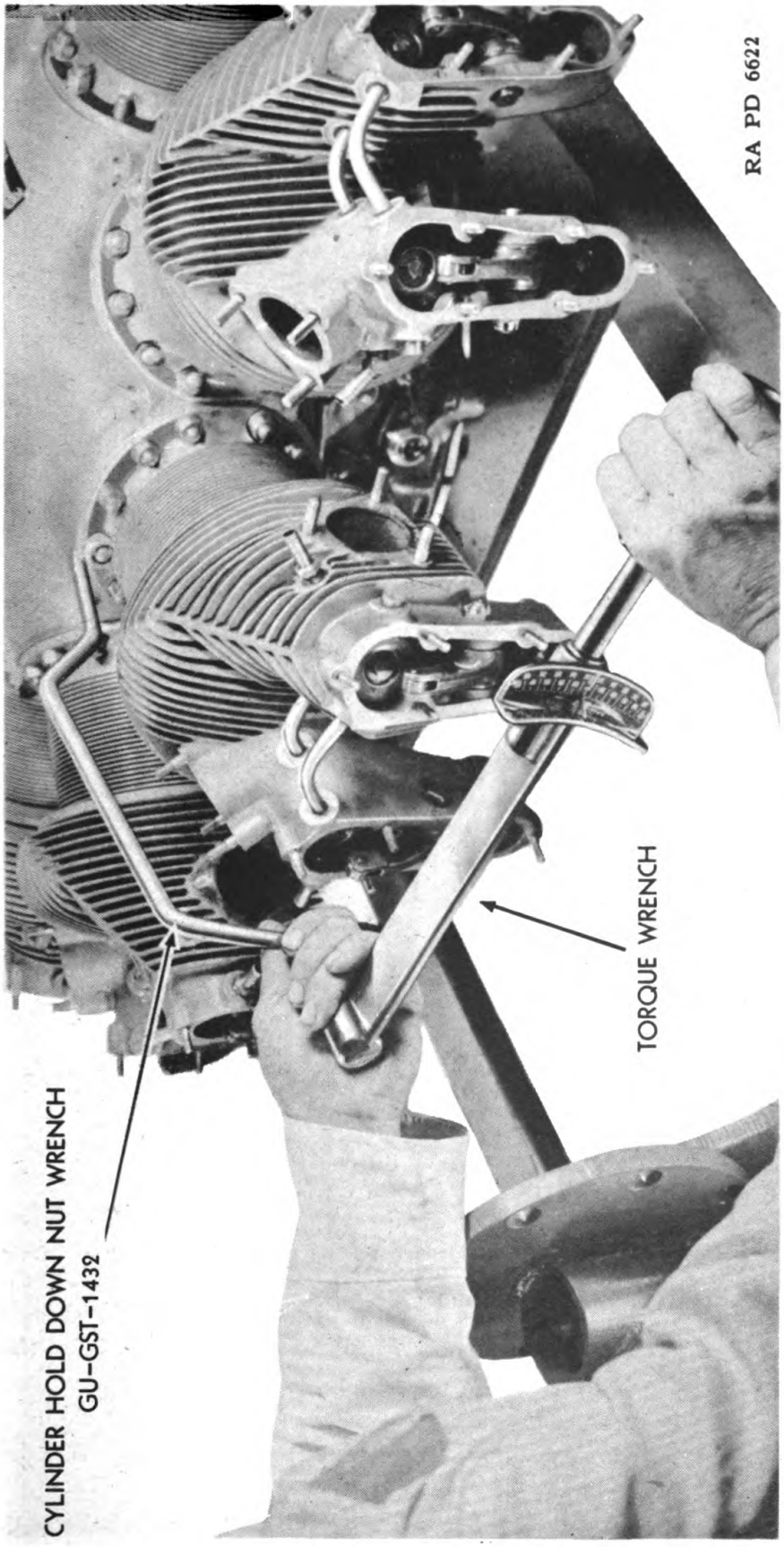


FIGURE 107—Tightening cylinder hold-down nuts with torque wrench.

(5) Repeat this operation until all cylinder barrels are installed.

(6) The nut at the left of each cylinder nearest the crankcase bolt does not need to be installed, as the baffle support will be placed there later, except on number six cylinder where the baffle is supported on the oil sump.

CAUTION: Be very careful that nothing is dropped into the inlet or exhaust openings while working on the engine.

(7) Tighten the nuts with a torque wrench, exerting 40 foot pounds of torque, and at 180° intervals around the barrel. Then replace the palnuts.

146. Install the push rod housings *(fig. 38).* — *a. Equipment.* —

Soft drift	Push rod housing nut wrench GU-GST-1306

b. Procedure. — (1) 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. The push rod housings are interchangeable for both intake and exhaust, and for all cylinders. A rubber gasket is placed over the shoulder of the valve tappet guide. Be 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. Tighten the circular nuts, using the push rod housing nut wrench (GU-GST-1306).

(2) A push rod housing cannot be installed when a tappet is at the high point of the cam lobe, because the tappet will project too far beyond the crankcase. Install the push rod housings at the cylinders at which the tappets are not resting on the high point of the cam. Then turn the valve cam until the tappets of the other cylinders rest on a lower point of the cam and install the push rod housings. Before the push rods are installed, the valve cam can be turned by using a fiber drift on the teeth of the valve cam.

147. Install the push rods *(fig. 108).* — *a. Equipment.* —

Crankshaft turning bar GU-GST-1344	Oil can
	Screwdriver

b. Procedure. — NOTE: Notice the arrow in the end of the push rod. This end goes in toward the crankcase, so that it rests on the tappet. The rod is drilled to carry oil to the rocker arm. At 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, so that the push rod is always full of oil. Before inserting the push rod, insert an oil can nipple into the oil passage at the arrow end and fill with oil until it comes out the other end.

(1) Remove the adjusting screws from the rocker arms. The push rods are inserted through these openings.

(2) Insert the arrow end of the rod into the push rod housing and

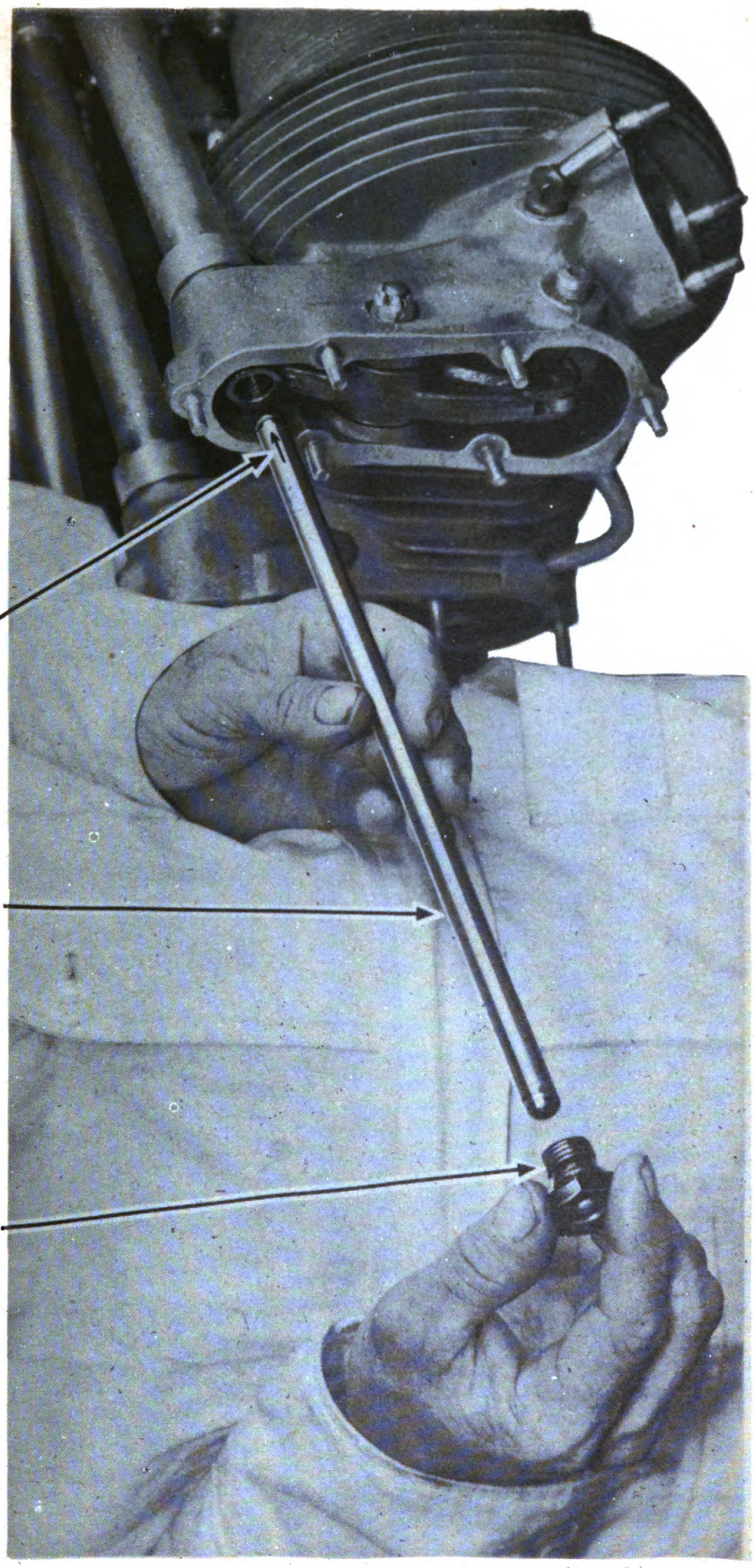


FIGURE 108—Installing the push rods.

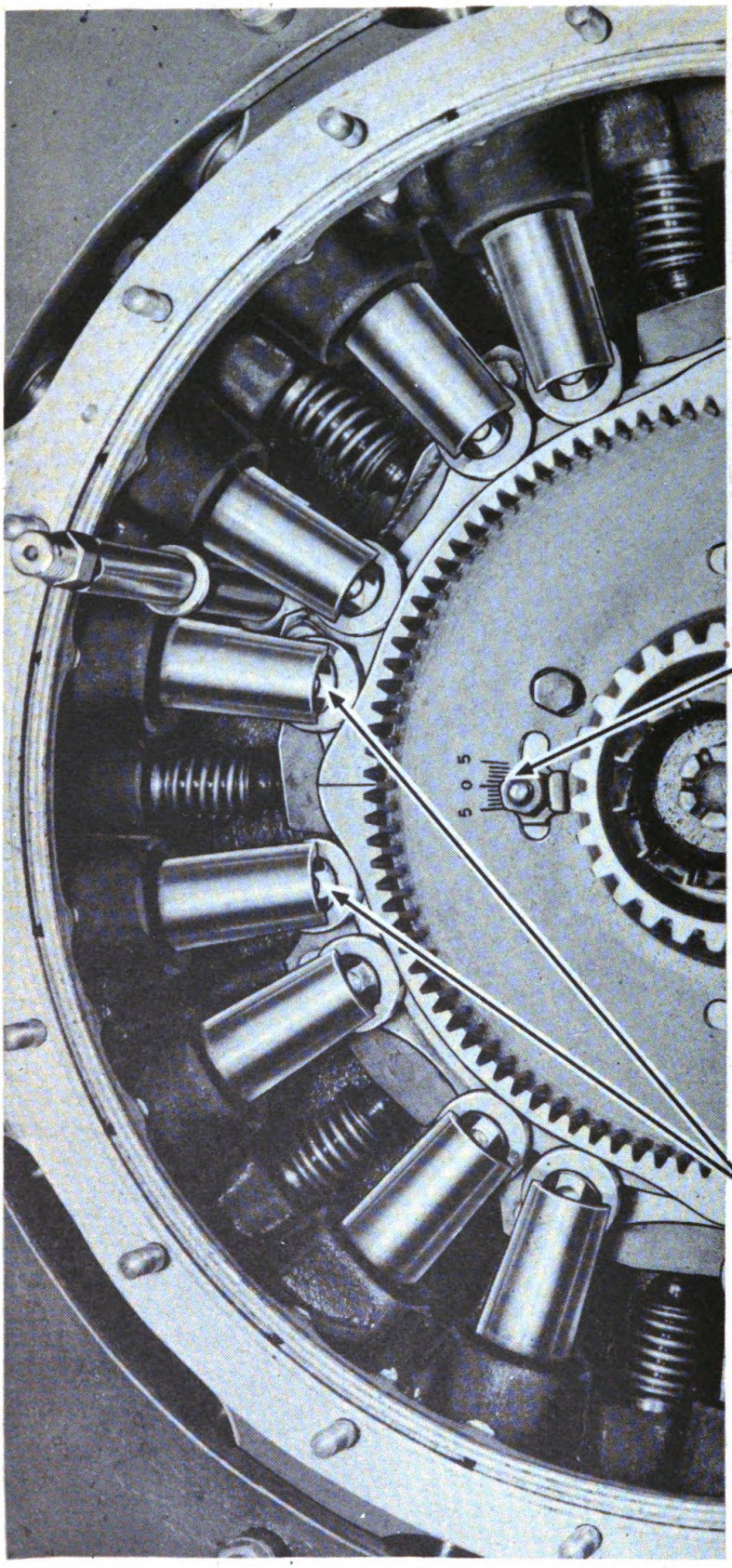


FIGURE 109—Tappet pins must be in same position.

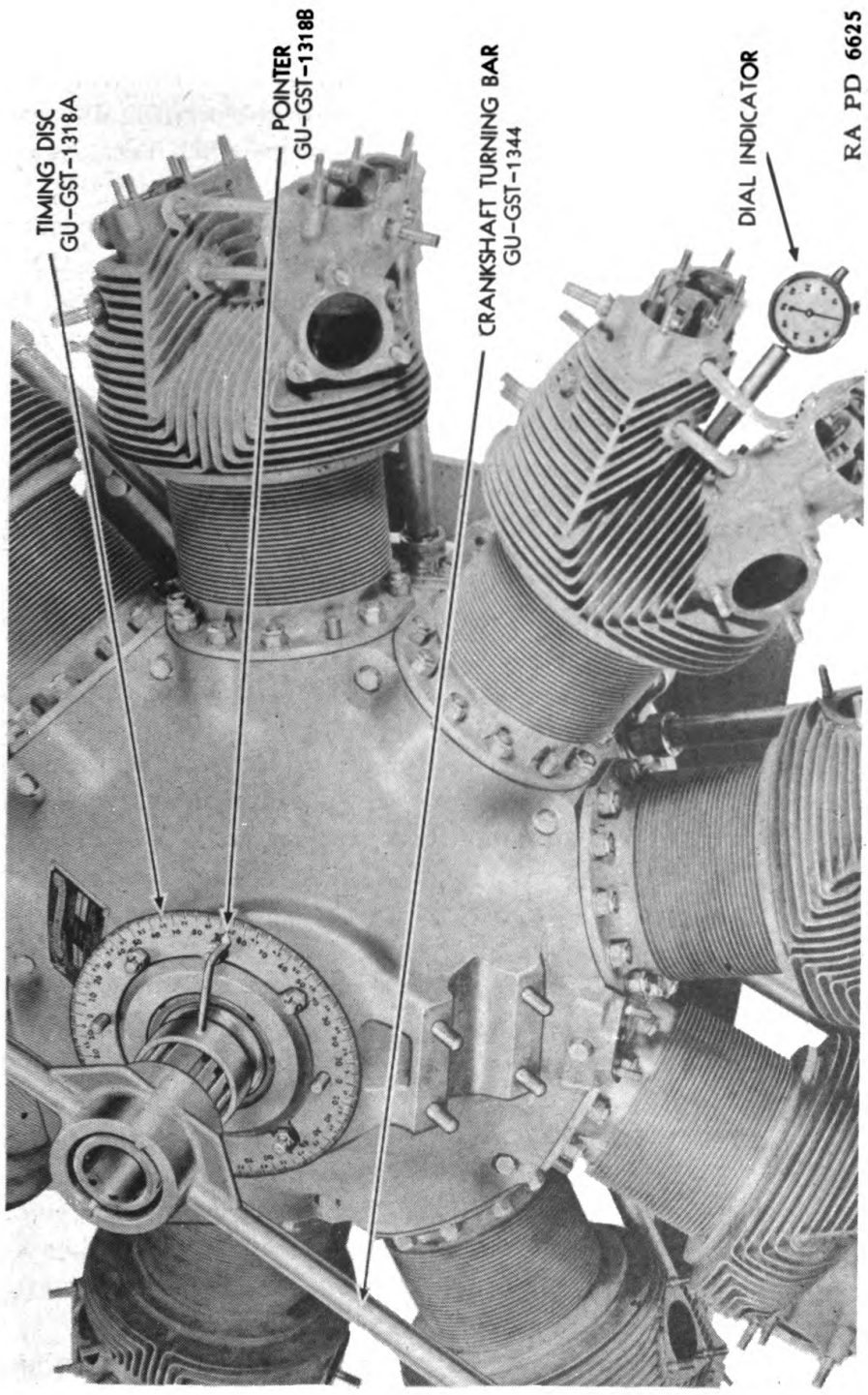


FIGURE 110—Timing the engine.

replace the adjusting screw. The push rods are not numbered and are interchangeable for all cylinders and for intake and exhaust. Screw the adjusting screws into the rocker arm until the tappets are tight against the cam. This will hold the cam in place.

(3) The push rods will not go in the tappets which are on the high lobe of the cam. Leave these out, then use the crankshaft turning bar (GU-GST-1344) to turn the valve cam so that these can be installed.

(4) Turn the engine so that the rear of the engine is facing upward. Turn the valve cam until the pins in the two tappets at the top are exactly an equal distance out of the guide, as shown in figure 109. It is important that this be exact for the valve timing procedure which follows.

148. Locating top dead center for No. 7 cylinder *(fig. 110).* —

a. Equipment. —

Crankshaft turning bar GU-GST-1344	Timing disk and pointer GU-GST-1318
Dial indicator	Top center indicator holder GU-GST-1355

b. Procedure. — NOTE: *Be sure the throttle is in wide open position for all timing operations.*

(1) The timing operations start with No. 7 cylinder (master rod cylinder). Remove the thrust plate from the front crankshaft, and install the timing disk (with one zero mark up, and the opposite zero mark down). Clamp the timing pointer at the center of the wide spline on the crankshaft. Place the crankshaft turning bar (GU-GST-1344) on the front crankshaft. Turning the crankshaft until the pointer is towards No. 7 cylinder will bring No. 7 piston to *approximate* top dead center. The next step is to set the timing pointer so that it will be at 60° on the timing disk when the piston is at exact top center.

(2) Install the top center indicator holder (GU-GST-1355) in the opening for No. 7 fuel injector, with its pointer parallel with the center line of the cylinder, and not at an angle.

(3) Turn the crankshaft until the lowest point on the dial indicator is reached. Set the dial indicator at zero at this point.

(4) Turn the crankshaft back about 30° (clockwise) to take out backlash. Move forward (anticlockwise) until the indicator reads zero, then continue until the dial indicator shows .010 inch and observe the degree reading of the timing pointer on the timing disk.

(5) Continue to turn the crankshaft anticlockwise until the No. 7 piston has passed top center, and the dial indicator is again at its lowest position.

(6) Turn clockwise until the dial indicator registers .010-inch, and again observe the degree reading of the timing pointer on the timing disk.

(7) Divide the difference between the two readings by two, and add to the lower degree reading.

(8) Turn the crankshaft until the pointer is on the figure obtained in the previous operation.

(9) Without disturbing the crankshaft, loosen the timing pointer, and reset it at 60° on the timing disk (bottom center for No. 7 piston).

(10) When the wide spline of the crankshaft is toward No. 7 cylinder and the timing pointer is at 60° on the disk, No. 7 piston will be at exact top center.

149. Install the generator drive on the accessory case. — *a. Equipment.* —

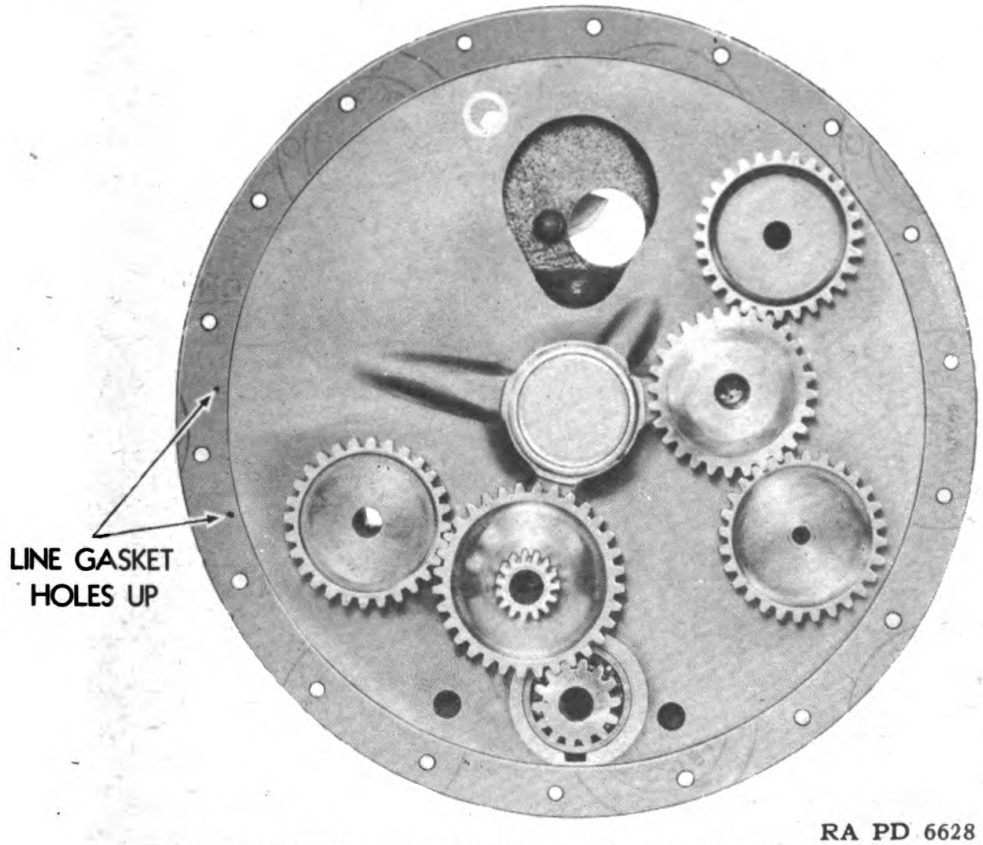
½-inch open-end wrench

b. Procedure. — Place the generator drive in position on the accessory case, and install the washers, nuts and palnuts, using a ½-inch open-end wrench.

