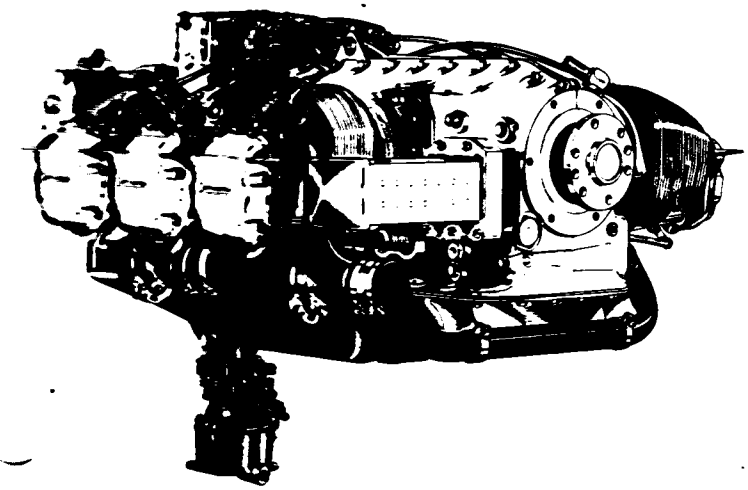
CONTINENTAL

Aircraft Engines

Models O-470-K
O-470-L
O-470-M



MAINTENANCE and OVERHAUL MANUAL

Continental Motors Corporation

Aircraft Engine Division

MUSKEGON, MICHIGAN, U.S.A.

Form No. A-081
6-1-56

WARRANTY

CONTINENTAL MOTORS CORPORATION warrants each new aircraft engine or aircraft engine part to be free from defects in material and workmanship, when properly installed and used under normal conditions, for one hundred fifty (150) days, or in no case to exceed one hundred (100) hours of operation after the shipment of each engine or part from the plant. This warranty is limited to replacing or repairing at its shops any part or parts which have been returned to the Aircraft Engine Division with transportation charges prepaid, and which, in its opinion, are defective. This warranty is expressly in lieu of all other warranties or representations, expressed or implied, and all other liabilities on the part of Continental Motors Corporation.

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The Aircraft Engine Division of Continental Motors Corporation will warrant each new accessory furnished by it to be free from defects in material and workmanship for ninety (90) days or fifty (50) hours of operation after original installation in an aircraft. Since many of these accessories are procurable from other sources, this clause applies only to accessories purchased on engines or as spare parts from Continental Motors Corporation.

The Aircraft Engine Division of Continental Motors Corporation reserves the right to change engine or parts specifications or prices without incurring any responsibility with regard to engines or parts previously sold or replaced.

Continental Motors Corporation
Aircraft Engine Division
MUSKEGON, MICHIGAN, U.S.A.

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont.)

DEFINITIONS AND ABBREVIATIONS

Term	Explanation
A.B.C. :	After Bottom Center
Approx. :	Approximately
A.T.C. :	After Top Center
Bar. :	Barometric
B.B.C. :	Before Bottom Center
B.H.P. :	Brake Horsepower
B.T.C. :	Before Top Center
C.A.A. :	Civil Aeronautics Administration
C.A.R. :	Civil Air Regulations
c.f.m. :	Cubic feet per minute
C.G. :	Center of Gravity
Dia. :	Diameter
^{o} :	Degrees of Angle
^{o}F :	Degrees Fahrenheit
Fig. :	Figure (Illustration)
Front :	Propeller End
ft. :	Foot or feet
G.P.M. :	Gallons per minute
H_2O :	Water
Hg. :	Mercury
I.D. :	Inside Diameter
in. ('') :	Inches
Hex. :	Hexagon
hr. :	Hour
Left Side:	Side on which No.'s 2, 4 and 6 cylinders are located
Lbs. :	Pounds
Lock wire :	Soft steel wire used to safety connections, etc.
Man. :	Manifold or manometer
Min. :	Minimum
30' :	Thirty minutes of angle (60' equal one degree)
N.P.T. :	National pipe thread (tapered)
N.C. :	National Coarse (thread)
N.F. :	National Fine (thread)
O.D. :	Outside Diameter
Press.:	Pressure
p.s.i. :	Pounds per square inch
Rear :	Accessory end of engine
Right Side :	Side on which No.'s 1, 3 and 5 cylinders are located
R.P.M. :	Revolutions per minute
Std. :	Standard
T.D.C. :	Top dead center
Temp. :	Temperature
Torque :	Force x lever arm (125 ft.-lbs. torque = 125 lbs. force applied one ft. from bolt center or 62-1/2 lbs. applied 2 ft. from center)

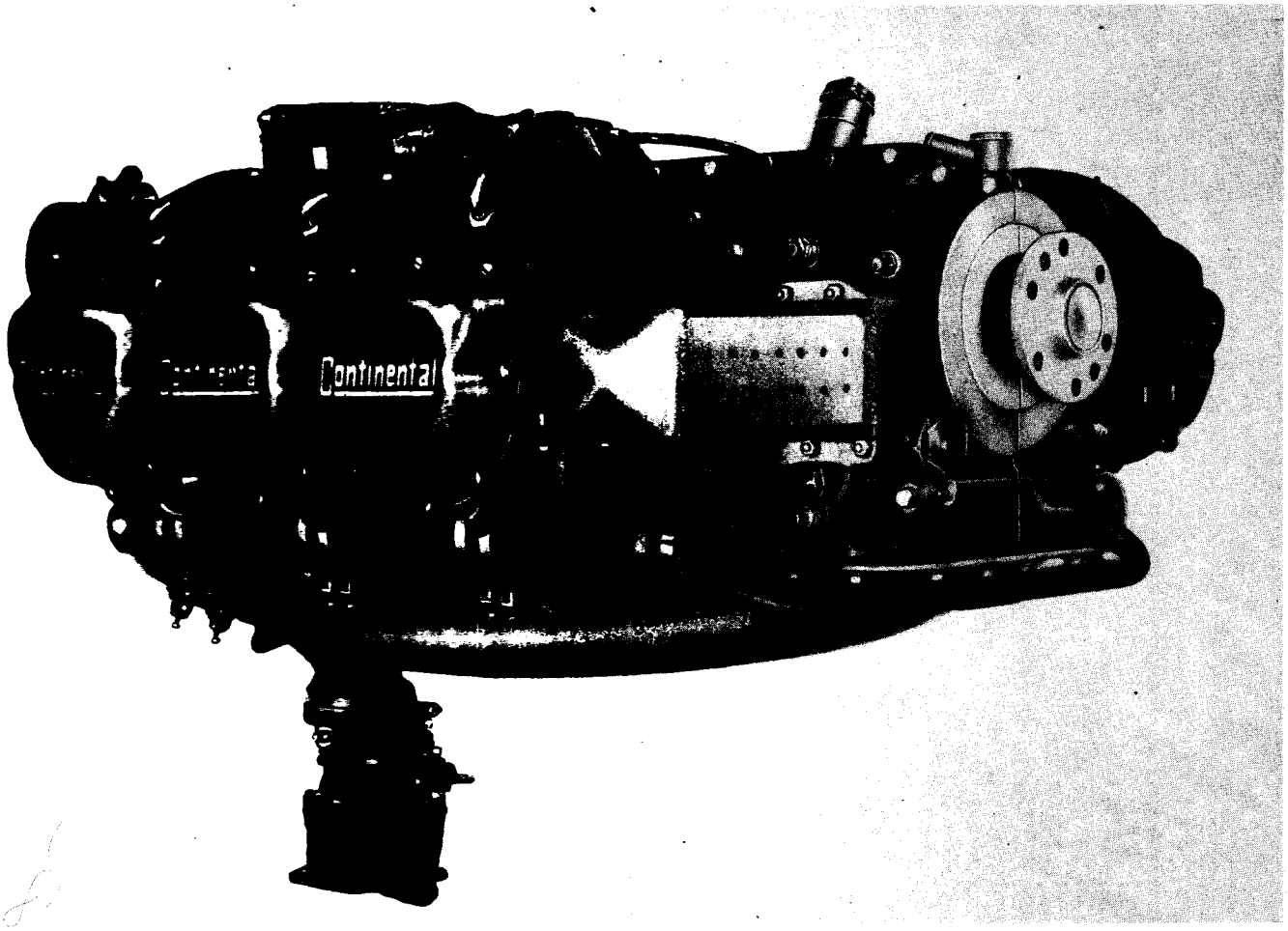


Figure 1. Three Quarter, Right Front View of O-470-K

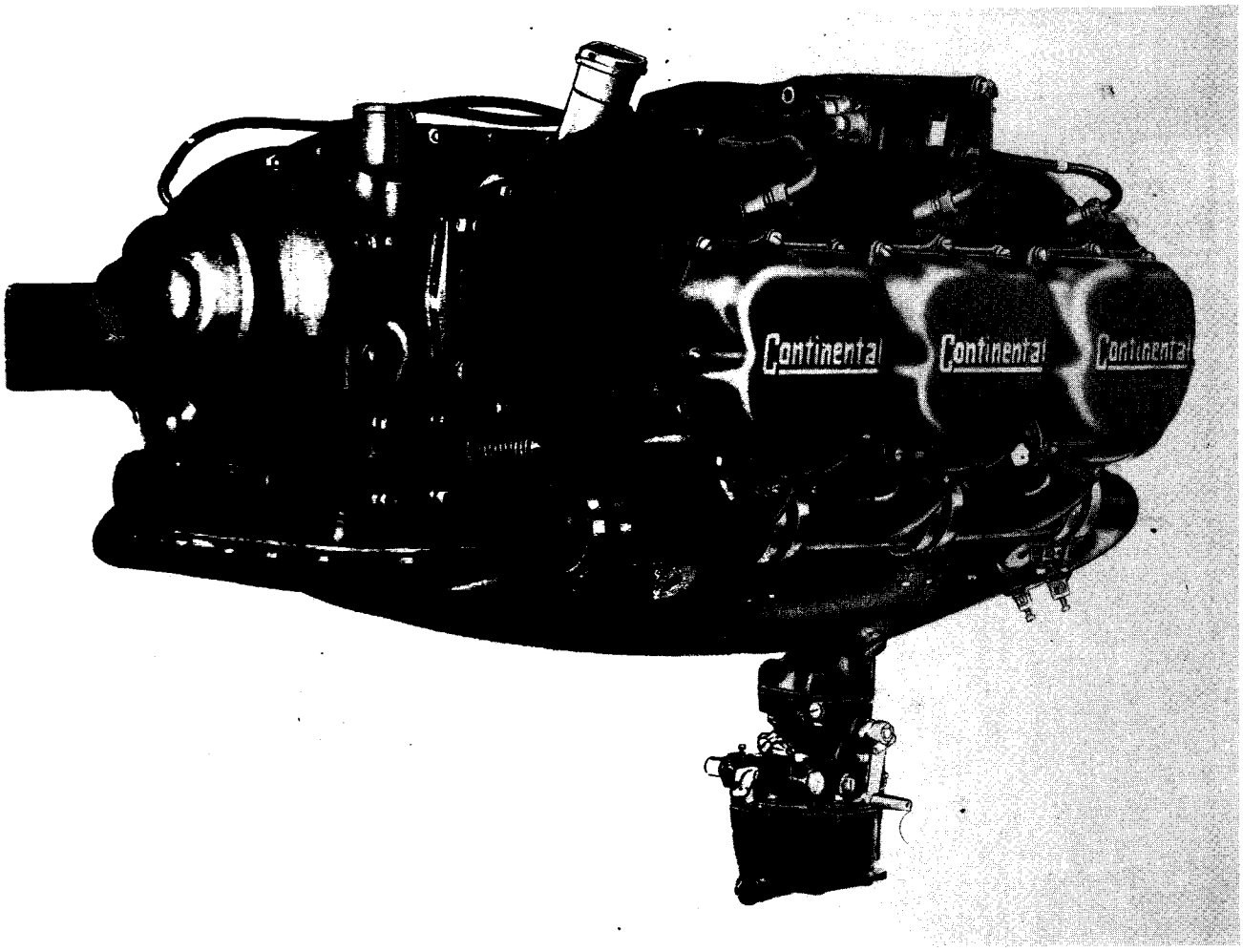


Figure 2. Three-Quarter, Left Front View of O-470-L

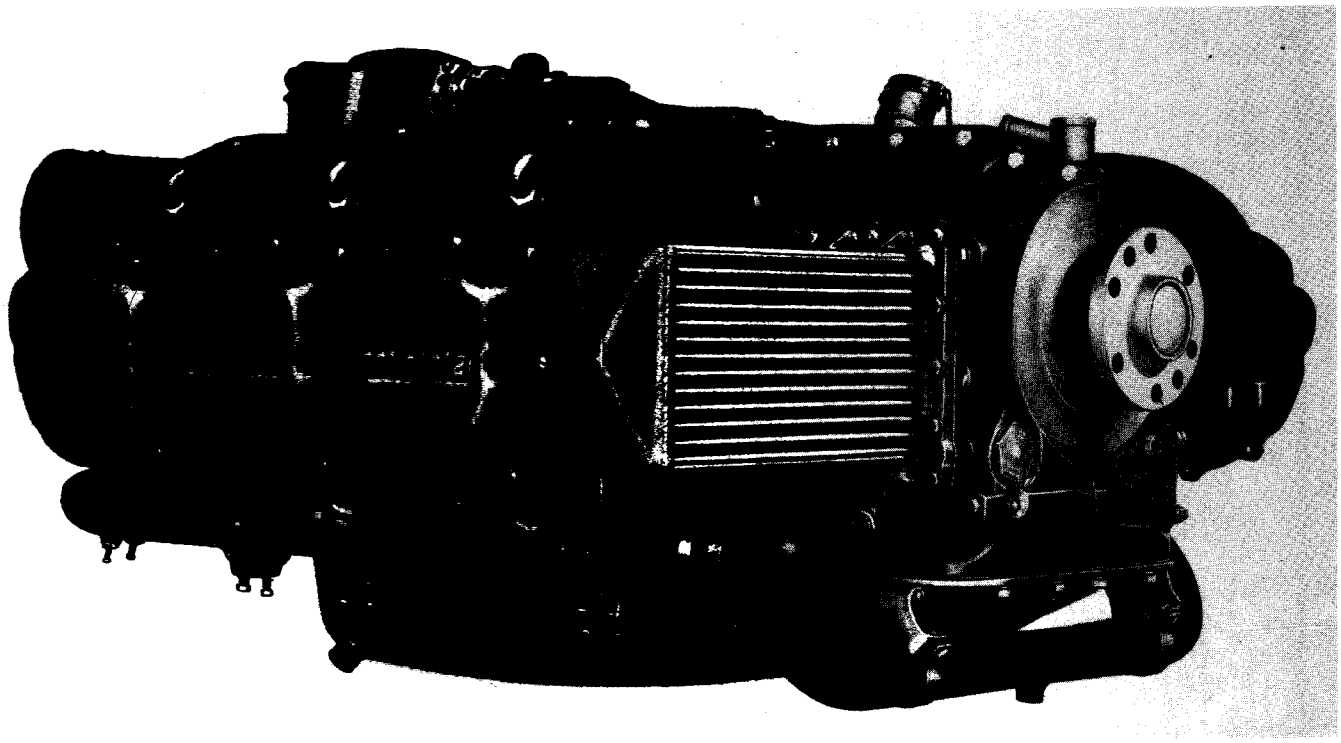


Figure 3. Three-Quarter, Right Front View of O-470-M

SECTION I

INTRODUCTION

1-1. SCOPE.

1-2. Material in this publication is applicable to model O-470 aircraft engines. A brief explanation of construction features and functional systems is included. This information is supplemented by the Limits and Lubrication Chart, which is composed of sectional drawings printed on the final pages. Tables of specifications, performance characteristics and operation limitations and performance charts are included in Section II. Dimensional specifications in the Table of Limits govern the permissible tight fits of "permanently" assembled parts and clearances of running parts as a guide for the determination of serviceability at overhaul. Other sections are devoted to instructions for operation, inspection, routine maintenance, trouble shooting and overhaul procedure. Descriptive text, specifications and part numbers mentioned herein are correct as of the date of publication; however, changes may be made in specifications and/or part numbers. Therefore, all replacement parts should be ordered in accordance with information contained in the Spare Parts Catalog, Form F-O81, and operation limitations herein should not be construed to authorize any departure from limits published in the applicable C.A.A. Type Specification. If more detailed information is necessary concerning any of the purchased accessories listed in Table I, it is requested that inquiries for such be made of the manufacturer or agency whose name and address is listed immediately behind the accessory in Table I.

1-3. AVAILABILITY.

1-4. Further copies of this and other Continental Motors aircraft engine service publications may be purchased through Continental Approved Distributors and Parts Dealers for aircraft engine parts. It is requested that all orders for such publications be placed with these agencies when not immediately available from their stock.

1-5. SERVICE BULLETINS.

1-6. Important changes in part numbers, interchangeability of parts, urgent inspections, mandatory replacements and modernization information are among the subjects of limited interest and duration covered by factory Service Bulletins, which are distributed to all Approved Distributors of aircraft engines and parts and are available for study at their offices. Service Bulletins of interest to aircraft owners, operators and maintenance personnel may be obtained by direct mail on an annual subscription basis. The charge for this service covers only postage and handling. Subscriptions are received by the factory Service Manager, to whom inquiries on this subject may be addressed.

1-7. SERVICE REPORTS AND INQUIRIES.

1-8. It is the policy of Continental Motors Corporation to handle all reports of service difficulty and requests for information through Approved Distributors. These agencies are constantly in touch with operation and repair. You will find them more than willing to help solve your maintenance problems and well equipped with experience and facilities to perform any necessary maintenance work on Continental aircraft engines. There is an Approved Distributor at every major airport.

SECTION II
SPECIFICATIONS, LIMITS AND CHARTS

TABLE I. PURCHASED ACCESSORIES

Accessory	Manufacturer	Model or Serial No.	Qty
Carburetor	Bendix-Stromberg Div., Bendix Aviation Corp.	PSD-5C	1
	Marvel-Schebler Div., Borg Warner Corp.	MA-4-5	1
Magneto	Scintilla Magneto Div., Bendix Aviation Corp.	S6RN-25	2
Spark Plug	Champion Spark Plug Co.	RC26S	12
		C27S	12
Starter	Delco-Remy Div., General Motors Corp.	10816	1
		11046	1
Generator	Delco-Remy Div., General Motors Corp.	X1428	1
		1101906	1
Oil Cooler	Harrison Radiator Div., General Motors Corp.	8520912	1
		8522493	1
		8524295	1
Fuel Pump	Romec Div., Lear Inc.	RD7430-2	1

TABLE II. IGNITION SYSTEM DETAILS

Feature		Value
Left magneto fires lower No. 1, 3, 5 and upper No. 2, 4, 6 plugs	O-470-K & O-470-L	22° B.T.C.
	O-470-M	24° B.T.C.
Right magneto fires upper No. 1, 3, 5 and lower No. 2, 4, 6 plugs	O-470-K & O-470-L	22° B.T.C.
	O-470-M	24° B.T.C.
Firing order (cylinder numbers)	All	1, 6, 3, 2, 5, 4
Spark plug gap settings (RC26S)	O-470-M	.015 - .018 in.
(C28S)	O-470-K & O-470-L	.015 - .018 in.
Permissible R.P.M. drop when switched from "Both" to either "Left" or "Right" magneto	All	75 R.P.M.

TABLE III. CHARACTERISTICS AND DIMENSIONS

Dimension	Model	Value
Piston strokes per cycle	All	4
Number of cylinders	All	6
Cylinder bore (in.)	All	5
Piston stroke (in.)	All	4
Compression ratio	O-470-K & O-470-L O-470-M	7:1 8:1
Total displacement (in.)	All	471
Over-all length (in.)	O-470-K & O-470-L O-470-M	36.03 43.31
Over-all width (in.)	O-470-K, O-470-L & O-470-M	33.56
Over-all height (in.)	O-470-K, O-470-L O-470-M	27.75 19.62
Number of mounting brackets	All	4
Rated maximum R.P.M.	O-470-K, O-470-L & O-470-M	2600
Rated maximum B.H.P.	O-470-K & O-470-L O-470-M	230 240
Total dry weight (lbs.)	O-470-K & O-470-L O-470-M	438 454

TABLE IV. FUEL SYSTEM DETAILS

Feature	Model	Value
Minimum fuel octane rating	O-470-K & O-470-L O-470-M	80 91
Fuel pressure required (psi)	O-470-K & O-470-L O-470-M	1.5 - 5 13 - 15
Fuel inlet to carburetor (N.P.T.)	All	1/4 in.
Venturi diameter	O-470-K & O-470-L O-470-M	1-13/16 in. 1-5/8 in.

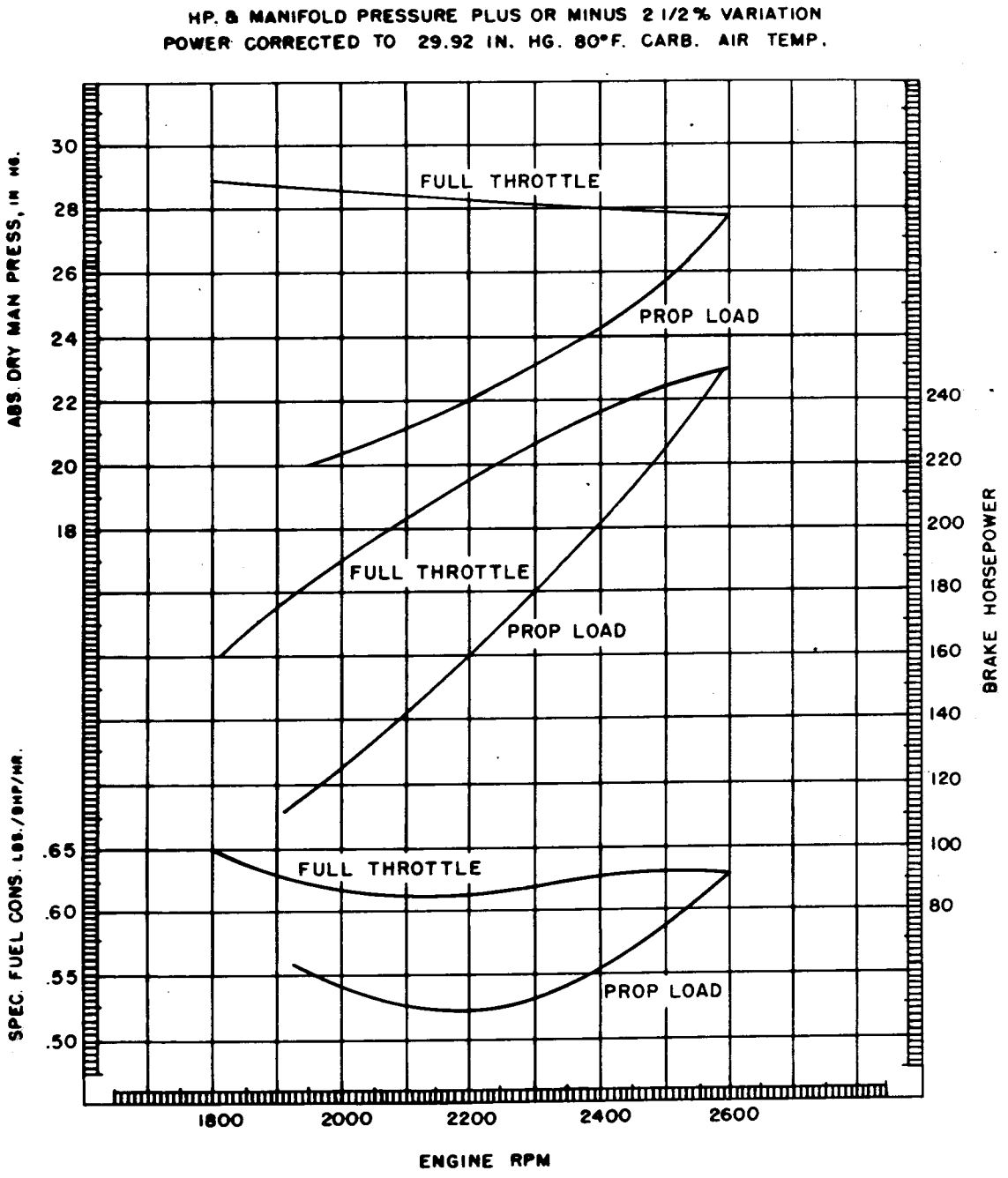
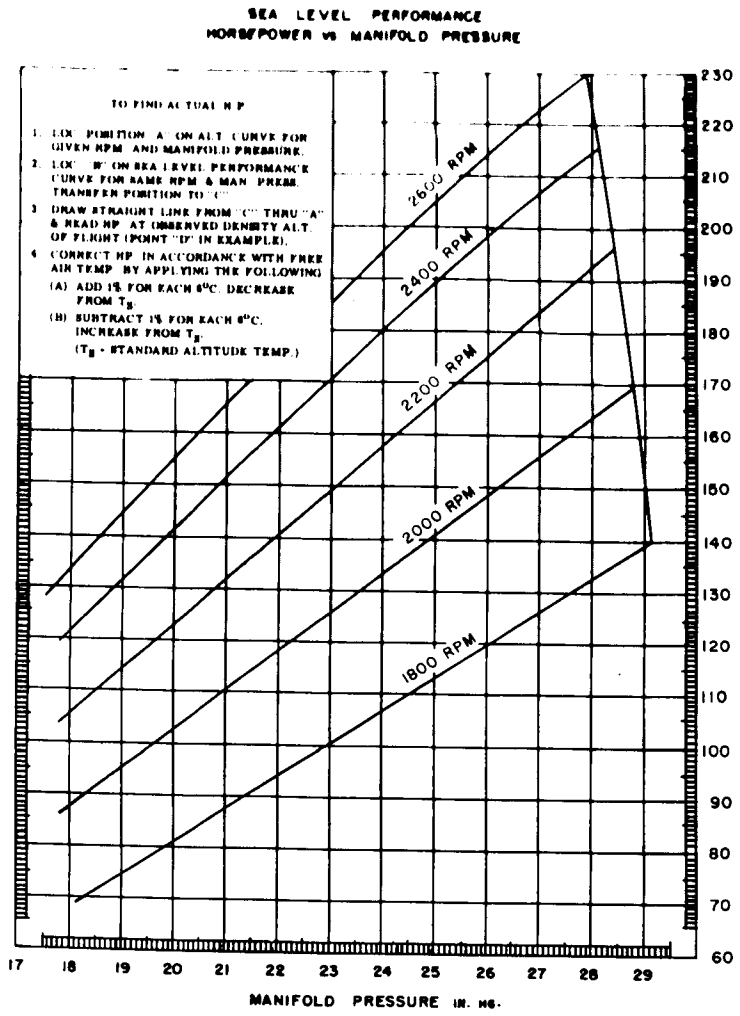
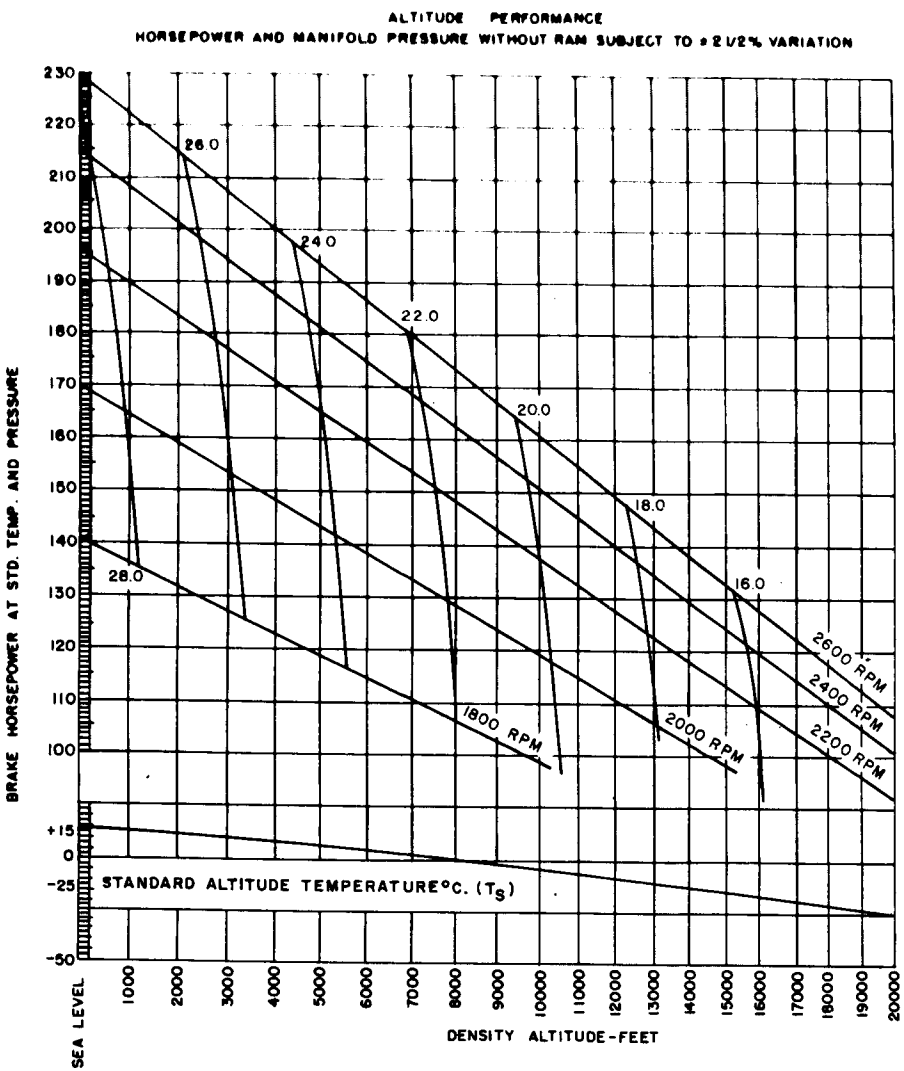


Figure 4. Brake Horsepower, Intake Manifold Pressure and Fuel Consumption vs RPM at Full Throttle and Propeller Load O-470-K and O-470L



Brake Horsepower vs Intake Manifold Pressure vs RPM at Sea Level, O-470-K and O-470-L



Brake Horsepower vs Intake Manifold Pressure vs RPM above Sea Level, O-470-K and O-470-L

Figure 5.

