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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OVERHAUL INSTRUCTIONS AIRCRAFT ENGINE MODEL 0-470-15

(CONTINENTAL MOTORS CORP.)

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NG: State AG; units—same as Active Army.
USAR: None.
For explanation of abbreviations used, see AR 320-50.

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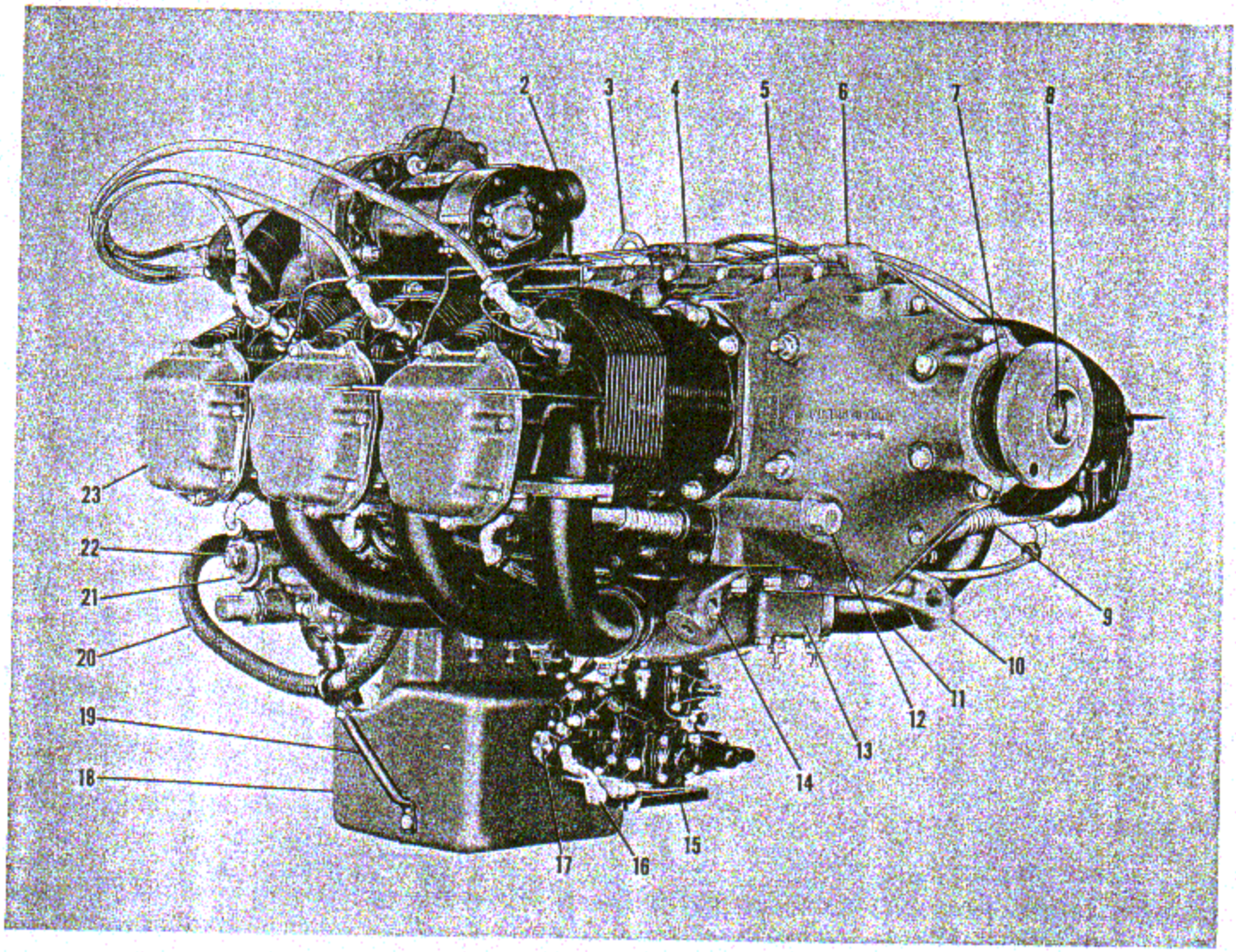
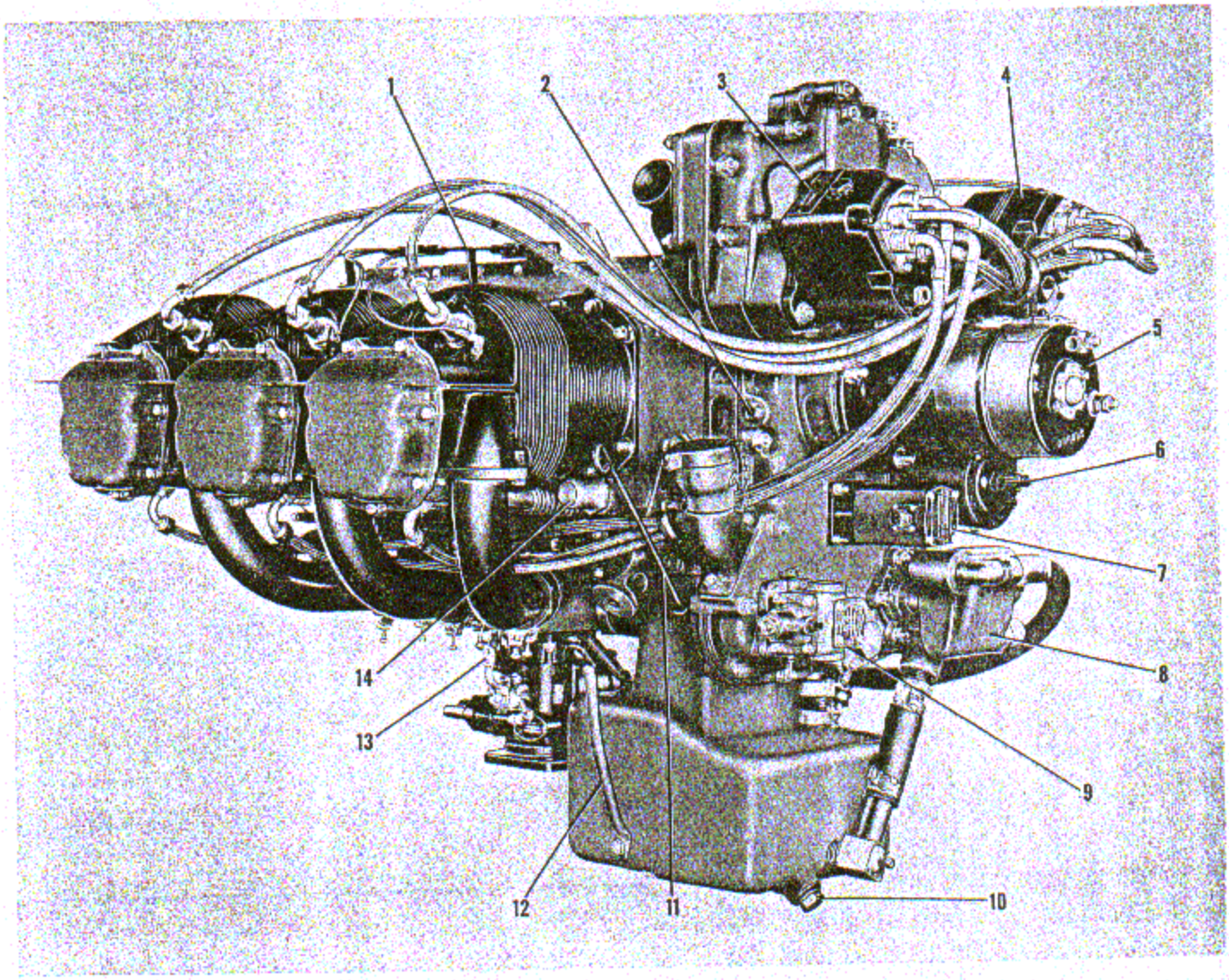


1. Generator
2. Generator blast tube
3. Engine lifting eye
4. Primer distributor
5. Plug in oil return hole
6. Crankcase breather elbow
7. Crankshaft oil seal
8. Crankshaft oil transfer plug
9. Pushrod housing spring
10. Left front engine mount bracket
11. Intake tube
12. Oil gallery adapter
13. Intake and oil drain manifold
14. Barrel nut (for engine mount bolt)
15. Carburetor
16. Manual mixture control and idle cut-off lever
17. Fuel strainer plug
18. Oil sump
19. Oil sump right side support
20. Oil pump discharge hose assembly
21. Pressure oil screen assembly
22. Plug in oil temperature gauge capillary hole
23. Valve rocker cover

Figure 1-1. Three-Quarter Right Front View of Continental Model O-470-15 Aircraft Engine



1. Left side primer line clamp assembly
2. Plug in oil return hole
3. Left magneto
4. Right magneto
5. Starter
6. Vacuum pump
7. Tachometer generator
8. Oil pump
9. Fuel pump
10. Oil sump drain plug
11. Oil level gauge
12. Oil sump left side support
13. Carburetor throttle lever
14. Low oil pressure relief valve

Figure 1-2. Three-Quarter Left Rear View of Continental Model O-470-15 Aircraft Engine

SECTION I

INTRODUCTION

1-1. SCOPE.

1-2. This publication comprises the overhaul instructions for the model O-470-15 engines manufactured by the Aircraft Engine Division of Continental Motors Corporation, Muskegon, Michigan.

1-3. ENGINE SECTIONS.

1-4. In figure 1-3 all sections and accessories of model O-470-15 engines are illustrated in "Exploded" positions and keyed by index numbers to the accompanying legend which gives correct nomenclature. Index numbers in ascending numerical sequence show the order of dismantling.

1-5. CYLINDER ARRANGEMENT.

1-6. Cylinder assemblies are attached to left and right sides of the crankcase assembly. The odd numbered cylinders are on the right, and even numbers on the left, as viewed from the rear or accessory end. In each cylinder bank, the low number is at the rear, and the numbers increase toward the front, or propeller end. This arrangement is illustrated in the top view drawing, figure 1-4. Notice that the corresponding left and right side cylinders are not quite opposite. This affects the locations of attaching parts in relation to the cylinder base flange. Cylinder numbers are cited in later sections when referring to specific positions in connection with dismantling, reassembly and timing. For cylinder firing order, refer to ignition timing instructions in Section VII.

1-7. TERMS AND ABBREVIATIONS.

1-8. Except for the special terms and abbreviations defined in this paragraph, all descriptive terms used in this publication are in accordance with normal shop practice, and all abbreviations conform to the requirements of MIL-STD-12A. Meanings of special terms and abbreviations are as follows:

a. After top center (A.T.C.): Positions of piston and crankpin after passing outward end of stroke.
b. Backward (referring to rotation): In the direction opposite normal rotation when engine is running.
c. Before top center (B.T.C.): Positions of piston and crankpin before reaching outward end of stroke.
d. Bottom: Below center of cylinders and crankshaft on upright engine or below center of assembly installed on upright engine.
e. Clockwise: In same direction as clock hands rotate.
f. Conterclockwise: Opposite of clockwise.
g. Forward (referring to rotation): In the direction in which the part turns when engine is running.
h. Forward (referring to position): Toward front of engine.
i. Front: Propeller end of engine or most forward of two or more identical features.
j. Lower (as an adjective): Nearest bottom of engine or assembly when engine is in upright position or assembly in installed position on (or as on) upright engine.
k. Lower (as a verb): To move a part toward the ground without dropping it.
l. Outer: Most remote from center of engine or an assembly.
m. Outward: Away from center of engine.
n. Rear: Accessory end of engine, or one of two or more identical parts nearest rear of engine.
o. Right side: Determined from view point behind upright engine.
p. RMS: Root mean square (mathematical average).
q. Top: Above center of cylinders and crankshaft when engine is upright.
r. Top dead center: Piston and crankpin position at outer end of stroke.
s. Upper: Nearest top of engine or assembly in upright position.
t. Upright: Engine in operating position, with oil sump at bottom, as illustrated in figures 1-1 and 1-2. Position of an assembly or part as installed on upright engine. (Exception: Cylinders are installed in horizontal positions and are considered to be upright when standing on open ends of barrels.)

1-9. REFERENCES TO ILLUSTRATIONS.

1-10. Index numbers connected by "leaders" to parts in the illustrations are used to key the illustrations to accompanying legends in which the correct nomenclature is given. In the text, the same number, followed by a comma and the figure number will indicate the same part. Such references are placed in parentheses immediately after the part name, which may be reduced to a single noun. For instance, the expression, "elbow (6, figure 1-1)" would refer to the crankcase breather elbow indicated by index number 6 in figure 1-1. When a majority of such references in any paragraph are to the same figure, that figure number will be placed in parentheses immediately following the paragraph head and preceding the text. When this is done, all index numbers not identified with another figure, as in the preceding example, will refer to the figure named at the beginning of the paragraph. This will apply only to that paragraph, except that when the figure is named immediately after a primary subject head, references by index number only will apply to it throughout all subordinate paragraphs down to the next primary subject head. (A primary head is defined as a paragraph number and title immediately followed by another paragraph number and subordinate head. Text is run

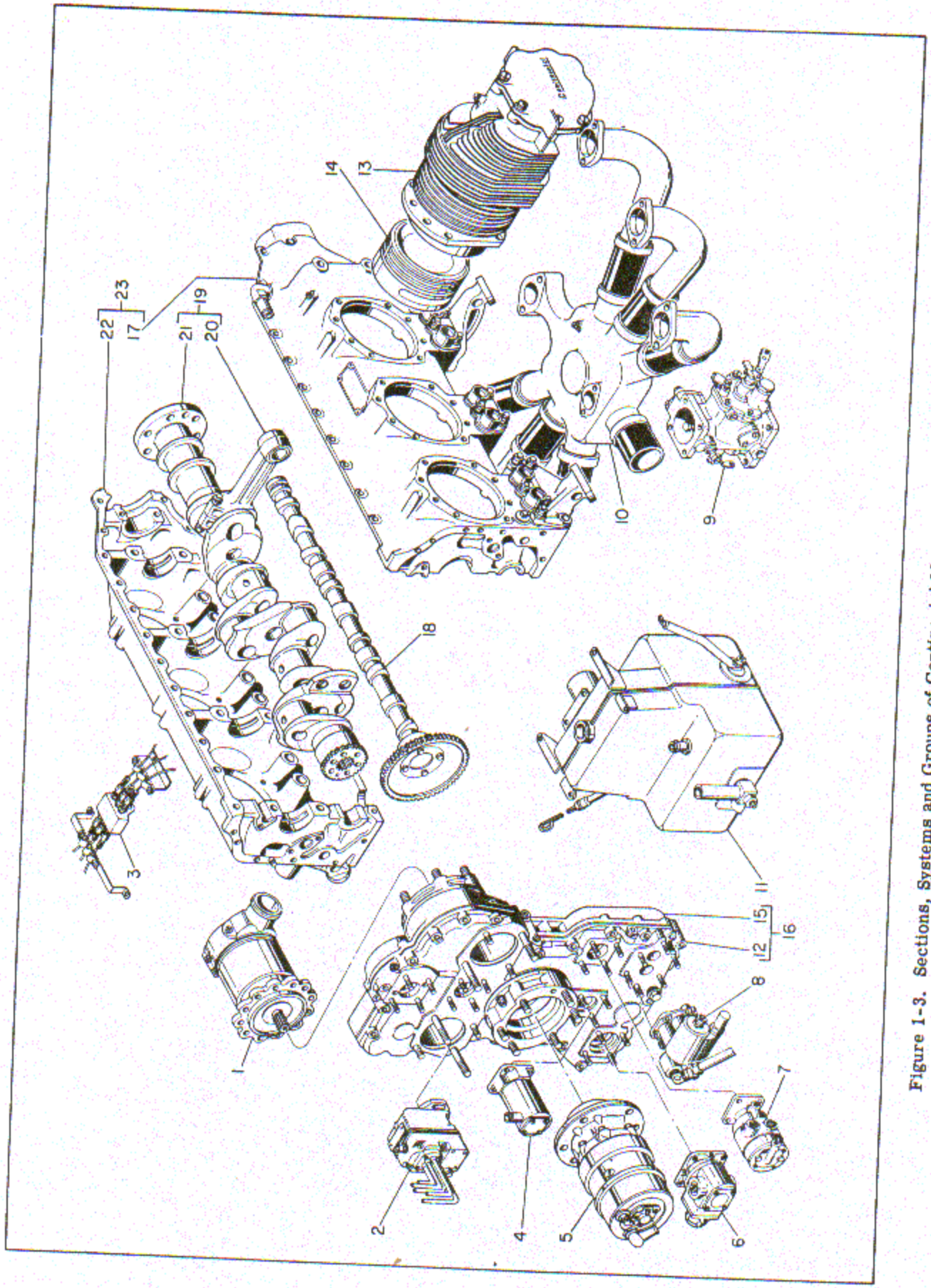


Figure 1-3. Sections, Systems and Groups of Continental Model O-470-15 Aircraft Engine

Legend for Figure 1-3

1. Battery charging generator
2. Left magneto and ignition harness
3. Cylinder priming system
4. Tachometer generator
5. Electric starter
6. Engine driven fuel pump
7. Vacuum pump
8. Oil pump
9. Carburetor
10. Intake and oil drain manifold and tubes assembly
11. Oil sump assembly
12. Accessory case rear half
13. Cylinder assembly
14. Piston assembly
15. Accessory case front half
16. Complete accessory case assembly
17. Crankcase right half
18. Camshaft and gear assembly
19. Crankshaft and connecting rods assembly
20. Connecting rod assembly
21. Crankshaft and gear assembly
22. Crankcase left half
23. Complete crankcase assembly

in on the same line with a subordinate head, of which there may be several under a primary head, except when the first text is procedure step "a".) The use of a figure number at the beginning of a paragraph to identify index numbers scattered throughout is illustrated in paragraph 4-17, where the expression "(See figure 4-2.)" means that all index numbers in parenthesis in the text refer to parts so numbered in figure 4-2, and this holds true down to the next paragraph, 4-18.

1-11. MEASUREMENTS AND WEAR LIMITS.

1-12. Frequent references in the following sections to the Table of Limits, Section X, are by reference number in that section. For example, the expression "(Refer to 17 and 18, Section X.)" means that the reader should turn to Section X and locate numbers 18 and 19 in the first, or "Ref. No." column to determine the permissible clearances of new or worn parts which are never stated in the text. Use the values in the Table of Limits for all operations involving measurement of critical dimensions with micrometer calipers and other gages.

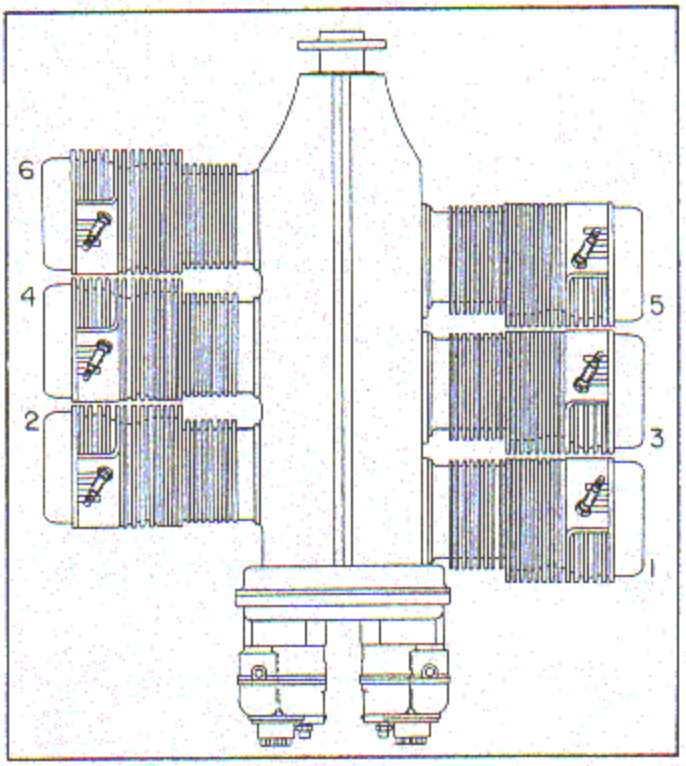


Figure 1-4. Cylinder Arrangement Diagram (Top View)

SECTION II

GENERAL DESCRIPTION

2-1. GENERAL.

2-2. TYPE. The model O-470-15 aircraft engine is of the horizontally opposed type, with left and right banks of three cylinders each staggered so that each connecting rod works on a separate crankpin of the six-throw, single piece, direct drive crankshaft. It has a wet sump lubrication system with force feed to all lubricated points; a dual, radio shielded, magneto ignition system with impulse couplings for starting; a cylinder priming system for cold weather starting; a pressure type carburetor with manual mixture control; an electric starter; a battery charging generator; a tachometer generator; a fuel pump and a vacuum pump, but no propeller governor or hydraulic pump, as supplied by the manufacturer.

2-3. SECTIONS, SYSTEMS AND GROUPS. (See figure 1-3.) Accessories (1, 4, 5, 6 and 7) are mounted on the accessory case or on gear adapters attached to it. Magnetos are mounted on gear adapters on the rear side of the accessory case at left and right sides. The left magneto and ignition harness (2) consititutes a complete system serving spark plugs on lower sides of cylinder heads, while the similar system on the right side, including an identical magneto, serves upper spark plugs. The cylinder priming system (3) is mounted above the crankcase and cylinders and serves all six cylinder heads. The oil pump (8) is mounted on the rear side of the accessory case at the lower right corner. It draws oil from the sump (11) and discharges through a hose assembly connected to an elbow in the right side of the crankcase to supply oil to all moving parts. The oil pump, oil sump and connecting hoses are the only parts solely for engine lubrication, though passages in other engine parts serve to distribute or drain oil in the system. The updraft carburetor (9) is mounted on the bottom of the intake and oil drain manifold casting shown as the central part of the manifold and tubes assembly (10), which is mounted on the bottom of the crankcase and cylinder heads and serves to distribute the carburetor's fuel-air mixture to bottom side cylinder intake ports. Six identical cylinder assemblies (13) enclose identical piston assemblies (14) and are attached to crankcase pads by studs and through bolts, the latter parts passing through crankcase webs above and below the crankshaft main bearings. There are six attaching studs and two through bolts per cylinder, but the bolts are in the two rear holes of base flanges of cylinders No. 1, 3 and 5 on the right and in the two front holes of even numbered cylinders on the left, due to the staggered cylinder arrangement. The accessory case assembly (16) consists of a rear half (12), with attached magneto adapters; a starter adapter; a front half (15), with an attached generator adapter, and all enclosed accessory driving gears, excepting those attached to the crankshaft and camshaft. The accessory case cannot be removed from the crankcase as a unit, since some attaching parts are internal. The two halves and attached adapters (excepting the starter adapter) are machined as an assembly to line ream bushings for straddle mounted gears. The camshaft (18) and the crankshaft (21) turn in bearings split vertically by the parting line between crankcase halves (17, 22) which make up the complete crankcase assembly (23). Mushroom type hydraulic valve lifters slide in guides machined in the crankcase halves and cannot be removed until the halves have been separated. The crankcase, crankshaft and connecting rods assembly (19) and camshaft may be considered an engine section and are so treated in dismantling and reassembly text. The priming system, the ignition system, the oil pump, the oil sump, the intake and oil drain manifold and tubes and the cylinders are treated as assemblies in dismantling, inspection, repair and reassembly text. The accessory case is treated as a section, except in dismantling and reassembly, where the halves must be handled at different stages. The crankcase, crankshaft, connecting rods and camshaft are treated separately in inspection and repair instructions.

2-4. CONSTRUCTION.

2-5. CRANKCASE. The two halves are aluminum alloy castings. These are milled on the parting surfaces and exterior vertical sides, then assembled and drilled for through bolts above and below the main bearing seats. All subsequent machining is performed on the assembled pair aligned by the through bolts acting as dowels to assure alignment of bearing seats, other bolt holes, the front end recess and the rear surface. The halves are, therefore, not interchangeable. Valve lifter guides and camshaft bearings are machined directly in the castings, while seats for main bearings accept replaceable inserts of steel backed, soft bearing metal faced construction. The front crankshaft bearing is flanged to act as a thrust bearing and has a lining of silver faced with lead-indium alloy. Front mount brackets attached to studded bottom pads below the front cylinders and rear mount brackets attached to studded pads at the rear of each outer side furnish four points for attachment to shear rubber shock bushings in the airframe or suitable brackets mounted on an assembly stand. Barrel nuts of semicircular shape with self locking thread inserts slide into longitudinal holes in the engine mount brackets to anchor the four mounting bolts coming up through holes drilled perpendicular to the oblique pads on the bracket ends. An oil pressure relief valve assembly is installed in the left rear mount bracket.

2-6. CRANKSHAFT. The six-throw forging is machined at the front end, where a propeller mount

flange is formed, on all main journals and crankpins and on the counterweight mounting blades at the sides of crankcheeks between No. 1 (rear) and No. 2 pins and between No. 3 and No. 4 pins. Dynamic damper type counterweights are held loosely on the blades by hardened steel pins working in hardened bushings shrunk in both shaft and counterweights. An oil transfer tube slides into an axial bore at the front end. It separates oil fed to the crankshaft bore for lubrication of the front main-thrust bearing from oil pumped by the governor for operation of the pitch control in the propeller hub. Governor oil output is fed into the crankshaft through a cross drilled hole surrounded by a brass collar with a tube seated and sealed in a hole leading from the outer side of the left crankcase. The oil reaches this hole through an elbow fitting and hose assembly leading from the accessory case. At the rear end of the crankshaft a large shouldered stud is screwed and pinned in an axial hole and projects rearward through the crankshaft gear's splined hole to center and attach a three-tooth starter jaw which is externally splined to mesh with gear splines. The gear is counterbored to pilot on the shaft's rear end and is attached by six hex head screws. A shaft dowel assures correct angular positioning of the gear for valve action timing, and indented marks on rear ends of two adjacent teeth serve to locate a marked camshaft gear tooth for the same purpose.

2-7. CONNECTING RODS. Each rod assembly is made of a single steel alloy forging, which is sawn through the big end to form the rod and the cap after cap bolt holes are drilled and reamed. The two parts, aligned by cap bolts, are machined as an assembly and are not interchangeable between assemblies. The big end bore is sized to receive the same type of inserts for a crankpin bearing as installed in the crankcase for main bearings. These are easily replaceable at overhaul, and the pressed-in piston pin bushing is replaceable but must be bored or reamed to size and in correct alignment with the big end.

2-8. CAMSHAFT ASSEMBLY. The alloy steel forging has a flange at the rear end which is machined to mount and pilot the gear. All journals are ground to size, and cam lobes are ground by a cam-controlled contour grinder, with a very slight taper on the toe lines to rotate hydraulic valve lifters. Distance across cam lobes from heel to toe is not critical, since hydraulic lifters compensate for any variation in base track diameter, but lift provided by cam contours is held closely and should be checked at overhaul to detect any wear. Attaching bolt holes in the camshaft flange and the gear web are unequally spaced to assure correct angular positioning of the gear, which has an indented timing mark on one tooth to mesh between similarly marked teeth on the crankshaft gear. This arrangement, plus the fixed angular relation of the crankshaft gear to the crankpins, requires only meshing of timing marks at assembly to assure proper valve timing and eliminates any adjustment between overhauls.

2-9. HYDRAULIC VALVE LIFTERS. (See figure 2-1.) The lifter assembly may be separated into three single pieces (the body, the pushrod socket and the snap ring) and a hydraulic unit composed of a cylinder, check valve and inlet tube assembly and a plunger and spring assembly. The small diameter of the body fits into a horizontal guide in the crankcase, with only enough clearance for an oil film, and the large diameter end follows the camshaft lobe. The follower face is ground and polished to a large spherical radius so that the point of contact with the tapered lobe will never be far off the body axis but enough to rotate the lifter with each lift cycle so as to prevent wear in a straight line, which would cause a groove. Oil holes drilled through the body wall from exterior grooves feed engine lubricating oil to the outer side of the hydraulic unit for valve rocker and valve stem lubrication via the hollow pushrod and to the inner side of the unit to replenish the reservoir. The two exterior grooves are connected by a flat. With this groove arrangement, body rotation does not affect the supply of oil from the fixed crankcase hole, which is so located as to register only when the lifter has been pushed to its outer extreme position by the cam lobe. This provides intermittent lubrication and prevents engine oil pressure from building up pressure in the lifter and holding the intake or exhaust valve open. The function of the hydraulic unit plunger spring is to expand the length from follower face to pushrod socket to take up any lash developed in the valve

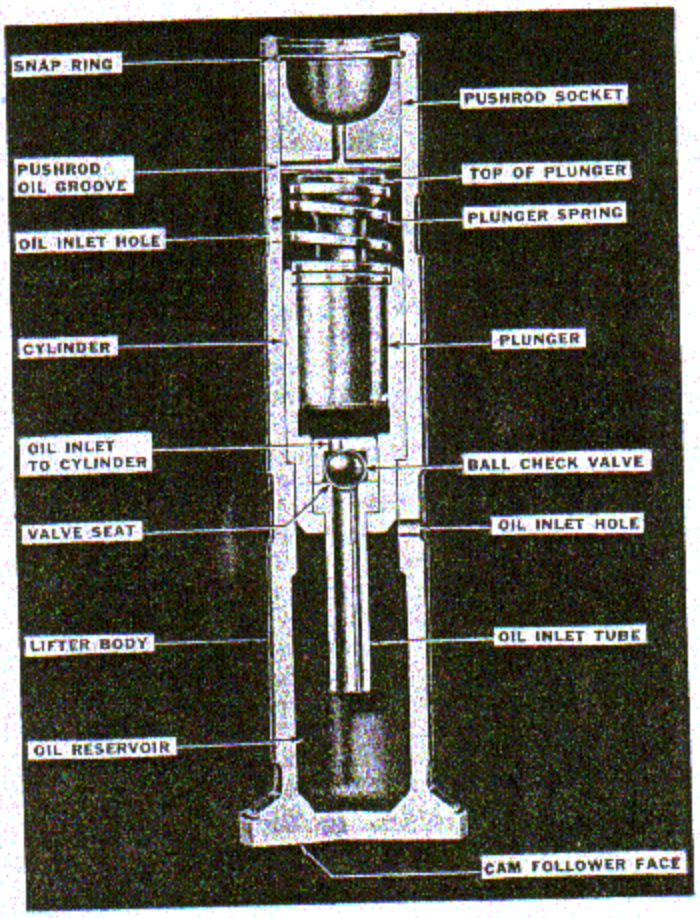


Figure 2-1. Cutaway View of Hydraulic Valve Lifter

train due to expansion of the engine cylinder as it is heated. The check valve under the plunger prevents oil which has entered the unit cylinder through the inlet tube from escaping back to the oil reservoir. A very small clearance between plunger and cylinder allows a small leak-down of oil with each lift cycle when the oil under the plunger is transmitting the cam force to the plunger and pushrod to open the engine valve. When the lifter returns, the small lash is again removed by the plunger spring, drawing more oil from the reservoir to replace the leakage. The leak-down is controlled to close limits, expressed by time in seconds, with a given load on the plunger and a specified type and viscosity of oil, to move the plunger inward a given distance. These test conditions cannot be duplicated economically by overhaul facilities, however a rough check of hydraulic unit condition is given in Section V.

2-10. PISTON ASSEMBLY. Each of the six pistons is an aluminum alloy forging machined all over the exterior. The part number and position number are stamped on the narrow flat annulus surrounding the concave center of the head. Three ring grooves lie above the pin bore. The upper two grooves are occupied by semi-keystone compression rings faced with hard chrome to withstand heat, and the bottom groove carries a center slotted oil control ring and has four oil drain holes drilled to the interior of the piston.

2-11. INTAKE AND OIL DRAIN MANIFOLD. The magnesium casting has two mounting pads milled flat and in line on the top side with two attaching bolt holes drilled downward from each pad through solid metal to the bottom. Between the pair of bolt holes in each mounting pad is a cored oil drail hole connecting to cored passages in the casting around and below the air manifold. The drain holes match front and center drain holes in the crankcase bottom bosses to which the manifold is attached over soft gaskets by four bolts. The oil drain passages converge at the rear and emerge from the casting in a tubular boss connected by a hose to an inlet at the front side of the oil sump neck. The carburetor mount pad milled on the casting bottom side has four studs for carburetor attachment and a central opening into the air manifold section of the casting which opens into six tubular bosses to which the six cylinder intake tubes are connected by rubber hoses. To detect any porosity or crack between the oil drain and air manifold sections or in exterior walls, the casting is tested with compressed air in a water tank during manufacture. This test will not need to be repeated at overhaul, unless the manifold has been subjected to severe shock by dropping or an aircraft crash. Leakage between the air and oil manifolds would be indicated by excessive oil in the cylinder heads, though this would be more likely to come from other sources.

2-12. ACCESSORY CASE. Magnesium castings are machined to make the accessory case front and rear halves, the two magneto adapters and the starter adapter attached to the rear side of the rear half, the generator adapter and upper hydraulic pump cover attached to the front half and the oil filler spout attached to the left side of the rear half. Covers installed on the governor and lower tachometer drive pads are aluminum alloy. A tubular steel filler neck is pressed into the oil filler spout and closed by a bayonet locking cap of pressed steel retained by two spring clips. All gears are machined steel forgings, and their oil seals are steel cased synthetic rubber. Bronze gear bushings are pressed, and in some instances pinned, in the case casting bores. Excepting the oil pump, fuel pump and generator drive gears, all gears in the case are straddle mounted in front and rear half bushings. To assure alignment and correct spacing of bearing surfaces, the gear bushings are bored after attachment of the generator adapter assembly and the two magneto adapter assemblies to the case halves and after the halves have been assembled and dowels installed in line-reamed holes in their parting flanges. This makes the two case halves and the three adapters noninterchangeable between assemblies. These parts compose a machining assembly supplied for replacement purposes. The factory fixtures and gauges for boring, facing and inspection of bushings cannot be duplicated economically at overhaul facilities.

2-13. OIL SUMP. Two half shells of pressed steel sheet are seam welded to form the sump enclosure. Steel inserts welded in both sides and on top at the front are tapped for attachment of tubular support brackets. The side support brackets are drilled at the upper ends, and these holes align with mounting bolt holes in the rear engine mount brackets. The spacers between sump brackets and mount brackets are occupied by vibration dampeners on the airframe, and mounting bolts pass through all three parts. When the engine is to be mounted on an assembly stand; the sump side support brackets should be removed to avoid interference with cradle adapters. Other inserts welded in the top and front of the sump form connections for oil drainage from the crankcase and accessory case. Mounting brackets are welded to both sides and the front of the sump at the top for attachment to crankcase studs. A support tube welded in the left side of the sump holds the bayonet type oil level gauge. An insert welded in the rear end at the bottom is tapped for a drain plug and the oil suction screen assembly, consisting of a perforated tube pressed into a machined steel elbow. The perforated tube extends into the sump, and the elbow is connected by a hose to an inlet nipple in the oil pump.

2-14. FUNCTIONAL SYSTEMS.

2-15. LUBRICATION SYSTEM. The lubrication system is among the most important of the functional systems at overhaul, inasmuch as many dimensional wear limits are dictated by the effect of resulting part clearances on engine oil pressure, and cleaning of oil passages is of primary importance in the process, since any plugging or restriction of these holes may cause failure of portion of the lubrication system and may result in serious damage to the engine from disintegration of overheated metal parts or may result in an aircraft crash due to seizure of an engine part. Also, test after overhaul may show oil leakage resulting from imperfect sealing of joints

in the lubrication system. For these reasons, it is important to know where the pressurized oil passages and drain passages are located, through which flanges and connectors they pass, where plugs must be installed and where all oil seals are located. These features are illustrated as well as possible in figure 2-2. In the illustration, unconfined colored arrows represent oil spray and open drainage, while confined arrows show direction of flow through passages. The crankcase, accessory case and oil pump are separated for clarity, and dotted lines, not identified as hoses, connect matching passage ports in the case sections.

2-16. (See figure 2-2.) Oil circulation starts and ends in the oil sump (91). A coarse strainer admits oil to the suction screen assembly (95) connected by a short hose (1) to an adapter (3), through which the oil enters the lower side of the gear chamber in the pump body (7). The oil is carried around and discharged at the top of the gear chamber against the resistance of the closed passage network shown in red, creating pressure throughout this system. It then passes into the cavity sealed at both ends by the filter (9), through the filter to its central outlet at the left end and into a body cavity to which is connected a hose (5) leading to the crankcase. Neglecting friction loss, the pressure is the same everywhere between the pump and the oil cooler (86). A high pressure relief valve assembly (including 2, 4 and 11) is adjusted so that the pressure in this part of the system, as indicated by a gauge connected to a nipple (65) in the right crankcase half, will remain between specified limits to protect the hose (5) and the oil cooler (86). Construction and action of the high pressure relief valve is the same as in the low pressure valve (including 62 and 63) in the left rear engine mount bracket, except that oil passing the high pressure valve is returned to the pump inlet, while oil escaping through the low pressure valve empties into the crankcase cavity, as illustrated in figure 2-3. The low pressure valve is adjusted to maintain a pressure in the left gallery (60) about 15 psi below that in the right side, producing a pressure differential of this amount across the oil cooler, thus assuring continuous oil flow through it. It will be observed that all crankshaft bearings (64, 69), camshaft bearings and valve lifter guides (59) are pressure lubricated. All crankpins receive oil from main bearings through steel tubes in the crankcheeks, like the one shown in the crankshaft front end section. All gear teeth, cam lobes, piston pins and cylinder walls are lubricated by an oil mist sprayed into the case cavities from bearings and bushings. This and valve rocker oil drainage through pushrod housings returns to the sump through three crankcase drain holes, the manifold (90) and its connecting hose (88) and from the accessory case through a nipple (38) and hose (37). When an oil cooler is installed the adapter (74) must be in place to close off the cross passage to the front camshaft bearing. If no oil cooler is used, a plug and gasket must be installed in place of the gallery adapter.

2-17. INDUCTION SYSTEM. The fuel pump, mounted on the lower left drive pad on the rear side of the accessory case, incorporates a vane type pump in the main body and has an attached valve body which encloses a combined pressure relief and pump bypass valve. The splined pump drive shaft is flexible coupled to accommodate any slight misalignment with the drive gear. The hose which connects the pump discharge port to the carburetor fuel inlet is not supplied with the engine. The Stromberg pressure carburetor is mounted on the bottom of the intake and oil drain manifold below the crankcase for updraft operation, with the throttle lever on the left side and the mixture control lever on the right. A decalcomania transfer on the carburetor gives the curing date of synthetic rubber parts. The manifold discharges fuel and air mixture through short hose couplings into six aluminum tubes which curve upward and enter the cylinder intake ports. In a circular indentation on the exterior of each tube where it enters the intake port is a special synthetic sealing ring of special shape. A loose, two-bolt flange, with counterbore in its upper side, fits closely around the sealing ring so that tightening of attaching bolts compresses the ring, both sealing the joint and holding the intake tube in place.

2-18. IGNITION SYSTEM. Identical magnetos, mounted on left and right side adapters attached to the rear of the accessory case, provide dual high voltage impulses for spark ignition in each cylinder. Braided shielding conduits, enclosing high tension ignition cables with corrosion resistant steel stranded conductors, are connected by hex coupling nuts to AN spark plug shield elbows and these are connected to the six upper spark plugs. The opposite ends of these six conduits have right angle shield elbows connected by ring coupling nuts to a high tension outlet plate on the rear end of the right magneto. The cables pass through a large rubber grommet on the front side of the plate, and the conductor strands are bent around slotted brass washers to form terminals which contact spark distributor terminal springs in the magneto. The rubber grommet seals the magneto opening against moisture, hence it fits tightly and requires care to withdraw the plate and grommet assembly without pulling the cable ends loose. Spark plug ends of the cables are equipped with AN ceramic terminal sleeves, above which are rubber bushings to prevent crushing. The six lower spark plugs are connected by a similar harness to the left magneto. The 12 radio shielded spark plugs have 18 mm threads to mate with helical coil inserts in cylinder head holes. The wrench hex is 7/8 inch across flats, on one of which are stamped six numerals indicating the date of manufacture, the first two representing the month, the second two the day and the last two the year. Three shell electrodes surround the center electrode molded in a ceramic insulator which extends to the top of the cable terminal well. Each magneto is driven through an impulse coupling which both retards cranking sparks and spins the rotor rapidly through its firing positions to produce full voltage spark for starting. The coupling stop latches are counterweighted, and the counterweights serve both to engage the latches to stop pins and, after starting, to hold them inactive by centrifugal forces applied. It is important to turn the coupling backward to the timing position before installing a magneto and not to turn it too far at any time during

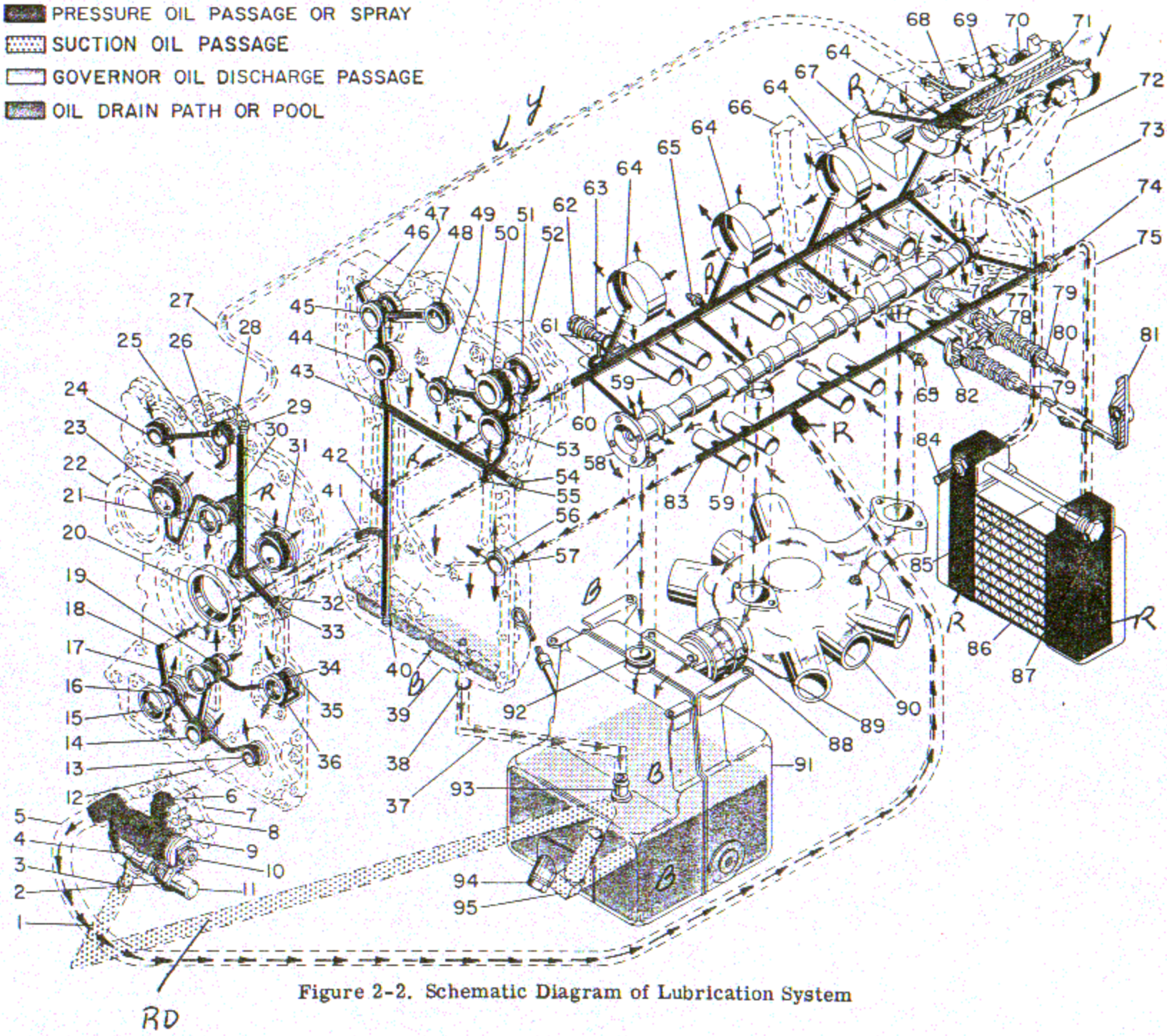


Figure 2-2. Schematic Diagram of Lubrication System

Legend for Figure 2-2

1. Oil suction hose
2. Relief valve adjusting screw
3. Hose adapter
4. High pressure relief valve piston
5. Hose assembly
6. Oil pump driver gear
7. Oil pump and oil screen body
8. Oil pump driven gear
9. Oil filter assembly
10. Plug in temperature gauge hole
11. Pressure relief valve cap
12. Accessory case rear half
13. Oil pump drive bushing
14. Fuel pump idler bushing
15. Oil seal
16. Fuel pump drive bushing
17. Oil seal
18. Oil inlet in front parting flange
19. Lower tachometer drive bushing
20. Starter jaw oil seal
21. Oil seal
22. Left magneto adapter
23. Magneto adapter bushing
24. Upper hydraulic pump drive bushing
25. Oil outlet to propeller governor
26. Oil inlet from propeller governor
27. Hose assembly (part of airframe)
28. Governor drive rear bushing
29. Pipe plug
30. Upper tachometer drive rear bushing
31. Right magneto adapter bushing
32. Oil inlet in parting flange
33. Pipe plug
34. Oil seal
35. Lower hydraulic pump drive rear bushing
36. Oil outlet to hydraulic pump
37. Hose
38. Hose nipple
39. Accessory case front half
40. Pipe plug
41. Oil outlet in rear parting flange
42. Oil inlet in front parting flange
43. Pipe plug
44. Left magneto drive front bushing
45. Upper hydraulic pump drive front bushing
46. Oil outlet to hydraulic pump
47. Oil seal
48. Governor drive front bushing
49. Upper tachometer drive front bushing
50. Generator drive gear bushing (in generator adapter)
51. Oil seal (in generator adapter)
52. Generator adapter
53. Right magneto drive front bushing
54. Pipe plug
55. Oil outlet in rear parting flange
56. Lower hydraulic pump drive front bushing
57. Oil supply hole in casting
58. Camshaft
59. Valve lifter guide bore in crankcase
60. Left crankcase oil gallery
61. O-ring seal
62. Relief valve adjusting screw
63. Oil pressure relief sleeve
64. Crankshaft main bearing
65. Optional flared tube to pipe thread nipple for pressure gauge connection
66. Left crankcase half
67. Crankshaft
68. Governor oil transfer collar assembly
69. Front main-thrust bearing
70. Crankshaft oil seal assembly
71. Crankshaft oil transfer plug
72. Right crankcase half
73. Oil cooler discharge hose
74. Oil gallery adapter
75. Oil cooler inlet hose
76. Hydraulic valve lifter
77. Pushrod housing packing
78. Pushrod housing spring
79. Pushrod housing
80. Pushrod
81. Valve rocker
82. Pushrod housing flange
83. Crankcase right oil gallery
84. Oil temperature gauge capillary
85. Oil cooler bypass
86. Oil cooler
87. Thermostatic bypass valve
88. Hose
89. Clamp
90. Intake and oil drain manifold
91. Oil sump assembly
92. O-ring seal
93. Hose nipple welded to sump
94. Oil sump drain plug
95. Suction oil screen assembly

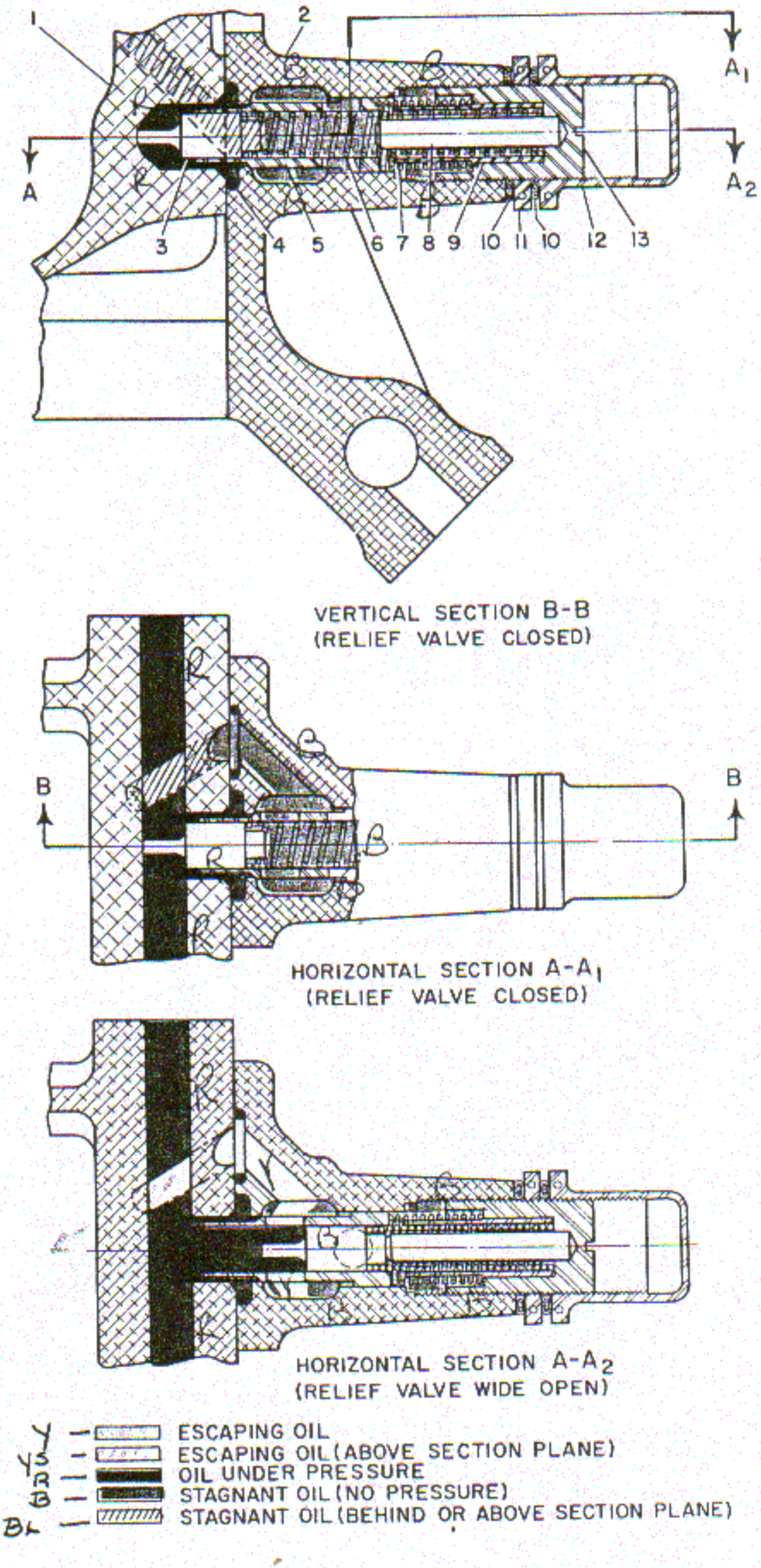


Figure 2-3. Construction and Action of Low Oil Pressure Relief Valve

Legend for Figure 2-3

1. Left crankcase half
2. Left rear mount bracket
3. Oil pressure relief piston
4. O-ring seal
5. Oil pressure relief sleeve
6. Inner spring
7. Outer spring
8. Pin
9. Bushing
10. Copper-asbestos gasket
11. Lock nut
12. Relief valve cap
13. Relief valve adjusting screw

the timing operation, as described in Section VII, in order to prevent stop latch engagement and incorrect timing to the engine. With the latches inactive, the magnetos are timed to the advance firing angle of the crankshaft at No. 1 cylinder. Two lugs on the front of the magneto coupling cup fit between rubber shock absorbing bushings in a flat sided steel cup held in a wide slot on the rear of the magneto drive gear in the magneto adapter. When the bushings have been worn by service, the coupling will come free easily, however now rubber bushings will be a very snug or light push fit.