150. Install the accessory case *(fig. 111).* — *a. Equipment.* —

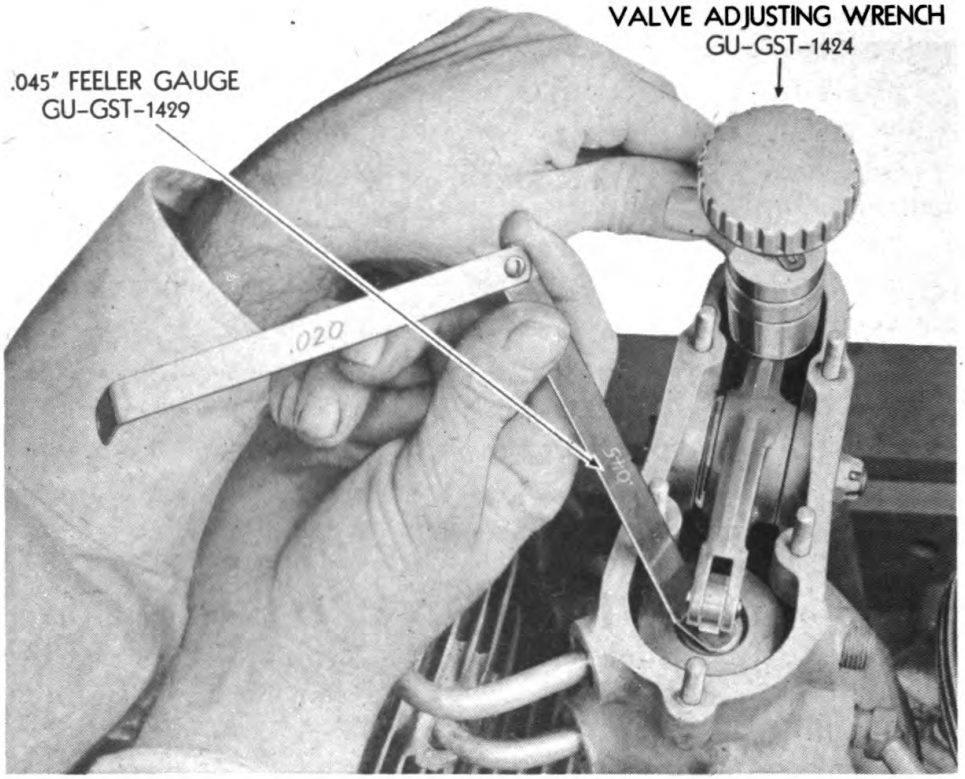
Crankshaft turning bar GU-GST-1344
½-inch socket wrench
Timing disk and pointer GU-GST-1318

b. Procedure. — (1) Place a gasket on the accessory case, being sure that the two small holes, as indicated by the arrows in figure 111



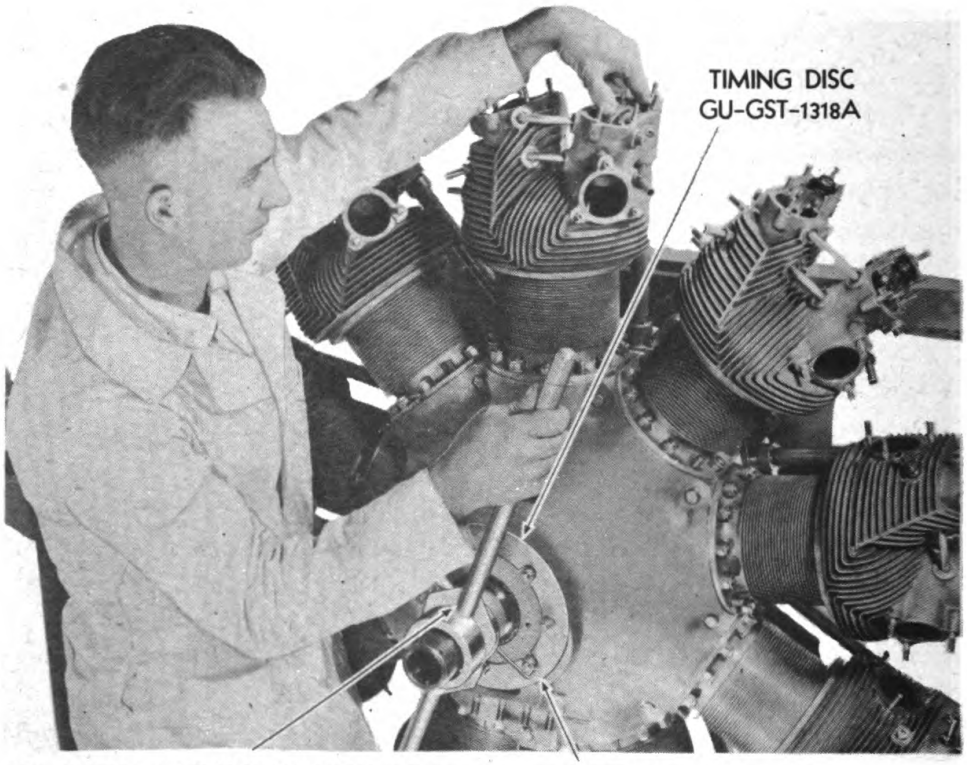
RA PD 6628

FIGURE 111—Placing the gasket on the accessory case.



RA PD 6629

FIGURE 112—Setting valve tappets to .045 inch clearance.



RA PD 6630

FIGURE 113—Valve timing No. 1 cylinder.

are directly lined up with the similar holes in the accessory case. This is the passage for the oil into the circular channel in the crankcase.

(2) With the gasket in place, and with the pointer of the timing disk pointing to 60°, or top center for No. 7 cylinder, hold the accessory case up to the rear crankcase and place in position with the gears meshed. *Be careful not to turn the valve cam gear.*

(3) To install the accessory case, the valve cam intermediate gear must mesh with the starter jaw gear, and the pinion gear must mesh with the internal gear of the valve cam at the same time. If they do not mesh, the accessory case cannot be bolted in place. In that case, remove the case and turn the intermediate gear one tooth and try again.

(4) When the accessory case is installed and the gears are in mesh, recheck the top dead center of No. 7 piston to make sure that the valve cam assembly was not disturbed while installing the accessory case. If the valve cam was disturbed, the accessory case must be removed and top dead center located again.

151. Valve timing No. 1 cylinder *(figs. 112 and 113).—a. Equipment.* —

	Crankshaft turning bar
Feeler gage	GU-GST-1344
Valve adjusting wrench	Timing disk and pointer
GU-GST-1424	GU-GST-1318

b. Procedure. — (1) No. 1 cylinder is chosen for valve timing because it is the most accessible. Turn the crankshaft turning bar (GU-GST-1344) to place the piston in No. 1 cylinder at top dead center, or so the timing pointer (GU-GST-1318) is pointing to zero on the timing disk (GU-GST-1318). If the exhaust rocker arm at No. 1 cylinder moves while the crankshaft is turned, the valve is on the exhaust stroke. If it does not move, turn the engine one complete revolution.

(2) Adjust the intake and exhaust tappets on No. 1 cylinder, using a .045-inch feeler gage with an angle end, as shown in figure 112. It is very important that both tappets be adjusted as nearly identical as possible. Use the valve adjusting wrench (GU-GST-1424) to adjust the clearance.

(3) Place the fingers on the adjusting nut of the exhaust valve to press the oil out from under the end of the push rod, and exert a slight pressure with the thumb on the roller to turn it, as shown in figure 113. Turn the crankshaft turning bar in the direction of rotation, or counterclockwise, until the roller just begins to tighten and will not rotate freely under the thumb. This indicates that the exhaust valve is just starting to open. Take a reading on the timing disk, which will be before bottom center.

(4) Now, hold the hand in the same position on the intake valve, and continue the crankshaft rotation to get the reading with the intake and exhaust tappets operating on the same lobe of the valve cam. When

the roller starts to tighten, the intake valve is beginning to open. Make a notation of the reading on the timing disk, which is before top center.

(5) Place the fingers on the exhaust rocker arm and continue the crankshaft rotation to get the reading of the exhaust valve closing after top dead center.

(6) Then, with the fingers on the intake rocker arm, continue the crankshaft rotation to get the intake valve closing after bottom center. 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.

(7) If these two figures do not balance, divide the difference between them by two and add to the smaller number. Turn the crankshaft turning bar until the pointer is at this new number on the timing disk. Then remove the accessory case so that the crankshaft can be turned without turning the valve cam. Turn the crankshaft turning bar until the pointer is at zero on the timing disk. Both the piston and the valve cam will now be at top center for No. 1 cylinder.

(8) Replace the accessory case, being careful not to disturb the valve cam, and install the washers, nuts and palnuts, using a ½-inch socket wrench.

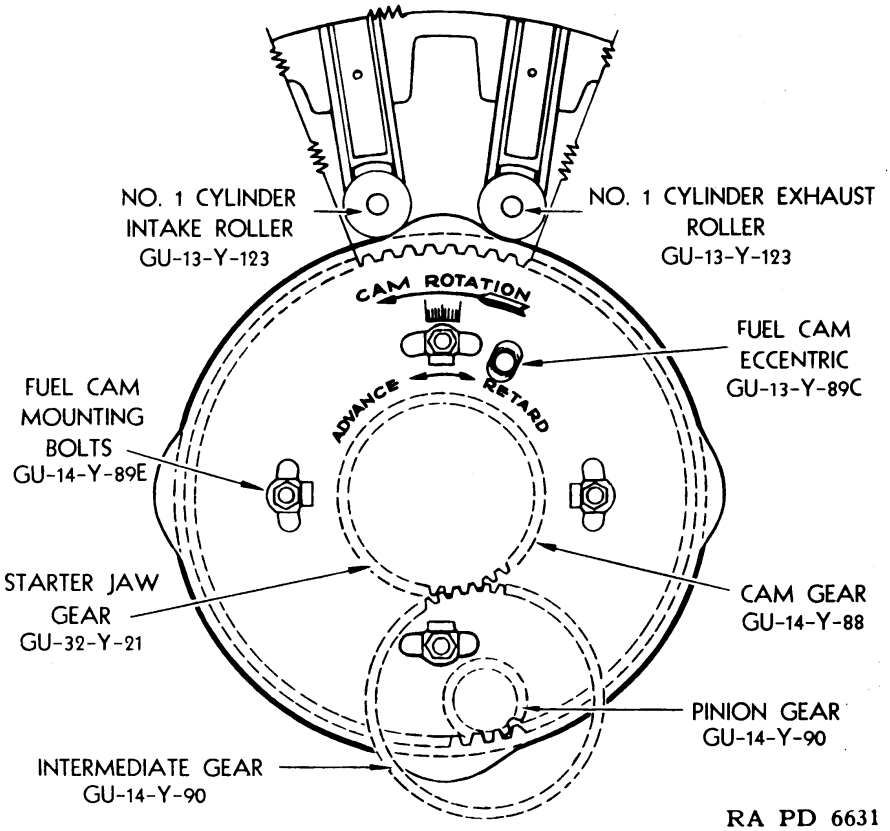


FIGURE 114—Fuel timing diagram.

152. Adjust tappets for running clearance. — *a. Equipment.* —

Crankshaft turning bar GU-GST-1344
Timing disk and pointer GU-GST-1318
Feeler gage
Valve adjusting wrench GU-GST-1424
$\frac{7}{16}$-inch box or open-end wrench

b. Procedure. — (1) Turn the crankshaft turning bar so that the timing pointer is at No. 1 cylinder with the piston on the compression stroke. (Hold the thumb over the fuel injector opening. A rush of air when the crankshaft is turned will indicate that the piston is on the compression stroke.) Use a .020-inch feeler gage to measure the valve clearance, and turn the adjusting screw with the valve adjusting wrench to get this clearance.

(2) Repeat this at the other cylinders, following their firing order rotation, which is 1-3-5-7-9-2-4-6-8. To facilitate setting the valves, the following suggestions are offered. After the engine has been brought to top dead center on the compression stroke on No. 1 cylinder, remove the turning bar and put it back on the crankshaft with the handle on the centerline of No. 1 cylinder. Then to find top dead center on compression of the next cylinder (No. 3) turn the crankshaft turning bar in the direction of rotation until the handle is on the centerline of No. 3 cylinder. Set the valves. Continue this procedure for the rest of the cylinders.

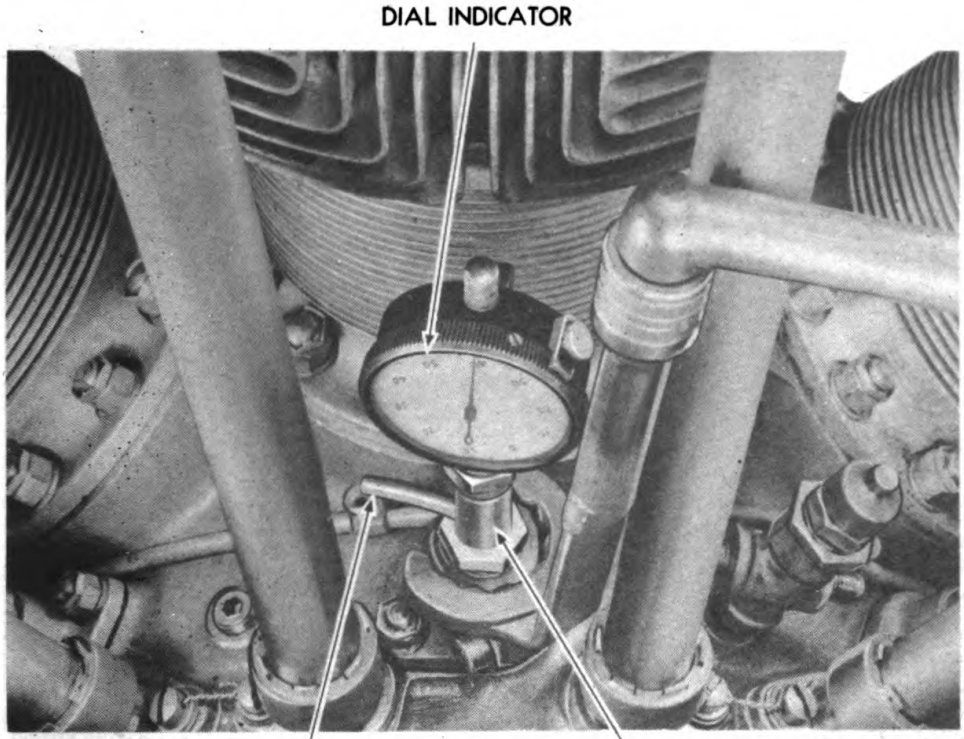


FIGURE 115—Fuel timing the engine.

(3) Oil the rocker arms thoroughly. Install new gaskets, and install the rocker box covers. Note the slight elevation in one corner of each rocker box cover. This goes to the outside. Leave the covers off of Nos. 5 and 6 inner rocker boxes which contain the rocker box scavenger sumps. Replace the washers and elastic stop nuts, using a $\frac{7}{16}$-inch box or open-end wrench, tightening the four center nuts first.

153. Fuel timing the engine *(figs. 114, 115 and 116).* — *a. Equipment.* —

Fuel pump indicator holder GU-GST-1351
Injector pump balancing wrench GU-GST-1419
Timing disk and pointer GU-GST-1318
Dial indicator with ½-inch travel
Crankshaft turning bar GU-GST-1344
⅞-inch open-end wrench
½-inch open-end wrench
Feeler gage

b. Procedure. — NOTE: The purpose of fuel timing is to get the injection of fuel to occur at the right time on the piston stroke. If the valve cam and fuel ring were not disassembled, the engine will not require fuel timing. The fuel timing is also done at No. 1 cylinder because this cylinder is most accessible.

(1) Remove the union, spring and check valve from the fuel injection pump, using a ⅞-inch open-end wrench. Insert the fuel pump indicator holder (GU-GST-1351) with the dial indicator as shown in figure

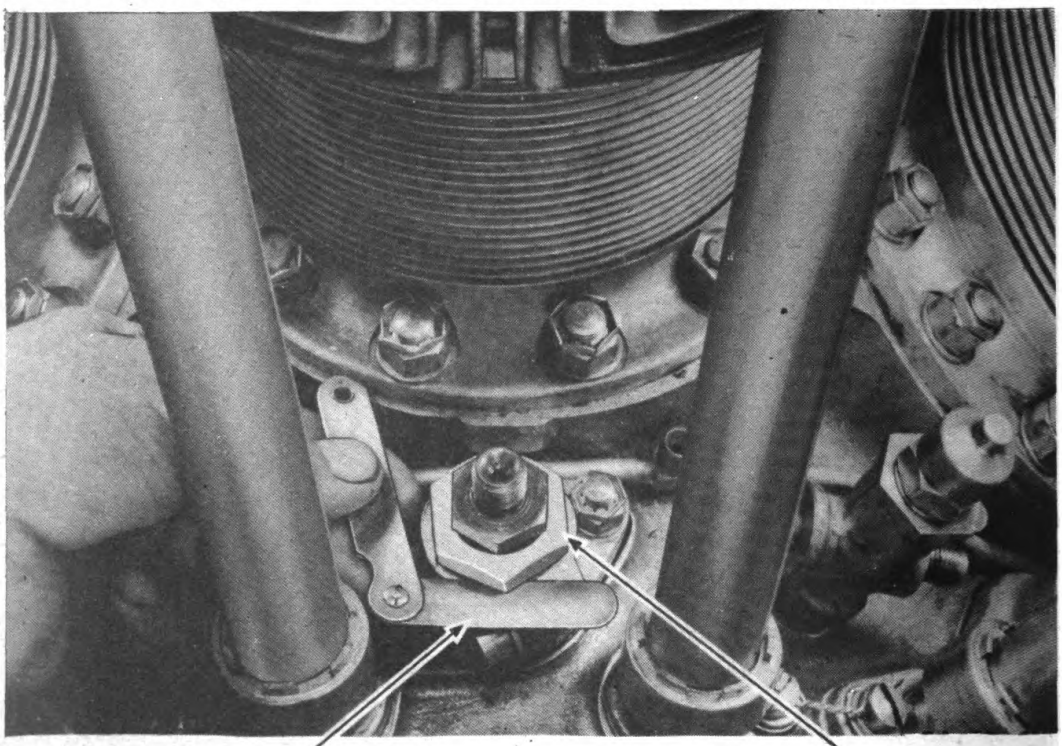


FIGURE 116—Checking fuel injection pump adjusting nut clearance.

115. 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. Use a ½-inch socket wrench to loosen the nuts on the valve cam so that the eccentric can be turned. NOTE: This is done through the inspection opening near the top of the accessory case. In turning these nuts, it is advisable to wire the wrench head to the handle, because if it should drop off within the accessory case, the case would have to be removed to get it out.

(2) With the calibrated marks on the valve cam at the top, and the piston on the compression stroke, turn the engine to get the lowest point on the cam, as shown on the dial indicator. Set the dial at zero at this point.

(3) Turn the engine in the direction of rotation to register 60 on the dial. At this point there should be a slow dripping of fuel from the nipple of the fuel pump indicator holder. The flow of fuel is adjusted by moving the injection pump sleeve up or down. Loosen the clamping bolt on the injection pump and turn the adjusting nut to move the sleeve up or down, using the injection pump balancing wrench (GU-GST-1419).

(4) When the fuel pump indicator holder shows a slow drip at the nozzle with the dial indicator registering 60, the piston should be 35° before top dead center, as shown by the pointer on the timing disk. If the pointer is not at the 35° mark, the fuel timing is incorrect, and must be corrected. Turn the crankshaft back about 30° to eliminate backlash, and then turn in the direction of rotation until the pointer is on 35. Turn the adjusting eccentric until the indicator again shows 60 and the fuel is coming out of the nozzle at a slow drip. Then tighten the nuts on the valve cam.

(5) This is the start of the injection. The plunger has moved up to a point where the fuel channel is almost completely closed. The next step is to find the duration of the injection.

(6) Turn the crankshaft turning bar in direction of rotation until the flow of fluid ceases from the nozzle of the fuel pump indicator holder. The injection has now ended. The distance that the pointer traveled on the timing disk beyond 35° is the duration of the injection. At this time the dial indicator needle should have traveled .069-inch. If it did not, recheck the fuel timing.

(7) Remove the dial indicator and fuel pump indicator holder from the injection pump and replace the spring, check valve and union in the injection pump.

(8) Use a feeler gage beneath the adjusting nut of the injection pump at No. 1 cylinder and set the pumps of the other cylinders at this clearance to get an approximate balance of the pumps. Leave the clamping bolts slightly loose, as the pumps will have to be more accurately balanced during the testing and run-in.

(9) Install a new inspection opening gasket on the accessory case and install the cover, washers and elastic nuts, using a ½-inch socket wrench.

(10) Remove the crankshaft turning bar, timing disk and pointer from the crankshaft.

154. Install the oil sump. — *a. Equipment.* —

½-inch open-end wrench

b. Procedure. — Remove the fuel check valve to provide access to the oil sump opening. Install the bell crank by means of the long bolt on the oil sump. Install new gaskets on the oil sump and place the sump in position at the sump opening. Before it is bolted tight, install the fuel check valve. Then bolt the sump to the bottom of the engine with washers, nuts and palnuts, using a ½-inch open-end wrench. The upper right nut is left off the oil sump until the baffles are put on.

155. Install the rocker box scavenger hose connections. — *a. Equipment.* —

Pliers

b. Procedure. — Install the rocker box scavenger hose connections on the nipples between the rocker boxes. Use new hoses whenever the motor has been overhauled. Turn the thumb screws on the connections down, to leave clearance for installing the cowling. Tighten the clamps to hold the hose connections to the nipples.

156. Install the intercylinder main baffles *(fig. 32).* — *a. Equipment.* —

Cylinder hold-down nut wrench GU-GST-M-1432

b. Procedure. — Five of the intercylinder main baffles fit over the exhaust elbow studs and are attached by brackets to a stud at the intake opening and at the cylinder barrel mounting flange. Two intercylinder main baffles have a passage for the steady rest tube. Install these two baffles first. Then install the baffle with the cut-out section for the oil sump on No. 5 cylinder. Install the baffle with the offset bracket on No. 6 cylinder. Then install the other baffles. When the baffles are in place, bolt them to the cylinder mounting stud where the nut was left off when the cylinder barrels were replaced. No washers are required. The baffles are not bolted at the intake and exhaust openings at this time.

157. Install the exhaust elbows *(fig. 36).* — *a. Equipment.* —

½-inch open-end wrench

½-inch open-end and 90° wrench GU-GST-1449

b. Procedure. — The exhaust elbows are bolted over the intercylinder main baffles to the cylinder head. Install the washers, lock washers, and brass nuts using a ½-inch open-end wrench. With the front of the engine facing upward, the exhaust elbow is installed with the opening facing down. All exhaust elbows are the same except the one for No. 6 cylinder, which is curved so that the opening slants off at an angle. A special 90° end wrench is necessary to reach the inner nut on No. 5 cylinder. Tighten the nuts evenly on each elbow.

158. Install small intercylinder baffles *(fig. 32).* — *a. Equipment.* — Screwdriver

b. Procedure. — Install the small intercylinder baffles between the cylinders with the Dzus fastener facing upward. Lock the Dzus fastener to the wire lock on the main intercylinder baffle, through the hole in the main baffle, by means of a screwdriver. Eight of the small intercylinder baffles are used, none being used between Nos. 5 and 6 cylinders where the oil sump is located.

159. Install the intake elbows *(fig. 34).* — *a. Equipment.* — ½-inch open-end wrench

b. Procedure. — NOTE: The intake elbows are numbered and should be replaced on the proper cylinder. Inspect the inner flange of the intake elbows to make sure it is in good condition and will make a tight seal, otherwise dirt might be sucked into the motor. Also inspect the elbows for roundness, so that the hose will clamp tightly around them.

(1) Install new gaskets over the studs at the intake elbow openings. Place the elbow on the studs with the opening pointing in toward the crankshaft.

(2) Place the main baffle support over the inner stud, then install the washers and nuts using a ½-inch open-end wrench. No washers are used on the studs which carry the main baffle supports. Do not tighten the nuts, as the elbows may have to be turned to install the manifold.

160. Install intake hose connections *(fig. 34).* — Place the intake hose connections on the intake elbows with the thumb screws pointed down toward the exhaust elbow. Do not leave these thumb screws projecting at the sides or there will not be sufficient clearance to install the cowling. Do not tighten the thumb screws at this time.

161. Install the intake manifold. — *a. Equipment.* — Pliers ½-inch open-end wrench

b. Procedure. — Place the intake manifold on top of the engine with the elbows down and the intake openings to the top of the engine. Line up the passage for the steady-rest tube with the passage in the crankcase. Pry the intake hose connections over the elbows on the manifold. Tighten the hose clamps down at each end of the hose to hold it to the intake elbows. Then tighten the nuts on the intake elbow mounting flange using a ½-inch open-end wrench. Be sure that none of the thumb screws rub against any of the hose connections, or they might damage the hose. Then screw the palnuts on the intake elbow studs.

162. Install the outer-cylinder cowling. — *a. Equipment.* — Screwdriver

b. Procedure. — Replace the outer-cylinder cowling over the intake and exhaust elbows. Four of these cowling sections are cut away to provide an opening for the steady-rest bar. The lower skirt of the cowling is inserted between the rocker boxes, and the sections are clamped together

by Dzus fasteners. The rocker box scavenger hose connections between Nos. 3 and 2, 2 and 1, 1 and 9, and 9 and 8 cylinders are on the inside of the cowling. The hose connections between all other cylinders are on the outside of the cowling.

163. Install the large washers and nuts on the exhaust elbow studs. — *a. Equipment.* — ½-inch socket wrench

b. Procedure. — Replace the large washer on the exhaust elbow stud at each cylinder. Install a lock washer and brass nut using a ½-inch socket wrench.

164. Install the scavenger rocker box covers. — *a. Equipment.* — $\frac{7}{16}$-inch box or open-end wrench

b. Procedure. — The rocker boxes on Nos. 5 and 6 cylinders have special covers to hold the oil drained down from the other rocker boxes through the scavenger connections. The rocker box scavenger pump gears in the oil pump pick up the oil from these scavenger rocker box covers. Install these covers on Nos. 5 and 6 rocker boxes with washers and elastic stop nuts, using a $\frac{7}{16}$-inch box or open-end wrench.

165. Install the engine steady-rest tube *(fig. 32).* — *a. Equipment.* —

$\frac{5}{8}$-inch open-end wrench $\frac{7}{16}$-inch open-end wrench

b. Procedure. — (1) Insert the engine steady-rest tube into its channel until it is an equal distance on each side of the manifold. The long side of the diagonally cut end of the tube is down toward the engine.