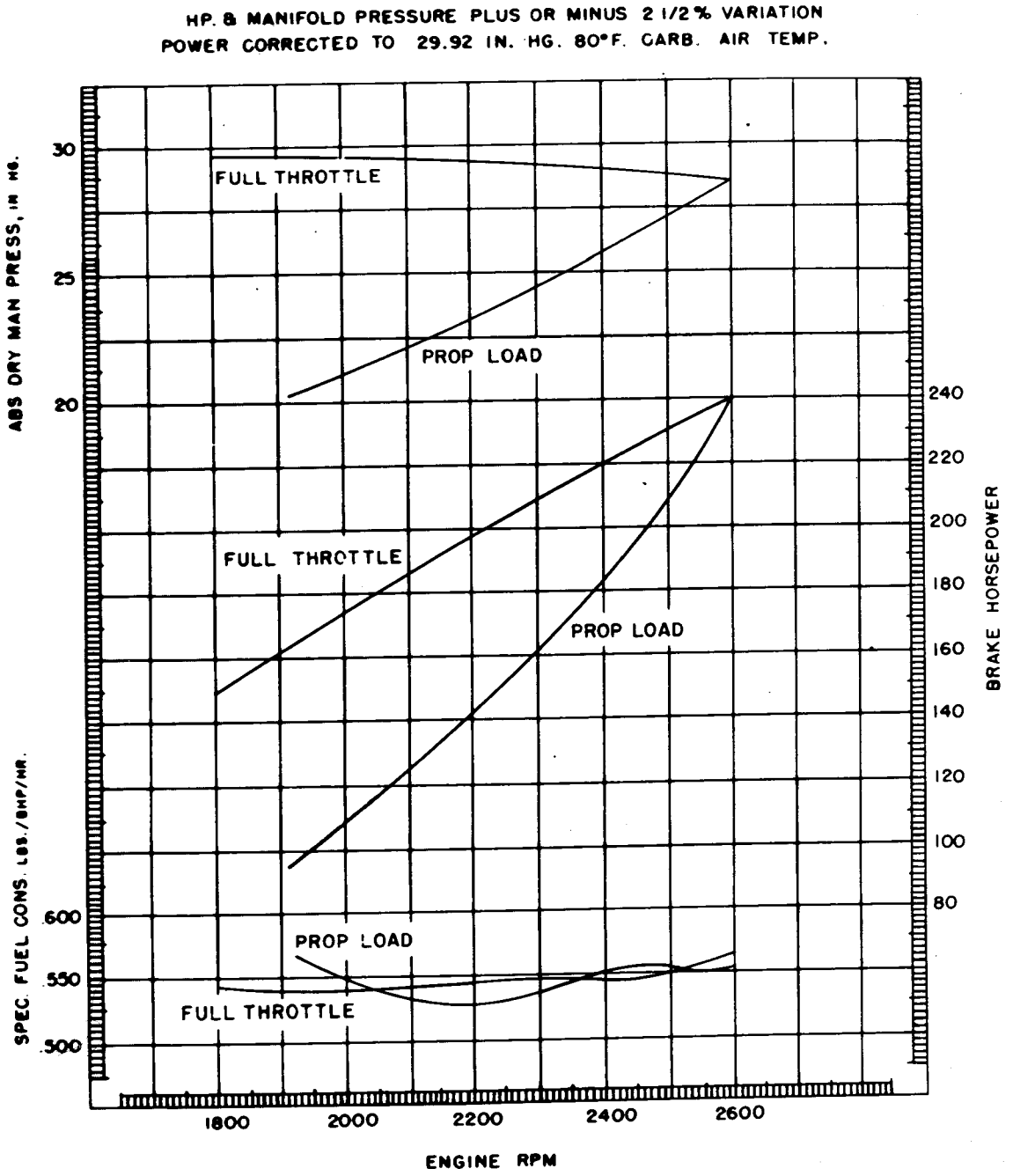
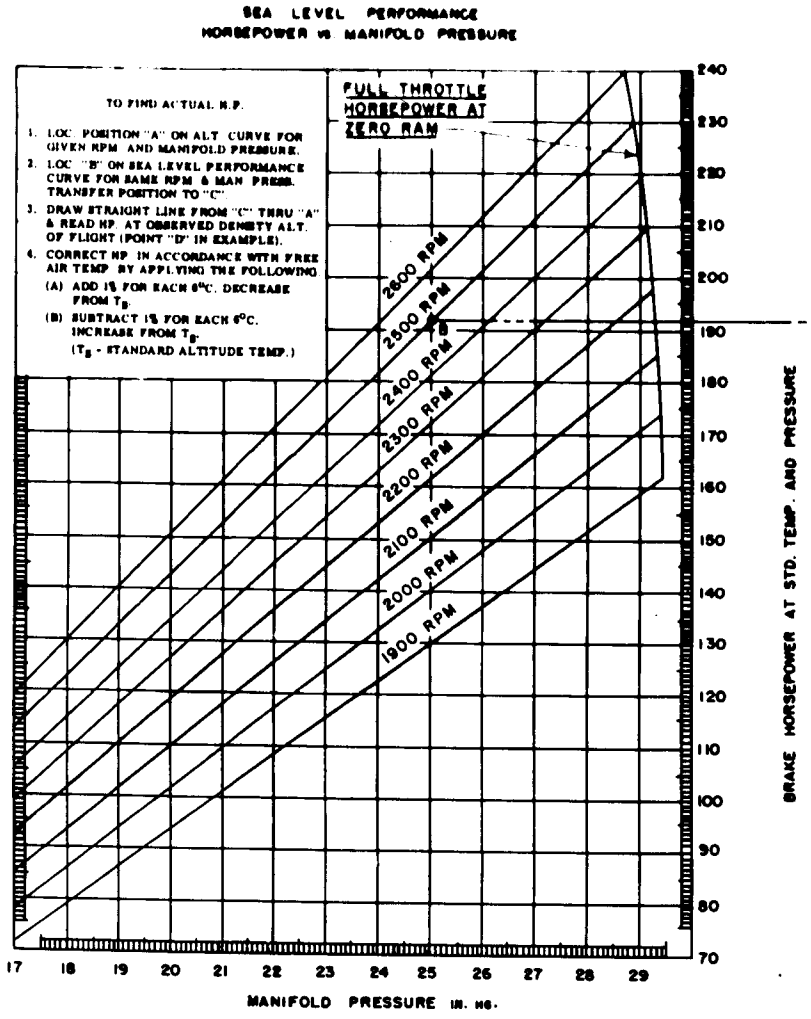


Figure 6. Brake Horsepower, Intake Manifold Pressure and Fuel Consumption vs RPM at Full Throttle and Propeller Load O-470-M



Brake Horsepower vs Intake Manifold Pressure vs RPM at Sea Level, O-470-M

Brake Horsepower vs Intake Manifold Pressure vs RPM above Seal Level, O-470-M

Figure 7.

TABLE V. TEMPERATURE LIMITS

Indicated Condition	Model	Minimum	Maximum
Oil temperature at take-off	All	75°F	-
Oil temperature in flight	All	-	225°F
Cylinder head temperature (downstream spark plug gasket)	All	-	500°F
Cylinder head temperature (bayonet thermocouple)*	-	-	450°F
Magneto temperature (at coil hold-down screw)	All	-	170°F

* Installed in tapped hole in bottom of cylinder head. Applicable only with downdrift cooling system.

TABLE VI. PRESSURE LIMITS

Indication	Minimum	Maximum
Oil pressure (idling)	10 p.s.i.	-
Oil pressure (in flight)	30 p.s.i.	60 p.s.i.

TABLE VII. OIL VISCOSITY GRADES

Oil Operating Temperature	S.A.E. Grade
Below 120°F	30
†120°F - 225°F	50

† Ambient air temperature is the controlling factor on all engines having Vernitherm valves installed.

2-1. OIL SUPPLY AND MEASUREMENT.

2-2. The capacity of the oil sump is 12 U.S. quarts. The minimum quantity of oil in the sump necessary to adequately lubricate the engine in all attitudes of flight is 6 U.S. quarts. The oil filler cap is marked "OIL 12 QUARTS". It is attached over the oil filler neck on top of the left crankcase. The oil sump is equipped with an oil level gauge notched and stamped with numerals, representing quarts, from 6, also stamped "L" (low), to 12, also stamped "F" (full) in increments of 2 quarts.

2-3. OIL FLOW AND CONSUMPTION.

2-4. When operated on a rigid test stand at normal rated power and speed with an oil inlet temperature of 215°F (with S.A.E. 50 oil) and oil pressure of 50 plus or minus 2 p.s.i., oil flow shall not exceed 60 lbs. per minute. Specific oil consumption shall not exceed 0.018 lbs. per B.H.P. per hr. at rated speed and power.

SECTION III
GENERAL DESCRIPTION

3-1. CONSTRUCTION.

3-2. GENERAL. The arrangement and appearance of engine components are indicated in figures 1 through 3 and 9 through 11. Additional information will be found in the installation drawing, and in the limits and lubrication chart. It will be observed that a minimum engine length has been achieved by mounting the starter on a right angle drive, which also drives the side mounted generator through a vee belt, and by mounting the magnetos in the forward side of the accessory gear compartment formed by the crankcase castings at the rear. The magneto location also serves to shorten the high tension cables as much as possible. The automotive type oil sump provides adequate capacity in minimum space.

3-3. CRANKCASE. Two aluminum alloy castings are joined along the vertical center plane to form the complete crankcase. The individual castings (with studs and inserts) will be called "the left crankcase" and "the right crankcase" throughout this publication.
3-4. Bosses molded in the crankcase castings are line bored, in the assembled castings, to form bearings for the camshaft and seats for precision, steel backed, lead alloy lined crankshaft main bearing inserts. Guides are bored through lateral bosses for the tappets and for the governor drive shaft (5 and 7, figure 13). A needle bearing is pressed into the right crankcase, to the right of the rear main bearing, to support the front end of the starter shaftgear.

3-5. Cylinder mounting pads on the left crankcase are farther forward than corresponding pads on the right crankcase to permit each connecting rod to work on a separate crankpin. Each pad has six studs and two through bolt holes for attachment of cylinder base flanges. The governor mount pad is located on the side of the left crankcase at the lower front corner. The oil cooler is mounted on the right crankcase directly in front of No. 5 cylinder. Two engine mount brackets are attached to studded pads on the side of each crankcase. (See 22 and 25, figure 9.)

3-6. The crankcase breather assembly for O-470-K, O-470-L and O-470-M engines is equipped with a pressed-in type breather consisting of a tube and baffles assembly with a side extension for hose attachment. The breather assembly is located on the left upper crankcase.

3-7. The flanged type oil filler neck is located on the top of the left crankcase between No's 4 and 6 cylinders. The filler neck is secured to the boss by three screws plain washers and lock wire. The cap is an automotive bayonet locking type.

3-8. The oil cooler is mounted on the right crankcase directly in front of No. 5 cylinder. For model O-470-K engine, the cooler is attached directly to the machined bosses and the cooling air flows from the topside down through the cooler core. For O-470-L and O-470-M engines, the cooling air flows through the cooler from front to rear. The mounting arrangement of these coolers requires the use of adapters between them and the crankcases. The O-470-L cooler is smaller in dimensions and requires five hex drilled head bolts and three nuts to attach it to the adapter. The O-470-M cooler is larger and requires 12 hex drilled head bolts for attachment.

3-9. CRANKSHAFT. The six-throw 120° steel alloy forging is machined all over excepting some surfaces of the crankcheeks. Main journals and crankpins are nitrided after grinding. A special flange is formed at the front end for attachment of the propeller. A center-bored hole from the front end intersects a radial hole from the front main journal to conduct engine oil under pressure from the governor through an interior groove in the front main and thrust bearing (41, figure 14) to the center of the propeller hub. The crankcheeks between No's. 1 and 2, 3 and 4 crankpins have side blades, each equipped with two hardened steel bushings for steel fulcrum pins on which one of the four pendulum counterweights is mounted. Oscillation of the counterweights on their fulcrum pins damps out crankshaft torsional vibration at the gear end.

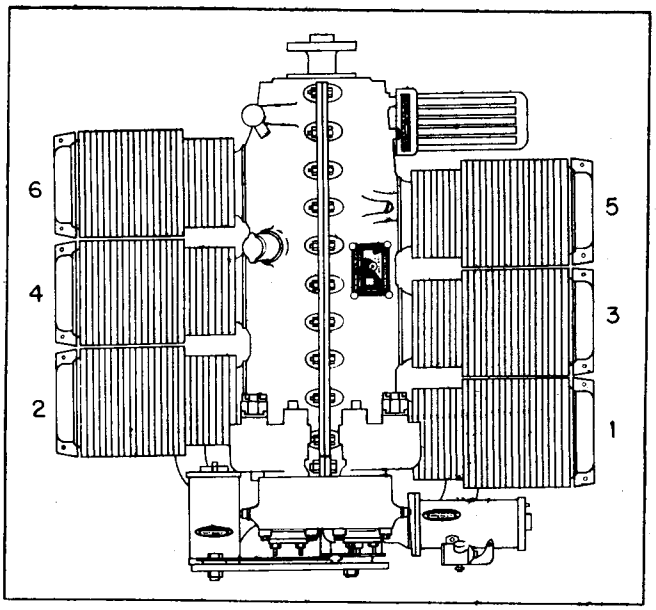
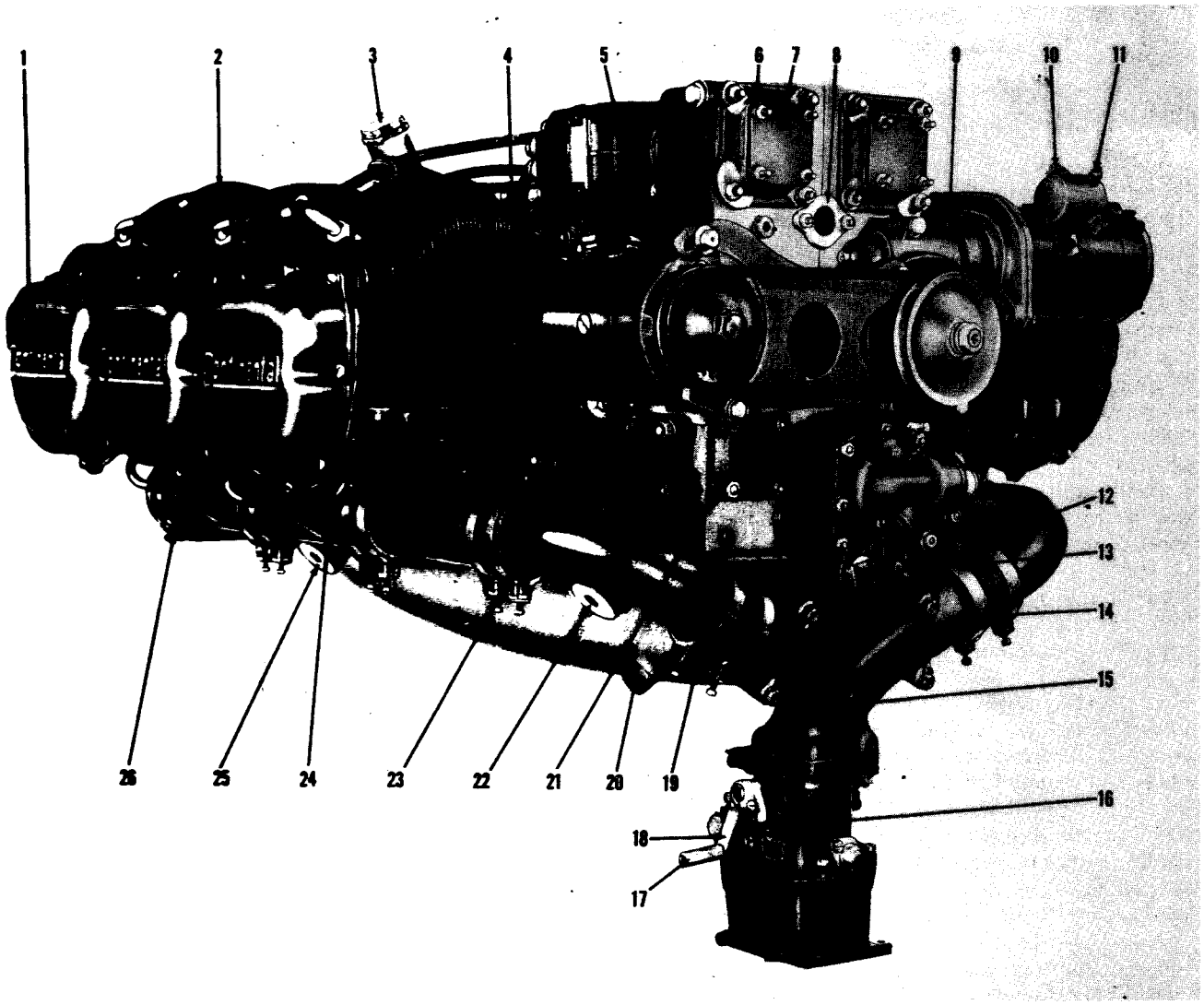
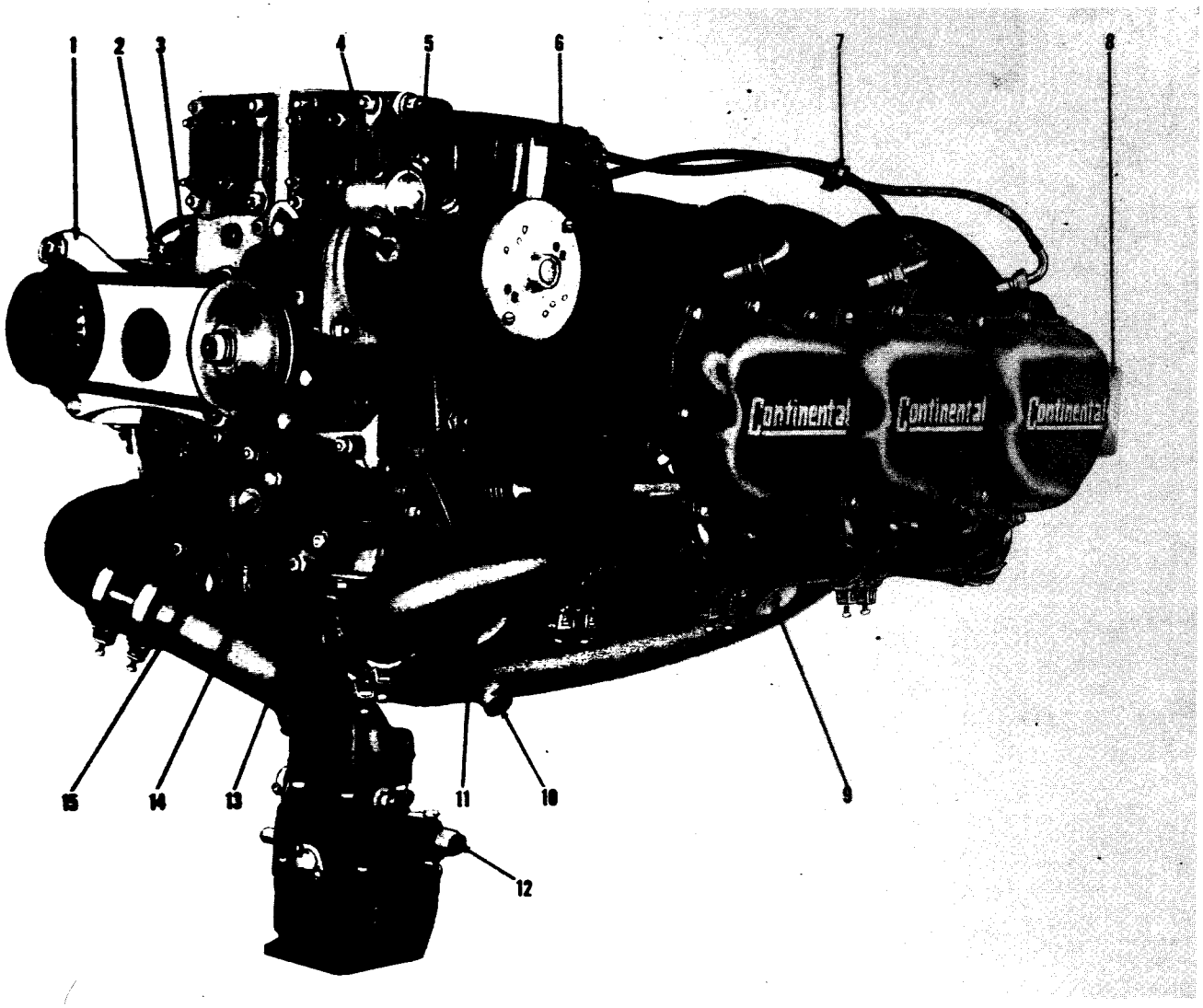


Figure 8. Cylinder Arrangement Diagram (Top View)



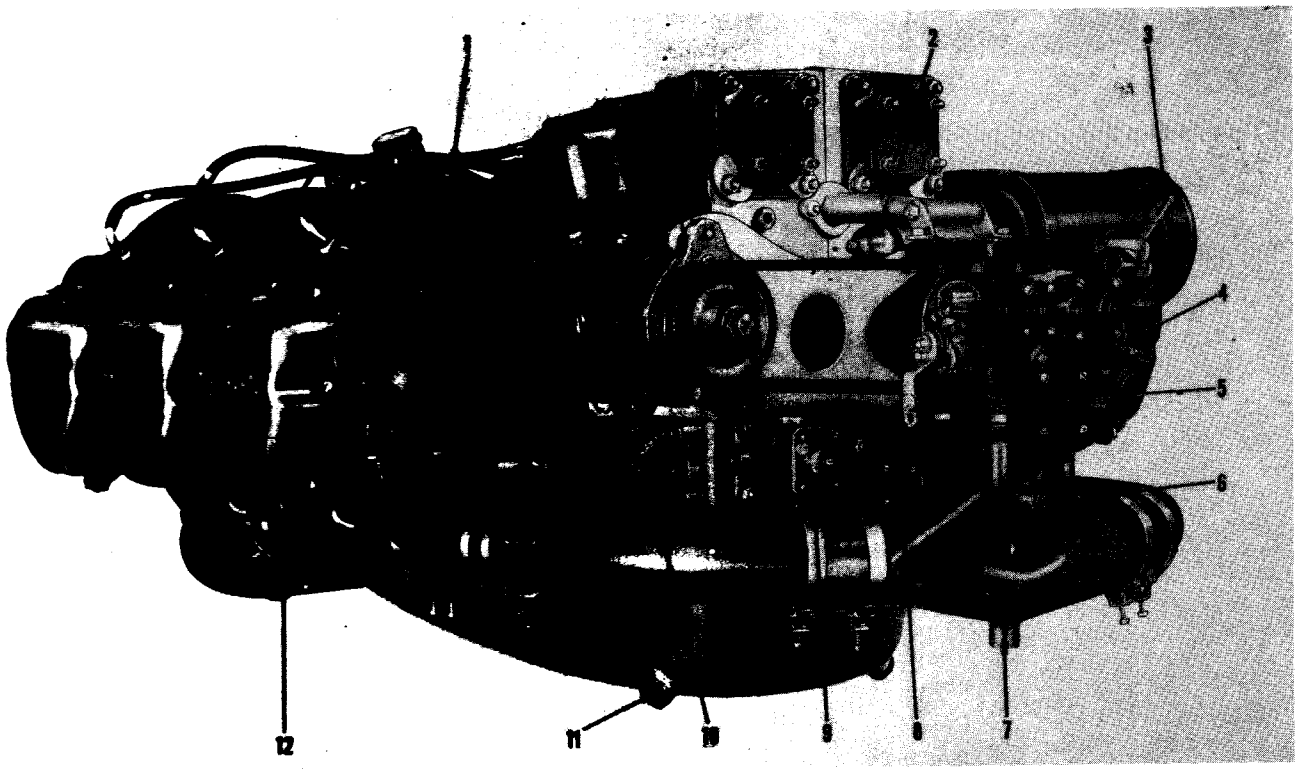
1. Valve rocker cover
2. Shielded ignition cable
3. Oil filler neck and cap
4. Generator blast tube connector
5. Left magneto
6. Magneto and accessory drive adapter
7. Accessory drive cover
8. Idler gear support pin
9. Starter adapter
10. Starter solenoid power terminal
11. Starter solenoid coil terminal
12. Intake manifold elbow
13. Oil pressure relief valve cap
14. Riser manifold
15. Manifold pressure gauge connection
16. Marvel-Schebler carburetor
17. Throttle lever
18. Throttle lever extension
19. Oil dilution connection plug
20. Oil sump left drain plug
21. Fuel pump mount pad cover
22. Left rear mount bracket
23. Oil level gauge
24. Intake manifold center tube
25. Left front mount bracket
26. Balance tube to intake manifold hose clamp

Figure 9. Three-Quarter, Left Rear View of O-470-K



1. Generator support bracket
2. Generator armature terminal
3. Generator field coil terminal
4. Starter solenoid coil terminal
5. Starter solenoid power terminal
6. Right magneto
7. Ignition cable bracket
8. Oil cooler
9. Right front mount bracket
10. Oil sump right drain plug
11. Right rear mount bracket
12. Carburetor fuel inlet
13. Oil filter
14. Oil filter bypass valve cap
15. Tachometer flexible shaft connector

Figure 10. Three-Quarter Right Rear View of O-470-L



1. Primer line
2. Carburetor support assembly
3. Manual mixture control lever
4. Bendix-Stromberg carburetor
5. Throttle lever
6. Manifold pressure gauge connection
7. Riser manifold drain connection
8. Tachometer drive gear cover
9. Romec fuel pump
10. Left rear mount bracket
11. Oil sump left drain plug
12. Manifold balance tube support bracket

Figure 11. Three-Quarter, Left Rear View of O-470-M

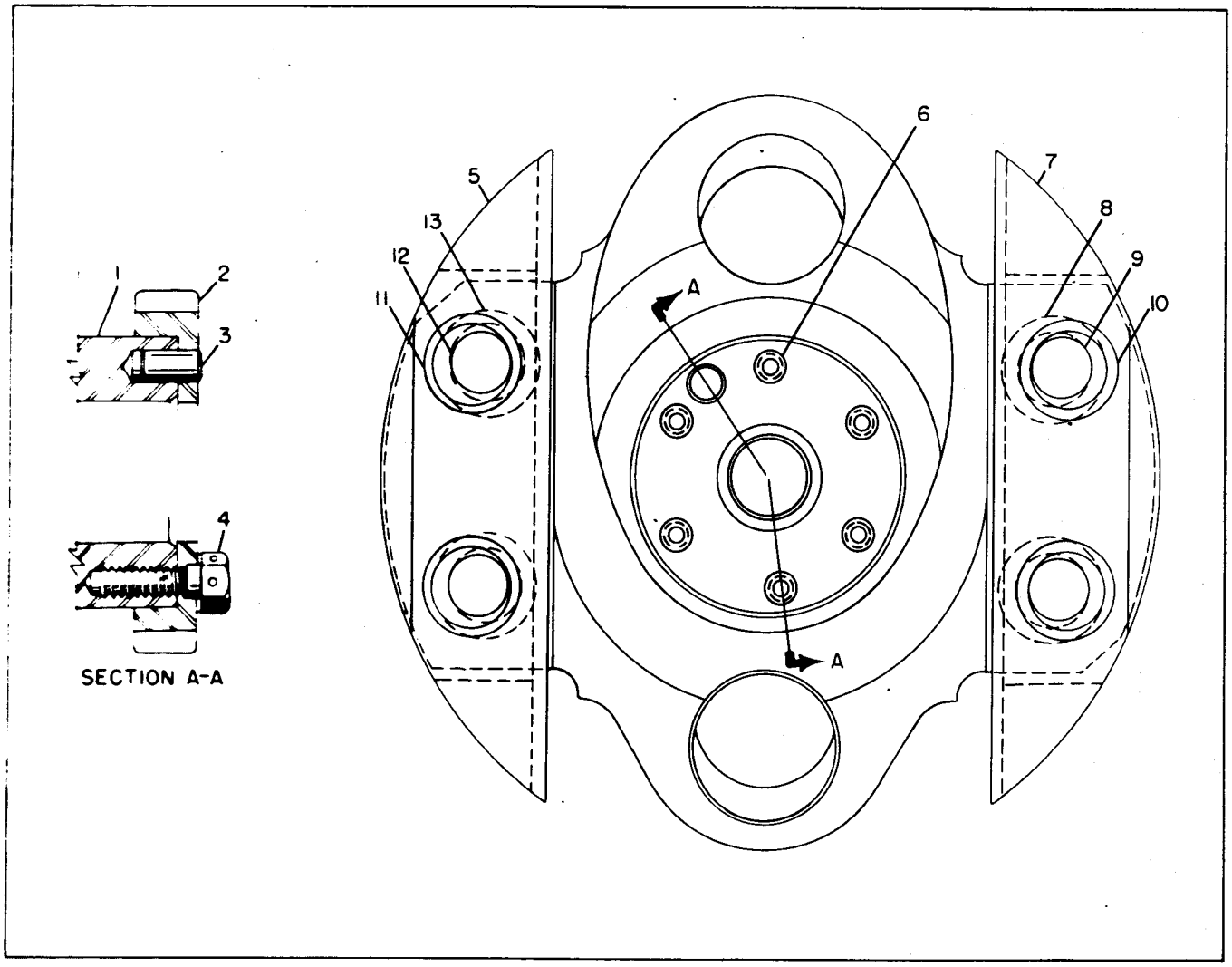
3-10. The O-470-K, O-470-L and O-470-M engines incorporate a crankshaft with four 6th order counterweights. The crankshaft gear is heated prior to installation to obtain a shrunk fit with the crankshaft. The gear is driven by a pilot dowel of uniform diameter, which is positively retained by a washer under the head of one of the six 5/16-inch gear retaining bolts.

3-11. A rubber composition oil seal (58, figure 14), held tightly between the crankcase castings in the front shaft exit, is sealed to the shaft by a helical spring inside the seal's cavity. A felt dust shield is cemented to the front of the oil seal to prevent abrasive materials working under the oil seal lip and scoring the crankshaft.

3-12. CONNECTING RODS. Automotive-type connecting rods have split bronze piston pin bushings and two identical precision inserts (of the same type as main bearings) at the crankpin end. Weight variation of rods in any engine set is limited to 1/4 ounce.

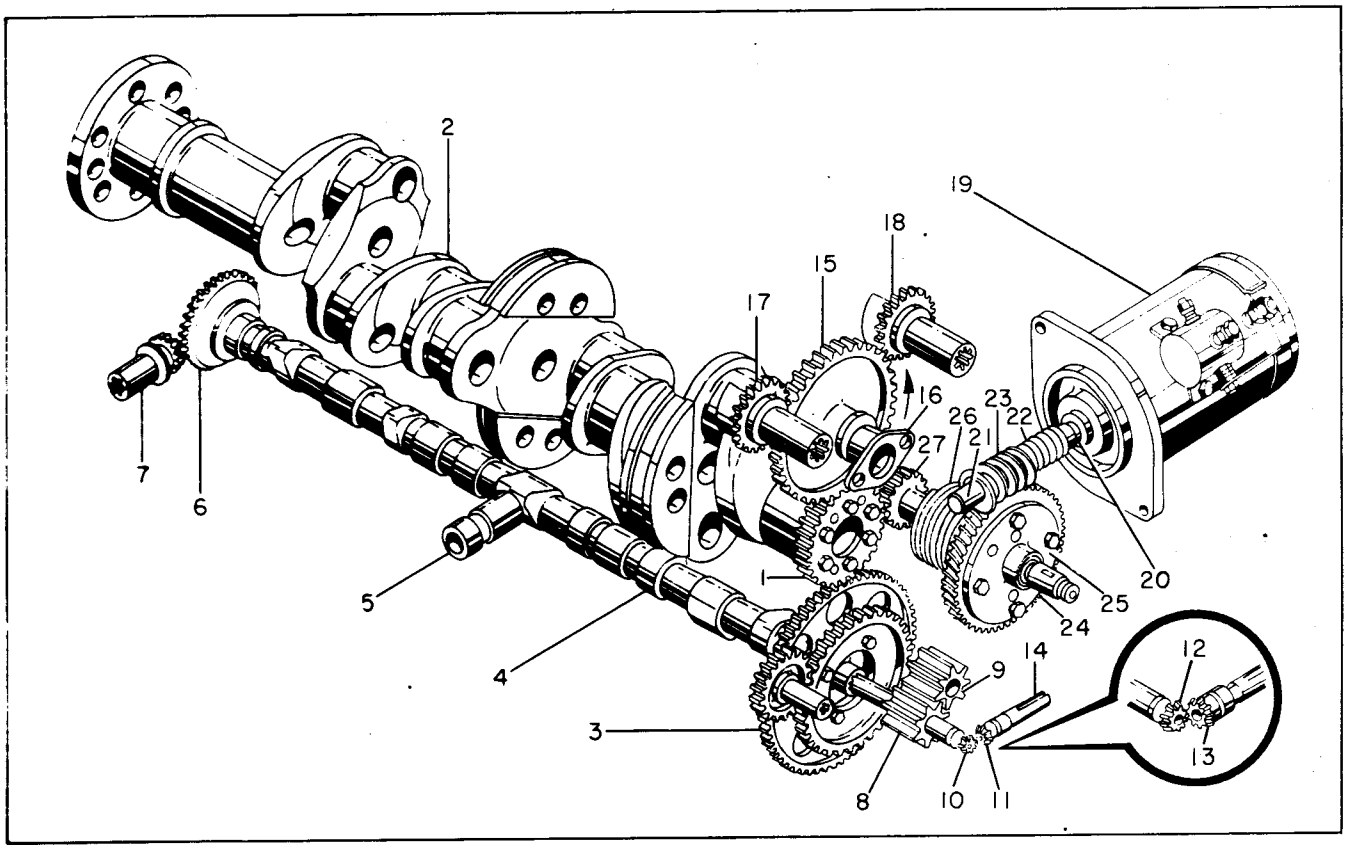
3-13. CAMSHAFT. A steel alloy forging is machined on four journals, nine cam lobes and the gear mount flange at the rear end. The lobes and journals are hardened and ground. A groove around the front journal passes engine oil from the right crankcase cross passage to the left case passage. (See 33, 36 and 37, figure 14.) The camshaft gear is attached by four unequally spaced bolts to locate its timing mark in relation to the lobes. On O-470-M engine, a cluster gear is bolted with the camshaft gear and drives the fuel pump gear.