SECTION III

SPECIAL OVERHAUL TOOLS

Group No.	Function / Tool Nomenclature	Tool No.	Figure No.	Index No.	Notes
1	Crankcase				
	Cam Bearing Gauge	J-2844	3-3	1	
2	Connecting Rod Bushing				
	Remover and Replacer	J-2879	3-4	1	
3	Cylinder and Valve				
	Holding Fixture	J-2858	3-4	3	
4	Cylinder Base Nut				
	Wrench	J-2882	3-4	2	
5	Cylinder Head Holding				
	Fixture	J-2861	3-4	4	
6	Cylinder Head Rocker Shaft				
	Bore Gauge	J-2860	3-3	9	
	Bore Reamer	J-2891	3-6	6	
7	Cylinder Head Valve Guide				
	Bore Gauge 0.005 in. oversize	J-2849-1	3-3	3	
	Bore Gauge 0.010 in. oversize	J-2849-2	3-3	4	
8	Cylinder Head				
	Valve Guide Hole Broach 0.005 in. oversize	J-2846	3-6	1	
	Valve Guide Hole Broach 0.010 in. oversize	J-7201	3-6	2	
	Valve Guide Hole Broach 0.020 in. oversize	J-7202	3-6	3	
9	Engine				
	Transportation Stand	J-5003	3-1		
10	Exhaust Valve Guide				
	Remover	J-2874	3-4	6	
	Gauge	J-2848-2	3-3	7	
	Driver	J-2842	3-4	7	
	Broach	J-2847-2	3-6	5	
11	Exhaust Valve Seat				
	Blueing Gauge	J-2887-A	3-3	8	
	Remover	J-2877-1	3-5	1	
	Replacer	J-2888-1	3-5	3	
12	Hydraulic Lifter				
	Bearing Gauge	J-2859	3-3	10	
13	Intake Valve Guide				
	Gauge	J-2848-1	3-3	6	
	Broach	J-2847-1	3-6	4	
14	Intake Valve Seat				
	Blueing Gauge	J-2887-B	3-3	9	
	Remover	J-2877-2	3-5	1	
	Replacer	J-2888-2	3-5	2	

Group No.	Function / Tool Nomenclature	Tool No.	Figure No.	Index No.	Notes
15	Magneto Drive Gear				
	Bushing Gauge	J-2852	3-3	11	
16	Piston				
	Gauge	J-2853-1	3-3	5	
	Ring Compressor	J-2839	3-4	5	
17	Pushrod Housing				
	Spring Compressor	—	3-2	1	
18	Rocker Arm				
	Removal Pressure Relieving Tool	J-2843	3-5	4	
19	Rocker Shaft Support				
	Boss Reamer Set	J-5129	3-7	1	
	Reamer 1st cut	J-5129-1			
	Reamer 2nd cut	J-5129-2			
	Reamer 3rd cut	J-5129-3			
	Kit, Cloth	J-5129-4	3-7	2	

NUMERICAL TOOL LIST

Tool Number	Group Number
J-2839	16
J-2842	10
J-2843	18
J-2844	1
J-2846	8
J-2847-1	13
J-2847-2	10
J-2848-1	13
J-2848-2	10
J-2849-1	7
J-2849-2	7
J-2852	15
J-2853-1	16
J-2858	3
J-2859	12
J-2860	6
J-2861	5
J-2874	10
J-2877-1	11
J-2877-2	14
J-2879	2
J-2882	4
J-2887-A	11
J-2887-B	14
J-2888-1	11
J-2888-2	14
J-2891	6
J-5003	9
J-5129	19
J-5129-1	19
J-5129-2	19
J-5129-3	19
J-5129-4	19
J-7201	8
J-7202	8

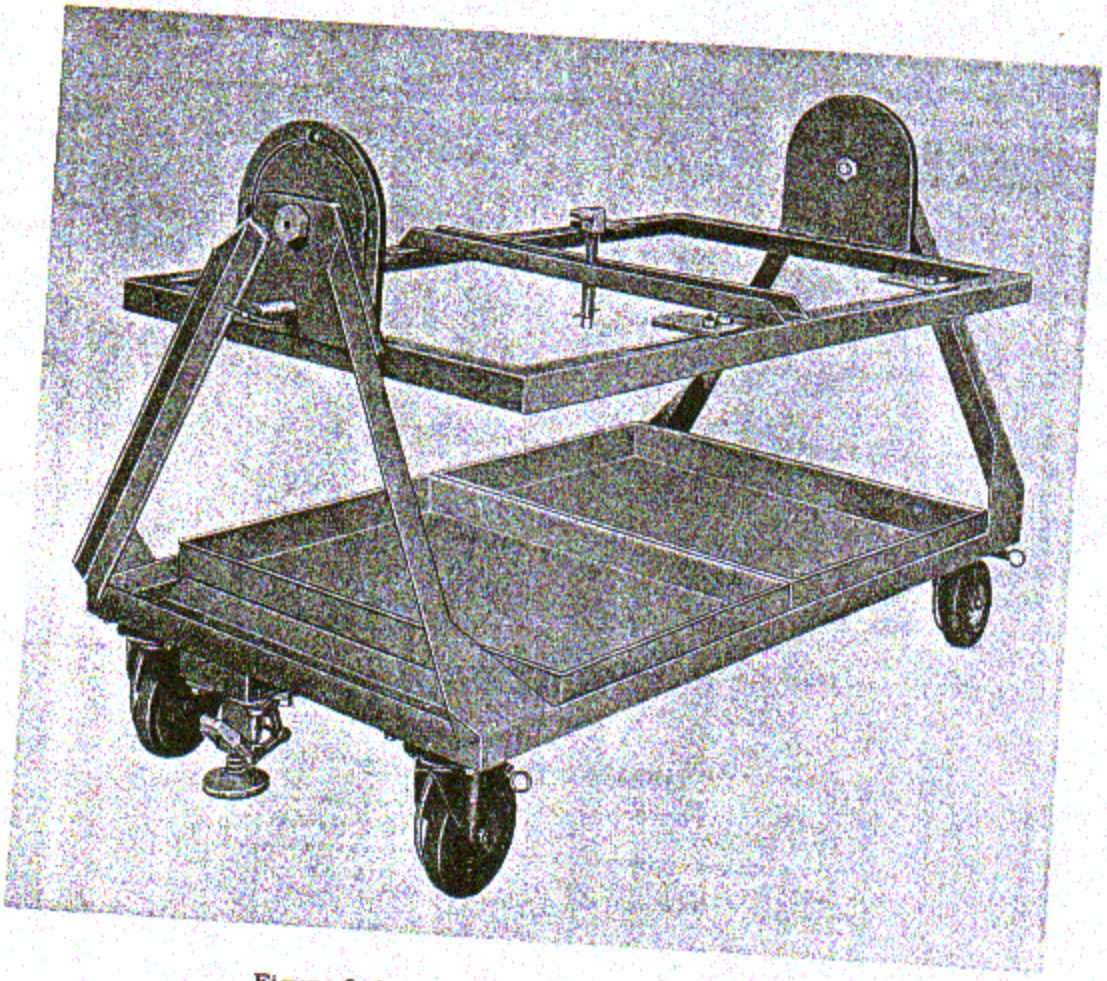


Figure 3-1. Engine Transportation Stand

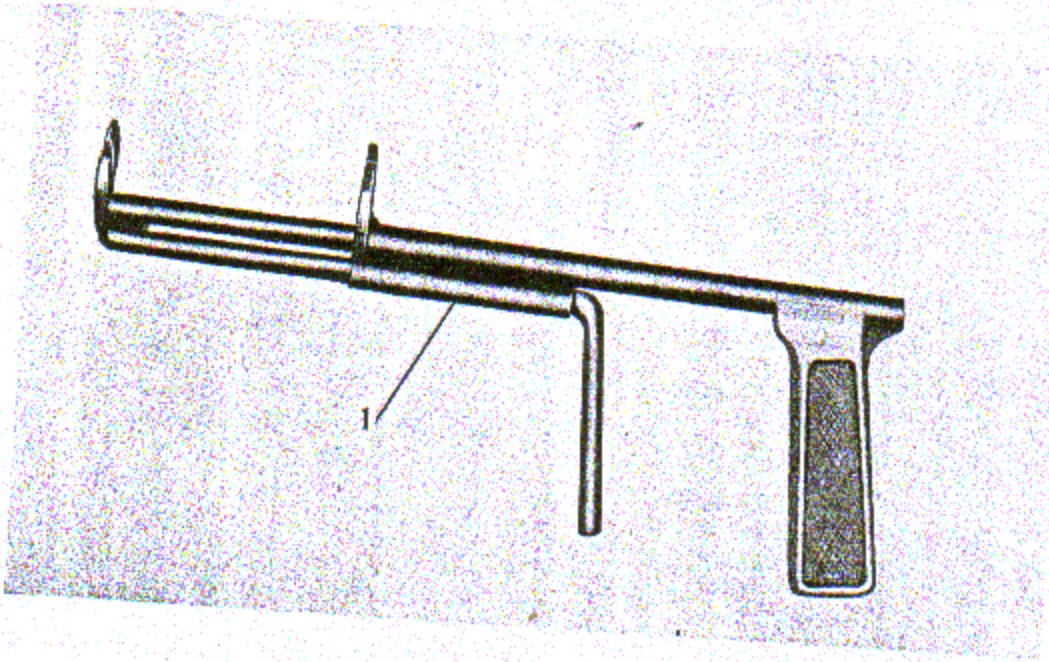


Figure 3-2. Pushrod Housing Tool

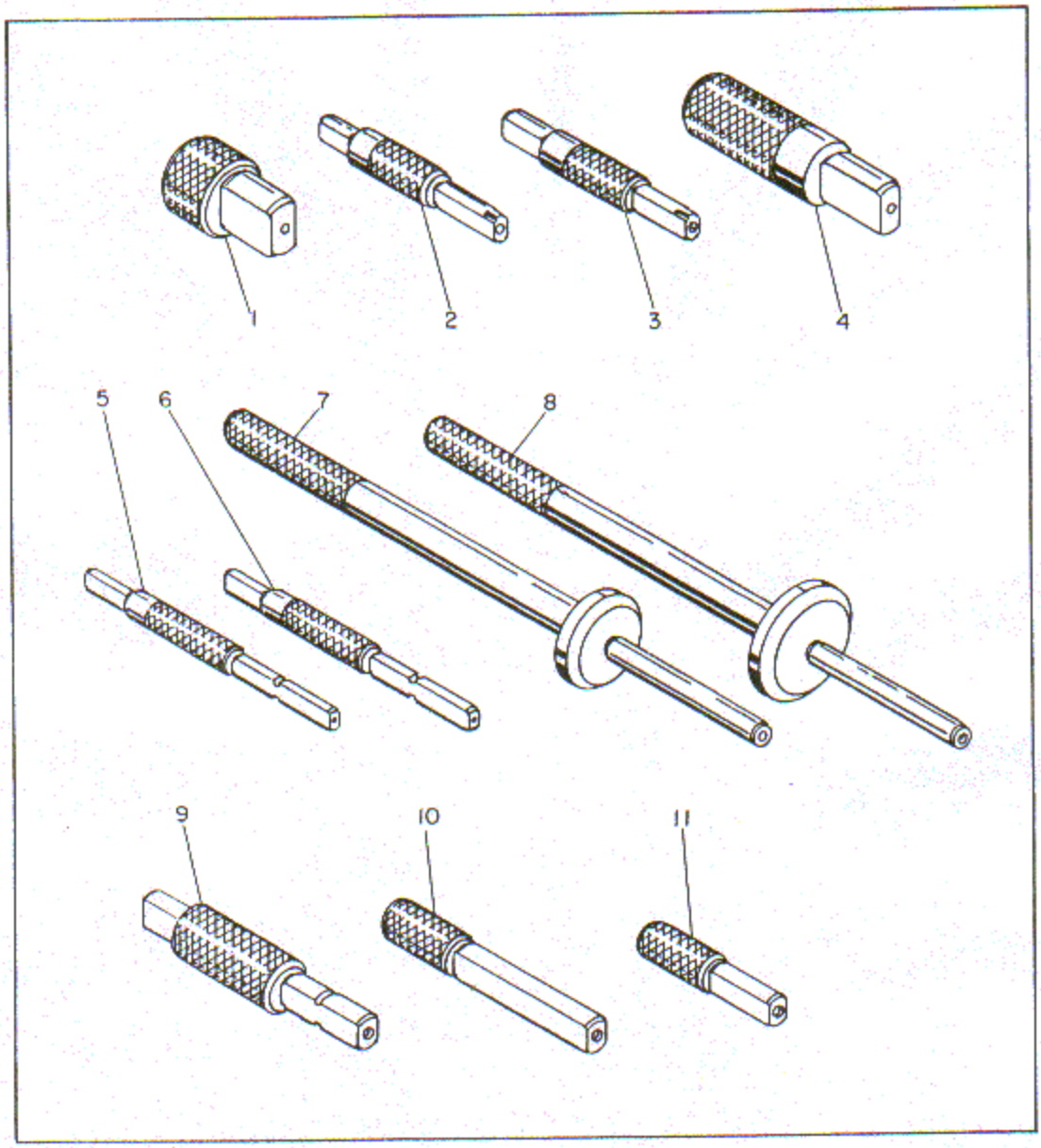


Figure 3-3. Special Gauges

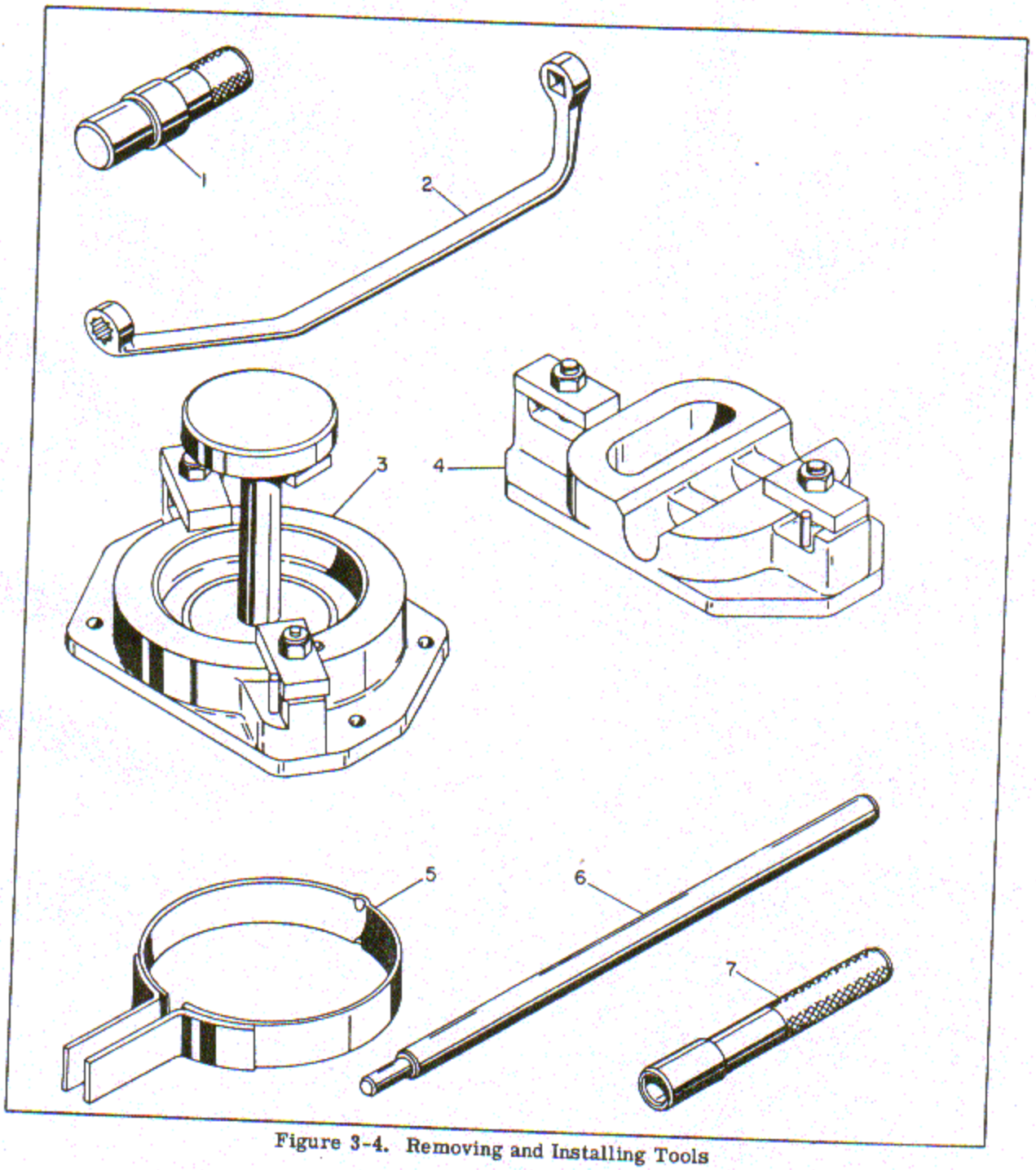


Figure 3-4. Removing and Installing Tools

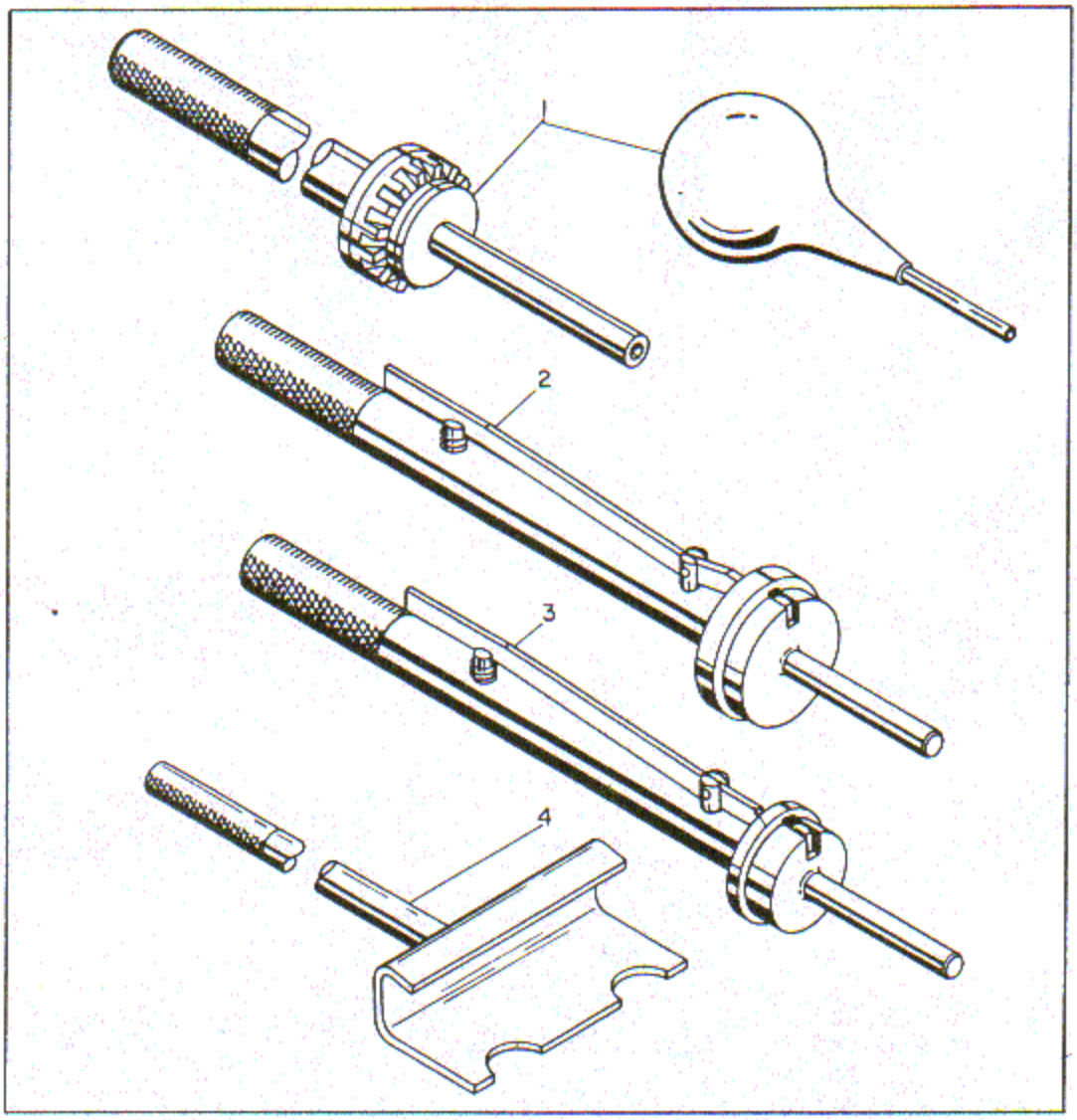


Figure 3-5. Removing and Installing Tools

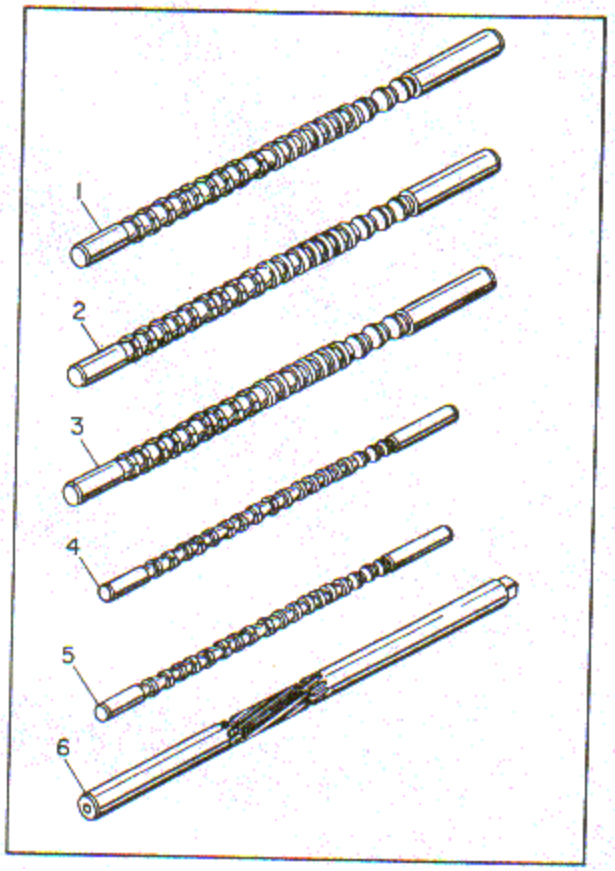


Figure 3-6. Reamers and Broaches

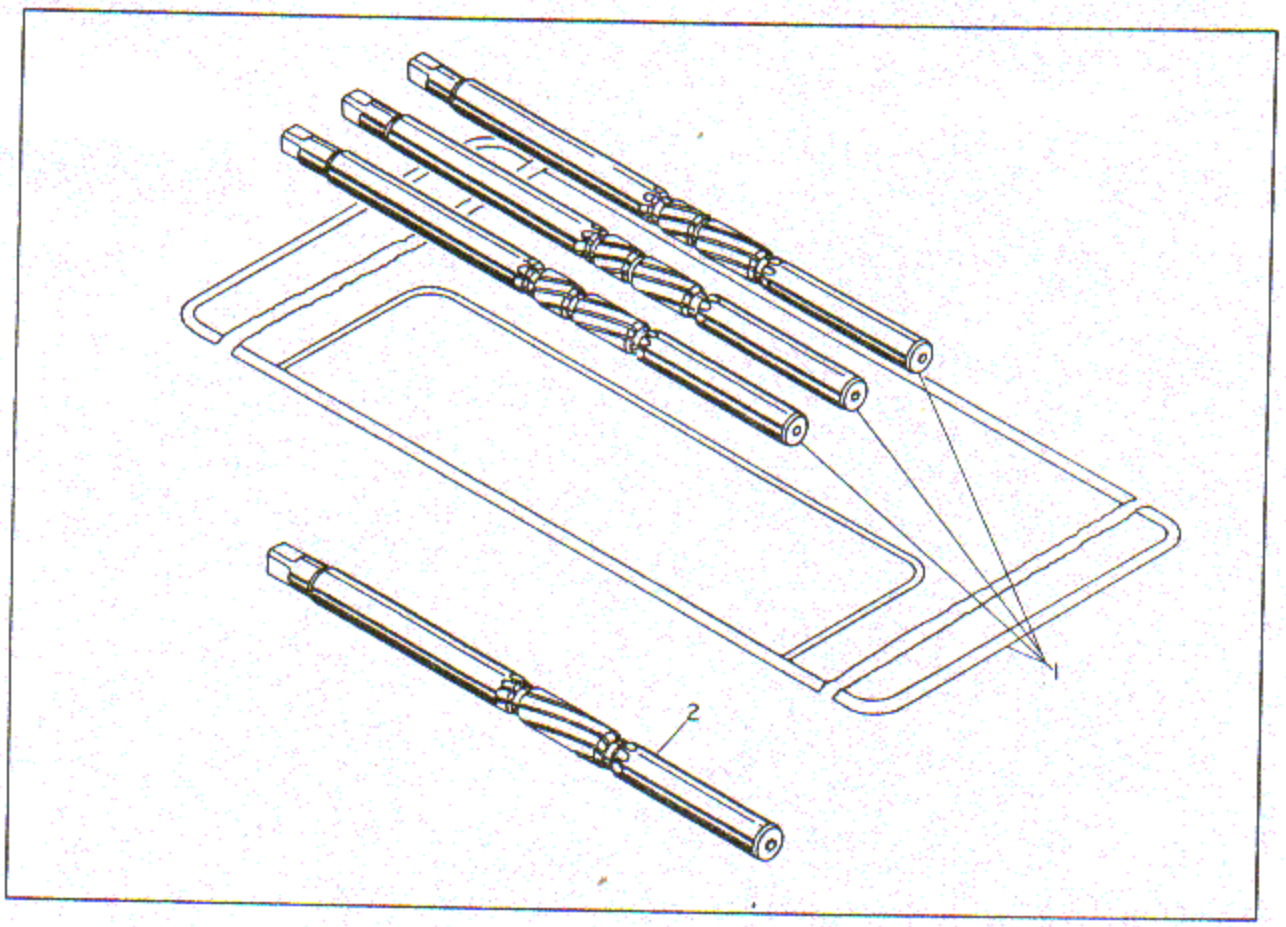


Figure 3-7. Special Overhaul Tools

SECTION IV

DISMANTLING AND DISASSEMBLY

4-1. GENERAL.

4-2. PRELIMINARY CLEANING. Before proceeding with dismantling, it is advisable to clean the exterior of the engine thoroughly. Pay particular attention to removal of caked dirt and oil from nuts, screw heads and other attaching parts which are to be removed. Cleaning may be accomplished by spraying in the manner specified in T.O. 2R-1-84.

4-3. DISASSEMBLY INSPECTION. During each stage of disassembly, examine all parts and assemblies for scoring or burning. Look for indications of work incorrectly performed during any previous overhauls. Report any such indications in accordance with current practice.

4-4. PARTS TO BE DISCARDED. Unless they are to be held for special inspection, discard upon removal all soft and copper-asbestos gaskets, "O" ring packings, rubber hose connectors (except the governor oil hose), lockwire, cotter pins, nut locks, lock nuts and lock washers.

4-5. USE OF ILLUSTRATIONS. Each line drawing reproduced in this section represents a subassembly or functional system "exploded" into its component parts. In most instances, these are identical to illustrations in the Illustrated Parts Breakdown, except that the index numbers indicate the exact order of disassembly, ie., attaching parts immediately precede the part attached in numerical sequence. The appearance of studs, bushings and other tight fitted inserts in "exploded" positions in illustrations does not constitute authority to remove them except when replacement of these parts is required.

4-6. ORDER OF DISMANTLING. The order of removal of parts and subassemblies is established by the numerical sequence of index numbers in figure 1-3. Exploded parts views of subassemblies in this section appear in the same order.

4-7. REMOVAL OF ENGINE FROM METAL SHIPPING CONTAINER.

4-8. Remove engine from metal shipping container in the following manner:

a. Remove cover from inspection port.

b. Unscrew the stem of the air filling valve to relieve the air pressure in the container.

c. After air has ceased flowing from the container, remove closure flange attaching parts.

d. Attach a sling and hoist to the container top half lifting eyes and lift it off carefully to avoid bumping the engine. Move top half to one side and lower it carefully onto a smooth flat surface to avoid damaging flange parting surface.

e. Attach a hoist to the engine lifting eye (3, figure 1-1) and take up weight of engine without lifting it.

f. Loosen nuts on attaching bolts of each mounting frame adapter bracket enough to permit shifting the brackets without vertical looseness.

g. Remove four bolts, barrel nuts and the steel backed, rubber engine mounts which attach the engine mount brackets to the mounting frame adapter brackets.

h. Lift engine clear of container lower section; then slide lower section aside. Remove oil level gauge (11, figure 1-2); then place a container of at least 10 quart capacity under oil sump drain. Remove plug (10, figure 1-2) and drain oil. Remove parts cartons, oil and waste material from container lower section; then replace bolts, washers and rubber mounts in container lower section.

i. Roll engine transportation stand, Section III, tool group 9 into position under engine. Loosen adapter to cradle attaching bolts until adapters have been bolted to engine mount brackets. Use 7/16-20 bolts and the same barrel nuts used to attach the engine to the mounting frame adapters.

NOTE

The engine transportation stand may be adapted to accept engine mount brackets of this model by fabricating adapters in accordance with the dimensions and details specified in figure 4-1.

j. Remove bags of dessicant from wire mesh basket and dispose of them in accordance with current Technical Orders on that subject.

k. Detach humidity indicator card wires from holder. Discard the card.

l. Remove receptacle cover and records. Attach records to engine; then replace cover.

m. Reinstall filling valve cover; then the container upper section. Leave bolts, nuts and washers in container unless it is to be hoisted, in which event all closure flange attaching parts should be installed.

n. Inspect entrance to carburetor barrel, if covered, remove covering material and any dessicant attached to it.

o. Remove caps or tape covers installed on breather, exhaust ports and any engine opening not plugged or otherwise covered.

4-9. DISMANTLING.

4-10. GENERATOR. Remove six sets of attaching nuts and washers and withdraw the generator from the adapter on the front side of the accessory case.

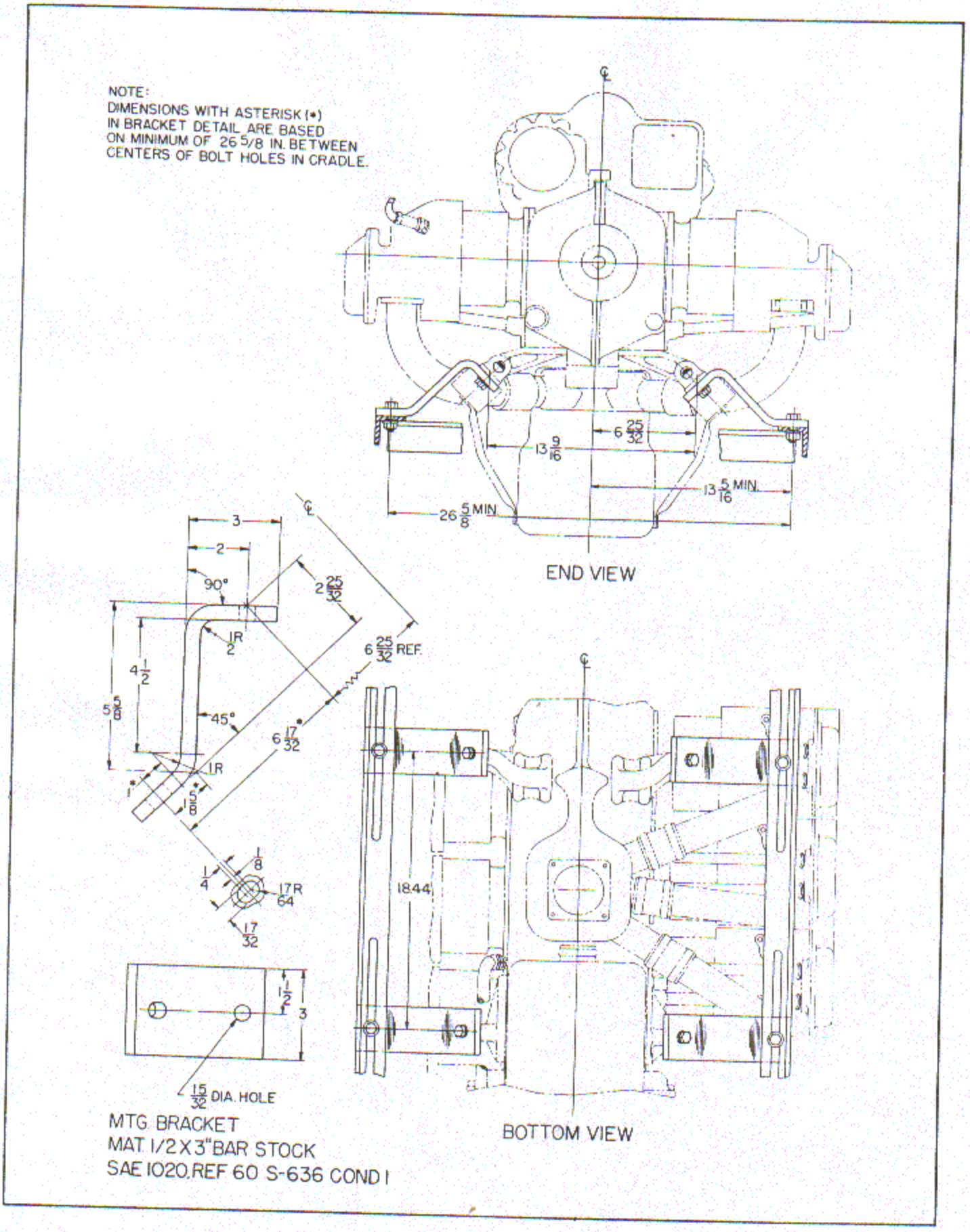
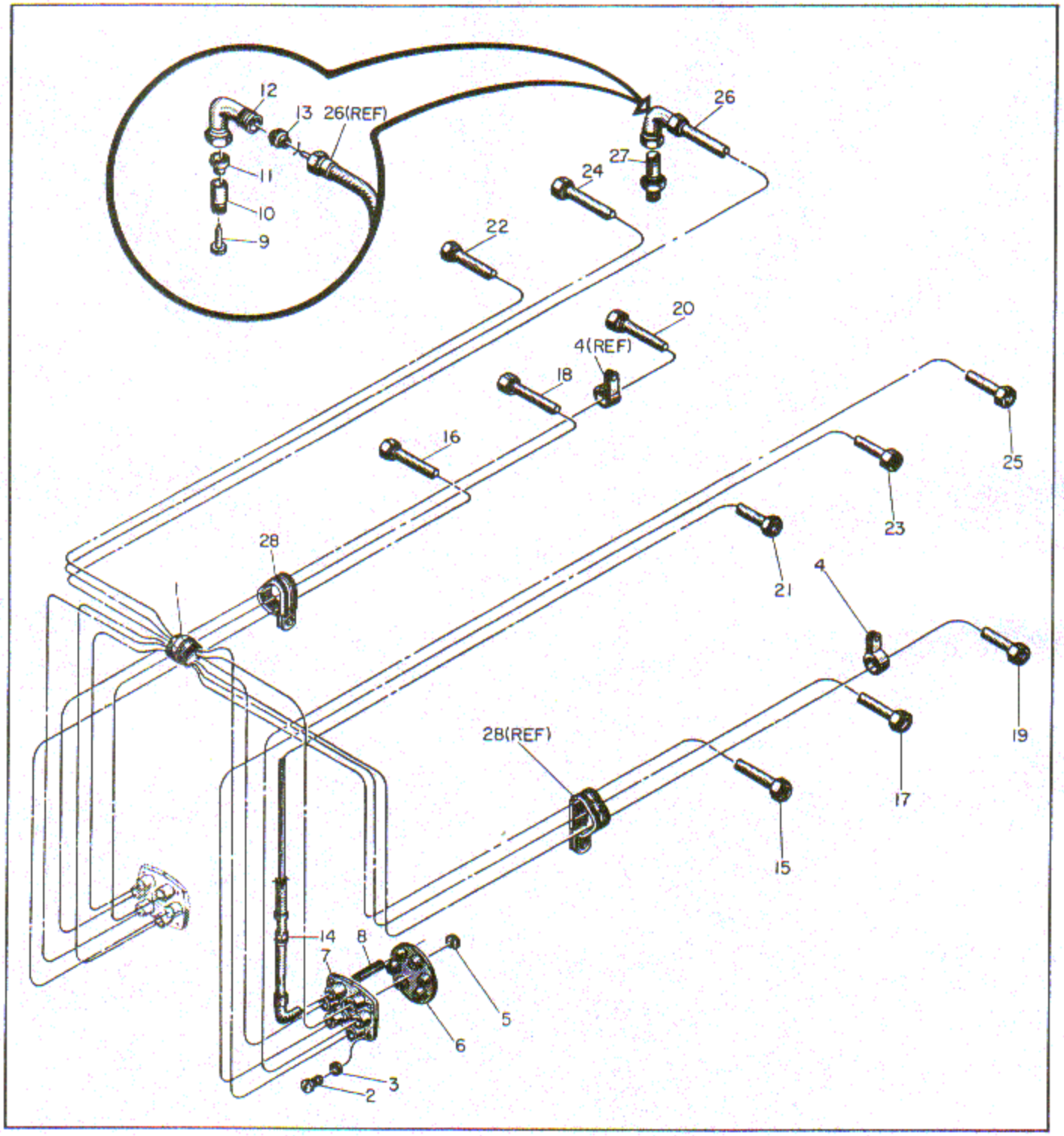


Figure 4-1. Dimensions of Engine Cradle Adapters



1. Clamp
2. Screw
3. Lock washer
4. Bracket
5. Washer
6. Outlet plate grommet
7. Distributor outlet plate
8. Socket
9. Pin
10. Terminal sleeve
11. Bushing
12. Elbow
13. Spacer
14. Cable
15. No. 1 lower conduit
16. No. 2 lower conduit
17. No. 3 lower conduit
18. No. 4 lower conduit
19. No. 5 lower conduit
20. No. 6 lower conduit
21. No. 1 upper conduit
22. No. 2 upper conduit
23. No. 3 upper conduit
24. No. 4 upper conduit
25. No. 5 upper conduit
26. No. 6 upper conduit
27. Spark plug
28. Bracket

Figure 4-2. Exploded View of Ignition Harness

4-11. IGNITION HARNESS. (See figure 4-2.) Unfasten and remove clamp (1) from group of conduits crossing behind magnetos. Brackets (4 and 28) will remain on conduits as will spark plug elbow parts (9 through 13) washers (5), grommets (6) and outlet plates (7).

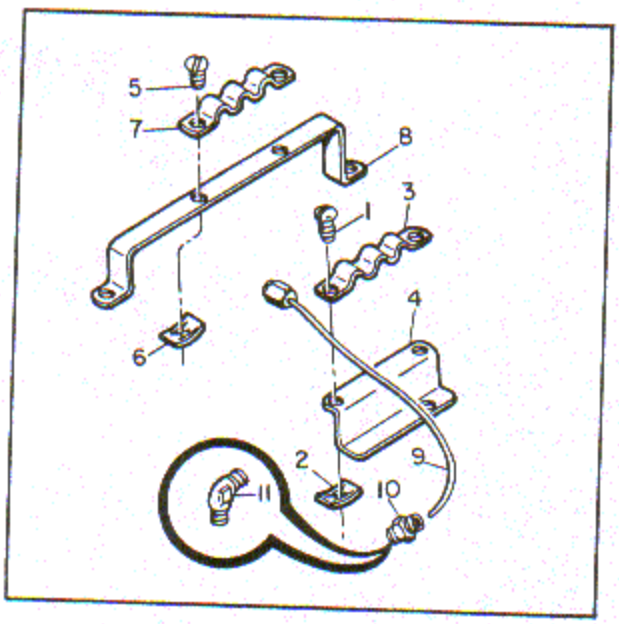
CAUTION

When withdrawing outlet plates from magnetos, pull steadily and no harder than necessary. Excessive withdrawal force may cause wire ends to be pulled loose from washers on outlet plate grommet. Rubber grommet is a tight fit in magneto.

4-12. PRIMING SYSTEM. (See figure 4-3.) Tube assemblies (9) will not be disassembled.

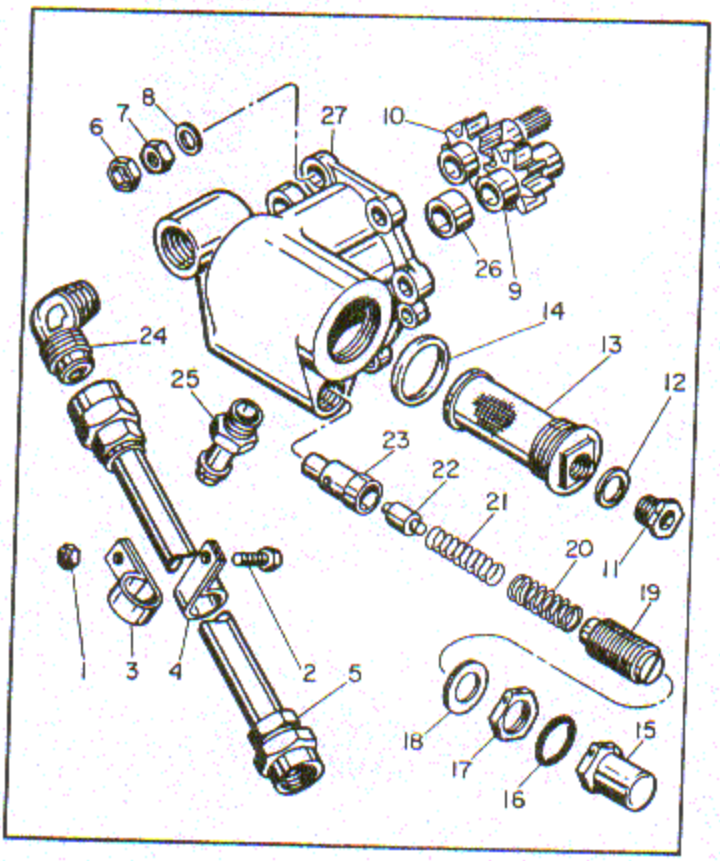
4-13. TACHOMETER GENERATOR. For location on engine see 7, figure 1-2. Special instructions are not required.

4-14. STARTER. For location on engine see 5, figure 1-2. Remove attaching parts and withdraw starter straight rearward. Adapter will remain on accessory case.



1. Screw
2. Speed nut
3. Clamp
4. Bracket
5. Screw
6. Speed nut
7. Clamp
8. Bracket
9. Tube assembly
10. Nipple
11. Elbow

Figure 4-3. Priming System



1. Nut
2. Bolt
3. Clamp
4. Clamp
5. Hose assembly
6. Nut lock
7. Nut
8. Washer
9. Oil pump driven gear
10. Oil pump driver gear
11. Plug
12. Gasket
13. Oil filter assembly
14. Gasket
15. Cap
16. Gasket
17. Nut
18. Gasket
19. Screw and bushing assembly
20. Outer spring
21. Inner spring
22. Plunger
23. Sleeve
24. Elbow
25. Adapter
26. Bushing
27. Oil pump body

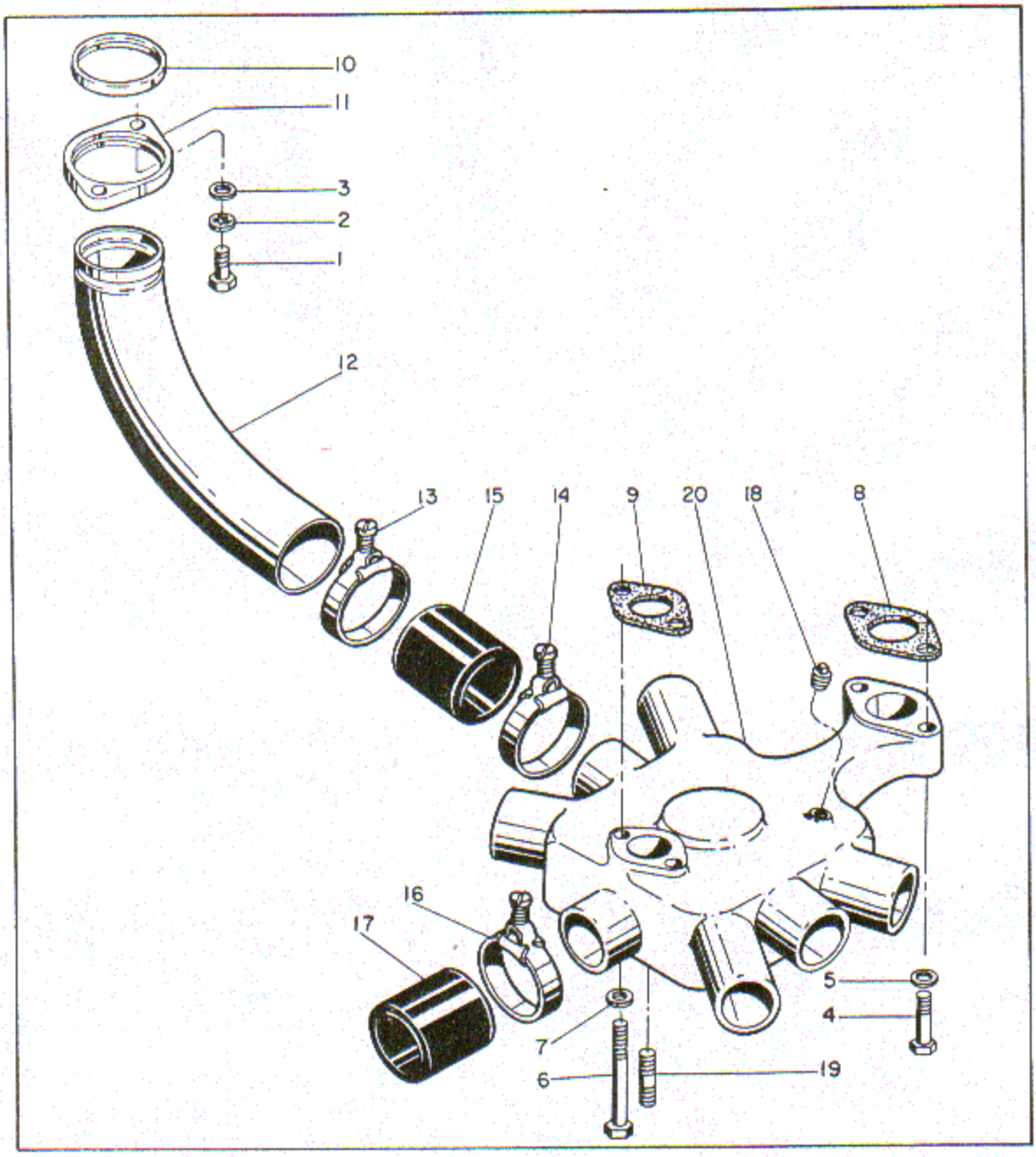
Figure 4-4. Oil Pump

4-15. FUEL PUMP. For location on engine see 9, figure 1-2. No special instructions are required.

4-16. VACUUM PUMP. For location on engine see 6, figure 1-2. No special instructions are required.

4-17. OIL PUMP. (See figure 4-4.) Remove nut (1) and bolt (2) to detach hose support clamp (4) from clamp (3) on right side of sump. To facilitate removal later, loosen elbow (24) and adapter (25).

4-18. CARBURETOR. For location on engine see 15, figure 1-1. Invert engine. Remove attaching parts and lift off carburetor.

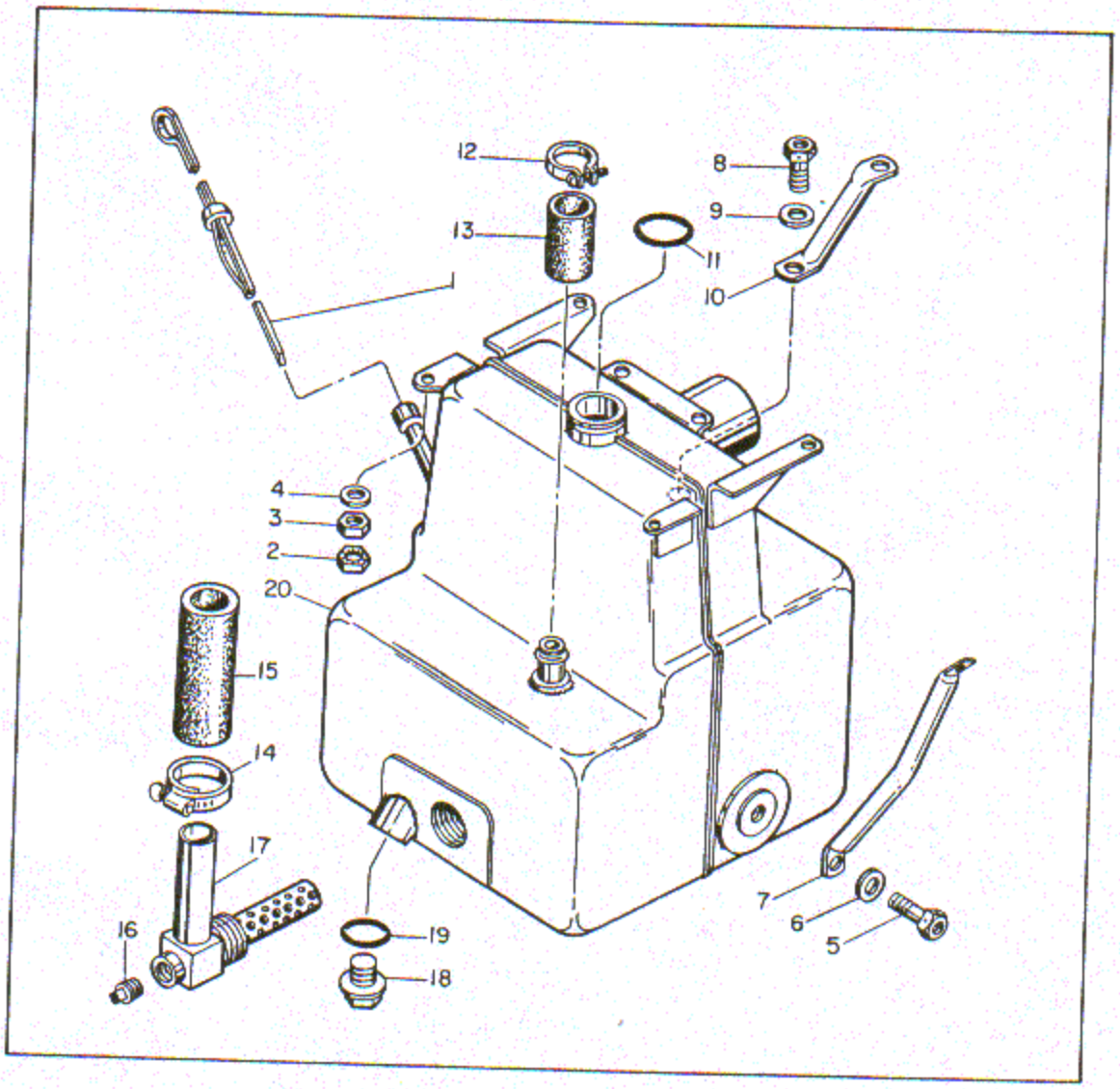


1. Bolt
2. Lock washer
3. Washer
4. Bolt
5. Washer
6. Bolt
7. Washer
8. Gasket
9. Gasket
10. Seal
11. Intake tube flange
12. Intake tube
13. Clamp
14. Clamp
15. Hose
16. Clamp
17. Hose
18. Plug
19. Stud
20. Intake and oil drain manifold

Figure 4-5. Induction System Assembly

4-19. INDUCTION SYSTEM ASSEMBLY. (See figure 4-5.) Remove lockwire from bolts (4 and 6). Exert withdrawal force on each intake tube carefully until they are all free to prevent damaging them.

4-20. OIL SUMP. (See figure 4-6.) Loosen suction oil screen (17) to facilitate removal later. Lift sump straight upward, rocking it slightly, if necessary, until upper inlet tube is clear of crankcase hole.



1. Oil gauge rod
2. Nut lock
3. Nut
4. Washer
5. Bolt
6. Washer
7. Bracket
8. Bolt
9. Washer
10. Support bracket
11. Seal
12. Clamp
13. Hose
14. Clamp
15. Hose
16. Plug
17. Suction oil screen assembly
18. Plug
19. Gasket
20. Oil sump

Figure 4-6. Oil Sump

4-21. ACCESSORY CASE REAR HALF. (See figure 4-7.) Return engine to its upright position. Remove attaching parts (32, 33, 34) from studs projecting rearward around parting flange of front half and from two studs at the sides projecting forward from rear half. Make sure all gears remain in the front half. (See figure 4-8.) Oil (tube) in upper hydraulic pump gear bushing above left magneto drive remains in rear half.