(2) Install the engine steady-rest clamp, tightening down the four flat washers, nuts and palnuts with a $\frac{5}{8}$-inch open-end wrench.

(3) Tighten the nuts at each end of the engine steady-rest with a $\frac{7}{16}$-inch open end wrench. Make sure that the bracket is safety-wired to the manifold.

166. Install the baffle tie bolts *(fig. 35).* — *a. Equipment.* — $\frac{3}{8}$-inch open-end wrench

b. Procedure. — Turn the engine mounting stand so that the rear of the engine is up. Insert the tie bolts, connecting the main and small intercylinder baffles at each cylinder. A flat washer should be used at the bolthead and also at the nut. Since there is no baffle between Nos. 5 and 6 cylinders due to the oil sump, a long tie rod is used to connect the two outside baffles at these cylinders. An elastic nut and flat washer are used at each end of this tie rod.

167. Install the fuel injectors *(fig. 37).* — *a. Equipment.* — ½-inch open-end wrench

b. Procedure. — The fuel injectors are numbered to show the cylinder to which they belong. Be sure that a new gasket is at the nozzle end, and insert the nozzle in the injector opening with the nipples up or toward the

rear of the motor. Replace the flat washers, nuts and palnuts using a ½-inch open-end wrench. Do not turn the nuts too tight or the flange of the injector might be broken.

168. Replace the injector lines *(fig. 37).* — *a. Equipment.* —

⅝-inch open-end wrench ½-inch open-end wrench

b. Procedure. — (1) There are two injector lines at each cylinder, held together with a clamp at the center which is safety-wired. The larger of the two lines carries the fuel from the injection pump to the injector. The smaller line carries fuel which was not injected back to the fuel return ring. Pressure should never be exerted on these lines.

(2) Use a ⅝-inch open-end wrench to screw the nuts on the injection line onto the nipples on the injector and injection pump.

(3) Use a ½-inch open-end wrench to screw the nuts on the return line onto the nipples on the fuel return ring and injector.

(4) Remove the caps on the nipples at each cylinder as the lines are installed.

(5) Start the four nuts on each set of lines before tightening any of them.

169. Install the fuel supply pump *(fig. 45).* — *a. Equipment.* —

½-inch open-end wrench

b. Procedure. — Turn the engine perpendicularly. Use a new gasket and place the fuel supply pump on the mounting studs of the accessory

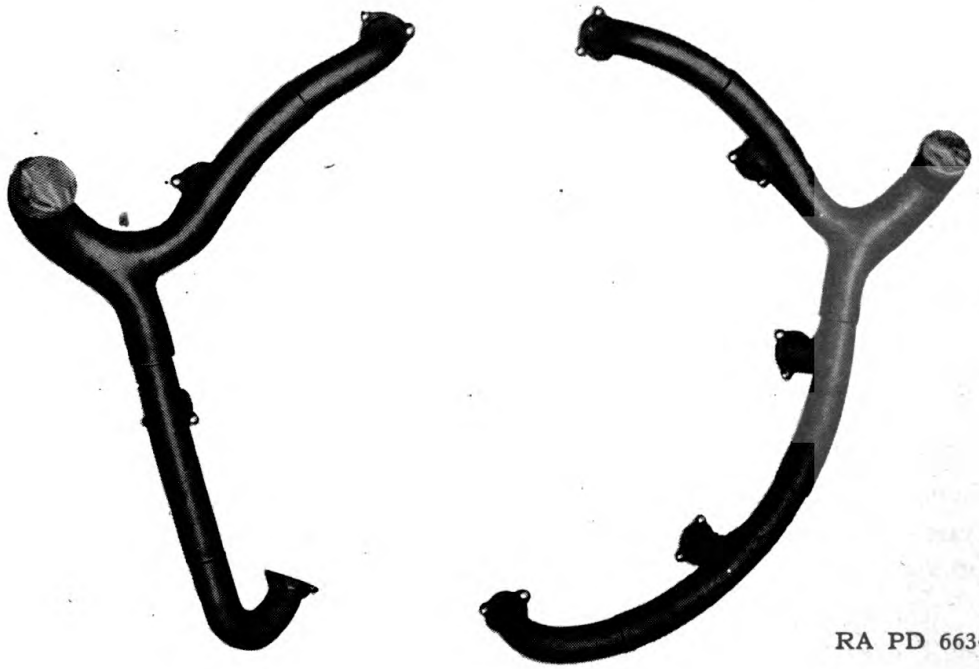


FIGURE 117—The exhaust manifolds.

case and install the washers, nuts and palnuts, using a ½-inch open-end wrench. Do not tighten the nuts until all nuts are on, since the pump will have to be lifted slightly to install the nut under the elbow, due to the small clearance.

170. Install the governor. — *a. Equipment.* —

½-inch open-end wrench

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, using a ½-inch open-end wrench.

171. Remove the engine from the engine mounting stand. — *a. Equipment.* —

Hoist
Lifting eye GU-GST-1308

b. Procedure. — With the engine turned so that the front of the engine is facing upward, screw the lifting eye (GU-GST-1308) on the end of the front crankshaft. Remove the bolts which hold the crankcase mounting flange to the engine mounting stand. Then raise the engine on a hoist.

172. Install the exhaust manifolds. — *a. Equipment.* —

½-inch open-end wrench

b. Procedure. — (1) The exhaust manifolds must be replaced before the engine mounting beam is installed. The sections of the exhaust manifolds are of different shapes and each section must be installed at the proper cylinder. If the sections were numbered to show the cylinder when they were removed, this will facilitate placing them while installing. Otherwise refer to figure 117 for the shapes and sizes of the sections.

(2) Place a new exhaust manifold gasket over the studs of each exhaust elbow.

(3) 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, using a ½-inch open-end wrench.

(4) Attach a paper over the ends of the manifold to prevent anything from falling in.

173. Place the engine on the engine beam mounting stand *(fig. 25).* — *a. Equipment.* —

$\frac{9}{16}$-inch open-end wrench
Hoist
Pliers

b. Procedure. — (1) Lower the engine onto the engine mounting beam in the stand, with the flat side of the engine mounting beam up toward the engine. The throttle spring support fork should be at No. 5 cylinder.

(2) Push the bolts through the bolt holes in the engine mounting flange and beam, using a flat washer at both the bolthead and nut. Tighten the nuts securely, using a $\frac{9}{16}$-inch open-end wrench. Line the cotter pin openings in the bolt and nut and insert the cotter pins.

174. Install the flywheel. — *a. Equipment.* —

Pliers
$2\frac{5}{16}$-inch box wrench
$\frac{7}{16}$-inch socket wrench

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.

(1) Coat the inside of the brass cone with Lubriplate, or equivalent, and slide it on the front crankshaft with the tapered side out and with the split in the cone exactly centered over the wide spline on the crankshaft.

(2) The flywheel can be installed with the front of the motor face up, or with the motor in a vertical position. Slide the flywheel onto the front crankshaft.

(3) 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 a $2\frac{5}{16}$-inch box wrench.

(4) The flywheel should be centered in the intake manifold and fan shroud assembly. If it is not, the fan shroud will have to be shifted to provide equal clearance.

(5) Insert the locking pin through the holes in the nut and the front crankshaft, and lock with a cotter pin.

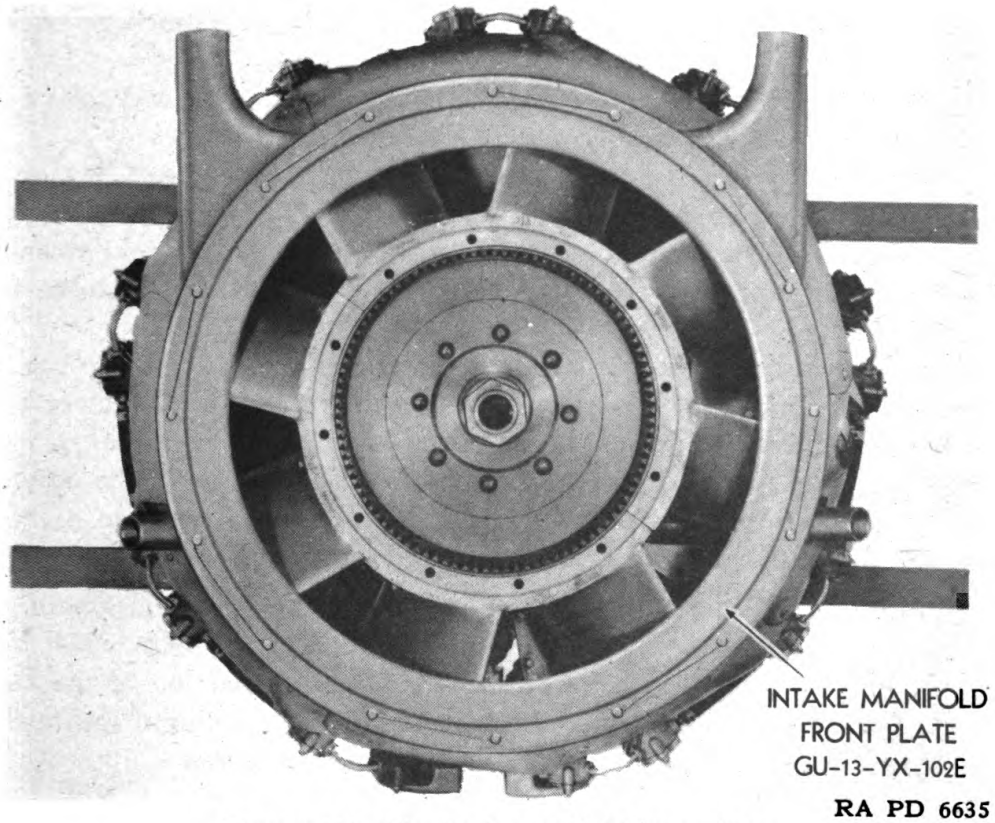


FIGURE 118—The intake manifold front plate.

(6) Place the intake manifold front plate on the manifold, and install the flat washers and bolts, using a $\frac{7}{16}$-inch socket wrench. Safety-wire the boltheads together in pairs.

175. Install the oil pump *(fig. 23).* — *a. Equipment.* —

Pliers
½-inch open-end wrench

b. Procedure. — Place the oil pump on the mounting studs and install washers, nuts and palnuts, using a ½-inch open-end wrench. Safety-wire through the dome of the oil pressure regulator and one of the holes of the packing nut of the oil filter.

176. Safety-wire the fuel pressure regulator. — Run safety wire from the dome of the fuel pressure regulator to the elbow on the regulator.

177. Install the starter *(fig. 23).* — *a. Equipment.* —

$\frac{9}{16}$-inch socket wrench

b. Procedure. — Use a new gasket and install the starter on the mounting studs with the ports up. Replace the washers and elastic stop nuts, using a $\frac{9}{16}$-inch socket wrench.

178. Install the throttle controls *(fig. 119).* — *a. Equipment.* —

¾-inch open-end wrench
$\frac{7}{16}$-inch open-end wrench
$\frac{9}{16}$-inch open-end-wrench
Pliers

b. Procedure. — (1) Slide the throttle control lever over the throttle control shaft and install the washer and nut, using a ¾-inch open-end wrench. Insert a cotter pin to lock the nut.

(2) Tighten the clamp bolt, using a $\frac{7}{16}$-inch open-end wrench, with a flat washer and lock washer underneath.

(3) Tighten the throttle control shaft adjusting screw (using a $\frac{9}{16}$-inch open-end wrench) until it rests on the idle control shaft lever.

(4) Install the governor control, using a $\frac{7}{16}$-inch open-end wrench. One end is attached to the throttle control lever and the other to the governor.

(5) The throttle control vertical tie rod is attached at the top to the throttle control lever by means of the tie rod clevis. The lower end of the spring linkage is attached by means of a bolt to the upper arm of the bell crank. A nut is used on each side of the bell crank. The outside nut is an elastic stop nut. The throttle control spring seats on a large washer on top of the fork on the engine mounting beam.

179. Install fuel supply pump hose *(fig. 23).* — *a. Equipment.* —

Pliers

b. Procedure. — Run a hose from the lower connection of the fuel supply pump down to the fuel check valve nipple, carrying it inside the throttle control spring. Tighten it on with the thumb screws.

180. Connect the oil sump to the oil pump *(fig. 23).* — *a. Equipment.* —

½-inch open-end wrench

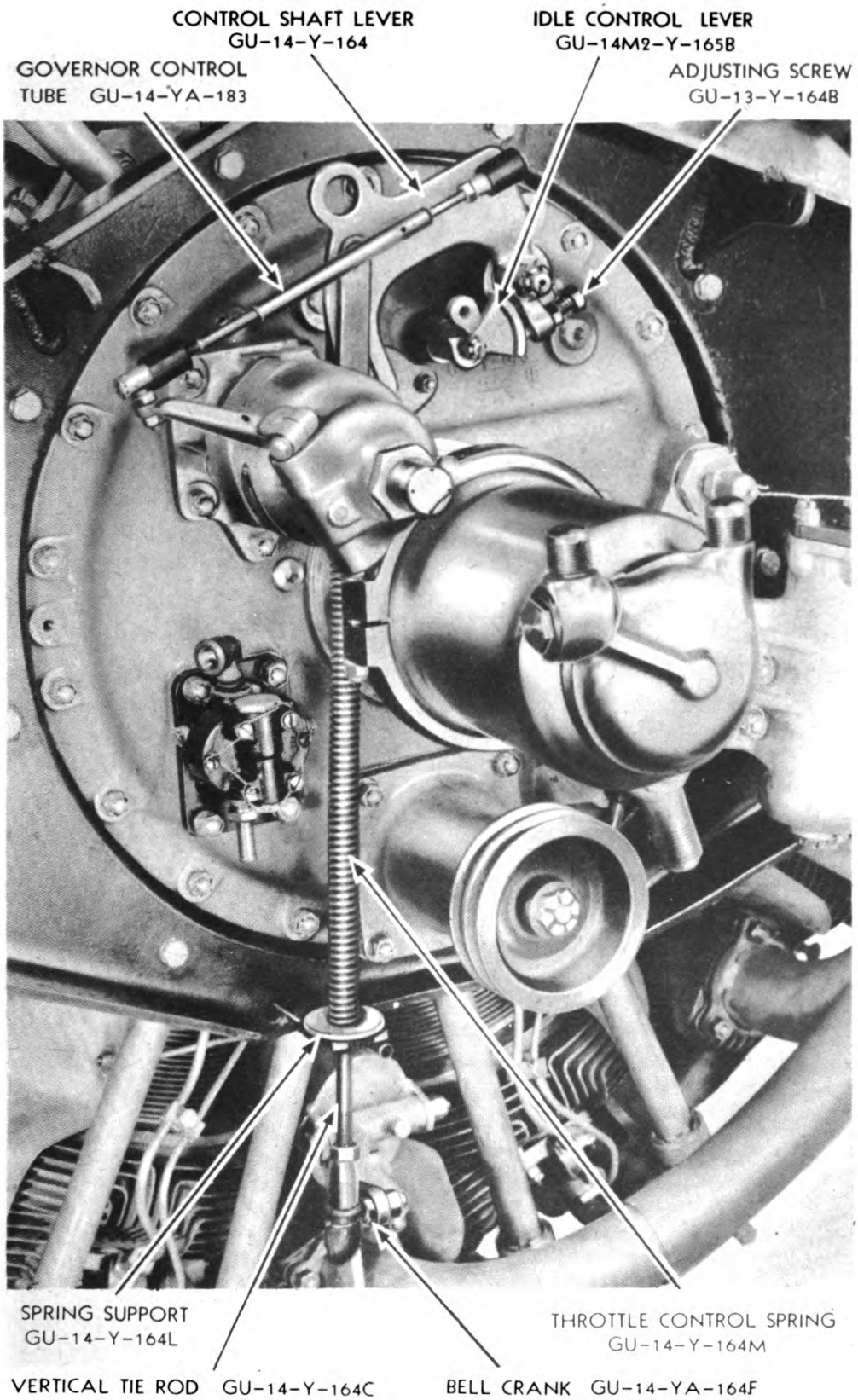


FIGURE 119—The throttle controls.

b. Procedure. — (1) 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.

(2) 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 oil sump opening 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 install the line with flat washers, nuts and palnuts, using a ½-inch open-end wrench.

181. Attach the rocker box scavenger hose. — *a. Equipment.* —

Pliers

b. Procedure. — 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 thumb screws.

182. Install the starter support *(fig. 23).* — *a. Equipment.* —

$\frac{7}{16}$-inch open-end wrench ½-inch open-end wrench

b. Procedure. — (1) Clamp the two halves of the starter support ring around the starter, using a $\frac{7}{16}$-inch open-end wrench, with the arms of the support on top.

(2) Attach the outer ends of the arms to the brackets on the engine mounting beam with a flat washer and elastic stop nut, using a ½-inch open-end wrench.

SECTION X

FITS AND CLEARANCES

183. Fits and clearances. —

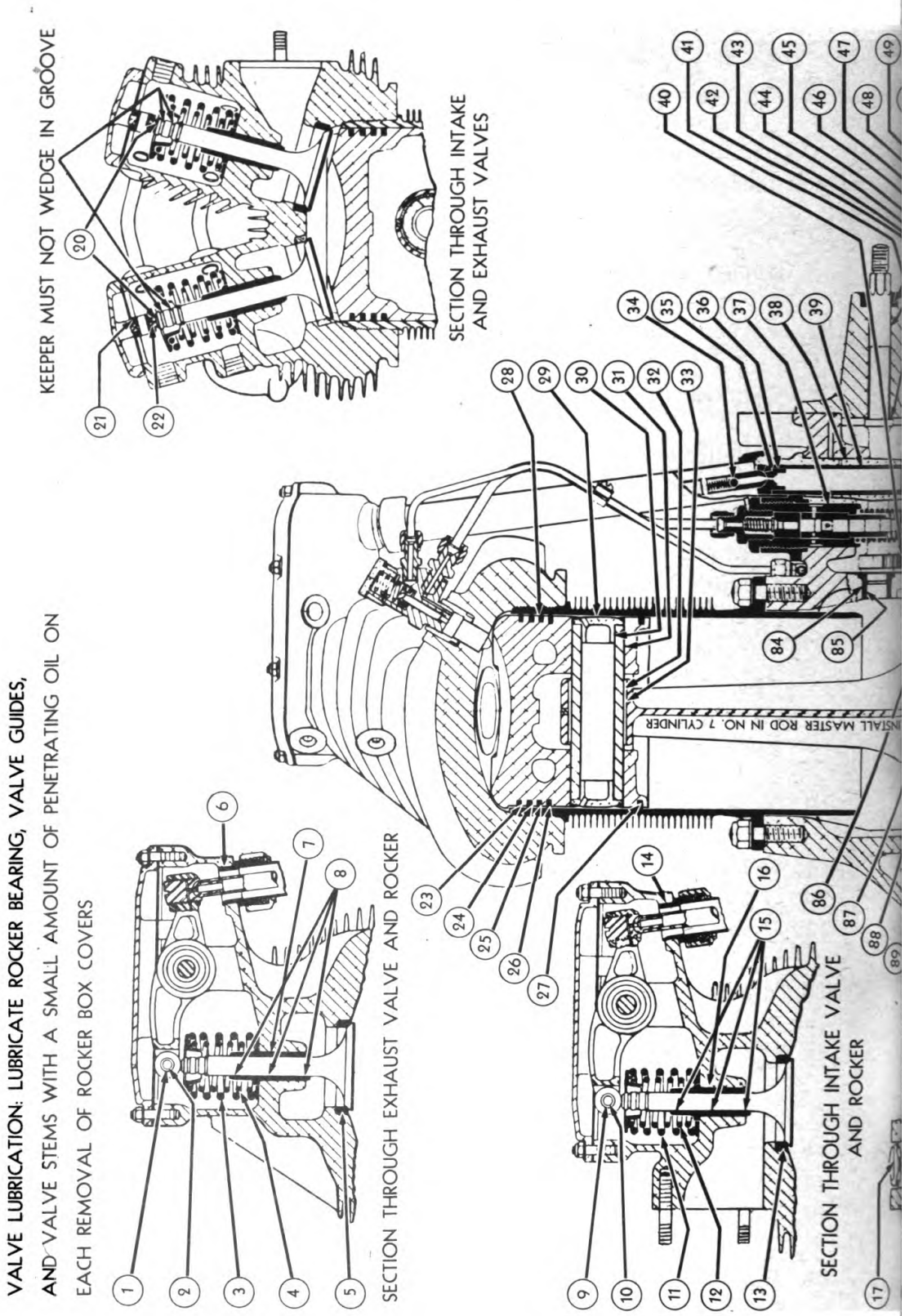
Clearance between:

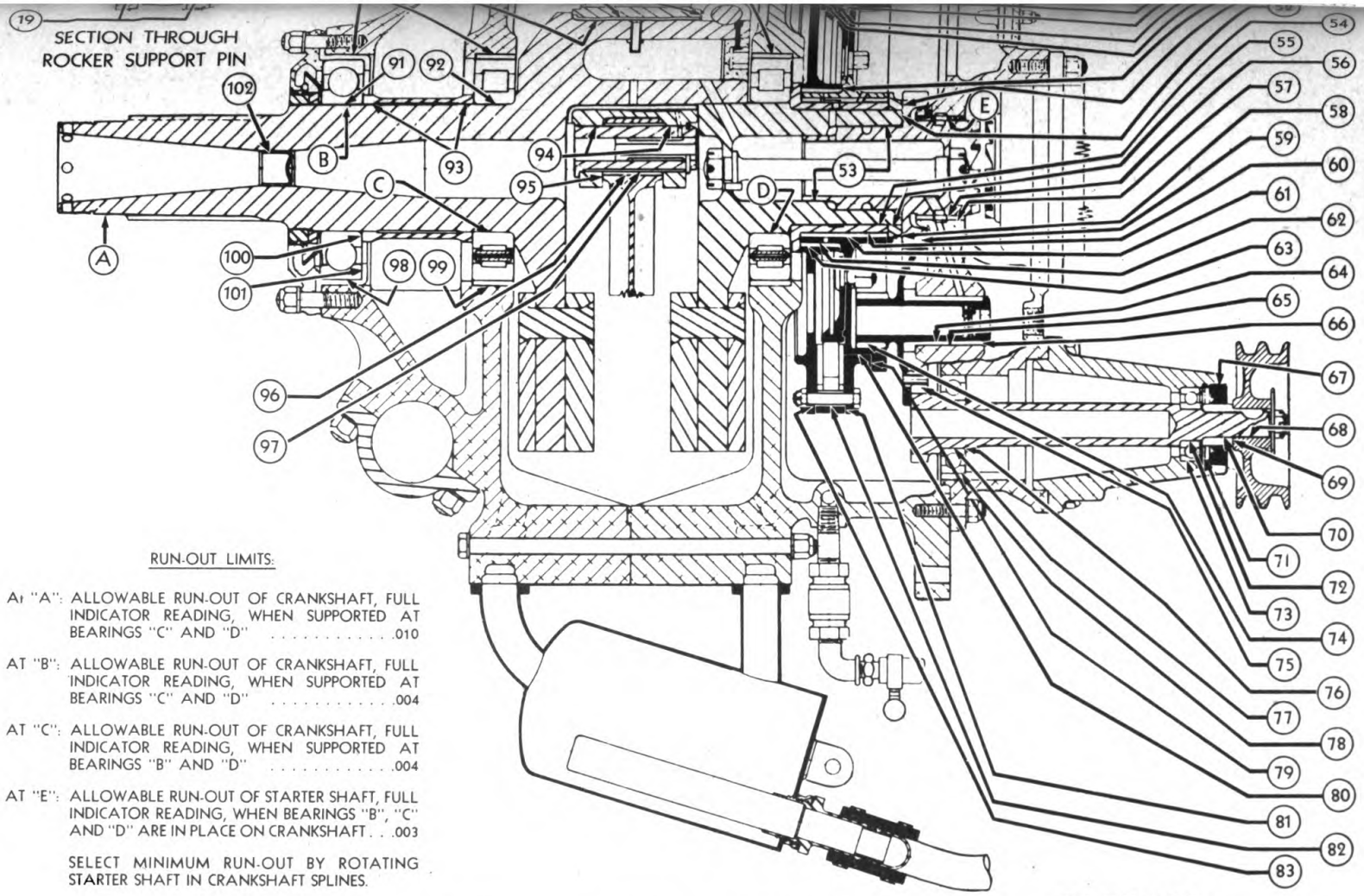
(Numbers refer to arrows on chart)

1. Rocker roller and rocker roller bushing.....	.002L-.004L *.010L
2. Rocker roller pin and rocker roller bushing.....	.0007L-.0027L *.009L
3. Cylinder valve outer spring.....	70# min. new at 1½" *66#
4. Cylinder valve inner spring.....	73# min. new at 1½" *69#
5. Exhaust valve seat insert and cylinder head.....	.006T-.008T
6. Push rod housing nipple and rocker box.....	.001T-.004T
7. Cylinder valve exhaust guide and cylinder head..	.002T-.004T
8. Cylinder valve exhaust guide and exhaust valve stem	.003L-.0045L *.012L at ends *.010L at center
9. Rocker roller and rocker roller bushing.....	.002L-.004L *.010L
10. Rocker roller pin and rocker roller bushing.....	.0007L-.0027L *.009L
11. Cylinder valve outer spring.....	70# min. new at 1½" *66#
12. Cylinder valve inner spring.....	73# min. new at 1½" *69#
13. Intake valve seat insert in cylinder head.....	.006T-.008T
14. Push rod housing nipple and rocker box.....	.001T-.004T
15. Cylinder valve intake guide and intake guide stem	.002L-.0035L *.012L at ends *.010L at center
16. Cylinder valve intake guide in cylinder head.....	.002T-.004T
17. Rocker bearing and rocker.....	.0007T-.0017T *.001L
18. Rocker support pin and rocker box.....	.005T-.002L *.005L

*Replace rings at every removal of piston.