3-14. PISTONS. O-470-K and O-470-L pistons are aluminum alloy castings. The skirt is solid and has cylindrical relief cuts at the bottom to clear the crankshaft counterweights. There are three ring grooves above the pinhole for top and second compression rings and the center-grooved and slotted oil



1. No. 539665 crankshaft
2. No. 536421 gear
3. No. 536573 dowel
4. No. 536379 screw (5/16-24)
5. No. 352117 6th order counterweight assembly
6. 5/16-24 NF gear retaining screw holes
7. No. 352117 6th order counterweight assembly
8. No. 350998 crankshaft bushing
9. No. 350999 counterweight pin
10. No. 350997 counterweight bushing
11. No. 350997 counterweight bushing
12. No. 350999 counterweight pin
13. No. 350998 crankshaft bushing

Figure 12. Features of Part No. 539665 Crankshaft Assembly



Index No.	Description	Speed Ratio
1.	Crankshaft gear	1:1
2.	Crankshaft	1
3.	Camshaft gear	1:0.5
4.	Camshaft	1:0.5
5.	Hydraulic tappet	-
6.	Governor drive bevel gear	1:0.5
7.	Governor driven bevel gear	1:1
8.	Oil pump and tachometer drive shaftgear	1:0.5
9.	Oil pump driven gear	1:0.5
10.	Tachometer drive bevel gear O-470-K and O-470-L	1:0.5
11.	Tachometer drive bevel gear O-470-K and O-470-L	1:0.5
12.	Tachometer drive bevel gear O-470-M	1:0.5
13.	Tachometer drive bevel gear shaft O-470-M	1:0.5
14.	Tachometer drive shaft assembly	1:0.652
15.	Idler gear assembly	-
16.	Idler gear support pin	1:1.5
17.	Left magneto drive gear	1:1.5
18.	Right magneto drive gear	48:1
19.	Electric starter	-
20.	Starter coupling	48:1
21.	Worm drive shaft	-
22.	Worm shaft spring	48:1
23.	Starter worm gear	2:1
24.	Starter worm wheel	2:1
25.	Starter clutch drum	2:1
26.	Clutch spring	1:2
27.	Starter shaftgear	

Figure 13. Gear Train Diagram, Typical of all Models

ring. The third groove has four oil drain holes to the interior. Piston pins are full floating, ground steel tubes with permanently forged-in aluminum plugs. Forged pistons, machined on all exterior surfaces, are used in the O-470-M engines. Although similar in appearance, the cast pistons maybe identified by the pattern number (539614) stamped on the piston pin boss inside the piston skirt.

3-15. TAPPETS. Wilcox-Rich barrel-type hydraulic tappets (5, figure 13) may be removed and replaced without complete disassembly of the engine, as described in Section VI. The construction and operation of the tappets are described in paragraph 3-31 and in figure 15.

3-16. CYLINDERS. For the O-470-K, O-470-L and O-470-M engines, externally finned aluminum alloy head castings are heated and valve seat inserts are installed before the head is screwed and shrunk onto an externally finned steel alloy barrel to make the permanent head and barrel assembly. Bronze valve guides are pressed into the cold cylinder assembly and reamed to slightly different diameters. Special 18 mm "Heli-Coil" thread inserts are installed in upper and lower spark plug holes. Smaller "Heli-Coils" are installed in exhaust manifold attaching stud holes. Both intake and exhaust ports are on the bottom of the head when the cylinder is installed. Exhaust valve faces are Stellite No. 6 and stem tips are hardened. Valve stems are solid. Outer retainers of the two concentric springs surrounding each valve are locked to the stems by tapered, semicircular keys which engage grooves around the stems. Rotocaps are installed on O-470-M engines in lieu of the outer retainer on exhaust valves only. The rotating action of this type retainer helps to prevent burning and eroding of the valve and valve seat. Inner spring retainers are pressed steel. Valve rocker covers are aluminum alloy castings. Rocker shafts are ground steel tubes, with a hole drilled in one end at a 90° angle to the longitudinal axis. The two inside rocker shaft bosses are drilled and tapped to accept the 5/16-inch rocker shaft retaining screws. Valve rockers are steel forgings with hardened sockets and rocker faces and pressed-in bronze bearings. They are drilled for lubrication. Pushrods are composed of steel tubes and pressed-in, hardened, forged steel ball ends, which are center-drilled for oil passages. The pushrod housings are beaded steel tubes. The bead at the cylinder end retains a washer and seal ring. The bead at the crankcase end retains a washer, heavy spring, washer and seal ring.

3-17. FUNCTIONAL SYSTEMS.

3-18. GEAR TRAIN. (See figure 13.) The crankshaft gear (1) is turned clockwise by the crankshaft (2) and turns the camshaft gear (3), and through it the camshaft (4), and the idler gear (15) in the opposite direction, as indicated by arrows on the drawing. Camshaft lobes actuate the hydraulic tappets (5). The governor driven bevel gear (7) mates with and is driven by the governor drive bevel gear (6) on the camshaft. The spline shaft turns in a crankcase bore centered on the governor mount pad.

3-19. The oil pump and tachometer drive shaftgear (8) is driven by the camshaft gear through mating splines. It projects forward and rearward from the oil pump and filter housing attached to the rear end of the crankcase and drives the driven gear (9) which turns freely on a stub shaft pressed into the housing. On the reduced rear end of the shaftgear (8) the tachometer drive gear (10) is mounted, and a slot in the front end of its hub is driven by a pin in the shaft shoulder. For the O-470-K and O-470-L engines it drives an identical bevel gear which is similarly mounted on and engaged to the tachometer drive shaft (13) supported in the tachometer drive and pump cover casting. For the O-470-M engine the bevel gear drives a one-piece shaftgear mounted in the tachometer drive and pump cover casting.

3-20. The idler gear (15) is mounted on an eccentric pin (16) whose rear end flange is attached to two crankcase rear end studs. It is driven counterclockwise and drives the two magneto drive gears clockwise, as seen from the rear. Optional accessories mounted on the crankcase rear are driven by the internal splines of the magneto drive gears. The magneto gear and accessory adapters are attached to the upper corners of the crankcase rear surface and have AND20000 type accessory mount pads on their rear sides centered on the gear shafts. The front hub of each magneto drive gear has a side slot in which the magneto drive bushings and retainer are held and driven. A steel sleeve pressed into the gear center hole prevents excessive distortion of the rubber bushings, between which the driving lugs on the magneto impulse coupling fit.

3-21. The electric starter (19) is mounted on a right-angle drive adapter which is attached to the rear end of the crankcase. The tongue end of the starter shaft mates directly with the grooved end of the worm shaft. The worm shaft is supported between a needle bearing at its left end and a ball bearing which is retained in the adapter by a Truarc snap ring. The worm (23) is driven by the shaft through a Woodruff key. The worm wheel (24) is attached by four bolts to a flange on the clutch drum (25) which bears on the shaftgear (27). Two dowels center the wheel on the drum and transmit the driving torque. A heavy helical spring (26) covers both the externally-grooved drum and a similarly grooved drum machined on the shaftgear just ahead of the clutch drum. The spring is retained on the clutch drum by an in-turned offset at its rear end which rides in a groove around the drum, just ahead of the flange. The in-turned offset of the clutch spring is notched and the clutch drum is drilled and tapped for a spring retaining screw. The front end of the spring fits closely in a steel sleeve, pressed into the starter adapter. When the starter is energized, friction between the clutch spring and the adapter sleeve and between the spring

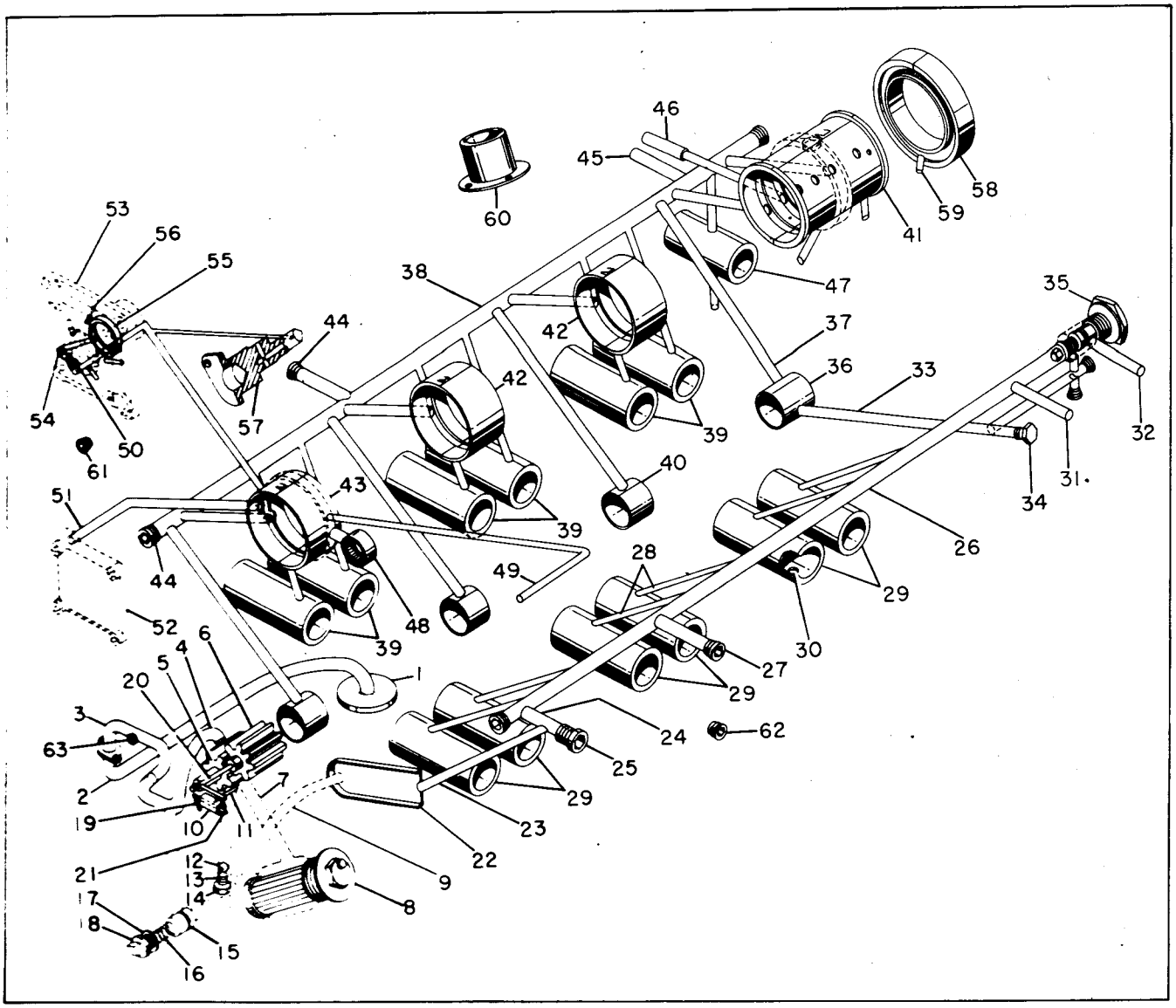


Figure 14. Lubrication System Diagram

and the clutch drum, which is turned by the worm wheel, tends to wind up the spring on the clutch and shaftgear drums, locking them together so that the shaftgear rotates and turns the crankshaft. As soon as the engine starts, the shaftgear is driven faster than the clutch spring and tends to unwind it, thus increasing the spring's I.D. so that the shaftgear spins free of the starter drive. The generator drive pulley (not illustrated) is mounted on the rear end of the shaftgear and driven through a Woodruff key so that it always turns at shaftgear speed.

3-22. LUBRICATION SYSTEM. (See figure 14.) The intake end (1) of the oil pump suction tube (2) is supported below the crankcase and below the level of oil in the sump when this level is at or above the "L" mark on the gauge. (Refer to paragraph 2-1.) The bottom side of the intake is covered by a perforated plate to exclude large solid particles. Atmospheric pressure on the surface of oil in the sump forces the oil up through the suction tube and through connecting passages (3, 4) to fill the volume continually displaced by rotation of the pump gears (5, 6). Oil carried around the pump chamber in tooth spaces is discharged into the filter chamber through a cored passage (7). The oil filter (8) blocks the bottom end outlet from its chamber and is sealed to the threaded mouth of the chamber by a copper-asbestos gasket. Oil passing through the corrugated screens leaves solid particles on the outside and flows from the bottom end of the filter's center tube through a cored passage (9) to the pump discharge port. A filter bypass valve is incorporated in the pump housing. From a boss on the bottom of the housing a passageway is drilled to the pressure side of the impeller gear chamber. The bottom end of the passage is machined to accommodate the ball (12), spring (13), gasket and plug (14) that make up the valve. Another passageway is drilled from below the ball seat to the filtered oil cavity below the oil filter. Should the oil filter be-

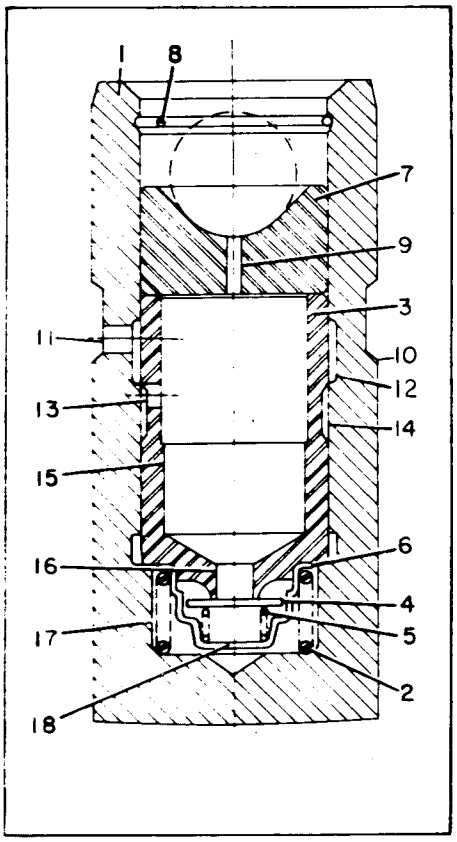
Legend for Figure 14.

1. Suction tube intake
2. Oil pump suction tube
3. Cored passage in crankcase
4. Cored passage in oil pump housing
5. Oil pump and tachometer drive shaftgear assembly
6. Oil pump driven gear
7. Cored passage in oil pump housing
8. Air-Mase oil filter
9. Cored passage in oil pump housing
10. Tachometer drive shaft bearing in tachometer drive and pump cover
11. Hole drilled from cored passage (7) to tachometer shaft bearing
12. Oil filter bypass check ball
13. Oil filter bypass spring
14. Oil filter bypass plug
15. Oil pressure relief valve plunger
16. Oil pressure relief valve spring
17. Oil pressure relief valve gasket
18. Oil pressure relief valve plug
19. Drain hole from bevel gear cavity to pump housing mount flange
20. Vent hole from bevel gear cavity to end of driven gear shaft hole
21. Tachometer drive oil seal drain and vent holes
22. Recess molded in rear of right crankcase
23. Hole drilled from recess (22) to intersection with lateral hole (24)
24. Hole drilled from right crankcase surface to oil gallery (26)
25. 5/8-18 drilled hex-head plug
26. Oil gallery cored in right crankcase
27. 3/8 in. countersunk hex-head pipe plugs
28. Holes drilled from tappet guides into oil gallery
29. Tappet guides for No's 1, 3 and 5 cylinders
30. Tappet guide and pushrod housing oil drain holes
31. Outlet port to oil cooler inlet
32. Return port from oil cooler outlet
33. Hole drilled from front camshaft bearing to right side of crankcase
34. 5/8-18 NF hex-head screw plug
35. Vernatherm temperature control valve
36. Front camshaft bearing
37. Hole drilled from front camshaft bearing
38. Oil gallery cored in left crankcase
39. Tappet guides for No's 2, 4 and 6 cylinders
40. Intermediate and rear camshaft bearings
41. Crankshaft front main and thrust bearings
42. Intermediate main bearings
43. Rear main bearing
44. 3/8 in. countersunk hex-head pipe plugs
45. Supply port to propeller governor
46. Discharge port for propeller
47. Governor spline shaft bearing
48. Starter shaftgear needle bearing
49. Right magneto drive oil supply port
50. Left magneto drive oil supply port
51. Fuel pump drive oil supply port
52. Fuel pump drive mount pad cover
53. Magneto and accessory drive adapter
54. Accessory mount pad oil supply port
55. Adapter groove around gear bushing
56. Oil seal drain and vent holes
57. Idler gear support pin
58. Crankshaft oil seal
59. Crankshaft oil seal drain hole
60. Oil filler neck
61. 3/8 in. countersunk hex-head pipe plug
62. 1/8 in. countersunk hex-head pipe plug
63. 1/8 in. countersunk hex-head pipe plug

come clogged, the oil will bypass the filter by the pressure pushing the ball downward and opening the path through the aforementioned passages and cavity to the pump discharge port. A passageway from the filtered oil cavity, of the pump, leads to the front of the relief valve. Oil in this passage is static until the pressure overrides the relief valve and permits the oil to return to the suction side of the pump. The spring force of neither the bypass nor the pressure relief valve is adjustable. The tachometer drive shaft bearing (10) receives oil from the discharge side of the pump gear chamber through a drilled hole (11). The tachometer drive bevel gears are lubricated by spray from the tachometer shaft bearing and around the rear end of the drive gear (5). This oil drains through a pump housing hole (19) to the crankcase. Oil escaping to the outer end of the tachometer shaft is stopped by a copper-asbestos gasket between the pump cover and the tachometer drive housing which is screwed into it. An oil seal, pressed into the threaded housing, rides the surface of the tachometer shaft. Oil from this area is drained through a hole (21-lower) which intersects the shaft drain hole (19). These oil cavities are vented to the hollow pump idler shaft through higher holes (20, 21-upper).

3-23. Oil discharged from the pump is carried by a recess (22) molded in the rear side of the crankcase, to a hole (23) drilled forward to a lateral hole (24) which is closed at the crankcase surface by a straight threaded plug (25) sealed by a copper-asbestos gasket, thence into the oil gallery (26) cored in the right crankcase. Right side tappet guides (29) receive oil from the right gallery through short drilled holes (28). Near the front end of the right gallery a short intersecting hole, drilled from the oil cooler mount pad, carries oil to the cooler inlet port (31). Oil returns from the cooler through a crankcase hole (32) to the recess in which the Vernatherm valve (35) is installed. A drilled hole from the bottom of this recess intersects a hole leading rearward to a cross oil passage (33). In this way, oil leaving the cooler circulates around the Vernatherm control and affects its length, closing its poppet valve against a seat at the front end of the gallery when the temperature is high or allowing contraction to open the valve when it is lower. Any oil which passes the poppet valve flows from the Vernatherm cavity directly to the cross passage, bypassing the cooler. The outer end of the cross passage (33) has a 5/8-18 NF thread for the plug (34) or an oil temperature gauge capillary.

3-24. A groove around the front camshaft journal carries the oil stream through the front camshaft bearing (36) and into the cross passage (37) of the left crank-



1. Valve lifter body
2. Expanding spring
3. Plunger
4. Check valve
5. Check valve spring
6. Check valve cage
7. Socket
8. Snap ring
9. Socket oil passage
10. Exterior body oil groove
11. Drilled oil inlet hole
12. Interior body oil groove
13. Plunger oil inlet hole
14. Plunger oil groove
15. Plunger oil reservoir
16. Plunger oil discharge hole
17. Body oil reservoir
18. Valve cage oil outlet hole

Figure 15. Cutaway View of Hydraulic Tappet

case. From the left main gallery (38) drilled holes carry oil to the left side valve tappet guides (39), the intermediate and rear camshaft bearings (40) and the crankshaft main bearings (41, 42, 43). An oil pressure gauge connector may be substituted for the pipe plug (44), at the left side of the crankcase between No's 2 and 4 cylinders.

3-25. The propeller governor inlet port aligns with and receives oil from the crankcase port (45). The governor discharges oil under higher pressure to the port (46), from which a connecting hole carries it into an interior groove (second from rear) around the front main and thrust bearing in line with the crankshaft pickup hole. To prevent loss of increased oil pressure, required for propeller control, nylon inserts are installed on both sides of the bearings oil transfer groove. The governor spline shaft bearing receives oil through a hole drilled into the left gallery. Oil escaping from the outer end of the bearing drains back to the crankcase through a hole drilled downward from the bottom of the governor pilot counterbore.

3-26. From a crankcase groove surrounding the rear main bearing, drilled holes conduct oil to the starter shaftgear bushing (48), the magneto and accessory drive supply ports (49, 50) and the fuel pump pad supply port (51). The latter is sealed off by a gasket and the pad cover. The magneto and accessory drive adapters, though similar in appearance, are not identical. To assure correct installation, the attaching studs are three of 5/16 inch and one of 3/8 inch diameter. (See 8 and 9, figure 28.) Each adapter has a milled slot to connect the oil hole leading to the rear side accessory mount pad with the crankcase port when installed. From the rear pad an intersecting hole leads to a groove surrounding the drilled gear bushing. The oil feed hole intersection is sealed off by a pad gasket and cover when no accessory is installed. Drain and vent holes (56) return oil stopped by the gear shaft seal (behind the bushing) to the crankcase interior. A horizontal oil hole from the idler gear support pin's front bearing through the left crankcase intersects the hole drilled from the rear main bearing seat groove to the left magneto drive and supplies oil to the drilled support pin (57) to lubricate the idler gear bushing.

3-27. The starter drive shaftgear is drilled on its axis from the front end. Oil is fed from the rear main bearing (43) through a passageway to the starter shaftgear needle bearing (48) and into the shaftgear axial hole, from which two other radial holes allow it to spray the integral drum and the bearing surface under the clutch drum. Other parts of the starter are lubricated by this spray. Oil drains back to the crankcase through a cored hole in the front side of the adapter at the bottom and through a slot at the bottom of the clutch spring sleeve.

3-28. A narrow space behind the crankshaft oil seal (58) is drained through a hole (59) at the crankcase parting line to prevent formation of a pool of oil and possible leakage at that point.

3-29. The oil filler neck (60) is described in paragraph 3-7. A 3/8-inch pipe plug (61), installed in the rear of the crankcase, may be replaced by an accessory drain connector. A 1/8-inch pipe plug (62) at the right side of the case closes another drain hole.

3-30. VALVE MECHANISM. Oil fed to the hydraulic tappets under pressure from the main galleries is divided between the overhead system, the tappet guide surfaces and the oil reservoirs inside the tappets. That which reaches the pushrod ball ends

is forced through the hollow pushrods to be drilled rockers and to grooves around their side-drilled bearings. Each intake valve rocker also passes part of its oil supply to a squirt nozzle aimed toward the exhaust valve stem. Spray from these nozzles and from bearing ends lubricates the valve stems and springs. Oil is returned to the crankcase through the tubular pushrod housings which are sealed to the cylinder heads by Silastic rubber rings and to the crankcase by Silastic rubber flanged washers. Heavy springs hold the crankcase seal inward in the case recesses and the housing and cylinder seals outward in the cylinder head recesses. Drain holes (30, figure 14) in the tappet guides permit the returning oil to fall into the sump.

3-31. (See figure 15.) The barrel-type hydraulic tappet consists of a steel body (1), an expanding spring (2), a plunger (3) and check valve assembly (4, 5, and 6), a socket (7) for the pushrod ball end, and a retaining snap ring (8). A groove (10) around the outside of the body picks up oil from the crankcase supply hole only when the tappet is near the outer end of its stroke so that engine pressure will not "pump up" the plunger and hold the intake or exhaust valve off its seat. From the exterior groove, oil is introduced to the interior body groove (12) through the oil inlet hole (11) and from the interior groove to the plunger reservoir (15) through the plunger oil inlet hole (13). This oil is withheld from the body reservoir (17) by a plate-type check valve (4) which is supported by a spring (5) and cage (6). The check valve is opened by outward motion of the plunger under pressure of the expanding spring whenever a clearance arises in the valve train due to cylinder expansion or leakage of oil past the plunger during the preceding lift cycle. Thus the body reservoir is kept full of oil which transmits lifting force from the body to the plunger. The plunger and socket are fitted to the body selectively to permit a definite leakage so that the tappet readjusts its effective length after each cycle, while the engine valve is closed, to return the "lash" in the train to zero. This also permits contraction of the valve train length when the engine cools. Tappet bodies, plunger, and socket assemblies are not interchangeable, because of the narrow limits of permissible diametrical clearance, but retaining rings and expanding springs may be interchanged without ill effect.

3-32. INDUCTION SYSTEM, MODELS O-470-K and O-470-L. The induction system installed on models O-470-K and O-470-L is composed of an intake manifold and carburetor. The updraft float-type Marvel-Schebler carburetor is attached to the bottom of the cast aluminum manifold riser. The riser manifold is supported by two brackets, one attached at each rear corner of the oil sump. The riser is connected by elbows to the rear cylinder intake tubes by connector hoses and clamps. These are connected to the center intake tubes and in turn the center to the front intake tubes in the same manner. Each intake tube is attached to a cylinder by a welded flange and four bolts and is sealed by a gasket. The front cylinder intake tubes are connected by a balance tube assembly. The balance tube is supported by a single bracket attached to the front of the oil sump.

3-33. INDUCTION SYSTEM, MODEL O-470-M. This system is similar to that described in paragraph 3-32, except the manifold riser is inverted and supported by a downdraft Stromberg pressure-type carburetor which is bracketed to the rear crankcase. Due to possible fuel leakage from the downdraft system, when the engine is not in operation, manifold drain valves are provided at the bottom of the manifold riser casting and the center of the balance tube. The balance tube assembly is supported by a bracket on each side, bolted to the oil sump flange.

3-34. FUEL AND FUEL PRIMING SYSTEMS.

3-35. On model O-470-M engine the fuel is supplied to the pressure carburetor by a Romec pump. The pump is installed on the lower left corner of the crankcase rear and is connected to the carburetor by a hose, supplied by the aircraft manufacturer. On models O-470-K and O-470-L engines fuel is supplied to the carburtor by gravity.

3-36. A priming system is installed as standard equipment only on the O-470-M engine but may be, at the owner's option, installed on any of the other models covered by this manual. A primer distributor manifold, attached to the crankcase top parting flange, is connected to the cylinder priming jets by steel tubes. The tubes are supported by steel brackets and protected from chafing by rubber sleeves. The priming jets are installed in the cylinder intake chambers outside the valve seat.

SECTION IV
UNPACKING AND PREPARATION FOR SERVICE, STORAGE OR SHIPMENT

4-1. UNPACKING.

4-2. Detach the assembly of shipping crate top and side panels from the crate base by unscrewing two machine bolts near the bottom of each side and end panel; then lift off the cover assembly. Engines received from the factory are covered by a moisture-proof paper shroud. Lift off the shroud and remove from the crate base the packages containing the spark plugs and carburetor for the O-470-K and O-470-L engines. For the O-470-M engine the carburetor is installed at the factory. Attach a chain hoist to the engine lifting eye, located at the top crankcase flange, before loosening the engine mount bracket attaching bolt nuts. Take up slack in the hoist; then remove the nuts, washers, horizontal bolts and shock mounts from the mount brackets and four supporting steel angle members. Lift the engine straight up until clear of the crate. It is advisable to support the engine on an assembly stand while removing packing materials and installing accessories.

4-3. Remove dehydrator plugs from the upper spark plug holes. If the engine is to be installed at once, turn the crankshaft as necessary, and inspect the interior of each cylinder with the aid of a flashlight. If a pool of oil is standing in any cylinder it must be drained before engine is installed. If compression cannot be built up in any cylinder by turning the crankshaft while the upper spark plug hole is plugged, remove the valve rocker cover from that cylinder, and check valve action. If a valve stem is sticking in its guide, apply castor oil or engine lubrication oil thinned with gasoline while the crankshaft is rotated and until the valve operates freely. Use a new gasket when replacing the valve rocker cover.

4-4. Remove the plastic caps from the magneto switch terminals, the breather elbow and the generator blast tube connector. On the O-470-K and O-470-L engines, remove the four nuts, spacers and cover from the riser manifold flange. Remove the bolts, spacers and cover from each cylinder exhaust port flange. Remove plastic protectors from detached spark plug cable elbows. Remove any moistureproof adhesive tape installed to cover vent holes during shipment.

4-5. PREPARATION FOR SERVICE.

4-6. The corrosion-preventive oil fed into the lubricating system and sprayed into cylinders before shipment of a new engine will mix with normal engine lubricating oil and will do no harm; hence, it does not need to be flushed out.

4-7. Before installing upper spark plugs, coat their 18 mm. threads with only a film of BG mica thread lube. After tightening the upper plugs, insert the cable terminals and screw on the elbow hex coupling nuts. Tighten them only moderately. If in doubt as to proper cable connections, refer to the ignition wiring diagram, figure 55.

4-8. Install the proper type of washer thermocouple under the lower spark plug of the cylinder specified by the aircraft manufacturer.

4-9. When installing the Marvel-Schebler carburetor on the riser manifold, use a new carburetor-to-manifold gasket and new shakeproof internal tooth lock washers. Position the carburetor on the manifold so the mixture control lever is to the front of the engine.

4-10. To install the oil gauge pressure line fitting, remove the 3/8 in. pipe plug located in the crankcase between No. 2 and 4 cylinders. Coat the pipe threads of the fitting with a thin film of Ledplate #250 before installing.

4-11. For engines requiring an electrical tachometer generator, remove the mounting pad cover and install the tachometer generator. Use a new gasket and new shakeproof internal tooth lock washers. Before installing any accessory where the driving (engine) shaft has an oil seal, apply a film of general purpose grease to the accessory shaft end.

4-12. Install the proper connector fitting for the intake manifold pressure gauge line in the 1/8-inch pipe tapped hole in the rear of the riser manifold. On O-470-M engine remove the plugs in the bottom of the riser manifold and the balance tube and install the manifold drain valve fittings.

4-13. PREPARATION FOR STORAGE.