4-22. CYLINDERS. (See figure 4-9.) Turn crankshaft until either of the front cylinders is at top dead center, with both valves closed. Using base nut wrench, tool group 4, loosen eight base nut locks (24); then loosen and remove nuts (25), leaving top ones until last. Support cylinder as last nut is removed, and withdraw cylinder straight outward keeping pushrods in housings and housings seated in cylinder heads. Catch piston as cylinder skirt uncovers it and lower it gently to avoid damage to crankcase hole. There is no fixed order of cylinder removal.

CAUTION

Before loosening base nut locks or base nuts, inspect if any nut locks or base nuts are loose. Report any loose parts to inspection personnel. Such cylinders and studs will be subject to special inspection and repair.

4-23. PISTONS. Immediately after removing each cylinder, and before proceeding to the next, remove exposed piston by pushing its pin endwise until clear of connecting rod bushing; then remove piston.

4-24. TIMING GEARS. Remove lockwire, attaching parts and withdraw gear from camshaft. Remove cotter pin, large hex nut, washer, starter jaw, lockwire and four bolts to free pinion gear from crankshaft.

4-25. ACCESSORY CASE FRONT HALF. (See figure 4-7.) Bend down tabs on washers (39) before removing bolts (38). When sliding off case front half, keep it parallel to crankcase to prevent it binding on long studs.

4-26. CRANKCASE. (See figure 4-10.) Loosen cap (18) to facilitate removal later. Turn engine cradle so that crankcase (80) is on top. Place a support under left crankcase half to hold it in position. Detach right engine mount brackets from cradle adapters. Remove parts (33 through 67). If through bolts (9, 14 and 67) must be tapped out, use drift of slightly smaller diameter to avoid scuffing holes. In turn, lift each pair of valve lifters in right crankcase, and pass an old cylinder base packing under and around them. Bring rubber packing out through adjacent cylinder openings; cross it and loop it around pushrod housing flange, to hold tension on lifters and prevent them from falling out when right crankcase half is lifted out. Stand 1, 3 and 5 connecting rods. Have a second person catch and lower rods as right crankcase half is lifted off. Lift out camshaft. Lift crankshaft straight up keeping shaft level until oil transfer tube is clear of crankcase opening and 2, 4 and 6 connecting rods have cleared cylinder openings.

4-27. DISASSEMBLY OF SUBASSEMBLIES.

4-28. OIL PUMP. (See figure 4-4.) Remove remaining parts of pump as necessary in ascending order of index numbers. Do not remove bushings (26) unless replacement is required.

4-29. INDUCTION SYSTEM. (See figure 4-5.) Remove remaining parts in ascending order of index numbers. Do not remove stud (19) unless replacement is required.

4-30. OIL SUMP. (See figure 4-6.) Remove remaining parts in ascending order of index numbers.

4-31. ACCESSORY CASE HALVES. (See figure 4-7.) Detach and remove generator drive adapter assembly. Mark each magneto adapter to identify its original position; then detach and remove them from the rear half. Remove remaining parts in ascending order of index numbers.

NOTE

Do not remove oil plugs (44, 47, 51) from the gear in which they are installed.

4-32. GENERATOR ADAPTER ASSEMBLY. (See figure 4-7.) Use a suitable puller to remove seal (59). With Truarc pliers, expand gear retaining ring (61) only enough to clear the shaft, and withdraw ring. Pull out gear (64). Do not remove its oil plug (63).

4-33. CYLINDERS. (See figure 4-9.) It is assumed that a suitable valve spring compressor is available for work described. If available, an arbor type valve spring compressor should be used which bears on the outer valve spring retainers without cocking them. If this type of compressor is not available, a suitable compressor may be fabricated from steel bar stock, formed and assembled to dimensions in figure 4-11.

a. Place valve holder in base recess of cylinder and valve holding fixture, tool group No. 3. Lower cylinder over top of valve holder and seat its base flange on fixture. Tighten fixture clamps to hold cylinder flange.

b. If cylinder is equipped with rocker shaft retaining screws (8) and washers (9, 10), remove these parts; then push rocker shaft (11) endwise, and remove rocker assemblies (12 through 17). Return shaft to its working position in support bosses.

c. Hook valve spring compressor under rocker shaft to bear on one of the rotocaps (28). Apply downward pressure to compress valve springs until keys (27) can be removed. Do not allow retainers to move upward until keys are out to prevent keys from binding between retainer and valve stems and nicking the stems.

CAUTION

Do not allow the spring compressor to cock the outer spring retainer to prevent it from scoring the valve stem.

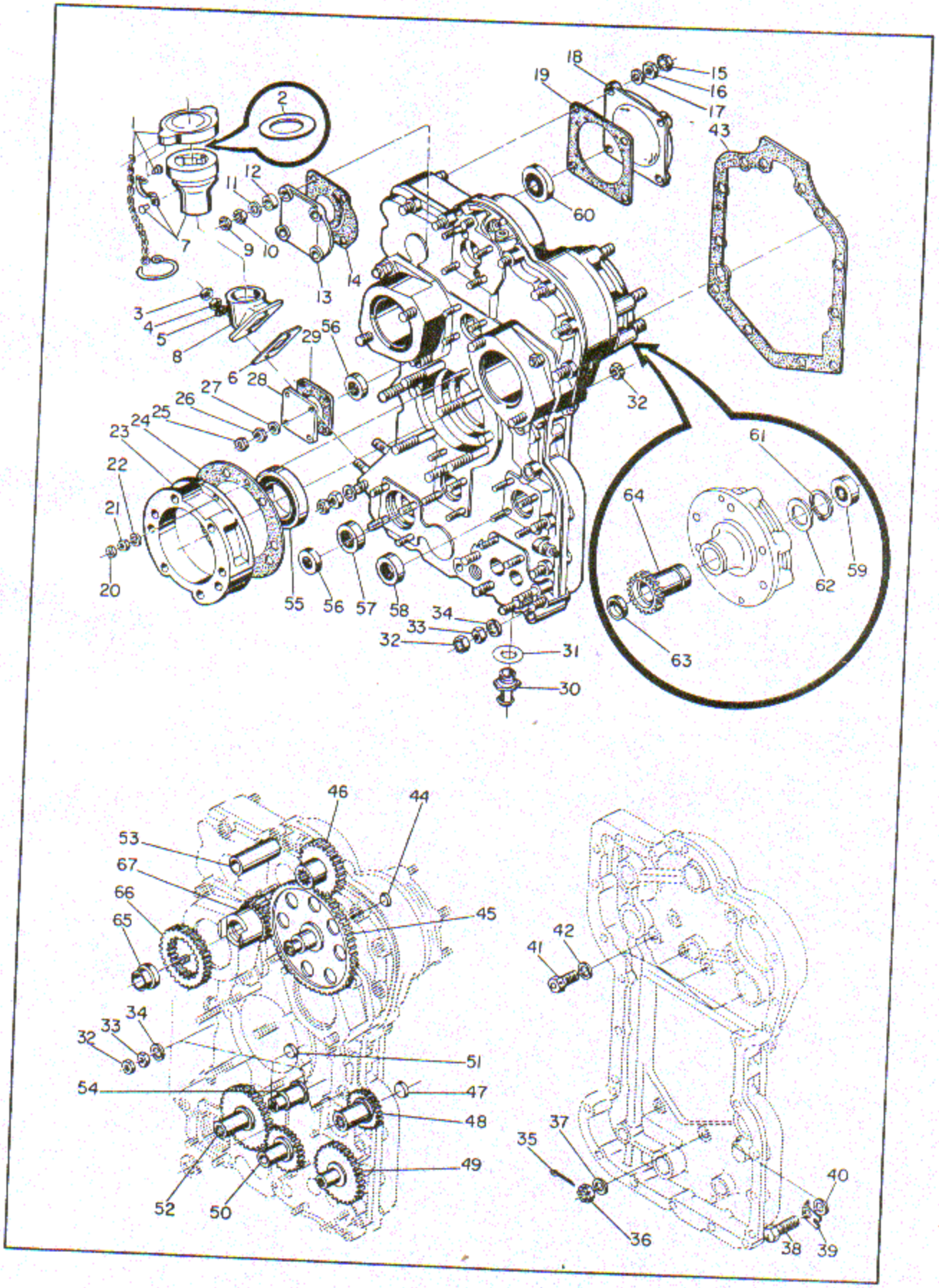


Figure 4-7. Accessory Case, Gears and Covers

Legend for Figure 4-7

1. Oil filler cap retainer assembly
2. Gasket
3. Nut lock
4. Nut
5. Washer
6. Gasket
7. Oil filler neck
8. Oil filler spout
9. Nut lock
10. Nut
11. Washer
12. Washer
13. Propeller governor drive cover
14. Gasket
15. Nut lock
16. Nut
17. Washer
18. Upper hydraulic pump drive cover
19. Gasket
20. Nut lock
21. Nut
22. Washer
23. Starter adapter
24. Gasket
25. Nut lock
26. Nut
27. Washer
28. Vacuum pump drive cover
29. Gasket
30. Nipple
31. Gasket
32. Nut lock
33. Nut
34. Washer
35. Cotter pin
36. Nut
37. Washer
38. Bolt
39. Tab washer
40. Washer
41. Bolt
42. Washer
43. Gasket
44. Oil plug
45. Tachometer drive upper gear
46. Prop governor drive gear
47. Oil plug
48. Hydraulic pump drive lower gear
49. Oil pump drive gear
50. Fuel pump idler gear
51. Oil plug
52. Fuel pump drive gear
53. Plug
54. Tachometer drive shaft
55. Seal
56. Seal
57. Seal
58. Seal
59. Seal
60. Seal
61. Retaining ring
62. Washer
63. Oil plug
64. Generator drive gear
65. Magneto drive gear sleeve
66. Magneto drive gear
67. Magneto drive shaft

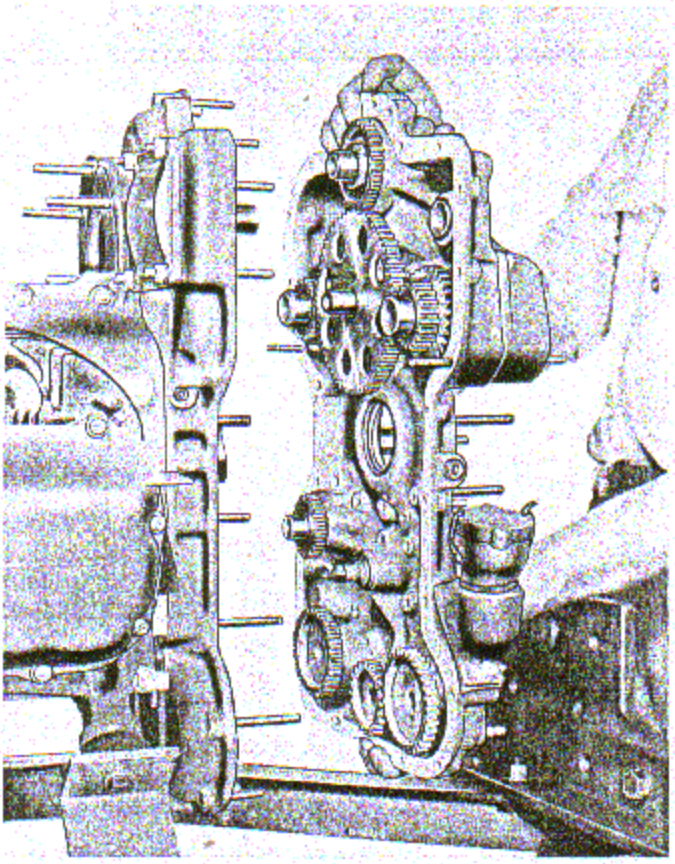
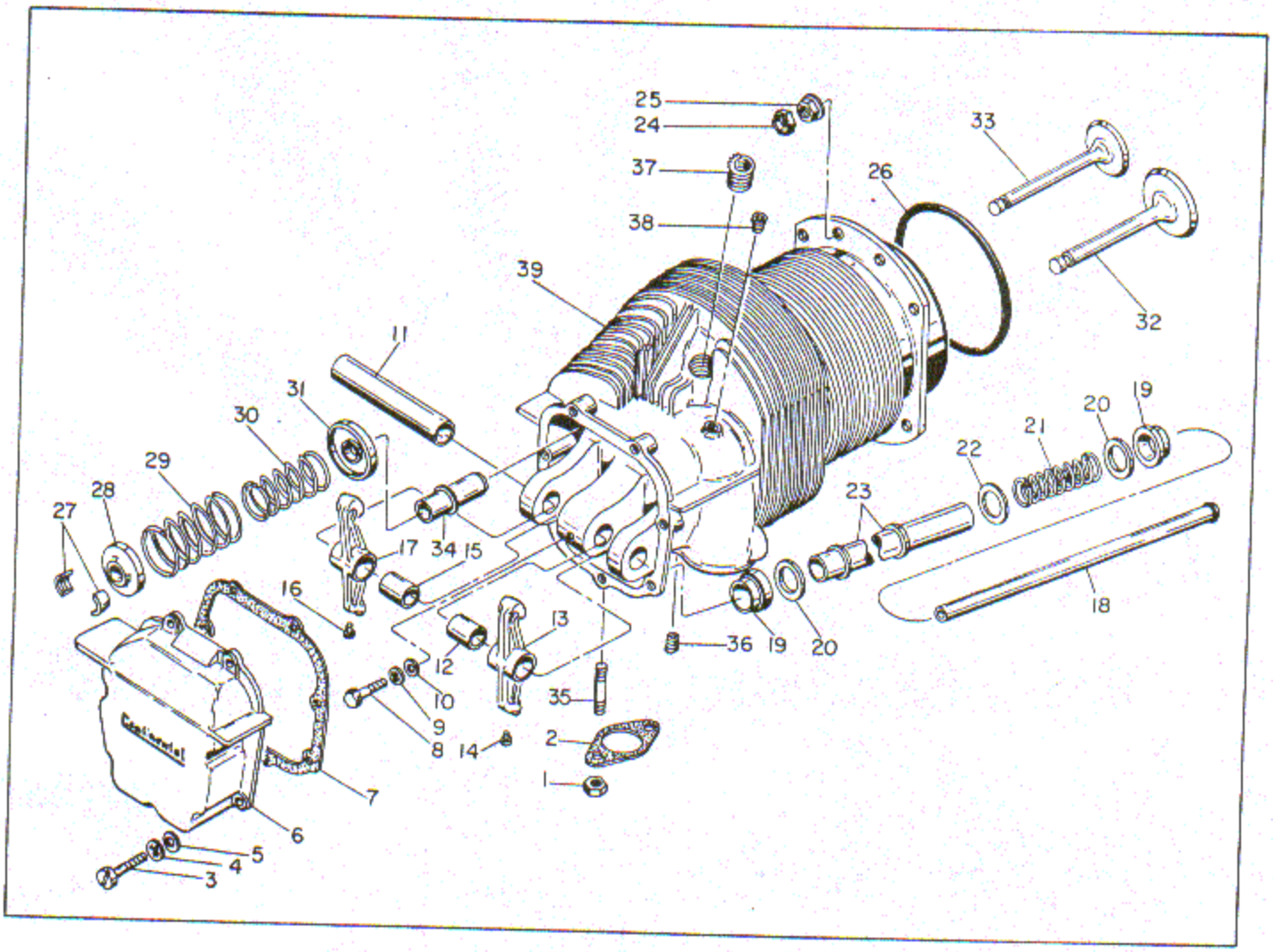
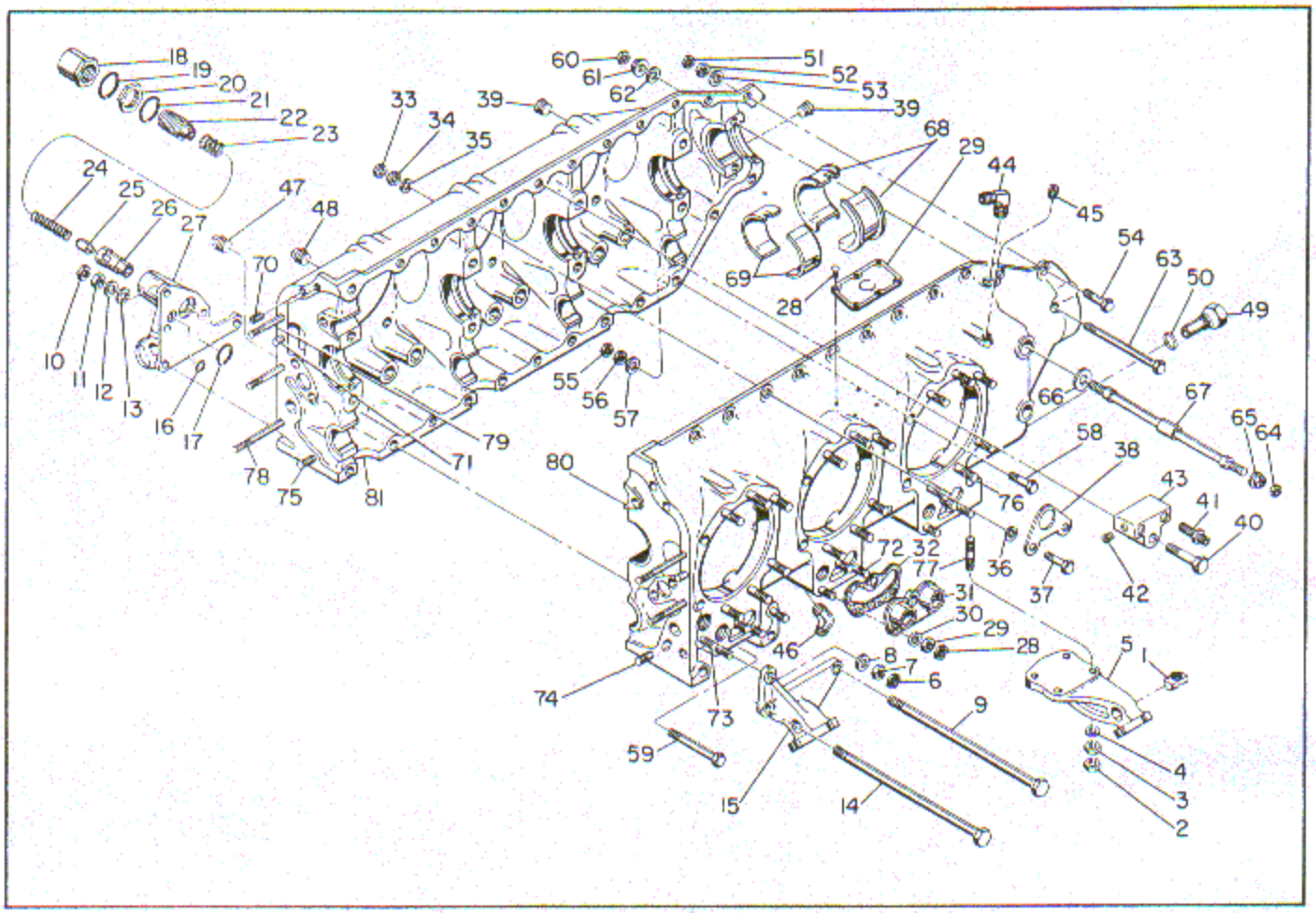


Figure 4-8. Lifting Off Accessory Case Rear Half and Gears



1. Nut
2. Gasket
3. Screw
4. Lock washer
5. Washer
6. Rocker cover
7. Gasket
8. Screw
9. Lock washer
10. Washer
11. Rocker shaft
12. Rocker bearing
13. Intake valve rocker
14. Screw
15. Rocker bearing
16. Screw
17. Exhaust valve rocker
18. Pushrod
19. Seal
20. Washer
21. Spring
22. Washer
23. Pushrod housing
24. Nut lock
25. Flanged nut
26. Seal
27. Keys
28. Rotocap
29. Spring
30. Spring
31. Retainer
32. Intake valve
33. Exhaust valve
34. Valve insert
35. Stud
36. Insert
37. Insert
38. Plug
39. Cylinder

Figure 4-9. Cylinder Assembly



1. Barrel nut
2. Nut lock
3. Nut
4. Washer
5. Front mount bracket
6. Nut lock
7. Nut
8. Washer
9. Bolt
10. Nut lock
11. Nut
12. Washer
13. Spacer
14. Bolt
15. Right rear mount bracket
16. Seal
17. Seal
18. Relief valve cap
19. Gasket
20. Nut
21. Gasket
22. Screw and bushing assembly
23. Spring
24. Spring
25. Piston
26. Sleeve
27. Left rear mount bracket
28. Nut lock
29. Nut
30. Washer
31. Pushrod housing flange
32. Gasket
33. Nut lock
34. Nut
35. Washer
36. Washer
37. Bolt
38. Lifting eye
39. Plug
40. Bolt
41. Nipple
42. Plug
43. Primer distributor
44. Elbow
45. Plug
46. Elbow
47. Plug
48. Plug
49. Adapter
50. Gasket
51. Nut lock
52. Nut
53. Washer
54. Bolt
55. Nut lock
56. Nut
57. Washer
58. Bolt
59. Bolt
60. Nut lock
61. Nut
62. Washer
63. Bolt
64. Nut lock
65. Nut
66. Spacer
67. Through bolt
68. Main thrust bearing
69. Main bearing
70. Insert
71. Dowel
72. Stud
73. Stud
74. Stud
75. Stud
76. Stud
77. Stud
78. Stud
79. Stud
80. Right crankcase half
81. Left crankcase half

Figure 4-10. Crankcase Group

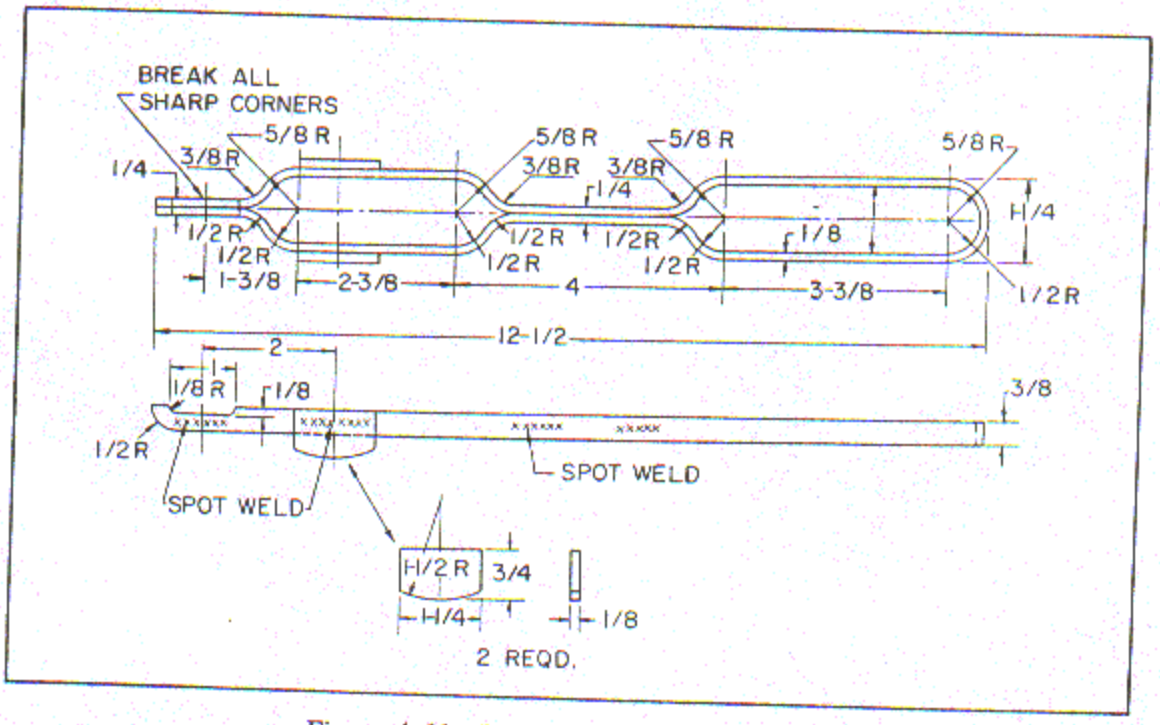


Figure 4-11. Valve Spring Compressor

d. Release pressure and remove compressor. Lift off Rotocap (28), two springs (29, 30) and inner retainer (31).

e. Disassemble parts from other valve in the same manner; then remove rocker shaft (11).

f. Loosen fixture clamps and lift cylinder by valve stems. Lay it on its side and withdraw valves through open end of cylinder.

CAUTION

Before removing valves, inspect upper ends of stems for nicks. Remove any upstanding edges with a hard Arkansas stone or fine India stone before pushing them out of their guides.

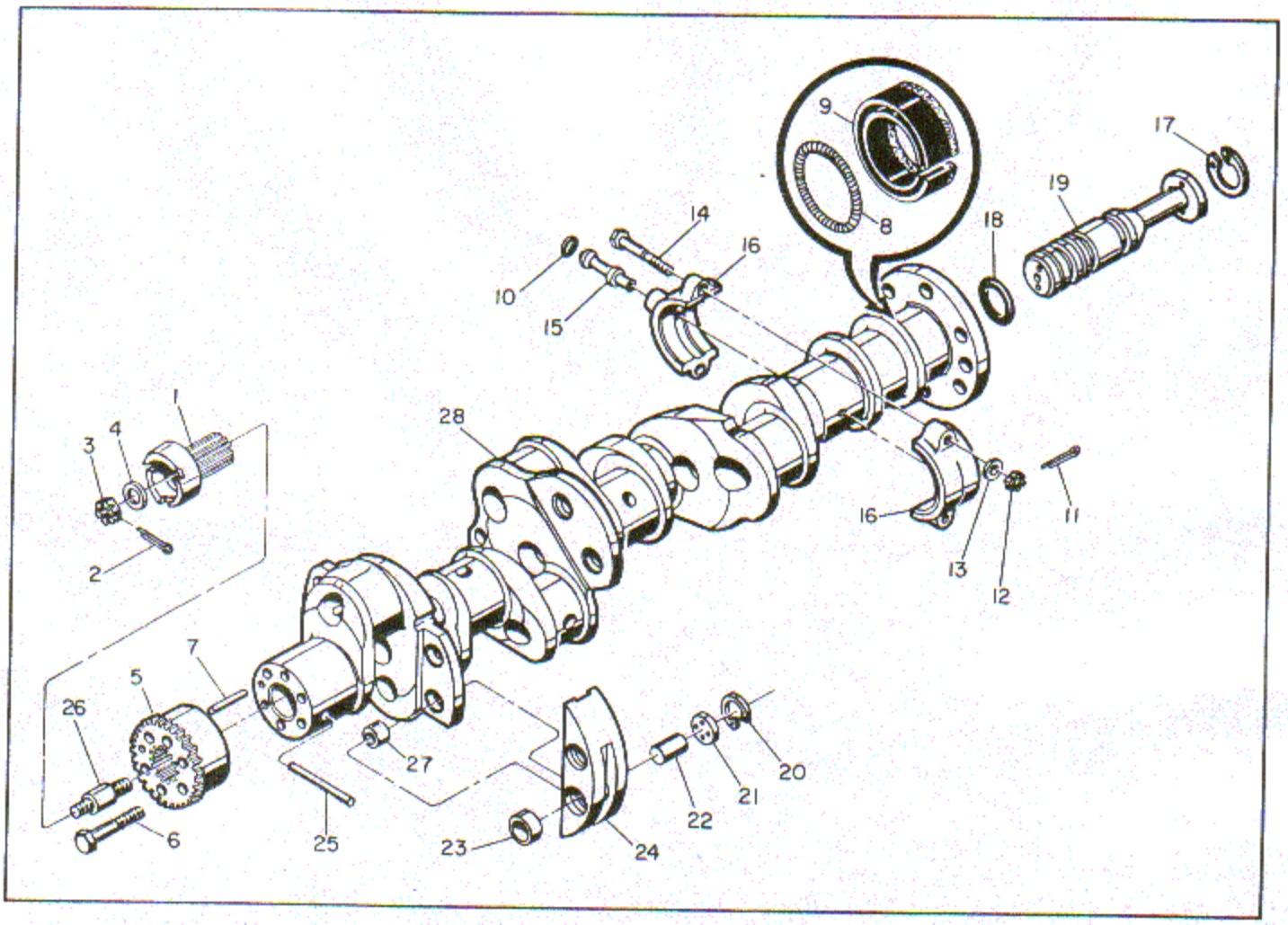
4-34. PISTON ASSEMBLIES. If a standard five-inch ring spreader is available use it to spread the piston rings and lift them off over piston head, otherwise use fingers. Take care to avoid scratching piston lands by forcing sharp ring ends over them. If any ring is seized in a groove, remove pin assembly and discard piston and rings. Discard all rings in any event. Push pin assembly back into piston and keep these parts together throughout cleaning and repair operations.

4-35. CRANKCASE HALVES. (See figure 4-10.) Remove identification plate only if castings are to be scrapped. Discard all main bearing inserts, rubber gaskets and copper-asbestos gaskets. Remove all plugs to permit flushing.

4-36. CRANKSHAFT AND CONNECTING RODS ASSEMBLY. Support front and rear shaft journals in notches cut in edges of 2 x 4 inch wood blocks to permit rotation. Keep parts of each rod assembly together. Discard bearing inserts; then reassemble each rod and cap for storage. Position numbers on bolt bosses must be on same side. Save oil seal spring (8, figure 4-12) for spare. Discard seal. Use Truarc No. 1 or No. 21 pliers to remove eight pin retaining rings (20, figure 4-12).

NOTE

Do not remove jaw attaching stud (26), the dowel (25), pinion dowel (7) or any of the steel tubes installed in the crankcheek oil holes. Do not remove steel bushings (23, 27) from crankshaft or counterweights.



1. Starter jaw
2. Cotter pin
3. Nut
4. Washer
5. Pinion gear
6. Screw
7. Dowel
8. Spring
9. Seal assembly
10. Seal
11. Cotter pin
12. Nut
13. Washer
14. Screw
15. Oil transfer tube
16. Oil transfer collar
17. Retaining ring
18. Seal
19. Oil transfer plug assembly
20. Retaining ring
21. Retaining plate
22. Counterweight pin
23. Counterweight bushing
24. Counterweight
25. Dowel
26. Stud
27. Crankshaft damper bushing
28. Crankshaft

Figure 4-12. Crankshaft Assembly

SECTION V

INSPECTION, REPAIR AND REPLACEMENT

5-1. DEFINITIONS OF TERMS.

5-2. The following definitions apply to terms used in this section to describe kinds of damage for which parts should be inspected.

a. Abrasion: Scratching of a surface, either by motion while in contact with another part or by mechanical cleaning or resurfacing with abrasive cloth or lapping compound.

b. Burning: As applied to valve heads, this term indicates roughening or erosion due to high temperature gases escaping past the valve faces. In other instances it indicates drawing of the temper of steel parts to the soft (blue) condition as a result of overheating in the absence of lubricant on moving surfaces, such as gear teeth, subject to high loading.

c. Burr: A sharp projection of metal from an edge. Usually the result of drilling, boring, countersinking, etc., but may also be caused by excessive wear of one or both surfaces adjacent to the burred edge.

d. Corrosion: Deterioration of a surface, usually caused by oxidation of metal.

e. Elongation: Stretching or increase in length.

f. Fretting: Scuffing or deterioration of a metal surface caused by vibration or chattering of or against another part. A fretted steel surface may appear dull, scuffed or corroded, depending on length of time subject to the action, dissimilarity and kind of contacting metal and presence or absence of moisture.

g. Galling: Excessive friction between two metals resulting in particles of the softer metal being torn away and "welded" to the harder metal.

h. Indentation: Dents or depressions in a surface caused by severe blows.

i. Oxidation: Chemical combining of a metal with atmospheric oxygen. Aluminum oxide forms a tough, hard film and protects the surface from further decomposition, however iron oxides do not form continuous cover or protect the underlying metal, thus oxidation of steel parts is progressive and destructive.

j. Pitting (or spalling): Small, deep cavities with sharp edges. May be caused in hardened steel surfaces by high impacts or in any smooth steel part by oxidation.

k. Runout: Eccentricity or wobble of a rotating part. Eccentricity of two bored holes or two shaft diameters. A hole or bushing out of square with a flat surface. Usually measured with a dial indicator, and limits stated indicate full deflection of indicator needle in one revolution of part or indicator support.

l. Scoring: Deep grooves in a surface caused by abrasion when fine, hard particles are forced between moving surfaces, as in a bearing and journal, or by galling when a moving part is not supplied with lubricant.

5-3. DIMENSIONAL INSPECTION.

5-4. LIMITS. In Section X, the two columns headed "Minimum" and "Maximum" under "New Parts" refer to manufacturing limits on parts dimensions, press fits and clearances and are applicable when both parts concerned are new replacement parts. The column headed "Replace. Maximum" contains values considered to represent the maximum departures from manufacturing limits which are acceptable for reassembly of worn parts. These are applicable when either of the parts concerned has been in service previously, regardless of the new or worn status of the mating part. When applicable, the "Replace. Maximum" limits, if not exceeded, permit the parts to be continued in service. If exceeded, they require either replacement of one or both of the parts concerned or repair by one of the methods described in this section. When no value appears in the "Replace. Maximum" column the fit must remain within "New Parts" limits. This occurs in all tight fits and in those applicable to parts having no relative motion to cause wear.

5-5. PARTS TO BE MEASURED FOR WEAR AT OVERHAUL. Table I contains a list of parts which the engine manufacturer recommends be measured for wear at each overhaul in order to assure acceptable oil consumption and power output, enable the pump to develop specified oil pressure and prevent rapid wear of mating parts. Dimensions of new parts are given in the table when necessary to assure correct overhaul practice. Special gauges are indicated in the table and should be used for measurement of those parts for which such gauges are available. For tool numbers of such gauges, refer to Section III.

5-6. TYPES AND USE OF SPECIAL PLUG GAUGES. These are flat plug gauges so that any out-of-roundness may be detected by inserting them in various radial positions. Some are step gauges, i.e., a "GO" gauge precedes a "NO GO" gauge on the same end of the tool, the "GO" gauge being slightly smaller and intended to just enter the smallest acceptable hole, while the "NO GO" step will not quite enter the largest acceptable hole. These are intended for checking bored or reamed inserts, such as replacement valve guides. If the "GO" gauge fails to enter it will indicate that the hole is too small, due to wear or incorrect adjustment of the cutting tool, and must be bored or reamed larger. If the "NO GO" gauge step enters the hole, then the boring or reaming tool is cutting oversize, and the tool must be corrected or replaced. Those plug gauges having only a "NO GO" plug are intended only for checking worn parts. If the plug enters the hole, the bearing or bushing is excessively worn and must be replaced or bored to a specified oversize to fit an oversize mating part.

NOTE

Dimensions stamped on plug gauges are manufacturing limits on new gauge dimensions and are to be used only for checking wear in the gauge plugs.

TABLE I. PARTS TO BE MEASURED FOR WEAR

Name of Part	Description of Measurement	Dimensions New	
		Minimum	Maximum
CYLINDER ASSEMBLY			
Cylinder and Head	Cylinder bore dia (lower 3-3/8 in. of barrel)	5.001	5.003
	Cylinder bore dia (at top of barrel)	4.991	4.995
	Cylinder bore out-of-round		
(0.015 in. oversize)	Cylinder bore dia (lower 3-3/8 in. of barrel)	5.016	5.018
	Cylinder bore dia (at top of barrel)	5.006	5.010
Valves	Intake valve guide hole dia	Gauge	Gauge
	Exhaust valve guide hole dia	Gauge	Gauge
	Exhaust valve length	4.806	4.826
	Intake valve length	4.804	4.824
	Exhaust valve stem dia	0.433	0.434
	Intake valve stem dia	0.433	0.434
Rocker Assemblies	Rocker bushings dia	0.719	0.720
Rocker Shafts	Outside diameters	0.7177	0.7182
Valve Springs	Lengths at specified leads		
PISTON ASSEMBLY			
(Standard)	Skirt dia at bottom	4.993	4.994
	Skirt dia below 3rd ring groove	4.984	4.986
	Pin hole dia	1.1250	1.1255
	Pin dia	1.1243	1.1245
	Ring side clearance		
	Ring gap in barrel		
CONNECTING ROD ASSEMBLY			
	Piston pin bushing bore dia	1.1263	1.1265
	Bushing and bearing twist and convergence		
CRANKSHAFT ASSEMBLY			
	Main journal dia	2.3740	2.3750
	Crankpin dia	2.2490	2.250
	Damper pin bushing inside dia	.624	.626
	Damper pin dia	.5554	.5574
	Run-out at center journals (shaft supported at front and rear journals)		
	Run-out at front end, between front end and flange (shaft supported at front and rear journals)		
	End clearance of shaft in front main thrust bearing (fully assembled)		
CAMSHAFT			
	Run-out at center journals (shaft supported at front and rear journals)		
	End clearance in assembled crankcase		
	Journal dia	1.248	1.249
VALVE LIFTER			
	Body dia	0.7177	0.7182
	Hydraulic unit leakdown		
CRANKCASE			
	Valve lifter guide dia	Gauge	Gauge
	Camshaft bearings	Gauge	Gauge
ACCESSORY CASE			
	Oil pump driver and driven gear bushing diameters	0.8120	0.8130
	Oil pump drive gear shaft dia	0.8095	0.8105
	Fuel pump idler gear bushing dia	0.8120	0.8130

TABLE I. PARTS TO BE MEASURED FOR WEAR (Cont.)

Name of Part	Description of Measurement	Dimensions New	
		Minimum	Maximum
ACCESSORY CASE (cont.)			
	Fuel pump idler gear shaft dia	0.8095	0.8105
	Fuel pump drive gear bushing dia	0.8120	0.8130
	Fuel pump drive gear shaft dia	0.8095	0.8105
	Lower hydraulic pump drive front and rear bushing dia	0.9370	0.9380
	Lower hydraulic pump drive gear front and rear shaft diameters	0.9345	0.9355
	Upper tachometer drive front and rear bushing dia	0.8120	0.8130
	Upper tachometer drive gear front and rear shaft dia	0.8095	0.8105
	Magneto cluster gear front bushing diameter	1.2495	1.2505
	Magneto cluster gear front shaft diameter	1.2465	1.2475
	Magneto adapter bushing diameter	1.7495	1.7505
	Magneto cluster gear shaft diameter	1.746	1.747
	Upper hydraulic pump plug front and rear bushing dia	0.937	0.938
	Upper hydraulic pump plug diameter	0.9335	0.9350
	Propeller governor drive front and rear bushing dia	0.937	0.938
	Propeller governor drive gear front and rear shaft dia	0.9345	0.9355
	Generator adapter bushing diameter		
	Generator drive gear shaft diameter	1.1215	1.1225
	Tachometer drive shaft diameter	0.8095	0.8105
OIL PUMP			
	Drive and driven gear shaft diameters	0.8095	0.8105
	Pump body bushing diameters	0.8120	0.8130

5-7. INSPECTION OF NONFERROUS CASTINGS.

5-8. Visually inspect machined surfaces for indentations and nicks, cracks and damaged or backed out studs. Old cracks may or may not be visible; therefore inspection of castings should be made after they have been thoroughly cleaned. New cracks may be detected by inspecting with fluorescent penetrant (trade name "Zyglo") equipment and method, as described in AMC Manual 74-4. Look for cracks particularly around studs, cylinder mount pads in crankcase castings, shaft bearing seats, gear bearing bosses, flange fillets and stud and bolt holes in mount flanges. Make sure that all oil passages drilled in crankcase and accessory case castings are clear.

5-9. MAGNETIC PARTICLE INSPECTION.

5-10. Stressed steel parts listed in Table III shall be inspected for fatigue cracks by the "Magnaflux" process indicated. All parts must be clean and free of carbon, oil and oil varnish deposits before inspection. The crankshaft journals, camshaft, rocker shaft and piston pins must be polished smooth before being magnetized. In the wet continuous process, Red magnaflux paste No. 9 is used in a mineral spirit vehicle. The suspension is maintained at a ratio of 1 to 1-1/2 ounces of paste to 1 gallon of liquid. Springs will not be inspected by the magnetic process.

NOTE

All parts shall be checked carefully for other indications such as grinding cracks, forging lips and seams. If the crankshaft is suspected of any defect it shall be demagnetized and magnetized longitudinally for further inspection.

CAUTION

All small openings, such as oil holes, leading to inaccessible cavities must be plugged with hard wood, fiber plugs, hard grease or a similar nonabrasive material which is readily soluble in engine lubricating oil before magnetization to prevent the accumulation of magnetic particles where they cannot be removed readily by washing and air blasting.

5-11. Demagnetize all parts after inspection and between successive magnetic operations. Parts which are irregular, and therefore difficult to demagnetize should be withdrawn from the coil at a rate of not over 12 feet a minute. The magnetic substance must be removed completely from all parts after inspection. Remove all plugs from small holes, and inspect for cleanliness of all visible surfaces. After cleaning, slush serviceable parts in the corrosion preventive compound specified in paragraph 5-13.

TABLE II. INSPECTION CHART

Subassembly and Part	Inspect	Nature of Inspection	Special Considerations
CYLINDER ASSEMBLY Head and Barrel	Interior walls	Corrosion, pitting, scoring	Defects not permissible after removal of glaze.
	Bore diameters	Wear in ring traversed area and step at top. Use dial-type gauge set to zero near open end of bore	Refer to Section X, Ref. No. 1 and 2 for standard size bore.
		After honing or roughening of glaze measure bore diameters, out-of-roundness and taper	Dimensional honing should remove ring step of more than 0.002 on diameter. Choke limit (Refer to Section X) must not be exceeded by honing.
			Wear and honing may increase bore diameter by 0.005 in. over standard, but only 0.002 in. over reground oversize.
	Bore walls	After roughening or honing, inspect scratch pattern (figure 5-4) and, if possible, measure surface roughness in micro inches rms of 10% of cylinders as a quality check. Surface roughness must be between 30-40 micro inches rms	
	Stem holes in valve guides	Scoring, diameter, flare at ends. Gauge for wear	Diameters of stem holes in new guides must be within limits for new parts and free of tool marks.
	Valve seats	Roughness caused by burning	If seats cannot be made serviceable by grinding within width limits, refer to paragraph 5-28 for replacement instructions.
	Cooling fins	Cracks and broken areas	Allow not over 10% reduction of head fin area.
	Base flange	If attaching nuts were found loose at disassembly, test for flatness of mounting face	Allow not over 0.001 in. out-of-flat on machined surface.
	Pilot	Out-of-roundness of pilot below face flange	
	Spark plug and Helical Coil inserts	Distortion or improper fit in cylinder head hole	
Valves	Stems	Scoring, nicks in key grooves, wear on tips	Polishing must not reduce diameter below minimum for new parts.

TABLE II. INSPECTION CHART (Cont.)

Subassembly and Part	Inspect	Nature of Inspection	Special Considerations
CYLINDER ASSEMBLY (Cont.)			
Valves (cont.)	Heads	Use dial indicator on heads to determine warp. Make sure that grinding has not cut through Stellite face of exhaust valve or entered edge round on intake valve head	Refer to T.O. 2R-1-18 for etching test for Stellite.
	Length	Use height gauge to detect stretch and check for reduction due to tip grinding	Stretched valves may fail. Shortened valve may exceed ability of hydraulic lifters to take up lash.
Valve rockers	Contact foot	Scoring	
	Bushing	Scoring, diameter	
	Oil passages	Obstructions	
Rocker shaft	Outside surface	Diameter, scoring, rough ends	
PISTON			
	Diameters	Measure below third ring groove and at bottom of skirt	Measure at right angles to pin bore. Refer to Section X, Ref. No. 19 and 20.
	Contact areas	Scores across full width of contact area	Allow short, light scores without repair.
	Head	Severe peening or numerous deep nicks	Reject part if battered or if nicks are too numerous or deep to be burnished out.
	Pin bore	Diameter, scoring	
	Ring grooves	Damage to fillets at bottom corners of grooves. Check for distortion of lands by installing new rings and measuring side clearances with standard thickness gauge. Leave new rings in place if clearances are satisfactory	Before installing new rings, check gaps in cylinder bore at level of base flange. If bore is 0.005 in. over standard size install 0.005 in. oversize rings in standard pistons. Do not attempt to correct distortion of lands by machining grooves.
CONNECTING ROD ASSEMBLY			
Bushing	Inside diameter	Measure with telescoping gauge and micrometer caliper	New bushings must be reamed within diameter limits for new parts. Sharp edges must be broken slightly. Refer to Section X, Ref. No. 28 for wear limit. Refer to Table I for new bushing limits. Refer to Section X, Ref. No. 31 for new bushing alignment limits.
CRANKSHAFT ASSEMBLY			
Crankshaft	Main journals	Diameters, scoring, burning	Must be polished before magnetic inspection. (Refer to paragraph 5-40 for crankshaft regrinding.)

TABLE II. INSPECTION CHART (Cont.)

Subassembly and Part	Inspect	Nature of Inspection	Special Considerations
CRANKSHAFT ASSEMBLY (Cont.) Crankshaft (cont.)	Crankpins	Diameters, scoring, burning	Must be polished before magnetic inspection.
	Oil seal race	Scoring	Must be polished.
	Dimensions	Refer to Table I	
	Run-out at center journals and on front end	Mount front and rear main journals in V-blocks on surface plate. Measure run-out at two center journals and at front end	Refer to Section X, for allowable eccentricity. This check is of importance only if shaft may have been subject to a shock.
	Damper pins and bushings in shaft and counterweights	Visual for scuffing and scoring. If apparently worn measure hole diameters and pin diameters	
	Oil seal race	Scoring and wear. After repair inspect for good polish	Any roughness will quickly destroy new oil seal. Deep scores may cause shaft to fail.
	Gear attaching screw holes	Visual and by inserting screw. Test for interference	
	Cleanliness	After magnetic particle inspection, check oil tubes and recesses for removal of plugs and presence of particles. Test for complete demagnetization	
CAMSHAFT	Journals	Dimensions and surface finish	If excessively worn or loose in bearings, check Air Force policy regarding factory reboring of bearings for oversize shaft.
	Cam lobes	Visual for pitting, scoring Mount between bench centers Measure lift with dial indicator set to zero on each journal. Slide indicator parallel to axis and check for run-out of center journals	
CRANKCASE	Surfaces	Inspect valve lifter guides and camshaft bearings visually for scoring and imbedded particles. Inspect all areas for cracks and pockets for removal of sludge	Look for cracks especially around bosses and cylinder pads. NOTE If camshaft bearings are excessively worn or rough, before discarding castings check Air Force policy regarding factory reboring for oversize camshaft.

TABLE II. INSPECTION CHART (Cont.)

Subassembly and Part	Inspect	Nature of Inspection	Special Considerations
CRANKCASE (Cont.)			
	Surfaces (cont.)	Inspect tapped holes and helical coil thread inserts for thread form	
	Studs	Look for studs with damaged threads, bent studs and studs partially backed out	If any cylinder attaching nuts were reported loose at disassembly, all studs and through bolts at that pad must be replaced.
	Dimensions	For cam bearing gauge, refer to Section III, Tool group 1	
	Mounting brackets	Check machined surfaces for cracks, flatness. Inspect oil pressure relief passages for cleanliness	
ACCESSORY CASE			
	Surfaces	Inspect front and rear half castings visually for cracks, flatness and smoothness of parting flanges	Look for scored or roughened oil seal counterbores.
	Bushings	Inspect bushings for tightness and smoothness	NOTE Before discarding accessory case because of worn or loose bushings check Air Force policy regarding returning assembly to the factory for replacement and machining bushings.
	Oil filler spout assembly	Inspect for crushing, bending looseness of neck and inoperative cap locking device	Check for warped parting flange and cracked casting.
	Studs	Look for damaged stud threads, bent or elongated studs	
	Oil passages	Check for removal of sludge and other foreign matter	
	Gears	Inspect teeth for cracks, chipping, pitting and visably worn profiles. Check gear shafts for cracks, scores, pitting and visible wear	Check that oil plugs in gears are tight.
	Adapters	Inspect oil holes and grooves for cleanliness. Tightness and smoothness of bushing bores. Stud condition, and oil seal counterbores	
	Tapped holes	Inspect pipe tapped holes for damaged threads, excessive enlargement and cracks in surrounding metal	

TABLE II. INSPECTION CHART (Cont.)

Subassembly and Part	Inspect	Nature of Inspection	Special Considerations
OIL PUMP	Oil filter assembly	Inspect for holes, broken mesh, foreign deposits, deformation, flange and thread condition	
	Gears	Inspect teeth for cracks, chipping, pitting and wear. If one gear requires replacement both should be replaced	
	Body	Look for scoring in gear chamber. Check bushing for smoothness and tightness. Compare measured valve of bushings with gear shaft diameters. Check relief valve plunger for scoring and other damage	Scored housings and gears not serviceable or repairable; indicate excessive wear or scoring on other parts.
	Relief valve springs	Measure relief valve spring strength and length. (Refer to Section X, Ref. No. 121)	

TABLE III. MAGNETIC INSPECTION DATA

Part Name	Method Of Magnetization	Amps.	Method Of Inspection	Possible Defects And Critical Areas
CRANKSHAFT	Circular	2500	Wet Continuous	All Journals—Fatigue cracks. Fillets and oil holes, No. 1 main journal and No. 1 and 2 crankpins—Fatigue cracks. Thrust flanges at front journal—Heat cracks.
CONNECTING ROD	Circular	1800	Wet Continuous	All areas—Fatigue cracks, opened inclusions.
CAMSHAFT	Circular	1500	Wet Continuous	All areas—Fatigue cracks.
PISTON PIN	Circular	1800	Wet Residual	Shear planes, ends—Fatigue cracks. All areas—Stringers.
ROCKER ARMS	Circular	1800	Wet Continuous	Valve contact face—Fatigue cracks. (Intake rocker only-squirt nozzle).
CAMSHAFT GEAR	Circular	1800	Wet Continuous	Teeth—Fatigue cracks. Square hole—Fatigue cracks.
ACCESSORY DRIVE GEAR	Circular	1800	Wet Continuous	Teeth—Fatigue cracks. Eccentric—Heat cracks. Screw holes—Fatigue cracks.

TABLE IV. REPAIR CHART

Assembly or Part	References	Repair Operations	Repair Inspection
CYLINDER AND HEAD ASSEMBLY		Roughen or hone bore. (Refer to paragraph 5-27.)	Scratch pattern (figure 5-4)
		Remove or refinish valve seats. (Refer to paragraphs 5-28, 5-30 and 5-31.)	Determine if roughness in counterbore requires boring for oversize seats.
		Remove worn valve guides. (Refer to paragraph 5-29.)	Determine if roughness in hole requires boring for oversize guide.
		Bore head hole for proper interference fit of oversize valve guide. (Refer to paragraph 5-29.)	
		Install replacement valve guide.	Tapered end exposed, flange seated.
		Bore or ream stem hole in new valve guide.	Diameter and surface roughness. (Refer to Table I.)
		Straighten any bent barrel fins.	Inspect for possible cracks.
		Replace damaged spark plug hole insert. (Refer to paragraph 5-32.)	Check size by screwing in new spark plug.
		Smooth edges of broken head fins with file. Drill "V" notch to stop radial cracks in head fin.	Only 10% of total fin area may be removed.
	Figure 5-8	Install repair bushings in worn rocker shaft support bosses. (Refer to paragraph 5-33.)	Diameters, alignment. Check that axis of bushed holes is not over 0.001 in. out-of-square with valve guides or out-of-parallel with line of valve guide centers.
Intake and Exhaust Valves		Reface. (Refer to paragraph 5-30.)	Excessive cutting. (Refer to T.O. 2R-1-18 for etch test.)
		Grind worn stem tips smooth and square with axis.	Refer to Section X, Ref No. 17 and 18.
		Lap to refinished seats. (Refer to paragraph 5-31.)	Line contact only at outer edge.
Pistons		Refer to paragraph 5-34.	Install and measure gaps and side clearances of new rings. Refer to "Ring" grooves under "Pistons", Table I.
Connecting Rod	Figure 5-9 Figure 5-10	Replace worn bushings. (Refer to paragraph 5-36.)	Bushing bore diameter, alignment and spacing. (Refer to paragraph 5-38.) If any rod is replaced, weigh each rod in set for engine. Weight variation must not exceed 1/4 ounce.