*Limit before replacement. Tight fits with no limits should be replaced when any looseness is found.





RUN-OUT LIMITS:

At "A": ALLOWABLE RUN-OUT OF CRANKSHAFT, FULL INDICATOR READING, WHEN SUPPORTED AT BEARINGS "C" AND "D" 010

AT "B": ALLOWABLE RUN-OUT OF CRANKSHAFT, FULL INDICATOR READING, WHEN SUPPORTED AT BEARINGS "C" AND "D" 004

AT "C": ALLOWABLE RUN-OUT OF CRANKSHAFT, FULL INDICATOR READING, WHEN SUPPORTED AT BEARINGS "B" AND "D" 004

AT "E": ALLOWABLE RUN-OUT OF STARTER SHAFT, FULL INDICATOR READING, WHEN BEARINGS "B", "C" AND "D" ARE IN PLACE ON CRANKSHAFT . . .003

SELECT MINIMUM RUN-OUT BY ROTATING STARTER SHAFT IN CRANKSHAFT SPLINES.

RA PD 6637

FIGURE 120—Clearances and tolerances chart.

19. Rocker support pin and rocker bearing	.0005T-.0005L *.002L
20. Rocker roller and valve stem	.019L-.021L Cold
21. Rocker roller bushing and rocker	.001T-.001L Rivet on ends
22. Rocker roller and rocker	.003L-.006L *.040L
23. Top compression ring (side clearance)	.008L-.0095L
Gap at cylinder — under mounting flange	.065-.070
24. 2nd compression ring (side clearance)	.0055L-.007L
Gap at cylinder — under mounting flange	.065-.070
25. 3rd compression ring	.0035L-.005L
Gap at cylinder — under mounting flange	.065-.070
26. Ventilated oil ring (side clearance)	.0035L-.005L
Gap at cylinder — under mounting flange	.040-.045
27. Beveled oil ring (side clearance)	.0015L-.003L
Gap at cylinder — under mounting flange	.040-.045
28. Cylinder barrel diameter	*5.137 diameter max. worn diameter at ¾" from top of barrel
29. Piston pin plug and cylinder barrel	.032L-.092L (side) at bottom of barrel
30. Piston pin plug and piston pin	.0005L-.0035L
31. Piston pin and piston	.000-.001L *.004L light hand push, oiled, at room temperature
32. Piston pin and piston pin bushing	.002L-.0035L *.006L
33. Link rod and piston pin bushing	.002T-.004T
34. Check valve in tappet end only of push rod	
35. Push rod and valve tappet socket	*worn .032 or rough or uneven
36. Valve tappet and valve tappet socket	.001T-.003T
37. Fuel injection pump body and rear crankcase	.0025L-.0045L
38. Valve tappet guide and rear crankcase	.000-.001L
39. Valve tappet and valve tappet guide	.000-.001L light hand push fit, oiled, at room temperature *.0036

Replace rings at every removal of piston.

*Limit before replacement. Tight fits with no limits should be replaced when any looseness is found.

40. Throttle control shaft gear and throttle control segment gear	.002-.004 backlash
41. Throttle control shaft oil seal and accessory case	.002T-.007T
42. Throttle control shaft and accessory case	.000-.002L *.012L
43. Throttle control shaft and accessory case	.015L-.060L (side)
44. Valve tappet roller and valve tappet roller pin	.002L-.004L
45. Valve tappet roller and valve tappet	.002L-.007L (side) *.020L
46. Valve tappet roller pin and valve tappet	.0005-.0025 *.005L
47. Fuel control lever and fuel control lever roller	.003L-.0065L *.20L
48. Fuel control lever roller and fuel control lever pin	.0015L-.003L *.005L
49. Fuel control lever and fuel control lever pin	.0005T min. selective fit
50. Decompression plate bushing and valve cam	.008L min. make-up (side)
51. Rear crankshaft spacer and starter shaft	clamp tight
52. Starter shaft and rear crankshaft	.003L(min.) side
53. Starter shaft and rear crankshaft	.0002L-.0012L
54. Rear crankshaft and rear crankshaft sleeve	.0005L-.002L select hand push fit, oiled
55. Rear crankshaft and rear crankshaft spacer	.0015L-.0065L
56. Starter shaft and starter shaft bushing	.0015L-.003L *.008L (important)
57. Starter shaft bushing and accessory case	.003T-.0045T
58. Rear crankshaft spacer and valve cam	.006L-.015L (side)
59. Starter shaft gear and intermediate gear	.006-.010 backlash
60. Rear crankshaft sleeve and valve cam bushing	.0035L-.0045L *.009L
61. Valve cam bushing and valve cam	.0025T-.0035T
62. Valve cam and decompression plate bushing	.0035L-.0045L *.009L
63. Decompression plate bushing and decompression plate	.0025T-.0035T
64. Intermediate gear and intermediate gear bushing	.0015L-.0035L *.008L
65. Intermediate gear bushing and accessory case	.0015T-.0035T

Replace rings at every removal of piston.

*Limit before replacement. Tight fits with no limits should be replaced when any looseness is found.

66. Intermediate gear bushing and intermediate gear nut	.003L-.017L (side) *.050L
67. Oil seal and generator adapter drive housing	.002T-.007T
68. Generator drive shaft and generator drive pulley	.0003L-.0007T
69. Generator drive bearing spacer and generator drive pulley	clamp tight
70. Generator drive shaft and generator drive bearing spacer	.001L-.0035L
71. Generator drive lubricating seal bearing and generator drive bearing snap ring	.0018L-.0158L (side)
72. Generator drive lubricating seal bearing and generator drive shaft	.0002T-.0012T
73. Generator drive lubricating seal bearing and generator adapter drive housing	.0005T-.0005L
74. Intermediate gear and valve cam gear	.008-.012 backlash
75. Intermediate gear and generator adapter drive gear	.004-.008 backlash
76. Generator drive gear bearing and snap ring	.0001L-.0131L (side)
77. Generator drive gear bearing and generator drive shaft	.0002T-.0011L
78. Generator drive gear bearing and accessory case	.0002T-.0011L
79. Decompression ring and valve cam	.005 (side) min. decompression plate and cam forward against spacer
80. Decompression ring and valve cam	.0065L-.0095L *.030L
81. Fuel control lever and decompression ring	.013L-.033 (side)
82. Fuel control lever bushing and fuel control lever	.001L-.0025L *.005L-out of round
83. Decompression plate and fuel control lever bushing	clamp tight
84. Throttle control shaft bushing and rear crankcase	.001T-.003T
85. Throttle control shaft and throttle control shaft bushing	.000-.0045L *.008L

Replace rings at every removal of piston.

*Limit before replacement. Tight fits with no limits should be replaced when any looseness is found.

FITS AND CLEARANCES

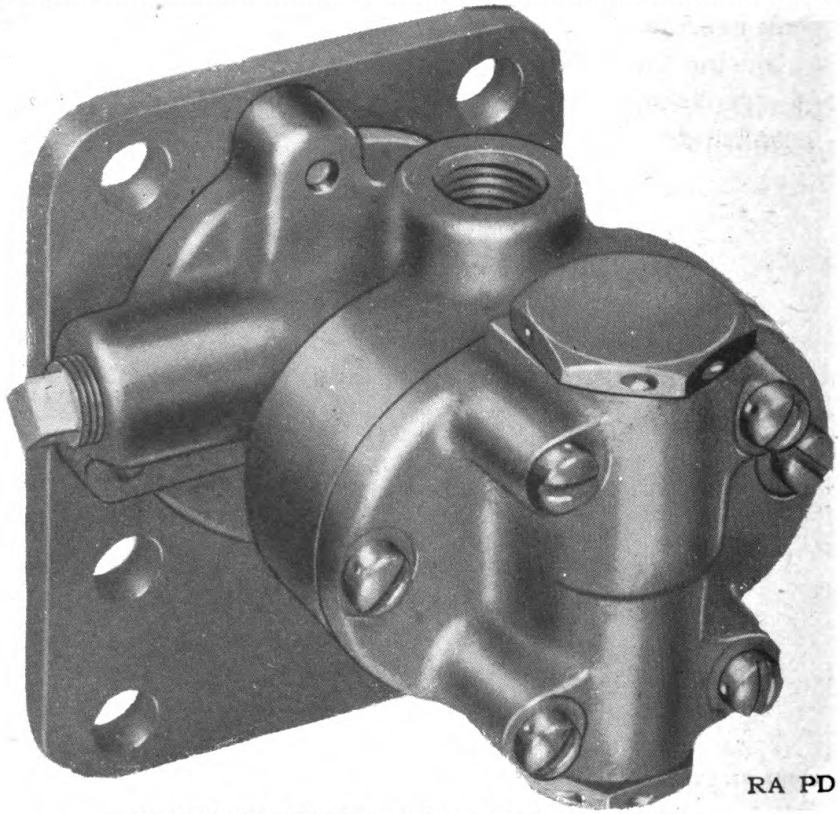
86. Intermediate bearing liner and rear crankcase.....	.004T-.006T
87. Master rod and rear crankshaft.....	.012L-.018L (side) *.025L
88. Master rod bushing and master rod.....	.003T-.005T
89. Crankpin and master rod bushing.....	.003L-.005L *.008L
90. Intermediate and front bearing liner and front crankcase	.004T-.006T
91. Front crankshaft and front ball bearing.....	.0001T-.0014T
92. Front crankshaft and main roller bearing.....	.0001T-.0011T
93. Front crankshaft and front crankshaft bearing spacer	.003L-.0044L
94. Knuckle pin and master rod.....	.0005T-.0015T
95. Knuckle pin and master rod.....	.007L-.016L (side) *.030L
96. Knuckle pin bushing and link rod.....	.002T-.004T
97. Knuckle pin and knuckle pin bushing.....	.0015L-.003L *.005L
98. Front main ball bearing and front bearing liner..	.0003T-.0009L *.003L
99. Main roller bearing and main bearing liner.....	.003T-.0007L *.003L
100. Front crankshaft bearing spacer and front main ball bearing.....	clamp tight
101. Front bearing liner and front main ball bearing..	clamp tight
102. Front crankshaft expansion plug and front crankshaft	tight press fit

Replace rings at every removal of piston.

*Limit before replacement. Tight fits with no limits should be replaced when any looseness is found.

SECTION XI

ACCESSORIES



RA PD 6643

FIGURE 121—The Pesco 386-A fuel supply pump.

184. 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 1750 rpm at 4-inches of mercury inlet depression and 10-inches of mercury discharges pressure. This pump is used on the Guiberson T-1020 series 4 and T-1400 series 2 engines. 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 5 pounds per square inch and is not adjustable.

b. Description (fig. 122). — **(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 between the drive gear and the bearing of the body assembly is retained by the seal by 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 by-pass valves. — These spring loaded valve assem-

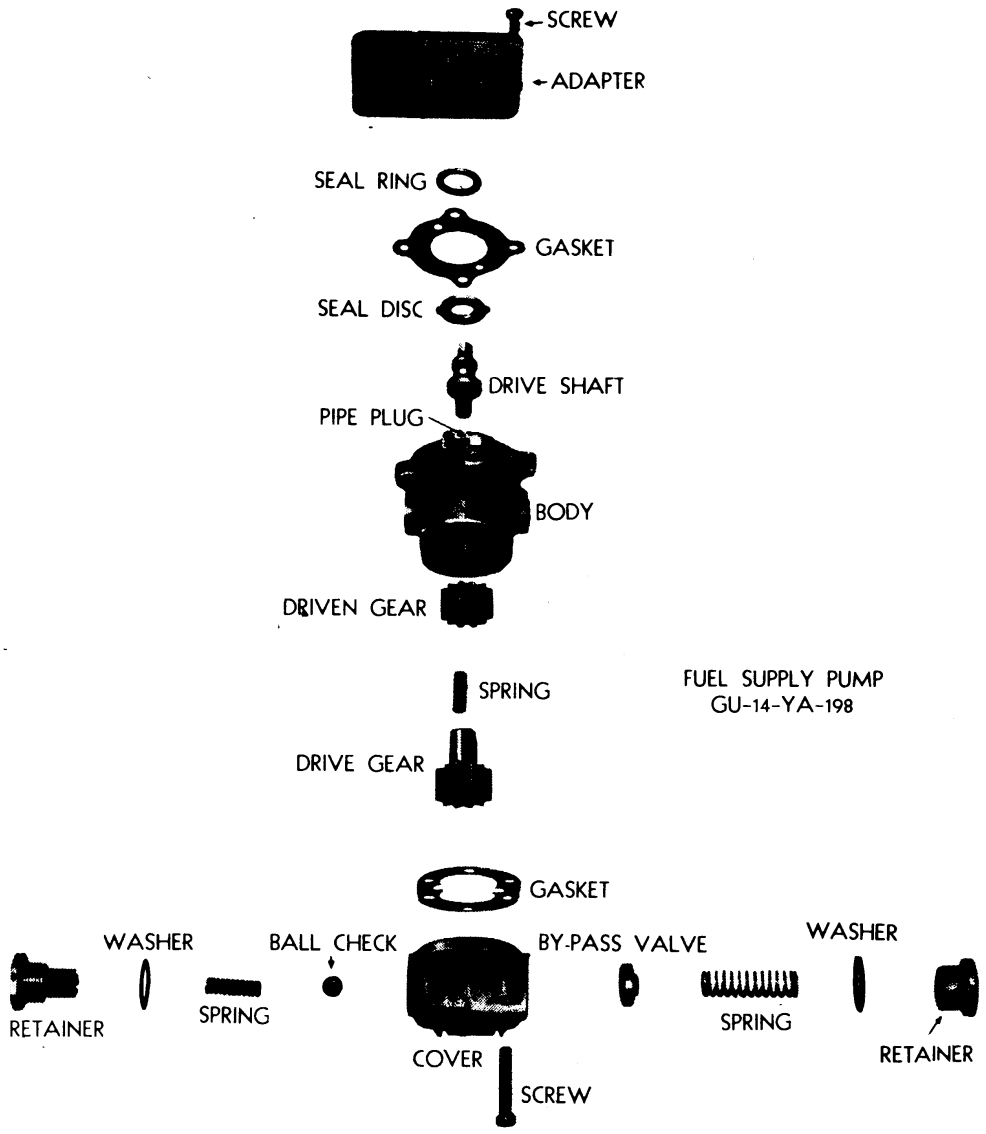


FIGURE 122—The Pesco 386-A fuel supply pump assembly.

blies 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 5 pounds per square inch. When the discharge pressure of the pump exceeds 5 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.

185. 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 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 satisfactory. *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 a means to determine the pump's mechanical condition without disassembly of the pump.

(a) Open fuel tank valves. (The tanks should be ¾ full.)

(b) Disconnect the fuel pump discharge line.

(c) Remove the fuel pump from the engine accessory case (par. 186 *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.

186. 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. 122). — The following list names all the tools necessary to disassemble the pump.

Pliers
13/16-inch box wrench
Screwdriver

(1) Remove relief valves from the cover.

15/16-inch box wrench
13/16-inch box wrench
15/16-inch box wrench

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 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.

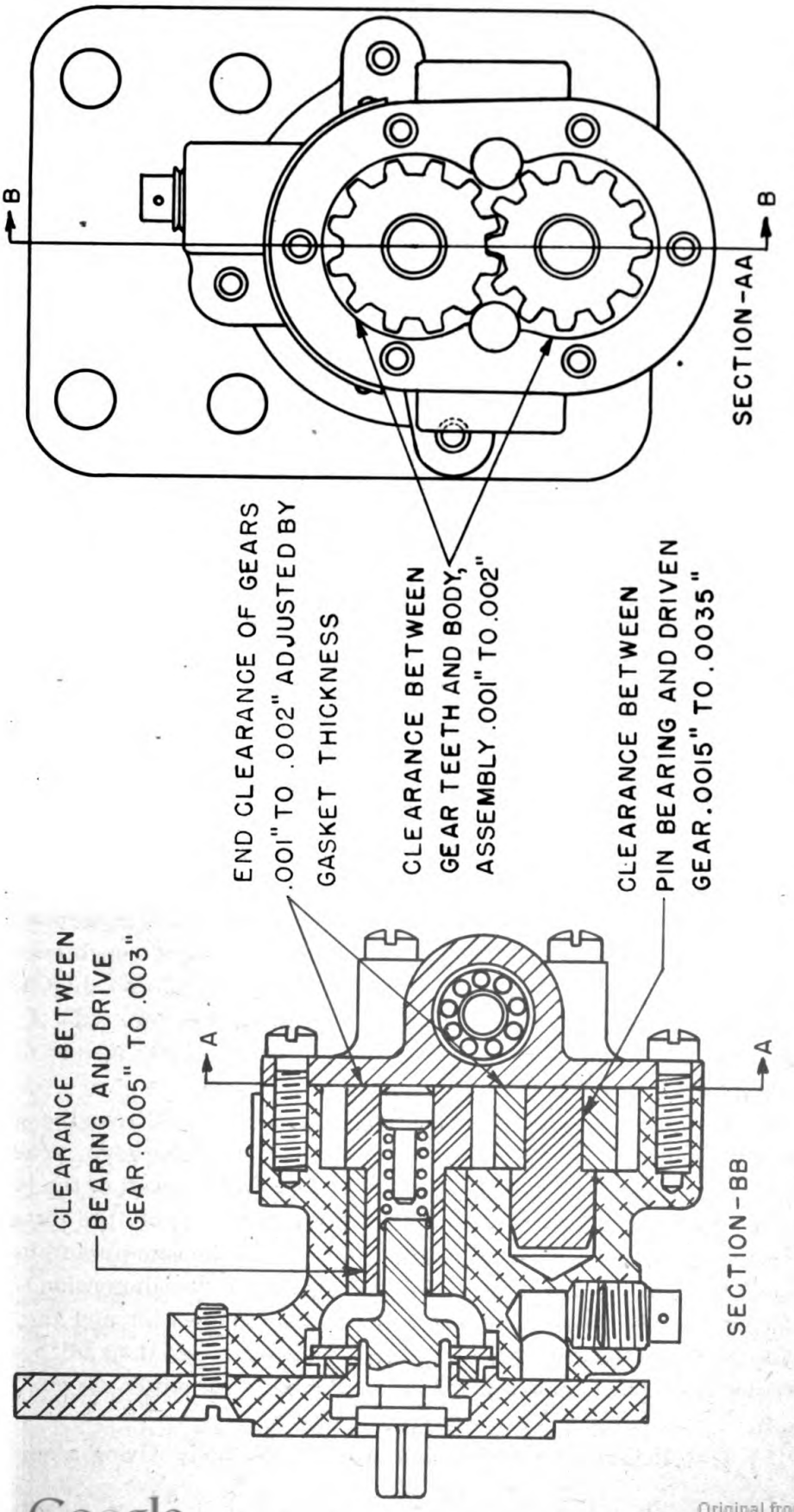


FIGURE 123—Clearance diagram for Pesco pump 386-A.

c. Cleaning. — Using dry cleaning solvent, 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.

187. 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 .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 .0015-inch, use a .001-inch gasket between the body and the cover. If the straightedge contacts the gears and the surface of the body, use a .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 .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 OD of the drive gear bearing and the OD of the metal plug. Subtract the OD of the drive gear from the OD of the metal plug to determine the clearance. If it is less than .0005-inch or more than .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 .0015-inch or greater than .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 .001-inch or greater than .002-inch, replace both gears and the body assembly.

(6) If the gears have cut away the cover to a depth of more than .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 dry cleaning solvent 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 dry cleaning solvent.

(b) Using the flat cast iron plate, dry-lap the sealing surface until a high finish is obtained over the entire sealing surface. Using dry cleaning solvent, 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 .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-inch deep and .510-inch plus or minus .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 cleaning solvent 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 4-inches long in the chuck of a lathe with 1-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 .685-inch plus zero minus .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.

(f) Place the valve ball in position on its seat in the cover assembly.

(g) Using a soft drive ½-inch in diameter and a small hammer, tap the ball into the seat.

(h) 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 dry cleaning solvent.

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.

188. **Pesco 386-A fuel pump assembly, test and installation.** — *a. Assembly.* — The following list mentions all of the tools necessary for this operation.

$\frac{3}{16}$-inch box wrench	Pliers
$\frac{5}{16}$-inch box wrench	Screwdriver

(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. 187 *a.* (3)) in position on the body. **NOTE:** These gaskets are available in three thicknesses, .001-inch, .0015-inch and .003-inch. The clearance between the gears and the cover must be between .001-inch and .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 $\frac{5}{16}$-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 $\frac{3}{16}$-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.

(2) Break-in run. — Place the pump on the test stand pump adapter, and break-in at 1750 rpm 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

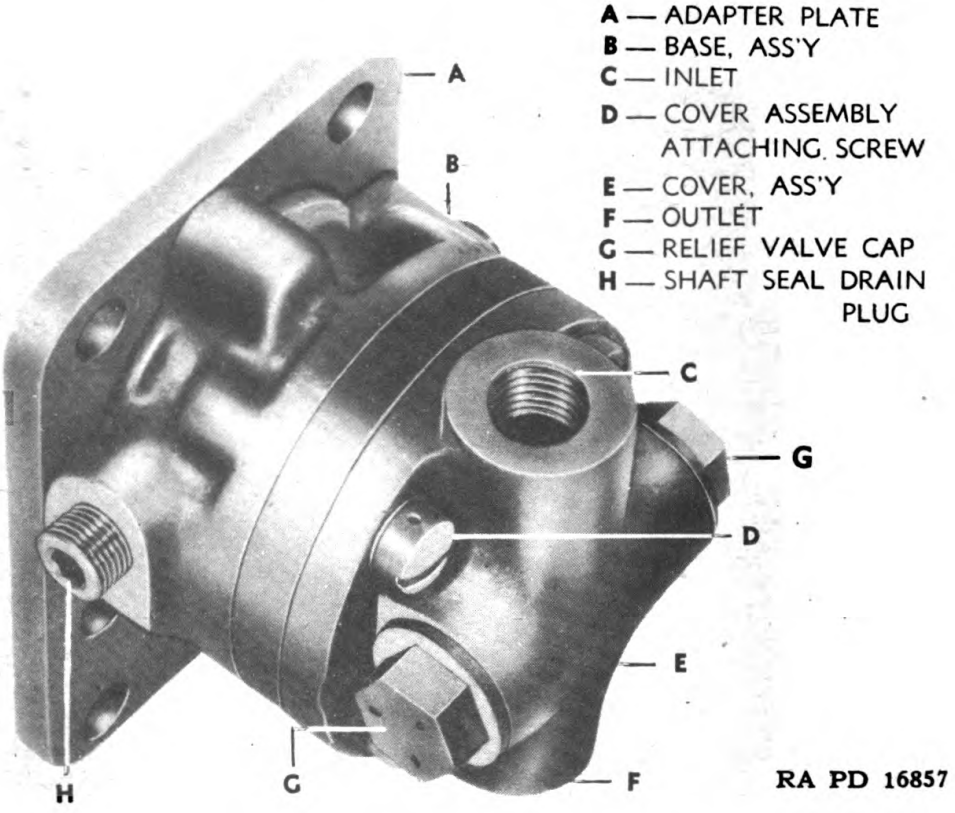


FIGURE 124—Romec fuel pump RB-4350.

with an accurate vacuum gage, or preferably a mercury manometer, connected to the suction port should be:

.....inch of mercury inlet depression at 1600 rpm.