4-14. If an engine, which has been in operation, is to be stored much longer than a week under normal climatic conditions, and if periodic running to circulate oil is not carried out, it is advisable to prepare it for storage in the following manner:

a. Operate the engine until the oil temperature reaches the normal range. Drain the regulator oil supply from the sump as completely as possible; then

replace the drain plug.

b. Fill the oil sump to the full (F) mark on the level gauge with a corrosion-preventive oil which will mix with normal oil and which is suitable as a lubricant. This oil must be preheated to 225°F. (We approve for this purpose Cosmoline No. 1123, supplied by E. F. Houghton & Co., 301 W. Lehigh Ave., Philadelphia, Pa.)

c. Run the engine at least five minutes at a speed between 1200 and 1500 R.P.M. with the oil temperature between 215 and 225°F. The cylinder head temperature must not exceed 450°F.

d. Inject the same type of corrosion-preventive oil used in the lubricating system into the carburetor intake, while the engine is running, at a rate of 1/2 gallon per minute until smoke comes from the exhaust pipe; then increase the spray until it stops the engine.

e. If possible, spray the corrosion-preventive oil into the cylinder exhaust ports.

f. Do not turn the crankshaft at any time after completion of the preceding steps.

g. Remove all spark plugs, and spray corrosion-preventive oil, without air, into the upper spark plug holes, then into the lower spark plug holes to assure complete coverage of the interior cylinder surfaces. This oil should be at a temperature of 150 to 180°F.

h. Replace the lower spark plugs, or install solid plugs in their places. Install dehydrator plugs in the upper spark plug holes.

i. Install plastic shipping plugs or other suitable covers on the detached spark plug cable terminals. Cover all engine and accessory vents and other openings, including the crankcase breather, with non-hygroscopic tape or other vaporproof material.

j. Drain the corrosion-preventive oil from the sump and replace the drain plug.

k. Post a conspicuous warning regarding drainage of the oil supply and other measures which must be undone before operation of the engine. If a propeller is installed, attach a warning placard against movement.

4-15. PREPARATION OF BENDIX-STROMBERG CARBURETOR FOR STORAGE OR SHIPMENT.

a. Drain all fuel from the carburetor after removing the strainer, the fuel pressure gauge fitting and the drain plug. Replace the strainer and tighten its plug. Install plugs in the three open pipe-tapped holes.

b. Remove the pipe plug from the regulator spacer to drain moisture from the air section and replace the plug immediately. Flushing oil to be introduced later must not enter the air section.

c. Place the mixture control lever in the "RICH" position and the throttle in "OPEN" position.

d. Connect the fuel inlet port to a source of clean, lightweight lubricating oil (SAE 10 or lighter) at a pressure of 5 psi and inject oil until a small amount has escaped from the discharge nozzle at the top of the throttle barrel.

CAUTION

Do not use for flushing, an oil containing a detergent additive.

e. The flushing oil may be either drained from the carburetor by removing the drain plug in the bottom of the regulator, or if the oil is new and unused, left in the carburetor for the period of storage.

NOTE

In the event the flushing oil contains 2 percent, by volume, or more of gasoline, it will deteriorate all synthetic rubber parts and cause a gummy deposit on the internal metal parts, necessitating a carburetor overhaul.

f. Install pipe plugs in the fuel inlet port and in the gauge connection and drain holes if removed for drainage.

g. Place the carburetor in a container which can be sealed tight and is dustproof. Also place in this container a 1/2 lb. bag of silica gel crystals so it cannot touch the carburetor. After sealing the first container, wrap it in moistureproof paper. If the carburetor is to be shipped, place the wrapped container in a strong wooden box.

4-16. The procedures described in the preceding paragraphs are applicable in nearly all details to engines being prepared for shipment. In addition, such engines should be further protected by covering the exposed end of the crankshaft with a suitable moistureproof material or heavy grease and by covering the entire engine with a moistureproof shroud after mounting in the shipping crate.

SECTION V
INSTALLATION IN AIRCRAFT AND REMOVAL

5-1. ACCESSORIES.

5-2. PROPELLER GOVERNOR. Remove the cover and gasket from the crankcase pad ahead of No. 6 cylinder. Apply grease to the governor shaft splines, and install a new governor gasket. Attach the governor with plain washers, new shakeproof lock washers and the nuts removed with the pad cover.

5-3. OPTIONAL ACCESSORIES. If a hydraulic pump or a vacuum pump is to be installed, remove the rear pad cover from one of the magneto and accessory drive adapters at the rear of the crankcase. Install a new gasket and attach the pump with plain washers, new shakeproof lock washers and the original cover attaching nuts. (See figure 14 for locations of drain connection plug in the crankcase.) If the aircraft has an oil dilution valve, install the fitting in place of the plug to the lower left of the fuel pump mounting pad on the crankcase rear.

5-4. INSTALLATION. Principal dimensions of the engine which affect mounting and locations of control and instrument connections are shown in the installation drawings. Shear rubber mount bushings of the recommended type are illustrated. These are not supplied with new engines.

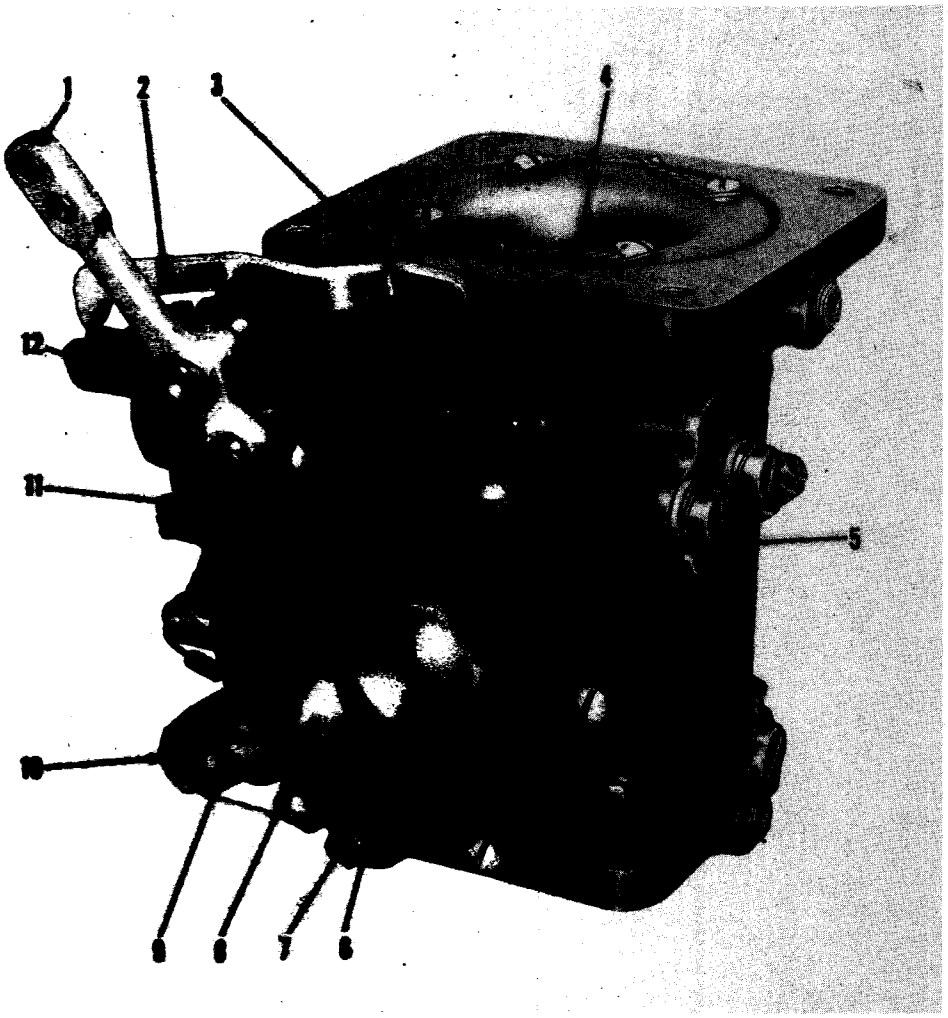
5-5. PRECAUTIONS. The engine assumes a nearly horizontal attitude when suspended by its lifting eye. It may be necessary to hold up the front end in order to align the engine mount brackets with attaching brackets of the aircraft. Make sure that the rubber mount bushings all contact the aircraft brackets uniformly and seat fully in the engine mount bracket holes when the mounting bolts are installed. Tighten the mounting-bolt nuts to the torque specified by the aircraft manufacturer.

5-6. CONTROL CONNECTIONS. The magneto switch wires should be installed first. If wire terminals are defective or missing, replace each with kit No. 352-24. To install the kit on the shielded wire slide the hex coupling nut, then the larger ferrule over the shield braid (ferrule flange toward end of wire), then the smaller ferrule over the insulated wire and into the end of the shielding. Pull the outer ferrule up over the inner ferrule to hold the braid between them. The wire insulation should end just outside the inner ferrule. Slide the insulating sleeve over the end of the wire and against the insulation; then slide on the brass washer. Bend the wire strands flat on it and secure them with a drop of molten solder. Use an induction soldering gun, if available, to prevent overheating the wire insulation. The strands must not project beyond the edge of the washer. Before installing the switch wire terminals in the magneto sockets, check each with a buzzer and battery for continuity with the switch in "LEFT" and "RIGHT" positions. Remember that the left magneto should be grounded through the switch when the switch is turned to "RIGHT" position and the right magneto should be grounded with the switch in the "LEFT" position. This is important when shooting ignition troubles. Connect the wires to the magnetos accordingly, tightening the hex coupling nuts only moderately. (See applicable installation drawing for terminal socket locations.)

5-7. To install a Bendix-Stromberg carburetor as part of an engine installation, or a carburetor replacement, place the pilot throttle control in the closed position, then move it slightly away from the stop. Place the carburetor throttle lever in the closed position with the screw in contact with the body stop stud. If the throttle rod cannot be connected to the lever in this position, either readjust the rod length or move the serrated lever, after removing the shaft nut and cotter pin, a notch or two as necessary. Before reinstalling the shaft nut and cotter pin, test the throttle action from stop to stop. At the half-throttle position the lever should be perpendicular to the control rod and should have the same angular travel each way from that position. Connect the manual mixture control linkage to the control lever. Test the control operation to make sure that the "R" on the link aligns with the arrow engraved in the cutoff lever when the lever is full rear and that the lever can be moved far enough forward to align the "OFF" mark with the arrow. Make any necessary readjustments of rod length to secure this range of operation. Connect the vapor vent (to the fuel tank) tube to a fitting installed in the topmost 1/8 in. pipe-tapped hole in the regulator cover and the fuel pressure gauge tube to fitting installed in place of the 1/8 in. pipe plug in the diagonal channel. Connect the fuel supply (from pump) tube to a fitting installed in the carburetor inlet port in place of the shipping plug.

5-8. FLUSHING, FILLING AND VENTING CARBURETOR. After installation of a new or overhauled carburetor, it is necessary to flush out the preservative oil and fill the fuel section with gasoline to displace all air and to soak the diaphragms. The carburetor metering adjustments were made on a flow bench with the diaphragms soaked and pliable. They must be restored to this condition before the carburetor will meter properly. At least eight hours should be allowed for soaking after the filling operation and before the engine is started.

a. Open the fuel supply line valve.



1. Manual mixture control lever
2. Idle cutoff lever
3. Idle cutoff plunger
4. Air section drain hole
5. Fuel inlet port shipping plug
6. Fuel strainer plug
7. Drain hole
8. Regulator needle valve plug
9. Fuel pressure gauge connection
10. Main metering jet plug
11. Vapor vent connection
12. Manual mixture control link

Figure 16. Three-Quarter Right Front View of Stromberg PSD-5C Carburetor

b. Place the manual mixture control in the full "RICH" position.

c. Open the throttle about halfway.

d. Remove the regulator cover drain plug.

e. Operate the wobble pump or electric boost pump slowly until the fuel flowing from the drain plug hole is free of oil.

f. Replace the drain plug. Continue pumping until a small amount of fuel has been discharged from the discharge nozzle and the flow appears to be free of air bubbles.

g. Place the manual mixture control in the "IDLE CUTOFF" position. Since the carburetor has a closed fuel system it will remain filled as long as the control remains in the "IDLE CUTOFF" position.

NOTE

The foregoing operation may be performed before installation of a carburetor if desired.

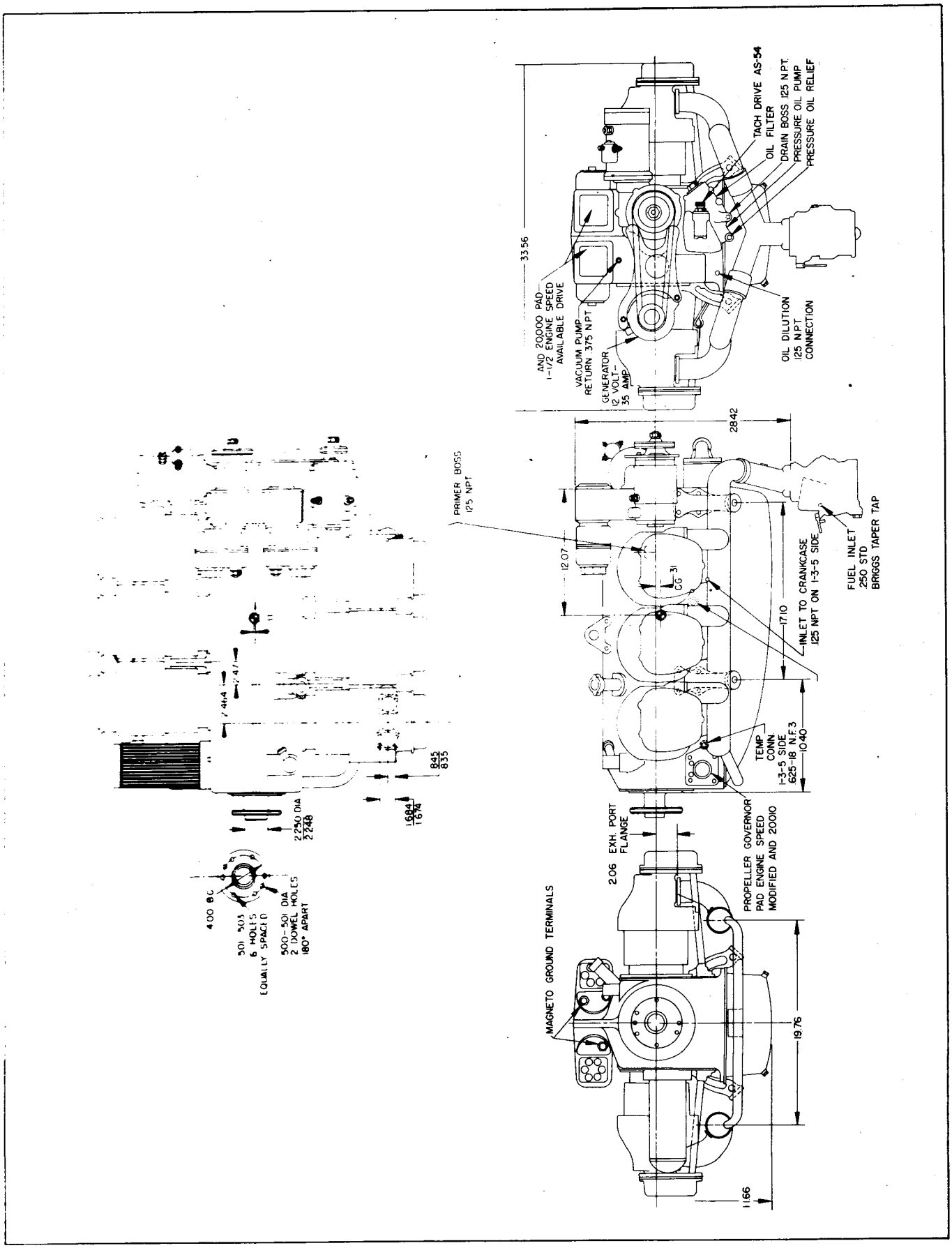


Figure 17. Installation Drawing O-470-K

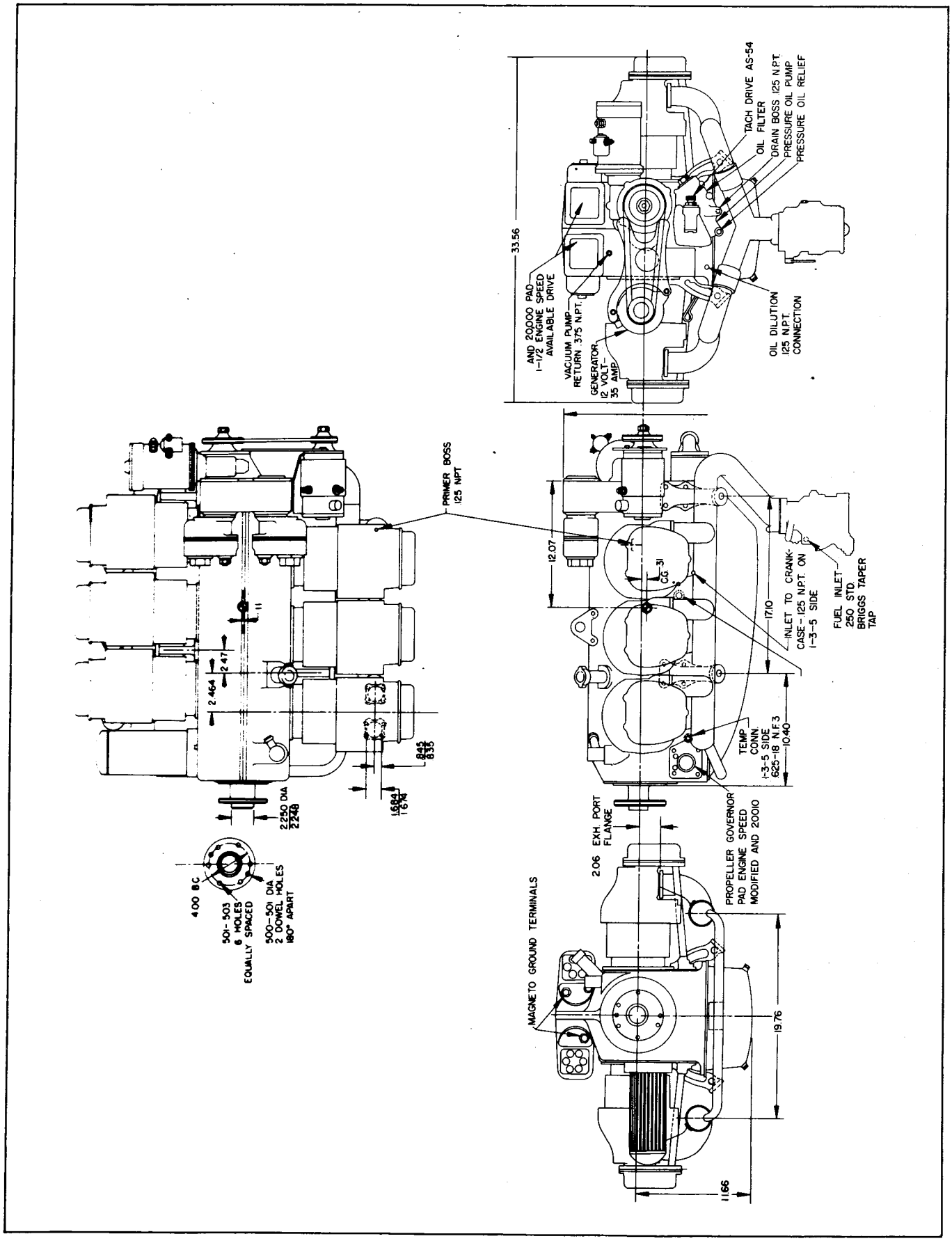


Figure 18. Installation Drawing O-470-L

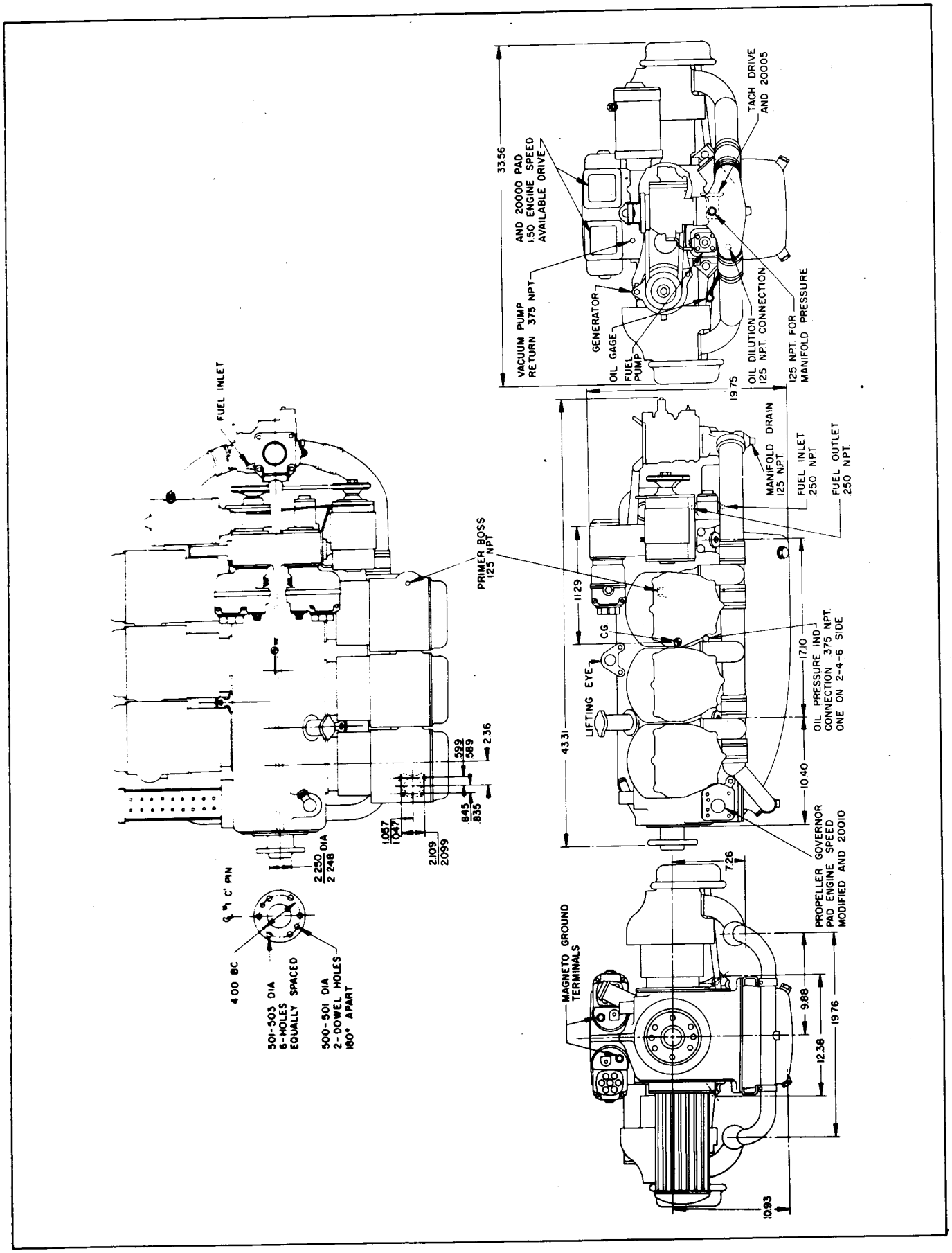


Figure 19. Installation Drawing O-470-M

Avoid excessive pressure when pumping fuel by manual means. If it proves difficult to keep the engine running after initial starting with a newly installed carburetor, remove the fuel channel plug and operate wobble pump until fuel stands level with the plug hold end. This will eliminate any air which may be trapped in the fuel line between the tank and the carburetor. Replace and tighten the plug immediately.

5-9. For engines equipped with a Marvel-Schebler carburetor connect the throttle and mixture controls where indicated on the installation drawings and check each for full range of operation. Connect the starter switch lead wire to the small center terminal screw of the solenoid mounted on the starter coil frame, and the battery power cable to the upper solenoid terminal screw. Connect the engine grounding strap where specified by the aircraft manufacturer. Connect the governor control as required. Connect the generator field coil ("F") and armature ("A") terminals to the regulator as indicated in the aircraft wiring diagram. The "F" terminal is nearest to the crankcase. Remove the pipe plug installed in the crankcase, located directly below the lower left fuel pump attaching stud, and install the fitting necessary for the attachment of the oil dilution tube.

5-10. INSTRUMENT CONNECTIONS. For engines equipped with a mechanical tachometer drive housing, apply grease to the flexible shaft end before inserting into the slotted drive shaft of the drive housing. After making sure the flexible shaft conduit is properly supported and without sharp bends, screw the conduit coupling nut onto the tachometer drive housing. Connect the oil pressure gauge tube to the fitting previously installed in the crankcase. Remove the hex-head plug and copper-asbestos gasket from the crankcase hole immediately below the oil cooler, and install in its place the oil temperature gauge capillary with a new gasket. Connect the cylinder head temperature gauge to the thermocouple previously installed on one of the cylinders. Connect the intake manifold pressure gauge tube to fitting previously installed in the manifold riser.

5-11. BLAST TUBE AND BREATHER. To provide the generator with cooling air, connect the aircraft blast tube to the connector projecting from the generator brush access cover. Install the aircraft breather hose on the crankcase breather and secure it with hose clamps.

5-12. ENGINE PRIMER. Remove the 1/8 in. countersunk hex-head pipe plugs from the intake valve chambers on top of the cylinder heads to which primer lines are to be connected, and install in their places the primer nipples or elbows specified by the aircraft manufacturer. Apply Parker Fuelube #44 sparingly to the nipples before screwing them into the heads. Connect the aircraft primer distributor discharge lines to the primer nipples after making sure that the cone seats are perfect.

5-13. FUEL SUPPLY LINE. Connect the fuel line to a suitable fitting installed in the 1/4 in. N.P.T. hole at the right front corner of the carburetor on the level of the manual mixture control lever.

5-14. AIRCRAFT PARTS. Install whatever engine baffles are required by the cowling of the aircraft in such a manner as to form a tight seal between the upper and lower compartments so that all cooling air will be forced to travel through the cylinder fins and the oil cooler fins. Attach the overboard drain lines to the previously installed manifold drain valve fittings. Install the carburetor air horn and air filter parts and the heat valve control. Make sure that the control will move the valve through its full range. Complete the installation of any other aircraft parts removed from the engine compartment, and install all parts of the cowling.

5-15. LUBRICATION. There are no grease fittings or points to be lubricated other than filling of the oil sump. Fill the sump with clean engine lubricating oil of a reputable brand and of the viscosity grade recommended in Table VII, according to climatic condition. The choice of detergent or straight mineral oil should be based on operating experience in the climate and the conditions of operation anticipated. Detergent oil is recommended only if it is used consistently from the time when the engine is installed, since it will loosen and circulate deposits of sludge precipitated from regular oil previously used in the lubricating system.

5-16. INITIAL OPERATION. A new or newly overhauled engine should be operated with lighter than normal loads for the first two hours to seat new running parts and avoid excessive temperatures at points not subject to measurement. Running on the ground should be conducted during the cool hours of the day in warm climates and should be interrupted whenever oil or cylinder temperatures approach dangerous levels. Full throttle operation on the ground should be limited to very short periods to check performance and instruments, since the ram effect of flying speed is necessary for cooling at normal power output or higher. During the first few hours of operation inspect all control, wire and tube connections frequently.

CAUTION

All ground operation must be conducted with the manual mixture control in the "RICH" position.

5-17. REMOVING ENGINE FROM AIRCRAFT. Remove all engine cowling, baffles, the carburetor air horn and other aircraft parts which will interfere with hoisting of the engine.

5-18. LUBRICATING OIL. Drain the oil sump as

completely as possible, then replace the drain plug.

NOTE

If the engine is to be shipped or stored it is advisable to preserve it, as described in Section IV, either before removal from the aircraft or on a test stand where it can be operated with corrosion-preventive oil and at the recommended temperature.

5-19. TUBE CONNECTIONS. Shut off the fuel supply; then disconnect the fuel line at the carburetor. For engines with Bendix-Stromberg carburetors, detach the vapor vent tube, the pressure gauge tube and loosen the tube connectors to facilitate removal later. For engines with Marvel-Schebler carburetors, remove the 1/4 in. square-head pipe plugs at the bottom of the front side of the carburetor, and drain the fuel; then replace the plug. Remove the fitting from the carburetor fuel inlet, and replace it with a 1/4 in. pipe plug. Disconnect the oil temperature gauge capillary below the oil cooler, and replace it with a 5/8-18 NF hex-head plug and gasket. Disconnect the oil pressure gauge tube, remove its connector, and replace it with a 3/8 in. pipe plug. Disconnect the intake manifold pressure gauge line from the riser manifold. Disconnect the blast tube from the generator. Disconnect the breather hose at the engine elbow. If a vacuum pump is installed, detach vacuum line and the oil separator from the pump and the drain tube from the engine. If a hydraulic pump is installed, disconnect it from the discharge and return pipes. If an oil dilution line is connected to the oil pump housing, disconnect the tube at the pump and replace its connector fitting with a 1/8 in. plug.

5-20. ELECTRICAL CONNECTIONS. Disconnect the two wires from the generator terminals and label them "A" and "F" ("F" nearest crankcase). Disconnect the two lead wires from the cylinder thermocouple. Disconnect the switch wire and the battery power cable from the starter solenoid. Disconnect the grounding strap from the engine. Immediately after detaching each wire, replace the attaching parts.

5-21. CONTROL CONNECTIONS. Disconnect the controls from the propeller governor, the carburetor-throttle lever, and the mixture-control lever.

5-22. HOISTING. When all wires, tubes and other parts attached to the aircraft have been detached from the engine and supported so as not to become entangled when it is lifted out, attach a hoist to the engine lifting eye and take up all slack without lifting the engine. Since the engine tends to assume a horizontal attitude, loosen the front mounting bolts first; then remove the rear mount bolts and rubber bushings, and last, hold up the propeller mounting flange as necessary while removing the front mounting bolts, nuts and bushings. While still holding the engine in the same attitude, lift it until it can be allowed to swing to the horizontal position without striking the aircraft; then hoist it clear and either roll the aircraft away, or move the hoist away from it.

5-23. PRECAUTIONS. Do not allow any part of the engine to touch the floor. If the engine is to be overhauled it should be mounted on the disassembly stand at once. If it is to be shipped, the preservation procedure recommended in paragraph 4-12, including removal of the carburetor on models O-470-K and O-470-L, and covering of all openings, should be carried out before the engine is mounted in the shipping crate. Rubber and steel shipping mount bushings, Part No. 535617, are the only kind recommended for attachment to the shipping crate supports.

SECTION VI
MAINTENANCE INSTRUCTIONS

6-1. DAILY INSPECTION. Before the first flight each day a general inspection should be made of engine control connections and operation, electrical wire terminal connections, and for leakage or looseness at fuel supply, primer and oil dilution tube connections. The oil level gauge should be inspected and oil added if the level is near the "L" mark. After the engine has been started and warmed up the engine instruments should be observed for possible irregularities in performance at various speeds from idling up to full throttle, with the propeller in the low pitch position. Operation at full throttle should be limited to the minimum time required to observe oil pressure and to test the individual ignition systems for excessive drop in R.P.M. by switching from "BOTH" to "L" then back to "BOTH", then to "R" then back to "BOTH". Leave the ignition switch in "L" and "R" positions only long enough to stabilize R.P.M. If no drop in speed is observed when operating on either magneto alone the switch circuit should be inspected for loose connections.