TABLE IV. REPAIR CHART (Cont.)

Assembly or Part	References	Repair Operations	Repair Inspection
CRANKSHAFT ASSEMBLY		Polish main journals, crankpins and oil seal race (before magnetic particle inspection). Refer to paragraph 5-40 for crankshaft regrinding.	
	Figure 5-11	Replace damaged starter jaw stud. (Refer to paragraph 5-41.)	
	Figure 5-12	Replace worn damper pin bushings in shaft and counterweights (Refer to paragraph 5-42.)	
CRANKCASE ASSEMBLY	Figure 5-2	Replace damaged studs. (Refer to paragraphs 5-14 through 5-17.) If stud hole is stripped or maximum oversize, repair with helical coil insert; then install new standard size. (Refer to paragraphs 5-14 through 5-17.)	
ACCESSORY CASE ASSEMBLY	Figure 5-3	Replace damaged studs. (Refer to paragraphs 5-14 through 5-17.)	
		Repair damaged screw or stud hole with helical coil thread insert. (Refer to paragraphs 5-18 through 5-25.)	
		Replace damaged or loose oil filler neck. (Refer to paragraph 5-44.)	
		Smooth any scores in oil seal counterbores with crocus cloth. Stone nicks on machined parting surfaces or accessory mount pads.	
		Replace broken or deformed oil filler neck spring clips. (Refer to paragraph 5-45.)	

5-12. CORROSION PREVENTION.

5-13. All steel parts which are not protected by an enamel coat or cadmium plating must be dipped in fingerprint remover compound, Specification MIL-C-15074, immediately after handling in order to neutralize acids present in certain skin oils and perspiration. After draining, coat the parts with ready mixed corrosion-preventive compound, Specification MIL-C-6529, Type II, or a blend of one part Type I concentrate and three parts engine lubricating oil, Specification MIL-L-6082, grade 1100.

CAUTION

Failure to neutralize acids deposited by fingerprints after handling dry parts in inspection and repair operations will allow etching action to proceed and deteriorate surface finish, even under a film of corrosion preventive compound.

5-14. STUD REPLACEMENT.

5-15. AVAILABLE OVERSIZES. As indicated in Table V, all studs supplied by the engine manufacturer under

TABLE V. IDENTIFYING FEATURES OF STANDARD AND OVERSIZE STUDS

Typical Part No.	Oversize on Pitch Dia of Coarse Thread (inches)	Optional Identification Marks on Coarse Thread End		Identification Color Code
		Stamped	Machined	
XXXXXX	Standard	None		NONE
XXXXXXP003	.003			RED
XXXXXXP006	.006			BLUE
XXXXXXP009	.009			GREEN
XXXXXXP007	.007			BLUE
XXXXXXP012	.012			GREEN

his part number are available with coarse threads made oversize on the pitch diameter. Each standard size stud part number may be suffixed by only three oversize designations, namely P003, P006 and P009 or P003, P007 and P012, depending on the part number. The latter series is used with standard stud part numbers in the range between 400000 and 500000. Refer to the Illustrated Parts Breakdown, T.O. 2R-0470-24 for available oversizes of each standard size stud, according to part number. It will be observed in the table that the P003, P006 and P009 oversizes may be identified by either of two kinds of mark on the coarse thread ends, while the P007 and P012 oversizes have only one type of identification. All oversizes of recent manufacture are further identified by dipping in an alcohol soluble dye, as indicated in the last column of Table V. The dye permits ready location of replaced studs for inspection purposes.

5-16. REMOVAL OF DAMAGED STUDS. Unscrew slowly with a standard type of stud extractor to prevent heating casting metal and tearing the tapped hole threads. Immediately after removal, examine the damaged stud to determine whether it is a standard size or one of the oversizes. Usually the next larger oversize will be required for replacement. Clean the vacated hole thoroughly with solvent, and blow out with dry compressed air.

5-17. STUD INSTALLATION. First try the oversize next larger than the stud removed from the same hole.

TABLE VI. CRANKCASE STUD DATA

Fig. No.	Index No.	Location	Thread Size	Total Qty.	Setting Height (inches)
5-2	1	Cylinder pads	7/16	36	0.87
5-2	2	Front mount bracket pads	3/8	8	1.12
5-2	3	Pushrod housing flange pads	1/4	18	0.69
5-2	4	Rear mount bracket pads	5/16	4	0.91
5-2	5	Rear parting flange	5/16	2	3.62
5-2	6	Rear parting flange	5/16	3	2.69
5-2	7	Rear parting flange	1/4	2	0.56
5-2	8	Oil sump mount pads	5/16	6	0.56

If this can be screwed in with less than the minimum installation torque specified in Section X try the next larger oversize. The maximum specified installation torque must not be exceeded as the stud approaches the setting height specified in Table VI, VII, VIII as applicable. Before installing a stud in a blind hole, coat the coarse threads with a film of anti-seize compound, Specification MIL-T-5544. If the stud is to be installed in a hole entering an interior engine cavity, use an oil resistant sealing compound, such as National Machine Products Co. Oil Seal Compound, Air Force Stock No. 8411-1288405. Use tee-handle-type stud drivers to install all new studs, and take care to avoid driving too deep, since backing out to specified setting height is not permissible.

NOTE

If any cylinder base attaching stud in crankcase must be replaced because of breakage, it will be necessary to replace all six studs in that same cylinder pad and the two through bolts originally installed there, because such breakage indicates that looseness existed and may have fatigued the remaining studs and through bolts, creating the danger of failure if they are used in rebuilt packettes. In this event the parting surface of the base flange of the cylinder previously mounted on that pad should be tested for bending and, if bent, the cylinder must be discarded.

5-18. HELICAL COIL THREAD INSERTS.

5-19. DESCRIPTION AND PURPOSE. Helical coil inserts are stainless steel screw thread bushings made from diamond-shaped cross section wire. Since wire forms male and female threads back-to-back, this method of repair involves a minimum removal of metal to repair a stripped or torn screw or stud hole. When installed, the interior surface of the insert has the exact size and shape of an original tapped hole, and will accept a standard size stud or screw. The entering end of each insert is bent inward, diametrically, to form a driving tang. Some types are notched near the tang to facilitate its removal, after the insert is installed. Aluminum alloy castings require lengths of 1-1/2 diameters and magnesium 2 diameters, to provide shear strength equal to the original metal.

NOTE

Helical coil inserts (as manufactured by Heli-Coil Corp., Danbury, Connecticut) are approved by the engine manufacturer for repair of all tapped holes in castings, with the exception of those in which cylinder attaching studs are installed.

5-20. DRILLING. Use a drill press and a twist drill of nominal screw or stud diameter to remove stripped

TABLE VII. ACCESSORY CASE STUD DATA

Fig. No.	Index No.	Location	Thread Size	Total Qty.	Setting Height (inches)
	ACCESSORY CASE REAR HALF				
5-3	1	Propeller governor pad	5/16	4	1.38
5-3	2	Tachometer drive pads	1/4	8	0.75
5-3	3	Magneto adapter pads	1/4	4	0.75
5-3	4	Magneto adapter pads	5/16	4	2.57
5-3	5	Front parting flange	5/16	2	1.22
5-3	6	Starter adapter pad	1/4	2	0.75
5-3	7	Starter adapter pad	3/8	6	2.55
5-3	8	Lower hydraulic pump pad*	1/4	4	0.88
5-3	9	Oil pump pad	5/16	6	0.94
5-3	10	Fuel pump pad	5/16	4	0.906
5-3	11	Oil filler spout pad	1/4	2	0.700
	ACCESSORY CASE FRONT HALF				
5-3	12	Upper hydraulic pump pad	5/16	4	0.906
5-3	13	Rear parting flange	5/16	1	1.81
5-3	14	Rear parting flange	5/16	2	2.06
5-3	15	Rear parting flange	5/16	13	1.19
5-3	16	Generator adapter pad	3/8	5	2.18
5-3	17	Generator adapter pad	1/4	2	0.75
5-3	18	Rear parting flange	5/16	1	2.12
	GENERATOR ADAPTER ASSEMBLY				
		Generator mount pad	3/8	1	1.02

* Vacuum pump mounted in this installation.

TABLE VIII. MISCELLANEOUS STUD DATA

Location	Thread Size	Total Qty	Setting Height (inches)
CYLINDER HEAD			
Exhaust pipe flange	5/16	12	0.78
INTAKE AND OIL DRAIN MANIFOLD			
Carburetor mount pad	5/16	4	0.87

or torn threads. For a blind hole, minimum tap drill depth equals the minimum length of assembled insert plus six times thread pitch, when standard plug taps are used. When casting thickness will not permit the above tap drill depth for standard plug taps, bottoming taps may be used which will allow the tap drill depth to be decreased by three times thread pitch. When drilling aluminum or magnesium, lubricate the drill with a mixture of one part lard oil, Federal Specification C-O-376 and two parts kerosene, Federal Specification VV-K-211. After drilling, countersink hole with 45-degree countersink to a diameter equal to maximum diameter of finishing tap or very slightly larger.

NOTE

Special bottoming taps are supplied by the insert manufacturer (Heli-Coil Corp., Danbury, Connecticut) for retapping blind holes which are of minimum depth.

5-21. TAPPING. After drilling out the damaged hole, use the proper roughing tap listed in Table IX then the corresponding finishing tap to cut threads for the thread insert. Always run the roughing tap into the hole first, leaving a small amount of stock to be removed with finishing tap. This is particularly important in lightweight metals. For tapping these use the same lubricant specified in paragraph 5-20 for drilling. Table IX lists only the tapered taps for use in through holes and those providing adequate depth below the threaded portion. Special bottoming taps may be obtained from Heli-Coil Corporation for use when the hole is not deep enough to clear a tapered tap run in far enough to cut full threads for an insert of the necessary length.

5-22. GAUGING. After finish tapping for a thread insert, blow out all liquid and chips with dry compressed air, and inspect the threads visually for cleanliness and form; then, if apparently satisfactory, screw in the appropriate "Heli-Coil" thread plug gauge listed in Table IX. The "GO" end is screwed into the hole first. It must enter until the shoulder is flush with the machined surface of the casting. If it does not, discard the worn tap, and retap the hole with a new tap. Particularly when using a new tap, check for possible overcutting by screwing in the "NO GO" thread plug end of the gauge. If this end enters the hole more than 1/2 turn the tap is cutting oversize. This may be corrected as the tap wears slightly, but it will require an oversize stud for proper tight fit or will produce an excessively loose fit with a normal screw.

TABLE IX. HELICAL COIL THREAD INSERTS AND TOOLS

Size	Length	PART NUMBER		TAPS		Thread Plug Gauges	Inserting Tools (Pre-winding Type)	Extractors
		Heli-Coil Corp.	Military Standard	Roughing	Finishing			
10-24	9/32	1185-3CNx.285	MS122120	*186-3	†7900-757070	*188-3	†7900-273987-2	†7900-278510
10-24	3/8	1185-3CNx.380	MS122160					
1/4-20	3/8	1185-4CNx3/8	MS122121	*186-4	†7900-757090	*188-4	†7900-273987-6	†7900-278510
1/4-20	1/2	1185-4CNx1/2	MS122161					
5/16-18	15/32	1185-5CNx15/32	MS122122	*186-5	†7900-757110	*188-5	†7900-273988-5	†7900-278510
5/16-18	5/8	1185-5CNx5/8	MS122162					
3/8-16	9/16	1185-6CNx9/16	MS122123	*186-6	†7900-757130	*188-6	†7900-273988-4	†7900-278510
3/8-16	3/4	1185-6CNx3/4	MS122163					
7/16-14	21/32	1185-7CNx21/32	MS122124	*186-7	†7900-757150	*188-7	†7900-273988-8	†7900-278515
7/16-14	7/8	1185-7CNx7/8	MS122164					
1/2-13	3/4	1185-8CNx3/4	MS122125	*186-8	*186-7	*188-8	*528-8N	†7900-278515
1/2-13	1	1185-8CNx 1	MS122165					
18 mm	11/32 (special)	C2-25		*2-22	†7900-759915	†7900-373980	†7900-373989-4	†7900-278515

* Heli-Coil Corporation tool numbers
† Air Force stock numbers

5-23. INSTALLATION OF THREAD INSERTS. Four types of installing tool are supplied by the insert manufacturer. The simplest kind is a slotted mandrel with a T-handle. The slotted end is inserted through the insert from the open end until the slot fits over the driving tang of the insert, which is then screwed into the retapped hole with the T-handle. Another type of tool is similar but has an additional collar for holding and guiding the mandrel. The prewinding type installing tools listed in Table IX have a sliding sleeve on the mandrel which is cut out on one side and threaded at one end. The insert is dropped into the side opening with driving tang facing threaded end; then the mandrel is advanced through the insert and the mandrel crank turned to screw the insert into the sleeve threads, compressing it to facilitate screwing into the casting hole. The sleeve is then held against the casting and the crank turned to advance the insert into the retapped hole. Production inserting tools for use in drill presses are intended for large quantity manufacturing operations and will not be described herein, though their operation is similar to that of the hand-powered prewinding type tools. The procedure for replacement of a spark plug hole insert is slightly different and is described in paragraph 5-32. Drive all other thread inserts into the casting until the outer end lies in the first full thread of the tapped hole.

5-24. INSPECTION. After installation of a new thread insert the pitch diameter of the female threads thus formed may be checked by screwing in the proper size of National Coarse Thread plug gauge, class 3 or 3B if the hole is for a screw, or class 4 if for a stud.

5-25. REMOVAL. Damaged thread inserts may be removed with an extractor tool of appropriate size, as listed in Table IX by tapping the sharp edges of the squared and tapered end into the wire so as to get a good "bite", then turning the tool to the left to unscrew the helix. (Refer to paragraph 5-32 for special procedure required to remove spark plug hole inserts.)

5-26. CYLINDER ASSEMBLY.

5-27. CYLINDER BORE REPAIR. If dimensional inspection indicated acceptable bore diameter, choke and roundness, and if step at top of piston ring travel does not exceed 0.002 inch, honing will not be necessary, and cylinder walls may be roughened to remove glaze by rubbing with aluminum oxide cloth, Federal Specification P-C-451, grit No. 100. Strokes must run at an angle to open cylinder end in both directions to form pattern illustrated in Figure 5-4 not parallel to either end or axis, in order to provide adequate ring support. This operation will produce channels for lubricating oil and will assist in wearing in new piston rings. Do not abrade walls more than enough to break up glaze. It is neither desirable nor necessary to remove entire surface. If step at top of ring travel exceeds 0.002 inch or if bore is excessively out-of-round, it may be possible to restore circularity and remove step by dimensional honing, as described in T.O. 2R-1-17, and yet keep parallel bore less than 0.005 inch oversize. If so, then standard piston rings may be used after such dimensional honing, which will also produce required scratch pattern and surface roughness. If it becomes necessary to hone to 0.005 inch oversize it will be necessary to use 0.005 inch oversize piston rings, or if bore was already of this diameter it will be permissible to enlarge slightly more by honing, provided that gaps of new 0.005 inch oversize rings in the refinished bore do not exceed specified limits. (Refer to Section X, Ref. No. 23 and 24 "Replace. Maximum" limits.) Further oversizing of bores must be accomplished by regrinding to oversize dimensions shown in table in figure 5-1. (Refer to Section X, for allowable oversize.) This operation must allow for dimensional honing (for proper bore choke, surface pattern and roughness) approximately 0.0005 in. to 0.001 in. on diameter. A cam controlled grinder is required. Honing must be accomplished with correct ratio of rotary speed to stroke (and without dwell) to produce scratch pattern specified in figure 5-4. For surface roughness limits of honed finish refer to figure 5-1.

5-28. VALVE SEAT REPLACEMENT. When regrinding has increased width of valve seats beyond limits specified in Table of Limits, they may be replaced with oversize seat inserts, which are available in sizes 0.005, 0.010, 0.015, 0.020 and 0.030 inch larger on the outside diameter than standard inserts. Cylinder head counterbores must be bored out to a size smaller than insert to be installed by the amount of interference (tight) fit specified in Ref No. 3 and 4, Section X. The sizes of counterbore and insert must be measured at room temperature. No special tools have been procured for boring cylinder head counterbores. Procedure and tools to be employed for replacement of inserts are as follows:

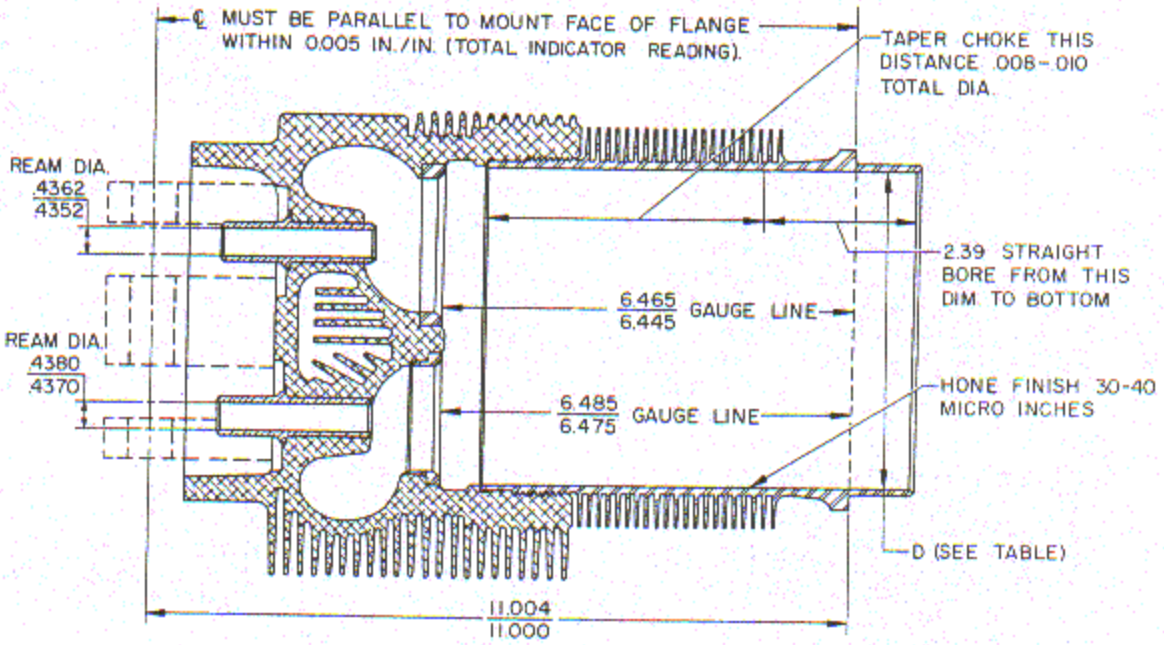
a. Place cylinder and head assembly in an oven and heat to a temperature of 301°C (575°F). Do not allow cylinder to remain in oven more than one hour.

b. Remove cylinder from oven and place it upright on cylinder and valve holding fixture, tool group 3, with valve holder removed. Support fixture so that valve seat removing tool may be inserted through opening in base. (See figure 5-5.)

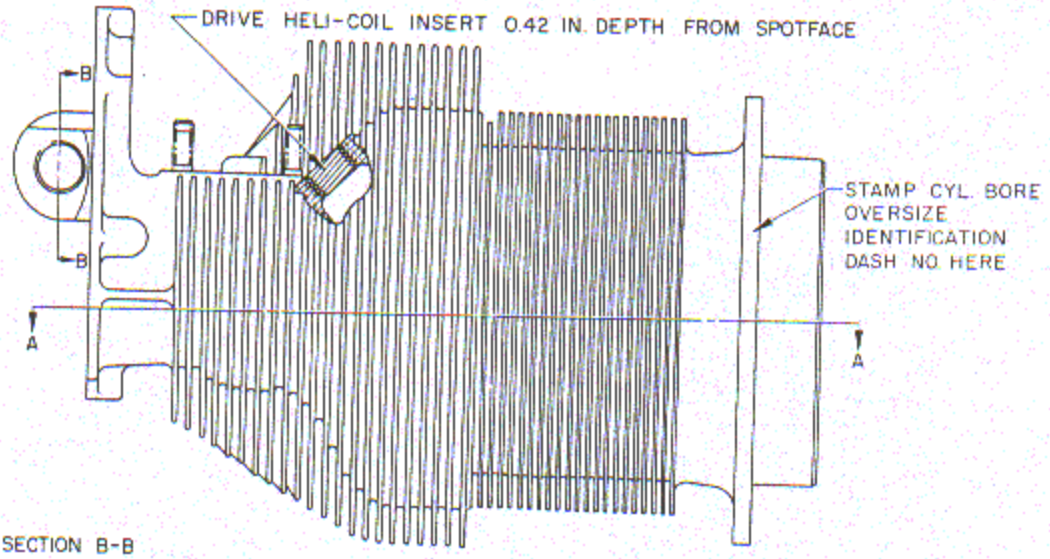
c. Insert correct valve seat remover, tool group 11 or 14, through open bottom of fixture and align remover pilot with guide stem hole. Push pilot through guide until magnet draws tool to insert.

d Rubber syringe should be filled with cool water while cylinder is being heated and should be ready for immediate use. Insert syringe tube into water hole in remover pilot end, and force a small, quick stream of water through radial holes above magnet to shrink insert. If weight of tool does not pull insert from its counterbore apply a slight force by hand without pulling magnet from seat.

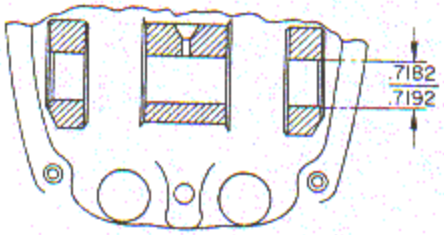
e. If first attempts result in only partial removal of insert reheat cylinder and repeat removal procedure. If insert can be moved enough to provide a gap above it, a positive, expanding puller may be used.



SECTION A-A



SECTION B-B



	"D" DIAMETER (INCHES)		
	MINIMUM	MAXIMUM	WORN PART MAXIMUM
STANDARD	5.001	5.003	5.006
OVERSIZE	5.016	5.018	5.021

Figure 5-1. Cylinder Dimensions

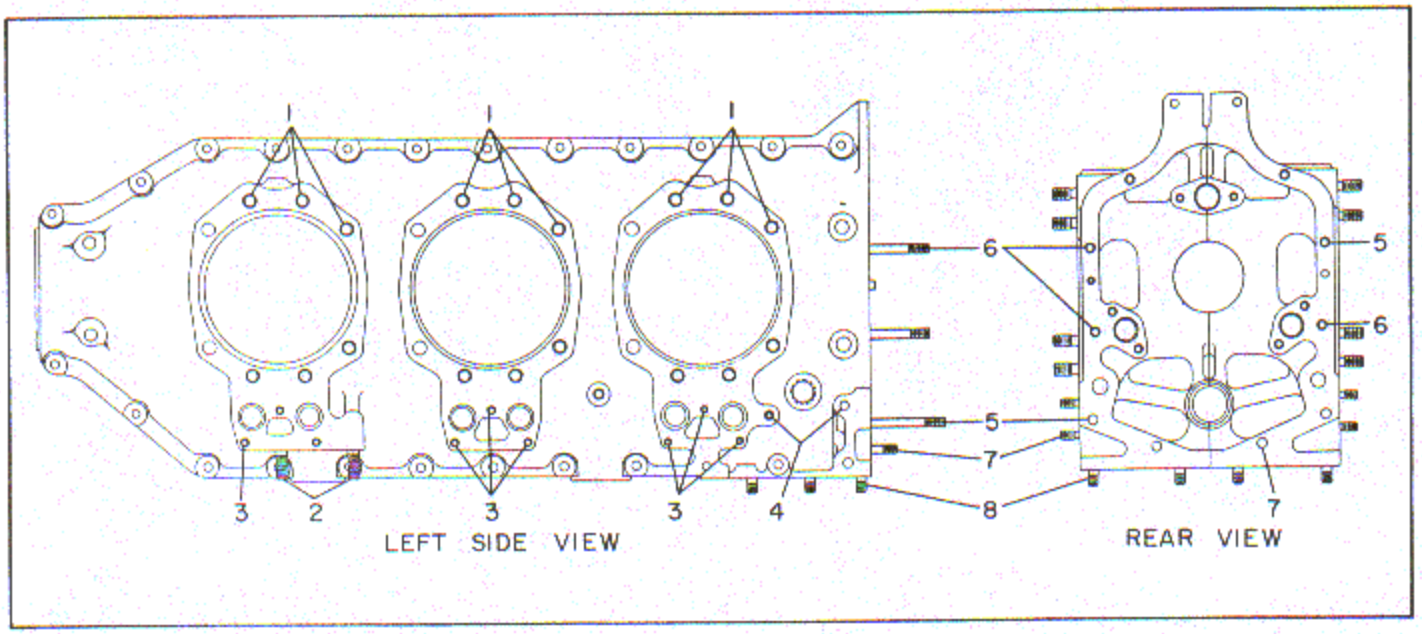


Figure 5-2. Crankcase Studs

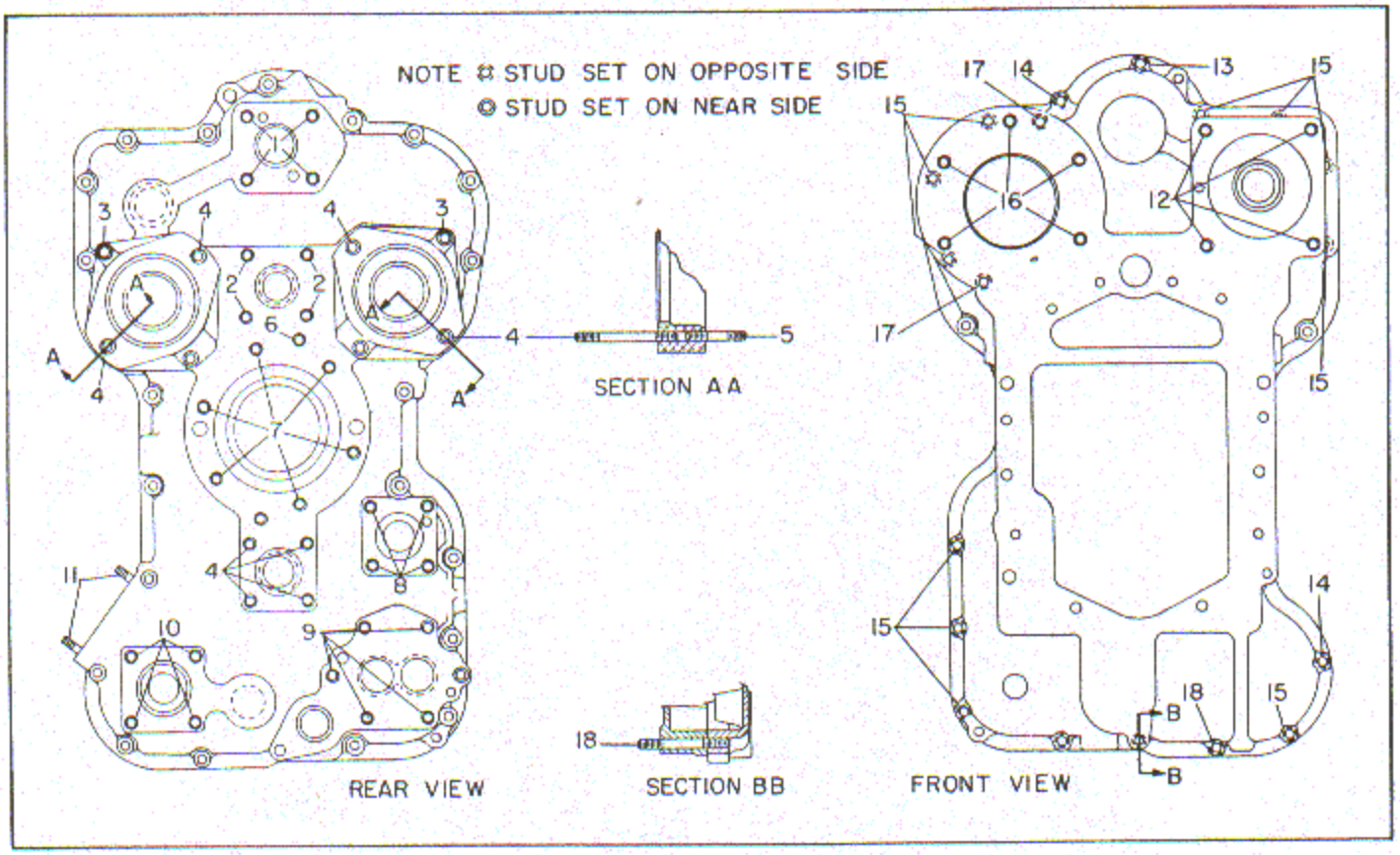


Figure 5-3. Accessory Case Studs

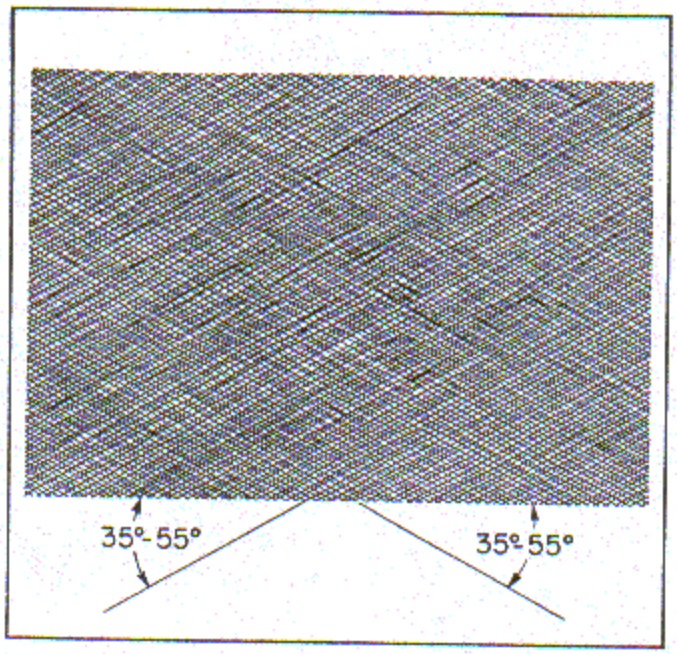


Figure 5-4. Scratch Pattern of Correctly Honed Cylinder Wall

NOTE

To avoid possible loss of magnetic strength and to assure best operation of insert removers, magnets should be cooled between successive operations. Keep faces of magnet segments clean to allow full contact with inserts.

CAUTION

Do not allow remover tool to drop. Any sharp blow on magnet may crack brittle material.

f. Clean and measure removed seat insert diameter. Compare measured value with appropriate column in Table X. Record standard or oversize designation of removed insert, since same oversize will be installed if cylinder head counterbore is undamaged. Part number of each insert is acid etched on insert face outside seat. This is formed by adding P005, P010, P015, P020, P030 to standard size part number.

g. Bore cylinder head counterbore to proper size for oversize insert to be installed, in accordance with Table X. A tolerance of 0.002 inch is allowed in counterbore diameter. While sizes within range are permissible, the smaller is to be preferred in order to secure the tightest fit consistent with safety.

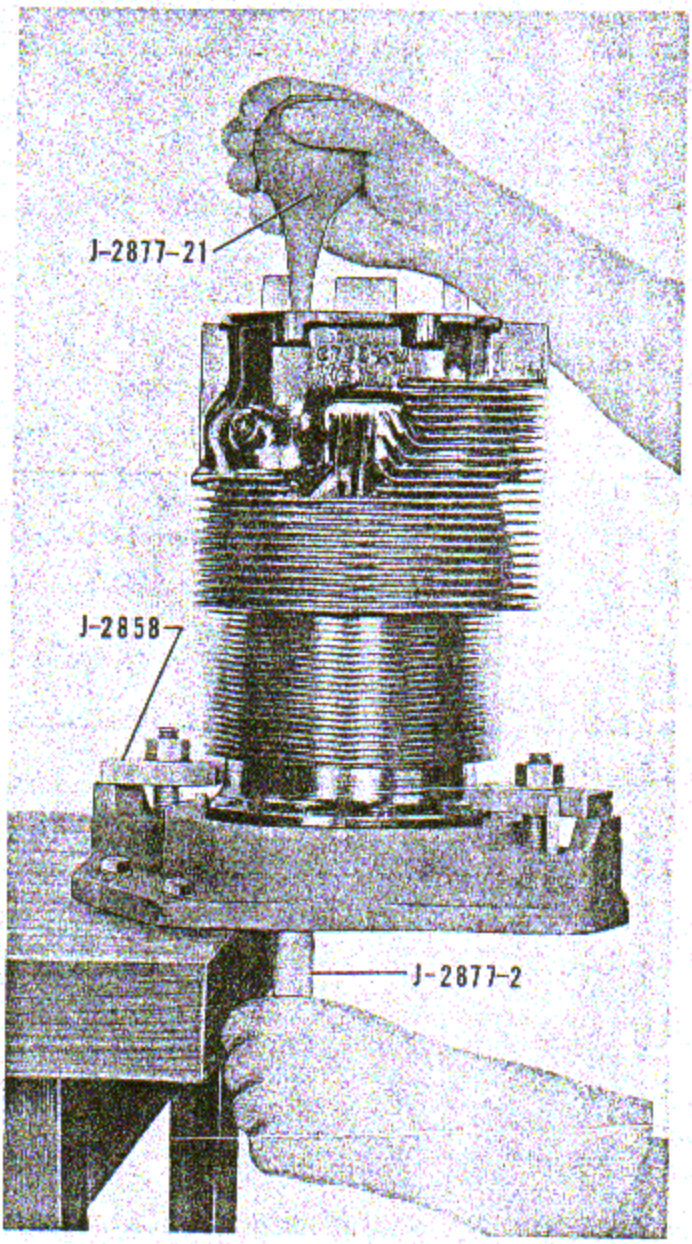


Figure 5-5. Replacing Valve Seat

TABLE X. VALVE SEAT INSERT AND COUNTERBORE DIAMETERS

Size (Inches)	Intake Valve Seat		Exhaust Valve Seat	
	Insert Dia. (Inches)	Counterbore Dia. (Inches)	Insert Dia. (Inches)	Counterbore Dia. (Inches)
Standard	2.528-2.529	2.517-2.519	1.796-1.797	1.787-1.789
0.005 OS	2.533-2.534	2.522-2.524	1.801-1.802	1.792-1.794
0.010 OS	2.538-2.539	2.527-2.529	1.806-1.807	1.797-1.799
0.015 OS	2.543-2.544	2.532-2.534	1.811-1.812	1.802-1.804
0.020 OS	2.548-2.549	2.537-2.539	1.816-1.817	1.807-1.809
0.030 OS	2.558-2.559	2.547-2.549	1.826-1.827	1.817-1.819

NOTE

The intake valve seat has a small step on the outside surface. The large diameter fits tightly in the straight counterbore of the head. The exhaust valve seat insert has a large step on the outer surface. Its smaller diameter fits tightly, while the larger end fits loosely in the stepped counterbore. Bore out only the smaller counterbore in the head.

h. Reheat cylinder and head assembly to 301.6°C (575°F), allowing time to heat throughout, but not over one hour.

i. Remove cylinder and place it in the inverted position in cylinder head holding fixture, tool group 5.

j. Place oversize seat insert on shoulder of proper valve seat replacer, tool group 11 or 14, with chamfered side against tool flange. Grip insert by depressing lever on handle.

k. Insert replacer pilot in inner end of valve guide and quickly thrust insert home. After a moment, release grip lever and rap insert sharply with tool to assure firm seating; then remove replacer.

5-29. VALVE GUIDE REPLACEMENT. Place the cylinder in the inverted position on cylinder head holding fixture, tool group 5, and install in an arbor press. Make sure the inner end of the old guide is free of carbon before attempting to press it out. Insert valve guide remover, tool group 10 into the guide stem hole and bring ram down on tool end, making sure that tool is square with guide. Press out guide from cylinder head bore. Remove cylinder from fixture and inspect guide bore for scoring. If bore is not damaged, it will be possible to make replacement with a standard size guide, provided proper tight fit can be obtained. (Refer to Ref. No. 5 and 6, Section X.) If scored head hole must be broached to clean up. (Refer to Section III, tool group 8 for broaches.) Oil inserting end of new guide before pressing in, and make sure that flange fillet goes against end of driver. Make sure that proper stem hole broach is used, since clearances of intake and exhaust valves must be slightly different. (Refer to Section III, tool groups 10 and 13 for broaches.) Use valve guide stem hole gauges, tool groups 10 and 13, to measure new guide stem holes.

5-30. GAUGING REFINISHED VALVE SEATS. Refer to Section III, tool groups 11 and 14, for valve seat blueing gauges (Refer to Table XI for gauging dimensions). Each gauge is ground to specify average seat angle and has a flat on periphery to check for maximum seat diameter. Apply oil base Prussian blue pigment to gauge, and turn it on seat to check for eccentricity and angle. Pigment should spread uniformly around refinished seats if concentric and from edge to edge if ground to correct angle. Use only a thin film of pigment to assure accuracy of test. Remove pigment from gauge, and apply to seat then turn gauge on seat, and observe if pigment spreads beyond gauge flat. If so, reduce seat with a 70 degree stone one time only.

5-31. LAPPING REFACED VALVES TO REFINISHED SEATS. An automotive type valve lapping tool with extended stem may be used to lap these valves. Such tools include a light spring which, placed under valve head, will lift it when tool is lifted after each few strokes to permit rotation of a quarter turn or so to keep lapping compound (Federal Specification SS-C-614) evenly distributed. Continue operation only until line contact (dull gray band not over 1/16 inch wide) has been established near outer edge of valve face Contact area will not touch edge of face unless seat outside diameter is too great. After lapping, clean cylinder head and valves thoroughly with solvent to remove all compound, and tag or store valve to maintain identification with specific cylinder.

5-32. REPLACEMENT OF SPARK PLUG HOLE INSERT. If inner end of insert is loose in hole or any other irregularity apparent, unlock outer end teeth by prying away from head metal with sharp, pointed tool until toothed portion is clear; then tap extractor (Table IX) into wire until sharp edges get a good "bite", and unscrew helix. (See figure 5-6.) Place tapered edges so that none presses outward on toothed area. Clean hole with solvent, and inspect for deformities in threads. If not damaged, install new insert, as described in paragraph 5-23. (See figure 5-7.) Drive to depth specified in figure 5-1. Break off driving tang by bending back and forth across hole (not in and out) with long nose pliers. Dip expanding tool (Heli-coil Corporation No. 520-2) in a mixture of white lead and oil, and run into insert with a suitable T-handle until tapered final threads force insert teeth into cylinder head metal.

5-33. ROCKER SHAFT SUPPORT BOSS REPAIR. Excessively worn rocker shaft bores in cylinder head bosses may be line reamed to dimensions specified in figure 5-8 to admit repair bushings. Use reamers, tool group 19 in ascending part number sequence to repair supports. After inspection of finished reamed bores, drive in repair bushings to positions illustrated in figure 5-8, starting with those in the center boss. Insert these two bushings, in turn, between bosses, and insert a suitable remover and replacer through outer bosses and into them. Drive center bushings in flush, as shown; then drive a bushing into each outer boss until flush with its inside surface. The bushings must not project into valve rocker spaces between them. Line ream the repair bushings for

TABLE XI. VALVE SEAT GAUGING DIMENSIONS

Insert	Gauging Depth (inches)	Gauge Diameter (inches)
Intake Valve Seat	6.455 - 6.465	2.250
Exhaust Valve Seat	6.475 - 6.485	1.781

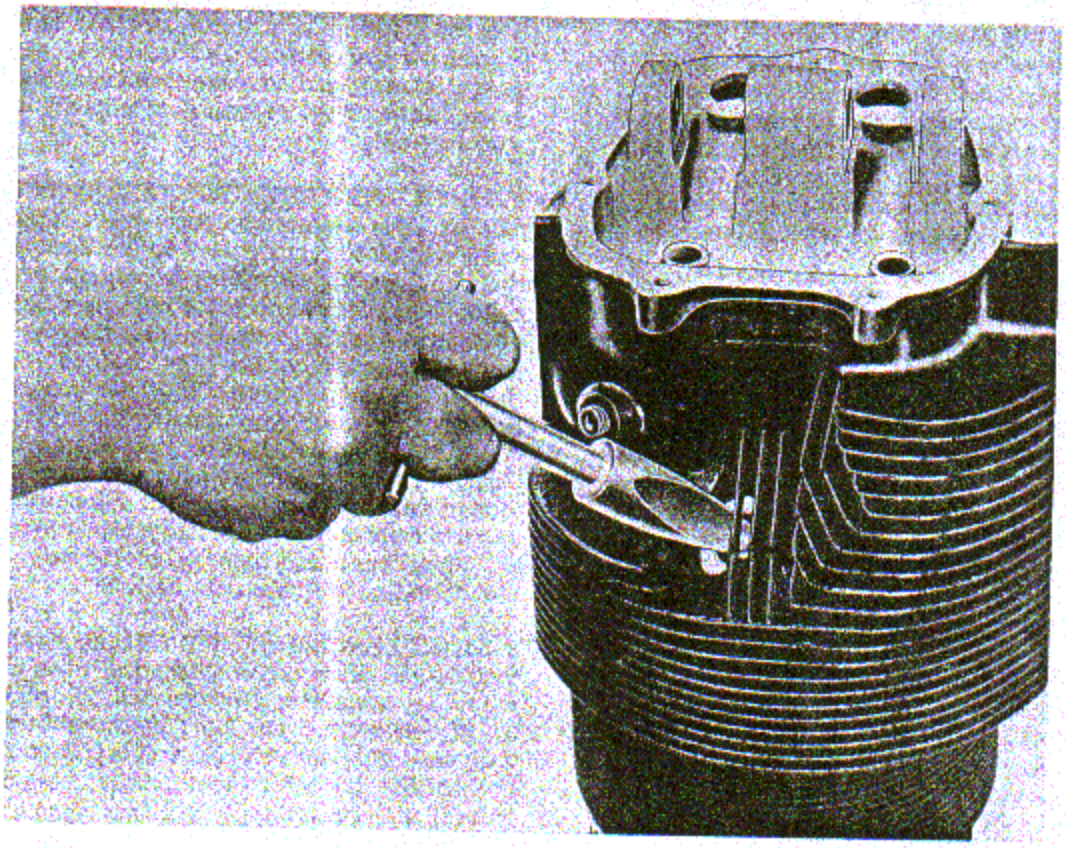


Figure 5-6. Removing Spark Plug Heli-Coil

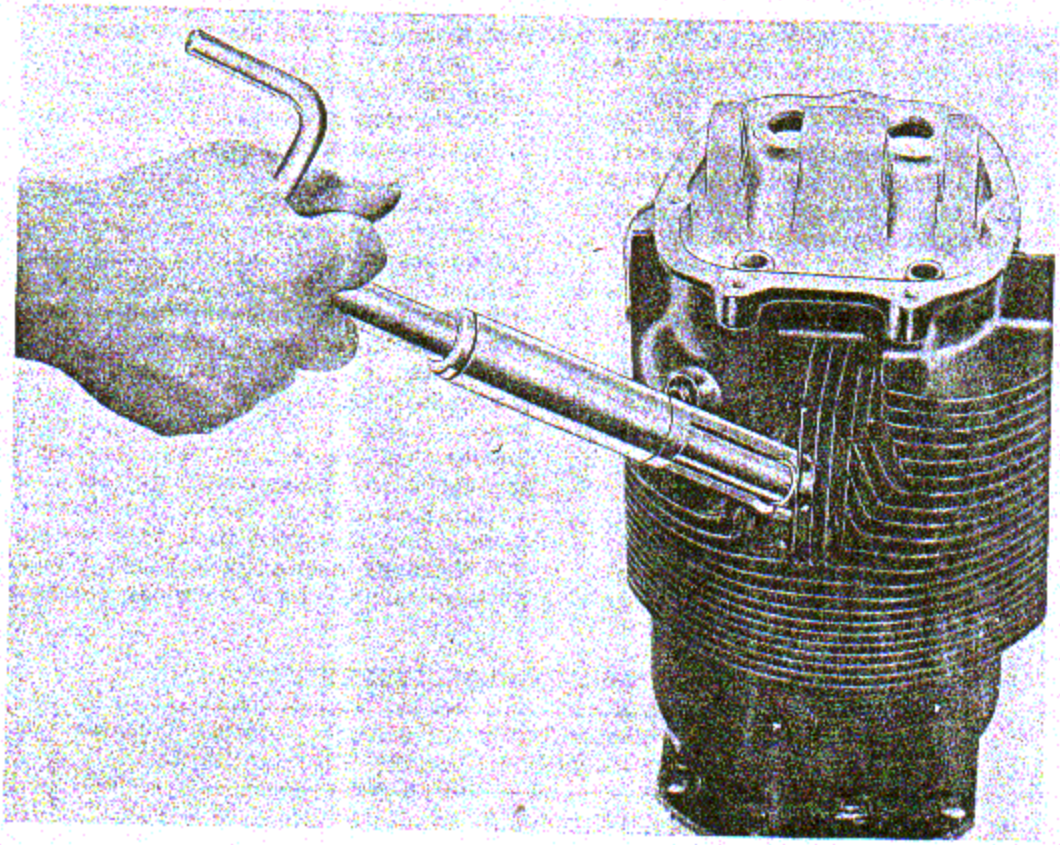


Figure 5-7. Installing Spark Plug Heli-Coil

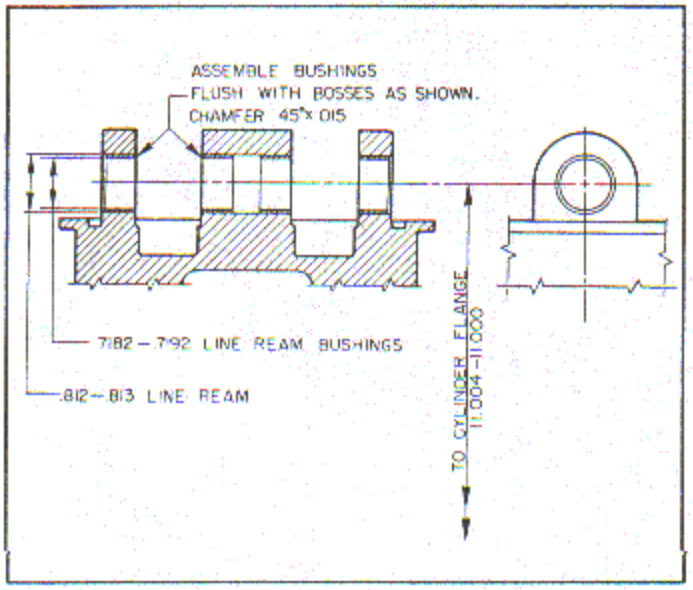


Figure 5-8. Dimensions of Rocker Shaft Support Bushings

proper fit on standard size rocker shaft. Refer to Table I and Section 10, Ref. No. 10. Break sharp edges at bushing bore ends approximately 0.010 inch (radius of chamfer). The bushing axis must be located within limits specified in figure 5-8 and must not be askew in any plane relative to valve guide centers and cylinder base flange. Finished bores must be free of tool marks.

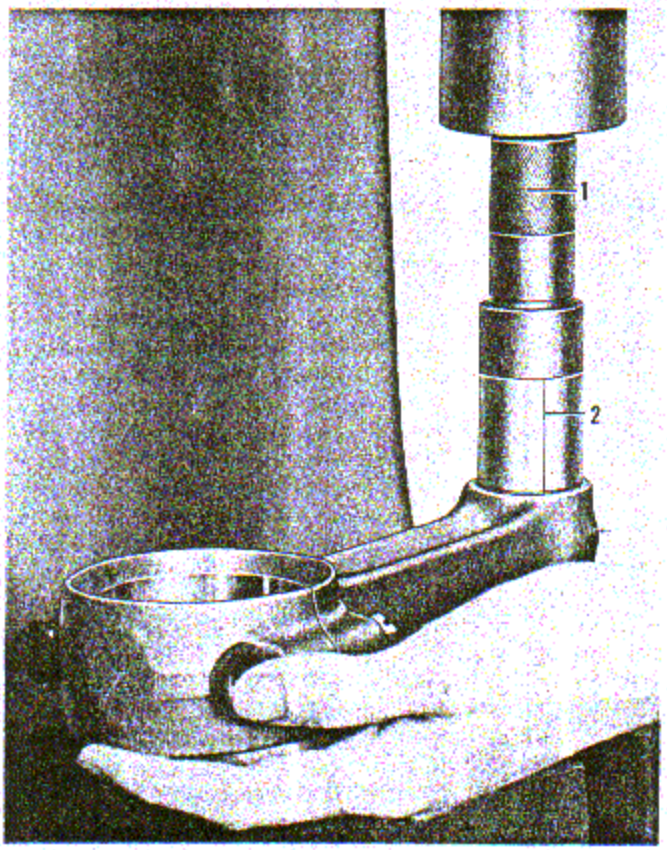
5-34. PISTON AND RINGS.

5-35. A burnishing tool may be used to smooth any small nick in piston heads. Light scoring on skirt contact areas need not be removed, and no polishing should be attempted, since diameter and contact area must not be altered. Before installing new piston rings, place them, one at a time, in cylinder in which they will work; then square up by pushing up with piston head to a point not over two inches beyond ground side of base flange, and, in that position measure gaps with a standard thickness gauge. If gaps exceed values specified in Section X, Ref. No. 23 and 24, try 0.005 inch oversize rings. These will give serviceable gaps in worn cylinders unless cylinders require regrinding to 0.015 inch oversize. Use 0.015 oversize rings only when piston and cylinder are the same oversize. Do not grind ring ends to alter ring gaps. After checking a new set of rings for gaps, install set in piston grooves with part numbers toward piston head, the two semi-keystone rings in the two top grooves and the slotted oil ring in bottom groove. Place all ring gaps in line; then hold a hard wood block (about 3.4 inch square by 4 inches long) against all ring lands of piston and hold rings against block, flush with piston surface, while measuring side clearance on either side of block with a standard thickness gauge. Make three such measurements of all three rings at three equally spaced positions around piston, and compare measurements with values specified in Section X, Ref. No. 21 and 22. If side clearances are excessive, due to wear on groove walls, or too small, due to collapse of lands, discard piston. If satisfactory, leave rings installed and push proper pin assembly back into place. If any piston is replaced, weigh and compare with weights of others in engine set. Permissible weight variation between heaviest and lightest in set is 1/2 ounce.

5-36. CONNECTING RODS.

5-37. Press out excessively worn piston pin bushing and install replacement with remover and replacer (1). (Refer to Section III, tool group 2.) For removal, small end of connecting rod must be supported on collar or plate bored just larger than bushing outside diameter. For installation, rod end must be supported on a flat plate. Lubricate bushing with engine lubricating oil before pressing in, and make sure that split line (2) is located as specified in figure 5-9. After reaming, break sharp edges if chamfer was removed. (See figure 5-10.) Check bushing bore and compare with diameter with values specified in Table I.