.....inch of mercury inlet depression at 400 rpm.

(4) Shaft seal test. — Open the lower drain boss in the base section during test. If the leakage is in excess of 5 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 $\frac{1}{64}$-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 $\frac{5}{8}$-inch, $\frac{11}{16}$-inch and ¾-inch openings, connect the swivel connector of the inlet fuel line to the inlet side of the pump.

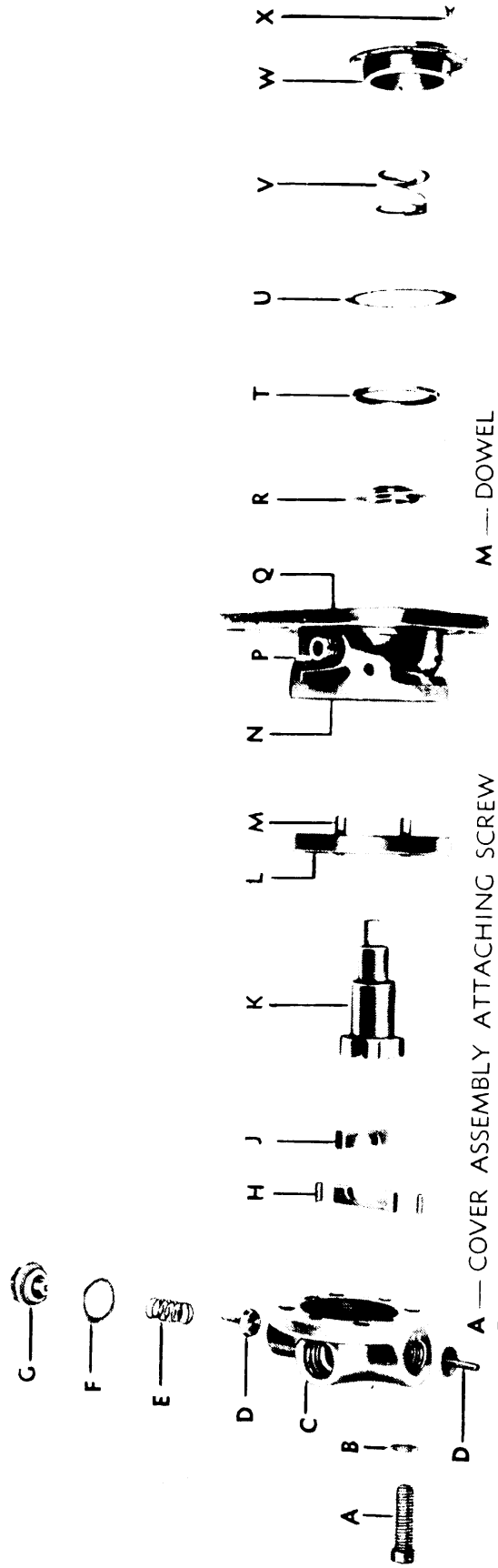
(5) Slip the hose of the pump discharge line over the fitting screwed in the pump discharge. Place the hose clamp in position and use pliers to tighten clamp on the hose.

(6) Remove the shaft seal drain plug.

(7) Open fuel tank valves and inspect for leaks.

189. Romec RB-4350 fuel pump specifications and description *(fig. 124).* — *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 1750 rpm at 4 inches of mercury inlet depression and 10 inches of mercury discharge pressure. This pump is used on the Guiberson T-1020 series 4, T-1400 series 2 and series 3 engines. 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. 125). — **(1) Rotor.** — The non-pulsating pumping 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



RA PD 16860

FIGURE 125—Exploded view—Romec fuel pump RB-4350.

grooved to 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.

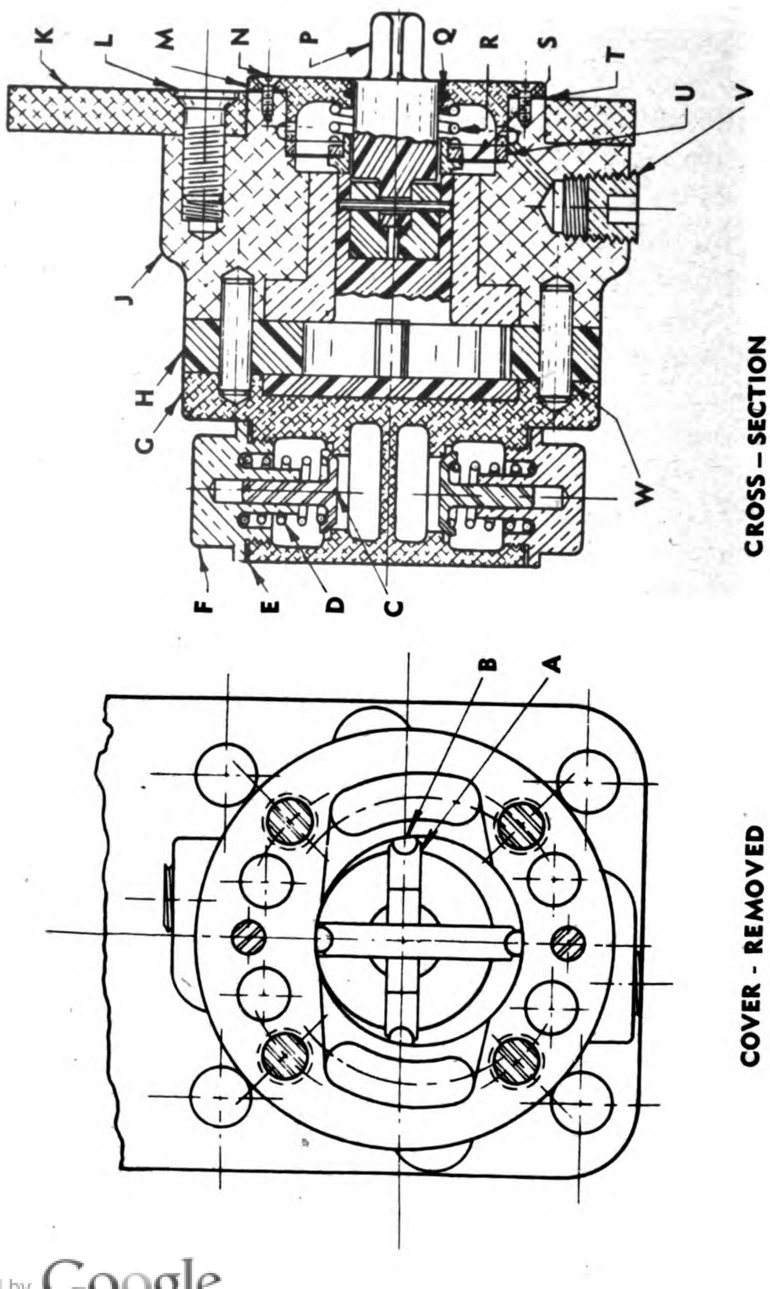
(4) Fuel and oil drain. — Fuel and engine oil which pass through their respective seals are drained from the base of the pump through a ⅛-inch pipe tapped hole in the base located behind and beneath the pump discharge line. Use a "L" shaped piece of hexagon bar stock $\frac{3}{16}$-inch in diameter across 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 dowelled 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 by-pass 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 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



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 ATTACHINC 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 126—Cross-section of Romec pump RB-4350.

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.

190. Romec RB-4350 fuel pump operation and inspection on the vehicle *(fig. 126).* — *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 oil 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 by-passed 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.

191. 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. 125). — The following list names all the tools necessary to disassemble the pump.

Screwdriver
9/16-inch box wrench

(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, using care not to injure the diaphragm of the shaft SEAL. Remove the shaft seal from the base.

(2) Remove by - pass valves. 9/16-inch box wrench

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 dowelled 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 fluid under pressure. Remove four ROCKERS from the ROTOR and DRIVE group assembly. Remove the dowel pins.

c. Cleaning. — Using dry cleaning solvent, 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 and efficiency.

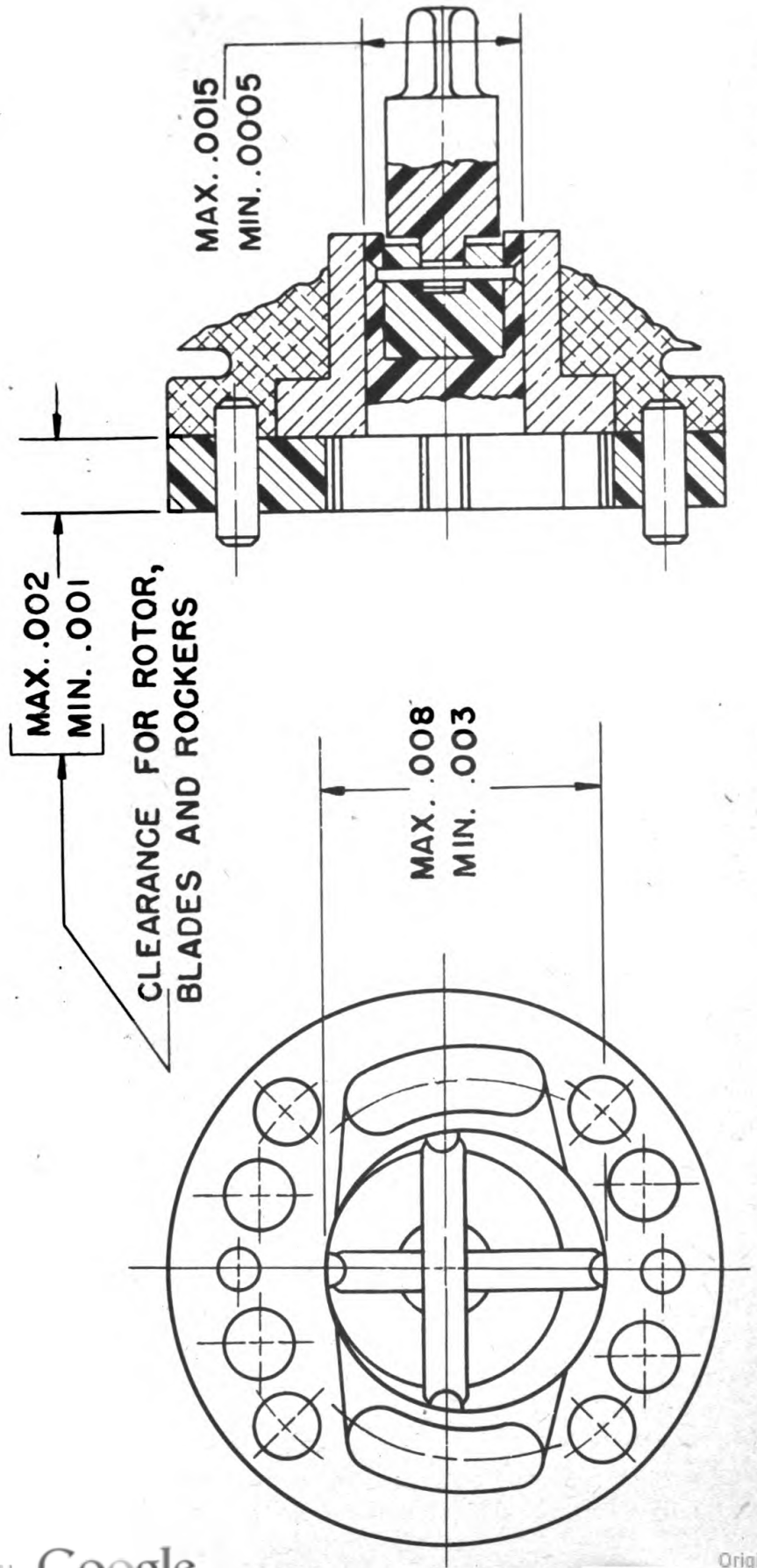


FIGURE 127—Clearance diagram for Romec fuel pump RB-4350.

192. 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 .0015-inch *(fig. 127)*.

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 of 1-inch 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 of approximately .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) Hone 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 gasoline. 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 dry cleaning solvent 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 dry cleaning solvent.

(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 dry cleaning solvent, 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 $\frac{9}{16}$-inch brass rod in the chuck of a lathe, leaving about 1-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 192 *e*. (1).

(f) The permissible tolerance between rotor blade rockers and the pump body is shown in figure 127. 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 on the diagram. If the clearance is greater than .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 .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 .015-inch. If the bearing is worn more than .001-inch and less than .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.

193. 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
$\frac{9}{16}$-inch box wrench

(1) Install cover assembly on body and the base assembly.

Screwdriver
Pliers
$\frac{9}{16}$-inch box wrench

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 correctly lined up. 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 $\frac{9}{16}$-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 jump 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 1750 rpm 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:

3½-inch of mercury inlet depression at 1600 rpm.
1½-inch of mercury inlet depression at 400 rpm.

(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 $\frac{1}{64}$-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 $\frac{5}{8}$-inch, $\frac{11}{16}$-inch and $\frac{3}{4}$-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.

194. General. — *a.* The engine driven governor on the Guiberson T-1020 engine is a protective over-speed 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

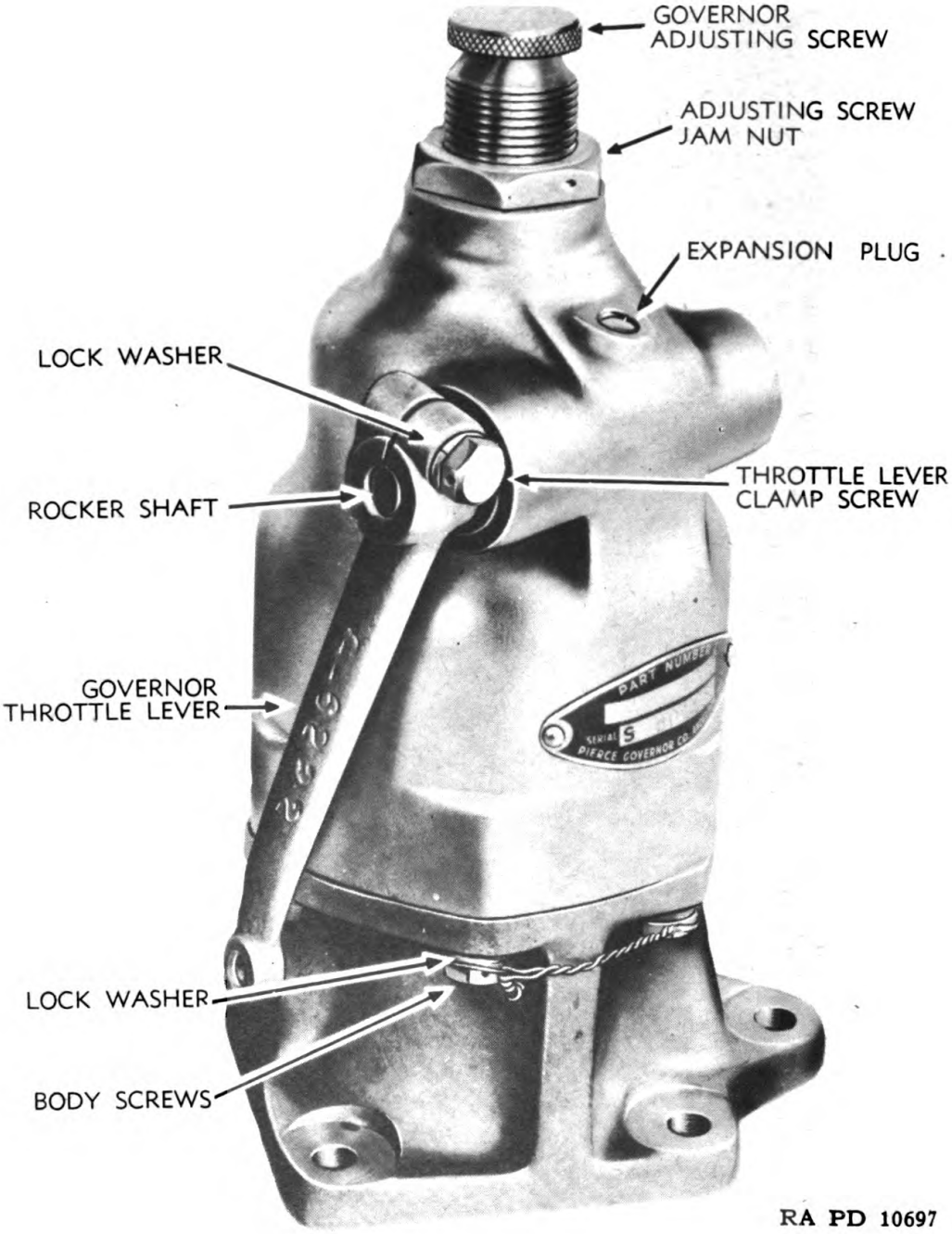


FIGURE 128—The governor assembled.

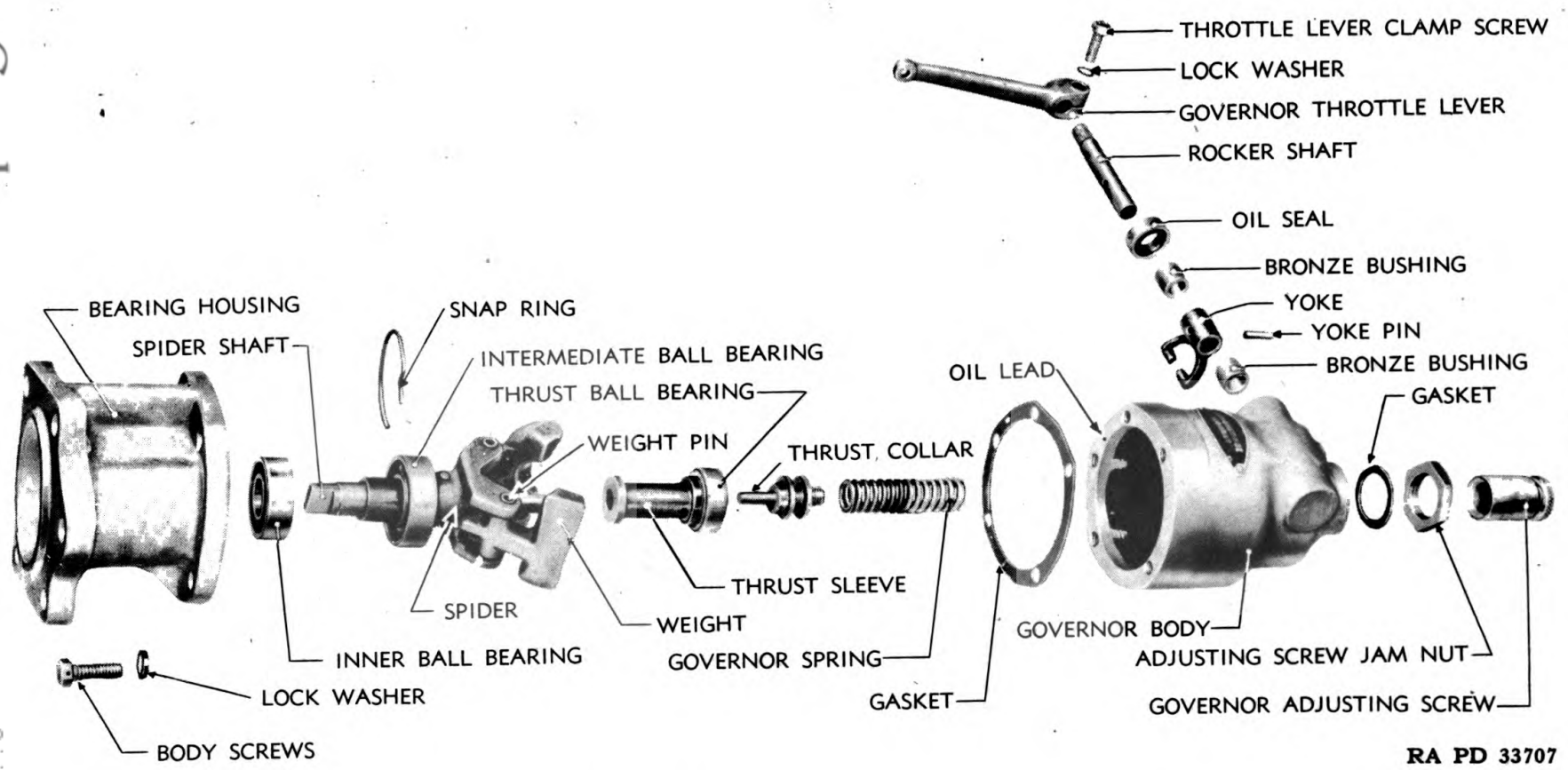


FIGURE 129—The governor disassembled.

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. 128 and 129). The governor mechanism is enclosed in an aluminum housing which is divided into two parts, the governor bearing housing (28) and the governor body (17). The action of the governor depends upon the position of two centrifugal weights fastened by means of a spider (26) to the main or spider shaft (29). A thrust sleeve (11) and thrust collar (13) transfer the action of the weights to a yoke (23) on the rocker shaft (16). On the serrated end of the rocker shaft is clamped a throttle lever (3). A spring (14) 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 (18) located at the end of the governor body. Two ball bearings support the shaft and sleeve mechanism, one (30) at the inner end of the spider shaft, an intermediate bearing (7) on the inner end of the spider. A thrust ball bearing (12) is pressed on the end of the thrust sleeve. Two bronze bushings (2 and 24) provide bearings for the rocker shaft. An oil seal (25) 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 which the governor limits the engine rpm.

195. 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.

196. Trouble shooting on the vehicle. — If the governor fails to hold the engine speed to the desired rpm, 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.

197. Removal from engine *(par. 66).* —

198. Disassembly. — *a. Equipment.* —

1⅜-inch open-end wrench	Aluminum drift
$\frac{7}{16}$-inch open-end wrench	Drift
Cutting pliers	Wedge
Screwdriver	Small cold chisel
Two wooden blocks, each 1¾-inch x 8 inches x 8 inches	Arbor press
	Spacer
	Hammer
Wooden block 1 inch x 1 inch x 2 inches	Grease
	Grinder wheel
Wooden block 1¾-inch x 1¾ inch x 4 inches with a ½-inch diameter hole bored through one of the 1¾-inch faces	Thrust sleeve support cylinder
	Drill
	Drill press

b. Procedure. —

(1) Removing governor spring.

1⅜-inch open-end wrench

Set the GOVERNOR on the bench, bearing HOUSING (28) down. With a 1⅜-inch open-end wrench, loosen the adjusting screw jam NUT (19) at the end of the governor BODY (17). Then unscrew and remove the adjusting SCREW and the NUT. Lift out the governor SPRING (14).

(2) Separate governor housing and bearing housing.

$\frac{7}{16}$-inch open-end wrench
Cutting pliers

Remove the safety WIRE from the five governor body cap SCREWS (cutting pliers). With a $\frac{7}{16}$-inch open-end wrench, unscrew the five cap SCREWS (20) and remove them along with the lock WASHERS (21) under their heads. Lift off the governor HOUSING and remove the GASKET (15).

(3) Remove spider and shaft assembly from lower body section.

Screwdriver
Two wooden blocks each 1¾-inch x 8-inch x 8-inch
Wooden block 1-inch x 1-inch x 2-inches
Hammer

Removing the governor BODY exposes the SPIDER (26) and SHAFT (29) assembly which is held in place in the bearing HOUSING (28) by a snap RING (locking ring) (6) in a groove in the bearing HOUSING above the top of the intermediate ball BEARING (7). Lift off the thrust COLLAR (13), thrust SLEEVE (11) with thrust BEARING (12). 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 eight-inches high. Then with a wooden block (dimensions 1-inch x 1-inch x 2-inches) and a hammer, drive the SPIDER and SHAFT assembly out of the bearing HOUSING along with the inner ball BEARING (30) and the intermediate ball BEARING. Slip the inner ball BEARING off the spider SHAFT.

(4) Cleaning. — Wash all parts with dry cleaning solvent.

(5) Remove governor weights from yoke.

Wooden block 1¾-inch x 1¾-inch x 4-inches with a ½-inch diameter hole bored through one of the 1¾-inch faces
Grinding wheel
Hammer
Grease
Pin punch

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** (9), 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** (10) 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-inch x 1¾-inch x 4 inches with a ½-inch hole bored through one of the 1¾-inch 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.

Hammer
Pin punch
Aluminum drift

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 a pin, punch through the large opening of the governor **BODY**, drive out the tapered **PIN** (22) that fastens the rocker **YOKE** to the rocker **SHAFT**. This **PIN** will push the expansion **PLUG** (27), *(fig. 128)* out of the way and may be removed through the hole thus exposed. Tap the rocker **SHAFT** (16) out of its **BEARINGS** by tapping against the throttle **LEVER** (3) 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** (23).