6-2. 100-HOUR INSPECTION. At intervals of approximately 100 hours of operating time, it is advisable to perform a thorough inspection of the engine installation to detect incipient troubles due to looseness of parts and connections, normal wear, fatigue cracks in visible metal parts and obstructions to air flow. This inspection should be made to coincide with a routine oil change. Any instance of improper attachment, leakage, support, fit or operation should be corrected to assure continued reliable performance of the engine and its accessories and to prevent small troubles from becoming dangerous ones, resulting in higher repair costs. The following points should be given particular attention:

a. Remove all cowling and surrounding baffles necessary to give full access to the engine, accessories and controls. Clean cowling and baffles to permit inspection for cracks and looseness of parts.

b. Drain and refill the engine lubricating system, as described in paragraph 6-3. The engine warm-up must be carried out before removal of the cowling.

c. Inspect fuel tubes, gauge tubes and the breather tube, connectors and supports, for security of attachment, cracks, and the possibility of tubes touching electrical wires or rigid members. Tubes are most likely to crack near end fittings and intermediate supports. Inspect tube grommets at the fire wall for secure installation and close fit.

d. Inspect all control linkages for range of movement, wear at pin joints, unusual friction or binding, and interference with other members.

e. Inspect all hoses and clamps for tightness of joints and general appearance. Ascertain that tightening of hose clamps at the joints has not deformed intake manifold parts so as to cause leakage.

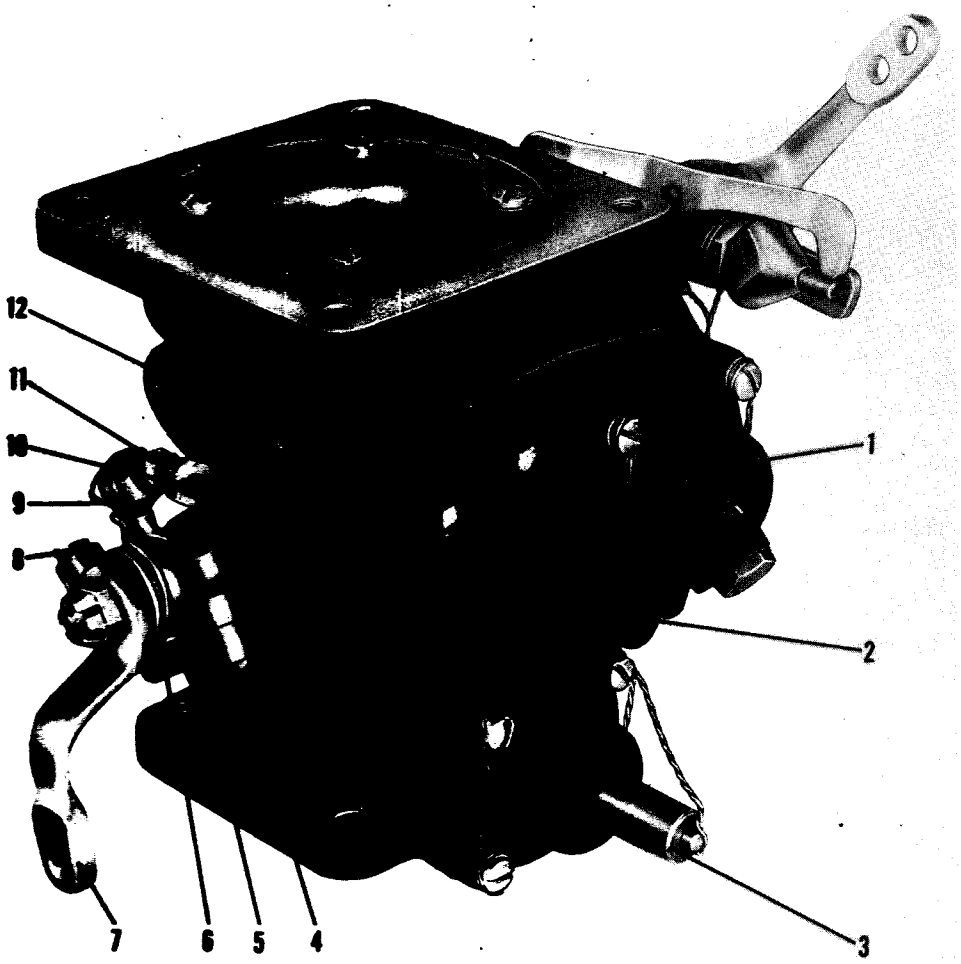
f. Inspect visually all attaching bolts and nuts, plugs and lock wires. If any appear to be loose test it with a wrench and tighten as necessary. Usually, oil leakage around parts attached to the crankcase will precede other evidence of looseness and should be corrected by tightening of the attaching parts unless the extent of leakage indicates that a gasket or oil seal should be replaced. Especially at the first periodic inspection after installation of a new or rebuilt engine, it is advisable to loosen palnuts around the cylinder bases and to test tightness of base attaching nuts with a wrench. After any necessary retightening, tighten the palnuts with fingers, then only 1/6 turn with the wrench.

g. Shut off the fuel supply to the carburetor. Disconnect the fuel supply line at the carburetor. Remove and clean the fuel strainer; then replace it, using a new tab washer and reconnect the supply line.

h. Remove, clean, inspect and measure gaps of all spark plugs. (Refer to Table II.) Replace any plug with a damaged insulator, loose or badly eroded electrode or damaged thread. Before replacing a plug, make sure that its gasket is smooth, and apply a thin film of BG mica thread lube to the 18 mm thread. Before reconnecting cables to the spark plugs, inspect the terminal elbows, springs and sleeves for damage. Inspect all cables for breaks or ruptures in the insulation and for secure attachment to the magneto outlet plate. Make sure that the grommets are properly installed where lower plug cables pass through intercylinder baffle slots.

i. If there was any sluggishness in the engine operation which was not traced to the fuel or induction system or to the spark plugs, the magneto switch wires may be disconnected (thus grounding the magneto primary circuits) and the breaker covers removed for inspection of point gap and condition. Ordinarily it is not necessary to check ignition timing; however, wear of the magneto breaker cam follower can result from lack of lubrication and make the timing late. For corrective procedure refer to paragraphs 6-9, 6-10 and 6-11.

j. Remove all valve rocker covers and inspect valve



1. Accelerating pump diaphragm cover
2. Idle and power enrichment valve and control rod cover
3. Discharge diaphragm adjustment screw
4. Idle and power enrichment valve control rod adjusting screw (idle mixture adjustment)
5. Fuel throttle stop on throttle stop assembly
6. Throttle stop block
7. Throttle lever
8. Idle speed adjustment screw
9. Idle control rod adjustment lever
10. Idle and power enrichment valve control rod
11. Power enrichment adjusting screw
12. Identification plate

Figure 20. Three-Quarter, Left Rear View of Stromberg PSD-5C Carburetor

stems, springs, retainers, keys and rockers for evidence of inadequate lubrication and breakage. All parts should be covered with oil. If there is any lash in any valve train when the valve is fully closed the hydraulic tappet is not operating properly. For removal procedure refer to paragraphs 6-19 and 6-20. Use new gaskets and shakeproof lock washers when replacing rocker covers.

k. Inspect cylinder fins for possible obstructions. Make sure that intercylinder baffles are securely attached and held in contact with the cylinders.

l. Remove, clean and replace the carburetor air cleaner according to the aircraft manufacturer's instructions.

m. Inspect the oil cooler fins for obstructions, and blow out any dirt with compressed air or flush with cleaning solvent.

n. Test engine mount bolt nuts and retighten to specified torque if found loose.

o. It is advisable to wipe any oil or caked dirt from

the engine surfaces in order to reduce the fire hazard and to enable early detection of any possible oil leakage.

6-3. OIL CHANGE PROCEDURE. Under normal operating conditions the oil sump should be drained and refilled with fresh oil of seasonal grade (Table VII) at intervals of 25 to 30 hours of flying time. In order to drain out as much as possible of the old oil it is advisable to drain it as soon as possible after a routine flight, and with the oil temperature not lower than 120°F. There are two hex-head drain plugs at the rear of the oil sump, one on each side. Only one need be removed. When it is reinstalled use a new copper-asbestos gasket. While the sump is draining remove the socket-type hex-head 1/8 in. pipe plug in the lower end of the oil filter housing and drain the oil filter. Unscrew the oil filter cap, and withdraw the Air-Maze filter from the oil pump housing. Slush it in solvent to remove all solid matter adhering to the outside of the screen; then dry it with dehumidified compressed air or allow it to drain until dry. If the filter was particularly dirty it is advisable to remove the oil standing in its housing with a rubber bulb syringe and to wipe out the housing with a bottle brush or cloth moistened with solvent, then with a dry cloth. Make sure that the housing threads are clean. It is advisable to use a new copper-asbestos gasket under the filter flange when it is reinstalled.

6-4. ADJUSTMENTS AND MINOR REPAIRS.

6-5. IDLE ADJUSTMENT, BENDIX-STROMBERG CARBURETOR.

a. Start and warm up the engine until oil and cylinder head temperatures are normal for take-off.

b. Test for R.P.M. drop-off by grounding each magneto, in turn, with the ignition switch. Correct excessive drop in R.P.M. due to fouled spark plugs or other ignition trouble before proceeding with the idle adjustment.

c. Close the throttle to its idle stop. If idling speed is appreciably above or below 600 R.P.M., turn the idle speed adjusting screw, a notch at a time, inward to increase or outward to decrease speed. If idling speed changes during the following steps, readjust in the same manner:

d. Move the manual mixture control slowly and smoothly into the "IDLE CUTOFF" position, watching the tachometer closely for any change in R.P.M. As soon as the first R.P.M. change occurs, return the control to its "FULL RICH" position before the engine can stop. An increase of more than 10. R.P.M. after "leaning out" the mixture in this manner indicates an excessively rich idling mixture, while an immediate drop in R.P.M. indicates an excessively lean mixture.

e. Correct excessively rich idling mixture by turning the idle mixture adjusting screw inward, positioning the needle valve closer to its seat. Correct excessively lean mixture by turning the mixture adjusting screw outward. Turn the screw only a notch at a time, and check the resulting mixture as described in the preceding step, between successive adjustments. The idling mixture will be correct when "leaning out" with the idle cutoff control results in a momentary increase of approximately 5 (never more than 10) R.P.M.

f. After each check and mixture adjustment and before testing the effect, run up the engine speed to about 2000 R.P.M. for a few seconds to clear the spark plugs. Make the mixture check after the throttle has closed and idling speed stabilizes at 600 R.P.M.

g. After the final mixture adjustment, set the idling speed at the desired value with the speed adjusting screw.

NOTE

The following method aims at an idle mixture setting which will give maximum R.P.M. with minimum manifold pressure. If the setting does not remain stable, check for looseness in the throttle linkage and the carburetor lever assembly which would allow the control rod freedom to move with the throttle closed. Allowance should be made for the effect of weather conditions on idling performance, though this method should eliminate frequent adjustments, except to correct for wide variations in weather and altitude. When making the adjustment, the aircraft should be parked cross-wind to avoid variations in propeller loading. If the foregoing adjustments have appreciably changed the angular relation between the power enrichment adjusting screw and the wide open throttle stop, it will be necessary to readjust the screw so that it will contact the end of the idle control rod when the wide open stop is approximately 35 degrees from the body stop stud. A sheet metal gauge can be made locally to rest on the body stud and space the lever wide open stop at 35 degrees, while the enrichment screw is readjusted and its lock nut tightened. After such adjustment, be sure to install lock wire in the enrichment screw and lever.

6-6. METERED FULL PRESSURE ADJUSTMENT. This adjustment is made on a flow bench and should not be changed, unless one of the following symptoms cannot be traced to any other source:

1. Rough or surging engine operation at cruising power or possibly higher power.

2. High cylinder head temperatures during extended engine operation at cruising power.

Before readjusting the discharged diaphragm adjusting screw to change the metered fuel pressure, observe the barrel of the screw. If the original factory adjustment has not been disturbed, a punch mark on the screw will align with another on the sleeve and a scribed mark around the screw barrel will align with the sleeve end. If the punch marks cannot be located, or if the scribed mark is not visible, scribe a new mark around the screw barrel at the end of the sleeve to establish the position before adjustment. Adjust as follows:

a. Start the engine and warm up until cylinder head and oil temperatures are normal for take-off.

b. With the propeller at low pitch, adjust the engine speed to 1700 R.P.M. Lock or leave the throttle in this position.

c. Move the manual mixture control toward the "Lean" position to lean the mixture only slightly. At the same time watch the tachometer for R.P.M. change and notice whether engine operation becomes smoother or rougher. The effect of leaning the mixture will be immediate. Do not operate on lean mixture for any extended time. Return the control to the "RICH" position.

d. If leaning the mixture aggravated engine roughness, turn the adjusting screw counterclockwise to enrich. If the leaning process increased smoothness of operation, turn the adjusting screw clockwise to lean the mixture. The adjusting screw has a spring-ball detent. Count the clicks as the screw is turned to judge the amount of adjustment. There will be six clicks per revolution. It should not be necessary to turn the screw either way more than one revolution from the original setting. Pause after each click to observe the effect.

NOTE

The discharge diaphragm adjusting screw should be set for the metered fuel pressure which will produce the best power with fixed throttle and fixed (low) propeller pitch. Best power will be accompanied by maximum R.P.M. under these conditions, and smooth engine operation should result. After any readjustment of the discharge diaphragm adjusting screw, it will be necessary to readjust the idling mixture, as described in paragraph 6-5.

6-7. FLUSHING REGULATOR NEEDLE VALVE. It is permissible to flush dirt from the regulator needle valve and seat if necessary, to correct any of the following troubles without removing the carburetor from the engine.

1. Engine does not stop when manual mixture control is placed in the "IDLE CUTOFF" position.
2. Idle too rich, requiring extremely lean idle mixture screw adjustment, resulting in poor acceleration and erratic cruise operation.
3. Poor deceleration of engine, resulting in rough operation and emission of black smoke from exhaust.

NOTE

Before flushing the needle valve, investigate all other possible causes of trouble symptoms as described in the TROUBLE SHOOTING CHART.

To flush the regulator needle valve and seat, proceed as follows:

a. Remove the needle valve plug, the spring and the needle valve.

b. With the wobble or boost pump, build up fuel pressure at the carburetor, and allow fuel to flow out and flush the valve seat.

c. Remove dirt or other foreign matter from the needle valve with a soft, lint-free cloth, or with a jet of dehydrated compressed air.

d. Reinstall the needle valve, spring, gasket and plug in that order.

NOTE

Do not force a wire into the needle valve seat or use any abrasive material to polish or clean the needle valve or its seat. These parts are a matched assembly. Any scratches or excessive wear on either part will result in leakage so that the valve will not function properly and will make it necessary to replace the valve and seat assembly.

6-8. For engines using the Marvel-Schebler carburetor, the manual mixture control lever at the front should be at its extreme right position (toward fuel inlet) when the cabin control is in the "IDLE CUT-OFF" position. If the engine cannot be stopped from idling speed by operation of the control, the lever may not be reaching its stop due to looseness or flexure in the control linkage. The same lever should reach its extreme left position when the cabin control is set for full "RICH" operation. The angle between the extreme lever positions is 64°, and each 32° from the straight forward position.

6-9. The idling mixture control is located at the front of the carburetor, above the manual mixture control lever. It should be set slightly rich to avoid stalling at idling speed. First, adjust the lever to produce smoothest operation and maximum R.P.M. with the throttle closed. If speed is much above or below 600 R.P.M. adjust it to that value by turning the idle speed stop screw (with spring) beside the throttle lever; then move the idling mixture lever slightly toward

the "R" (rich) side. Then if the manual mixture control is moved to "IDLE CUTOFF" position, the speed should increase 10 to 20 R.P.M. before starvation begins to stop the engine, since leaning the mixture with the cutoff momentarily corrects a slightly over-rich condition. If a greater increase in R.P.M. was observed, the idling mixture setting is too rich, and if no increase occurs, it is too lean. Always return the manual mixture control to the full "RICH" position before the engine stops if further running is desired. To avoid false results due to spark plug fouling, run up the engine speed to above 1500 R.P.M. after idling periods.

6-10. The carburetor may be removed for repair or replacement by detaching the air horn from its bottom flange, shutting off the fuel supply and detaching the fuel supply tube at the carburetor inlet, disconnecting the throttle and mixture controls and removing the four nuts, washers and bolts which attach the carburetor to the riser manifold. To drain the fuel from the float chamber remove the pipe plug at the bottom of the front side (below the mixture control lever).

6-11. FUEL PUMP. Engines having a Bendix-Stromberg pressure carburetor will also have a Romec engine-driven fuel pump. The volume output of the pump is constant; however, the fuel pressure may be adjusted by turning the relief valve adjusting screw located in the center of the pump cover. Rotate the screw clockwise to increase the pressure and counterclockwise to decrease the pressure. Consult Table VI for applicable pressure.

6-12. IGNITION CABLES. Cable assemblies connected to upper spark plugs of No's. 2 and 4 cylinders and those connected to upper plugs of No's. 3 and 5 cylinders are clamped together by a bracket and rivet to prevent excessive movement. These parts must be removed as units if either cable of the pair is to be replaced. All other spark plug cables may be removed and replaced independently. Before removing the bracket from a pair, mark its location on each cable as on the originals. To remove any cable, detach its elbow from the spark plug and pull out the terminal; then loosen the coupling nut which holds its ferrule to the magneto outlet plate. Remove the outlet plate attaching screws, and pull the plate from the magneto. The plate grommet will come with it. Remove the slotted-head screw and brass washer from the plate grommet projection in line with the cable to be detached, and unscrew the ferrule coupling nut. Withdraw the cable end. If it is a lower spark plug cable, detach the clip from the six-cable clamp mounted on the crankcase. Upper spark plug cables will be free when detached from the magneto outlet plate. Check the replacement cable assembly against the original for correct length, and install it in the reverse of the order of removal.

6-13. MAGNETO BREAKER. By disconnecting the switch lead wire and removing the cover plate to which it was attached, the breather assembly, breaker cam and condenser may be exposed for inspection. Absorb any oil lying in the breaker housing into a clean cloth. If the breaker points are oily remove the oil with a cloth moistened with unleaded gasoline. Do not touch the cam, since gasoline or any solvent would remove the oil with which it is impregnated. If, on the other hand, the breaker appears to be very dry, its felt wick may need a drop or two of S.A.E. 60 oil. Allow about 15 minutes for the oil to be absorbed; then blot off any excess. Avoid getting oil on the breaker points. The felt wick does not need oil if pressure with a fingernail causes oil to appear on the surface. It should never appear damp.

6-14. To check the breaker points for opening and surface condition, turn the propeller backward until the breaker cam follower is at the highest point of either cam lobe. The amount of gap is not specified. Contact surfaces should have a gray matte appearance. Pitting, burning, or transfer of metal from one point to another usually indicates a weak condenser. Do not file the contact surfaces. If they are unserviceable, replace the entire breaker assembly and the condenser.

6-15. If the breaker point gap appears subnormal, remove the timing inspection hole (hex-head) plug beside the magneto identification plate, and turn the propeller backward until the white distributor gear tooth aligns with the timing pointer in the magneto case. This is approximately full advance firing position for No. 1 cylinder. Back up the propeller only 8^{o} or so further; then tap it forward until the timing mark (See Table II) on the propeller attaching flange of the crankshaft aligns with the crankcase parting line (bottom). The breaker points should be just opening at this position. (For more accurate location of the advance firing angle refer to timing instructions in Section XII.) If a Scintilla timing light is used to detect opening of the breaker points while the cover is removed, insert a strip of heavy paper or thin card between the switch wire contact (primary ground) spring and the magneto case, and connect the timing light test leads to the case and to the grounding spring. If the breaker points do not open at the advance firing angle, due to wear in the cam follower, the breaker may be adjusted to compensate by loosening the fillister head screw at its slotted end partially and shifting the breaker toward the cam slightly. Tighten the attaching screw fully after each adjustment, and check by backing up the propeller a few degrees, then tapping it up to the firing angle. (If the propeller is backed up too far the magneto impulse coupling latch will engage when it comes forward, and the breaker cam will be held back.)

NOTE

Do not attempt to correct the breaker point opening position by the above method, unless the magneto timing pointer is approximately aligned with the white gear tooth when the crankshaft is at its advance firing angle. If the magneto is not correctly timed internally or to the engine, moving the breaker will not rectify the pre-

vious error. If magneto timing to the engine appears to be incorrect, check and correct it by one of the methods described in Section XII. Remember that correct internal timing of the magneto requires proper meshing of the magnet shaft and distributor gears, as well as proper adjustment of the breaker assembly position, so that the points will open when the gear and case timing marks are aligned.

CAUTION

Do not remove the magneto distributor housing (rear half) or its five attaching screws, because this would separate the magneto gears and cause the internal timing to be lost. After adjusting the breaker assembly, do not fail to remove the insulator strip placed between the grounding spring and the case. Make sure that the spring touches the case.

6-16. MAGNETO. Before removing a magneto for repair, and in order to facilitate timing of the replacement magneto (assuming that the original was properly timed to the engine), the timing inspection hole plug beside the identification plate may be unscrewed and a Scintilla No. 11-851 timing light may be used to locate the crankshaft position at which the breaker points open to fire No. 1 cylinder spark plug. If this is done the replacement magneto may be timed without further movement of the crankshaft, merely by clamping it at the position where its breaker opens to fire No. 1. If the breaker cover was not removed, screw into the switch wire terminal socket a Scintilla switch wire terminal assembly (Part No. 352024) assembled on a short wire to connect one of the red test leads to the insulated breaker point. Clamp the black (''GRD'') ground lead of the timing light on an unpainted engine part. Turn the propeller backward to the position at which the timing pointer in the magneto timing inspection hole aligns with the white gear tooth and the timing light indicator lamp is illuminated. Tap the propeller forward gently until the lamp is extinguished, and leave it in this position until the replacement magneto has been timed and clamped in place. To remove a magneto it is only necessary to detach the high tension outlet plate and to remove the two magneto flange clamp nuts, washers and clamps in order to pull it forward from the crankcase. As the magneto flange clears the case hole, watch the rubber drive bushings and steel retainer in the gear hub to make sure they will not drop out. If the rubber bushings have been deformed so that the space between them will not fit the magneto coupling lugs closely, they must be replaced with new parts.

6-17. Before installing a magneto, the crankshaft must be positioned at the advance firing angle of No. 1 cylinder spark plug, unless it was so positioned previously as described in the preceding paragraph. The correct procedure is described in Section XII. Also, the magneto timing inspection hole plug must be removed and the impulse coupling turned backward (so that the impulse coupling latches will not engage) until the timing pointer inside the case is aligned with the white gear tooth. While holding the magneto against its mounting pad, install the two clamps, washers and nuts, and tighten the nuts only enough that the magneto can be rotated without side play. With the timing light connected and the lamp dark, rotate the magneto counterclockwise (front view) only enough to illuminate the lamp; then tap it clockwise until the lamp is extinguished by opening of the breaker points. At this position clamp the magneto tight; then back up the crankshaft a few degrees and tap it forward to test, using the crankshaft flange timing mark.

6-18. GENERATOR. To adjust the vee belt tension loosen the three generator attaching bolts. Pull outward on the generator and tighten the upper bolt first, then the two lower bolts. The belt tension will be correct when either side of the belt, held midway between the sheaves, can be moved up or down 1/2 inch from its neutral position.

6-19. If the generator is to be replaced and the sheave removed, the shaft nut should be loosened before removal of the vee belt. Loosen the generator attaching bolts, push the generator towards the engine and remove the belt. Remove the attaching parts and pull off the generator. Reverse the removal procedure to install the generator.

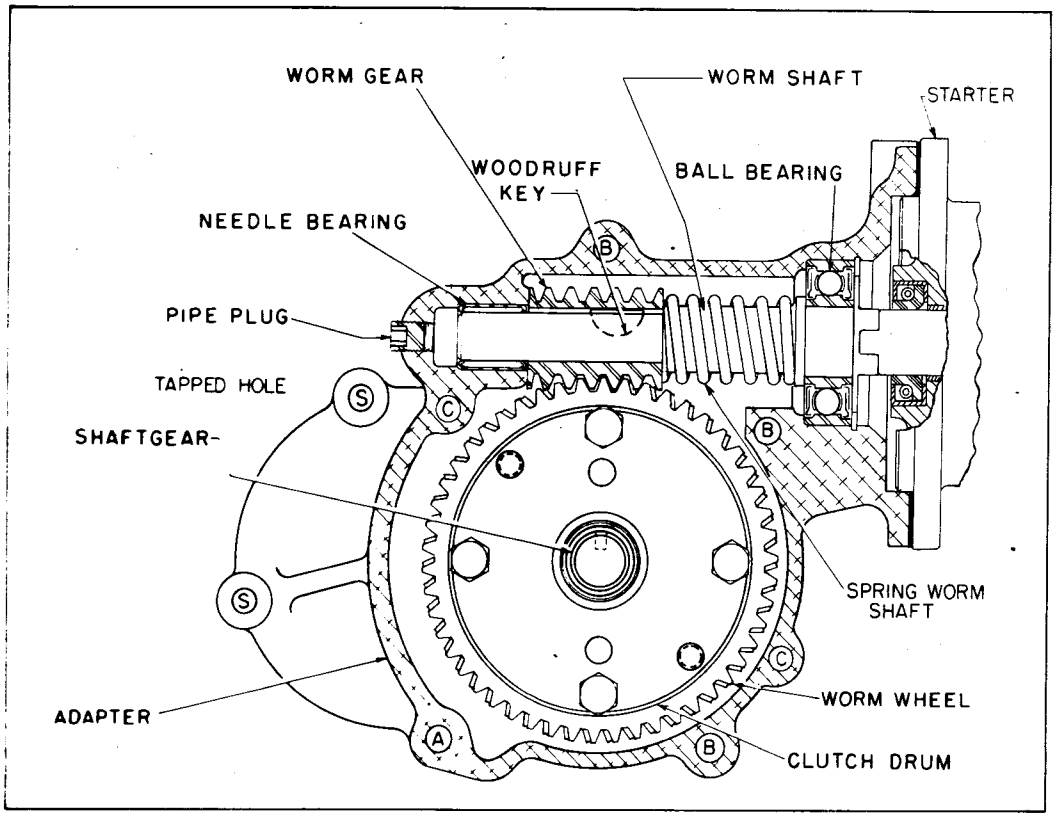
6-20. STARTER. The starter may be removed for inspection or repair by disconnecting the switch wire and the power cable from the solenoid and removing the two starter flange attaching nuts and washers. Pull the starter straight outward. Install a starter in the reverse of the order of removal.

6-21. STARTER DRIVE ADAPTER ASSEMBLY. Remove the generator. (See 6-18.) Remove the generator bracket to starter adapter attaching parts (A and upper C, figure 21) and the bracket. Remove the three adapter attaching bolts (B, figure 21); nuts and washers from the crankcase studs and pull the adapter straight to the rear. For disassembly and reassembly procedures refer to overhaul instructions. Reverse the order of removal to install the adapter assembly.

NOTE

If the adapter is to be disassembled, loosen the sheave retaining nut before detaching the adapter.

6-22. OIL COOLER. To detach the oil cooler it is necessary, for model O-470-K engines, to remove only its five attaching nuts and washers. For O-470-L engines remove five hex head bolts, three plain hex nuts, lock washers and plain washers. For the O-470-M engine remove the twelve attaching bolts. The adapter may remain on the crankcase.



A. Adapter cover and adapter-to-crankcase bolt
B. Adapter-to-crankcase bolts
C. Adapter cover-to-adapter bolts
S. Crankcase-to-adapter studs

Figure 21. Cross Section of Starter Drive

6-23. VERNATHERM CONTROL VALVE. To remove the valve (35, figure 14) after removing the lower cowling, it is only necessary to cut the lock wire which secures its 1-1/2-inch hex cap and to unscrew it. No repair parts are supplied for the Vernatherm valve, and readjustment is not recommended since special testing equipment is required to assure correct performance. The assembly may be cleaned with a solvent and inspected for damage. Normally it will operate properly if its spring-loaded poppet valve has a true face and if the seat in the crankcase is not damaged; however, sludge may lodge on the seat and prevent the valve from closing.

CAUTION

Do not remove the locking pin staked in a drilled hole in the hex adjusting nut at the poppet valve end. Do not remove the valve from the crankcase when the engine oil temperature is above 145° F.

6-24. OIL PRESSURE RELIEF VALVE. The relief valve (15 through 18, figure 14), is not adjustable. Its spring is designed to produce normal oil pressure when the oil pump and bearing clearances are within specified limits and undamaged. If low or fluctuating oil pressure indicates improper relief-valve action, the valve parts may be removed for cleaning and inspection by unscrewing the brass cap and withdrawing the spring and plunger. Clean the parts in a solvent and wipe the seat in the pump body with a clean cloth. Inspect the seat and the plunger face for scratches and other deformation. (Refer to Section XV for length of the free spring and length under specified load.) Use a new copper-asbestos gasket when replacing the cap.

6-25. OIL PUMP AND TACHOMETER DRIVE. The complete assembly is attached to ten crankcase studs which make it necessary to move the pump rearward approximately 2-7/8 inches for removal. To remove the assembly as a unit it is necessary only to remove the nuts from the attaching studs and to move the housing straight to the rear. Removal of the tachometer and pump cover or the tachometer drive shaft is not recommended, since the two tachometer drive bevel gears (11, 12, 13 and 14, figure 13) are not fastened to their shafts, unless the entire pump assembly has been removed from the engine. For disassembly and reassembly instructions refer to Sections VII and XI. Normally, the oil pump and tacho-

meter drive are very well lubricated and not subject to rapid wear or overheating; hence, they should give no trouble unless attaching parts loosen and allow oil leakage at the gasket, or oil leaks develop at the oil filter gasket, or the tachometer drive housing seal as a result of improper installation. The tachometer generator may be removed or the mechanical drive may be unscrewed for replacement of the oil seal or the assembly if the slotted shaft is held inward so as to remain in the cover.

CAUTION

The tachometer drive housing for O-470-K and O-470-L engines has a left-hand thread. Turn its hex clockwise to unscrew it.

6-26. MAGNETO AND ACCESSORY DRIVES. If an optional pump is installed on either of the drives behind the magnetos and there is evidence of oil leakage through the gear shaft oil seal, the drive may be removed and the seal replaced as described in Section X. Before removing any of the other parts disconnect the switch wire and the high tension cable outlet plate from the magneto in line with the drive adapter to be removed; then place the magneto and crankshaft in No. 1 cylinder advance firing position; then remove the magneto. (Refer to paragraph 6-12.) Remove the pump from the drive adapter pad. Mark the meshed teeth of the magneto drive and idler gears to facilitate reassembly and timing; then push the magneto drive gear and bushings assembly forward, and remove it through the magneto pilot hole, taking care not to drop the rubber bushings into the case. Remove the four adapter attaching nuts and washers and the adapter assembly. Notice the position of the oil inlet hole. Install a new gasket and the adapter assembly in the original position. The rubber bushings and retainer should be in place in the gear when it is installed and meshed in the original position. Push the gear shaft gently through the oil seal lip to avoid damage to the lip. Both the seal lip and the gear shaft should be well lubricated. Refer to paragraph 6-13 for magneto installation procedure.

6-27. CRANKSHAFT OIL SEAL. If an oil leak should develop around the seal at the front of the crankcase, the rubber ring may be pried out with a pointed tool inserted at the outer edge, using a wood block as a fulcrum and moving around the circle several times until it is free. Lift out the inner spring, and unhook its end loops. Twist the rubber ring to remove it from the shaft. Before installing a new seal assembly, clean out the crankcase counterbore and inspect the shaft surface for roughness. Smooth it with crocus cloth, if it is at all rough. Spread a film of lightweight Tite-Seal paste in the case recess and on the periphery of the new seal. Use only enough to form the thinnest possible film in the case. Remove and unhook the spring of the new seal. Spread on the seal lip a coat of Gredag No. 44 grease. Twist the seal as before, and slide it over the crankshaft; then align the ends. Hook the new spring around the shaft behind the seal, and lift it into the groove, starting at the split and working both ways. Position the split 5/8 in. on either side of the case parting line above the crankshaft, and push the ring in evenly with two flat bars prying against blocks behind opposite sides of the shaft flange until the front side is flush with the surface.