5-38. CHECKING BUSHING IN ALIGNMENT. In order to check for twist or convergence of bushing axis and big end bearing seat axis it will be necessary to



1. Connecting rod bushing remover and replacer
2. Bushing split line

Figure 5-9. Installing New Bushing in Connecting Rod

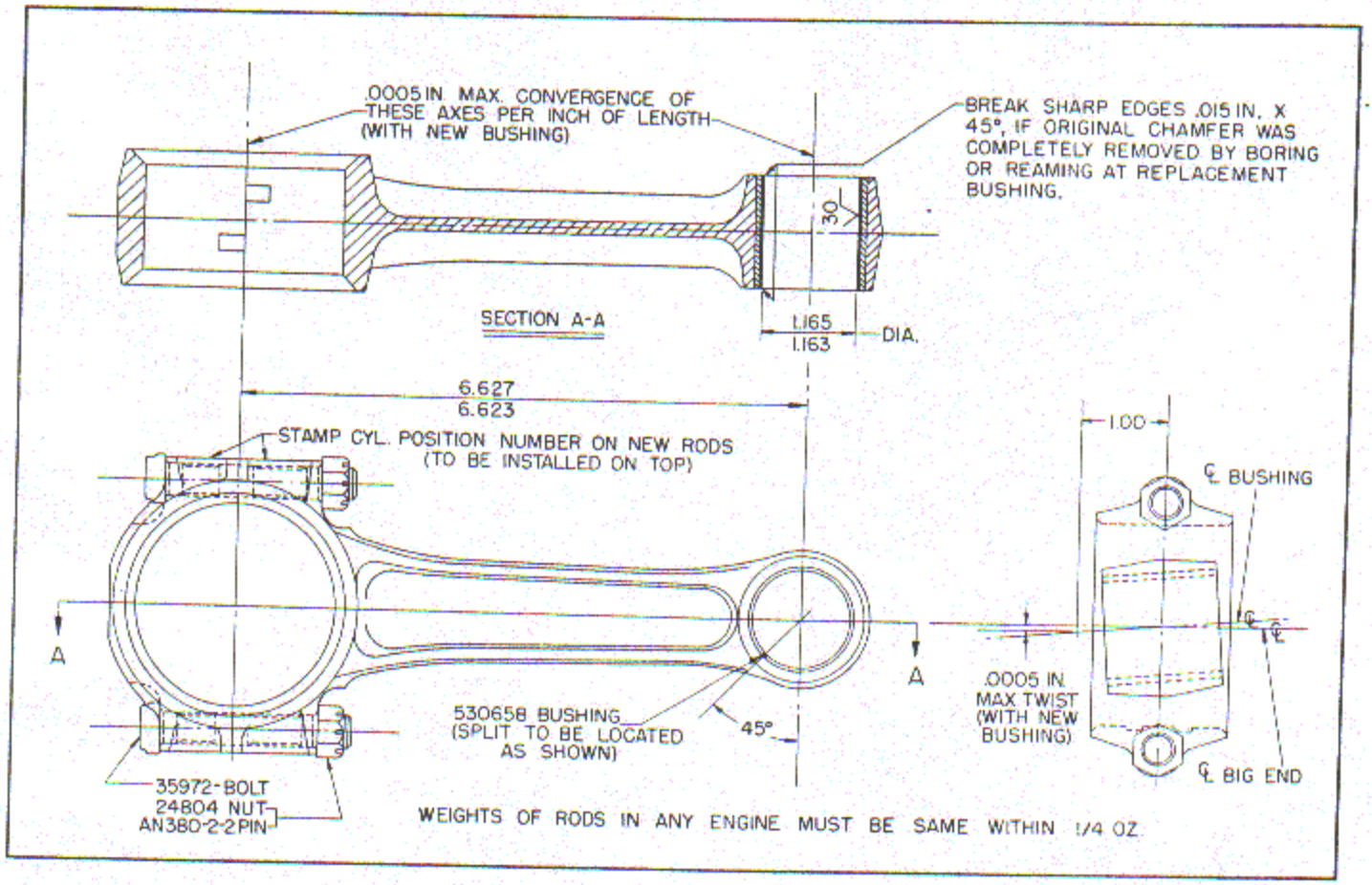


Figure 5-10. Connecting Rod and Bushing Dimensions

assemble rod, cap, bolts and nuts with rod and cap position numbers on one bolt boss matched and on the same side. Tighten nuts to specified torque. It will be necessary to provide push fit arbors for bearing seat bore and bushing bore. These need to be full diameter only through rod and bushing, but ends, if reduced in diameter must be of same diameter on each end of each arbor. Each arbor should be eight or nine inches in length. After pushing two arbors through rod bores, support big end arbor ends in matched V-blocks placed on surface plate and bushing arbor ends on two ground parallel steel blocks of same thickness such that rod center line will be horizontal. With standard thickness gauge measure clearance under either end of bushing arbor. This value divided by distance in inches between support points will give axis twist per inch. It must not exceed limit specified in end view of figure 5-10. To measure axis convergence, swing rod to vertical position, pivoting big end arbor, against stop, and determine heights of two points on bushing arbor, (e.g. six inches apart) with a dial indicator mounted on vernier height gauge or on surface gauge. The measured difference divided by separation of points in inches will be convergence per inch of axis and must not exceed limit specified above sectional view in figure 5-10. If both twist and convergence measurements are excessive, use dial indicator to determine whether there is any difference in height of two ends of big end arbor. Any error here must be added or deducted, as applicable, to readings.

5-39. CRANKSHAFT REPAIR AND REPLACEMENT.

5-40. CRANKSHAFT REGRINDING. When crankshaft main journals and/or crankpins are worn beyond, or out-of-roundness is greater than, values specified in Ref. No. 36, 37 or when end clearance specified in Ref. No. 34 (with new main thrust bearing) is in excess of "Replacement Maximum" values, crankshaft may be repaired by grinding journals, crankpins and thrust flanges to undersize dimensions specified on engine manufacturer's drawing No. 536061. Reground crankshafts must be installed with 0.010-inch undersize bearings. The following requirements must be observed.

a. Spacing of reground thrust and anti-thrust flanges must be 1.705 - 1.714 inches.

b. Leave 1/4-inch of rear journal original diameter (measured from the rear end) for accessory drive gear pilot.

c. Center crankshaft on the chamfer inside the front hub and the chamfer at the rear end surrounding the tapped hole for the starter jaw retaining stud.

d. For grinding crankpins offset grinder centers two inches from axis of rotation.

e. All journals and crankpins must clean up within a range 0.010 inch smaller than diameters specified in Ref. No. 36 and 37 for new parts. Allowance must be made for final lapping.

f. Maximum out-of-roundness of new journals and crankpins specified in the Table of Limits must not be exceeded.

g. Taper in diameter of any crankpin or journal from end to end must not exceed 0.0005 inch and must be uniform.

h. Fillets at ends of all crankpins and journals must blend smoothly into adjacent surfaces, except that grinding reliefs between fillets and crankcheeks shall not be completely removed.

i. Fillet radii, after regrinding, shall be within the following limits: Between front journal and thrust flanges: 0.160-0.165 inch. Ends of all other main journals and all crankpins: 0.234-0.250 inch. (A 0.094 inch radius gauge placed in any position on these fillets must make contact at one point only.)

j. Fillets and journals must show no grinding marks.

k. Reground shafts shall be nitrided to produce a case depth of 0.015 - 0.025 inch.

l. After grinding and before lapping journals and crankpins, shaft ends must be tin flash plated for a distance of 2.25 inches from front of flanged end. Remove propeller bolt bushings from flange and mask flange holes before plating. Remove masks after plating.

m. After nitriding, main journals and crankpins must be lapped to specified size and with maximum surface roughness of 6 micro inches RMS.

n. The resized shaft shall be checked for run out at center journals while supported at front main thrust and rear journals and for run out at front hub and face of propeller mount flange. (Refer to Table of Limits for allowable eccentricity.)

o. The resized shaft shall be reinspected magnetically for grinding cracks.

p. After inspection, undersize shafts shall be marked for identification in accordance with current Technical Orders on this subject.

NOTE

Crankshafts reground to 0.010 inch undersize by the engine manufacturer are marked by acid etching the undersize designation ".010 US" on the front surface of the front (anti-) thrust flange.

5-41. STARTER JAW STUD. In event of damage to starter jaw retaining stud in rear end of crankshaft, the damaged part may be removed after driving out brass locking pin near rear end of shaft journal. Unscrew stud with pipe wrench. Install new stud, using 9/16-18 hex nut screwed on small thread as a means of engagement to a wrench socket. Driving nut must not project beyond end of stud. Use a depth gauge to measure projecting length of stud, and set it to a height within limits given in figure 5-11. Drill and ream a hole through inserted end of stud for a locking pin, and install a new brass pin as indicated in the note in illustration.

5-42. REPLACEMENT OF CRANKSHAFT AND COUNTERWEIGHT BUSHINGS. If these steel bushings should be worn badly out-of-round, they may be pressed out and new bushings installed without machining operations. Figure 5-12 shows identification and bushing bore dimensions of counterweight equipped at the factory with oversize bushings. If such an assembly is encountered it may be repaired by installation of same oversize bushings. Observe that bushings

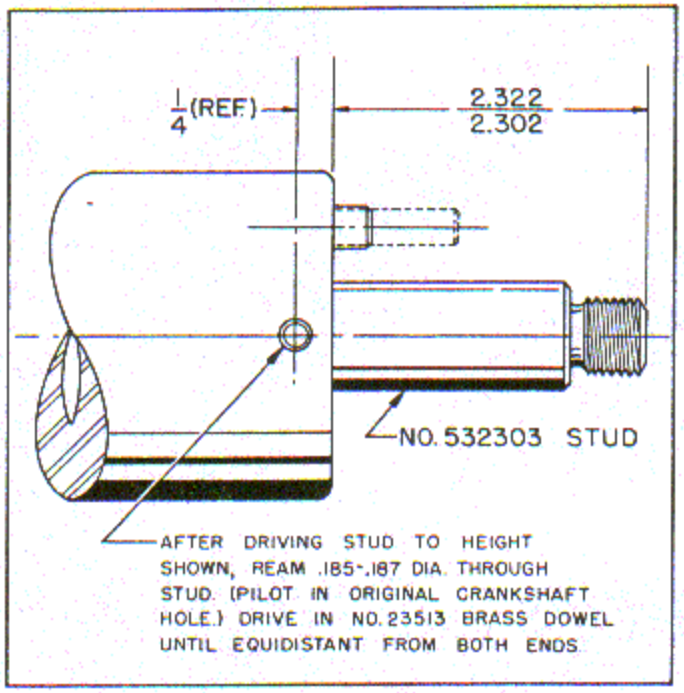


Figure 5-11. Installation Dimensions of Starter Jaw Retaining Stud

are pressed flush with slot walls. This will be accomplished automatically if counterweight is supported on a solid steel plate inserted through slot. Support counterweights in same manner to press out old bushings, except plate used as support must be bored to clear outside of bushing. Support crankshaft in same manner on front side of its crankcheek extension. Do not heat either shaft or counterweights for removal or installation of bushings. To facilitate insertion, new bushings may be chilled in dry ice or deep freeze unit. Since they will swell immediately upon contact with warm shaft or counterweight, an installing driver with a bushing detent ball and spring below driving shoulder should be used to speed operation.

5-43. ACCESSORY CASE ASSEMBLY.

5-44. OIL FILLER SPOUT ASSEMBLY. If pressed steel filler neck is deformed it may be cut off below the bulge and the remaining sleeve collapsed with pliers. If spout casting bore is rough, smooth it with crocus cloth. Press a new filler neck into spout casting while the latter is held firmly on a flat metal surface of an angle of 45 degrees to the arbor press table. After such repair work recheck flatness of spout parting flange. If necessary restore flatness of gasket surface by lapping on a flat plate, using fine grade lapping compound. After lapping, flush away all abrasive particles with dry cleaning solvent, Federal Specification P-S-661. If spout casting is cracked replace neck and spout assembly.

5-45. SPRING CLIPS. Damaged spring clips on neck may be replaced by shearing rivet and attach replacement clip with 5/32 dia x 1/4 in. round head, mild steel rivet.

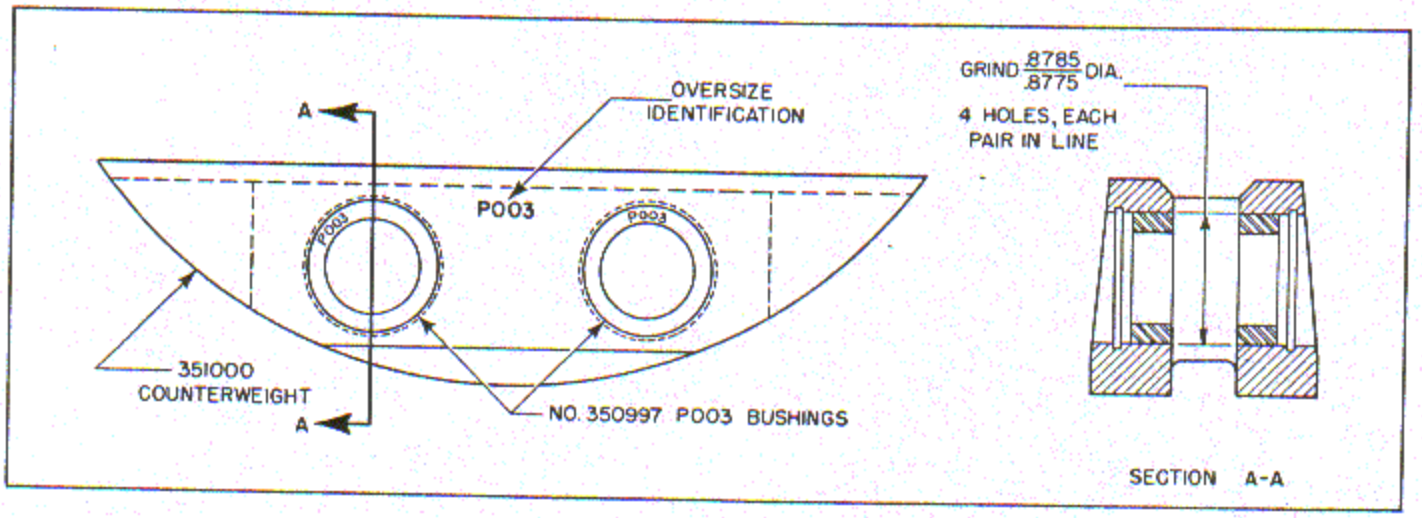


Figure 5-12. Counterweight with Oversize Bushings

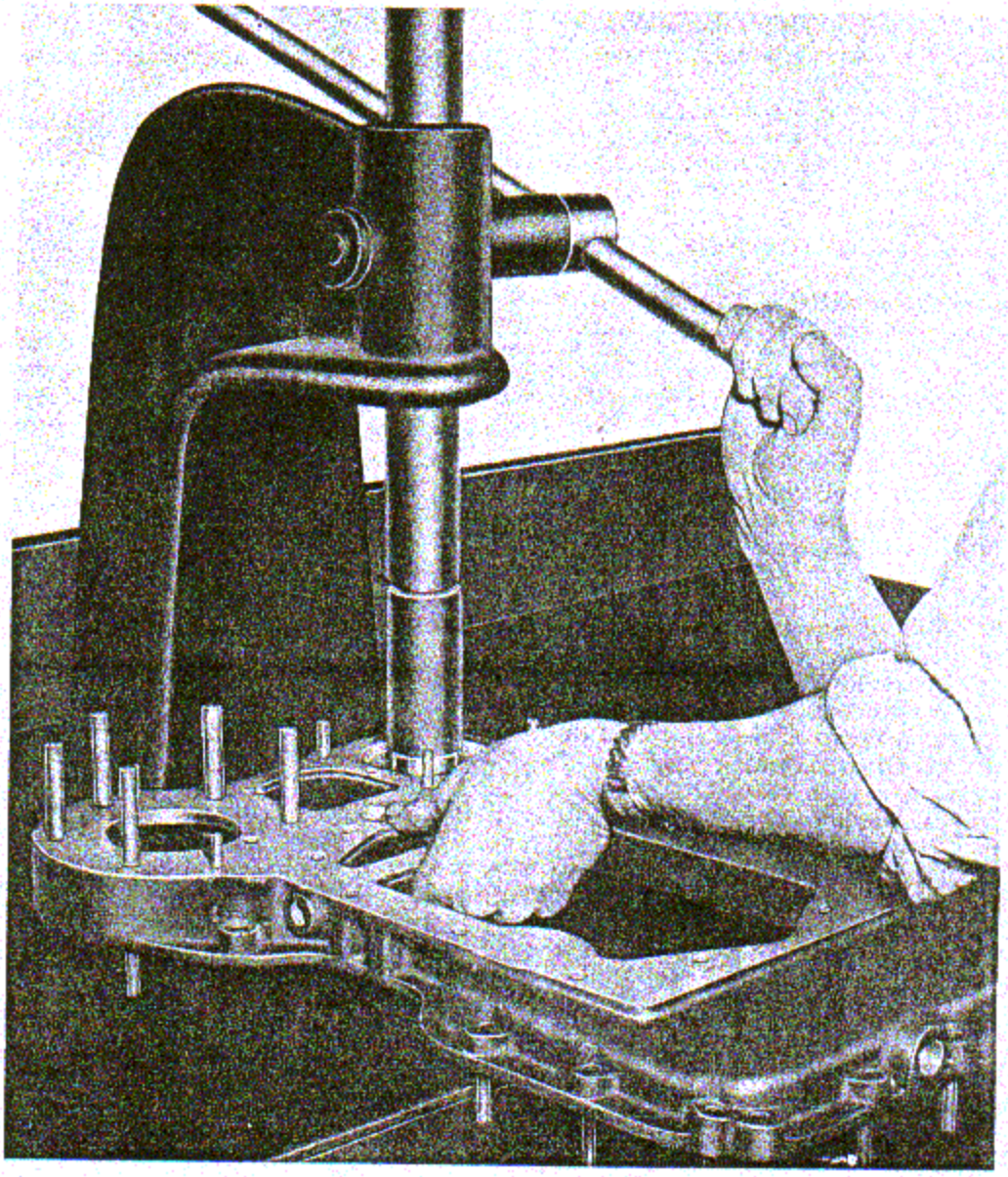


Figure 5-13. Installing Upper Hydraulic Pump Gear Oil Seal (Typical)

5-46. OIL SEALS. Inspect seal recesses in castings after old oil seals have been removed, and smooth any roughness with crocus cloth. Coat the periphery of the new oil seals with a thin film of lubricating grease, Federal Specification VV-G-632, before driving or pressing in with smooth flat end of a drift of seal diameter. (See figure 5-13.) Make sure that seal lip faces toward interior of case.

5-47. PROTECTIVE COATINGS.

5-48. The manufacturer is in the process of changing his method of protecting aluminum parts from corrosion. Newly manufactured parts will be coated with "Alodine 1200" per specification, MIL-C-5541. Although the protective coatings differ, the application, interchangeability and part numbers of the parts are not affected. "Alodine" coated parts are easily distinguished by their gold color. In order to maintain a uniform appearance, the manufacturer is painting certain steel and magnesium parts with gold colored enamel (No. 62-8536, Gold Heat Resisting Enamel, Grand Rapids Paint and Varnish Co., Grand Rapids, Mich.).

5-49. Table XII, lists the various parts of the engine

TABLE XII. PROTECTIVE COATINGS

Description of Part	Material	Code	
		Preferred	Optional
Adapter, Generator	Magnesium	abh	abe
Adapters, Magneto	Magnesium	abh	abe
Adapter, Starter	Magnesium	abh	abe
Body, Oil pump and screen	Magnesium	abh	abe
Bracket, Front engine mount	Magnesium	abh	abe
Bracket, Oil sump front support	Steel	h	i
Bracket, Primer line clamp	Aluminum	k	df
Bracket, Primer line clamp	Aluminum	k	df
Bracket, Rear engine mount	Magnesium	abh	abe
Cap, Oil filler	Steel	dg	
Cap, Relief valve	Steel	i	
Case, Accessory	Magnesium	abh	abe
Cover, Governor pad	Aluminum	k	ae
Cover, Hydraulic pump upper pad	Magnesium	abh	abe
Cover, Tachometer drive lower pad	Aluminum	j	df
Cover, Valve rocker	Aluminum	k	ae
Cylinder and valve assembly	Aluminum & Steel	k&h	e
Crankcase	Aluminum	k	ae
Distributor, Primer	Magnesium	abh	abe
Eye, Lifting	Steel	i	
Flange, Intake manifold	Aluminum	k	df
Housing, Pushrod	Steel	i	
Manifold, Intake and oil drain	Magnesium	abh	abe
Spout, Oil filler	Magnesium	abh	abe
Sump, Oil	Steel	h	f
Tube, Intake manifold	Aluminum	k	ad

TABLE XIII. CODING EXPLANATION FOR PROTECTIVE COATINGS

Code	Protective Coating Designation	Spec. No.	Type	Color	Color No.	No. of Coats
a	Seal chrome Pickle	MIL-M-3171	11	-	-	-
b	Primer - Zinc chromate	MIL-P-6889	I	-	-	1
c	Primer - Zinc chromate	MIL-P-6889	I	-	-	2
d	Primer - Synthetic	TT-P-636	-	-	-	1
e	Enamel - Heat resisting	MIL-E-5557	11	Black	515	2
f	Enamel - Gloss	MIL-E-7729	11	Gray	513	2
g	Enamel - Gloss	MIL-E-7729	11	Orange	506	2
h	*Enamel - Heat resisting	-	-	Gold	62-8536	2
i	Cadmium Plate	AMS 2400-1	-	-	-	-
j	Alodize	Alodine 1200	-	-	-	-

* Source: Grand Rapids Paint and Varnish Co., Grand Rapids, Michigan.

which require protective coatings, the material and a code designating the applicable protective coating. In the event cleaning and/or repair procedures remove the "Alodized" finish, the part should be refinished per instructions in paragraphs 5-52 through 5-55. For activities not having at their disposal equipment or materials to renew an "Alodine" finish, refer to Table XII for the optional protective coating and treat the part accordingly.

5-50. REPAIR OF ENAMEL SURFACES.

5-51. Refinishing of enamel coated parts shall be accomplished in accordance with the code specified in Table XII. Ferrous parts coded for gold enamel will be baked, with infra-red equipment, for 15 minutes at 275° - 285°F following application of each coat. Magnesium parts coded for gold enamel will be pickled and primed as coded; then baked, with infra-red equipment, for 15 minutes at 275° - 285°F following application of each coat of enamel. (In lieu of infra-red baking equipment the painting can be oven dried at 290° - 350°F for 45-60 minutes.)

NOTE

If a part which was originally "Alodized" is to be refinished with enamel, it will not be necessary to apply zinc chromate primer except to the surface areas completely stripped of "Alodine".

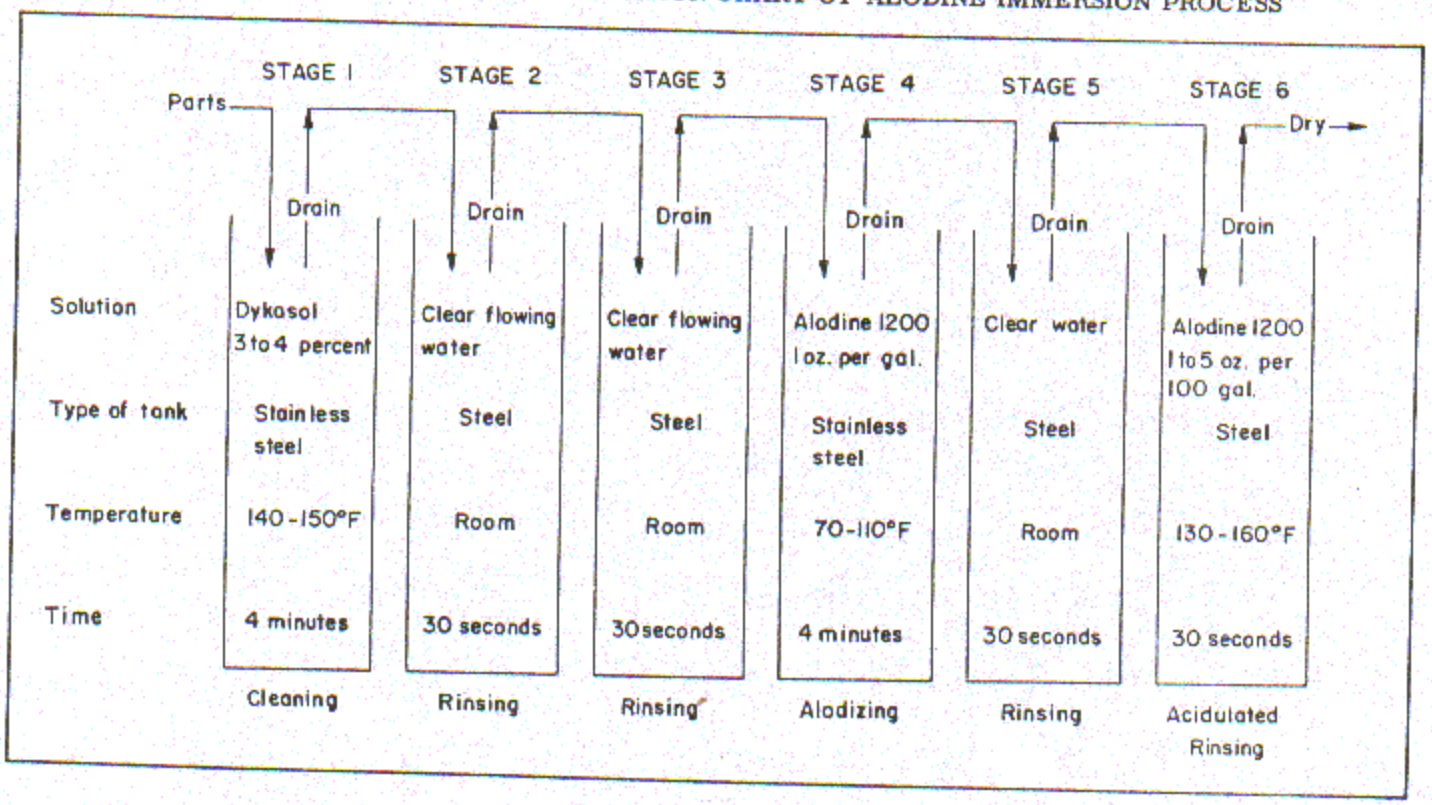
CAUTION

Before application of primer and enamel to a part, carefully mask all connection joints and mating surfaces. No primer or enamel is permissible on interior surfaces, accessory case, oil sump, crankcase or any other parts contacted by engine lubricating oil after assembly.

5-52. "ALODIZING" AND REPAIR OF "ALODIZED" SURFACES.

5-53. GENERAL. Aluminum alloy castings, sheet metal and tubing may be protected from corrosion by treating all surfaces, of the parts, with "Alodine 1200" (American Paint and Chemical Co., Ambler, Penn.). "Alodine", unlike enamel or primer, will not flake or peel off to contaminate engine lubricating oil; therefore corrosion protection can be afforded to all interior aluminum surfaces and parts. If an enamel coating is required for a part previously treated with "Alodine", application of a primer before painting is not necessary. "Alodizing" will be performed after all machining and/or repair operations have been completed. The surface color of an "Alodized" part may vary from light gold to dark brown. When a part is treated with "Alodine 1200" the thickness of the film, or build up, on the mating or bearing surfaces is so fine that the effect on dimensional tolerances is negligible.

TABLE XIV. FLOW AND SPECIFICATION CHART OF ALODINE IMMERSION PROCESS



5-54. APPLICATION OF "ALODINE 1200". The method of application as performed by the manufacturer is depicted in Table XIV. In the event the original finish of an aluminum part has deteriorated or been removed, the part may be "Alodized" per Table XIV or as described in "Alodine" manufacturers Technical Service Data Sheet No. AL-1200-D. Wrought or die cast (smooth surface) parts, such as valve rocker covers and intake tubes, should be tumble or sand blasted to roughen surface before treatment.

5-55. REPAIR OF ALODIZED SURFACES. If "Alodized" parts have been remachined, rubbed with abrasives or scratched in handling so as to expose areas of bare aluminum, the surface may be repaired by local application of "Alodine" solution in the following steps:

a. Clean the parts' bear area thoroughly with carbon tetrachloride. Do not under any circumstances use an oil base solvent such as Federal Specification, P-S-661, TT-T-291 or alkaline cleaner.

b. Mix a small quantity of hot water (180°F) with 1-1/2 to 2 ounces of "Alodine 1200" powder to form a paste, then gradually dilute with hot water until a solution, of one gallon, is attained. This solution is to be adjusted with nitric acid addition to a PH value of 1.6 (1.5 to 1.7).

c. Application shall be made, with a rubber set paint brush, in such a manner that the solution flows over the area.

d. Allow solution to remain on the part from one to five minutes or until color of the new film is approximately the same as the original.

e. Flush part with clear water and dry with air. Do not blast or rub with cloth to dry new film area. If color is too light, repeat steps "c" and "d" until desired color is obtained.

NOTE

If "Alodine" does not adhere to metal a more severe cleaning method must be used. A solution of 12 to 16 ounces of Oakite No. 61 per one gallon of water is preferred. Apply and remove the solution with caution because an alkaline cleaner of this type will remove any "Alodine" film previously applied. Remove cleaning solution thoroughly with plenty of hot water and vigorous brushing.

SECTION VI

ASSEMBLY OF SUBASSEMBLIES

6-1. LUBRICANTS AND LUBRICATION.

6-2. CORROSION-PREVENTIVE MIXTURE. Wherever in this section this material is mentioned it shall be construed to mean ready mixed compound conforming to Specification MIL-C-6529, Type II, or a mixture of Type I concentrate procured under the same specification with aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100, in the ratio of one part concentrate to three parts oil. When this material is used for slushing or dipping parts already covered with any other liquid it must be checked daily and must be discarded when content of foreign liquid reaches a level which will impair corrosion inhibiting properties of compound. Without further instructions, apply corrosion-preventive mixture to all unplated steel parts and bushings for which no special lubrication instructions are given herein. Before such applications, clean parts thoroughly with approved solvent and blow off with dry compressed air.

6-3. THREAD LUBRICANT. Tightening torques in Section X are for use with oiled threads and are not applicable when a special thread lubricant is employed, unless use of such a lubricant is specified in the table for particular parts. If a thread lubricant is employed, specified tightening torques should be reduced approximately 20%.

6-4. SPECIAL LUBRICANTS. In certain instances specific lubricants have been selected by the engine manufacturer as a result of tests to determine most suitable materials for specific assembly operations. These materials alone are recommended by the manufacturer for the operations where they are mentioned. Some of these products have been assigned stock numbers by specific depots and may be procured from such stock. If not stocked, the local source of any product may be obtained from the manufacturer.

6-5. GASKET AND SEALING COMPOUNDS.

6-6. The impregnation of soft gaskets with lightweight Tite Seal compound (Radiator Specialty Co., 2000 Dowd Road, Charlotte, N.C.) immediately before they are installed, will aid in preventing oil leaks which sometimes result when dry gaskets take a permanent "set", or compression, under the combined effect of heat, vibration and compressive force of attaching parts. No. 3 Aviation Permatex (Permatex Co., Inc., 1720 Avenue Y, Brooklyn, N.Y.) is to be used, when specified in the test, to form a seal between parting surfaces where gaskets cannot be used.

6-7. Apply sealing compounds sparingly to avoid lumps which may be squeezed into interior cavities and carried by lubricating oil to small passages where they may lodge and cut off circulation.

6-8. TIGHTENING TORQUES.

6-9. Tables of tightening torques for specific and general applications will be found in Section X. (Refer to paragraph 6-3 in regard to lubricants.)

6-10. PROCEDURE. Use torque wrenches for tightening, never for loosening nuts and screws. Install threaded part and tighten by hand until snug; then tighten with torque indicating wrench to lower limit of specified torque range. If a nut slot and cotter pin hole must be aligned, inspect; then tighten further if necessary to align. If alignment cannot be obtained within specified torque range, loosen with another wrench; then remove and replace part with another, and repeat tightening procedure. Always keep socket extension used with torque indicating wrench in line with screw or stud to avoid false indications and possible damage of thin wall sockets. When tightening screws and nuts around a parting flange or cover, screw in all of them snug; then tighten in small steps, moving around flange in sequence of attaching parts and attempting to tighten each part to the same degree in each step until specified torque has been applied. This sequence is not followed in cylinder attachment, as described in Section VII.

6-11. SAFETY DEVICES.

6-12. Nut locks, lockwire, toothed lock washers, tab washers and cotter pins must be new parts. If such a part is removed after installation for any reason, discard it and install another new part in final assembly operations. Use of previously installed parts of these kinds is dangerous, since installation and/or removal may fatigue the metal so as to cause it to fail after engine is returned to service.

6-13. NUT LOCKS. These pressed steel parts (trade name: Palnuts) need be tightened by wrench only 1/6 turn. Never tighten more than 1/4 turn, since further tightening will distort locking teeth and may cause damage to stud threads when part is removed.

6-14. LOCKWIRES. (See figure 6-1.) Three sketches illustrated proper methods of installing lockwires to anchor a threaded part to a bolt or stud, an anchor lug on a casting or another threaded part. The latter applies to bolt heads; the first two may be bolts or plugs. Observe that direction of twist is such that loop around square or hexagon is held down. If three or more screws are wired in series this applies on both sides of each, excepting the first. Do not twist or pull lockwires so tightly as to approach elastic limit of the material, though the twisted length must be held fairly taut to prevent excessive vibration. Always bend twisted ends down against head, stud or lug to reduce hazard of snagging clothing during maintenance operations.

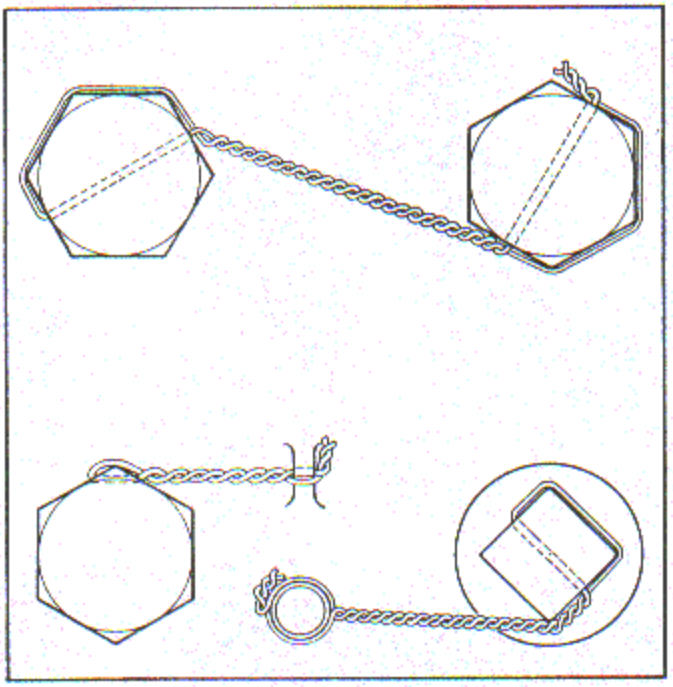


Figure 6-1. Installation of Typical Lockwires

6-15. COTTER PINS. (See figure 6-2.) Select correct length of cotter pin to give appearance labelled "RIGHT" in the drawing and correct diameter to fit hole. Always bend down legs firmly against the engine parts to prevent snagging clothing of maintenance personnel. Observe in illustration that cotter pin head is fully seated in nut slot without being flattened and that pin is below top of nut. If cotter pin hole is too high to permit this last condition it will usually indicate that either attached parts have been reduced in thickness or that wrong attaching parts have been installed or that stud or bolt has been stretched or stud backed out. Any such condition should be investigated and cause determined and corrected before proceeding.

6-16. IGNITION HARNESS.

6-17. Instructions for repair and reassembly of two cable and conduit assemblies appear in Section IX.

6-18. PRIMING SYSTEM.

6-19. Damaged priming tube assemblies should be replaced with new assemblies listed in Illustrated Parts Breakdown. There are no subassembly operations.

6-20. OIL PUMP
(See figure 4-4.)

6-21. Coat pipe threads of all fittings and plugs with a film of Led Plate No. 250 compound (Armite Laboratories, 6609 Broad St., Los Angeles Calif.) before installation. Coat parts indexed 19 through 23 with a film of corrosion preventive compound before installation. Assemble pump in reverse order of index numbers assigned. Do not tighten cap at this time. Driving gear with splined shaft must be on left as viewed from rear.

6-22. INDUCTION SYSTEM.
(See figure 4-5.)

6-23. Make sure seal (10) is fully seated in seal groove. Assemble system parts in reverse sequence of index numbers assigned in referenced illustration.

6-24. OIL SUMP.
(See figure 4-6.)

6-25. Coat pipe threads of suction oil screen assembly (17) and drain plug (18) with Led Plate No. 250 prior to installation. Parts indexed 1, 5, 6 and 7 will be installed at final assembly. Assemble all other parts in reverse order of index numbers assigned. Tighten suction oil screen assembly oil tight. Straight tube must point upward and to the right at an angle of approximately 30 degrees to the vertical.

6-26. ACCESSORY CASE FRONT HALF AND GENERATOR DRIVE. (See figure 4-7.)

6-27. GENERATOR DRIVE. Apply a coating of corrosion-preventive compound to gear (64) and thrust washer (62). Ascertain that retaining ring (61) is properly seated in shaft groove. If gear, thrust washer are new parts, measure clearance behind gear with standard thickness gauge and compare with Ref. No. 91, Section X. If satisfactory lubricate periphery of new oil seal (59) with grease, Federal Specification VV-G-632, grade 1, type B, and press into adapter as shown in figure 6-3. Make sure that lip of oil seal is on leading side (inward) and is not reversed in passing over shaft end.

6-28. ACCESSORY CASE FRONT HALF. (See figure 4-7.) Ascertain that oil seal (60) is installed in upper hydraulic pump drive pad counterbore; then push sleeve plug (53) through seal and bushing. Attach pad gasket (19) and cover (18) with four sets of attaching parts (15, 16, 17). Coat pipe threads of oil drain nipple (30) and install in tapped hole in bottom of case over copper-asbestos gasket (31).

6-29. ACCESSORY CASE REAR HALF.

6-30. Coat pipe threads of all fittings and plugs with Led Plate No. 250 prior to installation. Spread a thin

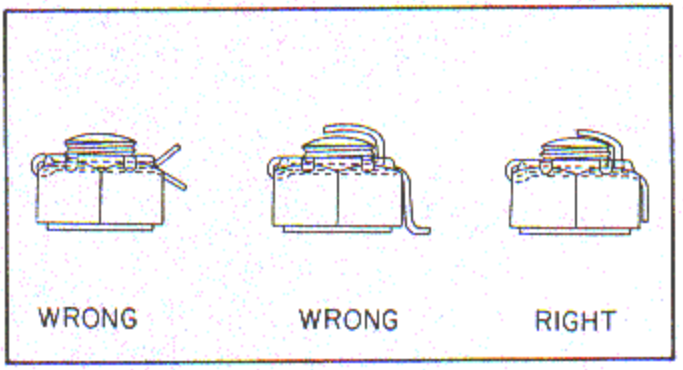


Figure 6-2. Cotter Pin Installation

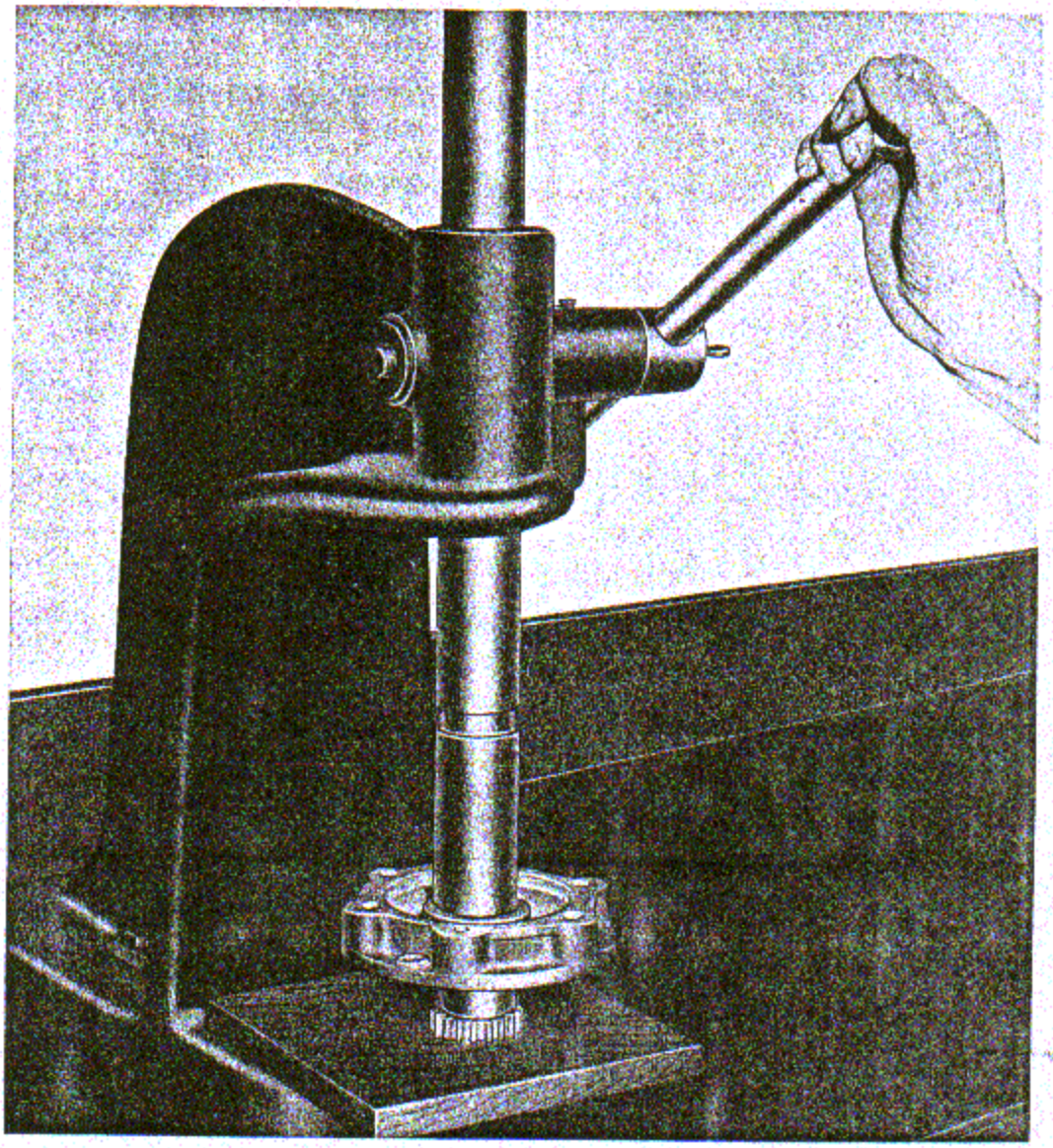


Figure 6-3. Installing Generator Drive Seal

film of lightweight Tite Seal on oil pump mount pad, but not on studs or in gear bushings. Lay a loop of No. 50 silk thread on treated pad inside studs but clear of bushings. Install and attach oil pump. Spread a film of Gredag No. 44 grease (Gredag Inc., 3949 Streeter Bldg., Niagara Falls, N.Y.) on lips of oil seals and gear shafts prior to installing gears. Take care when installing gears to prevent reversing oil seal lips.

NOTE

Wide slots in rear ends of magneto gear shafts must be at right angles to each other when gear teeth are meshed with upper tachometer gear.

6-31. PISTON ASSEMBLIES.

6-32. Instructions for fitting and installing rings will be found in paragraph 5-35. Piston and rings should already be assembled at this stage. Do not lubricate pistons, rings or pins until ready to install in cylinders or onto connecting rod.

6-33. CYLINDER ASSEMBLIES. (See figure 4-9.)

6-34. For assembly operations the cylinder and valve holding fixture must have the valve holder installed. It will also be necessary to have available the valve spring compressing tool shown in figure 4-11. If piston and valve train parts are to be installed separately at final assembly the instructions in steps "a" through "e" apply.

a. Lay all pushrods in pan of castor oil, Federal Specification JJJ-C-86, with one end of each slightly elevated to permit air to escape as tubes fill. When bubbles cease, rods will be full and ready for installation.

b. Lubricate stems of intake and exhaust valves (32, 33) with Shell Grease, Alvania No. 2 (Shell Oil Co., 50 W. 50th Street, New York, N.Y.) Install valves in contact with seats to which they were lapped.

c. Holding valve stems in place, lift cylinder onto cylinder and valve holding fixture, tool group 3, Section III. Again lubricate valve stems with Alvania No. 2 grease.

d. Lubricate and install inner retainer (31) and springs (29, 30); then lay Rotocap (28) on. Push rocker shaft (11) through supports; then compress valve springs with tool shown in figure 4-11. Insert keys (27) and release springs slowly.

CAUTION

Rotocaps must be depressed slowly without side force or cocking. These hard parts will score valve stems if allowed to make contact.

e. After installing both sets of valve springs and retainers lift cylinder off fixture and lay it on its side.

f. Lubricate stem ends and rocker arm feet with Lubriplate No. 707 grease (Fiske Bros. Refining Co., Lubriplate Division, P.O. Box 38 Station "A", Toledo 5, Ohio); then slide rocker shaft outward to clear spaces between supports. Install rockers assemblies (12 through 17). If rocker shaft and cylinder support boss are drilled for installation of a shaft retaining screw (8), washers (9, 10), align hole in shaft with hole in support before pushing shaft through. Install the clamping parts.

g. Coat cylinder walls, piston skirts, rings and grooves and piston pins with corrosion-preventive and oil mixture if engine is not to be assembled and/or tested immediately. If final assembly and testing will follow immediately, lubricate with Lubriplate 130 AAA.

h. Locate oil control (slotted) piston ring gap in radial alignment with part number on piston head, and stagger other two gaps 120 degrees from it and each other. Compress rings with ring compressor (Section III tool group 16), and hold cylinder, open end up, while piston is bumped by hand into bore until pin hole is just clear of pilot to permit pushing pin out for cylinder installation. Oil control ring gap must be at top when cylinder is in installed position. Insert piston pin. Place cylinders so that they are resting on slope formed by upper edges of head fins. Line up cylinder and piston assemblies on bench in this attitude as assembled and in numerical order of position numbers.

i. Slide two steel washers (20, 22) on housing ends, spring (21) against washer (22), a second washer (20) against spring, and a new seal, flat side first, on each end. Install two on each cylinder by inserting anti-spring housing ends and seals into rocker box holes.

j. Install a new seal (26) on cylinder pilot against base flange and without twist.

k. Plug elevated end holes of two pushrods with thumbs, and insert opposite ends into housings. Seat ball ends in rocker sockets. Equip each cylinder in same manner. Leave cylinder assemblies in inclined positions on bench until ready to install on engine.

6-35. CRANKCASE SUBASSEMBLY. (See figure 4-10.)

6-36. Lay crankcase halves, flange side down, on suitable supporting blocks. Apply a film of Led Plate No. 250 compound (Armite Laboratories, 6609 Broad St., Los Angeles, Calif.) to any plug that was removed for cleaning, inspection or repair and reinstall plug. Attach three pushrod housing flange gaskets (32) and flanges (31) to each crankcase half with attaching parts (28, 29, 30). Tighten all plain hex nuts to specified torque before installing nut locks. Attach front mounting brackets (5) to each crankcase half with four sets of attaching parts (2, 3, 4). Before attaching right rear bracket (15) insert short through bolt (59) through lower parting flange bolt hole; then attach bracket (15) with three sets of attaching parts (6, 7, 8). Install relief valve parts (18 through 26) and install in mount bracket (27). Do not tighten cap (18). Place two seals (16 and 17) in their respective seats in bracket. Make sure seals are fully seated in bracket counterbores; then install mount bracket. Make sure that main and thrust bearing seats in crankcase halves are thoroughly clean and smooth; then snap a new bearing insert (68, 69) into each, as applicable. Bearing inserts (68) belong in front seat of each case. Make sure that locating tangs position each insert sidewise and that flat ends of each bearing stands only slightly and equally above case parting surface. Correct any cause of interference.

6-37. CRANKSHAFT AND CONNECTING ROD ASSEMBLY. (See figure 4-12.)

6-38. To facilitate reassembly of crankshaft, support front and rear journals in notched 2 x 4 in. wooden blocks (see figure 6-4.) Proceed with reassembly as follows:

a. Install three new seals (18) in deep grooves of oil transfer plug assembly (19).

b. Lubricate plug and seals with oil, Specification MIL-L-6082 and push the assembly into center bore at flanged end of crankshaft. Install retaining ring (17).

c. Determine original position of each counterweight assembly; then lay them on the bench and install one retaining plate (21) in each counterbore hole above pin bushing. Install retaining ring (20) in groove above each retaining plate. Leave other end of each hole open.

d. Hold each counterweight (24), in turn, on its crankshaft blade and insert two pins (22); then install remaining plates and retaining rings over them.

e. Lubricate and install oil transfer collar (15, 16) behind front thrust journal, with screw (14) held in half which includes the tube. Install two sets of attaching parts (11, 12, 13). Install a new seal (10) in tube groove.

NOTE

It is not permissible to interchange counterweights between crankshafts due to dynamic balance requirements.

6-39. CONNECTING RODS.

a. Lay six rod assemblies on bench in numerical order, according to position numbers stamped on bolt bosses. Disassemble them.