(7) Remove oil seal and rocker shaft bronze bushings.

Drift
Drill press
Hammer
Small cold chisel
Drill
Screwdriver

If the rocker shaft bronze **BUSHINGS** (2 and 24) are worn, they should be removed as follows: Pry out the oil **SEAL** (25), and with a drift or driving tool, drive the outer bronze **BUSHING** (25) 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.** Cutting pliers
Wedge
$\frac{7}{16}$-inch open-end wrench

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 (5) and using a $\frac{7}{16}$-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 dry cleaning solvent. After washing, dry with compressed air. Clean the oil leads in both aluminum castings with compressed air.

199. Inspection and repair. — *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 .010-inches. 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. 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.

200. Assembly and Installation — *a. Assembly.* — The following list names the tools necessary to assemble the governor:

Arbor press
Spacer
$\frac{7}{16}$-inch straight reamer
Fiber hammer
Expansion plug seating tool
Wedge
Scriber
No. 27 drill
Drill press
Hammer
Special bearing driver
Pliers
$\frac{7}{16}$-inch open-end wrench
$1\frac{3}{8}$-inch open-end wrench
No. 1 taper reamer
Ball peen hammer
Riveting block or anvil
Bearing driver
Screwdriver
Pin punch

(1) Install new rocker shaft bronze bushings.

$\frac{7}{16}$-inch straight reamer
Arbor press
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 $\frac{1}{32}$-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 ($\frac{7}{16}$-inch 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.

Scriber
No. 1 taper reamer
Hammer
Fiber hammer
Expansion plug seating tool
No. 27 drill
Pin punch
Drill press

Scribe a line around the rocker shaft $\frac{31}{32}$-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.

Pin punch
Hammer
Fiber hammer
Expansion plug seating tool

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.

Ball peen hammer
Riveting block or anvil

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.

Hammer
Bearing driver
Screwdriver
Special bearing driver

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: .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.

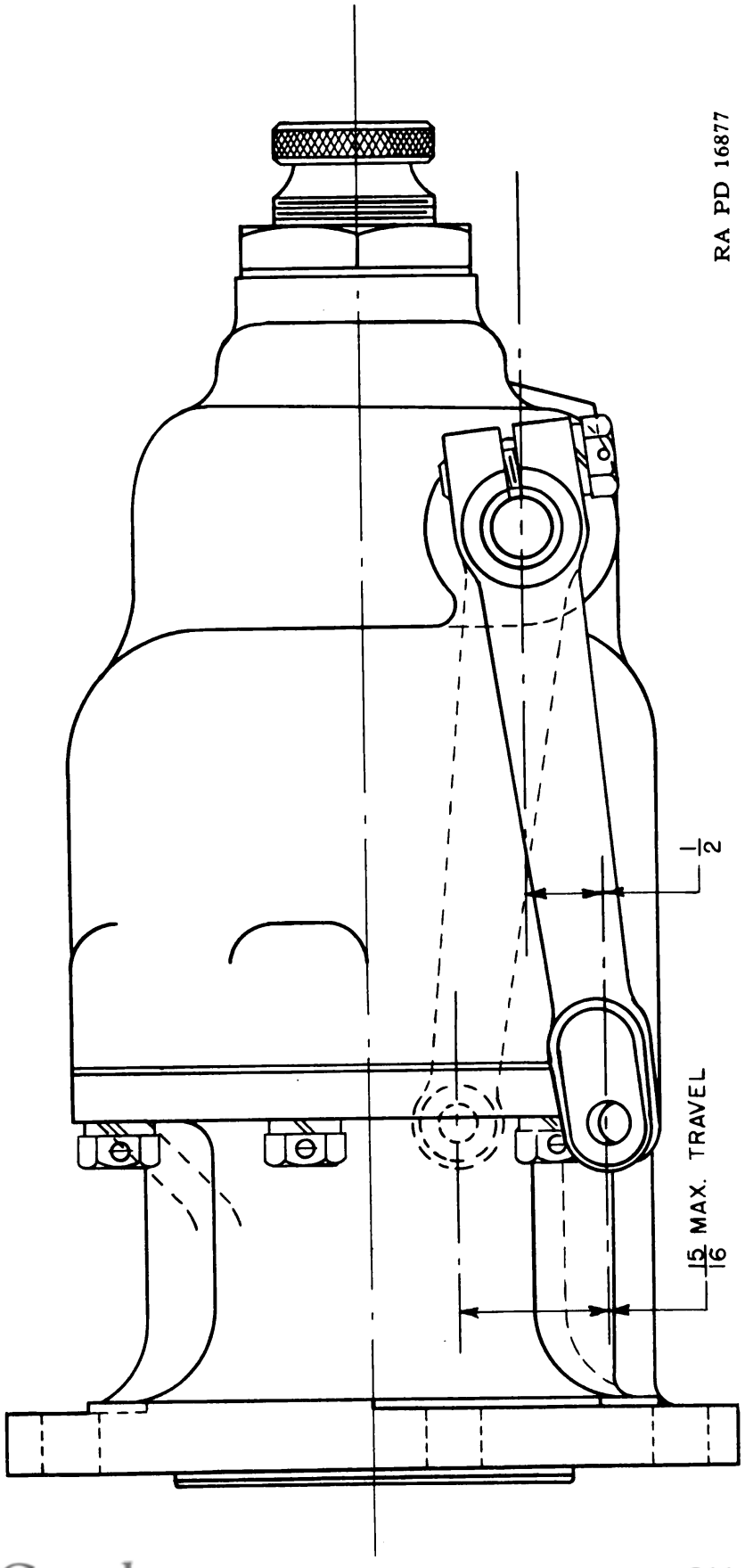


FIGURE 130—Position of governor throttle lever.

(6) Join bearing housing to governor body.

Pliers
$\frac{7}{16}$-inch open-end wrench

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 ($\frac{7}{16}$-inch open-end wrench). Secure the heads of the body cap screws with safety wire (pliers).

(7) Install governor spring in governor body.

$1\frac{3}{8}$-inch open-end wrench

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 $1\frac{3}{8}$-inch open-end wrench.

(8) Install governor throttle lever on rocker shaft.

Pliers
$\frac{7}{16}$-inch open-end wrench
Hammer
Wedge

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 as shown in figure 130. Remove the wedge, install and tighten clamp screw, install safety wire ($\frac{7}{16}$-inch open-end wrench, pliers).

b. Installation. — Refer to paragraph 170.

201. Installation of throttle controls. — Refer to paragraph 178.

202. Generator. — Refer to TM 9-1730.

203. Starter. — Refer to TM 9-1731.

SECTION XII

INSTALLATION OF ENGINE IN VEHICLE

Paragraph

204. Installation of engine in engine compartment. — *a. Equipment.* — The following is a complete list of equipment necessary to install the engine in the tank:

5/8-inch socket wrench	7/8-inch open-end wrench
15/16-inch socket wrench	3/8-inch open-end wrench
1 1/4-inch open-end wrench	7/16-inch open-end wrench
3/4-inch open-end wrench	(2) 15-inch wrench extensions on a hinge handle
3/4-inch socket wrench	Engine lifting sling or rope
9/16-inch open-end wrench	Screwdriver
9/16-inch socket wrench	Pliers
1/2-inch open-end wrench	Hoist
1-inch open-end wrench	
3 chains and spacer	

b. Procedure. —

(1) Place engine in engine compartment *(fig. 24).* — Engine lifting sling or rope; Hoist

Attach a lifting sling to the openings in the engine mounting beam, with a chain around the hub of the clutch pressure plate. If a lifting sling is not available, a rope can be used, which is passed under the rocker boxes of No. 1 cylinder. Raise the engine, and lower it into the engine compartment. The engine will have to be turned diagonally as it is installed, to permit the manifolds to clear.

(2) Engine mounting beam. — 9/16-inch socket wrench

Bolt the engine mounting beam into place at the engine mounting beam bracket by means of the four bolts at each end, using a 9/16-inch socket wrench.

(3) Engine steady rest clamp. — 3/4-inch socket wrench with two 15-inch extensions on a hinge handle

Install the steady rest clamp at each end of the engine steady rest by means of the two bolts at each end, using a 3/4-inch socket wrench with two 15-inch extensions on a hinge handle.

(4) Ground wire cable. — 9/16-inch open-end wrench

Install the ground wire cable at the left side of the engine mounting beam, using a 9/16-inch open-end wrench.

(5) Air intake tubes. — Pliers

Install the hoses from the air intake tubes on the intake manifold, tightening the clamps with pliers.

(6) Throttle control.

Pliers
$\frac{9}{16}$-inch open-end wrench (2)

Raise the throttle control cable into position, and install the lug that holds the throttle control spring to the lower side of the engine mounting beam, using two $\frac{9}{16}$-inch open-end wrenches. Install the clevis of the throttle control on the throttle control lever, and insert the clevis pin to hold it in position. Install a cotter pin in the clevis pin.

(7) Shroud.

$\frac{3}{8}$-inch open-end wrench
$\frac{7}{16}$-inch open-end wrench

Install the shroud in position at the front of the engine, and secure it with the required bolts and nuts, using a $\frac{3}{8}$-inch open-end wrench on the bolt and a $\frac{7}{16}$-inch open-end wrench on the nut.

(8) Decompression control cable *(fig. 23).*

Pliers
$\frac{9}{16}$-inch open-end wrench
$\frac{1}{2}$-inch open-end wrench

Remove the clevis from the end of the cable. Insert the decompression control cable through the opening in the shroud and secure it to the bracket on the engine mounting beam, using a $\frac{1}{2}$-inch open-end wrench. Install the clevis on the cable, using a $\frac{9}{16}$-inch open-end wrench. Install the decompression control cable clevis on the decompression control lever and secure it with the clevis pin. Install a cotter pin in the clevis pin.

(9) Generator *(fig. 23).*

$\frac{9}{16}$-inch socket wrench
Pliers

Install the generator in position on its mounting pad in the engine mounting beam, and use a $\frac{9}{16}$-inch socket wrench to install the four cap screws to hold it in place. Safety-wire the cap screws.

(10) Fire extinguisher line *(fig. 23).*

$\frac{3}{4}$-inch open-end wrench

Connect the two sections of the fire extinguisher line, using a $\frac{3}{4}$-inch open-end wrench.

(11) Oil pressure gage line *(fig. 23).*

$\frac{9}{16}$-inch open-end wrench
$\frac{3}{4}$-inch open-end wrench

Use a $\frac{9}{16}$-inch open-end wrench and a $\frac{3}{4}$-inch open-end wrench to connect the oil pressure gage line.

(12) Engine shut-off solenoid *(fig. 23).*

Screwdriver
$\frac{1}{2}$-inch open-end wrench

Connect the wire to the solenoid and bracket, using a screwdriver and a $\frac{1}{2}$-inch open-end wrench.

(13) Breather line to air intake *(fig. 23).* — 7/8-inch open-end wrench

Insert the free end of the breather line through the opening at the left in the shroud. Remove the plug or cloth from the end of the breather line. Connect it to the air intake, using a 7/8-inch open-end wrench.

(14) Starter intake tube *(fig. 23).* — 1-inch open-end wrench

Insert the starter intake tube through the shroud. Attach the curved end to the right port of the starter and the other end to the breech in the driver's compartment, using a 1-inch open-end wrench.

(15) Fuel lines *(fig. 23).* — 1/2-inch open-end wrench
9/16-inch open-end wrench
3/4-inch open-end wrench

Install the fuel return line connector on top of the engine mounting beam, using 1/2-inch and 9/16-inch open-end wrenches. Connect the line from the fuel filter to the connector at the top of the fuel supply pump, using 1/2-inch and 3/4-inch open-end wrenches.

(16) Oil pump lines *(fig. 23).* — 1 1/4-inch open-end wrench
Pliers

Connect the oil line from the oil tank to the intake fitting of the oil pump; also to the oil lines from the valve assembly of the oil pump, using a 1 1/4-inch open-end wrench. Connect the tachometer drive line at the oil pump by tightening the knurled nut.

(17) Mufflers *(fig. 22).* — 9/16-inch socket wrench

Place the mufflers in their brackets, with the muffler vents facing in toward the engine. Connect the mufflers to the exhaust manifolds. Install the brackets around the mufflers with the castellated nuts, using a 9/16-inch socket wrench.

(18) Channel *(fig. 22).* — 3/4-inch socket wrench
15/16-inch socket wrench
Screwdriver

Install the channel in position as shown in figure 22. Using a 3/4-inch socket wrench, install the two bolts that hold the channel to the bracket at each end. Use a 15/16-inch socket wrench to install the two bolts at each side that hold the channel to the rear armor plate. Install the tail light cable clips on the channel, using a screwdriver.

(19) Oil expansion tank *(fig. 22).* — 7/8-inch open-end wrench

Remove the cloth or plugs from the lines and install the lines from the accessory case and the oil tank on the oil expansion tank, using a 7/8-inch open-end wrench.

(20) Fram oil filters *(fig. 22).* — 1/2-inch open-end wrench; 9/16-inch socket wrench; 3/4-inch socket wrench

Place the filters in position and bolt the supporting bracket of the filters to the channel, using a 3/4-inch socket wrench. Install the outlet line that is attached to the engine mounting beam to the filter at the left, using a 1/2-inch open-end wrench. Install the inlet line from the oil pump to the filter at the right, using a 1/2-inch open-end wrench.

(21) Inspection cover — 9/16-inch socket wrench

Using a new gasket, install the inspection cover underneath the engine compartment by means of the fourteen screws, using a 9/16-inch socket wrench.

(22) Propeller shaft. — 5/8-inch socket wrench; 3/4-inch open-end wrench

Connect the companion flange to the propeller shaft by installing the nuts with a 3/4-inch open-end wrench. Install the propeller shaft tunnel cover, using a 5/8-inch socket wrench.

(23) Armor plate *(fig. 21).* — Screwdriver; 3 Chains and spacer; Hoist

With two chains to the handles on each side of the top armor plate, and a spacer between them, and a third chain hooked under the front of the top armor plate, raise the armor plate with a hoist and install it in position over the engine compartment. Use a screwdriver to install the bolts that hold the top armor plate to the angle of the side armor plate. Install the four bolts across the front of the top armor plate; the four bolts on the diagonal section of the side armor plate; and the three bolts on the vertical section that secure the angle of the top armor plate to the side armor plate.

(24) Oil expansion tank. — 9/16-inch socket wrench

Enclose the oil expansion tank in its hanger. Bolt the hanger to the top armor plate by the four bolts which extend through the top armor plate at the left side, using a 3/4-inch socket wrench.

(25) Engine compartment doors. — ¾-inch socket wrench

Close the doors and bolt them shut, using a ¾-inch socket wrench.

(26) Flywheel compartment guard. — $\frac{9}{16}$-inch socket wrench

Install the guard and secure it in place with the four bolts and washers, using a $\frac{9}{16}$-inch socket wrench.

(27) Deflector *(fig. 20).* — Screwdriver

Install the deflector in place and secure it with the nine bolts, using a screwdriver.

(28) Radio antenna bracket *(fig. 20).* — ¾-inch socket wrench

Swing the bracket around into position. Install the three bolts which were removed and tighten the fourth, using a ¾-inch socket wrench.

(29) Guard *(fig. 20).* — ¾-inch socket wrench

Install the guard in position underneath the rear of the hood and use a ¾-inch socket or box wrench to secure it in place.

(30) Tail lights *(fig. 20).* — $\frac{7}{16}$-inch open-end wrench

Install the tail lights in position and secure them by means of the nut on each side, using a $\frac{7}{16}$-inch socket wrench.

(31) Tool boxes *(fig. 20).*

Install the tool box on each fender and strap in position.

SECTION XIII

PREPARING THE ENGINE FOR STORAGE

205. Storage protection procedure *(fig. 131).* — *a. Rust preventative.* — (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 fifteen minutes on fuel containing 10 per cent Penola A.E. 603-B (Penola, Inc., Pittsburgh, Pennsylvania) (or equivalent) and with 100 per cent Penola A.E. 603-B (or equivalent) circulating through the engine lubricating system.

(2) After shutting down the engine, remove it from the tank (Section V). It should be thoroughly cleaned with kerosene, brushes, and scrapers over a drip pan and with the aid of compressed air. Slush the portions of the engine interior requiring protection, particularly the combustion chambers. Spray Penola A.E. 603-B (or equivalent) 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.

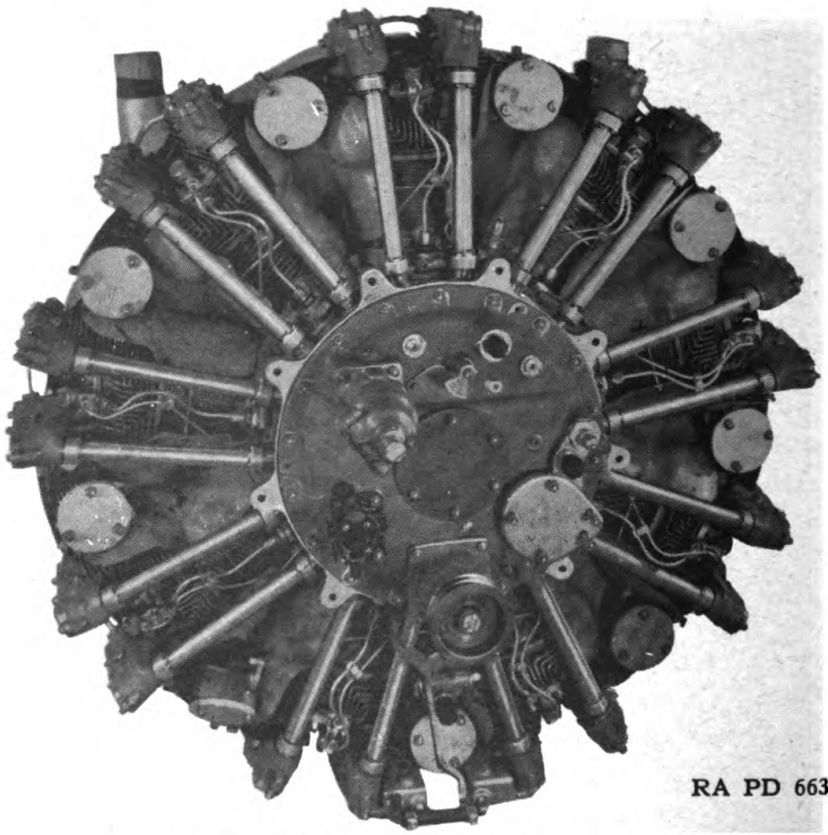


FIGURE 131—Engine prepared for storage.

c. Cover all openings. — All openings and ports in the engine should be covered with plugs, as shown in figure 131, to prevent dirt or foreign material from falling into the engine.

d. When engine is to be overhauled. — If the engine is to be overhauled before placing in storage, follow the procedure given in Sections VI, VII, VIII and IX of this manual. When the engine is reassembled, the precautions against corrosion given above should be followed.

e. 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, need 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 XIV

REMOVAL OF ENGINE FROM SHIPPING CRATE

Paragraph

206. Removing the shipping crate *(figs. 132, 133 and 134).* — *a. Equipment.* —

Hoist
Lifting eye (GU-GST-1308)
Pliers

b. Procedure. — 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. The procedure for unpacking the engine and installing the accessories is as follows:

(1) Remove the cover. — 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 132. Raise the cover straight up until the engine is cleared.

(2) Remove engine from crate platform. — (a) The engine is bolted to the platform through the engine mounting flange. Remove these bolts.

(b) The engine is shipped with the flywheel NUT (GU-13-YX-100D) and CONE (GU-13-YX-100C) installed on the crankshaft, taped to hold the cone in place. Remove the tape and lift out the two halves of the front cone. Pull the cotter key from the lock PIN (GU-YX-448) through the nut and lift out the lock pin. Remove the flywheel nut and install a lifting eye 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.

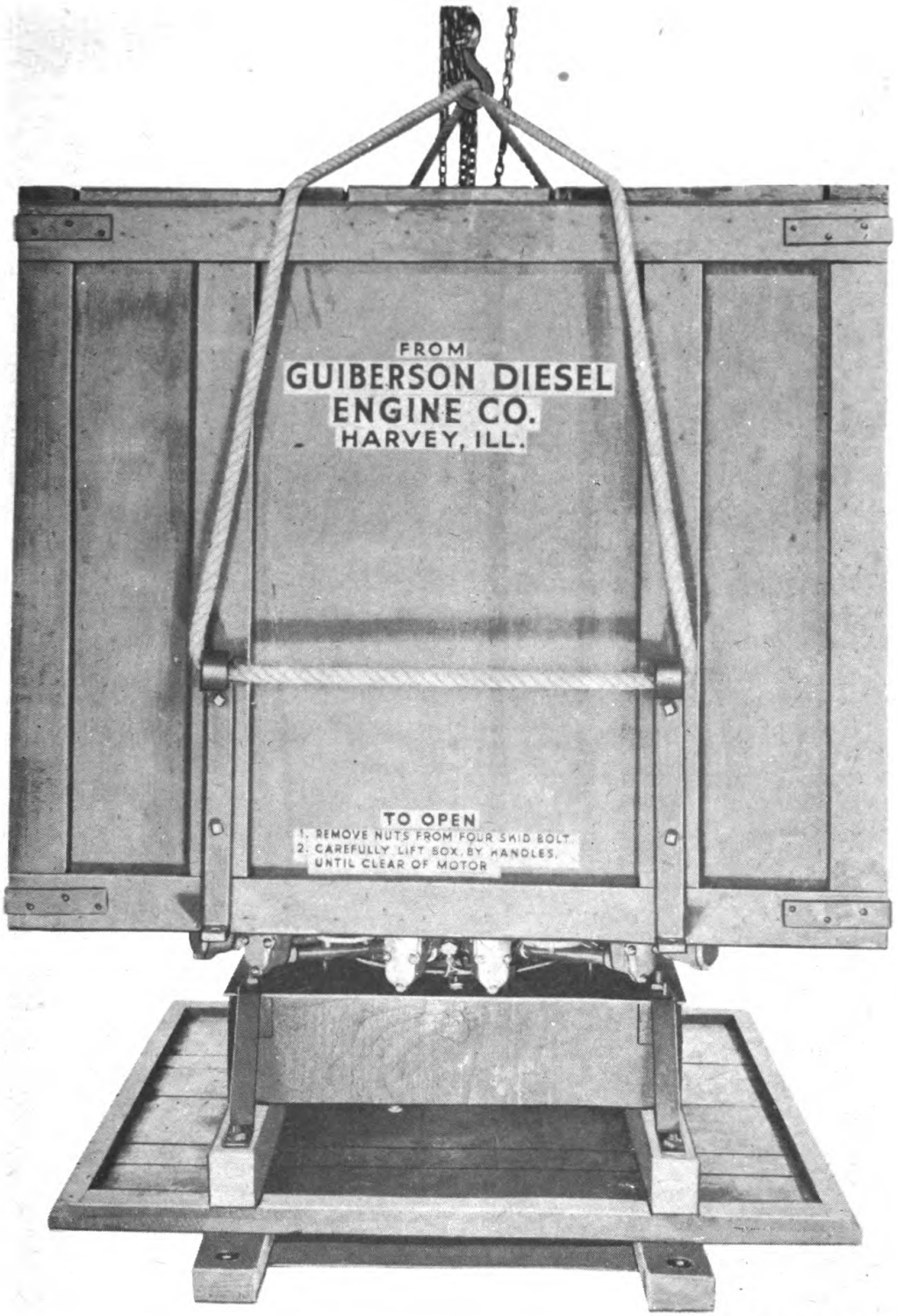
(c) Remove the plugs from the exhaust elbows, while the engine is suspended from the hoist.

207. Assemble the engine *(fig. 135).* — *a. Equipment.* —

$\frac{1}{2}$-inch open-end wrench
$\frac{9}{16}$-inch open-end wrench
Hoist
Pliers
$2\frac{5}{16}$-inch box wrench
$\frac{7}{16}$-inch socket wrench
$\frac{1}{2}$-inch socket wrench
$\frac{3}{4}$-inch open-end wrench
$\frac{7}{16}$-inch open-end wrench
$\frac{9}{16}$-inch socket wrench

b. Procedure. — **(1) Install the exhaust manifolds.** — The exhaust manifolds must be replaced before the banjo is installed. Place a

REMOVAL OF ENGINE FROM SHIPPING CRATE



RA PD 6639

FIGURE 132—Removing the shipping crate cover.