6-28. INDUCTION SYSTEM. The balance tube which connects the front ends of No's. 5 and 6 cylinder intake tubes, may be removed after loosening the two front hose clamps and removing the two balance tube attaching bolts. For model O-470-M disconnect the front manifold drain, then loosen the front hose clamps, remove the bracket clamp and remove the balance tube assembly. Cylinder intake tubes may be removed after loosening the connecting hose clamps, pushing the hoses endwise clear of the joints and removing the flange attaching bolts. On O-470-K and O-470-L engines, to remove the riser manifolds disconnect the manifold pressure line, disconnect and remove the carburetor. Then loosen the hose clamps on the manifold-to-elbows connecting hoses and slide the hose back on the elbow until clear of the joint. Cut the safety wire and remove the four manifold-to-supporting bracket bolts. For O-470-M engine disconnect the rear manifold drain and manifold pressure line, loosen the hose clamps and push the connecting hose clear of the joints. Remove the four nuts and washers on the carburetor bottom flange and the bolt and washers from the front of the riser, then pull the manifold riser straight down until its studs clear the carburetor mount bracket. Before installing a cylinder intake tube on the engine, replace the gasket on the cylinder connecting flange. Make sure that both ends of any manifold part removed for inspection are truly round. Attach intake tube flanges to the cylinders before attempting to push the hole connectors over their tube ends.

6-29. VALVE MECHANISM. Valves and valve seats may be refaced in accordance with instructions in Section X. If a valve is found to be sticking it may be attributed to the following:

a. Insufficient clearance between stem and guide. Refer to Section X for repair procedures.

b. Valve tappet malfunction due to carbon, sludge, metallic particles, etc. Refer to Section XIII for repair and testing of valve tappets.

c. Insufficient lubrication. On new or overhauled engine installations this is sometimes caused by installing the pushrods "dry". Pushrods, before being installed, should be allowed to soak, completely immersed, in a pan of new, clean, lightweight oil until air stops bubbling out of the ends. To correct a sticking valve, providing the stem is not scored, lubricate the stem with a squirt can while the engine is being motored over, until oil pressure forces

the air from the pushrod. For older engines sludge, carbon or metallic particles could block the oil passage of the pushrod and cause this malfunction. In the event this would accur, remove the cylinder per instructions in paragraph 6-32 and clean out the oil passages. Reface the valves and valve seats, if necessary, per instructions in Section X.

6-30. VALVE TAPPETS. If a hydraulic tappet will not maintain zero lash in the valve train, its plunger may be held inward by a ring of carbon or scored by abrasive particles in the oil, or the check valve may be held open by a sludge deposit. Any such condition should be brought to the operator's attention, since it indicates a need for more frequent inspection and cleaning of the oil filter.

6-31. To remove a hydraulic tappet, first disconnect the cable from the lower spark plug and unscrew the plug. Next, detach and remove the valve rocker cover; then turn the propeller backward until the rocker which the tappet operates allows the intake or exhaust valve to close fully. If there is no lash in the valve train the propeller may be turned further to open both valves and the valve spring retainers clamped in their depressed positions by a locally made clamp attached to the rocker cover screw holes above the valve springs. Then the propeller may be turned until the tappets retreat and the rocker shaft pushed endwise until the rocker can be removed. Withdraw the pushrod from its housing. To remove the housing it will be necessary to push it toward the crankcase against its spring until the outer end is clear of the cylinder head hole. This may be accomplished with the aid of a long bar or screw driver; however, a safer tool is one with a yoke at the end (see figure 22) to fit around the housing in line as it leaves the cylinder; then pull it down clear of the head before releasing its spring force. If the two steel washers and red Silastic seal do not come out with the housing, remove them with a finger. The tappet may be pulled out by its snap ring with a wire hook. Refer to Section XIII for disassembly and cleaning instructions on tappets. Reinstall parts in the reverse order, using new pushrod housing seals, a new valve rocker cover gasket, and new shakeproof lock washers on the cover attaching screws. If a suitable type of spring compressor is available it should be used to compress the pushrod housing spring (see figure 50). This method will allow the red Silastic seal, sandwiched between the two thin steel washers, to be placed on the end of the housing before installation. It is more difficult - and involves the possibility of damaging the seal - to place the seal and washers in the crankcase recess and to push the housing obliquely through them without previously compressing its spring. If a valve spring compressor is used, insert the housing into the crankcase until the seal is in the recess; then swing the housing into line with the cylinder head hole, and move the housing outward until the seal enters the head. This will avoid possible damage to the outer seal when the compressor is released. Release it slowly. If the valve springs were depressed by a clamp, lubricate and install the pushrod and rocker; then turn the crankshaft until the rockers open the valves before loosening the screws which attach the clamp.

6-32. CYLINDERS. To remove a cylinder proceed in the following steps:

a. Detach ignition cables and unscrew both spark plugs.

b. Remove the exhaust manifold section connected to the cylinder.

c. Remove the intake tube assembly connected to the cylinder.

d. Remove the valve rocker cover.

e. Turn the crankshaft until either valve stem has moved inward at least 1/4 in. from its closed position. Attach a locally-made clamp to the upper cover screw hole in the head flange above the valve to hold its spring retainer at this position. In the same manner depress and clamp the other valve spring retainer; then turn the crankshaft until both rockers have clearance and the piston is at T.D.C.

f. Push the rocker shaft endwise to clear the rocker, in turn, and remove the rockers. Return the shaft to its working position.

g. Withdraw the pushrods from their housings.

h. Remove each pushrod housing by compressing its spring until the outer end clears the cylinder head hole, lowering and withdrawing it from the crankcase. Remove the inner end seal and washer also.

i. Remove the baffle clamp bolts and clamps on both sides of the cylinder, and remove the intercylinder baffles which contact it.

j. Remove 8 palnuts from cylinder attaching studs, then the 8 cylinder base nuts.

k. Cradle the cylinder in one arm, and withdraw it straight forward. With the other hand catch the piston as it comes free, and lower it carefully.

l. After storing the cylinders, push the piston pin endwise and remove the piston. Apply hot oil to the piston, if necessary, to free the pin.

6-33. When removing piston rings do not allow their sharp ends to scratch the piston. If valves are to be removed from the cylinder, support it on a post to hold the valve heads up. Depress the valve spring outer retainers with a locally made fork designed to bear under the rocker shaft and on both sides of the retainer exactly on the diameter with ample space for access to the stem keys. Remove the temporary clamps used to depress the retainers; then depress the

springs until the keys can be lifted out. After grinding valves to the angle specified in Section XV, lap them to refinish seats for line contact only. Install piston rings with part numbers toward the piston head, and install the piston with its part number (on rim of head) toward the propeller. Use a simple ring clamp to compress piston rings. Before reinstalling the cylinder on the installed piston assembly, lubricate both liberally with engine oil or, particularly if they are new parts, with castor oil. Space the piston ring gaps equally around the piston with the oil control (3rd) ring gap on top. Install parts in the reverse of the order in which they were removed. (Refer to paragraph 6-31 in regard to pushrod housings.)

MAINTENANCE AND OVERHAUL MANUAL

TABLE VIII. TROUBLE SHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
Engine will not start	Fuel tank empty	Fill with 80 octane gasoline.
	Mixture control in "IDLE CUTOFF" position	Move to full "RICH" position.
	Fuel supply line plugged	Disconnect at carburetor. Check flow. Clean out. Check strainer.
	Fuel line shutoff valve closed	Open valve.
	Carburetor screen plugged	Clean thoroughly. Remove moisture.
	Carburetor flooded	Disassemble and clean. Check float needle and seat.
	Cylinders overprimed	Place mixture control in "IDLE CUT-OFF" position. Switch ignition off. Open throttle wide. Turn propeller several revolutions.
	Insufficient priming (puffs of white smoke and weak combustion)	Prime more. In cold weather draw plunger slowly back, push hard. Check pump output at priming jet.
	Switch wires disconnected from both magnetos	Install terminals.
	Magnetos improperly timed to engine	Refer to timing instructions in Section XII.
	Magneto internal timing incorrect or timed for opposite rotation. Latch studs improperly set. Weak condenser. Breakers improperly adjusted	Refer to Scintilla "User Operating Instructions" or "Service Instructions for Model S6RN-25", depending on operation performed on magnetos.
	Spark plugs fouled	Remove and clean; check gaps and insulators. Use new gaskets. Check cables to persistently fouled plugs.
	Weak spark, magneto coils burned out by overheating, moisture in distributors	Remove and ground upper spark plugs. With mixture control at "IDLE CUT-OFF", throttle open, switch at "BOTH", turn propeller forward slowly. Listen for clicks of impulse couplings and observe sparks at plug gaps. If weak, inspect distributors. If dry, test cables. If good, overhaul magnetos.
	Spark plugs loose	Tighten to specified torque.

TABLE VIII. TROUBLE SHOOTING CHART (Cont.)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine will not start (Cont.)	Leak in intake manifold	Check and correct hose connector positions. Tighten the flange attaching bolts.
	No fuel in carburetor	Refer to paragraph 6-7.
	Insufficient fuel pressure	Check fuel strainer and fuel pump adjustment.
	Excessive starter slippage	Replace starter adapter
Engine will not run at idling speed	Idle stop screw or idle mixture lever Incorrectly adjusted	Refer to paragraph 6-5 or 6-9.
	Carburetor idling jet plugged	Clean carburetor and fuel strainer.
	Propeller control set in high pitch position	Use low pitch position for all ground operation
	Air leak in intake manifold	Tighten loose connection or replace damaged part.
	Spark plugs fouled by oil escaping past piston rings.	Top overhaul.
Rough idling	Idling mixture lever improperly adjusted	Refer to paragraph 6-5 or 6-9.
	Manual mixture control set for lean mixture	Use full rich mixture for all ground operation.
	Fouled spark plugs	Remove and clean. Adjust gaps. Test cables. Inspect magneto breakers. If persistent, perform top overhaul.
	Priming pump leaking	Repair or replace.
	Small air leak into induction system	With mixture control at "IDLE CUT-OFF", ignition switch at "OFF" and throttle open, brush soap lather around tube joints and carburetor mount flange, one at a time, and turn propeller backward to check for bubbles at points of leakage. Tighten connection or replace damaged gasket or seal.
	Burned or warped exhaust valves, worn seats, scored valve guides	Top overhaul.
	Hydraulic tappet fouled	Listen for loud tappet noise. Refer to paragraph 6-22 and 6-25.
	Leaking poppet valve	Flush regulator poppet valve per paragraph 6-7.
	Leaking accelerating pump diaphragm	Remove the pump cover and inspect.
	Leaking discharge nozzle	Overhaul carburetor.
	Leakage through engine fuel pump vent line	Disconnect pump vent line and check for leaks.

TABLE VIII. TROUBLE SHOOTING CHART (Cont.)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine runs too lean at cruising power	Air leaks into suction side of air diaphragm	Overhaul carburetor.
	Fuel pressure too low	Check fuel strainer and fuel system.
	Foreign material in main metering	Check by removing jet plug in regulator cover.
	No. 70 restriction missing from vapor vent connection in carburetor	Disconnect vapor vent line and check
	plugs missing or loose	Check all 1/8 in. and taper seat plugs for tightness.
Engine runs to rich at cruising power	Manual mixture control in wrong position	Check control linkage.
	Restriction in air scoop	
	Carburetor airheat valve open	
Engine runs too lean or too rich at take-off or rated power, but satisfactorily at cruising power	Improper fuel pressure	Check gauge and clean strainer if pressure will not rise when boost pump is used.
	Incorrect jet installed	Check by removing jet plug in regulator cover.
	Power enrichment and idle needle not opening properly	Remove housing and check
Engine does not accelerate properly	Cold engine	Warm up longer.
	Mixture control set for lean mixture	Set control at full "RICH" position.
	Propeller control set for high pitch	Set for low pitch, high R.P.M. for all ground operation.
	Restrictions in carburetor air intake	Clean air filter.
	Restrictions in carburetor jets, low float level, plugged fuel screen	Clean and repair carburetor.
Engine does not accelerate properly, but runs satisfactorily with slow throttle movements	Idle setting too lean	Adjust, refer to paragraph 6-5 or 6-9.
	Suction hole to air side of accelerating pump diaphragm closed	Remove pump cover and check to see that the channels are properly aligned and open.
	Pump spring broken or weak	Remove pump cover and inspect.
	Punctured pump diaphragm	Remove pump cover and inspect.
Engine does not shut off with manual mixture control in "IDLE CUTOFF" position	Mechanism does not permit poppet valve to close completely	Overhaul carburetor.
	Fuel leakage through primer	
	Leakage at fuel pump seal	
	Linkage does not permit idle cutoff lever to reach "OFF" position	

TABLE VIII. TROUBLE SHOOTING CHART (Cont.)

TROUBLE	PROBABLE CAUSE	REMEDY
High cylinder head temperature (Cont.)	Dirt between cylinder fins	Clean thoroughly.
	Exhaust valves leaking	Top overhaul.
High oil temperature	Cooler fins plugged with dirt	Clean thoroughly.
	Cooler core plugged	Remove cooler and flush thoroughly
	Vernatherm control valve damaged or held open by solid matter	Remove. Clean valve and seat. If still inoperative, replace.
	Low oil supply	Replenish.
	Oil viscosity too high	Refer to Table VII for recommended seasonal grades.
	Prolonged high speed operation on ground	Hole ground running above 1500 R.P.M. to a minimum.
Low oil pressure	Low oil supply	Replenish.
	Oil viscosity too low	Drain and refill with correct seasonal grade. Refer to Table VII.
	Sludge or foreign material in relief valve.	Remove and clean valve parts.
	Foam in oil due to emulsification of alkaline solids	Drain and refill with fresh oil.
	Scored pressure pump	Replace pump.
	Defective pressure gauge	Test gauge. Clean gauge tube (or test connecting wire and engine unit of electric gauge).
	Internal leak, burned bearing or damaged gasket	
	Worn bearings	Major overhaul.
Oil leak at front of engine	Damaged crankshaft oil seal	Replace.
Oil leak at pushrod housing	Damaged pushrod housing packing	Replace.
Low compression	Cylinder wall worn out-of-round and choke reduced.	Replace cylinder and piston rings.
	Intake valve guides worn	Top overhaul
	Valve faces and seats worn	Top overhaul
	Piston rings excessively worn	Top overhaul
	Cylinder barrel worn out-of-round	Replace cylinder and piston rings.
	Valves sticking to guide	Refer to paragraph 6-29.

SECTION VII
DISASSEMBLY

7-1. DISASSEMBLY STAND.

7-2. A stand with a pivoted engine bed of sufficient length to permit working space at each end of the engine may be adapted by making brackets for attachment of the engine mount brackets to the bed rails. Hardwood cone plugs or engine shipping mounts, part No. 535617, may be installed between the mounting bolts and the engine mount brackets. A pipe should be provided to fit over one of the cylinder attaching studs and support the crankcase in the position illustrated in figure 24 while it is being dismantled. Refer to the applicable installation drawing for all dimensions affecting mounting provisions, clearances required, and the center of gravity location.

7-3. PARTS TO BE DISCARDED.

7-4. Discard all palnuts, shakeproof lock washers, lock wires, tab washers, rubber seal rings, oil seals, gaskets, cotter pins, hose connectors and magneto coupling (rubber) bushings in such a manner that they will not be used again inadvertently. The rubber bushings for the downdraft carburetor support bracket should be replaced at every overhaul of the engine.

7-5. PRELIMINARY CLEANING.

7-6. Spray or apply with a clean paint brush a solvent used for general cleaning of engine parts. Remove caked dirt on bolt heads and nuts especially. At the same time the oil sump drain plugs should be removed to drain any remaining oil. If the disassembly stand has no drip pan the valve rocker covers should be removed and oil allowed to drain from the rocker boxes away from the disassembly area.

7-7. AIRCRAFT PARTS AND OPTIONAL ACCESSORIES.

7-8. Instructions in this section are based on the assumption that all parts attached by the aircraft manufacturer, excepting intercylinder baffles and optional pumps, have been removed from the engine.

7-9. DISMANTLING.

7-10. IGNITION SYSTEM.

a. Disconnect cables from spark plugs.

b. Detach clip from cable bracket on top of crankcase.

c. Detach high tension cable outlet plates from the magnetos, and withdraw them to free the cable assemblies.

d. Remove two attaching nuts, washers and clamps from each magneto, and withdraw the magnetos forward from the crankcase.

e. Unscrew all spark plugs.

7-11. PRIMING SYSTEM. Remove connecting lines from distributor manifold to cylinders. Remove distributor manifold from crankcase top parting flange. Remove priming jets from cylinder assemblies.

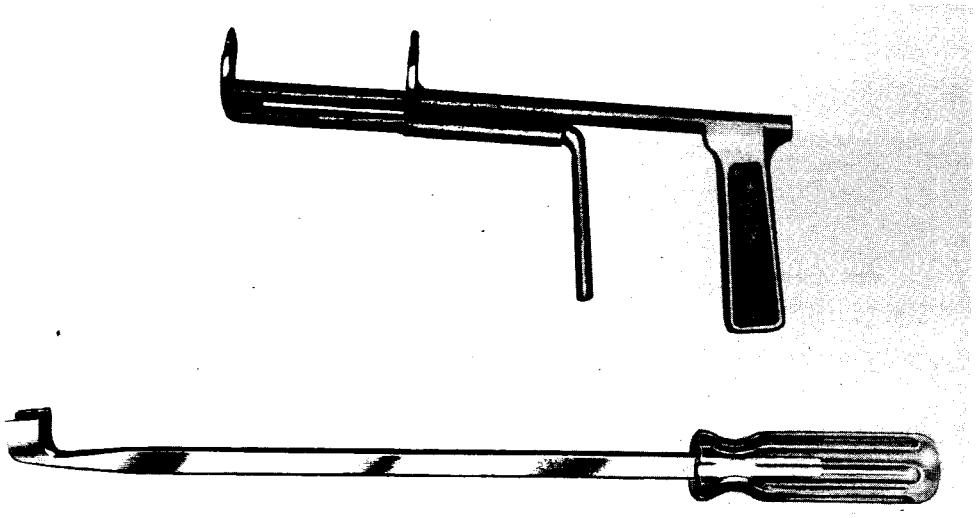


Figure 22. Pushrod Housing Removal and Replacement Tools

7-12. GENERATOR.

a. Before loosening the vee belt, loosen the sheave retaining hex nut on both generator and starter adapter.

b. Cut the lock wire and loosen the three generator retaining bolts. Push the generator inward. Remove the vee belt and the upper retaining bolt.

c. Remove the two pivot bolts and pull generator free.

7-13. MAGNETO AND ACCESSORY DRIVES.

a. Detach the adapters from the crankcase studs.

b. If the gaskets hold the adapter, tap the gears with a hammer handle to break them loose. Withdraw the assemblies rearward.

c. Pull the gear from each adapter, and remove the rubber coupling bushings and steel retainer from each gear. Do not remove the gear plugs.

d. If covers are installed on the adapters detach and and remove them.

7-14. OIL COOLER.

a. Unscrew two long bolts to detach clamps from the front intercylinder baffles, and remove the left side clamp.

b. Remove one screw to detach the right clamp from the baffle between No. 5 cylinder and the cooler, and remove the clamp. Allow the baffle to drop clear of the cooler mount flange.

c. For O-470-K engines, remove the five nuts and washers, then withdraw the oil cooler from the crankcase studs.

d. For O-470-L engines, remove the five hex head screws, three plain hex nuts, lock washers and plain washers.

e. For O-470-M engines, remove the 12 hex-head screws and washers to remove the oil cooler from the adapter.

f. Remove the nuts and washers, then withdraw the adapter from the crankcase studs.

g. Take off the cooler-to-cylinder baffle and the cooler gasket.

7-15. DOWNDRAFT CARBURETOR AND MANIFOLD RISER.

7-16. For O-470-M engines, disassembly procedures are as follows:

a. Loosen the manifold riser to intake elbow hose clamps and slide the connecting hoses back on the elbows until they clear the joints.

b. Loosen the intake elbow to intake tube hose clamps and remove the elbows.

c. Detach and remove the manifold casting from the carburetor and lower supports.

d. Remove the manifold lower supports from the engine.

e. Hold the carburetor with one hand while removing the two fillister-head screws that secure it to the carburetor upper support assembly.

f. Detach and remove the carburetor upper support assembly from the idler gear shaft studs.

7-17. UPDRAFT CARBURETORS AND MANIFOLD RISERS.

7-18. For O-470-K and O-470-L engines, disassembly procedures are as follows:

a. Detach and remove carburetor from manifold riser.

b. Loosen the manifold riser to intake elbow hose clamps and slide the connecting hoses clear of the joints.

c. Loosen the intake elbow to intake tube hose clamps and remove the elbows.

d. Detach and remove the manifold casting from its support brackets.

7-19. STARTER AND DRIVE ADAPTER ASSEMBLY. (See figure 26.)

a. Remove the starter and gasket.

b. Remove attaching bolts, nuts and washers, excepting the cover attaching bolts (19, figure 26). Pull the adapter assembly off to the rear, and remove the gasket.

7-20. OIL PUMP ASSEMBLY. (See figure 25.)

a. Loosen the oil filter cap (5) to facilitate removal later. Loosen the tachometer drive housing (10) on O-470-K and O-470-L engines by turning the hex on the right.

b. Remove the attaching nuts and washers (1, 2, 3) from the ten crankcase-to-pump studs, but not those numbered 7, 8, 9 on the two cover attaching studs.

c. Pull the pump assembly straight to the rear and remove the gasket.

7-21. OIL FILLER NECK.

7-22. Cut the lock wire and take out the three fillister-head screws in the filler neck flange, and remove the filler neck and gasket.

7-23. FUEL PUMP. For O-470-M engines remove the four sets of attaching parts, the fuel pump, its gaskets, spacer, adapter and drive gear.

7-24. VALVE ROCKER COVERS AND OIL GAUGE.

7-25. Pull the oil level gauge from its support behind No. 2 cylinder. If the rocker covers were not removed earlier, detach them by removing seven fillister-head screws from each, and tap with a hammer handle to loosen.

7-26. INTAKE AND BALANCE TUBES.

a. Invert the pivoted engine bed, and lock it in position.

b. Loosen the hose clamps on all the manifold connecting hoses.

c. For O-470-M engines, detach and remove the clamps from the balance tube brackets. For O-470-K and O-470-L engines, remove the two balance tube bracket to oil sump retaining bolts.

d. Remove the balance tube and its connecting hoses.

e. Detach and remove the intake tubes, each set of three at a time, and separate the parts.

f. Detach and remove the manifold support brackets from the oil sump flange.

7-27. OIL SUMP AND OIL SUCTION TUBE.

a. On model O-470-M, detach and remove the balance tube support brackets.

b. Remove the remaining bolts, lift off the sump and remove the gasket.

c. Remove the bolts securing the suction tube assembly to the crankcase and lift off the assembly.

7-28. VALVE MECHANISM.

a. Turn the crankshaft until the tappets of any cyl-

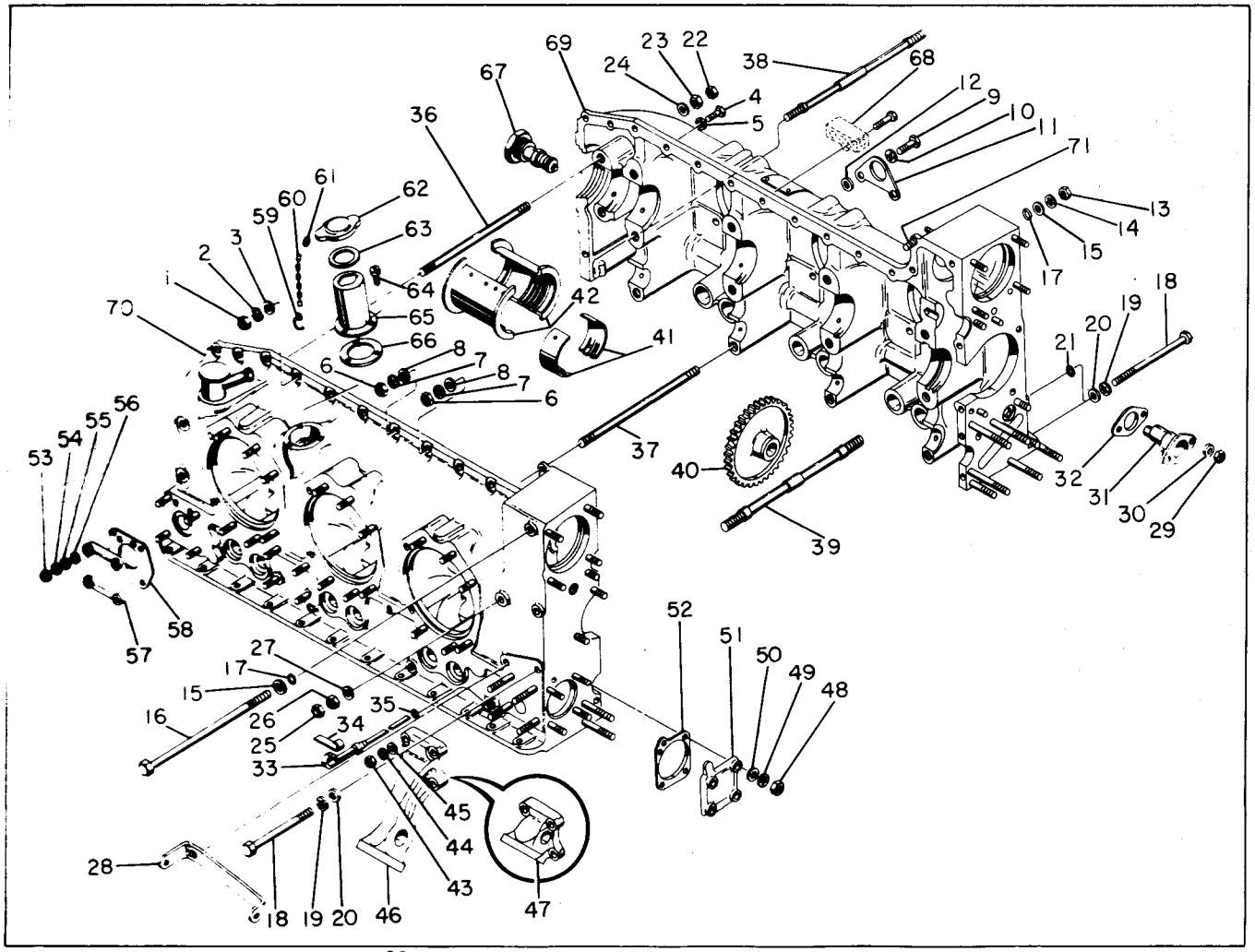


Figure 23. Exploded View of Crankcase Assembly

Legend for Figure 23.

1. Plain hex nut (11)
2. Lock washer (11)
3. Plain washer (11)
4. Hex-head bolt (10)
5. Plain washer (10)
6. Plain hex nut (2)
7. Lock washer (2)
8. Plain washer (2)
9. Hex-head bolt (2)
10. Lock washer (2)
11. Lifting eye
12. Spacer (2)
13. Plain hex nut (3/8-24) (1)
14. Lock washer (1)
15. Plain washer (1/8 in. thick)(2)
16. Hex-head bolt (9-13/16 in. long)(1)
17. O-ring packing (2)
18. Hex-head bolt (5-1/4 in. long) (5)
19. Lock washer (5)
20. Plain washer (5)
21. O-ring packing (1)
22. Palnut (7/16-20) (12)
23. Flanged nut (7/16-20) (12)
24. Plain washer (12)
25. Palnut (1/2-20) (16)
26. Flanged nut (1/2-20) (16)
27. Plain washer (16)
28. Generator mount bracket
29. Plain hex nut (1/4-28) (2)
30. Lock washer (2)
31. Idler gear support pin
32. Gasket
33. Oil gauge rod
34. Identification band
35. O-ring packing
36. Through bolt (8-7/8 x 7/16-20) (2)
37. Through bolt (10-1/2 x 7/16-20) (4)
38. Through bolt (9-13/16 x 1/2-20) (1)
39. Through bolt (10-3/4 x 1/2-20) (7)
40. Idler gear assembly
41. Crankshaft main bearing (6)
42. Crankshaft thrust bearing (2)
43. Plain hex nut (16)
44. Lock washer (16)
45. Plain washer (16)
46. Mount bracket (O-470-K and O-470-L) (4)
47. Mount bracket (O-470-M) (4)
48. Plain hex nut (4)
49. Lock washer (4)
50. Plain washer (4)
51. Fuel pump pad cover
52. Fuel pump pad gasket
53. Plain hex nut (4)
54. Lock washer (4)
55. Plain washer (4)
56. Spacer (4)
57. Governor pad cover
58. Governor pad gasket
59. Oil cap retainer ring
60. Oil cap retainer chain
61. Retainer ring
62. Oil filler cap
63. Oil filler cap gasket
64. Screw (3)
65. Oil filler neck
66. Oil filler neck gasket
67. Vernatherm valve
68. Primer distributor
69. Right crankcase
70. Left crankcase
71. Bolt

inder are on the heels of the cam lobes.

b. Remove the rocker shaft retaining bolts.

c. While holding the lower ends of both rockers inward, push the rocker shaft out to free both rockers and remove them. Withdraw both pushrods. Repeat the process on the other cylinders.

d. To remove each pushrod housing push it toward the crankcase against its spring until the outer end is clear of the cylinder hole; then lift the cylinder end and withdraw the housing and spring. Remove the two steel washers and red Silastic seal from the crankcase counterbore.

NOTE

Local manufacture of the pushrod housing tools, illustrated in figure 22, will facilitate removal and installation of pushrod housings.

e. After all pushrod housings have been removed, lift out all intercylinder baffles; then push out and remove all valve tappets.

7-29. CYLINDERS AND PISTONS.