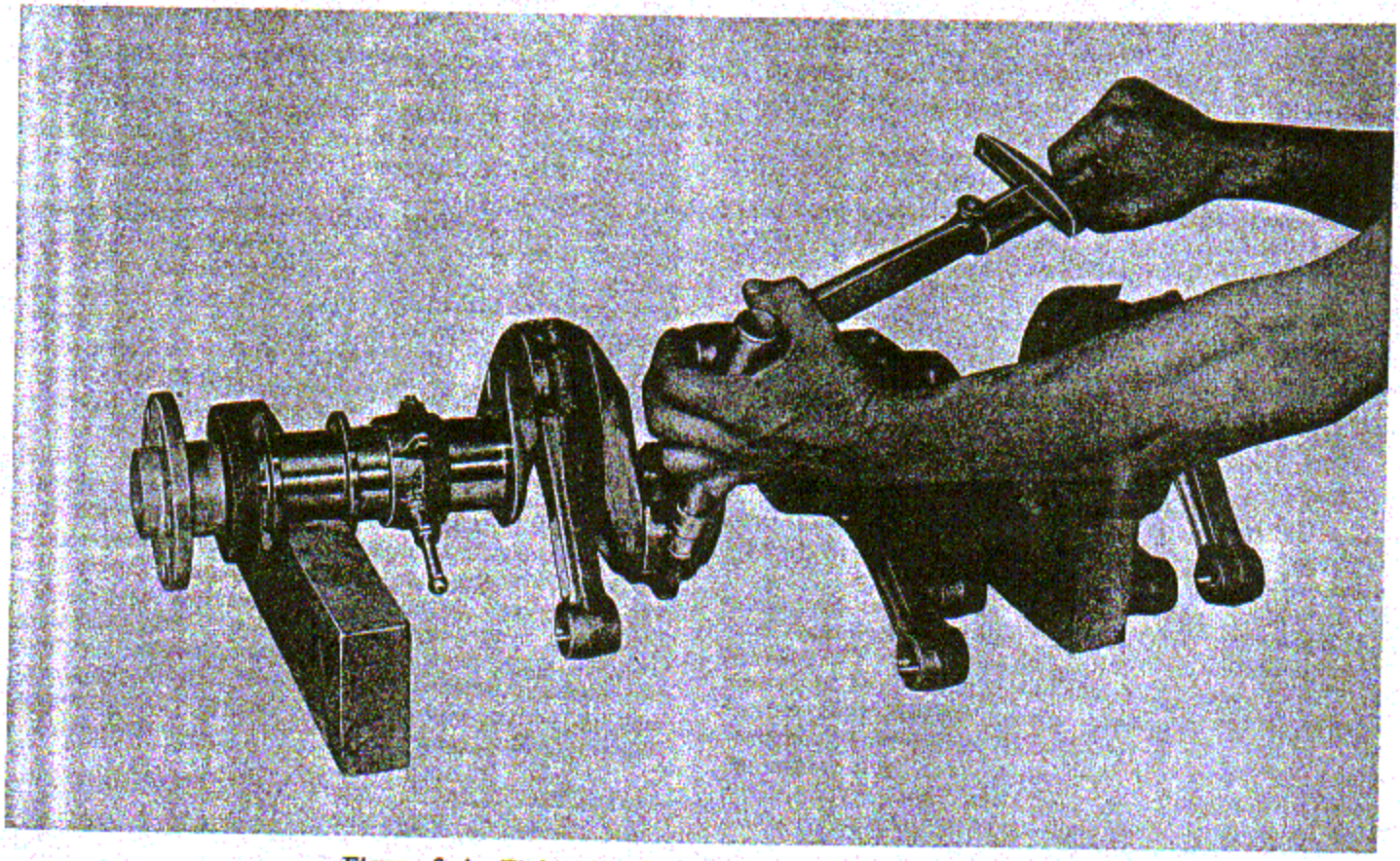


Figure 6-4. Tightening Connecting Rod Cap Bolt Nut

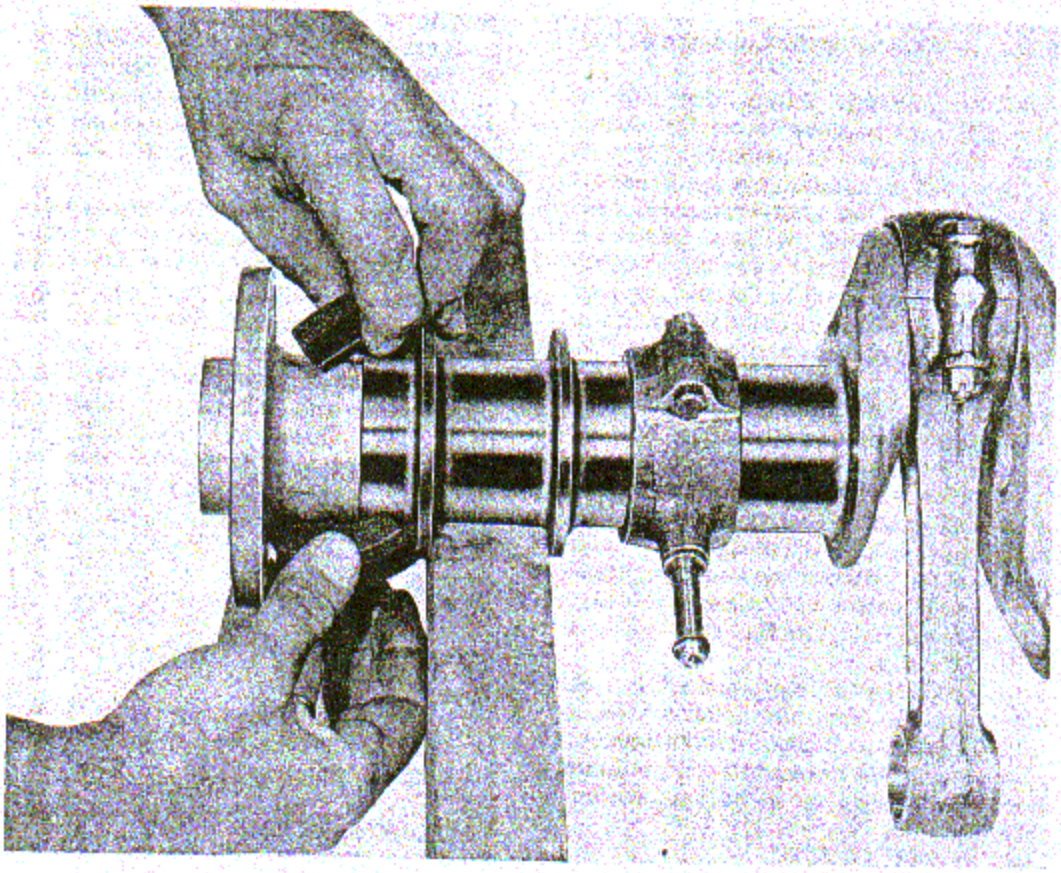


Figure 6-5. Installing Crankshaft Oil Seal

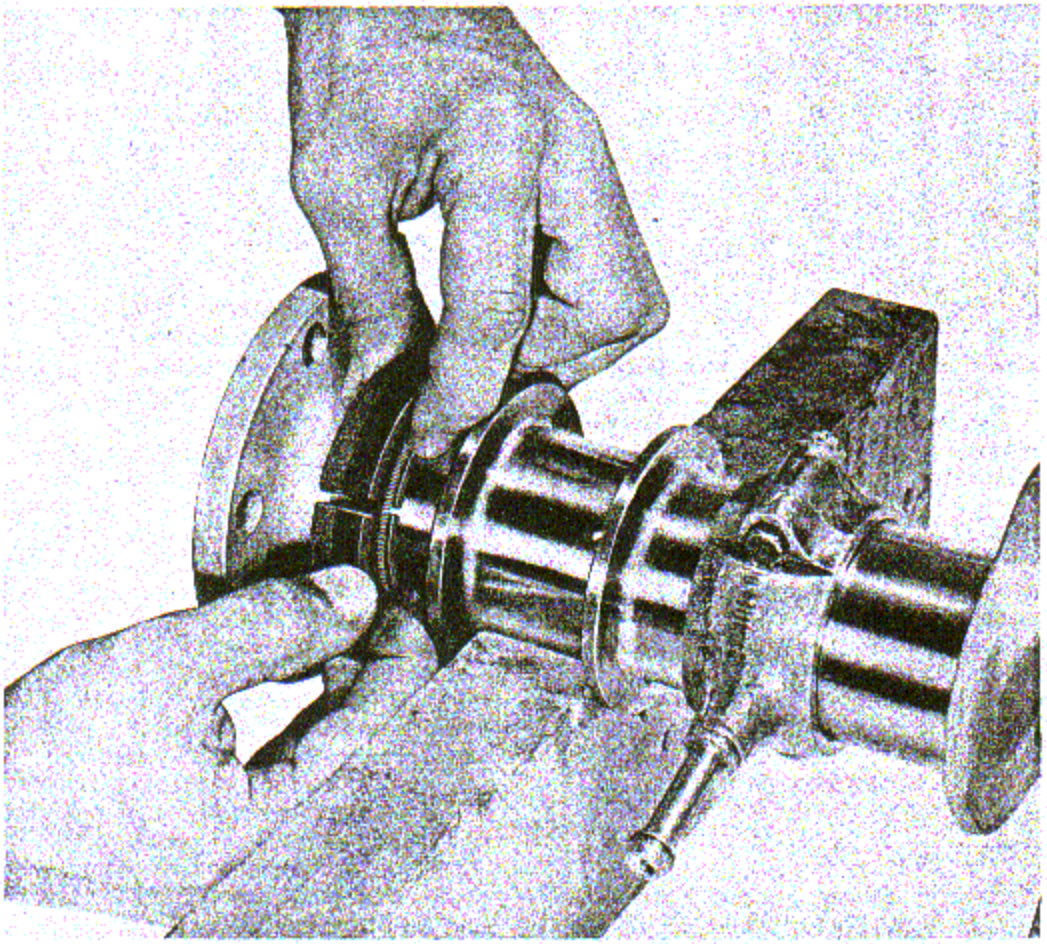


Figure 6-6. Installing Crankshaft Oil Seal Spring

CAUTION

If a new connecting rod is included in the set, it and other rod assemblies must be weighed to make sure that the difference between the lightest and heaviest in the set does not exceed 1/4 ounce. Stamp position number on any new rod and cap in the same location as on original parts.

b. Snap a new bearing insert into each rod and each cap. Tangs will locate them sidewise. Ascertain that ends of each insert project equally and only very slightly above parting surface of rod and cap. If not, the interference with seating must be removed.

c. Lubricate each crankpin and each connecting rod bearing with Sunoco Way Oil (Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.) before installing rod assembly.

d. Install No. 1 connecting rod between counterweight and rear journal with numbered rod and cap bolt bosses on top and the rod extending to the right. Start two bolts in through cap. Before installing hex nuts, spread a film of anti-seize compound, Specification MIL-C-5544, on bolt threads. Tighten nuts only with fingers.

e. Install remaining connecting rods, in numerical order, following the procedure in step "d." Numbered bosses must be on top and No. 3 and 5 rods extending to the right and the No. 2, 4, 6 rods extending to the left.

f. Use a torque indicating wrench and a suitable length of extension to drive a 1/2-inch hex socket; then start at No. 1 rod and progressing forward, tighten all cap bolt nuts to a torque within limits specified in Table of Tightening Torques, Section X. (Refer to paragraph 6-15 regarding slot alignment.) (See figure 6-4 for method of holding rod and maintaining torque wrench alignment.)

6-40. CRANKSHAFT OIL SEAL.

6-41. Remove spring from a new oil seal assembly and unhook its end loops. Spread a film of Gredag No. 44 grease on seal lip and on parting faces at the split. Twist seal and pass it over crankshaft just behind propeller flange, with spring recess away from flange, as illustrated in figure 6-5. Straighten up seal, and bring its parting faces together. Pass spring around shaft on recessed side of seal, and hook its ends together. Turn spring so that joint is opposite seal split (180 degrees away). Lift spring into recess at split line, and work both ways from that point until entire spring lies in deepest part of recess (See figure 6-6.) Make certain seal lip is in contact with shaft's polished race all around, that it is adequately lubricated and that seal ends are in contact at the split.

SECTION VII

FINAL ASSEMBLY

7-1. GENERAL.

7-2. Refer to paragraph 6-1 for general lubrication instructions, paragraph 6-8 for tightening instructions and paragraph 6-11 for instructions relative to safety devices. Instructions in paragraph 6-5 are also applicable to work described in this section.

7-3. PREPARATION OF ASSEMBLY STAND.

7-4. Use transportation stand (Section III, tool group 9) for final assembly. Roll the stand into position and lock brake on each end. Position mount bracket adapters to allow sufficient space at both ends for installation of other subassemblies. Tighten adapter bolts. Turn cradle to position shown in figure 7-1.

7-5. FINAL ASSEMBLY OPERATIONS.

7-6. CRANKCASE.

a. Attach left crankcase assembly to engine stand and support the case on a steel pipe of suitable length to hold the parting flange in the horizontal plane as shown in figure 7-1.

b. Lubricate six hydraulic valve lifter assemblies with oil and install the assemblies in guides of left crankcase.

c. Lubricate and install other six hydraulic valve lifters in guides in right crankcase. As each pair is installed, loop a discarded cylinder base packing around bodies under cam followers, and pass rubber ring out through adjacent cylinder opening. Cross ring and pass it around pushrod housing flange installed below opening to produce a side force on lifters and prevent them from falling out while case is being installed.

d. Spread only a thin, uniform film of lightweight Tite Seal in crankshaft oil seal counterbores of each crankcase casting.

e. Lubricate all main crankcase bearings with corrosion-preventive compound or with castor oil, Federal Specification JJJ-C-86, if testing will immediately follow reassembly. With assistance of another person, lift the crankshaft subassembly directly above its working position above left crankcase with No. 1, 3, 5 connecting rods on top. Keep shaft horizontal as it is lowered and guide even-numbered connecting rods through cylinder openings. As shaft approaches its seated position, adjust it endwise so that its thrust flange will clear thrust bearing. Guide oil transfer sleeve tube and its "O" ring into proper case hole; then adjust crankcase oil seal so that its split will lie inside case counterbore approximately 5/8-inch from parting surface. Seat seal fully in counterbore before letting shaft all the way down.

f. Lubricate camshaft bearings in left crankcase and lay camshaft in position.

g. Measure end clearances of crankshaft and camshaft in their thrust bearings. (Refer to Ref. No. 34 and 52, Section X.)

h. Spread a thin, uniform film of No. 3 Aviation Permatex gasket compound (Permatex Inc., P.O. Box 1, Brooklyn 5, N.Y.) on top and bottom parting flange surfaces inside bolt holes. Do not allow compound to enter flange bolt holes or crankcase interior. Lay a length of No. 50, Grade A thread on each parting flange. Thread must lie inside bolt holes but clear of edge, as illustrated in figure 7-1. If bottom flange thread is carried across drain openings, clip it after completion of crankcase assembly and before turning it upright. Allow threads to overhang slightly at rear end and lead them off flanges in contact with crankshaft oil seal at front end. Clip off overhanging portions after other half of crankcase has been installed.

i. While a second person holds up odd numbered connecting rods, lower right crankcase subassembly into position on left crankcase, taking care to guide crankshaft oil seal counterbore over oil seal without displacing it. This procedure will be made easier if No. 5 rod and crankpin are directly above shaft and if other two are balanced in upright position so that helper can reach through cylinder openings and grasp them just as No. 5 rod enters its opening.

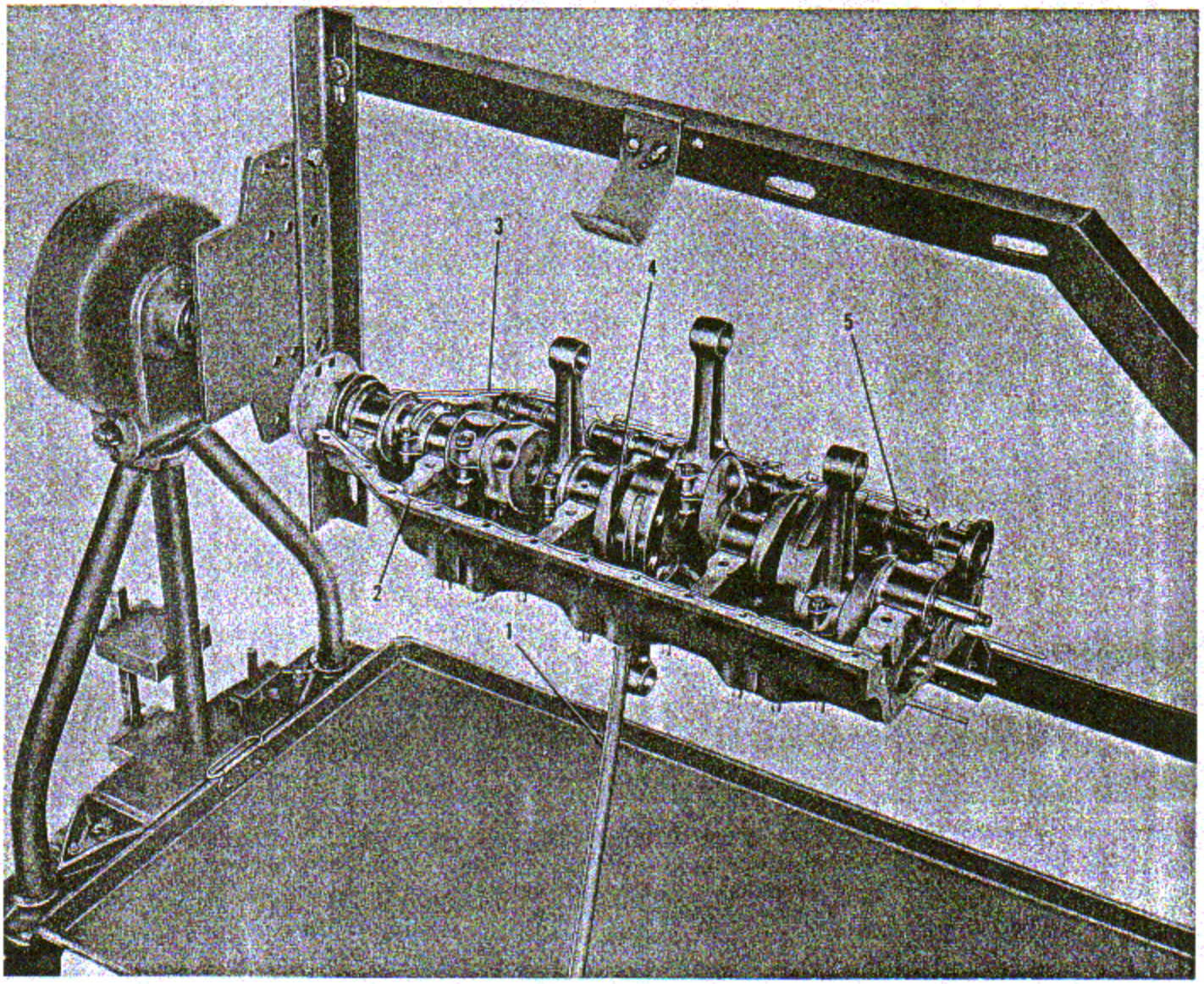
j. Insert eight through bolts (2, figure 7-2). Use a rubber or rawhide mallet and tap lightly to drive bolts through case until they project equally on both sides.

k. (See figure 7-2.) Install four sets of through bolt washers, spacers and flanged nuts, two sets on the upper ends of front through bolts (2) and other two sets on lower ends of those at rear. Do not install nut locks at this time.

l. Install seven sets of 5/16-in. attaching parts (10) in the bottom flange holes ahead of rear mount bracket and two sets of 1/4-in. attaching parts (11) in two front holes of bottom parting flanges. Similarly install nine sets of 1/4-in. attaching parts in the upper flange holes, excepting 4th, 5th and 6th holes from rear. In the 4th and 5th holes install lifting eye (6) and its two sets of attaching parts (5) and in 6th hole install primer distributor assembly (4) and its attaching parts (3). Install two 3/8-in. hex head bolts (1) above and below thrust bearing; then install plain washers and flanged hex nuts.

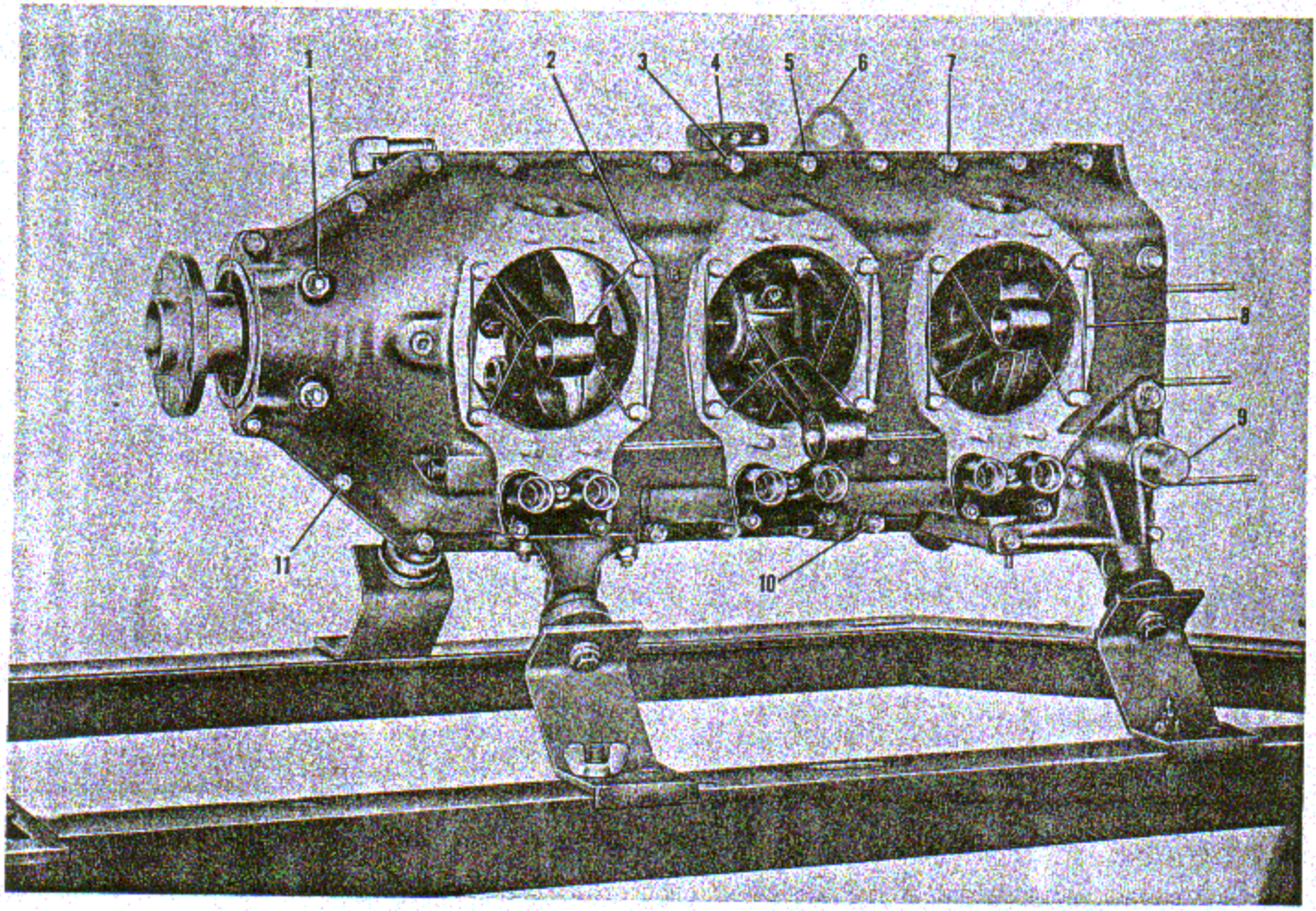
m. Attach right front and rear mount brackets to cradle adapters.

n. Tighten all nuts on case-to-flange bolts, through bolts, excepting headless through bolts and all rear mount bracket attaching nuts. (Refer to Table of Tightening Torques, Section X.)



1. Crankcase left half support
2. Silk thread
3. Silk thread
4. Crankshaft
5. Camshaft

Figure 7-1. Left Crankcase Half, Crankshaft and Camshaft on Engine Stand



1. Hex head bolt, washers, flanged nut, nut lock
2. Through bolt
3. Bolt, washers, spacer, nut, nut lock
4. Primer distributor assembly
5. Bolt, washers, nut, nut lock
6. Lifting eye
7. Bolt, washers, nut, nut lock
8. Cylinder base packing
9. Oil pressure relief valve and cap
10. Bolt, washers, nut, nut lock
11. Bolt, washers, nut, nut lock

Figure 7-2. Completed Crankcase Assembly

7-7. ACCESSORY CASE FRONT HALF.
(See figure 7-3.)

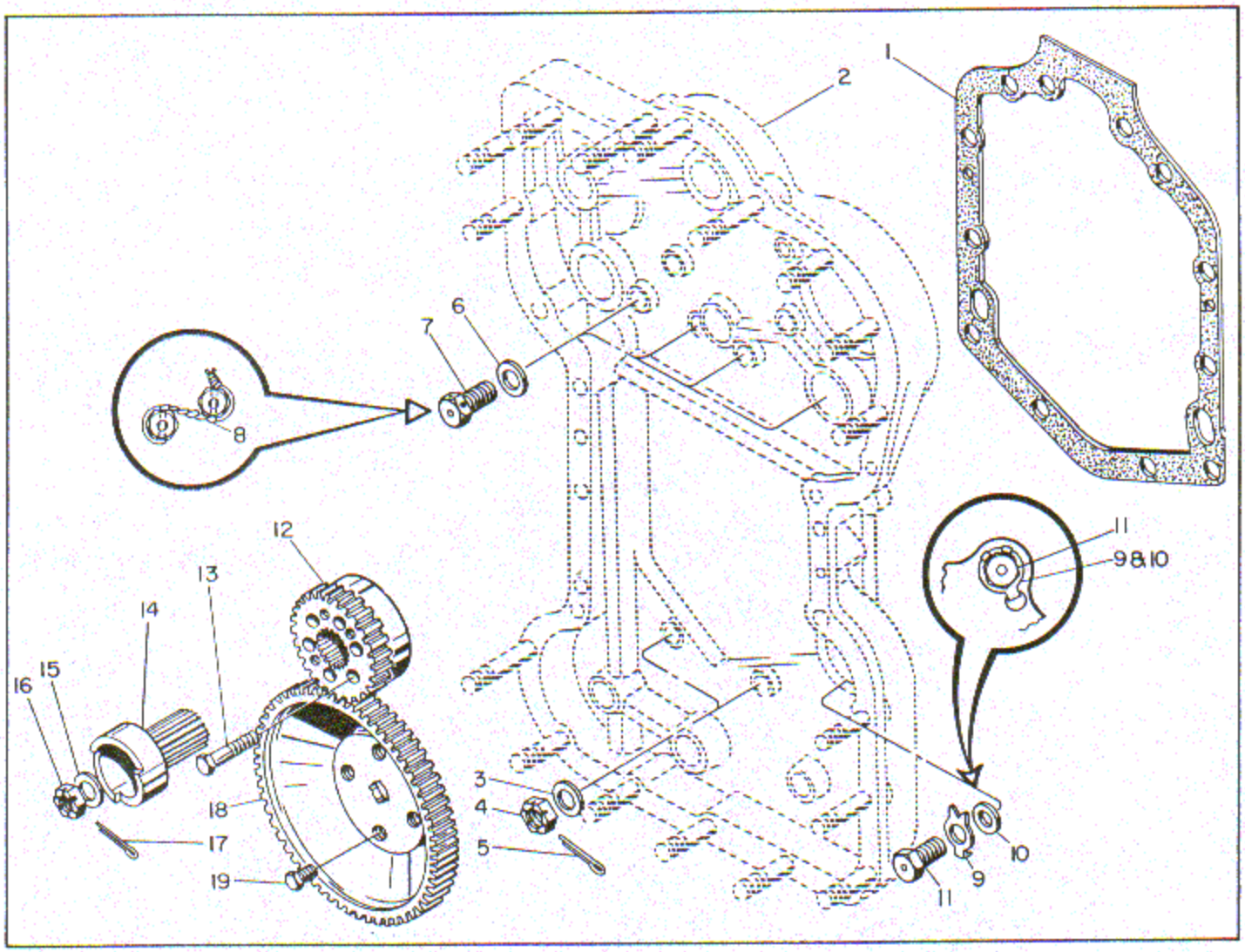
a. Place a new gasket (1) on crankcase studs and dowels.

CAUTION

Make certain that gasket is placed on the crankcase so that the oil hole in gasket matches the oil hole in the right crankcase.

b. Slide case assembly over studs to seat on gasket all around.

c. Install two sets of attaching parts (3, 4) one bolt and washers (9, 10, 11) and four bolts and washers (6, 7); then tighten in stages on opposite sides of casting until all parts have been tightened within specified torque limits before installing safety devices (5, 8). Make sure that lug of tab washer (9) is seated in casting hole near bolt hole. After tightening bolt, bend tabs of tab washer beside bolt head. Notice how lockwires are installed to lock each pair of upper attaching bolts. Tighten oil drain hose nipple in bottom.



1. Gasket
2. Accessory case front half
3. Plain washer
4. Castel nut
5. Cotter pin
6. Plain washer
7. Drilled head bolt
8. Lock wire
9. Tab washer
10. Plain washer
11. Drilled head bolt
12. Pinion gear
13. Drilled head screw
14. Starter jaw
15. Special plain washer
16. Castel nut
17. Cotter pin
18. Camshaft gear
19. Drilled head bolt

Figure 7-3. Attachment of Accessory Case Front Half and Timing Gears

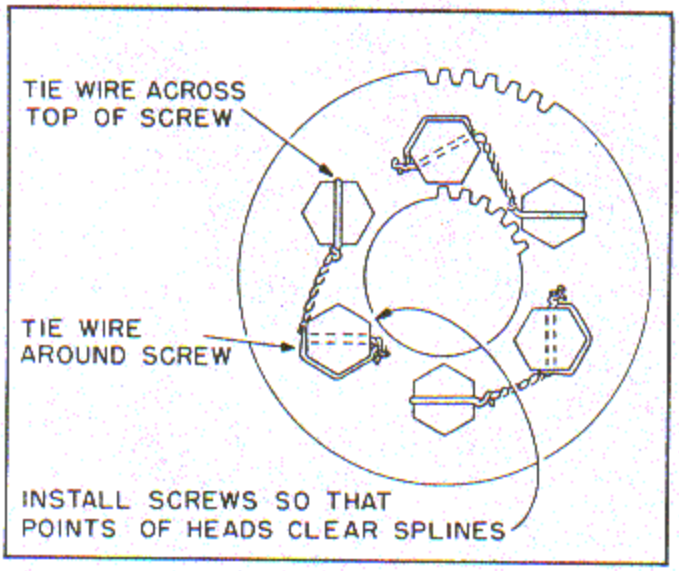


Figure 7-4. Positions and Lockwiring of Pinion Gear Attaching Screws

7-8. TIMING GEARS.

a. Install pinion gear (12) and attaching screws (13) first. Crankshaft dowel assures correct positioning of gear on shaft. Refer to figure 7-4 for precaution regarding screw head positions and for correct installation of lockwires. Refer to Ref. No. T6, Section X, for tightening torque limits.

b. Lubricate starter jaw and pinion gear with corrosion preventive compound; then install jaw on crankshaft stud in any radial position and install attaching parts. Refer to Ref. No. T9, Section X for tightening torque limits.

c. Turn crankshaft until timing marks on pinion gear are at bottom. Turn camshaft until screw holes in flange align with unequally spaced holes in gear, when gear is held so that timing punch marked tooth will mesh between punch marked teeth on pinion gear; then attach gear with four bolts (19). Tighten bolts alternately in several steps to the torque specified in Ref. No. T7, Section X, and secure in pairs with lockwire.

7-9. CYLINDERS AND PISTONS. There is no fixed

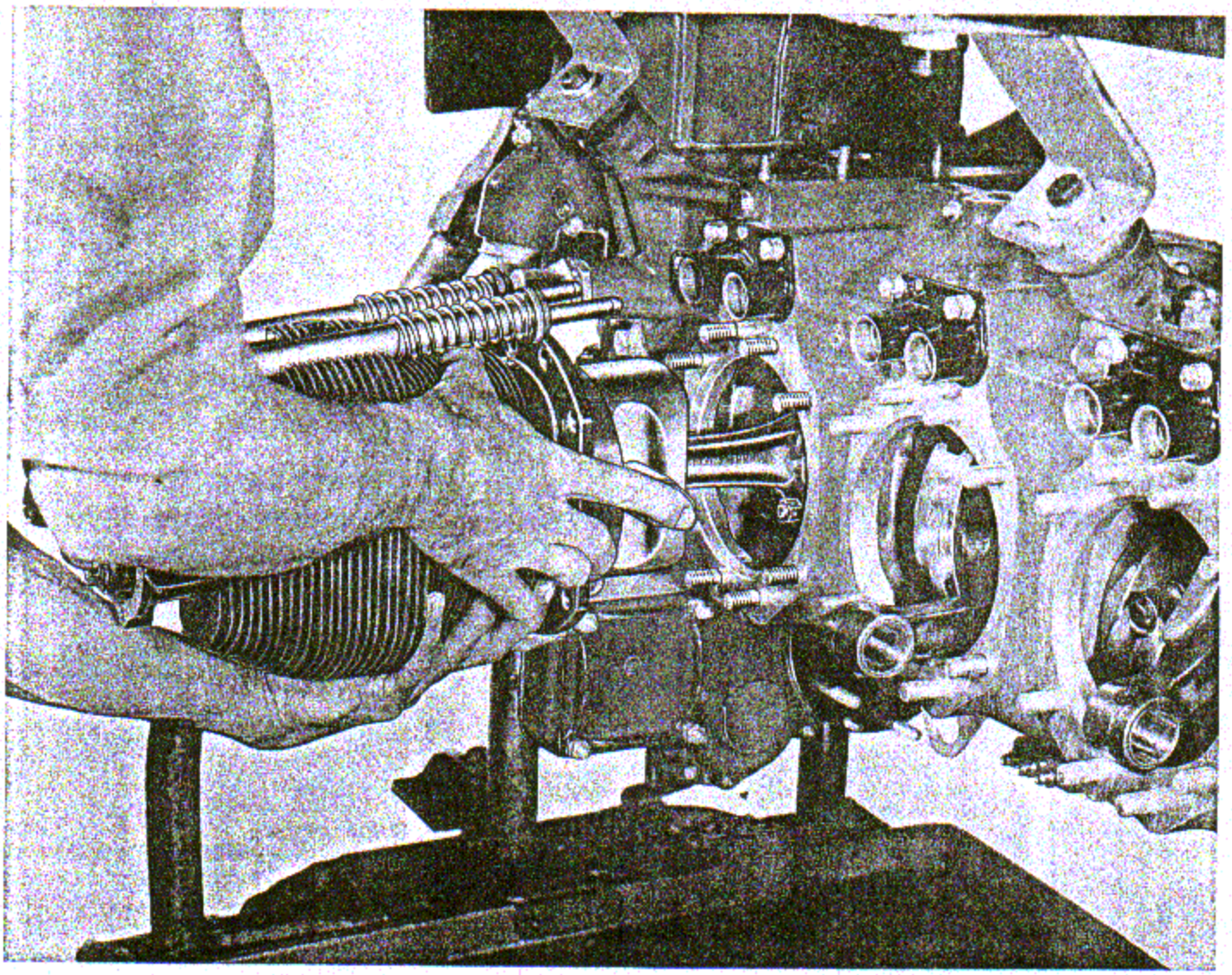


Figure 7-5. Installing Cylinder, Piston and Valve Train Assembly

order of cylinder installation, however to facilitate installation the left side of each cylinder should be clear since piston pins will be pushed into position from the left side. If cylinder, piston and valve train are to be installed as a unit, proceed as follows:

a. Invert engine, then turn crankshaft until connecting rod for first cylinder is at top dead center.

b. Lubricate rod housing. Push piston pin out of piston just enough to clear rod, and install piston and cylinder assembly, as illustrated in figure 7-5, by pushing pin through rod bushing and cylinder into crankcase.

c. Guide pushrods and seals into flanges on crankcase. If valve lifters are full of oil it will not be possible to seat cylinder base flange fully. Draw down with cylinder base nuts. Pressure of valve springs will bleed down lifters within a few minutes.

d. Tighten base nuts snug with a box end wrench. When all cylinders have been installed, use a torque indicating wrench and the special cylinder base nut wrench, tool group 4, to tighten all base nuts to the torque specified in Ref. No. T4, Section X, starting at No. 1 position in the diagram in figure 7-7 and proceeding in ascending order of sequence numbers. Finally, start at No. 1 position, and proceed in the clockwise direction around the base, again tightening to specified torque. Both nuts on crankcase through bolts must be tightened as described.

e. After tightening all cylinder base nuts on the engine, install nut locks snug with fingers; then 1/6 to 1/4 turn with a wrench.

7-10. If piston assembly, cylinder and valve assembly and valve train parts are to be installed separately proceed in the following manner:

a. Lubricate pushrods as described in paragraph 6-34, step "a".

b. Lubricate piston, rings and piston pin assembly and cylinder walls. (Refer to paragraph 6-34, step "g".)

c. Turn crankshaft until connecting rod on which first piston is to be installed is at top dead center.

d. Install piston assembly on connecting rod, with pin centered. Part number stamped on piston head should be on top and position number toward propeller end of engine. (Refer to figure 1-4 for cylinder position numbers.)

e. Stagger piston ring gaps so that slotted oil control ring gap is on top and the other two at equal angles from it and each other.

f. Hang piston ring compressor, tool group 16, on connecting rod. Cradle cylinder and valves assembly in arm. Work ring compressor into position on rings, and compress them firmly; then push cylinder over piston. (See figure 7-6.) Remove ring compressor, and seat cylinder on crankcase.

g. Install eight cylinder base nuts, and tighten snug with box end wrench.

h. Assemble pushrod housing parts, as described in paragraph 6-34 step "i". Compress spring with compressor, tool group 17, claws grasping housing flange and end of spring (not seal and washer). (See figure 7-8.) Insert end of housing and seal into

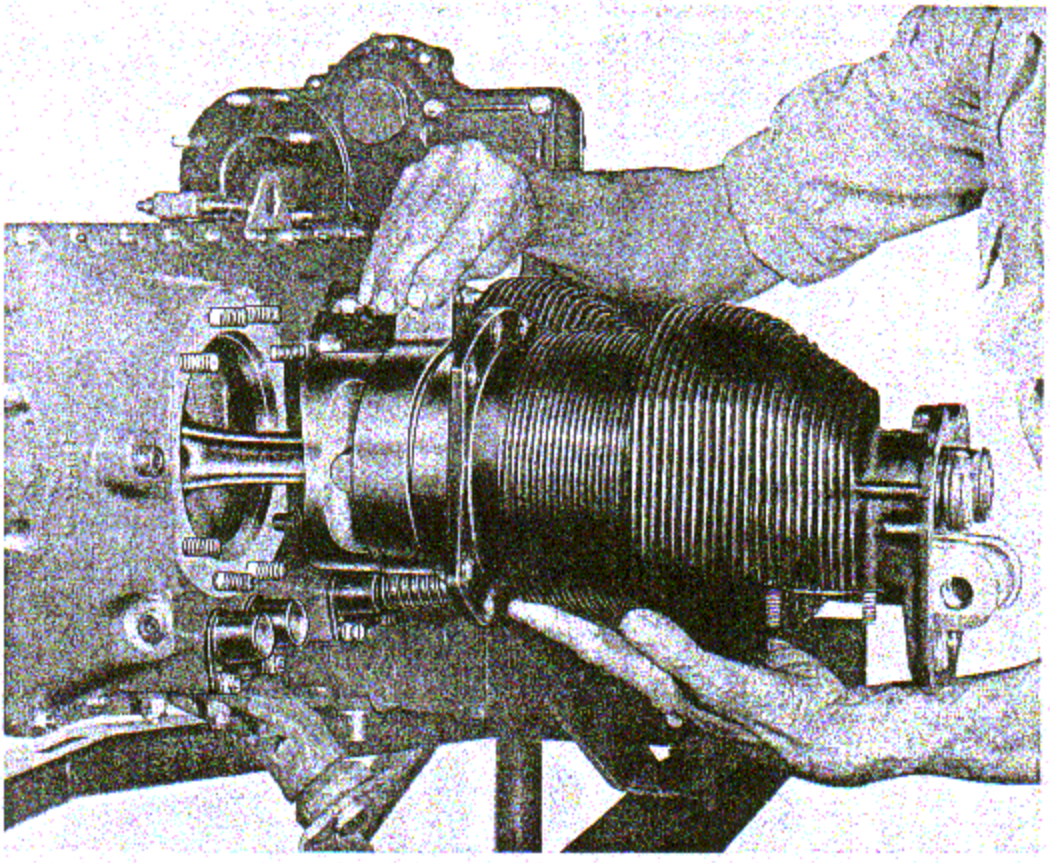


Figure 7-6. Installing Cylinder and Valve Assembly Alone

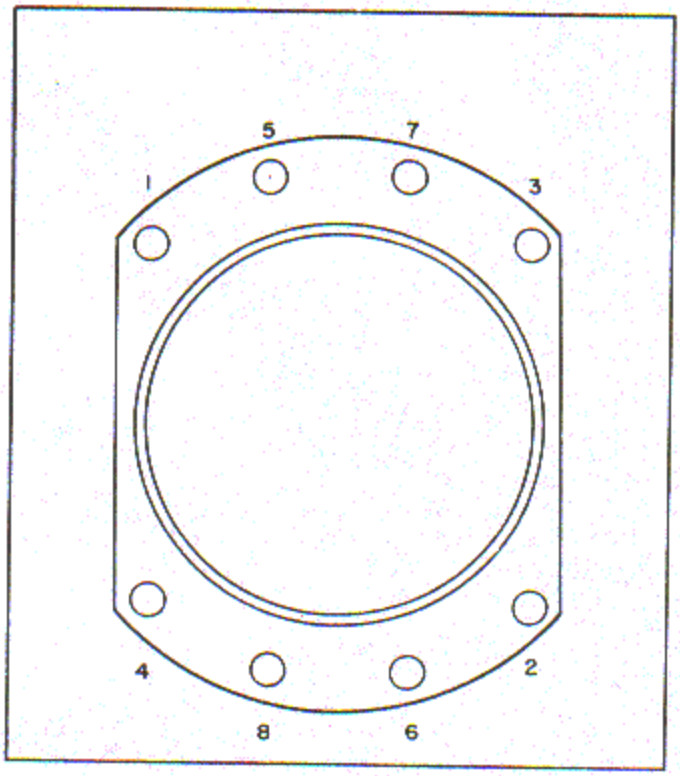


Figure 7-7. Cylinder Base Nut Torque

flange on crankcase; then swing outer end of housing into line, and release pressure on spring slowly as housing and outer seal are guided into rocker box hole. (See figure 7-8.) If such a tool is not available invert engine, insert end of housing and seal into flange; then compress spring by pushing on end of housing (See figure 7-9) then guide other end into rocker box hole before releasing spring.

i. Plug elevated ends of two pushrods in oil pan, and insert opposite ends through housings to seat in lifter sockets.

j. Use pressure relieving tool, tool group 18, and compress valve springs. Slide rocker shaft out clear of either recess, and install lubricated assembly of valve rocker and bearing; then push shaft other way and install other rocker assembly. If rocker support and shaft are drilled for a retaining screw, align shaft hole with hole in the support; then return shaft to working position and release Rotocaps and valve springs. Install shaft retaining parts.

k. When all cylinders have been installed tighten all cylinder base nuts to specified torque as described in paragraph 7-9, step "d".

NOTE

In order to observe valve action during magneto timing, valve rockers should not be installed until magneto timing has been accomplished.

7-11. ACCESSORY CASE REAR HALF.

a. Turn crankshaft until No. 1 piston is near bottom center.

b. Install a Time-Rite piston position indicator, Air Force Stock No. 7800-438860, equipped with a scale and contact arm specified for this engine model, into No. 1 cylinder upper spark plug hole. Mount arm so that hook will point away from piston when installed in cylinder. Screw shell snug; then insert cap and arm assembly, and turn so that scale is

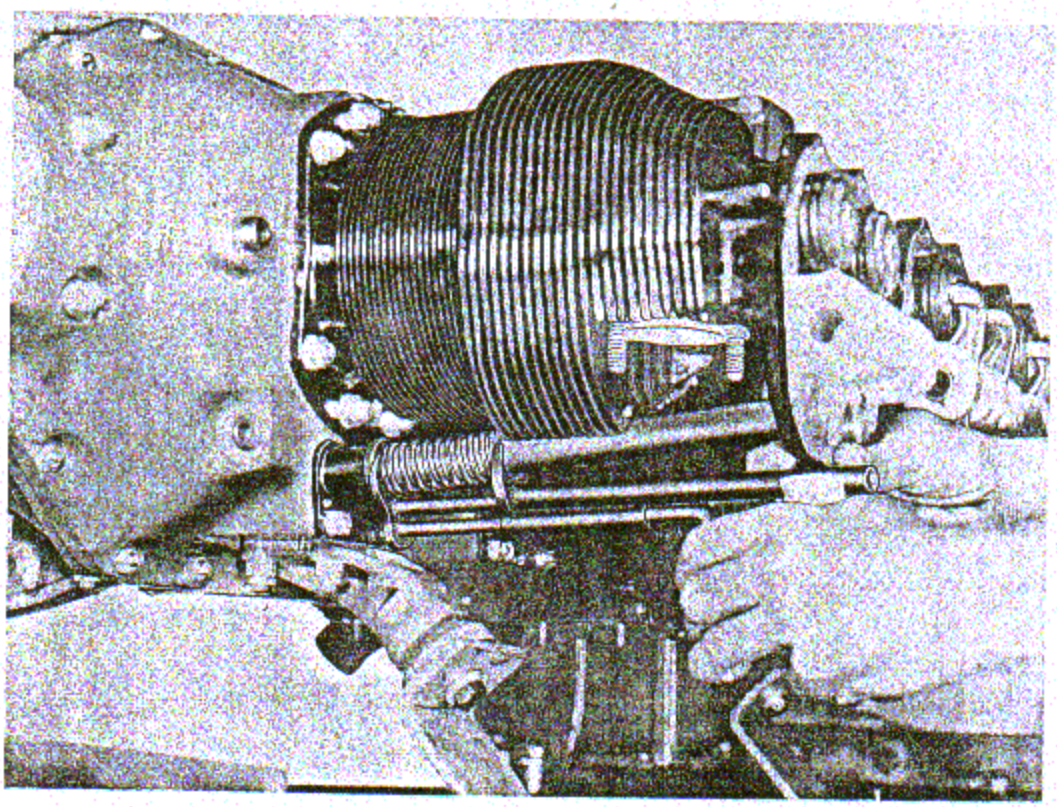


Figure 7-8. Installing Pushrod Housing Assembly

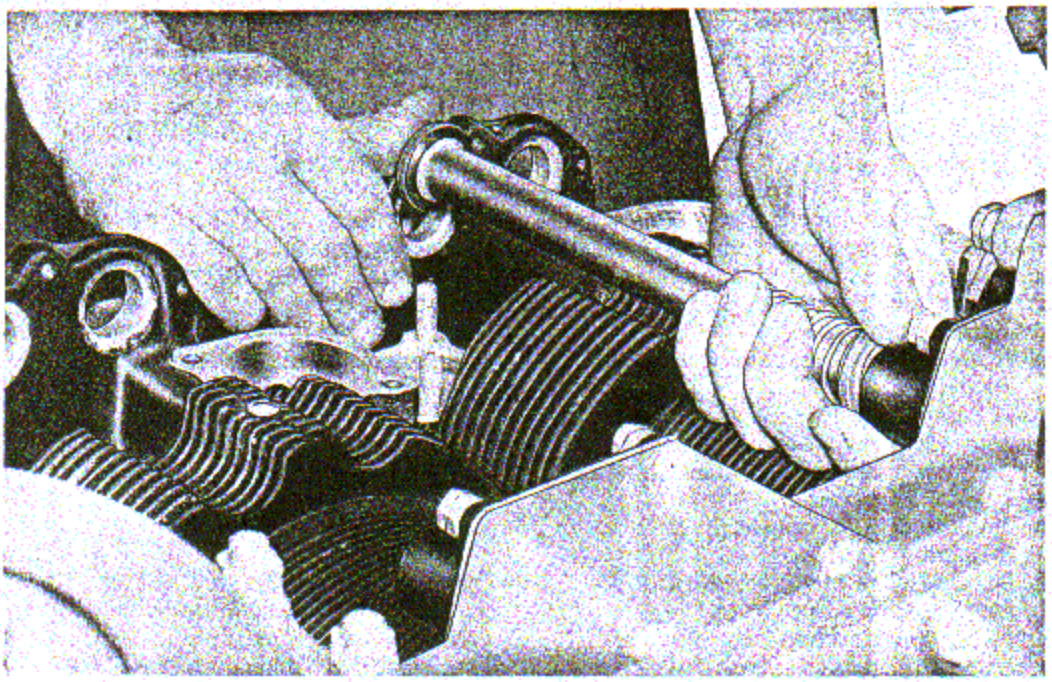


Figure 7-9. Installing Pushrod Housing Assembly

above slide slot and points to nearest rocker cover attaching screw hole in rocker box flange.

c. Move Time-Rite plastic slide down part way in slot. Turn crankshaft forward (counterclockwise in front view) until No. 1 piston has passed over top dead center, leaving Time-Rite slide at high point of its travel. Turn shaft backward or forward until No. 1 piston is about midway on its compression stroke with both valves fully closed. Move Time-Rite scale until its zero mark aligns with index mark on side.

d. Move Time-Rite slide down into contact with arm. Indicating lamp should be illuminated. If not, replace battery and/or bulb, as necessary, and repeat step "c"; then place slide so that its index mark is aligned with 26-degree mark on scale.

e. Turn crankshaft forward, tapping turning tool gently in last few degrees of movement, until Time-Rite lamp is illuminated. No. 1 piston is now at firing angle. Move Time-Rite slide away from arm to save battery.

NOTE

If Time-Rite instrument is not available, No. 1 piston and crankpin positions can be determined by aligning crankcase split line with one of the seven marks on edge of propeller mount flange. (End marks are numbered "20" and "32", and each mark represents two degrees of shaft rotation.)

f. Place new gasket on accessory case front half studs and dowels.

g. Hold accessory case rear half assembly in mounting position behind front half, and turn upper tachometer drive gear until sides of wide slot in rear end of left magneto drive gear are vertical and slot in right gear shaft horizontal.

h. Slide accessory case rear half assembly forward over studs, and turn fuel pump idler gear, lower hydraulic pump drive gear and oil pump drive gear until they will mesh with camshaft gear. Turn upper tachometer drive gear as little as possible either way to nearest meshing point, so as to keep magneto drive gears in positions located in step "g". As case approaches gasket, turn lower tachometer drive shaft from rear end to mesh with hole in camshaft gear. Seat case assembly on gasket.

CAUTION

Watch starter oil seal as it passes over starter jaw to make sure that lip is not damaged or reversed. Accessory case rear half must be parallel to front half at this stage.

i. Attach accessory case rear half with plain washers, lock washers and plain hex nuts on all studs projecting rearward around parting flange and on two studs projecting forward in line with lower magneto attaching studs; then tighten in several stages alternately at opposite points moving clockwise.

NOTE

Leave Time-Rite indicator in position until magnetos have been installed and timed.

7-12. GENERATOR DRIVE. Place a new gasket on pad at upper right corner of accessory case front side, and lubricate gear in drive assembly with corrosion-preventive compound before installing. Turn gear shaft to mesh teeth as adapter is moved into position on studs. Attach with two plain and lock washers and hex nuts.

7-13. STARTER ADAPTER. (See figure 4-7.) Place a new gasket (24) on accessory case studs and dowels. Install adapter (23) and two sets of attaching parts (20, 21, 22).

7-14. OIL SUMP. (See figure 4-6.)

a. Invert engine cradle and lock it in position.

b. Invert sump assembly and lower into position on crankcase guiding rear drain nipple hose (13) onto accessory case nipple, its upper inlet tube and seal (11) into crankcase rear drain hole and its bracket holes over crankcase studs. If necessary loosen clamps (12) to facilitate installation.

c. Attach sump assembly with six sets of attaching parts (2, 3, 4).

d. Place the two sump side support brackets (7) in position and attach with bolt (5) and washer (6).

e. Space rear drain hose on accessory case and sump nipples and tighten two hose clamps.

f. Push oil suction tube hose connector over oil pump adapter. Tighten hose clamps.

g. Coat threads of plug (16) with Led Plate No. 250 and screw it into suction oil screen.

h. Connect oil pump discharge hose assembly to oil pump discharge elbow and crankcase connection elbow. Attach hose to right sump support bracket with two hose clamps, bolt and self-locking nut.

7-15. INDUCTION SYSTEM. (See figure 4-5.)

a. Place new manifold gaskets (8, 9) on crankcase studs.

b. Place inverted manifold casting (20) on its mounting pad gaskets with bolt holes aligned.

c. Swing oil sump front support into position over left rear manifold bolt hole. Install attaching parts (4, 5, 6, 7) and tighten evenly to torque specified in Table of Tightening Torques, Section X. Lockwire front and rear bolts in pairs.

d. Tighten oil sump to front support bracket bolt and secure it to tube with lockwire.

e. Push sump to oil drain manifold hose connector forward so that it covers equal portions of each tube end. Tighten hose clamps. It should be impossible to turn hose by hand if clamps are properly installed and hose is dry.

f. Push curved end of each tube (12) into its cylinder port and align loose flange and cylinder bolt holes.

CAUTION

It is important to maintain perfect roundness of intake tube ends. Any distortion of tubes due to rough handling or overtightening of clamps will allow air leakage into manifold, regardless of clamp tightness. Lean mixtures caused by such leaks may result in severe damage to the engine.

g. Attach each flange to cylinder with two sets of attaching parts (1, 2, 3).

7-16. CARBURETOR. Install a new carburetor to manifold gasket on studded manifold pad. Check carburetor for installation of all plugs and fuel inlet and vent line fittings required for testing. Invert carburetor and place it on pad gasket. Install four sets of washers and nuts. Tighten nuts securely; then install nut locks. Cover carburetor bottom flange with a suitable stiff cover to keep out dust.

7-17. FUEL PUMP. While engine is inverted, install fuel pump on accessory case mounting pad over a new gasket. Attach pump with four plain washers, plain nuts and nut locks.

7-18. PRIMING SYSTEM. Turn engine upright and lock it in this position. Coat threads of six union nipples installed in primer distributor, four nipples and two elbows installed in cylinders with antiseize compound, Specification MIL-T-5544. Attach six priming tubes between primer distributor union nipples and fittings in cylinder head. Attach long, narrow tube support to cylinder baffle member on left bank and short support to similar member above right bank. Rubber tube protectors lie atop supports and wavy clamps over them. Attach clamps with two screws and speed nuts.

7-19. MAGNETO INSTALLATION.

a. Place crankshaft in advance firing position of No. 1 piston, as described in paragraph 7-11.

b. Inspect positions of wide slots in rear ends of magneto drive gear shafts. Sides of left gear slot should be verticle and right gear slot horizontal.

c. Insert pressed steel retainer in slot of each magneto drive gear and two rubber coupling bushings in each retainer, with long rounded edges inward to fit retainer corners and rounded short edges each side of cut-out exposed to guide magneto drive lugs in.

d. Place new gasket on each magneto adapter.

e. Remove hex head inspection plug from top of magneto case. While looking into inspection hole, turn magneto drive coupling backward, so that latches will not engage stop pin in case, until white distributor gear tooth aligns with pointer inside case.

f. Hold magneto in mounting position behind either adapter, and verify alignment of drive lugs with slot between rubber coupling bushings. Slight force will be required to insert lugs between new bushings. Attach magneto with special flat washers and hex nuts. Tighten nuts only enough to prevent side play, while permitting rotation of magneto case.

g. Install second magneto in same manner as described in steps "e" and "f".

7-20. MAGNETO TIMING.

a. Install a test lead, made up of Scintilla terminal parts and a short length of insulated, stranded wire cable, in either magneto grounding switch terminal.

b. Place a timing light instrument, Scintilla No. 11-851 or equivalent, on engine so that its lamps can be seen from accessory case end. Connect one red test lead clip to magneto test wire, or one to each magneto if both are equipped with test wires. Connect black "GRD" lead of instrument to a stud or other unpainted engine part. If powered by alternating current, connect power cable of timing light instrument to AC outlet. Place instrument switch on "ON" position.

c. Rotate magneto case to clockwise limit allowed by slotted mount flange holes. Timing indicator lamp will be illuminated if magneto gear and shaft positions are as described in paragraph 7-19.