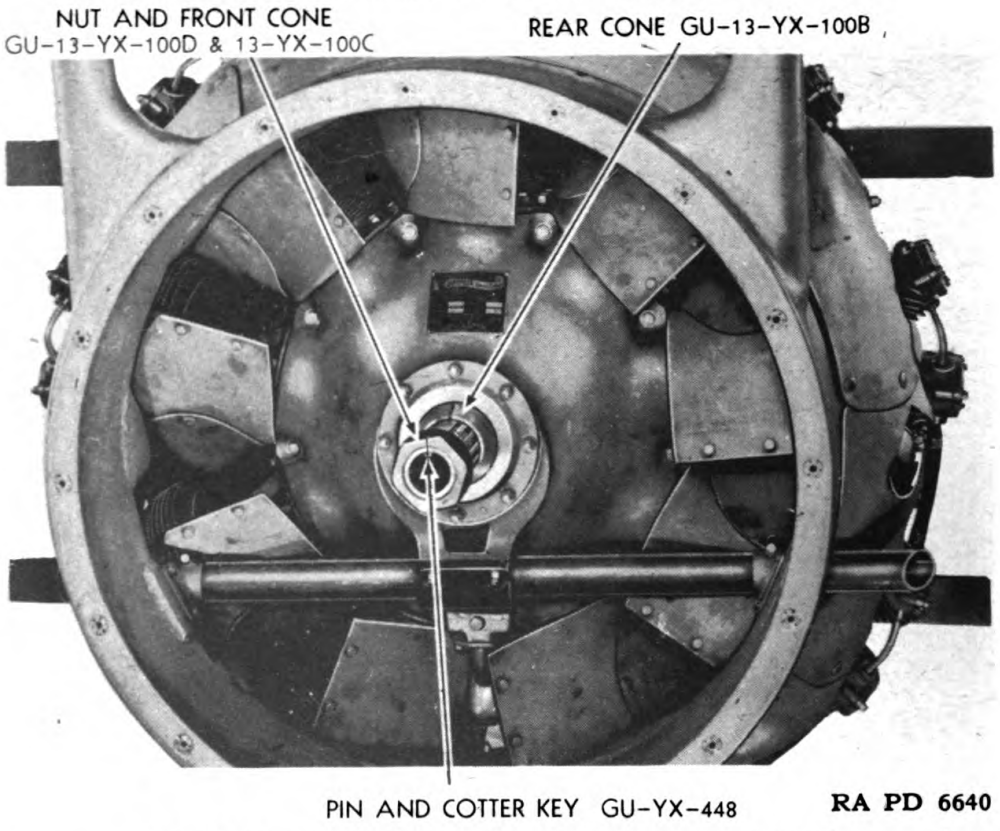


FIGURE 133—Flywheel nut and cone are taped to crankshaft.

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, using a ½-inch open-end wrench. 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. — (a) Lower the engine onto the engine mounting beam in the stand, with the flat side of the engine mounting beam up toward the engine. The throttle spring support fork on the beam should be at No. 5 cylinder. Lower the accessory case of the engine through the beam opening.

(b) 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 $\frac{9}{16}$-inch open-end wrench.

(c) Line the cotter pin openings in the bolt and nut, and insert them.

(d) Remove the plugs and tape from all the openings in the engine except the manifold openings.

(3) Install the flywheel. — 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.

REMOVAL OF ENGINE FROM SHIPPING CRATE

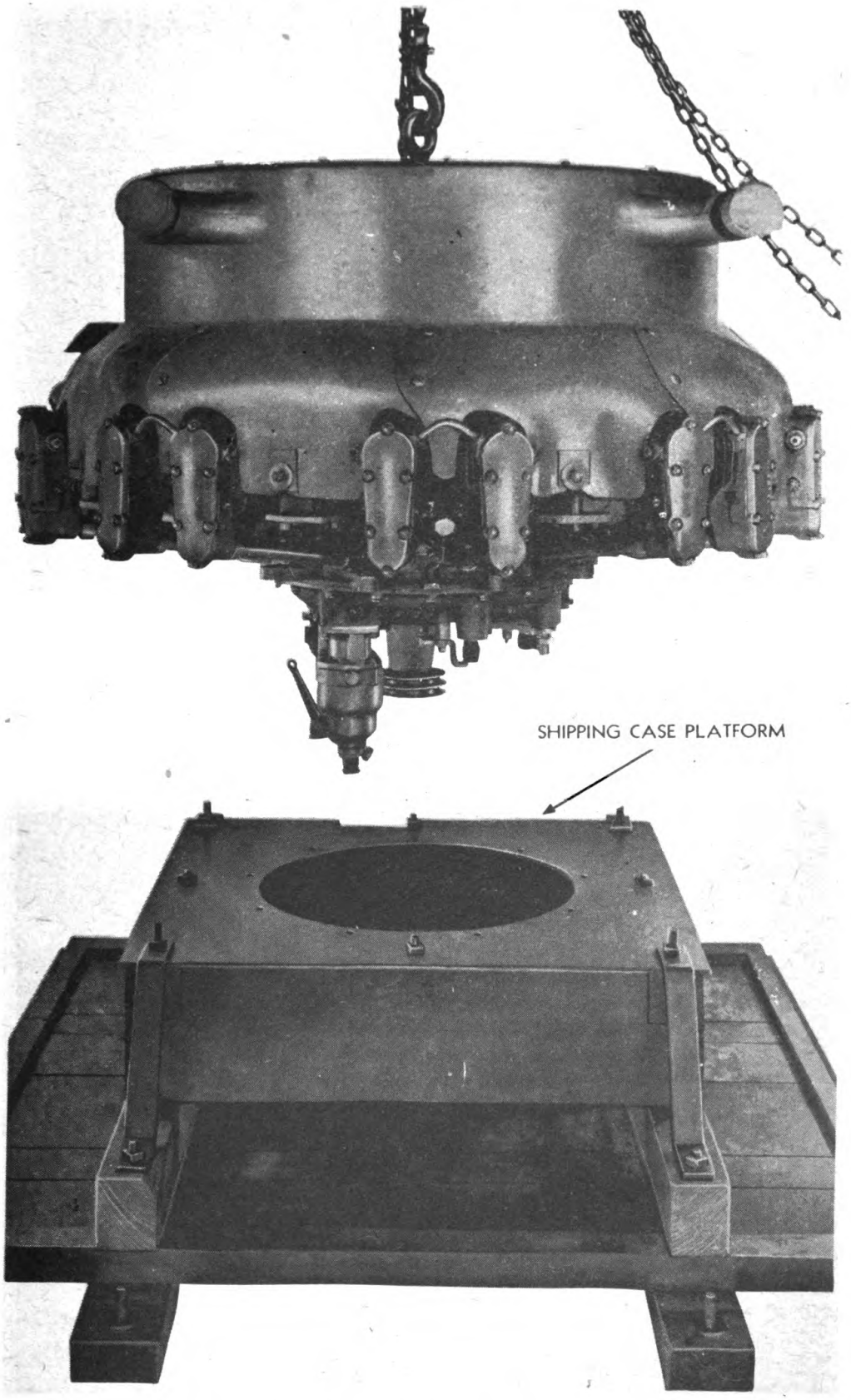


FIGURE 134—Lifting the engine from the shipping crate. RA PD 6641

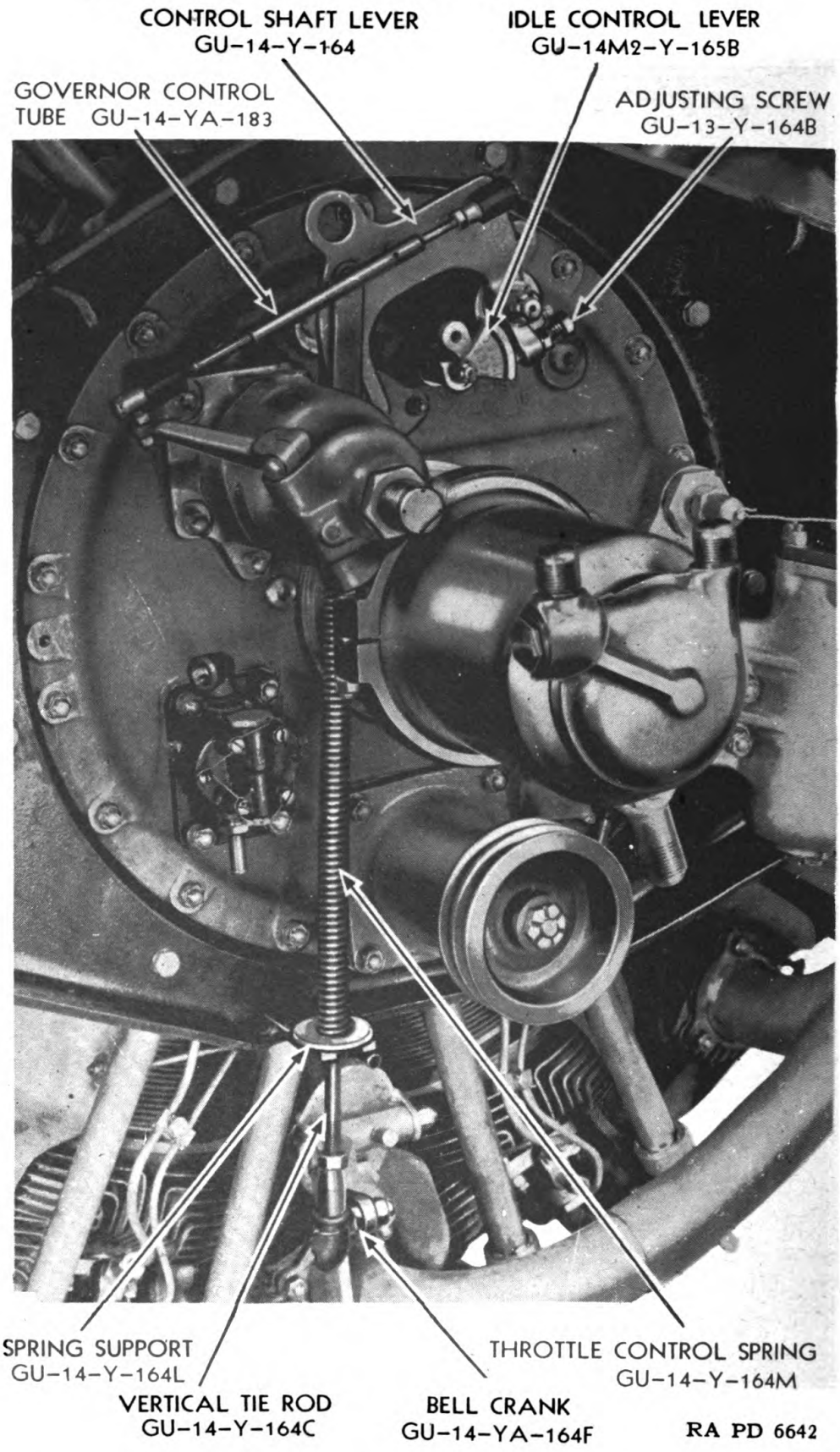


FIGURE 135 — The throttle connections.

(a) Coat the inside of the brass cone with Lubriplate or equivalent, and slide it on the front crankshaft with the tapered side out and with the split in the cone exactly centered over the wide spline on the crankshaft.

(b) The flywheel can be installed with the front of the motor facing upward, or with the motor in a vertical position. Slide the flywheel on to the front crankshaft.

(c) Place the two halves of the rear 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 ($2\frac{5}{16}$-inch box wrench).

(d) The flywheel should be centered in the intake manifold and 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, and lock with a cotter pin.

(f) Place the intake manifold front plate on the manifold, and fasten with flat washers and bolts, using a $\frac{7}{16}$-inch socket wrench. Safety-wire the bolt heads together in pairs.

(4) Install the oil pump. — Place the oil pump on the mounting studs and install the washers, nuts and palnuts, using a $\frac{1}{2}$-inch 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.

(5) Safety-wire the fuel oil pressure regulator. — Run safety-wire from the dome of the fuel pressure regulator to the elbow on the regulator.

(6) Install the starter. — Install the starter with a new gasket on the mounting studs with the ports up. Install washers and elastic stop nuts, using a $\frac{9}{16}$-inch socket wrench.

(7) Install the throttle controls. — (a) Slide the throttle control shaft LEVER (GU-14-Y-164) over the throttle shaft and install the washer and nut ($\frac{3}{4}$-inch open-end wrench). Insert a cotter pin to lock the nut. Tighten the clamp bolt ($\frac{7}{16}$-inch open-end wrench) with a flat washer and lock washer underneath. Using a $\frac{9}{16}$-inch open-end wrench, tighten the throttle control shaft adjusting SCREW (GU-13-Y-164B) to rest on the idle control LEVER (GU-14M2-Y-165B). Use a $\frac{7}{16}$-inch open-end wrench to install the governor control TUBE (GU-14-YA-183). One end is attached to the throttle control lever and the other to the governor.

(b) The throttle control vertical tie ROD (GU-14-Y-164C) is attached at the top to the throttle control lever through the clevis. The lower end of the tie rod is attached by means of a bolt to the upper arm of the bell CRANK (GU-14-YA-164F). A nut ($\frac{9}{16}$-inch open-end

wrench) is used on each side of the bell crank, the outside nut being an elastic stop nut. The throttle control spring seats on a SUPPORT (GU-14-Y-164L) on top of the fork on the banjo.

(8) Install fuel supply pump hose. — Run a hose from the lower connection of the fuel supply pump down to the fuel check valve nipple, carrying it inside the throttle control spring. Tighten it on with the thumb screws.

(9) Connect the oil sump to the oil pump. — 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 and place the line over the other end of the liner. Slide the hose up over the oil sump connection 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. Install a gasket and bolt the line in place, using flat washers, nuts, and palnuts (½-inch open-end wrench).

(10) Attach the rocker box scavenger hose. — Connect a hose from the nipple on the scavenger rocker box to the nipple on the oil pump, tightening the clamp at each end by means of the thumb screws.

(11) Install the starter support. — Clamp the two halves of the ring of the support around the starter using a $\frac{7}{16}$-inch open-end wrench with the arms of the support on top. Attach the outer ends of the arms to the braces on the engine mounting beam, using a flat washer and elastic stop nut (½-inch open-end wrench).

SECTION XV

SERVICE, ASSEMBLY, AND OVERHAUL TOOLS

208. List of service, assembly, and overhaul tools. — *a.* This list is of the tools used in servicing, assembling, and overhauling the Guiberson T-1020 Engine, Series 4. Numbers listed under the heading "Tool No." are of the complete tool. Numbers listed under the heading "Part No." are of individual parts that make up the complete tool. These can be supplied separately.

b. Special tools—T-1020 Engine, Series 4. —

Tool No.	Part No.	Name
1. GST-1349		Wrench, Inter. & Idler Gear Nut
2. GST-1324		Wrench, Oil Pump Drive Gear Nut
3. GST-1325		Wrench, Generator Drive Gear Nut
4. GST-1322		Wrench, Fuel Supply Pump Gear Nut
5. GST-1312		Holder, Fuel Supply Pump & Idler Gears
	GST-1312A	Plate, Fuel Supply Pump & Idler Gears Holder
	GST-1312B	Pin, Fuel Supply Pump & Idler Gears Holder
6. GST-1350		Plate Wrench, Oil Pressure Relief Valve Seat
7. GST-1370		Driver, Governor Gear
8. GST-1369		Driver, Fuel Supply Pump Gear
9. GST-1368		Driver, Oil Pump Gear
10. GST-1367		Puller and Adapters, Accessory Case Gears
		a. Adapters
		b. Short Arms
11. GST-1360		Puller, Accessory Case
12. GST-1304		Remover, Push Rod
13. GST-1432		Wrench, Cylinder Hold Down Nut
14. GST-1356		Remover, Rocker Bearing
	GST-1356A	Driver, Rocker Bearing Remover
	GST-1356B	Receiver, Rocker Bearing Remover
15. GST-1357		Inserter, Rocker Bearing
	GST-1357A	Holder, Rocker Bearing Inserter
	GST-1357B	Guide, Rocker Bearing Inserter
16. GST-1358		Driver, Valve Tappet Guide
17. GST-1303		Holding Bar, Fuel Pump & Fuel Injector
18. GST-1306		Wrench, Push Rod Housing Nut
19. GST-1365		Puller, Valve Tappet Guide & Fuel Pump

	Tool No.	Part No.	Name
		GST-1309A	Tie Bolt, Valve Tappet Guide Puller
		GST-1309B	Lower Nut, Valve Tappet Guide Puller
		GST-1309C	Upper Nut, Valve Tappet Guide Puller
		GST-1309D	Connector, Valve Tappet Guide Puller
		GST-1309E	Hammer, Valve Tappet Guide Puller
20.		GST-1365B	Adapter, Fuel Pump Puller
21.	GST-1347		Wedge, Crankshaft
22.	GST-1331		Remover, Knuckle Pin
23.	GST-1353		Compressor, Valve Spring
		GST-1353A	Body, Valve Spring Compressor
		GST-1353B	Plunger, Valve Spring Compressor
		GST-1353C	Bushing, Valve Spring Compressor
		GST-1353D	Guide, Valve Spring Compressor
		GST-1353E	Spring, Valve Spring Compressor
		GST-1353F	Pin, Valve Spring Compressor
		GST-1353G	Roller Pin, Valve Spring Compressor
		GST-1353H	Handle, Valve Spring Compressor
		GST-1353I	Roller, Valve Spring Compressor
		GST-1353J	Bolt, Valve Spring Compressor
		GST-1353K	Nut, Valve Spring Compressor
		GST-1353L	Washer, Valve Spring Compressor
		GST-1353M	Cap Screw, Valve Spring Compressor
		GST-1353N	Set Screw, Valve Spring Compressor
24.	GST-1336		Aliner, Rocker Support Pin
25.	GST-1338		Remover, Crankcase Bolt
		GST-1338A	Weight, Crankcase Bolt Remover
		GST-1338B	Head, Crankcase Bolt Remover
		GST-1338C	Shaft, Crankcase Bolt Remover
26.	GST-1335		Aliner, Knuckle Pin
27.	GST-1311		Puller, Main Bearing & Front Crankcase
		GST-1311A	Tie Bolt, Front Crankcase Puller
		GST-1311B	Cross-Arm, Front Crankcase & Main Brg. Puller
		GST-1311C	Plate, Front Crankcase Puller
		GST-1311D	Tee, Front Crankcase & Main Brg. Puller
		GST-1311E	Arm, Main Bearing Puller
		GST-1311F	Pin, Main Bearing Puller
		GST-1311G	Guide, Front Main Bearing Puller
		GST-1311H	Guide, Rear Main Bearing Puller
		GST-1311J	Holding Bar, Fr. Cnkcs. & Main Brg. Puller
28.	GST-1307		Wrench, Front Bearing Nut
29.	GST-1354		Holder, Fuel Pump Indicator

SERVICE, ASSEMBLY, AND OVERHAUL TOOLS

Tool No.	Part No.	Name
	GST-1354A	Body, Fuel Pump Indicator Holder
	GST-1354B	Cap, Fuel Pump Indicator Holder
	GST-1354C	Nut, Fuel Pump Indicator Holder
	GST-1354D	Plunger, Fuel Pump Indicator Holder
	GST-1354E	Spring, Fuel Pump Indicator Holder
	GST-1354F	Drain, Fuel Pump Indicator Holder
30. GST-1355		Holder, Top Center Indicator
	GST-1355A	Stem, Top Center Indicator Holder
	GST-1355B	Collar, Top Center Indicator Holder
	GST-1355C	Spring, Top Center Indicator Holder
	GST-1355D	Sleeve, Top Center Indicator Holder
	GST-1355E	Cap, Top Center Indicator Holder
	GST-1355F	Plate, Top Center Indicator Holder
	GST-1355G	Screw, Top Center Indicator Holder
31. GST-1318		Timing Disk and Pointer
	GST-1318A	Timing Disk
	GST-1318B	Timing Pointer
	GST-1318C	Plug, Timing Pointer
	GST-1318D	Cap Screw, Timing Pointer
32. GST-1344		Turner Crankshaft
33. GST-1301		Puller, Starter Jaw Gear
	GST-1301A	Body, Starter Jaw Gear Puller
	GST-1301B	Screw, Starter Jaw Gear Puller
34. GST-1308		Engine Lifting Eye
35. GST-1319		Driver, Front Crankshaft Bearing
	GST-1319A	Steel Bushing, Front Crankshaft Bearing Driver
	GST-1319B	Sleeve, Front Crankshaft Bearing Driver
	GST-1319C	Bronze Bushing, Front Crankshaft Bearing Driver
36. GST-1371		Tester for Master Rod Oil Passages
37. GST-1332		Receiver, Knuckle Pin & Master Rod
38. GST-1333		Drift, Knuckle Pin Inserter
39. GST-1372		Generator Drive Pulley Puller
40. GST-1419		1¼" Fuel Pump Adjusting Wrench
41. GST-1424		Valve Adjusting Wrench
	GST-1424A	Driver, Valve Adjusting Wrench
	GST-1424B	Socket, Valve Adjusting Wrench
42. GST-1363		Installation Tool, Inter-Rocker Box Drain Lines
	GST-1363A	Anvil, Installation Tool
	GST-1363B	Punch, Installation Tool

Tool No.	Part No.	Name
	GST-1363C	Screw, Installation Tool
	GST-1363D	Pin, Installation Tool
	GST-1363E	Cotter Pin
43. GST-1352		Compressor, Piston Ring
c. Standard tools—T-1020 Engine, Series 4 and Series 3.—		
GST-1400		¾" x ⅞" Open-End Wrench
GST-1401		⅜" x 7/16" Open-End Wrench
GST-1402		7/16" x ½" Open-End Wrench
GST-1403		9/16" x ⅝" Open-End Wrench
GST-1404		⅝" x ¾" Open-End Wrench
GST-1405		13/16" x 1" Open-End Wrench
GST-1406		Pliers
GST-1407		7/16" x ½" Box Socket Wrench
GST-1408		9/16" x ⅝" Box Socket Wrench
GST-1409		2 15/16" Box Socket Wrench with 36" Tubular Handle
GST-1410		9/16" Socket with ½" Square Drive
GST-1411		⅞" Socket with ½" Square Drive
GST-1412		5" Socket Extension
GST-1413		½" Square Drive Sliding T-Handle
GST-1414		¾" Square Drive Sliding T-Handle
GST-1415		4" Screwdriver
GST-1416		6" Screwdriver
GST-1417		1⅛" Socket, Single Broach with ¾" Sq. Dr.
GST-1418		1½" Socket, Single Broach with ¾" Sq. Dr.
GST-1419		1¼" Fuel Pump Adjusting Wrench
GST-1420		1 7/16" Fuel Pump Adjusting Wrench
GST-1421		6" Chisel
GST-1422		8" Punch
GST-1423		Vacuum Valve Grinder
GST-1424		Valve Adjusting Wrench
	GST-1424A	Driver, Valve Adjusting Wrench
	GST-1424B	Socket, Valve Adjusting Wrench
GST-1425		9/16" Allen Wrench
GST-1426		12" Adjustable Wrench
GST-1427		8" Adjustable Wrench
GST-1428		Hammer (12 oz.)
GST-1429		Feeler Gage, Valve Tappet Adjusting
	GST-1429A	.020" Feeler 6" Long
	GST-1429B	.045" Feeler 6" Long

SERVICE, ASSEMBLY, AND OVERHAUL TOOLS

Tool No.	Part No.	Name
GST-1430		Feeler Gage (.002" — .013" inc.) and (.015" & .045")
GST-1431		Brass Punch
GST-1432		Wrench, Cylinder Hold Down Nut
GST-1433		Remover, Knuckle Pin Retainer Ring
GST-1434		Alemite Grease Gun
GST-1435		$\frac{13}{16}$" x $\frac{7}{8}$" Open-End Wrench
GST-1436		$\frac{15}{16}$" x 1" Open-End Wrench
GST-1437		$\frac{7}{16}$" Socket with ½" Square Drive

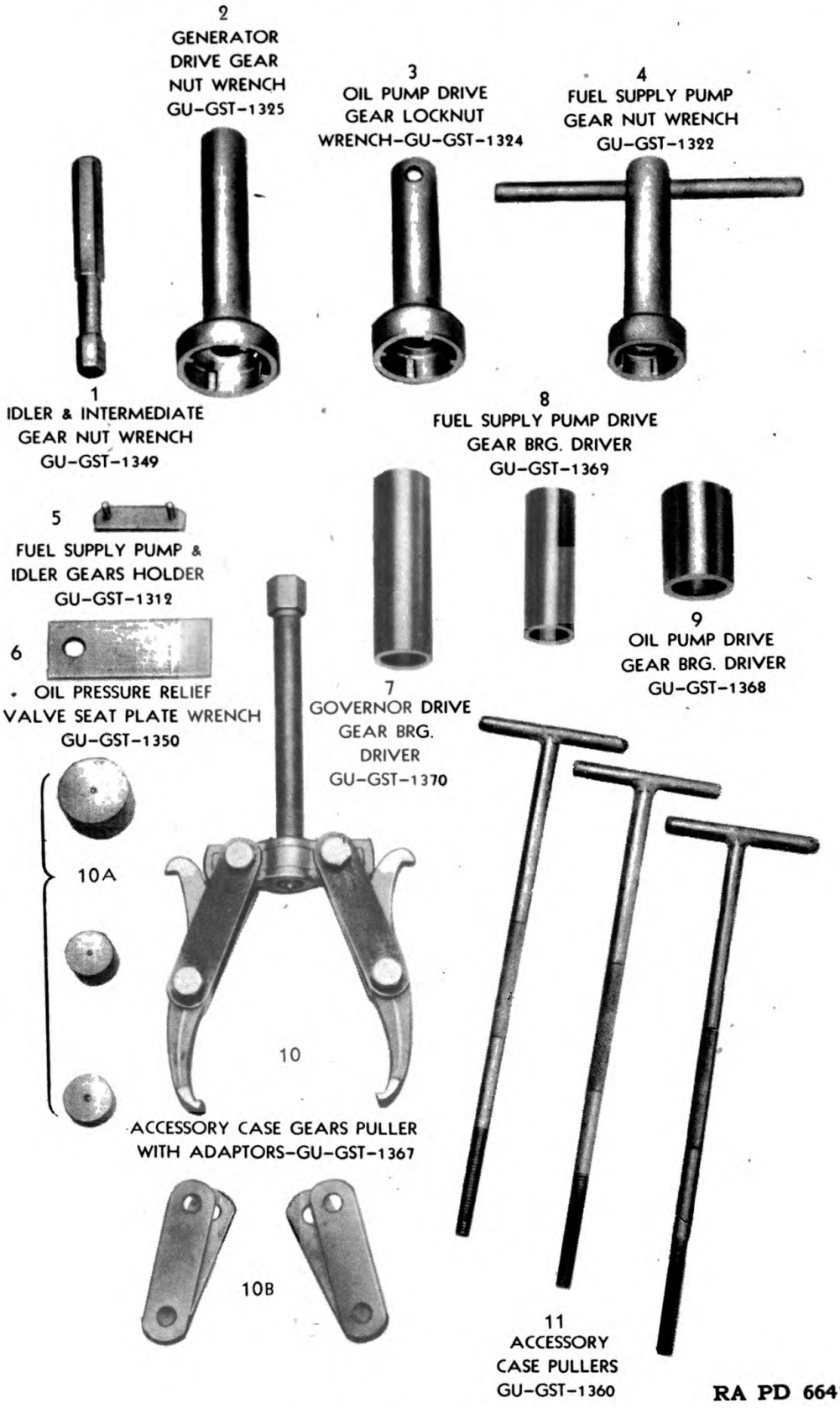


FIGURE 136—Special Tools.