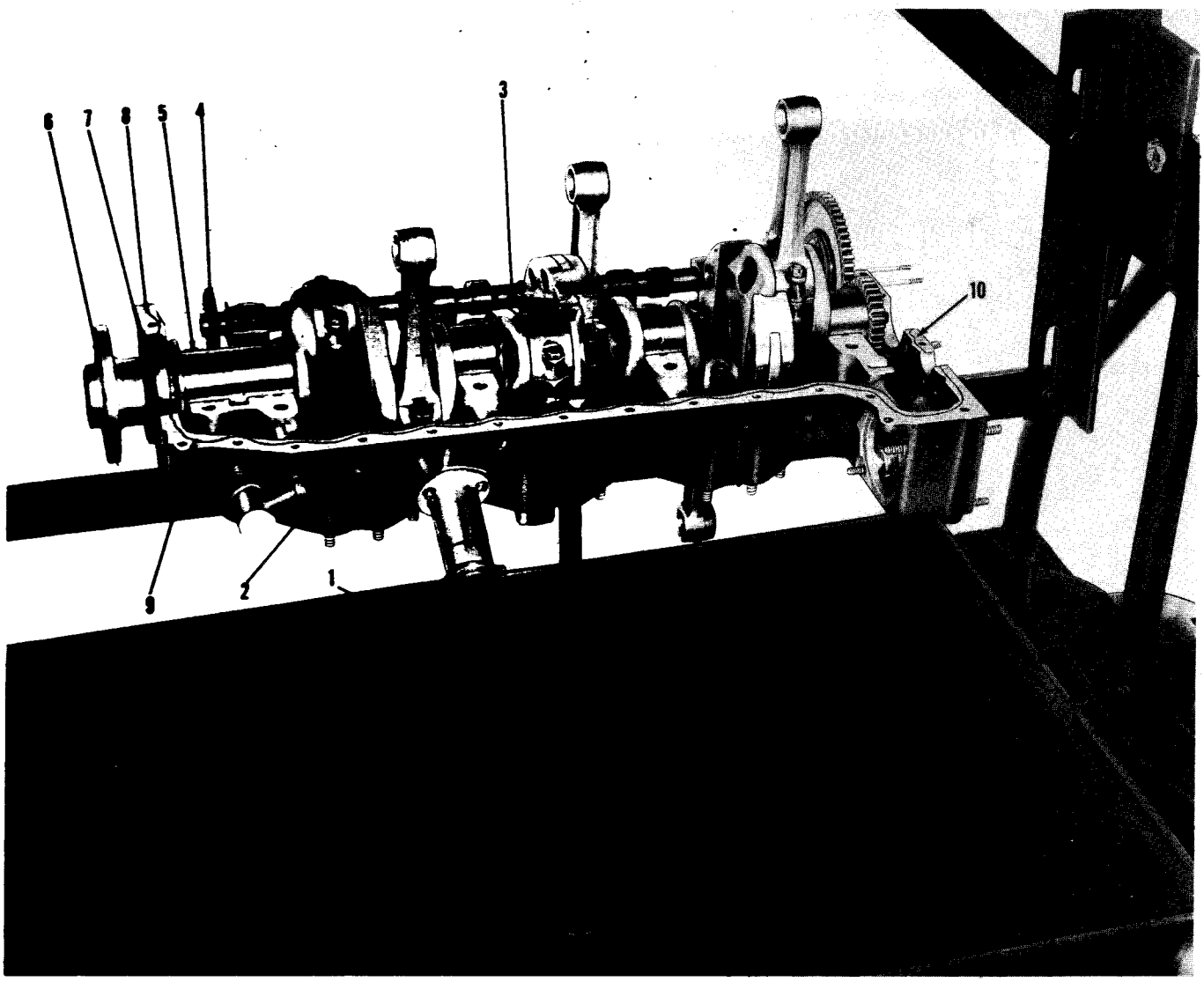
a. While the engine remains in the inverted position, remove the palnuts and base nuts from the attaching studs and the through bolt on the sump side of the cylinder base flange.

b. Turn the engine to the upright position.

c. Turn the crankshaft until any piston is at T.D.C. Remove the palnuts and base nuts from three top attaching studs and through bolt at that cylinder. Cradle the cylinder in either arm, and withdraw it straight outward. Catch the piston with the other hand as the cylinder skirt comes off, and lower it carefully.

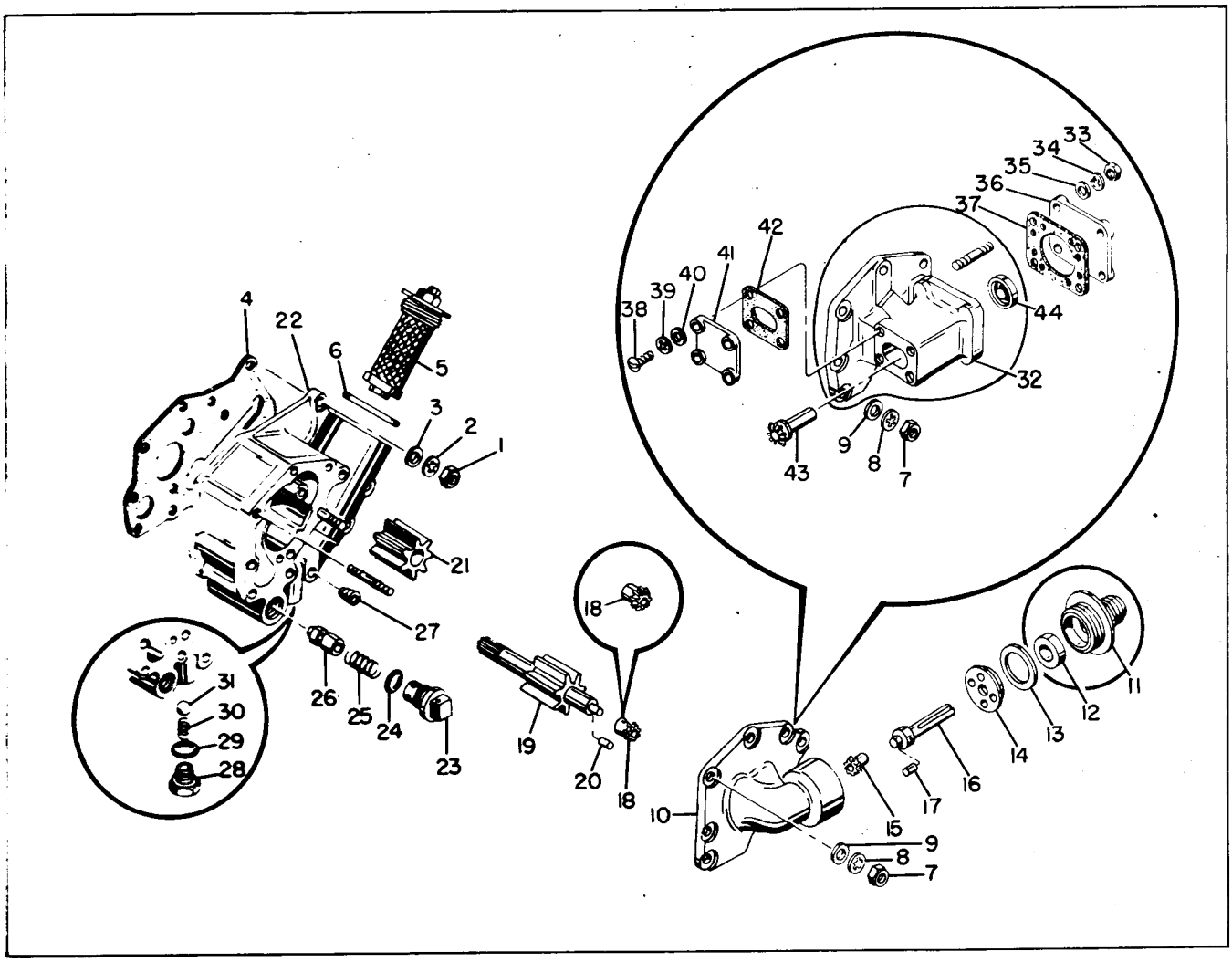
d. After removing each cylinder, free its piston assembly by pushing the pin endwise, clear of the rod, and remove the piston.

e. Repeat steps "c" and "d" to remove each of the



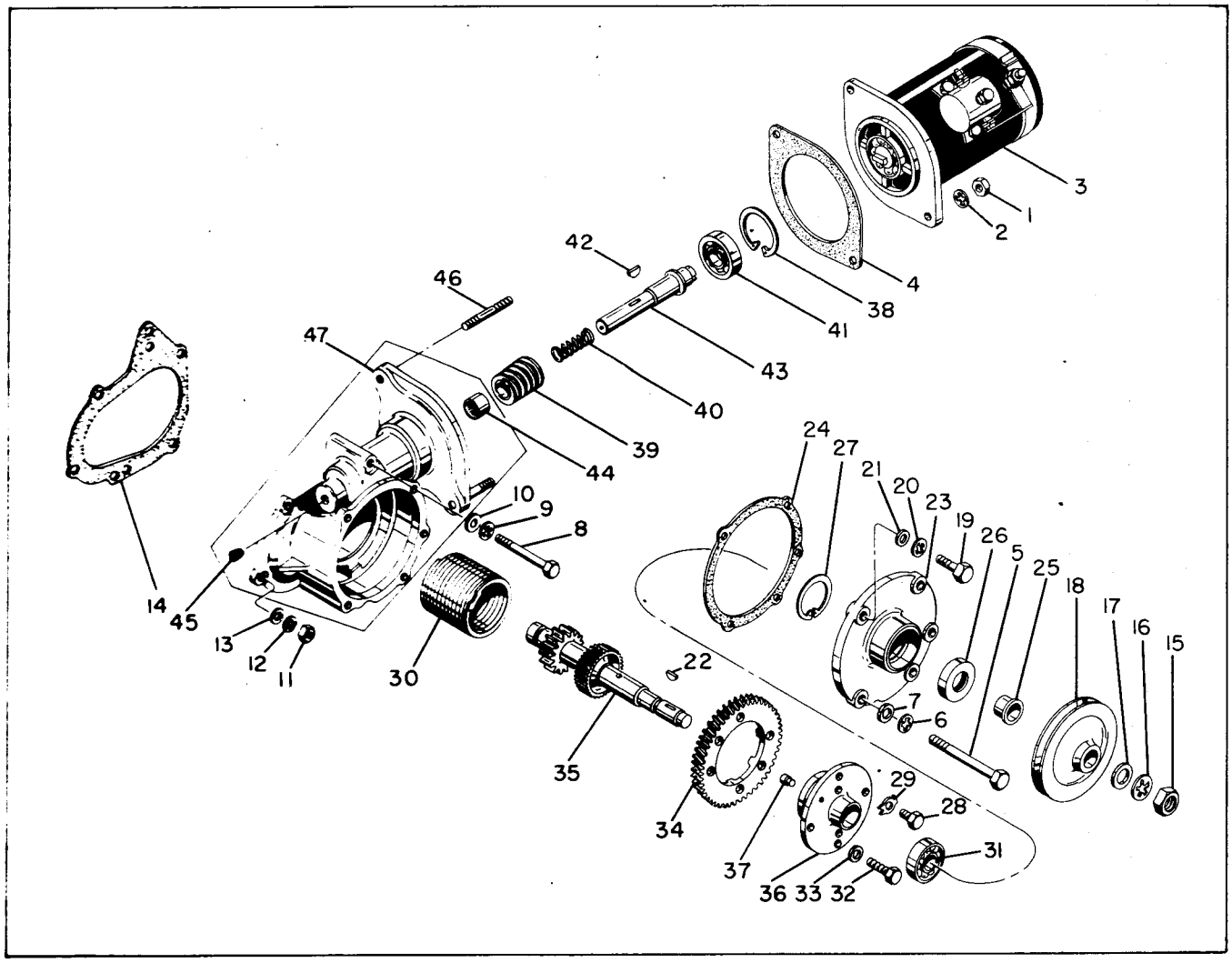
1. 1/2 inch iron pipe of suitable length
2. Left crankcase with parting flange horizontal
3. Camshaft assembly
4. Governor driver bevel gear
5. Governor driven bevel gear and shaft assembly
6. Crankshaft, connecting rods and gear assembly
7. Crankshaft oil seal assembly
8. No. 50 silk thread on front parting flange below crankshaft
9. No. 50 silk thread on upper parting flange
10. No. 50 silk thread on rear parting flange between crankshaft and idler gear support pin holes

Figure 24. Left Crankcase and Shafts Supported for Dismantling or Final Assembly



1. Plain hex nut
2. Lock washer
3. Plain washer
4. Oil pump to crankcase gasket
5. Oil filter
6. Oil filter gasket
7. Plain hex nut
8. Lock washer
9. Plain washer
10. Oil pump cover and mechanical tachometer drive housing
11. Mechanical tachometer drive housing
12. Seal
13. Gasket
14. Thrust washer
15. Tachometer driven gear
16. Tachometer drive shaft
17. Dowel pin
18. Tachometer driving gear
19. Oil pump driver gear
20. Dowel pin
21. Oil pump driven gear
22. Oil pump housing assembly
23. Pressure relief valve cap
24. Gasket
25. Pressure relief valve spring
26. Pressure relief valve plunger
27. Plug
28. Bypass valve cap
29. Gasket
30. Bypass valve spring
31. Bypass valve check ball
32. Oil pump cover and tachometer generator drive housing
33. Plain hex nut
34. Lock washer
35. Plain washer
36. Drive housing pad cover
37. Gasket
38. Screw
39. Lock washer
40. Plain washer
41. Tachometer gear case cover
42. Gasket
43. Tachometer drive gear shaft
44. Seal

Figure 25. Exploded View of Oil Pump Assembly



1. Plain nut (2)
2. Lock washer (2)
3. Starter
4. Gasket
5. Bolt, cover and adapter attaching (3)
6. Lock washer (3)
7. Plain washer (3)
8. Bolt, adapter attaching (1)
9. Lock washer (1)
10. Plain washer (1)
11. Plain nut (2)
12. Lock washer (2)
13. Plain washer (2)
14. Gasket
15. Plain nut (1)
16. Lock washer (1)
17. Plain washer (1)
18. Generator drive sheave
19. Bolt, cover
20. Lock washer
21. Plain washer
22. Woodruff key
23. Cover
24. Gasket
25. Sleeve
26. Oil seal
27. Retaining ring
28. Bolt, spring retaining (1)
29. Tab washer
30. Clutch spring
31. Bearing
32. Bolt (4)
33. Lock washer
34. Starter worm wheel
35. Starter shaft gear
36. Starter clutch drum
37. Stepped dowel
38. Retaining ring
39. Starter worm gear
40. Spring
41. Bearing
42. Woodruff key
43. Worm drive shaft
44. Bearing
45. Plug (1)
46. Stud (2)
47. Adapter

Figure 26. Exploded view of Starter Drive

remaining cylinders. There is no fixed order of removal, but it will be found best to work from left to right or from right to left on each side, as preferred, alternating sides to prevent excessive unbalance.

7-30. CRANKCASE. (See figures 23 and 24.)

a. Turn the engine bed so that the left crankcase will be downward and support it with a 1/2 inch pipe, as illustrated in figure 24.

b. Detach the right engine mount brackets from the assembly stand.

c. Remove the attaching parts and attached parts (1 through 27, figure 23) in the ascending order of index numbers.

d. With a nonmarring hammer, tap the upper ends of the right through bolts 36, 37, 38, 39, figure 23) and pull them downward and out.

e. Detach the idler gear support pin (31, figure 23) and hold the idler gear (40, figure 23) while the pin is withdrawn; then lower it to rest in the left crankcase. Remove the gasket.

f. Lift off the right crankcase subassembly.

g. Lift out the camshaft assembly, and remove the governor driver bevel gear. Lift out the governor driven gear, the idler gear assembly, then the assembly of crankshaft, connecting rods, gears and oil seal.

h. Detach the left engine mount brackets from the assembly stand, and lift off the left crankcase subassembly.

NOTE

Do not remove the upper flange attaching bolt and washer (71, figure 23). These two parts are installed before the nearest magneto attaching stud and cannot be removed before removal of that stud without damaging the crankcase hole. Take care to avoid damage to the bolt thread during subsequent overhaul operations.

7-31. DISASSEMBLY OF MAJOR SUBASSEMBLIES.

7-32. CRANKCASE. (See figure 23.)

a. Detach and remove from the left crankcase the parts numbered 48 through 58 with the exception of the three 3/8 in. pipe plugs.

b. Rotate and lift out of the right crankcase the main and thrust bearing inserts (41, 42) installed there. Discard all main and thrust bearing inserts from both crankcase subassemblies.

c. Unscrew the Vernatherm valve (67) and the straight thread plugs from the right crankcase. The four 3/8 in. socket-head pipe plugs need not be removed from the right crankcase.

d. Removal of engine mount brackets and attaching parts (46 or 47) from either crankcase casting is optional and dependent on the nature of repair operations to be performed.

7-33. CYLINDERS.

a. Remove the rubber seal rings from all cylinder skirts.

b. Use of a cylindrical wood block anchored to a workbench, with provisions for clamping the cylinder in place, is recommended to aid in the removal of the valve springs and to prevent dropping of the valves.

c. If the rocker shaft was removed, push it back into the cylinder head supports, and use it as a fulcrum for a lever-type spring compressor unless an arbor-type valve spring compressing stand is available.

d. Compress the valve springs with force applied at diametrically opposite points on the outer spring retainers, in turn, taking care not to allow the retainers to score the valve stems due to cocking. While each pair of springs is depressed, remove the two stem-locking keys from the retainer hole; then release pressure and lift out the outer retainer, springs, and inner retainer.

e. Hold the valve stems while lifting the cylinder from its support; then lay it on its side, and stone any nicks on the upper valve stems to prevent scoring the guides before removing the two valves.

7-34. CRANKSHAFT.

a. Crankshaft supports can be made by sawing a vee notch in the short side of each of two 2 x 4 x 10 in. wood blocks. Stand these edgewise on the bench, and lay the front and rear shaft journals in the notches.

b. Detach and remove the connecting rods. Rotate and remove their crankpin bearing inserts. Discard all inserts. Loosely reassemble the rods, cap bolts and nuts with position numbers matched.

c. With Truarc No. 1 or No. 21 pliers, compress the internal retaining rings; then remove the retaining plates and pins from the counterweights, and take the counterweights from the shaft.

d. Remove lock wires and six gear attaching screws and remove the crankshaft gear.

e. Lift the spring from the oil seal and unhook its ends. Twist and remove the rubber seal ring from the shaft.

7-35. CAMSHAFT. Cut and remove the two lock wires,

and take off the gear if it is to be inspected by the Magnaflux process. For this purpose also remove the governor driving gear Woodruff key.

7-36. OIL PUMP ASSEMBLY. (See figure 25). The attaching parts and gasket (1 through 4) were removed earlier. Remove the other parts in the order of index numbers, excepting the shaft pins (17, 20).

CAUTION

The tachometer drive housing coupling on O-470-K and O-470-L engines has a left-hand thread. Unscrew it by turning to the right. The arrow on the edge of the flange indicates the tightening direction.

7-37. STARTER ADAPTER ASSEMBLY. (See figure 26.)

a. Index numbers 1 through 14 indicate parts removed earlier. Start the disassembly with the nut (15).

b. Clamp the spur gear lightly in lead-shielded vise jaws while the nut is loosened.

c. Proceed in the order of index numbers, with the spur gear still clamped in the vise until the key (22) has been tapped out, the cover attaching parts (19 through 21) removed, and the cover assembly pulled from the gear shaft, carrying with it the sleeve (25).

d. Remove the retaining ring (27) with Truarc No. 3 or No. 23 pliers.

e. Use an arbor press and a round metal block of slightly smaller diameter than the hole to press out the oil seal (26).

f. To remove the shaftgear and clutch assembly from the adapter, support the rear side of the latter on blocks and tap the front end of the clutch spring (30) with a brass drift or (very carefully) with a pin punch all around.

g. Use a wheel puller or an arbor press to press the shaftgear (35) from the drum (36) and bearing (31) after removing the worm wheel.

h. To remove the clutch spring, clamp the drum flange between lead-shielded vise jaws. Remove the retaining screw (28) and washer (29). Rotate the spring until its depressed rear end lies across the upper 1/4 inch hole in the flange. Insert a 3/16 inch wide screwdriver blade, and pry the spring end outward clear of the drum groove. Hold it out while pulling the spring away.

i. To remove the worm and shaft assembly, unscrew the pipe plug (45), and clamp the adapter between shielded vise jaws. Use Truarc No. 5 or No. 25 pliers to remove the retaining ring (38). Insert a pin punch through the plug hole at a slight angle to the shaft (43) and tap on the chamfer around the shaft hole until the bearing is free.

j. The worm gear may fit slightly tight on the sides of the key. Remove the Woodruff key (42) and the helical spring (40). If the ball bearing (41) is to be removed only to permit Magnaflux inspection of the shaft, support its inner race on a sleeve with an inside diameter just large enough to clear the shaft flange, and press the shaft out. (Supporting on the outer race will damage the bearing).

SECTION VIII
CLEANING PARTS

8-1. MATERIALS AND PROCESSES.

8-2. Equipment, processes and materials in general use in aircraft engine overhaul shops will be entirely satisfactory for cleaning O-470 engine parts. All light metal parts of these engines are aluminum alloys.

8-3. Do not use any strong alkaline solution to clean aluminum alloy castings or wrought aluminum alloy parts, because all such solutions attack the bare surfaces too rapidly to permit cleaning without destruction of the finish. For these parts use a fortified mineral spirit solvent, sold under various trade names, for degreasing. If rosin (oil varnish) or stubborn carbon deposits must be removed from aluminum alloy parts, they may be immersed in an agitated bath of an inhibited mild alkaline cleaning solution marketed for that purpose. The bath should be maintained at a temperature of 180°F. to 200°F., and the parts should remain in it only long enough to loosen the deposits. Immediately after such cleaning, flush away all traces of the alkaline material with a jet of wet steam or by repeated brush application of a mineral spirit solvent.

CAUTION

Any alkaline deposits remaining on engine interior parts will react with acids formed in the lubricating oil to form soap, which will cause violent foam and may result in failure of the lubricating system.

8-4. Trichlorethylene condensation plants provide excellent degreasing action for steel, aluminum and bronze parts. Their disadvantages lie in the toxic quality of the vapors, removal of enamel from painted parts, and the drying and hardening effect on carbon deposits.

8-5. No polishing compound or abrasive paste or powder should be needed or employed for cleaning engine parts. Do not use wire brushes or wire brush wheels, putty knives, or scrapers to remove hard carbon deposits, since scratches resulting from such methods allow a concentration of stress at the scratch and may cause fatigue failure.

8-6. Various hot and cold working solutions have been marketed for loosening carbon. Any of these may be employed for that purpose if they do not attack the metal; however, most such materials are ineffective against hard carbon deposits, since they loosen by dissolving adhesive rosins which cannot be dissolved after they have been carbonized by heat.

8-7. Various blasting techniques can be employed to remove hard carbon deposits if suitable equipment is available. The most suitable types of grit for dry blasting are plastic pellets and processed natural materials, such as wheat grains and crushed fruit pits or shells. Air pressure should be the lowest that will produce the desired cleaning action. Small holes and finished surfaces which do not require cleaning should be protected from the blast by seals and covers, particularly if the grit is sharp. Sand and metal grit and shot used for blasting industrial metals are too abrasive and too heavy for use on soft metals such as aluminum. The vapor grit process employs abrasive grit, but of much smaller size and carefully controlled grades for various purposes. Carbon may be removed from piston heads by the vapor grit blasting process, using No. 80 grit, which is also suitable for cylinder head interiors, but much too coarse for finished piston walls and ring grooves. No 50 vapor blast grit may be used on cylinder heads for more rapid cleaning. In any event, the cylinder walls and valve guides must be shielded. After any blasting process, blow off all dust with dehumidified compressed air and make sure that no grains have lodged in crevices.

8-8. SPECIFIC PARTS.

8-9. VALVES. Hard carbon may be scraped from valve heads with a smooth edge scraper, preferably while the valve is rotated in a high speed polishing head or lathe. After removal of carbon, polish the stems first with crocus cloth moistened in kerosene, then with dry crocus cloth.

8-10. CYLINDERS. Remove oil and loose material with a solvent by spraying or brushing. Remove carbon from the combustion chambers by soft grit or vapor grit blasting if equipment is available. Mechanically driven wire brushes are not recommended for this purpose, due to the difficulty of avoiding abrasion of the top ends of the barrels.

8-11. PISTONS. Do not use wire brushes or scrapers of any kind. Soft and moderately hard carbon deposits may yield to solvent action, which should be tried first in preference to harsher methods. If deposits remain, blast the heads with soft grit or by the vapor grit method, first having installed tight-fitting skirt protectors. Ring grooves may be cleaned by pulling through them lengths of binder twine or very narrow strips of crocus cloth. Do not use automotive ring groove scrapers, since the corner radii at the bottoms of the grooves must not be altered, nor any metal removed from the sides. Discoloration and light scoring need not be removed from piston skirts. The use of abrasive cloth on the skirts is not recommended, because the diameters and cam-ground contour must not be altered. Heavily scored or burned pistons should be discarded.

8-12. CRANKSHAFT. After degreasing, including thorough cleaning of oil tubes and the front end recess, polish main journals and crankpins, preferably while the shaft is rotated in a lathe at approximately 100 R.P.M. First use crocus cloth moistened in kerosene, then dry crocus cloth.

8-13. CRANKCASE. If possible, the oil passages should be pressure-flushed with the usual mineral spirit solvent and inspected as well as possible with the aid of a flash light. If the castings are immersed in an alkaline bath, it is strongly recommended that such treatment be followed by spraying with a jet of wet steam and this followed by flushing of the oil passages with solvent. After the castings have dried, inspect them thoroughly for alkaline residues, and remove any traces of scum.

8-14. BALL BEARINGS. The grease-sealed starter worm shaft bearing should not be soaked in any solvent. Clean it by wiping with a cloth moistened in solvent, and dry it with dehumidified compressed air or with a dry cloth. Soak the other starter drive ball bearing in solvent or spray with solvent, and dry with compressed air.

CAUTION

Do not spin unlubricated ball bearings or allow an air blast to rotate them. Spinning does not give any indication of the bearing condition and will cause unnecessary wear.

8-15. Immediately after cleaning bare steel parts and ball bearings, spray them with or dip them in clean engine oil or, for longer storage, in a corrosion-preventive oil mixture. Wrap ball bearings in waxed paper. Wrap or cover other clean parts to protect them from abrasive dust in the air.

SECTION IX
INSPECTION

9-1. PROTECTION FROM CORROSION.

9-2. Bare steel parts should be covered with oil or a corrosion-preventive oil mixture except during the actual inspection operations. Since inspection involves handling of dry steel parts it is advisable to apply a fingerprint remover solution after such handling, particularly since perspiration and skin oils often have a high acid content. Application of lubricating oil or corrosion-preventive mixture will not necessarily stop corrosion from this cause.

9-3. VISUAL INSPECTION.

9-4. Parts without critical dimensions and all small parts, as well as running parts and others of major importance, should be inspected visually under good light for surface damage such as nicks, dents, deep scratches, visible cracks, distortion, burned areas, pitting, pick-up of foreign metal and removal of enamel coating. Visual inspection should also determine the need for further cleaning of obscure areas. Inspect all studs for possible bending, looseness or partial removal. Inspect all threaded parts for nicks and other damage to the screw threads. After visual inspection the engine parts should be in three groups: apparently serviceable parts, repairable parts and parts to be discarded.

9-5. MAGNETIC PARTICLE INSPECTION.

9-6. Inspection by the Magnaflux method should be conducted on all ferrous parts listed in Table IX and in accordance with the methods and data in that table before they are inspected dimensionally. The Magnaglow method is recommended whenever the necessary equipment is available. This method employs magnetic particles coated with a fluorescent organic material which may be illuminated with "black light", as in the Zyglo process, to amplify weak indications. If a crankshaft is doubtful after circular magnetization and inspection, demagnetize and remagnetize it longitudinally for further inspection.

NOTE

Before magnetic particle inspection, piston pins and valve rocker shafts must be polished with crocus cloth.

CAUTION

Before magnetic particle inspection of any part, plug small holes leading to obscure cavities with tight-fitting wood plugs or with a hard grease which is soluble in lubricating oil to prevent particles from lodging in places from which they would be difficult to remove and which places are not subject to visual inspection. After magnetic particle inspection, remove all such plugs and clean the part thoroughly in solvent; then dry with compressed air. Check for complete demagnetization. Do not inspect springs by the Magnaflux process.

9-7. FLUORESCENT PARTICLE INSPECTION.

9-8. This process, commonly known under the trade name of "Zyglo", is recommended for inspecting aluminum alloy parts for invisible cracks. The standard operating technique for the process is applicable.

9-9. DIMENSIONAL INSPECTION.

9-10. INSTRUMENTS. Areas of running parts and bushings subject to wear should be inspected for serviceable fit with mating parts by comparative linear measurements and alignment measurements, using standard pattern precision measuring instruments such as micrometer calipers, telescoping gauges and dial indicators. The use of a dial-type cylinder bore gauge is recommended in preference to other tools not specifically designed for this purpose.

9-11. DIMENSIONAL LIMITS. After comparative measurements of mating parts and determination of running clearances, refer to the Table of Limits, Section XV, and to the Limits and Lubrication Chart to locate the reference number of each fit and the acceptable limits assigned to it. Limits under the column heading "New Parts" are manufacturing limits. All running clearances in this column apply to mating parts, both of which are new, and the low limit applies in all instances; however, such clearances are allowed to increase with wear to, but not beyond, the values in the column headed "Serviceable Limit". All press and shrink fits must be maintained as specified in the "New Parts" columns when the inserted member is replaced. Oversize parts are supplied, in some instances, to permit conformity to this requirement.

9-12. ORIGINAL DIMENSIONS. Although comparative measurements of mating parts will determine the serviceability of the fit, it is not always easy to determine which part has worn the most, and in some

TABLE IX. MAGNAFLUX INSPECTION DATA

Part	Method of Magnetization	Amperes	Method of Inspection	Critical Areas	Possible Defects
Crankshaft	Circular	2500	Wet Continuous	Journals, fillets, oil holes, Nos. 1 and 2 crankpins, thrust flanges	Fatigue cracks, heat cracks
Connecting rod	Circular	1800	Wet Continuous	All areas	Fatigue cracks
Camshaft	Circular	1500	Wet Continuous	All areas	Fatigue cracks forging laps
Piston pin	Circular	1500	Wet Residual	Shear planes, ends	Fatigue cracks, stringers
Rocker arms	Circular	1800	Wet Continuous	Rocker face, socket, around squirt nozzle	Fatigue cracks
Camshaft gear	Circular	1800	Wet Continuous	Teeth, splines	Fatigue cracks
Crankshaft gear	Circular	1800	Wet Continuous	Teeth, around screw holes	Fatigue, heat cracks
Starter shaftgear	Circular		Wet Continuous	Teeth, drum	Heat, fatigue cracks
	Longitudinal		Wet Continuous	Shaft between spur gear and drum	Fatigue cracks
Starter worm shaft	Circular		Wet Continuous	Slotted end, around key slot	Fatigue cracks
Starter worm gear	Longitudinal		Wet Residual	Teeth	Fatigue cracks
	Circular			Keyway	Fatigue cracks
Starter clutch drum	Circular		Wet Continuous	Drum surface and groove	Fatigue cracks

instances (e.g., main journals in new bearing inserts), accurate measurements of fit are not possible. While no limits of wear on critical dimensions have been assigned to specific parts in most instances, it is helpful in estimating wear to know the original dimensions. Hence, the following list of manufacturing limits on important dimensions of new parts should be consulted when the serviceability of a specific part is in doubt.

9-13. SPECIFIC INSPECTIONS.

9-14. CRANKCASE. If any cylinder base nut was loose at disassembly or if any of the cylinder attaching studs are bent, even slightly, or if there is definite evidence that a cylinder was loose at any time, then it is possible that reversal of stress has fatigued the studs and through bolts installed on that cylinder pad, in which case all of them should be replace. Test for bent studs with a toolmaker's-square. When inspecting for casting cracks pay particular attention to areas on and adjacent to the cylinder mount pads, tappet guides, bottom flange and bearing bosses. Look for nicks on machined surfaces and scoring in shaft bearings and the shaftgear bushing. The castings must be clamped together at all attaching points before dimensional inspection of camshaft bearings.