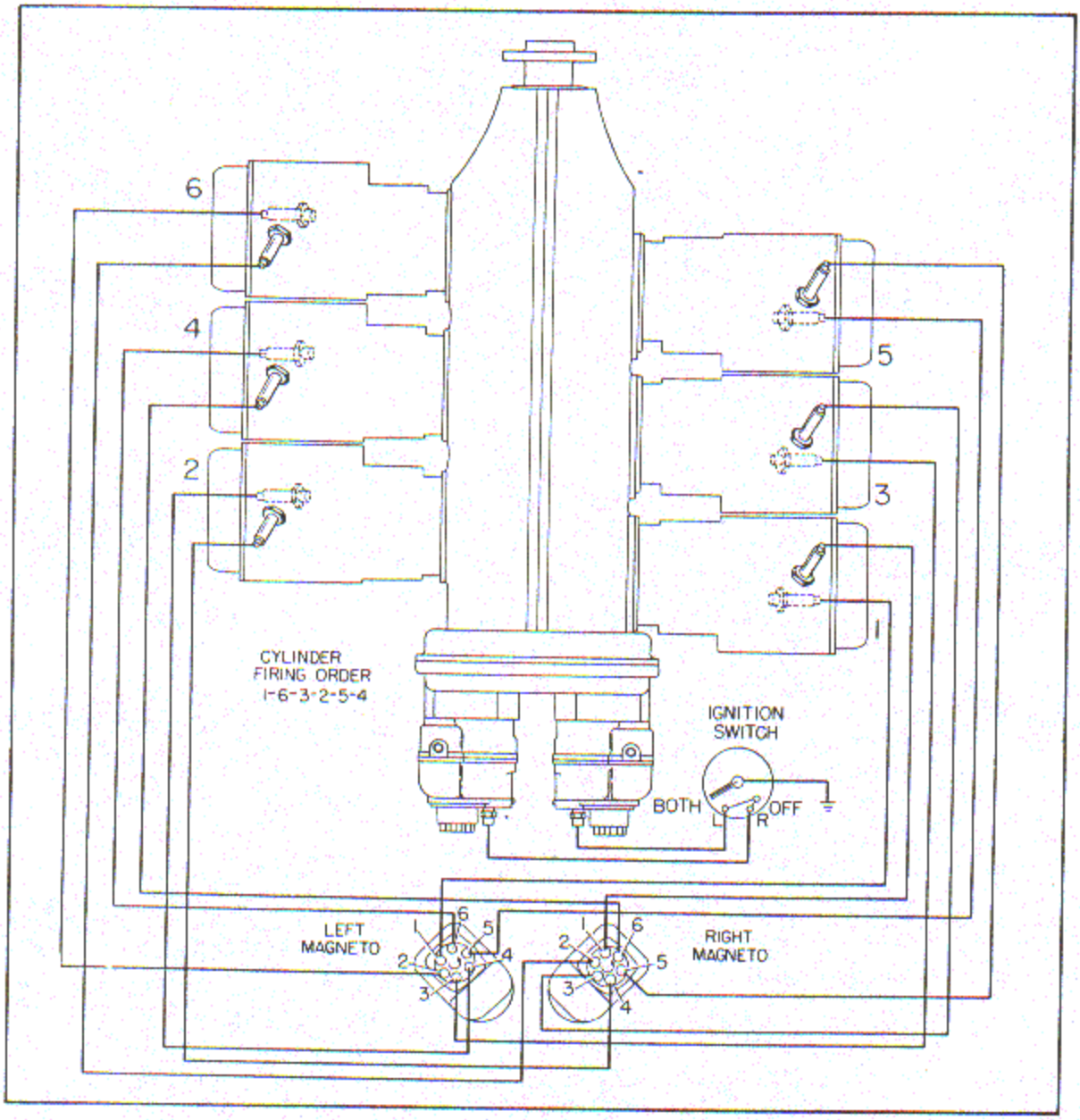


Figure 7-10. Ignition Wiring Diagram

d. Tap magneto case counterclockwise with non-marring hammer until timing indicator lamp is extinguished, indicating opening of magneto breaker points.

e. Tighten magneto attaching nuts without shifting position of case.

f. If instrument has two red leads and indicator lamps, proceed to time the second magneto in same manner as described in steps "a" through "e". If not, switch lead and proceed as described in steps "a" through "e" above. Both magnetos must be timed to fire at 26 degrees before top center.

g. Back up crankshaft not over four degrees. Make sure that Time-Rite slide index mark is on 26-degree mark; then tap crankshaft turning tool forward (counterclockwise in front view) until Time-Rite lamp is illuminated. If magneto timing is correct, timing light instrument lamp will be lighted at same instant. If it is not, check for error in procedure before changing magneto position. If crankshaft is backed up too far, magneto latches will engage stop pin and hold back rotor, preventing opening of breaker points at advanced firing angle. If Time-Rite scale has been moved it will not indicate correct crankshaft angle and must be readjusted, as described in paragraph 7-11.

7-21. SPARK PLUGS. Immediately before screwing spark plug into a cylinder head, substitute washer-type thermocouples for copper gaskets under each downstream spark plug until completion of the test run. Use of mica thread lubricant on spark plug threads is optional. If applied, make sure that none gets on gasket or plug sealing surfaces or on elec-

trodes. Tighten spark plugs only with a special spark plug type deep socket, extension and torque indicating wrench. Apply torque specified in Ref. No. T8, Section X.

7-22. VALVE ROCKER COVERS. Assemble seven sets of fillister head screws, internal tooth lock washers and plain washers for each valve rocker cover. Place eight sets in each cover and lay a new cover gasket on top. Lay these cover sets on cylinders; then install each of them, and tighten screws moderately. Avoid over tightening.

NOTE

It is advisable to squirt corrosion preventive oil mixture on moving parts in each rocker box immediately before installing cover.

7-23. IGNITION HARNESS. Attach harness assembly with longest conduit and connector assembly (44 inches) to right magneto and lead conduits to lower spark plugs. Attach other harness assembly to left magneto and lead conduits to upper spark plugs. (Refer to Table XVIII) for orientation of elbows on high tension outlet plates attached to magnetos.) If installed on wrong sides elbows will not assume these directions and cable lengths will be wrong. To check for correct connections refer to figure 7-10, where rear view of magnetos shows firing sequence of high tension outlet plate terminals by ascending numerical order of terminal numbers. Support each of two lower front spark plug cable conduits with single-cable rubber lined clamp attached to rear stud of pushrod housing flange below front cylinder and support three lower spark plug conduits on each side with triangular clamp connected to upper rear attaching stud of rear engine mount bracket. Clip sponge rubber lined band clamp around group of six conduits crossing between magnetos. Check condition of spring ceramic contact sleeve before inserting into each spark plug. Replace if cracked. Tighten conduit to spark plug elbow coupling nuts on spark plugs only enough to prevent rotation of elbows.

7-24. GENERATOR. Place a new gasket on drive adapter, and install generator so that its horizontal centerline bisects the blast tube and center terminal. The blast tube must be located on left side and terminals on the right when viewing installation from front of engine. Turn splined drive shaft to mesh with gear shaft splines. Attach with plain washers, plain hex nuts and nut locks.

7-25. STARTER. Place a new gasket on adapter, and hold starter in position, with cable terminals as illustrated in figure 8-1, while installing attaching parts. After tightening nuts install nut locks.

7-26. VACUUM PUMP. Install new gasket, then pump, in position illustrated in figure 8-1.

7-27. TACHOMETER GENERATOR. Install on pad below starter, as shown in figure 8-1.

7-28. COVERS AND CLOSURES. Install gasket, square cover and attaching parts on small tachometer drive pad above starter. Make sure that covers have been installed on upper hydraulic pump pad and at upper left on front side of accessory case. If engine is to be tested immediately, fittings required to connect test stand instruments may be installed in lieu of plugs specified in Sections VI and IX. All fittings must be covered with nonhygroscopic tape or with plastic caps to exclude grit and moisture. Oil line connection elbows and crankcase breather elbow must be similarly covered. Install oil gauge rod in sleeve at left side of oil sump.

SECTION VIII

TESTING AFTER OVERHAUL

NOTE

The instructions in this section and T.O. 2R-1-12 are applicable to and shall be followed by personnel engaged in the testing of Air Force aircraft engines after overhaul.

TABLE XV. SEA LEVEL POWER RATINGS

Rating Designation	Brake Horsepower	RPM
Take-off Power	213	2600
Maximum Continuous Power	190	2300
90% Rated Power	171	2220
80% Rated Power	152	2135
70% Rated Power	133	2045

TABLE XVI. MAXIMUM ALLOWABLE CYLINDER TEMPERATURES

Cylinder Part	Where Measured	Max. Allowable Temperature	
		°C	°F
Head	Downstream spark plug gasket	274	525
Head	Bayonet thermocouple in tapped hole in bottom of head (down draft cooling only)	232	450
Barrel	Barrel-to-flange fillet on downstream side of barrel (contact type thermocouple)	157	315

8-1. PREPARATION OF ENGINE FOR TEST.

8-2. DRESSING AND INSTALLATION. The equipment which is to be mounted on the engine for testing purpose may be installed while the engine is mounted on transportation stand, or after it has been attached to the test stand, whichever is more convenient for the

TABLE XVII. INSTRUMENT AND CONTROL CONNECTIONS

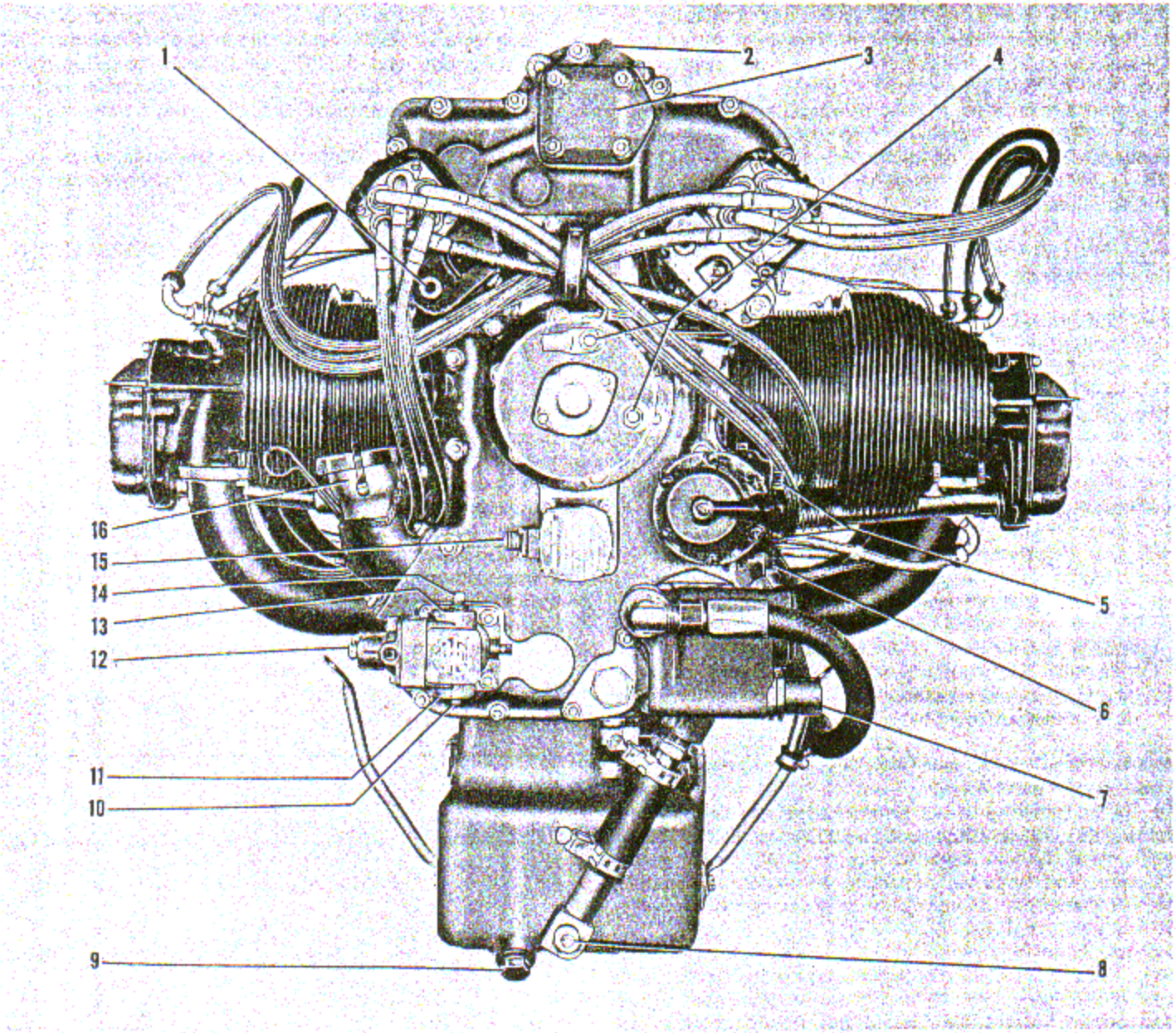
Item to be Connected	Connect to	Provision for Attachment	Special Instructions
Throttle control	Carburetor lever (13, figure 1-2)		
Manual mixture and idle cut-off control	Carburetor lever (16, figure 1-1)		
Magneto grounding switch	Magneto grounding cable sockets (1, figure 8-1)		
Manual priming pump	Primer distributor (4, figure 1-1)	1/8 in. pipe tapped hole	
†Oil cooler inlet hose	Adapter (12, figure 1-1)	3/8 in. pipe tapped hole	Only if oil supply will be carried in engine sump. (Refer to paragraph 8-5.)
††Oil cooler discharge hose	Front end of left crankcase oil gallery	3/8 in. pipe tapped hole	
Oil supply hose	Oil pump inlet port	AN840-16 hose to pipe thread adapter	Only if engine will be supplied with oil from an external tank. (Refer to paragraph 8-3.)
Scavenge pump inlet hose	Oil sump rear side	3/4 in. NPT hole	
Intake manifold pressure manometer	Top of intake and oil drain manifold	1/8 in. NPT hole	
Fuel supply hose	Fuel pump inlet port (11, figure 8-1)		

TABLE XVII. INSTRUMENT AND CONTROL CONNECTIONS (Cont.)

Item to be Connected	Connect to	Provision for Attachment	Special Instructions
Fuel pump to carburetor hose	Carburetor regulator cover	1/4 in. NPT hole	
	Fuel pump discharge port	1/4 in. NPT hole	
Fuel pump seal drain tube (Optional)	Bottom boss on fuel pump mounting flange	1/8 in. NPT hole	Install pipe thread to flared tube fitting in lieu of plug (10, figure 8-1).
Fuel pump vent (Optional)	Boss at top of pump mount flange	1/8 in. NPT hole	Install pipe thread to flared tube fitting in lieu of drilled plug.
Fuel pressure gauge	Carburetor regulator cover	1/8 in. NPT hole	Install coupling in lieu of plug (6, figure 8-5).
Oil pressure gauges	Side of each crankcase half	1/8 in. NPT holes	Install pipe thread to flared tube nipples (65, figure 2-2) in lieu of 1/8 in. pipe plugs
Oil temperature gauge	Oil cooler outlet	NOTE If thermostatic bypass is housed in piping external to cooler, provide capillary well in outlet pipe. If bypass is internal, install capillary in outlet header.	If external oil supply is used connect capillary type gauge by screwing bulb into 5/8-18 straight tapped hole in oil filter cap in lieu of plug (22, figure 1-1.)
Cylinder head temperature gauge	Gasket type thermocouples installed under downstream spark plug or bayonet type thermocouples screwed into tapped holes in bottom of cylinder heads		Connect thermocouple leads through a selector switch to the gauge, to read temperature of each cylinder head at frequent intervals until cooling system has been tested and equal cooling of cylinders has been verified.
Starter power cable from battery	One switch terminal of magnetic switch and connect a cable between terminal stud on top of starter and other switch terminal of magnetic switch	Spring lock washer and nut on 3/8-18 starter stud	Magnetic switch coil leads should be connected to a push button switch on control panel.
Battery negative terminal	Lower starter terminal (marked "GROUND")	3/8-18 stud, lock washer, nut	
Tachometer	Tachometer generator receptacle (15, figure 8-1)	Refer to drawing AN5547	

† Remove oil gallery adapter (12, figure 1-1), and install 5/8-18 hex hd plug and copper-asbestos gasket if engine is to be supplied with oil from an external tank.

†† Install a 3/8 in. pipe plug in left crankcase instead of hose if engine is to be supplied with oil from an external tank.



1. Magneto grounding switch cable terminal socket
2. Countersunk head pipe plug in governor oil discharge port
3. Governor mount pad cover
4. Starter power and grounding cable terminals
5. Shipping plugs in vacuum pump ports
6. Countersunk head pipe plug in accessory case oil return hole
7. High oil pressure relief valve cap
8. Pipe plug in oil dilution port
9. Oil sump drain plug
10. Fuel pump seal drain plug (at mount flange)
11. Fuel pump inlet port
12. Fuel pressure adjusting screw and lock nut
13. Fuel pump discharge port
14. Fuel pump seal vent plug (at mount flange)
15. Tachometer electrical cable receptacle
16. Oil filler neck

Figure 8-1. Rear View of Continental Model O-470-15 Aircraft Engine

test activity concerned. All equipment should be installed in accordance with standard shop practices. Before engine is installed in test stand, applicable portions of the appropriate check list in AFTO 27 should be complied with. Information contained in Table XVII and figure 8-1 may be used as a guide in connecting instruments and controls. Refer to T.O. 2R-1-12 for approved types of spark plugs to be used and for installation instructions.

8-3. PROCEDURE FOR TESTING ENGINE WITH AN EXTERNAL OIL SUPPLY SYSTEM.

8-4. Oil supplied from an external supply tank to engine oil pump must be gravity fed, or supplied from a low pressure pump. The system must include a scavenge pump which must be capable of returning oil to the external supply tank at a rate of flow not less than 44 pounds per minute. The external supply system must include means of controlling engine oil temperature, hence no oil cooler is connected directly to the engine.

CAUTION

Failure to remove oil gallery adapter and install plug as specified in Table XVII will result in no oil flow through the left gallery, main bearings or gear bushings since adapter blocks off a crankcase oil passage.

Before proceeding with the test run, the following operations must be performed.

a. (See figure 4-6.) Loosen clamps (14) and slide hose (15) down onto suction oil screen assembly (17) until hose clears adapter in oil pump body. Loosen and remove suction oil screen assembly.

b. Connect test block oil supply and scavenge systems as shown in figure 8-2.

c. Remove oil pressure relief valve cap, gaskets, lock nut, screw and bushing assembly, inner and outer springs and piston from low pressure relief valve (14, figure 1-2). Install blocking pin (fabricated locally to the dimensions and shape shown in figure 8-3) to block off relief passage; then install outer spring and screw and bushing assembly. Turn screw and bushing assembly into mount bracket until it seats on blocking pin. Install gasket and lock nut and tighten lock nut. (If relief valve cap is installed, be sure to tighten it less than lock nut to prevent loosening the nut when cap is removed.)

d. During initial run and as soon as engine speed has stabilized at 1000 rpm, adjust high pressure relief valve in oil pump so that gauge indicating pressure in the right oil gallery reads 62-68 psi. This adjustment must be made at beginning of any subsequent test run following engine disassembly.

e. After completion of final run and after stopping engine, remove blocking pin from low pressure relief valve and install piston, inner and outer springs, screw and bushing assembly, gaskets and nut lock. Turn screw and bushing assembly until it projects 1/2 inch beyond lock nut; then tighten lock nut. Start engine, and slowly increase engine speed to 2300 rpm; then adjust low pressure relief valve so that gauge indicating oil pressure in left crankcase gallery reads between 47 and 52 psi. Check both gauge readings. Gauge connected to right crankcase should indicate a pressure not less than 5 psi higher than gauge connected to left crankcase. Slowly decrease engine speed to 600 rpm and check that oil pressure is not less than 40 psi.

f. Upon completion of oil pressure adjustments, install gasket and cap on each valve. Lockwire cap and lock nut through corner holes.

8-5. PROCEDURE FOR TESTING ENGINE WITH OIL SUPPLY IN SUMP.

NOTE

This procedure may be employed when test block does not have an oil tank, oil weighing scale, scavenge pump, means of controlling oil temperature and piping system; however, it is not recommended since it precludes accurate measurement of oil consumption and oil flow rates. When this procedure is followed, an oil cooler, thermostatic cooler bypass and cooler outlet temperature gauge must be connected by hoses to gallery adapter at front of right crankcase and tapped hole at front of left crankcase, as indicated in Table XVII.

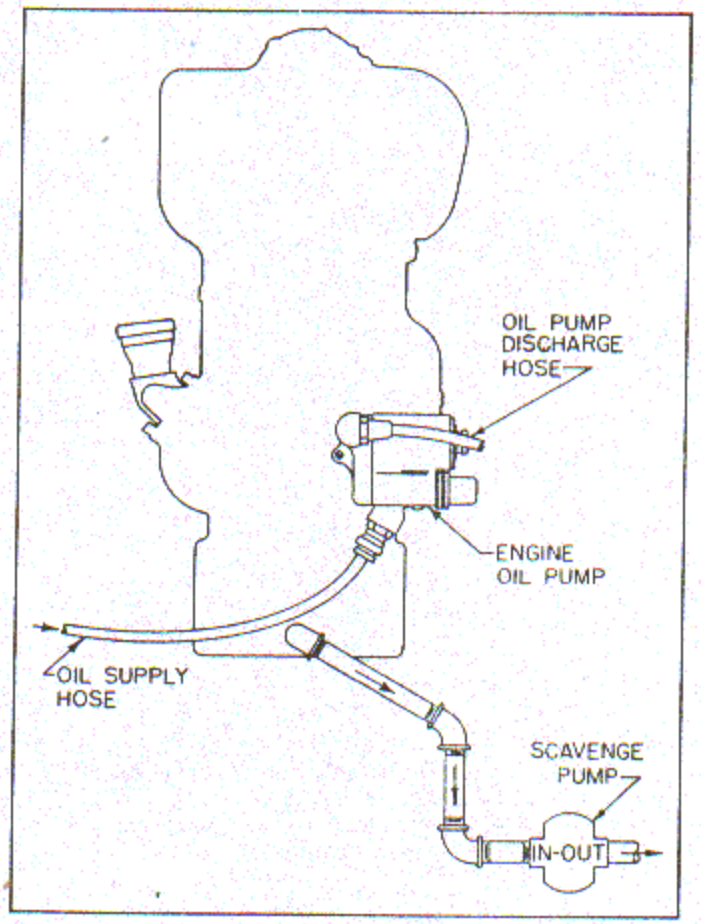


Figure 8-2. External Oil Supply Connections

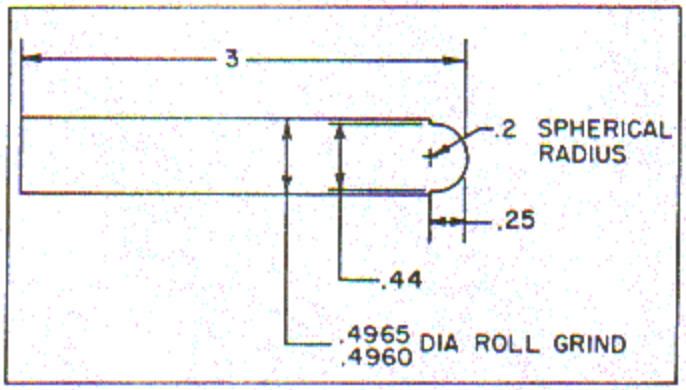


Figure 8-3. Low Pressure Relief Valve Blocking Pin

8-6. Fill oil sump with 10 quarts of engine lubricating oil conforming to Specification MIL-L-6082, grade 1100. Start and warm up engine. After engine speed has stabilized at 100 rpm, proceed as follows:

a. Remove caps from the high and low pressure relief valves.

b. Adjust low pressure relief valve (14, figure 1-2) so that gauge indicating oil pressure in left oil gallery reads approximately 47 psi.

c. Adjust high oil pressure relief valve in pump so that gauge connected to right crankcase gallery reads approximately 15 psi higher than other gauge and between 62 and 68 psi.

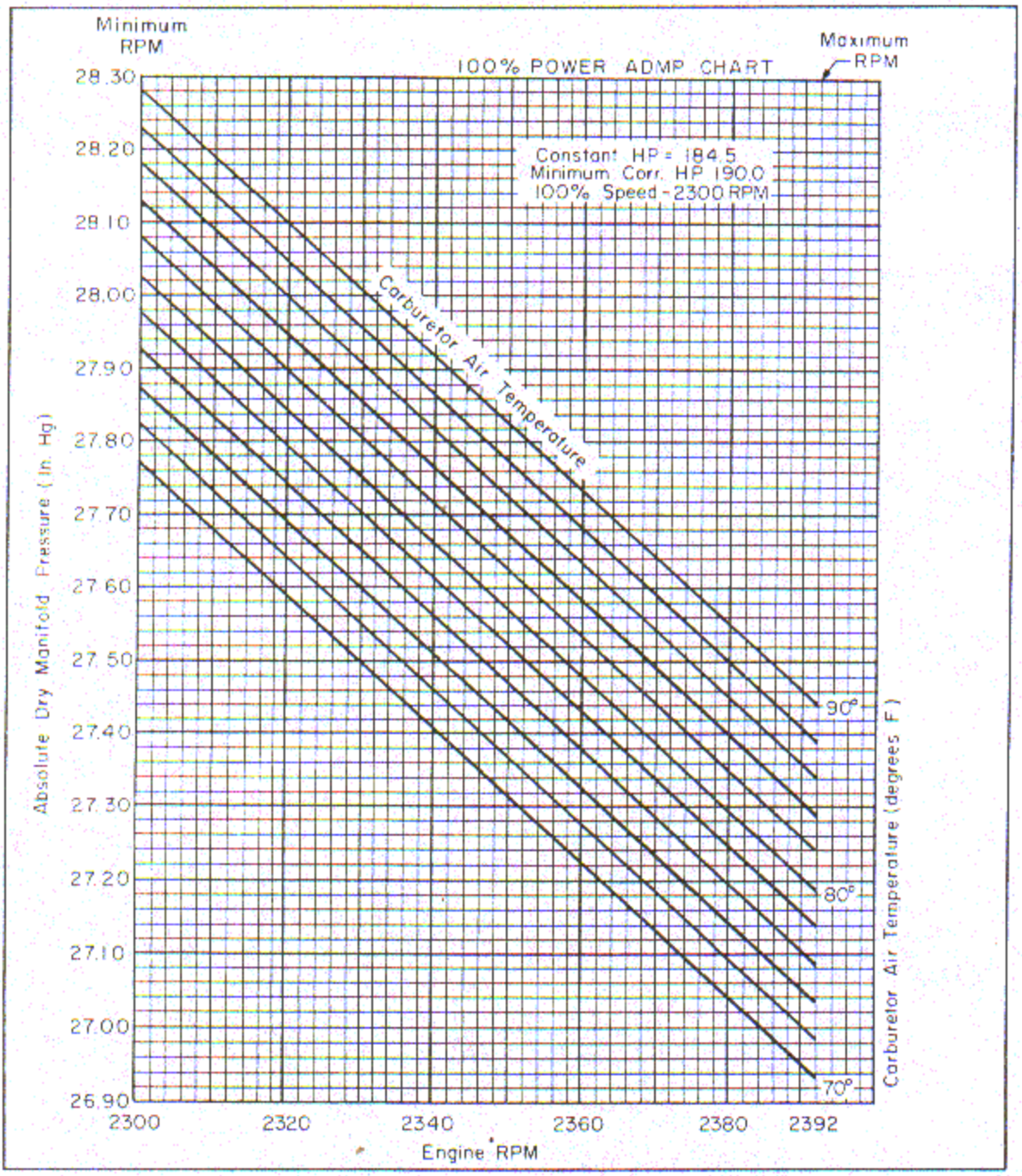


Figure 8-4. Absolute Dry Manifold Pressure vs RPM vs Carburetor Air Temperature

d. During full throttle period of final run readjust low oil pressure relief valve, if necessary, to hold left crankcase gallery pressure between 47 and 53 psi and adjust high pressure relief valve to maintain a pressure 15 psi higher in right crankcase gallery.

8-7. OVERHAULED ENGINE BLOCK TEST RUN SHEET. Engine test will be accomplished according to schedules and limits set forth in AFTO 27.

8-8. FUEL.

8-9. TYPE AND GRADE. During block test, model O-470-15 engines shall be supplied with aircraft engine fuel conforming to Specification MIL-F-5572, grade 80 or higher.

8-10. FUEL PRESSURE. As measured by a gauge connected to carburetor inlet, fuel pressure shall be between 9 and 15 psi under all operating conditions. Immediately upon stabilizing engine speed, adjust relief valve adjusting screw on left side of pump to bring pressure within these limits. If engine is running at an idle speed of 600 rpm, set pressure near low limit of range. Pressure should then remain within limits throughout engine operating range.

8-11. INSTRUCTIONS FOR USING FIGURE 8-4.

a. Locate observed rpm on bottom scale.

b. Follow the vertical line, corresponding to observed rpm, to the point where it intersects the oblique line corresponding to observed carburetor air temperature.

c. Read desired Absolute Dry Manifold Pressure (ADMP) (to produce 184.5 HP) on the horizontal line which passes through the intersection located in step "b".

d. With the desired and observed Absolute Dry Manifold Pressure and the constant BHP known, the following formula may be used to calculate the actual BHP produced at the time of test:

$$\frac{\text{Actual ADMP}}{\text{Desired ADMP}} \times \text{Constant BHP} = \text{Actual BHP (at time of test)}$$

8-12. FILLING, FLUSHING AND VENTING CARBURETOR.

8-13. At least eight hours before scheduled start of block test, carburetor must be filled with fuel and kept filled thereafter until engine is started. Allow enough fuel to flow through carburetor passages to flush out preservative oil left in carburetor after testing and adjustment at the factory or overhaul base. This is necessary in order to soak diaphragms. The following procedure is recommended by carburetor manufacturer.

NOTE

Care must be exercised to insure that threaded areas of all connecting fittings to carburetor are free from nicks, burrs or other thread damage which might cut or shave off aluminum cuttings from regulator cover and force them into unprotected cavity around poppet valve. Extreme care should also be exercised when applying Seal Lube or other thread compounds to carburetor connections. The presence of thread shavings and thread compounds in metered fuel channels and poppet valve cavity will cause erratic engine operation or complete engine stoppage.

a. Connect fuel supply tube to carburetor fuel inlet port. The supply line must have a means, independent of engine, of feeding fuel under a pressure of 10 psi.

b. Connect throttle and mixture control linkages to carburetor levers.

c. Connect fuel pressure gauge tube to carburetor. (Install coupling in lieu of 6, figure 8-5.)

d. Before installing air scoop or air filter connections on carburetor bottom flange, remove 1/8 inch pipe plug (1, figure 8-5) from vent hole near bottom of regulator cover. Place mixture control in "RICH" position. Operate independent pump at low output until fuel discharged is free of oil.

e. Replace drain plug. Continue pumping until fuel discharged from vapor vent connection hole near top of regulator cover is free of air bubbles and oil.

f. Connect vapor vent tube to nipple installed in lieu of pipe plug (1, figure 8-5.)

g. Open throttle about half way.

h. Continue pumping until fuel flows from discharge nozzle and is free of air bubbles and oil.

i. Place manual mixture control in "IDLE CUTOFF" position, and allow it to remain there until ready to start engine. Carburetor fuel passages will remain filled as long as mixture control is not moved.

CAUTION

Do not apply a pressure higher than 10 psi to carburetor during preceding operation.

NOTE

If engine tends to stall after starting it may be due to air trapped in fuel line. To remove air, remove headless plug (5, figure 8-5) from its position in fuel channel on regulator cover and pump fuel slowly until it stands level with top of plug hole; then replace plug.

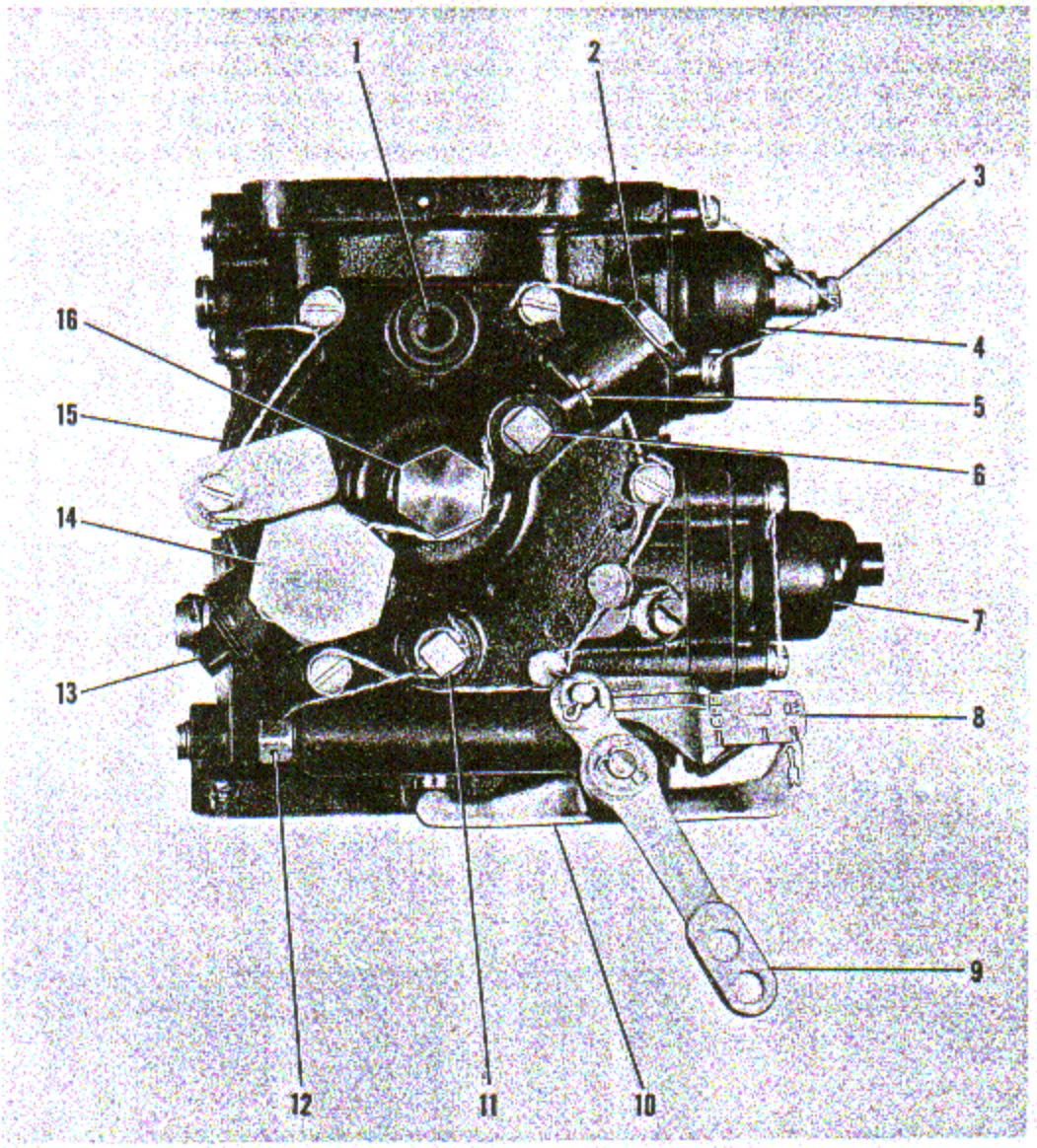
8-14. IDLE SPEED AND MIXTURE ADJUSTMENTS.

8-15. At the point indicated in test schedule indicated in AFTO 27, adjust idling speed and mixture in the following manner to give maximum rpm with minimum manifold pressure.

a. Correct spark plug fouling or other ignition trouble before proceeding with idle adjustments.

b. Close throttle to its idle stop. If idling speed is appreciably above or below 600 rpm turn idle speed adjusting screw (3, figure 8-5) a notch at a time inward to increase, or outward to decrease speed. If idling speed changes appreciably during the following steps, readjust in the same manner.

c. Move manual mixture control slowly and smoothly into "IDLE CUT-OFF" position, watching tachometer for any change in rpm. As soon as first rpm change occurs, return control to its "FULL RICH" position before engine can stop. An increase of more than 10 rpm after "leaning out" mixture in this manner

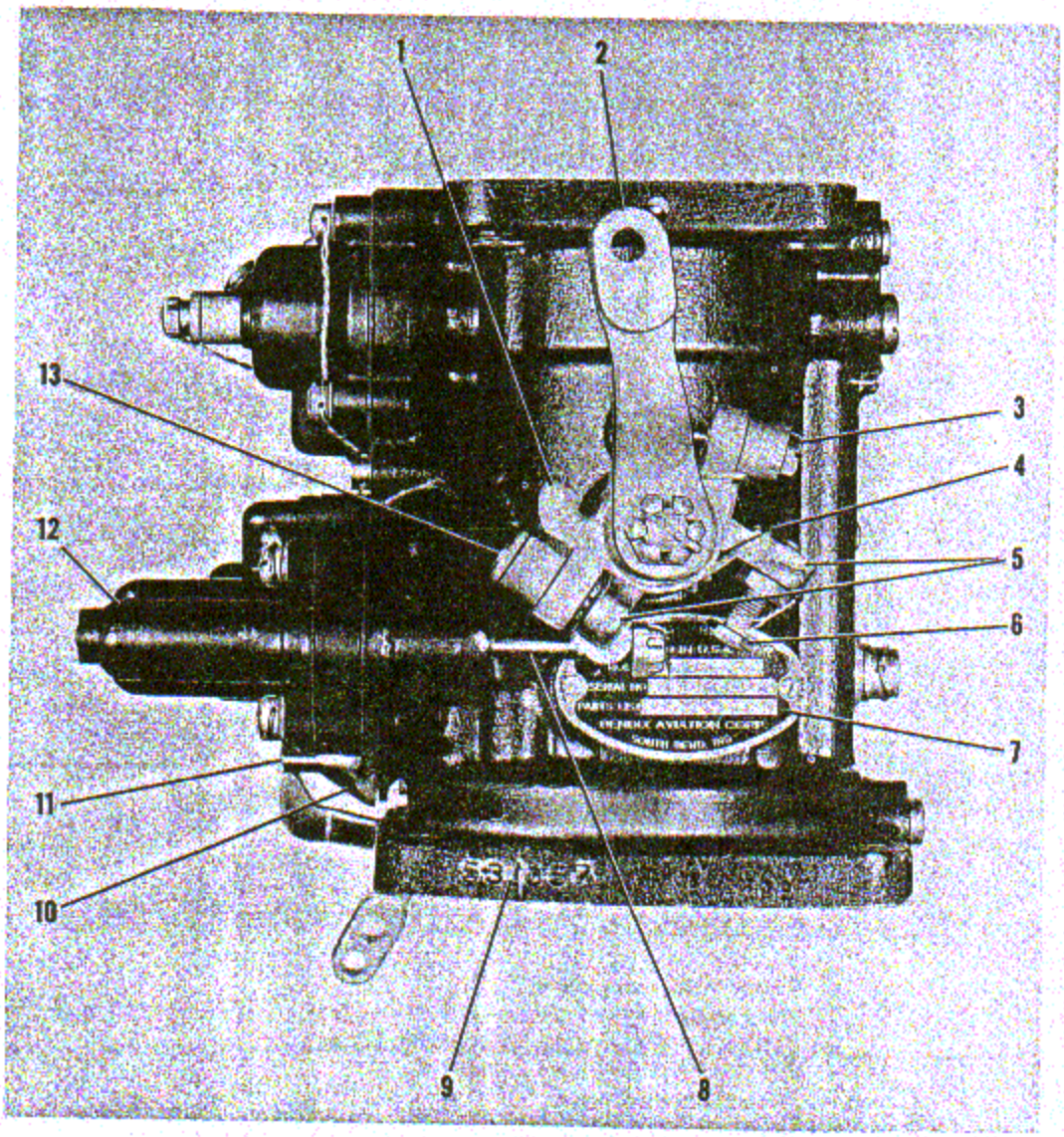


1. Vapor vent connection
2. Main metering jet plug
3. Discharge diaphragm adjustment screw
4. Discharge diaphragm cover
5. Fuel channel plug
6. Fuel pressure gauge connection
7. Accelerating pump diaphragm cover
8. Manual mixture control link
9. Manual mixture control lever
10. Idle cut-off lever
11. Drain hole plug
12. Air section drain plug
13. Fuel inlet port
14. Fuel strainer plug
15. Regulator diaphragm cover
16. Regulator poppet valve cover plug

Figure 8-5. Right Side View of Stromberg Model PS-5C Carburetor

indicates an excessively rich idling mixture, while an immediate drop in rpm indicates an excessively lean mixture.

d. Correct excessively rich idling mixture by turning idle mixture adjusting screw (13, figure 8-6) to the right (inward) to pull the idle and power enrichment control rod farther out and needle valve closer to its seat. Correct excessively lean mixture by turning the same screw to the left (outward). Turn screw one click at a time and check the effect of resulting mixture after each adjustment by repeating step "c". The idling mixture will be correct when "leaning out" with the idle cut-off results in a momentary increase of approximately five rpm before engine begins to



1. Fuel throttle stop on throttle stop assembly
2. Throttle lever
3. Idle speed adjustment screw
4. Lever and throttle stop spring
5. Idle control rod adjustment lever
6. Power enrichment adjusting screw
7. Identification plate
8. Idle and power enrichment control rod
9. Engine manufacturer's part number
10. Idle cut-off lever cam
11. Manual mixture control needle valve
12. Idle and power enrichment valve and control rod cover
13. Idle and power enrichment valve control rod adjusting screw (idle mixture adjustment)

Figure 8-6. Left Side View of Stromberg PS-5C Carburetor

starve. After each adjustment, and before testing the effect, run up engine speed to 1800-2000 rpm for a few seconds to burn any oil from spark plugs; then return to idling speed with throttle closed, and re-adjust to 600 rpm if necessary.

NOTE

If idling procedure adjustment involved more than a slight movement of idle mixture adjustment screw, it also altered throttle shaft angle at which enrichment valve adjusting screw (6, figure 8-6) contacts idle and power enrichment control rod. This screw must contact rod end (which must project slightly from castle nut) when throttle valve shaft is at an angle of 35 degrees from its wide open stop. This angle may be checked with a flat gauge whose dimensions are given in figure 8-7. If adjusting screw (6, figure 8-6) does not contact rod end at precisely the same time when throttle stop touches the gauge, remove lockwire and loosen its lock nut; then readjust screw while holding throttle against gauge, and tighten its lock nut. Replace lockwire through head and nut to prevent loosening of either.

8-16. SPECIFIC INSTRUCTIONS.

8-17. OIL PRESSURE AND TEMPERATURE. If the oil pressure, after starting, does not register on the gauge immediately, the engine should be stopped and an investigation made of the cause. During test run, oil pressure will be maintained within limits at all times. Oil temperature will be brought up to the minimum as specified in applicable run sheet before engine is started.

8-18. CHECKING FUEL CONSUMPTION. During the test run fuel flow readings will be recorded at each test period in pounds per hour.

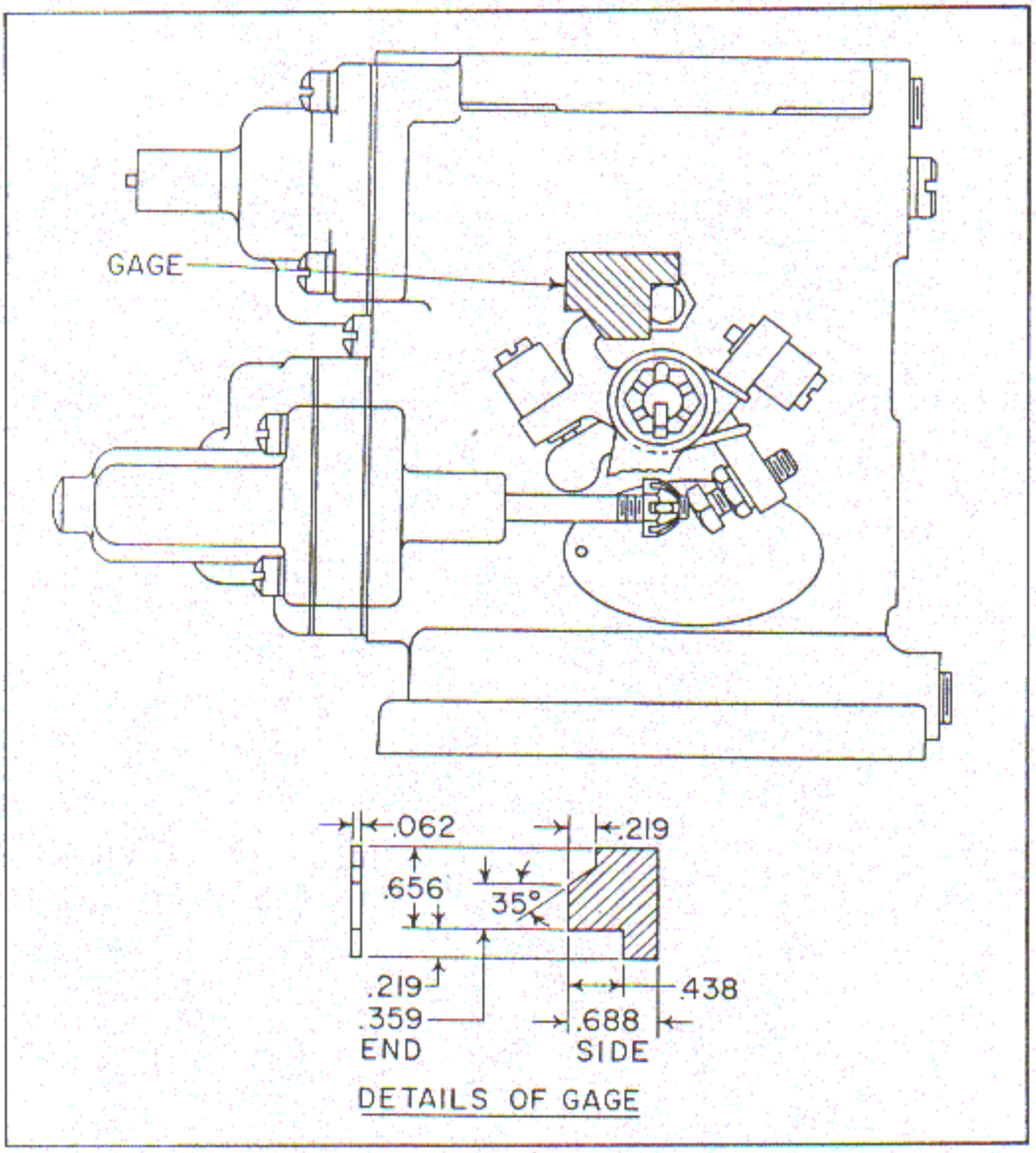


Figure 8-7. Manual Power Enrichment Screw Adjustment and Gage

8-19. CHECKING OIL CONSUMPTION. The oil consumption should be determined at a definite speed and time. During this interval the oil temperature in the circulating system should be stabilized and no oil should be added. The consumption is ascertained by subtracting the weight of oil, as indicated on the weight tank scales at the end of the period, from the weight indicated at the beginning of the period. Oil consumption will be held to the limits as specified in AFTO Form 27.

8-20. FINAL ENGINE CHECK. After the scheduled engine run has been completed, and penalty runs as required, the engine performance will be checked according to periods specified in AFTO 27.

8-21. HORSEPOWER CHECK. There are many variables which affect horsepower and it is not feasible for the average overhaul base to maintain the complete equipment and personnel necessary for close horsepower measurements. When an engine has been overhauled as recommended in the preceding sections of this technical order, it should develop essentially the same horsepower as when new, provided the carburetor and ignition system have also been overhauled and tested correctly. A check on manifold pressure and RPM using a calibrated test propeller will provide sufficiently close check on horsepower output.

8-22. COMPRESSION CHECK. A cylinder compression check will be performed before the corrosion preventive run is made using a compression tester assembly, Type S-1, Part No. 47R1192 or equivalent. To obtain constant readings the compression test must be performed immediately after the engine has been shut down. The minimum allowable compression when using the S-1 Type tester is 60 psi. The applicable sections of T.O. 2R-1-12 should be consulted for detailed instructions and correction action for cylinders that do not meet this minimum.

8-23. ENGINE SHUT DOWN.

8-24. CORROSION-PREVENTIVE RUN. Before removal of an engine to be boxed for shipment or storage, carry out the following procedure.

a. Drain the engine oil sump while the oil is still warm after a period of operation. Replace the drain plug.

b. Fill oil sump to gauge "FULL" mark (10 U.S. quarts) with corrosion-preventive oil mixture conforming to Specification No. MIL-C-6529A.

c. Detach normal fuel supply tube from fuel pump and connect a source of 80 octane unleaded gasoline, or drain the aircraft fuel tank and line and refill.

d. Start and warm up engine in the normal manner; then run at 1500 rpm. During this period maintain an oil temperature of 104.44°C (220°F) to 121.11°C (250°F) by baffling the oil cooler.

8-25. FOGGING PROCEDURE. At the completion of the corrosion preventive run, and while engine is still warm, carry out the following procedure:

a. Remove carburetor air filter.

b. Spray the same corrosion-preventive mixture specified in paragraph 8-24 into carburetor air inlet, at a rate of 1/2 gallon per minute while engine is running at 1200 to 1500 rpm, until heavy smoke comes from exhaust manifolds. Increase the rate of spray enough to stop the engine.

c. Do not turn propeller at any time after engine stops.

d. Drain engine oil sump; then reinstall drain plug.

SECTION IX

ACCESSORIES

9-1. IGNITION HARNESS. (See figure 4-2.)

9-2. DISASSEMBLY.

a. Remove the clamp band (1) and brackets (4) if these parts are still on any of the conduits.

b. Detach slotted washers (5) from all cables by inserting a pointed tool under the bare wire strands and pulling their ends from behind the washers.

c. Remove the outlet plate grommets (6).

d. Unscrew all conduit to outlet plate coupling nuts, and withdraw all cables and conduits from the plates.

e. Pry out the brass pin (9) which tighten the wire strands in the terminal sleeves (10); then withdraw the sleeves and the rubber bushings (11).

f. Unscrew the conduit to spark plug elbow coupling nuts, and slide off all elbows (12).

g. Withdraw the cable from each serviceable conduit assembly, and discard the old cables.

9-3. CLEANING. Clean the outlet plates and all cable conduits with dry cleaning solvent, and dry them thoroughly.

9-4. REPAIR. Small frayed spots in the conduit braid may be patched with solder in emergencies. Ordinarily, it is advisable to discard any damaged part. Cut a length of new 5 mm dia high tension cable, MIL-C-3162, type 1, grade A, class 2, for each conduit, according to the cutting length information in Table XVIII.

9-5. ASSEMBLY. (See figure 4-2.)

a. Feed the new cables into the conduits through the magneto end elbows. (Refer to Table XVIII for identification of conduits by elbow style.) Leave approximately three inches of cable length projecting from each elbow. Mark each conduit according to the cylinder number and magneto to which it will be connected.

b. Strip the insulation from a length of 3/8 inch at the elbow end of each cable.

c. Push new rubber sockets (8) over the stripped cable ends, and guide the bare strands through the small holes at the closed ends.

d. Refer to figure 8-1 and observe the directions of the conduits and elbows connected to the magneto outlet plates. It is essential that they be assembled in these positions. Long elbows are required where they must cross over short elbows.

e. After determining the direction in which each conduit will run and the outlet in which it will be installed, insert the cable ends through the proper outlet plate holes, and screw in the elbow coupling nuts. Install the cable and conduit assemblies with short elbows first.