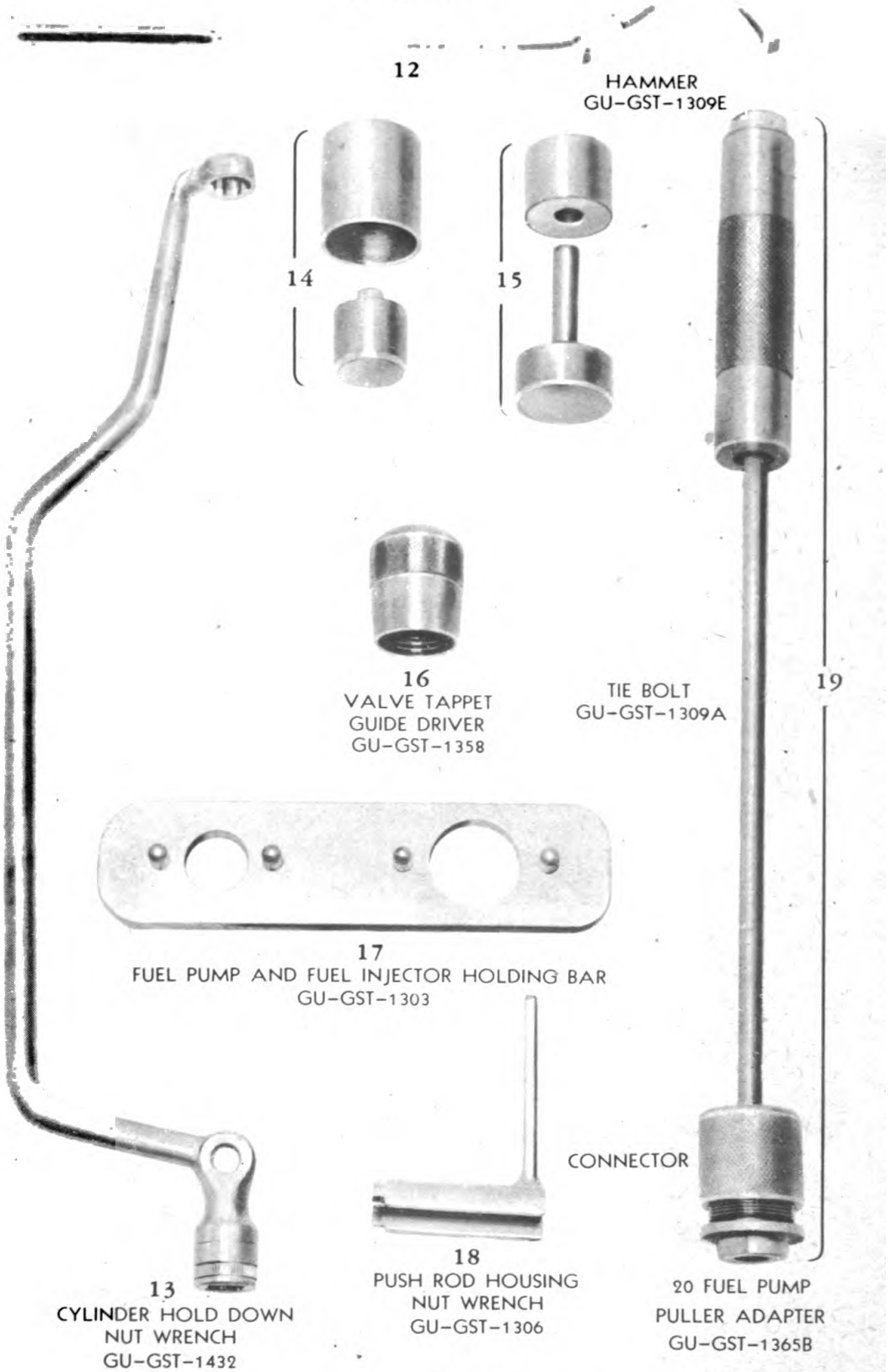


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FIGURE 137—Special Tools.

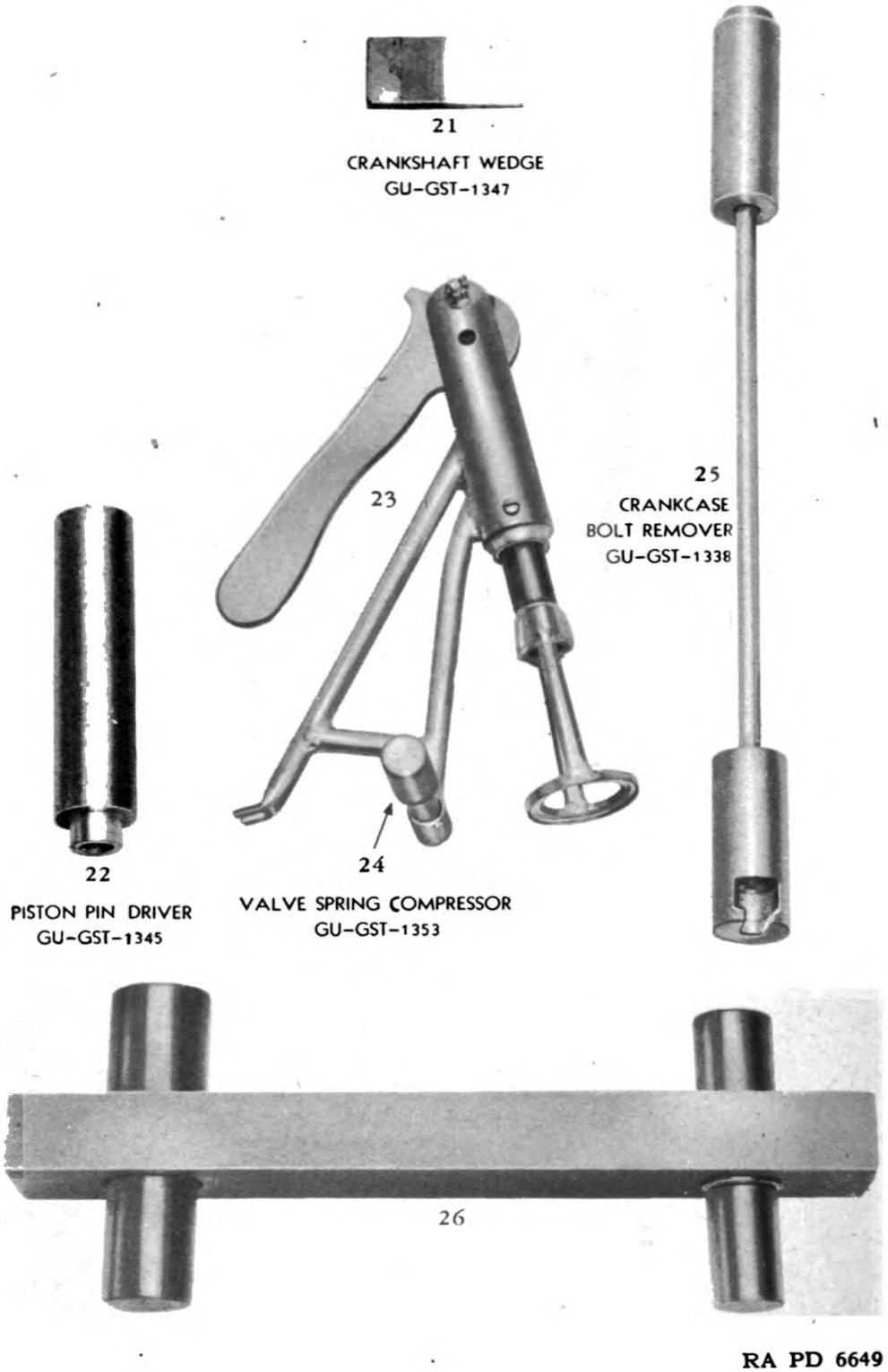


FIGURE 138—Special Tools.

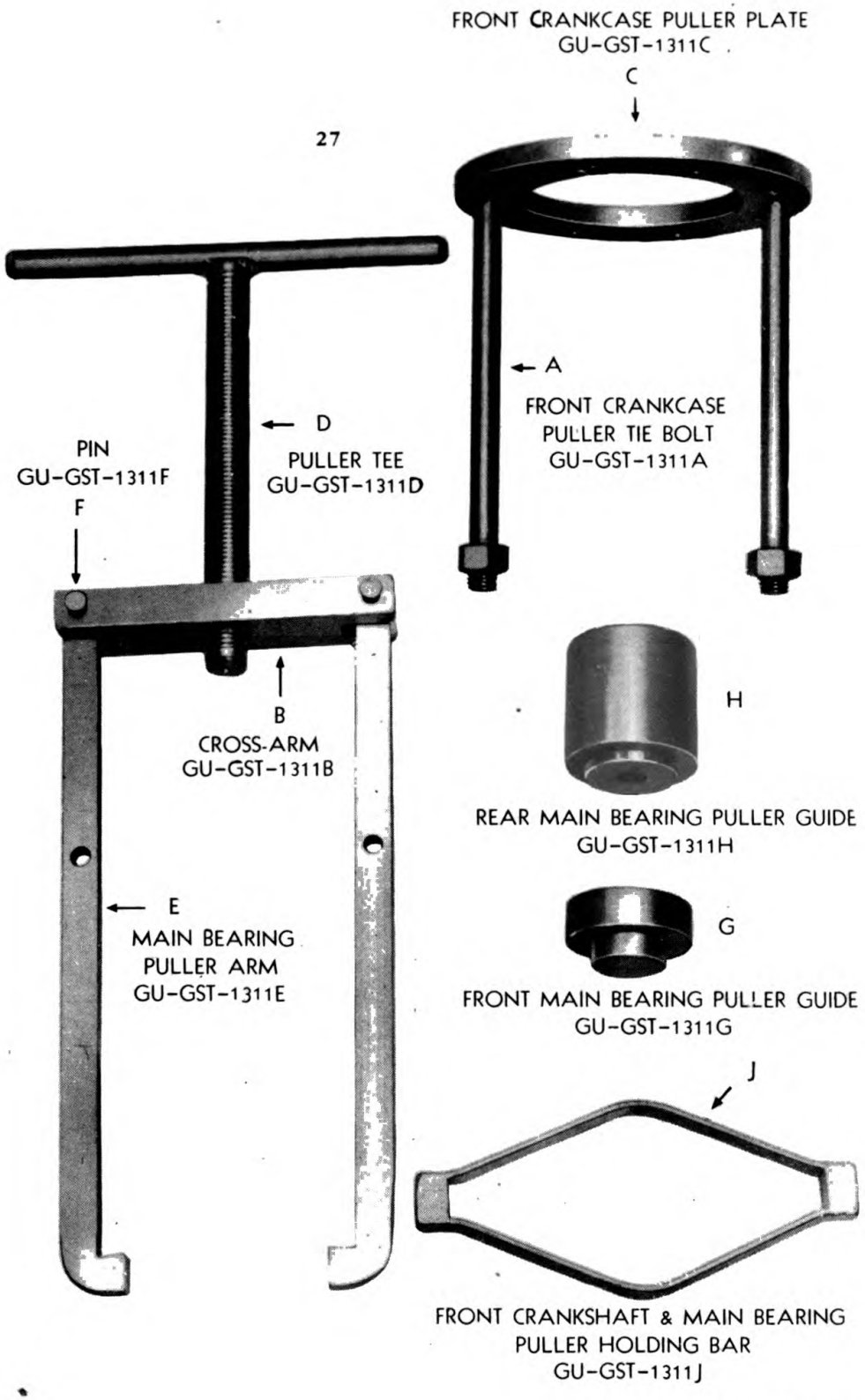


FIGURE 139—Special Tools.

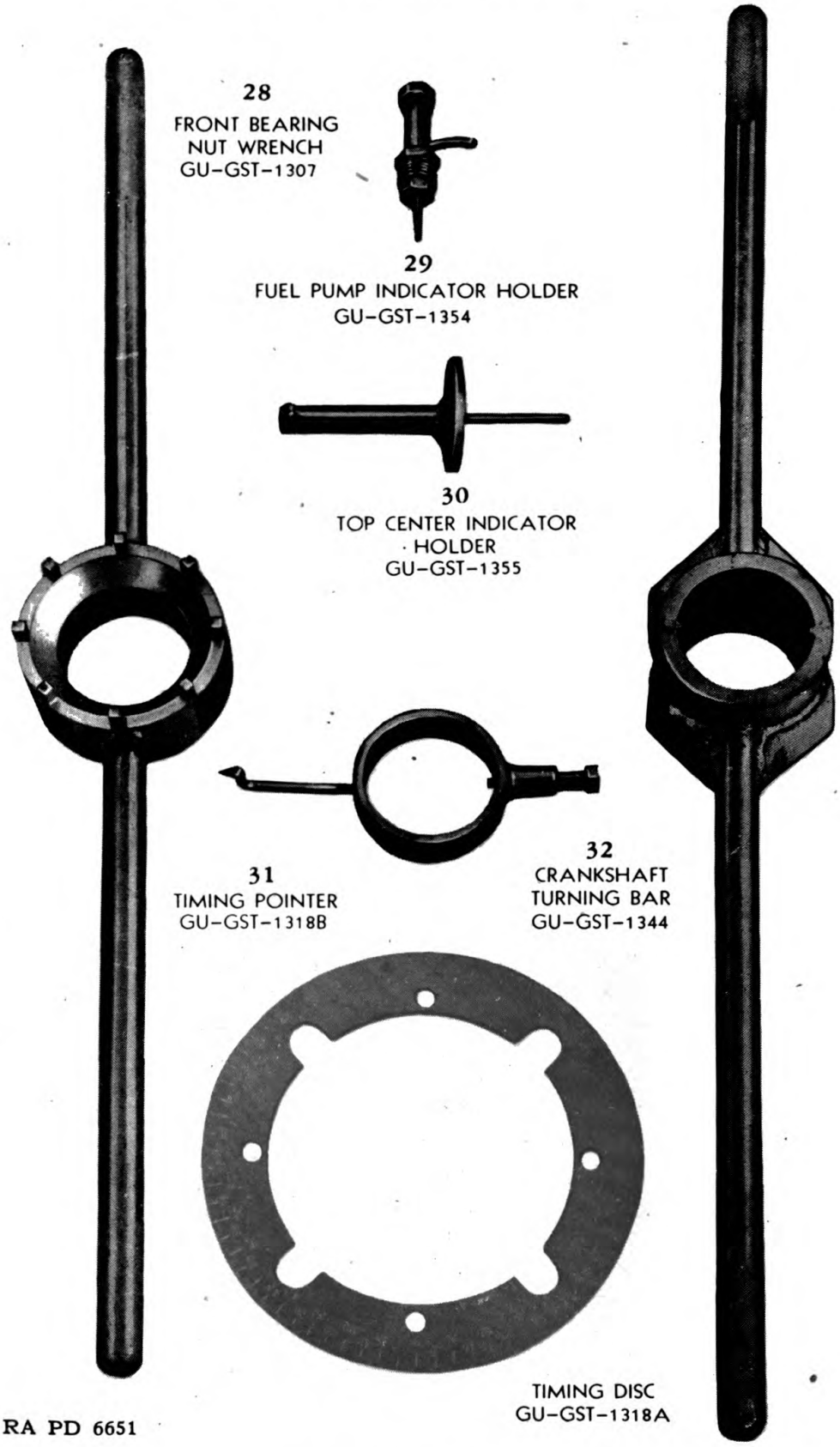
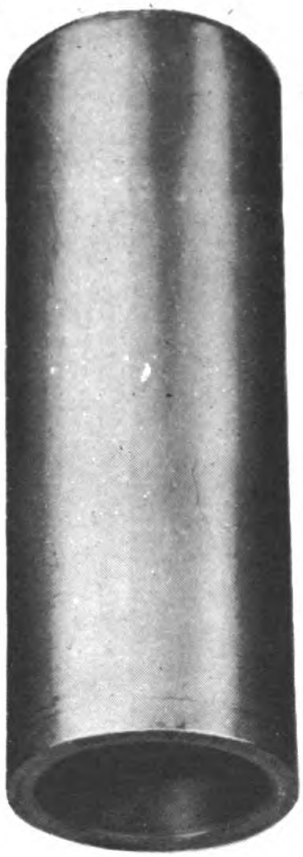


FIGURE 140—Special Tools.

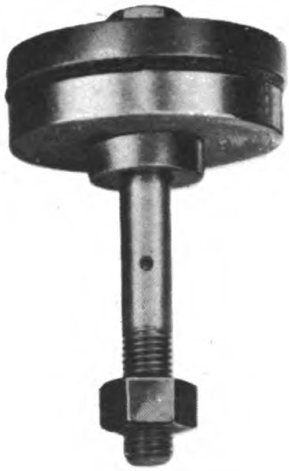
33

PULLER, STARTER
JAW GEAR
GU-GST-1301



35

FRONT CRANKSHAFT
BEARING DRIVER SLEEVE
GU-GST-1319-B



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TESTER FOR
MASTER ROD
OIL PASSAGES
GU-GST-1371

34

ENGINE LIFTING EYE
GU-GST-1308

37

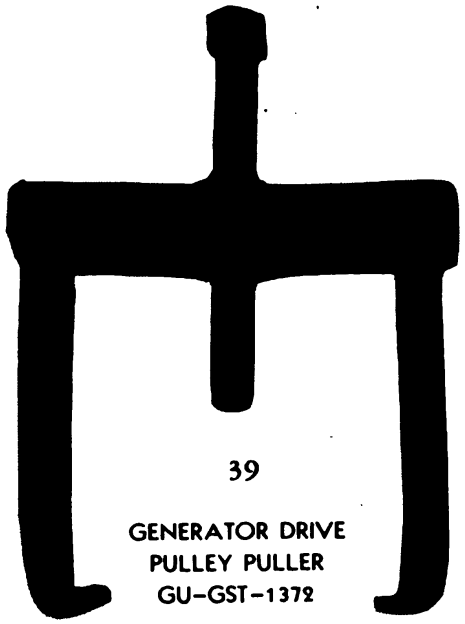
KNUCKLE PIN & MASTER
ROD RECEIVER
GU-GST-1332

38

KNUCKLE PIN
REMOVER
GU-GST-1331

RA PD 6652

FIGURE 141—Special Tools.

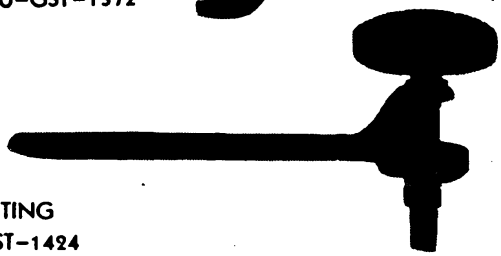


39

GENERATOR DRIVE
PULLEY PULLER
GU-GST-1372

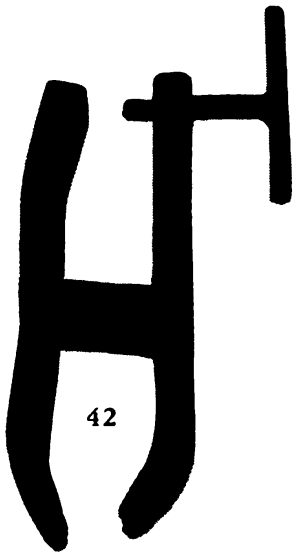
40

1¼" FUEL PUMP
ADJUSTING
WRENCH
GU-GST-1419



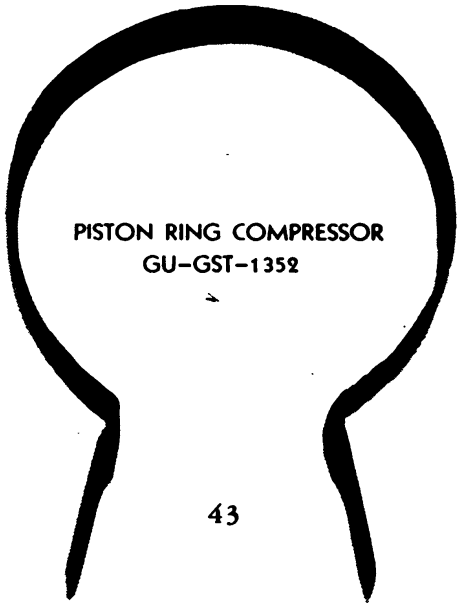
41

VALVE ADJUSTING
WRENCH-GU-GST-1424



42

INSTALLATION TOOL, INTER-ROCKER BOX
DRAIN LINES-GU-GST-1363



PISTON RING COMPRESSOR
GU-GST-1352

43

RA PD 6653

FIGURE 142—Special Tools.

SECTION XVI

REFERENCES

209. Standard nomenclature lists. —

Gun, Machine, Cal. .30, Browning M1919A4, Fixed and Flexible	SNL A-6
Gun, 37 mm, M5 and M6, and Cradle, Tank, 37 mm, T2	SNL A-45
Cleaning, Preserving, and Lubricating Materials, Recoil Fluids, Special Oils, and Similar Items of Issue	SNL K-1
Tank, Light, M3	SNL G-103
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

210. Technical manuals. —

Light Tank, M3	TM 9-726
Cleaning, Preserving, Lubricating and Welding Materials and Similar Items Issued by the Ordnance Department	TM 9-850
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A.G. 062.11 (2-4-42)
By order of the Secretary of War:

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E. S. ADAMS,
Major General,
The Adjutant General.

G. C. MARSHALL,
Chief of Staff.

DISTRIBUTION: D 17(5); B 17(5); IBN 9(1); IC 9(3)
(or 91 Medium and Heavy Maintenance Companies)

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