NOTE

The No. 1 outlet hole of each outlet plate is identified by the numeral "1" cast near it on the exterior side of the plate.

f. Push each cable into one of the sockets in a new outlet plate grommet (6), guiding the bare strands through the small grommet holes, until all cables in each assembly have been inserted into a grommet for that assembly; then place over the bare strands of each cable, in turn, a slotted brass washer (5). As each washer is installed, separate the wire strands into two approximately equal groups, and bend each group opposite to the other, through one of the washer slots and behind the washer so as to hold it as tightly on the grommet as possible.

g. When slotted washers have been installed on all cables of an assembly, push grommet and pull opposite ends of cables carefully and as uniformly as possible to seat grommet on outlet plate.

h. Push a new spacer assembly (13) over spark plug end of each cable, and seat it on conduit ferrule.

i. Work each cable through a serviceable spark plug connecting elbow and screw conduit coupling nuts onto elbow threads, but do not tighten them yet.

TABLE XVIII. IGNITION CABLE CUTTING LENGTHS

Cylinder No.	For Right Magneto and Upper Spark Plugs		For Left Magneto and Lower Spark Plugs	
	Cable Cutting Length (inches)	Style of Mag. Elbow	Cable Cutting Length (inches)	Style of Mag. Elbow
1	22	short	30	long
2	32	short	27	long
3	30	long	36	short
4	38	long	34	short
5	36	short	43	short
6	44	short	40	short

j. Push new rubber bushing (11) shouldered end first, over end of each cable.
k. Strip 1/4 inch of insulation from exposed end of each cable. Twist bare strands to keep them together.
l. Push ceramic sleeve and contact spring assembly onto end of each cable, guiding wire strands through sleeve eyelet. Separate strands and bend them radially down over eyelet end.
m. Drive brass pin (9) into center of each sleeve eyelet to hold wire strands firmly in place.
n. After completion of two cable and conduit assemblies, install single cable brackets (4) where illustrated, and three-cable brackets where illustrated for attachment to engine.

NOTE

In order to protect spark plug contact springs, install protectors over them.

9-6. HYDRAULIC VALVE LIFTERS.

9-7. PARTS RACK. In order to prevent accidental interchange of parts, particularly the two separable parts of each hydraulic unit, it is advisable to place each part, immediately after disassembly and cleaning, in a holder designed for it on a rack containing holders for all parts of the 12 lifter assemblies in each engine. By arranging the parts holders for each lifter in a straight row their assembly relationship will be preserved with a minimum of effort during the overhaul procedure. The rack should hold each part so as to allow cleaning solvent to drain from it, and the design should provide for drainage of solvent from the rack itself.

9-8. DISASSEMBLY. (See figure 2-1.)
a. With a pointed tool pry one end of the wire snap ring from the body groove, and remove the ring, while holding down the pushrod socket with a pushrod or other ball end tool.
b. Invert the lifter body, and the socket and hydraulic unit will fall into the palm of the hand.
c. Place the parts disassembled at this stage in a clean pan, such as a deep cake pan, filled to a depth

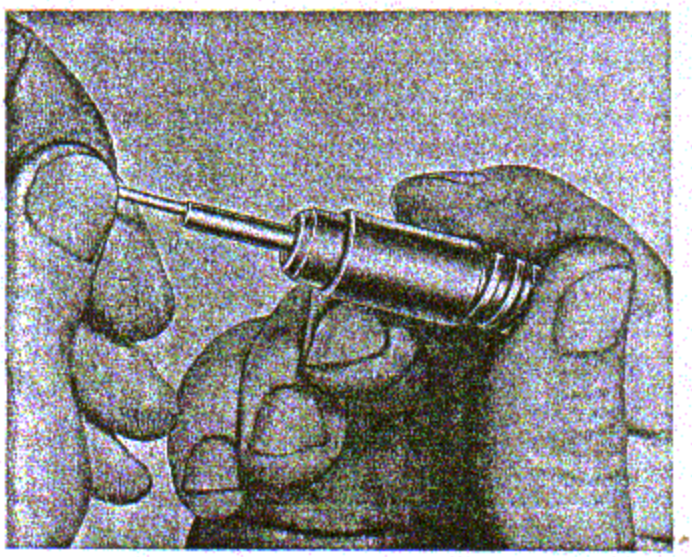


Figure 9-1. Releasing Hydraulic Unit Check Valve

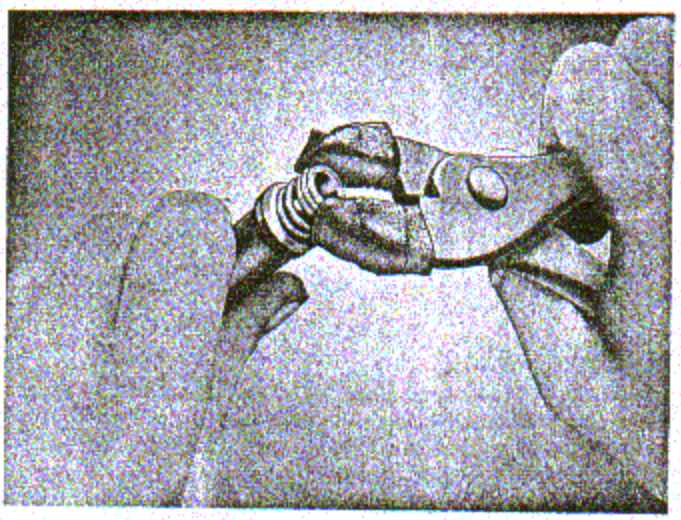


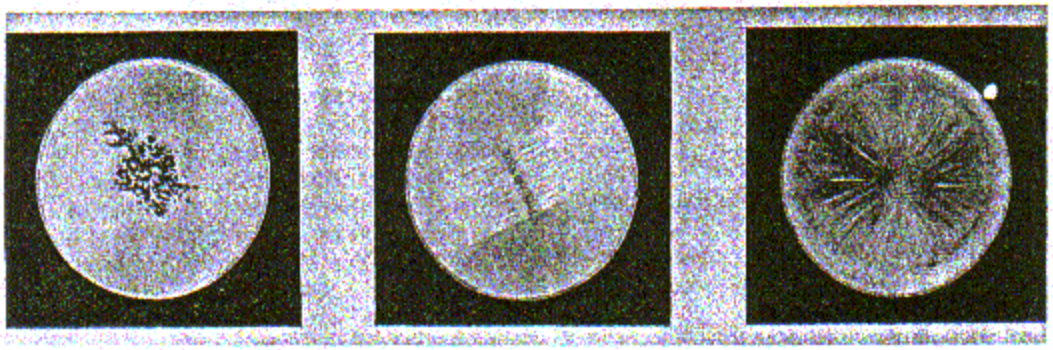
Figure 9-2. Disintegrating Carbon Ring to Release Hydraulic Unit Plunger

of an inch or so with fresh dry cleaning solvent, Specification P-S-661.
d. Unless the plunger is seized or held in the hydraulic unit by a ring of carbonized gum, it may be removed by twisting in the direction which tends to wind up the spring under its head while pulling outward. If the plunger cannot be removed in this manner, release oil trapped under it by inserting a match stick or medical swab stick into the inlet tube and depressing the ball check valve while pressing the plunger inward. (See figure 9-1.) If the plunger cannot be moved in this manner it is seized in the cylinder, and the unit must be discarded. If the plunger can be depressed it will be possible, in most instances, to disintegrate the ring of carbon which prevents its removal by gripping the plunger head with tape covered jaws of a pair of common pliers and twisting with an oscillating motion while pulling outward. (See figure 9-2.)

9-9. CLEANING. Place the parts of each valve lifter assembly in the pan of dry cleaning solvent as they are disassembled. When disassembly of one lifter has been completed, clean those parts by brushing with a clean, soft bristle brush, such as a small paint brush, to dislodge loosened sludge deposits. When all foreign matter has been removed from any part, drain solvent from it briefly into the pan; then place the part in the proper holder in the parts rack. For simplicity, it is advisable to start at one end of the rack and to fill the rows of holders progressively as the twelve lifters are disassembled and cleaned. Do not place more than one lifter in the cleaning solvent pan at a time.

CAUTION

Disassembled parts must not stand longer than a few minutes after removal of oil in the cleaning operation and without a film of corrosion preventive compound and oil mixture on their surfaces.



Pitting (Spalling) Worn in Groove Scoring

Figure 9-3. Defects of Valve Lifter Body Cam Follower

9-10. INSPECTION AND TESTING.

a. Inspect the face of the cam follower and the shank on each lifter body. If any body has been damaged by spalling (deep pits) or by deep scores, it must be discarded. (See figure 9-3.)

NOTE

A straight line wear pattern on the face indicates that the lifter has not been rotating. This is probably due to insufficient taper on the toe of the cam lobe which actuated it.

b. Inspect each pushrod socket for restriction of the oil hole or the oil groove on the flat side, scoring in the socket and other visible damage. Discard any socket which is obviously unserviceable.

c. Test the two separable parts of each hydraulic unit for proper operation, immediately after cleaning and drying, in the following manner. Start the dry plunger into the dry cylinder, held upright between the fingers and thumb. With the forefinger of the same hand press the plunger inward, (see figure 9-4) and release it quickly. If the plunger and cylinder are not excesively worn, and if the ball check valve in the cylinder is seating properly, the plunger will compress the air trapped under it and will kick back promptly. By rapid repetition of this rough check, the plunger can be forced gradually into the cylinder, since some air will escape each time it is pressed inward. This is not a disqualifying condition, since a definite "leakdown" rate is essential to correct operation and is controlled by selective fitting of plungers and cylinders, however, there must be a prompt kickback each time the plunger is depressed. If the plunger does not kickback promptly or very near to its original position it may be worn excessively, or the check valve seat may be worn out-of-round, or the check ball may be held off its seat by a particle of dirt. To eliminate check valve faults from the test, plug the end of the oil inlet tube with a finger of the other hand, and repeat the test for kick-back. If the response is still unsatisfactory the unit may be considered to be excessively worn, and it must be discarded. If the plunger kicked back promptly on the last test the trouble is in the check valve. In that event, clean the cylinder again to remove any possibility of dirt on the valve seat; then dry the cylinder, and repeat the first test (with inlet tube open). If the plunger does not kick back promptly in this test the valve may be considered to be unserviceable. Since none of the hydraulic unit parts can be repaired, and since the plunger and cylinder are non-interchangeable, any visible defect or failure to pass the operation tests shall be cause for rejection and discard of the entire unit.

9-11. REPAIR AND REPLACEMENT. Light scoring on the shank of a valve lifter body may be polished off with crocus cloth if, in the judgement of inspection personnel, the damage is not dangerous. The follower face is hardened and ground on a spherical radius, hence it is not subject to repair. Snap rings, sockets, bodies and hydraulic units may be replaced independently of each other in any assembly with new parts of the same types and manufacturer's part numbers. Separable parts of the hydraulic unit form a matched assembly and are supplied only in the as-

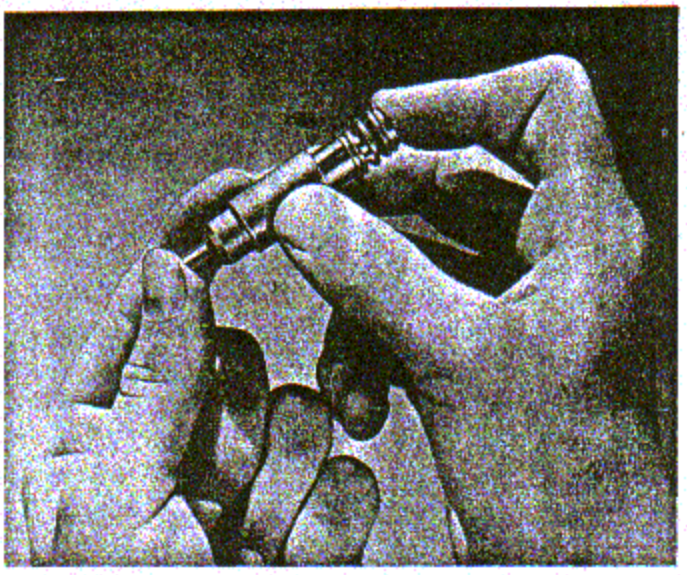


Figure 9-4. Testing For Leaking Check Valve

sembled condition. These parts must not be interchanged between hydraulic units, since there is no method available for checking the leak-down rate.

NOTE

Hydraulic units in type O-470-15 engine valve lifters are designed for a leak-down rate of 3 to 6 seconds. Dimensionally equivalent units supplied under other part numbers are not interchangeable with these units.

9-12. ASSEMBLY.

a. If the parts of each valve lifter are not assembled immediately after cleaning and testing they will be coated with a corrosion preventive compound. Since such a film tends to hold grit deposited from the atmosphere, and since any such abrasive material must be excluded from the lifter assemblies, all parts should be cleaned again and dried thoroughly immediately before final lubrication and assembly.

b. In order to facilitate final assembly of the engine the lifters should be assembled with only a film of corrosion preventive compound and oil mixture on the internal surfaces and no oil in the reservoirs in the bodies (under the hydraulic units). Apply the oil mixture immediately before assembling each part, and do not lay the part down after lubrication.

c. Push the plunger and spring assembly into the hydraulic unit cylinder, and turn the plunger in the direction required to wind up the spring until the spring end snaps into the cylinder counterbore.

d. Insert the hydraulic unit into the lifter body, tube first, until it rests on a body shoulder.

e. Drop the pushrod socket, flat side first, into the body on top of the hydraulic unit plunger.

f. Stand the lifter body upright on a clean surface, and insert a ball end tool, such as a pushrod, through one of the wire snap rings. Depress the socket with the tool until the snap ring can be engaged in the small groove around the inside of the body. Make sure that the ring is firmly seated in the groove all around.

g. Wipe any dust from the follower face; then lightly coat all exterior surfaces of the lifter body with corrosion preventive compound and oil mixture. Store the assembled lifter on a clean rack, and cover or otherwise protect the completed assemblies from grit.

9-13. OTHER ACCESSORIES.

9-14. For overhaul instructions on accessories not covered in this section, refer to applicable Air Force handbooks.

SECTION X

TABLE OF LIMITS

10-1. PURPOSE.

10-2. The tables of dimensional limits in this section are applicable only to Continental model O-470-15 aircraft engines. These tables shall be used in connection with inspection, repair and assembly operations described and indicated in the preceding sections of this publication, to determine whether worn parts are dimensionally serviceable and to determine the extent of wear as well as the serviceability of repair and replacement work.

10-3. USE OF TABLES.

10-4. DEFINITIONS OF TERMS AND ABBREVIATIONS. In the following tables, loose fits — such as diametrical clearances, side clearances and end plays—are denoted by the letter "L" following the numerical value. Interference (tight) fits, in which the female part is smaller than the male part— when measured at room temperature — are denoted by the letter "T". The abbreviation "Replace. Maximum" indicates the term "Replacement Maximum", defined in paragraphs 10-5 and 10-6. All dimensions are stated in inches.

10-5. SIGNIFICANCE OF LIMITING VALUES. In the following tables dimensions limits are placed in three columns. Values in the two columns under the heading "New Parts," apply when both mating parts concerned in a specification of fit are new parts drawn from stock for replacement purposes, or when the dimension applies to a single part of the same status. Dimensions placed in the "Replace. Maximum" column represent the greatest departure from desired fits, sizes and strength permissible in rebuilt engines and apply to worn parts. It will be observed that "Replace. Maximum" dimensions are not always larger in numerical value than corresponding dimensions of new parts.

10-6. DETERMINATION OF SERVICEABILITY. Minimum and maximum values of dimensions applicable to new parts are set up as ideal limits. Measurements which indicate no greater departure from ideal sizes and clearances and strength than the replacement maximum values permit the parts concerned to be continued in service. When no figure appears in the "Replace. Maximum" column, the fit must be within limits stated in the "New Parts" column.

10-7. MEASUREMENT OF PARTS. Use dimensional data in these tables and in Table I to determine the extent of wear on critical dimensions of parts for which special gauges are not provided.

10-8. REJECTION AND REPAIR. Parts and assemblies rejected for excessive wear, but otherwise serviceable, shall be discarded only when no repair procedure is described or indicated in Section V. Inspection personnel will specify installation of available oversize parts to maintain interference fits within "New Parts" limits.

10-9. TIGHTENING TORQUES. Torque values specified in the table of tightening torques are applicable when threads are coated with a minimum film of engine lubricating oil. When a graphited thread lubricant is applied the torque values should be reduced approximately 20%.

TABLE XIX. TABLE OF LIMITS

Ref. No.	Chart No.	Description	New Parts		Replace.
			Minimum	Maximum	Maximum
		CYLINDER AND HEAD ASSEMBLY			
1	1	Cylinder bore (lower 3-3/8 in. of barrel) .. dia:	5.001	5.003	5.006
2	1	Cylinder bore (at top) . . . . . dia:	4.991	4.995	
	1	Cylinder bore (from 2-3/8 in. above flange to top) . . . . . .choke:	.008	.010	.006
		Cylinder bore . . . . . out-of-round:			.002
		Cylinder bore . . . . . allowable oversize:			.015
3	1	Exhaust valve seat insert in cylinder head . dia:	.007T	.010T	
4	1	Intake valve seat insert in cylinder head. . .dia:	.009T	.012T	
5	1	Exhaust valve guide in cylinder head . . . . .dia:	.001T	.0025T	
6	1	Intake valve guide in cylinder head . . . . . .dia:	.001T	.0025T	
7	1	Exhaust valve seat . . . . . width:	.120	.156	
8	1	Intake valve seat . . . . . width:	.107	.171	
9	1	Valve seat to guide axis . . . . . angle:	45°	45° 30'	

TABLE XIX. TABLE OF LIMITS (Cont.)

Ref. No.	Chart No.	Description	New Parts Minimum	New Parts Maximum	Replace. Maximum
		ROCKER ARMS AND SHAFT			
10	1	Rocker shaft in cylinder head bosses . . . . dia:	.000	.0015L	.003L
11	1	Rocker shaft in rocker arm bearing . . . . . dia:	.0002L	.0023L	
12	1	Rocker arm bearing in rocker . . . . . dia:	.0005T	.002T	
		VALVES			
13	1	Intake valve in guide . . . . . dia:	.0012L	.0032L	.005L
14	1	Exhaust valve in guide . . . . . dia:	.003L	.005L	.008L
15	1	Intake valve face (to axis) . . . . . angle:	45°	45°30'	
16	1	Exhaust valve face (to axis) . . . . . angle:	45°	45°30'	
17	1	Intake valve . . . . . length:	4.714	4.724	4.699
		Intake valve . . . . . max tip regrind:			.015
18	1	Exhaust valve . . . . . length:	4.698	4.708	4.683
		Exhaust valve . . . . . max tip regrind:			.015
		PISTONS, RINGS AND PINS			
19	1	Piston (bottom of skirt) in cylinder . . . . . dia:	.007L	.010L	.0145L
20	1	Piston (below third groove) in cylinder . . . dia:	.015L	.019L	
21	1	Top two rings in piston groove . . . side clear.:	.006	.008	.012
22	1	Third (oil control) ring in piston groove . . . . . side clear.:	.0032	.0049	.0075
23	1	Piston compression rings (rings in cylinder barrel) . . . . . gap:	.037	.051	.057
24	1	Piston oil control ring (ring in cylinder barrel) . . . . . gap:	.032	.046	.052
25	1	Piston pin in piston . . . . . dia:	.0005L	.0012L	.002L
26	1	Piston pin in cylinder . . . . . end clear.:	.036L	.048L	.090
27	1	Piston pin in connecting rod bushing . . . . . dia:	.0018L	.0022L	.003L
		CONNECTING ROD			
28	1	Piston pin bushing in connecting rod . . . . . dia:	.0025T	.0050T	
29	1	Connecting rod bearing on crankpin . . . . . dia:	.0009L	.0034L	
30	2	Connecting rod on crankpin . . . . . end clear.:	.006L	.010L	.016L
31	1	Connecting rod bearing and bushing (per in. of length) . . . twist and convergence:	.000	.0005	.001
32	1	Bolt in connecting rod. . . . . dia:	.0005T	.001L	
		CRANKSHAFT			
33	2	Crankshaft in thrust bearing . . . . . dia:	.0009L	.0041L	
34	2	Crankshaft in thrust bearing . . . . . end clear.:	.004L	.010L	.014L
35	2	Crankshaft in intermediate and main bearings . . . . . dia:	.0005T	.0025L	
36	2	Crankpins . . . . . dia:	2.2490	2.250	2.247
		Crankpins . . . . . out-of-round:	.000	.0005	.0015
37	2	Main and thrust journals . . . . . dia:	2.3740	2.3750	2.372
		Main journals . . . . . out-of-round:	.000	.0005	.0015
38	2	Center main journals (shaft supported at thrust and rear journals (full indicator reading) . . . . . eccentricity:	.000	.015	.015
39	2	Propeller hub of flanged crankshaft (shaft supported at thrust and rear journals) (full indicator reading) eccentricity:	.000	.0035	.0035
40	2	Face near perimeter of propeller mount flange (shaft supported at thrust and rear journals) (full indicator reading . . . . . out-of-plane:	.000	.0035	.0035
41	2	Damper pin bushing in crankcheek extension . . . . . dia:	.0015T	.003T	
42	2	Damper pin bushing in counterweight. . . . . dia:	.0015T	.003T	
		Damper pin in bushings . . . . . dia:	.0674L	.0714L	.080L

TABLE XIX. TABLE OF LIMITS (Cont.)

Ref. No.	Chart No.	Description	New Parts Minimum	New Parts Maximum	Replace. Maximum
		CRANKSHAFT (Cont.)			
43	2	Damper pin in counterweight . . . . . end clear.:	.011L	.033L	.050L
44	2	Crankshaft in counterweight . . . . . side clear.:	.006L	.012L	.020L
45	2	Crankshaft gear on crankshaft pilot . . . . . dia:	.000	.002L	
		GOVERNOR OIL TRANSFER COLLAR			
46	2	Collar assembly on crankshaft . . . . . dia:	.001L	.0025L	.004L
		Tube in collar . . . . . dia:	.0005T	.0025T	
		Screw in collar . . . . . dia:	.0005T	.0015L	
		CRANKSHAFT OIL TRANSFER PLUG			
47	2	Plug assembly in crankshaft . . . . . dia:	.001L	.004L	
		CRANKCASE			
48	2	Crankshaft oil seal in crankcase . . . . . dia:	.011T	.017T	
49	2	Through bolt in crankcase . . . . . dia:	.0007T	.011L	
50	1	Hydraulic valve lifter in crankcase guide . . dia:	.0005L	.0020L	.0035L
		CAMSHAFT			
51	2	Camshaft journals in bearings . . . . . dia:	.001L	.003L	.005L
		Camshaft center journals (shaft supported at front and rear journals) (full indicator reading) . . . . . eccentricity:	.000	.001	.001
52	2	Camshaft in crankcase . . . . . end clear.:	.005L	.009L	.014L
53	2	Camshaft gear on flange . . . . . dia:	.0005T	.0015L	
		ACCESSORY CASE			
54	2	Magneto adapter pilot in case. . . . . dia:	.0005L	.0025L	
55	2	Bushing in magneto adapter . . . . . dia:	.0015T	.0035T	
56	2	Magneto cluster gear in adapter bushing . . dia:	.0025L	.0045L	.006L
57	2	Sleeve in magneto cluster gear. . . . . dia:	.001T	.004L	
58	2	Magneto pilot in adapter . . . . . dia:	.001L	.005L	
59	2	Upper hydraulic pump drive gear in rear bushing . . . . . dia:	.0015L	.003L	.0045L
60	2	Upper hydraulic pump drive rear bushing in case . . . . . dia:	.001T	.003T	
61	2	Upper hydraulic pump drive gear . . end clear.:	.010L	.030L	.035L
62	2	Upper hydraulic pump drive front bushing in case . . . . . dia:	.001T	.003T	
63	2	Upper hydraulic pump drive gear in front bushing . . . . . dia:	.0015L	.003L	.0045L
64	2	Upper hydraulic pump drive oil seal in case . . . . . dia:	.000	.006T	
65	2	Magneto cluster gear front bushing in case . . . . . dia:	.001T	.003T	
66	2	Magneto cluster gear in front bushing . . . . dia:	.002L	.004L	.0055L
67	2	Magneto cluster gear . . . . . end clear.:	.014L	.046L	.051L
68	2	Propeller governor drive gear bushing in case . . . . . dia:	.001T	.003T	
69	2	Propeller governor drive gear in rear bushing . . . . . dia:	.0015L	.0035L	.0045L
70	2	Propeller governor drive gear . . . . end clear.:	.010L	.030L	.035L
71	2	Propeller governor drive gear in front bushing . . . . . dia:	.0015L	.0035L	.0045L
72	2	Propeller governor drive front bushing in case . . . . . dia:	.001T	.003T	
73	2	Upper tachometer drive gear . . . . . end clear.:	.010L	.030L	.035L
74	2	Upper tachometer drive gear in front bushing . . . . . dia:	.0015L	.0035L	.005L
75	2	Upper tachometer drive gear front bushing in case . . . . . dia:	.001T	.003T	

TABLE XIX. TABLE OF LIMITS (Cont.)

Ref. No.	Chart No.	Description	New Parts Minimum	New Parts Maximum	Replace. Maximum
		ACCESSORY CASE (Cont.)			
76	2	Upper tachometer drive rear bushing in case. . . . . dia:	.001T	.003T	
77	2	Upper tachometer drive gear in rear bushing . . . . . dia:	.0015L	.0035L	.005L
78	2	Upper tachometer drive oil seal in case dia:	.001T	.007T	
79	2	Starter jaw on stud . . . . . dia:	.010L	.030L	
80	2	Starter jaw oil seal in case . . . . . dia:	.002T	.008T	
81	2	Fuel pump idler gear . . . . . end clear.:	.013L	.033L	.038L
82	2	Fuel pump idler gear in bushing . . . . . dia:	.0015L	.0035L	.005L
83	2	Fuel pump idler gear bushing in case . . . . dia:	.001T	.003T	
84	2	Lower tachometer drive bushing in case . . dia:	.001T	.003T	
85	2	Tachometer drive shaft in bushing . . . . . dia:	.0015L	.0035L	.005L
86	2	Tachometer drive shaft oil seal in case . . . dia:	.001T	.007T	
87	2	Fuel pump drive gear . . . . . end clear.:	.013L	.033L	.038L
88	2	Fuel pump drive bushing in case . . . . . dia:	.001T	.003T	
89	2	Fuel pump drive gear in bushing . . . . . dia:	.0015L	.0035L	.005L
90	2	Fuel pump drive oil seal in case . . . . . dia:	.001T	.007T	
91	3	Generator drive gear . . . . . end clear.:	.003L	.041L	
92	3	Generator drive bushing in adapter . . . . . dia:	.002T	.004T	
93	3	Generator drive gear in adapter bushing . . dia:	.002L	.004L	.0055L
94	3	Oil seal in generator adapter . . . . . dia:	.001T	.007T	
95	3	Generator pilot in adapter . . . . . dia:	.0005L	.0025L	
96	3	Lower hydraulic pump drive gear . . end clear.:	.010L	.032L	.037L
97	3	Lower hydraulic pump drive rear bushing in case. . . . . dia:	.001T	.003T	
98	3	Lower hydraulic pump gear in rear bushing . . . . . dia:	.0015L	.0035L	.005L
99	3	Lower hydraulic pump drive oil seal in case . . . . . dia:	.000	.005T	
100	3	Lower hydraulic pump drive gear in front bushing . . . . . dia:	.0015L	.0035L	.005L
101	3	Oil pump drive gear . . . . . end clear.:	.013L	.033L	.038L
102	3	Oil pump drive gear bushing in case . . . . . dia:	.001T	.003T	
103	3	Oil pump drive gear in bushing . . . . . dia:	.0015L	.0035L	.005L
		OIL PUMP			
104	3	Oil pump drive and driven gears. . . end clear.:	.003L	.005L	.006L
105	3	Oil pump driver and driven gears in accessory case bushings . . . . . dia:	.0015L	.0035L	.0045L
106	3	Oil pump drive and driven gear teeth in pump body . . . . . dia:	.003L	.005L	
107	3	Oil pump drive and driven gear shafts in pump bushings . . . . . dia:	.0015L	.0035L	.0045L
108	3	Oil screen ferrule in pump body . . . . . dia:	.005L	.025L	
109	3	Oil pressure relief valve sleeve in pump body . . . . . dia:	.035L	.050L	.055L
110	3	Oil pressure relief valve sleeve in pump body . . . . . dia:	.002L	.005L	.007L
111	3	Oil pressure relief valve plunger in sleeve . . . . . dia:	.0025L	.0045L	.007L

TABLE XX. BACKLASHES

Ref. No.	Chart No.	Description	New Parts Minimum	New Parts Maximum	Replace. Maximum
112	3	Upper tachometer drive gear to propeller governor drive gear	.008	.012	.016
113	3	Upper tachometer drive gear to magneto cluster gears	.008	.012	.016
114	3	Right magneto cluster gear to generator drive gear	.008	.012	.016
115	3	Pinion gear to upper tachometer drive gear	.008	.012	.016
116	3	Pinion gear to camshaft gear	.008	.012	.016
117	3	Camshaft gear to lower hydraulic pump drive gear	.008	.012	.016
118	3	Oil pump driver gear to oil pump driven gear	.018	.026	.032
119	3	Fuel pump idler to fuel pump drive gear	.008	.012	.016
120	3	Fuel pump idler to camshaft gear	.008	.012	.016

TABLE XXI. SPRING TEST DATA

Ref. No.	Chart No.	Description	New Parts Minimum	New Parts Maximum	Replace. Maximum
121	3	Oil pressure relief valve spring No. 533106 (Compressed to 2.69 in.) load	6.25 lb	8.25 lb	5.25 lb
122	1	Pushrod housing spring No. 535052 (Compressed to 2.25 in.) load	22.5 lb	27.5 lb	18 lb
123	1	Inner valve spring No. 520106 (Compressed to 1.329 in.) load	78 lb	88 lb	71 lb
		(Compressed to 1.809 in.) load	43 lb	49 lb	37 lb
124	1	Outer valve spring No. 520105 (Compressed to 1.360 in.) load	107 lb	120 lb	100 lb
		(Compressed to 1.840 in.) load	65 lb	71 lb	62 lb

TABLE XXII. TIGHTENING TORQUES

Ref. No.	Chart No.	Description	Size	Per Engine	Torque (In. Lbs.)
		Nut — Front mount bracket stud	3/8-24	8	275 - 325
T1	2	Nut — Crankcase through bolt	5/16-24	3	180 - 220
T2	2	Nut — Crankcase front through bolt	3/8-24	2	370 - 390
T3	1	Nut — Crankcase through bolt	7/16-20	16	490 - 510
T4	1	Nut — Cylinder to crankcase stud	7/16-20	36	490 - 510
T5	1	Nut — Connecting rod bolt (with Alcoa thread lube)	3/8-24	12	400 - 420
T6	2	Screw — Gear to crankshaft	5/16-24	6	240 - 260
T7	2	Screw — Gear to camshaft	5/16-24	4	240 - 260
T8	1	Spark plug (With BG mica thread lubricant)*	18mm.	12	300 - 360
T9	3	Nut — Starter jaw to crankshaft stud	9/16-18	1	575 - 625

* Lubricant optional.

TABLE XXIII. PIPE PLUG TIGHTENING TORQUES

Size	Torque	
	In. Lbs	Ft. Lbs
1/8	80-100	6.7-9.3
1/4	160-180	13.3-14.9
3/8	235-265	19.8-22.2
1/2	315-345	26.3-28.7
3/4	390-430	32.5-35.7

TABLE XXIV. TIGHTENING TORQUES FOR GENERAL USE

Size	Torques for Driving Studs		Torques for Tightening Nuts and Bolts	
	In.-Lb	Ft-Lb	In.-Lb	Ft-Lb
10/32			36-50	3.0-4.2
1/4-20	50-70	4.2-5.8		
1/4-28			90-110	7.5-9.1
5/16-18	100-150	8.3-12.5		
5/16-24			180-220	15.0-18.4
3/8-16	200-274	16.6-22.8	220-260	17.9-22
3/8-24			275-325	22.9-27.1
7/16-14	300-424	25.0-35.4		
7/16-20			400-450	33.4-37.6
1/2-20			550-600	45.8-50.0

Note: Tightening torques in Table XXIV for bolts and nuts are for oiled threads, not for use when a special thread lubricant is applied. Stud driving torques are for use with thread lubricants specified in Section V.

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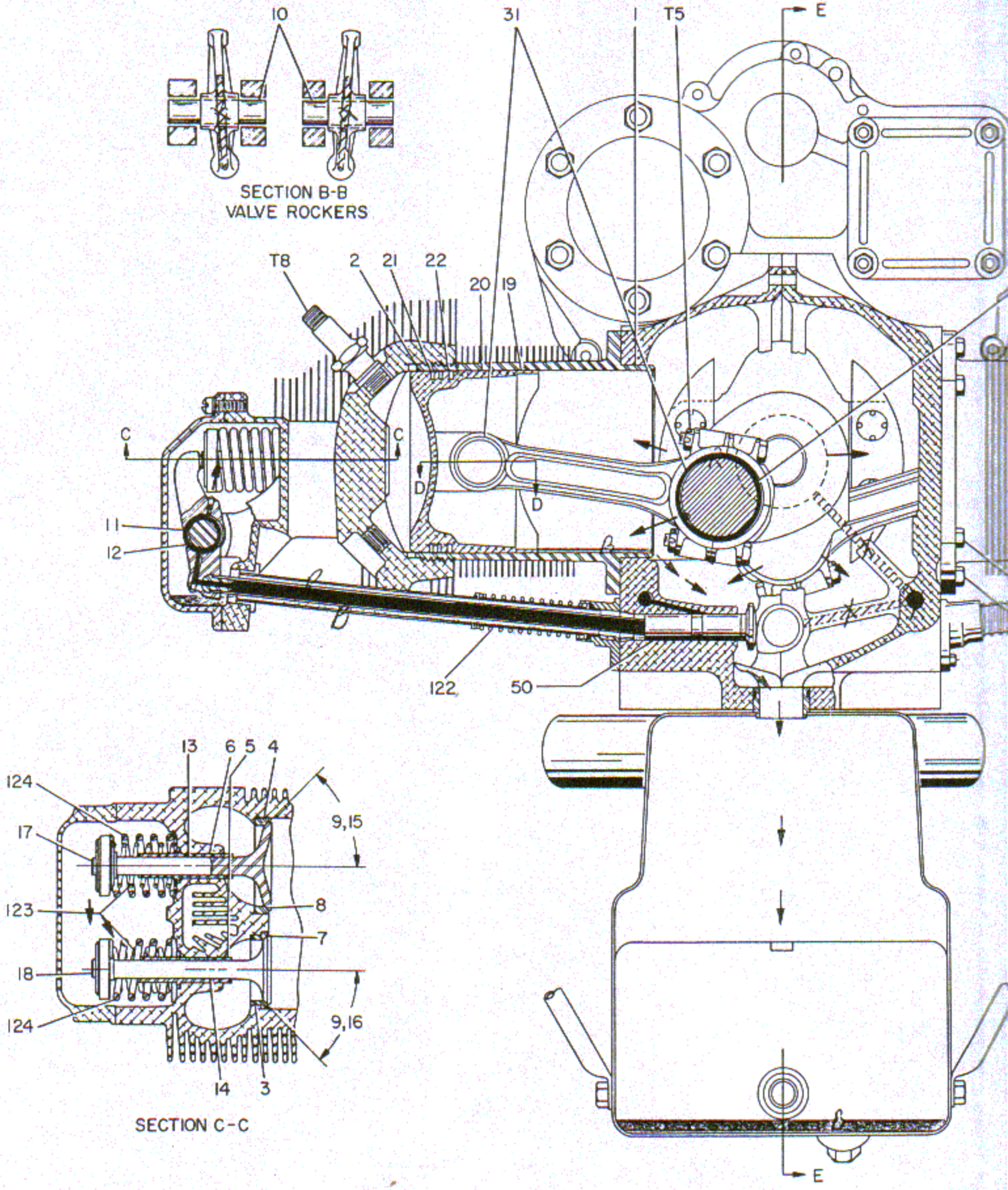
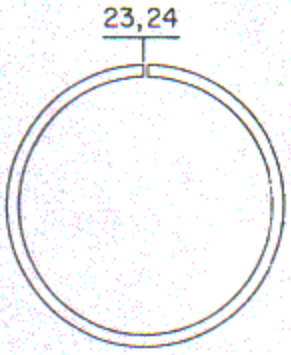
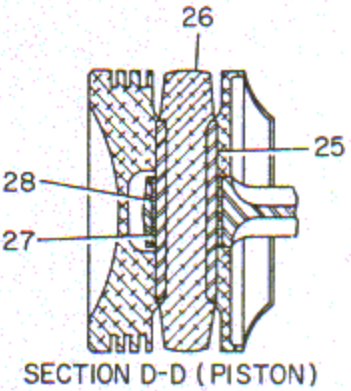


Figure 10-1. Limits and Lubrication Chart (Sheet 1 of 3)



PISTON RING

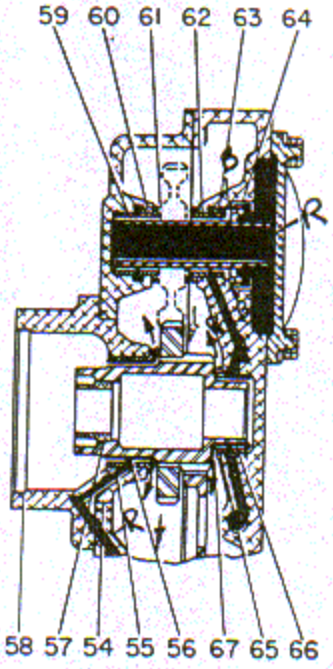


SECTION D-D (PISTON)

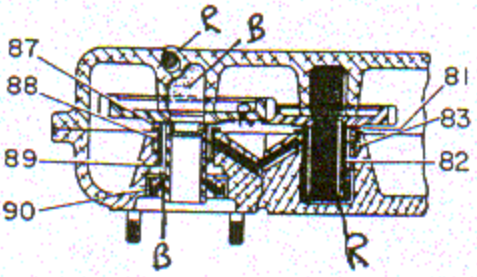
R OIL UNDER SYSTEM PRESSURE

X INVISIBLE PRESSURE OIL PASSAGE

B OIL DRAIN PATH OR POOL



SECTION G-G
LEFT MAGNETO DRIVE
AND UPPER HYDRAULIC
PUMP DRIVE



SECTION J-J
FUEL PUMP AND
IDLER GEARS

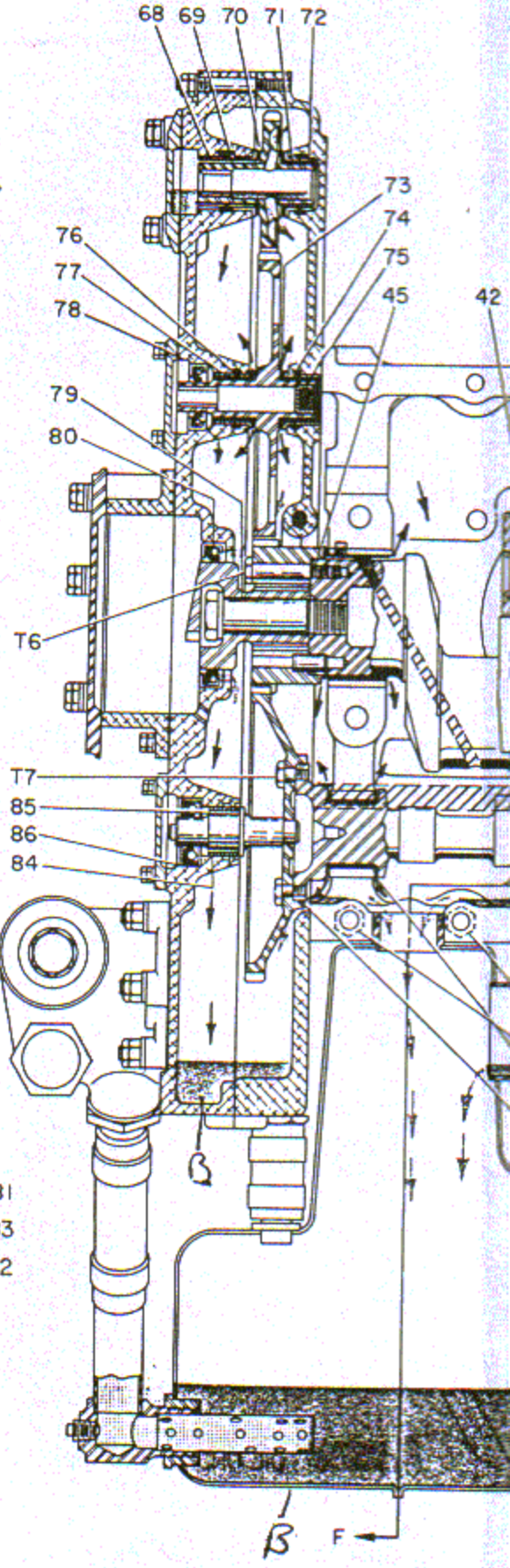
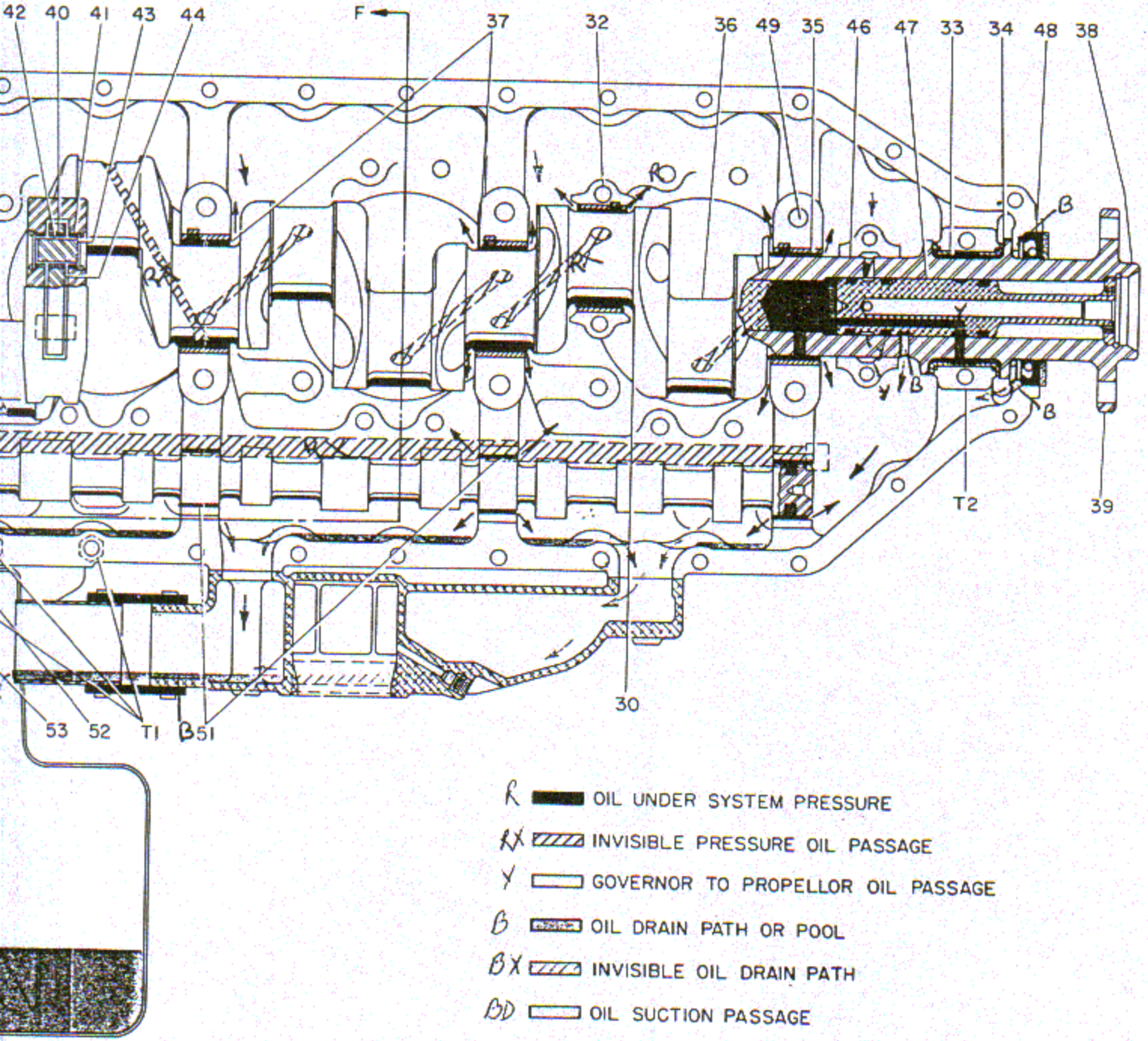
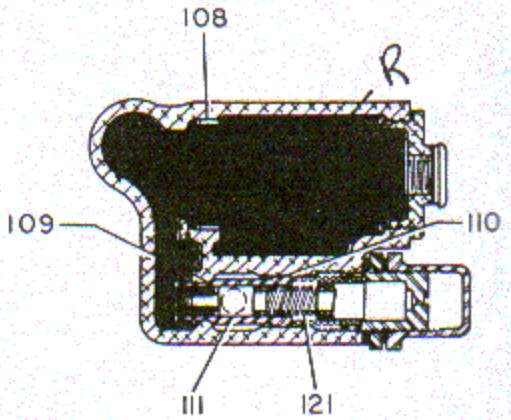


Figure 10-1. Lin



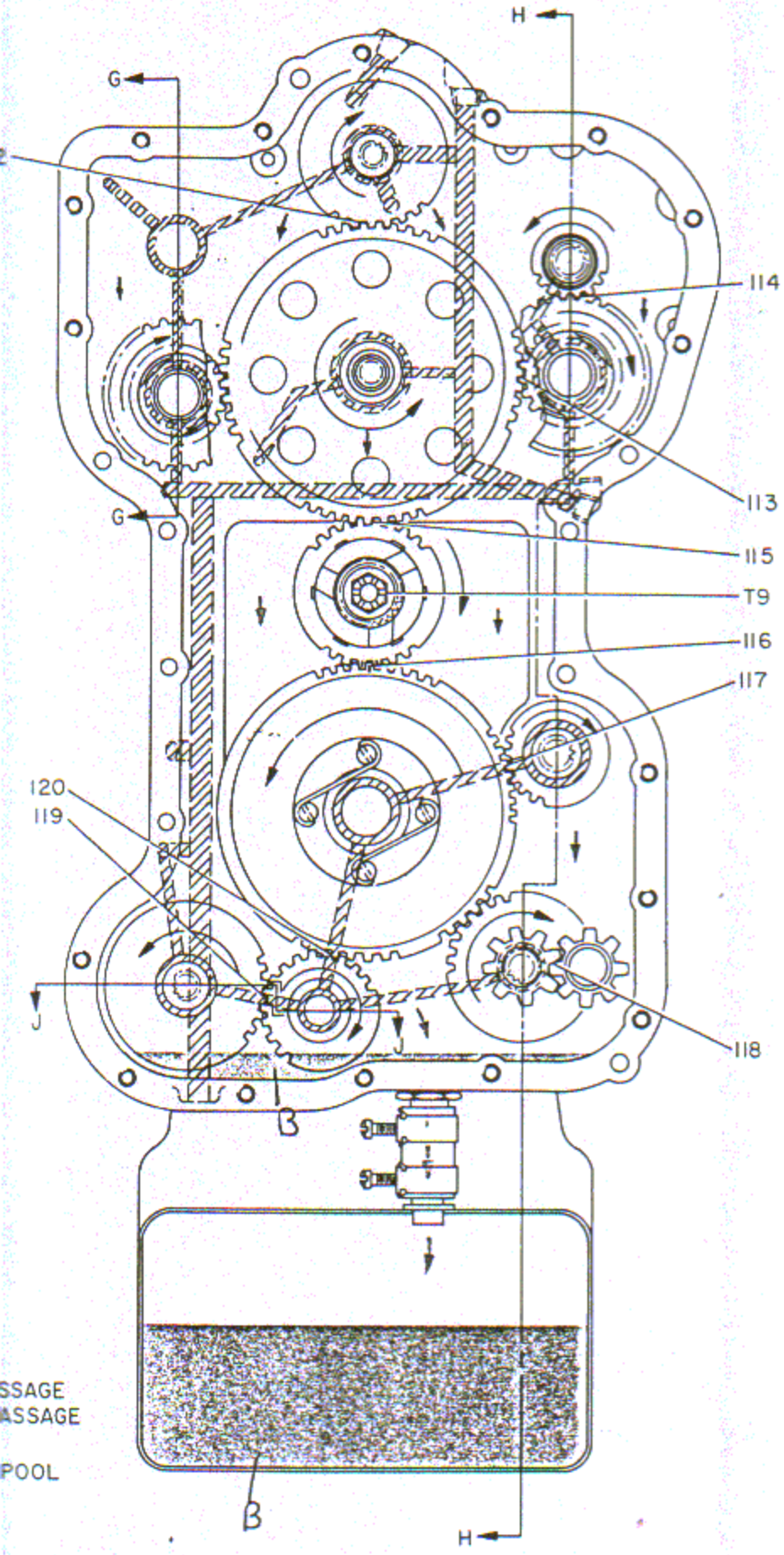
SECTION E-E

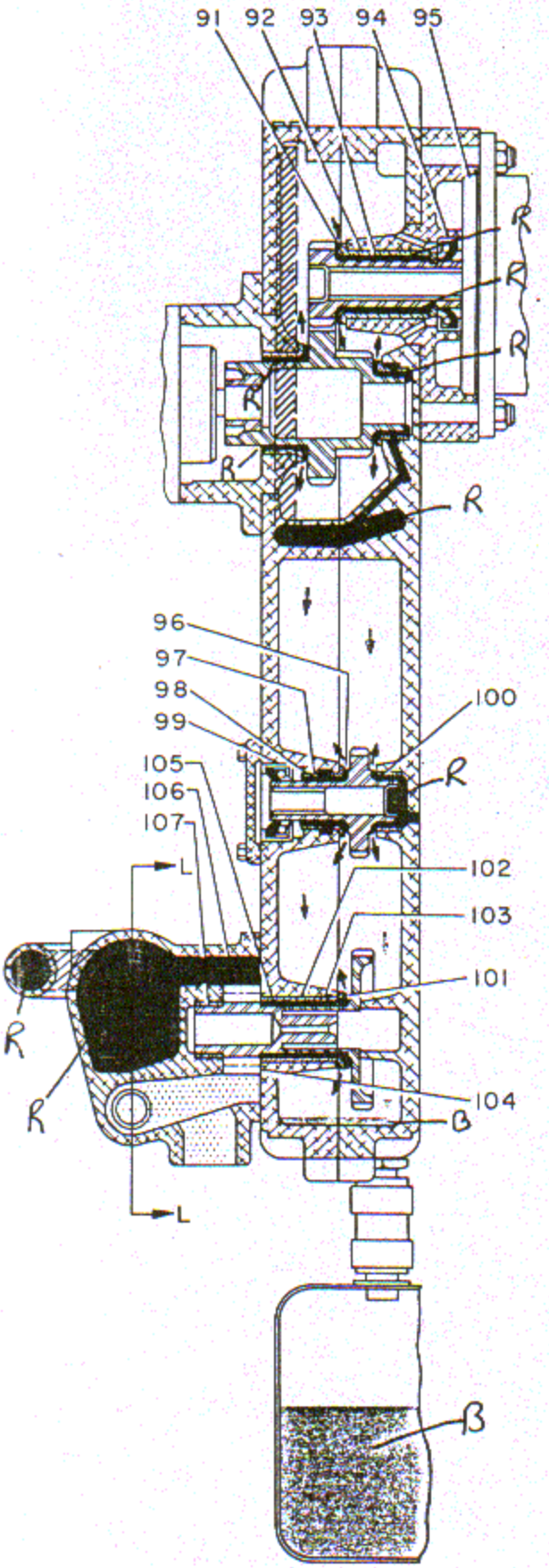
Limits and Lubrication Chart (Sheet 2 of 3)



SECTION L-L
PRESSURE OIL SCREEN
AND
PRESSURE RELIEF VALVE

R VISIBLE PRESSURE OIL PASS
INVISIBLE PRESSURE OIL PAS
SUCTION OIL PASSAGE
B OIL DRAIN PASSAGE OR P





SECTION H-H
GENERATOR DRIVE, RIGHT
MAGNETO DRIVE, LOWER
HYRAULIC PUMP DRIVE
AND OIL PUMP

Figure 10-1. Limits and Lubrication Chart (Sheet 3 of 3)