Part Name	Feature	New Dimension (Inches)
Cylinder barrel (Std.)	Bore dia. (lower 4-1/4 in.)	5.001 - 5.003
	Bore dia. (top of barrel)	4.989 - 4.993
Cylinder barrel (.015 O.S.)	Bore dia. (lower 4-1/4 in.)	5.016 - 5.018
	Bore dia. (top of barrel)	5.006 - 5.012
Cylinder head	Rocker shaft boss bore	0.7182 - 0.7192
	Intake valve guide bore	0.4352 - 0.4362
	Exhaust valve guide bore	0.4370 - 0.4380

Part Name	Feature	New Dimension (Inches)
Valve rocker shaft	Outside diameter	0.7177 - 0.7182
Valve rocker bushings	Inside diameter	0.7192 - 0.7202
Intake valve	Stem diameter	0.433 - 0.434
	Length	4.804 - 4.824
Exhaust valve	Stem diameter	0.433 - 0.434
	Length	4.806 - 4.826
Piston (Std)	*Diameter below 3rd groove	4.984 - 4.985
	*Diameter at bottom	4.994 - 4.995
	Pin bore diameter	1.1250 - 1.1255
	Top ring groove width	0.1005 - 0.1015
	Second ring groove width	0.0990 - 0.1000
	Third ring groove width	0.1585 - 0.1595
Piston (0.015 O.S.)	*Diameter below 3rd groove	4.999 - 5.000
	*Diameter at bottom	5.009 - 5.010
Piston pin assembly	Outside diameter	1.1243 - 1.1245
	Length (including plugs)	4.945 - 4.965
Connecting rod	Bushing bore diameter	1.1257 - 1.1261
	Bushing center to crankpin center	6.623 - 6.627
Crankshaft assembly	Main journal diameter (4)	2.3740 - 2.3750
	Crankpin diameter (6)	2.2490 - 2.2500
	Damper pin bushing I.D. (4)	0.624 - 0.626
	Damper pin O.D. (4)	0.5554 - 0.5574
Camshaft	Journal diameter (4)	1.248 - 1.249
	Cam lobes across heel and toe (large end)	1.5354 - 1.5578
Hydraulic valve tappets	Outside diameter	0.9990 - 0.9995
Crankcase	Camshaft bearings dia.	1.250 - 1.251
	Tappet guides dia.	1.000 - 1.001
	Starter shaftgear bushing I.D.	0.813 - 0.814
	Governor driven gear bearing dia.	0.875 - 0.876
Starter worm drive shaft	Small end diameter	0.5615 - 0.5625
Starter worm needle bearing	Diameter inside needle rollers	0.5625 - 0.5634
Starter shaftgear	Front journal diameter	0.8105 - 0.8115
	Knurled drum diameter	1.993 - 1.994
	Clutch drum support dia.	0.787 - 0.789
Starter clutch drum	Knurled drum diameter	2.019 - 2.020
	Inside diameter	0.790 - 0.791
Starter clutch spring	Outside diameter	2.374 - 2.376
	Large inside diameter	2.032 - 2.034
	Small inside diameter	2.000 - 2.002
Starter drive adapter	Sleeve front end I.D.	2.341 - 2.343
Oil pump driver gear	Shaft diameter	0.5600 - 0.5605
Oil pump driven gear	Shaft hole diameter	0.5030 - 0.5040
Oil pump housing and shaft assembly	Driven gear shaft diameter	0.5015 - 0.5025
	Driver gear shaft hole diameter	0.5620 - 0.5630
	Gear chamber depth	1.438 - 1.440
Magneto drive gears	Shaft diameter	0.812 - 0.813
Magneto and accessory drive adapter	Bushing inside diameter	0.8145 - 0.8155

Part Name	Feature	New Dimension (Inches)
Idler gear assembly	Bushing inside diameter	0.812 - 0.813
Idler gear support pin	Gear support diameter	0.8095 - 0.8105

* Measures piston diameters at right angles to pin bore.

NOTE

If camshaft bearings are excessively worn, the crankcase may be returned to the factory through any Continental Authorized Distributor to be line bored for a 0.020 inch oversize camshaft.

9-15. CRANKSHAFT. In addition to magnetic particle, visual and dimensional inspection, the shaft should be mounted on matched vee blocks on a surface plate (supporting the front and rear main journals) and rotated under a dial indicator placed to bear on the center main journal in order to detect excessive bending. This is of particular importance if the aircraft has been involved in an accident resulting in a broken or bent propeller. (Refer to the Table of Limits for limits of "run-out" at the center journal.)

9-16. CAMSHAFT. Inspect the journals for scoring, corrosion and overheating, and the lobes for pitting at the toes and evidence of overheating or unusual wear.

9-17. CONNECTING RODS. Use a telescoping gauge and an outside micrometer caliper to measure all worn bushings and locally-replaced bushings. If a bushing was replaced locally it is also necessary to check its alignment with the big end bearing seat. The simplest method of making alignment measurements requires a push fit arbor, preferably at least eight inches long, for the bushing bore and another for the bearing seat, a surface plate, two matched vee blocks and two blocks of ground flat steel stock of equal height. To measure twist, insert the arbors into the rod bores; then lay the big end arbor in the vee blocks on the surface plate, and place the ground steel blocks under the ends of the bushing arbor at a measured distance apart. A feeler gauge may be used to detect any clearance at either end under the bushing arbor. This, divided by the separation of the blocks in inches, will give the twist per inch of length. (Refer to limit in Section XV.) To measure bushing and bearing convergence, mount a dial indicator on a surface gauge, and swing the rod around the big end arbor to the vertical position against a firm stop. Pass the indicator over the bushing arbor at points an exact number of inches apart. The difference in readings at the two ends, divided by the distance between points of measurement, again gives the misalignment per inch, as specified in Section XV.

NOTE

If desired, connecting rods may be returned to the factory through any Continental Authorized Distributor for bushing replacement.

9-18. GEARS. Inspect gear teeth for signs of overheating and excessive wear. Normal wear produces a fine polish on the tooth thrust faces. Alteration of the tooth profiles, score marks and pitting are sufficient cause for rejection.

Figure 27. Inspecting Ring Side Clearance

9-19. PISTONS AND RINGS. Inspect the skirt for long, deep scores which indicate overheating and are sufficient cause for rejection. If a telescoping gauge is used to measure the pin bore, do not allow the spring pin to expand rapidly so as to strike the wall hard. Inspect visually for thorough cleaning, including the oil relief holes in the bottom ring groove. It is not necessary to remove light scores or discoloration from the exterior surfaces, and it is not advisable to use abrasive (including crocus cloth) on the skirt, since the cam-ground contour should not be altered. If the piston is dimensionally serviceable in other respects and apparently sound, measure side clearances of new rings (after measuring their gaps while squared in the cylinder barrel) by installing the slotted oil control ring in the bottom groove and the two compression rings in the top and second grooves, with part numbers toward the piston head, and inserting various thickness gauges on either side of each ring. (See figure 27.) The gaps of rings in the barrel should be measured first so that those selected may be left in the piston grooves, if the grooves are not excessively worn or distorted. When installing rings, take care not to allow their sharp ends to scratch the piston lands. If the cylinder barrel has not been ground oversize and fits the piston within the allowable clearance limit, it is permissible to install either standard or 0.005 inch oversize rings, whichever have the specified gap, as measured with the ring pushed up by the piston head to a point in line with the base flange.

9-20. CYLINDERS. Measure the barrel bore near the top of the ring travel limit and at the 4-1/4 inch station from the open end in the thrust direction and at right angles to that in order to detect out-of-roundness and wear-in taper. There should be little or no wear at the open end. Look for bent barrel fins and broken head fins. Barrel fins can be straightened if not badly bent or cracked. A reduction of not over 10% in area of head fins due to breakage is allowable. Look for cracked head fins, and specify repair of any radial crack by drilling a vee notch to remove it. If a radial crack extends to the root of a fin it may have penetrated the wall; hence, the cylinder should be rejected. If the cylinder base nuts were loose at disassembly, or if the base studs were loose or bent, test the machined side of the cylinder flange for bending, which is cause for rejection. Measure valve guides for wear, and look for scoring in their bores. Valve seats should be inspected after refacing to make sure that their outside diameters are still less than the valve head diameters. Exhaust valves should be checked for warpage before refacing, and all valves should be measured in length if the stem tips were ground. Inspect the spark plug hole and intake flange screw hole "Heli-Coil" inserts for looseness, deformation and position. The outer ends should lie in the first full thread of the tapped holes in which they are installed. The spark plug hole "Heli-Coil" has teeth at the outer end which are forced into the head metal and should not be visible. If there was any evidence of overheating of cylinder or piston, check as well as possible for turning of the head in relation to the barrel flange.

NOTE

Cylinder assemblies with serviceable heads and worn standard-size barrels may be returned to the factory through any Continental Authorized Distributor for oversize grinding. Those with excessively worn oversize barrels and good heads may be exchanged for factory rebarreled assemblies. The same exchange service is provided for replacement of valve guides and valve seat inserts.

SECTION X
REPAIR AND REPLACEMENT

10-1. CASTINGS.

Remove the raised edges of nicks in machined surfaces with a hard Arkansas stone. Unobstructed flat surfaces, such as valve-rocker cover flanges, may be returned to true flatness by lapping if a true lap plate is available. Use fine grade lapping compound and move the casting in a figure 8 stroke without rocking it.

10-2. STUD REPLACEMENT. Remove damaged whole studs with a standard pattern stud remover or a small pipe wrench, turning slowly to avoid heating the casting. Remove broken studs which cannot be gripped by drilling on center to the correct diameter for unscrewing them with a splined stud extractor. (Splined extractors and drills are usually sold in sets.) Examine the coarse thread end of the damaged stud before discarding it to determine its size. Standard studs have no marking. For oversize stud identification refer to Table X. Clean the casting tapped hole with solvent and blow dry with compressed air; then examine the thread. If it is not torn install the next larger oversize stud. If the old stud was of the maximum oversize, or if the thread is damaged, the hole may be tapped and a "Heli-Coil" insert installed for a standard-size stud. Coat the new stud's coarse thread with Alcoa thread lube if the hole is blind or with National Oil Seal compound if the hole goes through to a cavity subject to oil spray. It is advisable to drive the new stud with a tee handle stud driver. Turn it in slowly, and compare the estimated torque values listed in Section XV. Drive the stud in until it projects a distance equal to the appropriate "Setting Height" listed in Table XI or XIA.

10-3. "HELI-COIL" INSERT INSTALLATION. Bronze "Heli-Coil" inserts are installed at the factory in four tapped holes of each crankcase bottom flange, in three holes in the left crankcase parting flange and two in the right crankcase parting flange and in four bolt holes at each cylinder head intake port flange. Stainless steel "Heli-Coil" inserts of special design are installed in all spark plug holes. Any of these inserts may be replaced, if damaged, with the aid of tools listed in Table XII, which are available through Authorized Distributors of the Heli-Coil Corporation, Danbury, Connecticut. Refer to Table XII for part numbers of "Heli-Coil" inserts and manufacturer's numbers of all manually-operated special tools required to install them in tapped casting holes which have been damaged or excessively enlarged. The manufacturer's bulletin No. 650-R lists both manual and power-driven installing tools, tang break-off tools, special taps and plug gauges. A tap drill bulletin is also available from the manufacturer. "Heli-Coil" inserts are available in both National Coarse and National Fine series in lengths equal to 1, 1-1/2 and 2 times nominal diameter and in pipe thread sizes. They are made of either carbon steel, phosphor bronze or stainless steel, as specified by part number. They are supplied with or without a notch above the driving tang. The notch is provided to facilitate breaking off the tang in open holes.

10-4. "Heli-Coil" inserts are helical coils of wire with a diamond-shaped cross section forming both a male and a female thread. The diameter of the insert, when compressed into a special tapped hole at the widest part of the wire (between male and female threads), is equal to the nominal screw size. The special finishing taps listed in Table XII size the casting hole so that the pitch diameter of the female thread of the installed insert conforms to class 3 fit with standard bolt threads or class 4 (tight) fit with standard-size studs. The difference in fit is due to a difference in pitch diameters of bolts and studs, so that only one set of "Heli-Coil" special taps is required for installation of these inserts in both bolt holes and stud holes. Top drilling depths and tapping depths for "Heli-Coil" inserts to be installed in blind holes should conform to the recommendations relative to inserts of length equal to 2 times nominal diameter, as tabulated in the manufacturer's bulletin No. 650-R. "Heli-Coil" tap drills and special taps must be run in perpendicular to the machined surface of the casting. Drilling should be done in a drill press after the casting is firmly supported and clamped and alignment checked. The tap will tend to follow the drilled hole. For drilling and tapping aluminum alloy castings use a lubricant made by mixing one part lard oil with two parts kerosene to prevent overheating of the metal and tearing of the thread.

10-5. To remove a damaged "Heli-Coil" insert use the proper size of extracting tool for the nominal thread size. Tap it into the insert so that the sharp edges get a good "bite"; then turn the tool to the left, and back out the "Heli-Coil" until it is free. To install a new insert in a properly tapped hole (after blowing out all liquid and chips), slide it over the slotted end of the driving mandrel of the proper size of installing tool and engage the driving tang (bent end) of the "Heli-Coil" in the mandrel slot; then wind the insert slowly into the tapped hole. (See figure 30.) The outer end of the insert should lie just within the first full thread of the hole. Break off the driving

TABLE X. STANDARD AND OVERSIZE STUD IDENTIFICATION

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

tang of a notched "Heli-Coil" by bending back and forth across the hole with long-nose pliers or with a special tang break-off tool.

10-6. CYLINDERS.

10-7. FIN REPAIRS. Straighten slightly-bent barrel fins with long-nose pliers. File to smooth the edges of broken head fins. If it becomes necessary to cut out a vee notch to stop a head fin crack, a slotted drill bushing to fit over the fin and a 3/16 inch twist drill may be used to cut the notch. Its apex must be rounded and the edges should also be rounded. If such repairs and previous breakage have removed as much as 10% of the total head fin area the cylinder assembly has reached the limit of such repair.

10-8. SPARK PLUG HOLE "HELI-COIL" INSERTS. Before attempting to back out a damaged insert, use a sharp pointed tool to pry the teeth at outer end away from the cylinder head metal. Tap a "Heli-Coil" extracting tool into the insert until it has a good bite. (See figure 31.) Place a new "Heli-Coil" in the cut-out side of the installing tool sleeve with its driving tang toward the threaded end. Engage the tang with the slotted end of the driving mandrel and wind the insert into the sleeve thread, thus compressing it. Hold the sleeve so that the "Heli-Coil" can be seen through the slot in the threaded end, and turn the mandrel crank until the insert starts into the cylinder head hole. If the sleeve is then not in contact with the head surface, grip sleeve and mandrel and turn until the sleeve touches lightly. (See figure 32.) Wind the "Heli-Coil" into the cylinder head until its toothed end lies just within the first full thread. The teeth should be in position to enter the depressions made by the original insert. If driven too far the insert will emerge in the combustion chamber and will have to be wound on through. When the "Heli-Coil" is in correct position, use long-nose pliers to bend the driving tang back and forth across the hole until it breaks off at the notch. Coat a Heli-Coil Corporation No. 520-2 expanding tool threaded end with Alcoa thread lube or a mixture of white lead and oil, and screw it into the new insert until its final thread forces the teeth firmly into the cylinder head metal. (See figure 33.)

10-9. VALVE GUIDES. If the valve guides are to be replaced, the new guides must be installed so that the valve stem hole is accurately square and aligned with the valve seat. When pressing or driving out a worn guide, the cylinder assembly should be firmly supported in the inverted position with space below to allow the guide to drop out. The driving tool should pilot inside the guide and drive on its inner end. All carbon must be removed from the guide's inner end. If the cylinder head hole is not scored or enlarged a standard size guide may be installed as a replacement. If the head hole is rough it must be broached or reamed to a diameter smaller than the next larger oversize guide by the amount of interference ("T") specified in Section XV. Valve guides are supplied in oversizes of 0.005, 0.015 and 0.020 inch. The cylinder assembly must be supported firmly while the new guide is driven or pressed into place with a driver which fits over its end and bears on the filleted flange. Driving on the guide end will

TABLE XI. CRANKCASE STUD SETTING HEIGHTS

Index Number	Location	Thread Sizes	Setting Height	Models K	L	M
1	Cylinder mount pads	7/16-14 x 7/16-20	13/16	36	36	36
2	Engine mount pads	3/8-16 x 3/8-24	1-1/4	1	1	1
3		3/8-16 x 3/8-24	1-3/16	15	15	7
4		3/8-16 x 3/8-24	1-1/16			8
5	Oil cooler mount pad	1/4-20 x 1/4-28	1-5/8	5	3	
5		1/4-20 x 1/4-28	1-1/16		2	
5		1/4-20 x 1/4-28	57/64			5
6	Governor mount pad	5/16-18 x 5/16-24	1-3/8	4	4	4
7	Magneto mount pad	5/16-18 x 5/16-18	43/64	4	4	4
8	Magneto and accessory drive adapter pad	5/16-18 x 5/16-24	3/4	6	6	6
9		3/8-16 x 3/8-24	13/16	2	2	2
10	Idler pin pad	1/4-20 x 1/4-28	1/2	2	2	
10		1/4-20 x 1/4-28	5/8			2
11	Starter drive pad	5/16-18 x 5/16-24	13/16	2	2	2
12	Fuel pump pad	5/16-18 x 5/16-24	29/32	4	4	
12		5/16-18 x 5/16-24	1-5/16			4
13	Oil pump pad	1/4-20 x 1/4-28	2-9/32	2	2	2
14		1/4-20 x 1/4-28	7/8	1	1	1
15		1/4-20 x 1/4-28	2-13/16	2	2	2
16		1/4-20 x 1/4-28	3-1/8	5	5	5

TABLE XIA. STUD SETTING HEIGHTS

Location	Thread Sizes	Setting Height	Models K	L	M
Cylinder	1/4-20 x 1/4-28	11/16	4	4	4
Oil pump	1/4-20 x 1/4-28	5/8	2	2	2
Oil pump cover	1/4-20 x 1/4-28	3/4			4
Starter drive adapter	3/8-16 x 3/8-24	3/4	2	2	2
Riser manifold	5/16-18 x 5/16-24	1-5/8	4	4	
Riser manifold	5/16-18 x 5/16-24	1			4

spread it. Before installing a new guide, dip the end to be inserted in engine lubricating oil. The flat side of the guide flange must go against the cylinder head. Watch for peeling of bronze and correct misalignment which causes it. It is not necessary to freeze the new guide before installing it. Valve guide broaches may be purchased from the factory Service Department on special orders through Continental Authorized Distributors. Sizes for intake and exhaust valve guides are slightly different. These tools are very expensive and may be broken during the operation if not perfectly aligned with the hole. They are intended for use in a broaching machine not normally available in overhaul shops. Valve stem holes may be reamed if solid spiral reamers of correct diameters and with 0.431 in. diameter pilots are available. (Refer to paragraph 9-12 for stem hole finished sizes.)

10-10. VALVE AND VALVE SEAT REFACING. Numerous grinding machines are marketed for these purposes. Operating instructions are furnished with each machine and need not be repeated here, except that certain precautions must be observed. These are:

a. Use only soft stones on these hard alloy metals to avoid overheating and surface roughness.

b. Keep stones trued to angles specified in Section XV.

c. Use the coolant system at all times when grinding.

d. Replace chucks and pilots whenever results indicate excessive wear.

e. Do not grind seats more than a few seconds without lifting the stone. Keep the grinding head of the valve-facing machine in constant motion back and forth across the valve face without running off the edges.

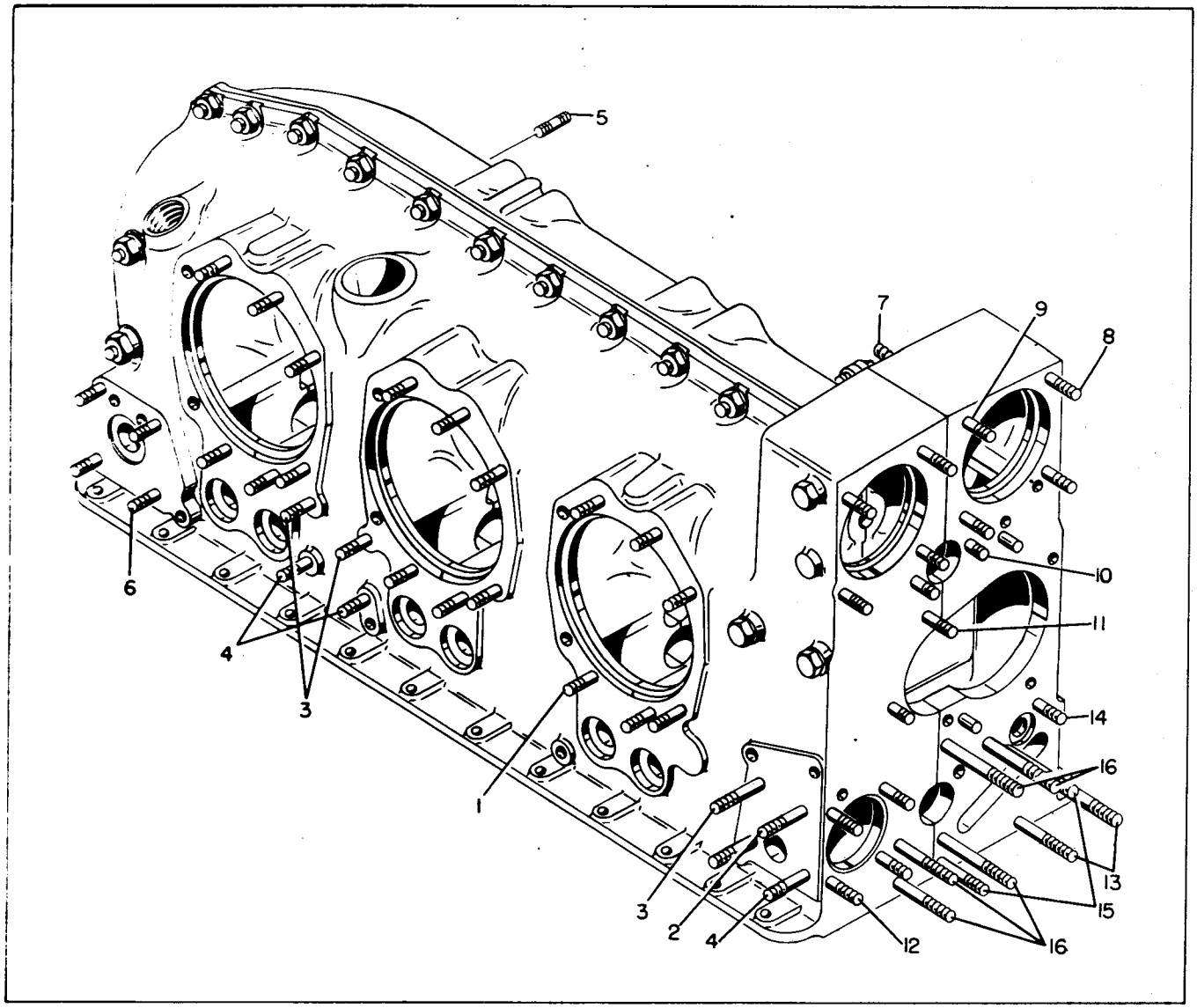


Figure 28. Crankcase Stud Heights

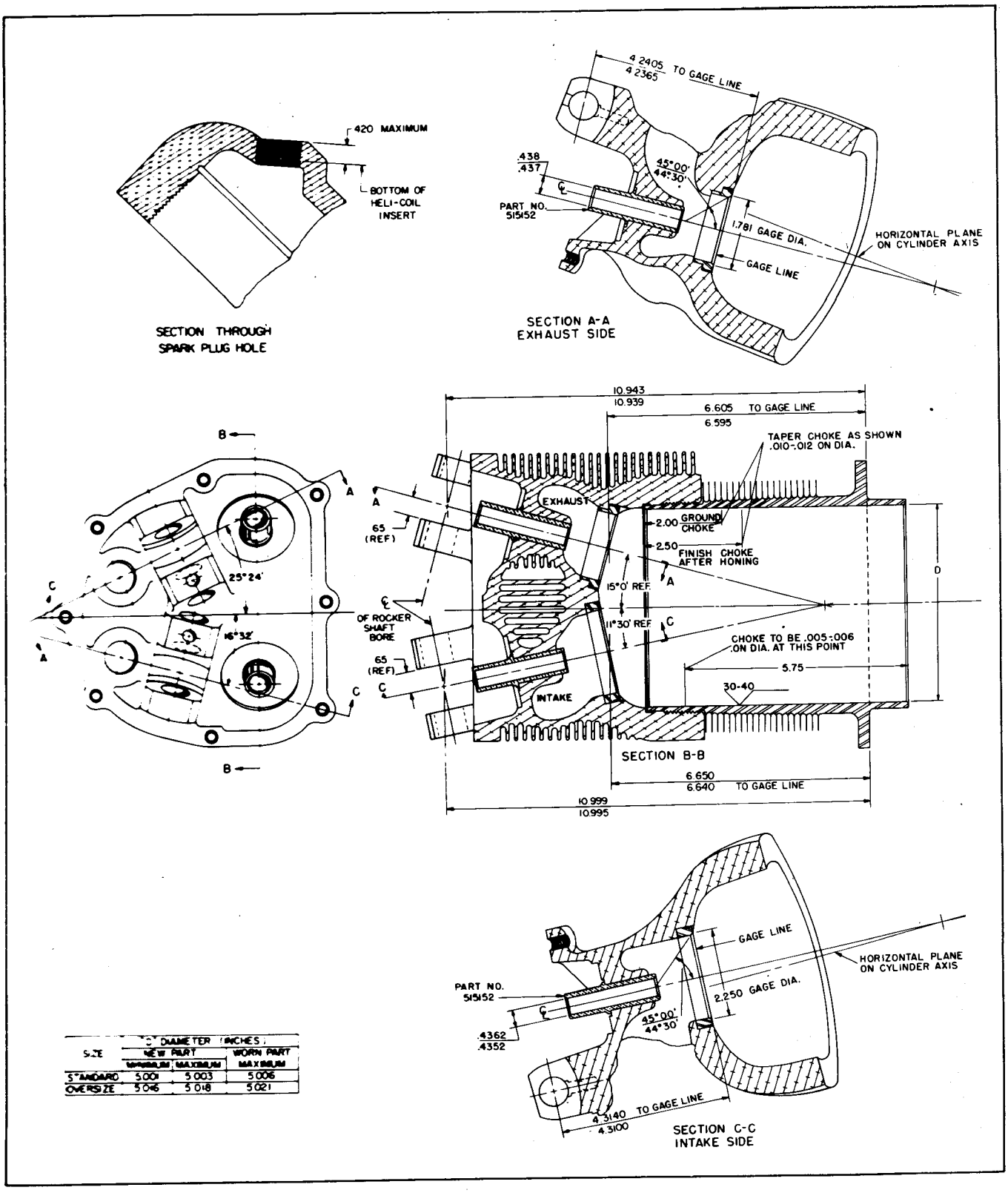
TABLE XII. "HELI-COIL" AND SPECIAL TOOL DATA

Thread Size	Basic C.M.C. Part No.	Heli-Coil Corp. Part No.	Drilled Hole Diameter	Heli-Coil Special Tap No.* Rough	Heli-Coil Special Tap No.* Fin.	Heli-Coil Thread Plug Gauge No.	Heli-Coil Installing Tools Standard	Heli-Coil Installing Tools Prewind	Tang Break-off Tool	Heli-Coil Extractor
1/4-20	24323-4	1185-4	.261 - .266	186-4	187-4	188-4	724-4N	528-4N	1195-4	1227-6
5/16-18	24323-5	1185-5	.328 - .333	186-5	187-5	188-5	724-5N	528-5N	1195-5	1227-6
3/8-16	24323-6	1185-6	.390 - .395	186-6	187-6	188-6	724-6N	528-6N	1195-6	1227-6
7/16-14	24323-7	1185-7	.453 - .458	186-7	187-7	188-7	724-7N	528-7N	1195-7	1227-16
18mm	520112	C2-52	.718 - .723	2-22	2-21	2-1	—	543	—	1227-16

Notes: * For aluminum alloy castings. For numbers of taps designed for steel refer to the manufacturer's bulletin No. 650-R.

C.M.C. Part Numbers: to basic part number add "B" for phosphor bronze, or "C" for stainless steel. Add -1, -1.5 or -2 for length equal to nominal diameter times 1, 1-1/2 or 2, respectively. (All C.M.C. furnished inserts are notched.)

Heli-Coil Part Numbers: To basic part number, as listed, add "B" for phosphor bronze, or "C" for stainless steel and "N" for a notched insert, if desired. Add "X" and length desired, expressed as a fraction of an inch. Example: 1185-5CN x 15/32 represents a 5/16-18 N.C. insert of stainless steel whose length is 15/32 inch, or 1-1/2 times its nominal diameter.



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

Figure 29. Standard Cylinder Assembly Dimensions

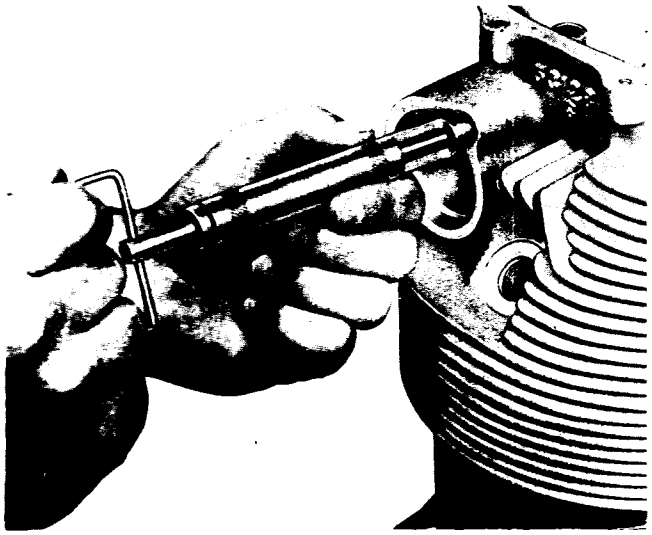


Figure 30. Installing Typical Heli-Coil Insert

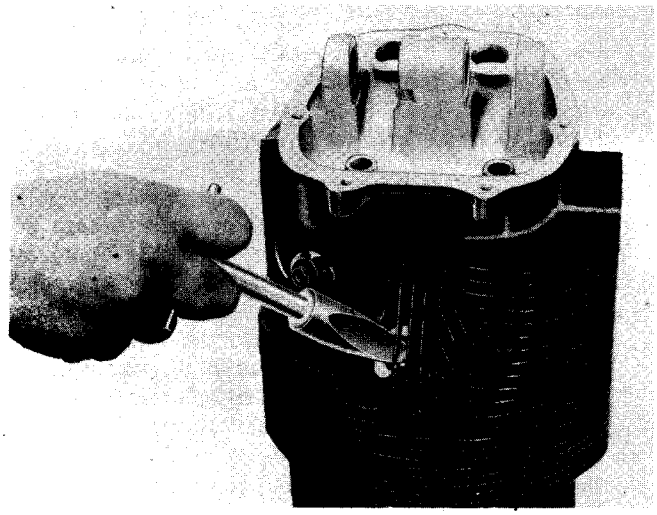


Figure 31. Removing Spark Plug Hole Heli-Coil Insert

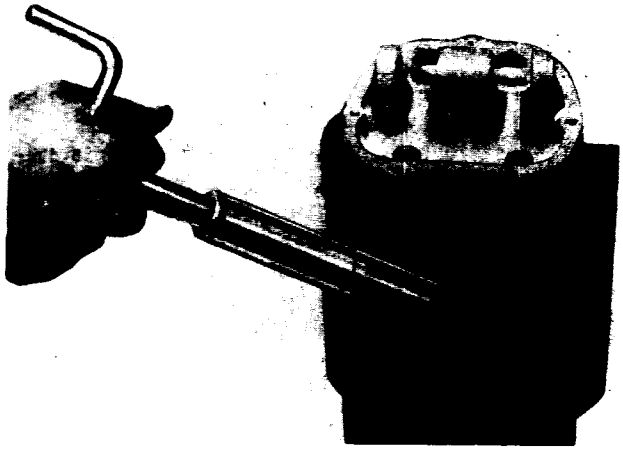


Figure 32. Installing Spark Plug Hole Heli-Coil Insert

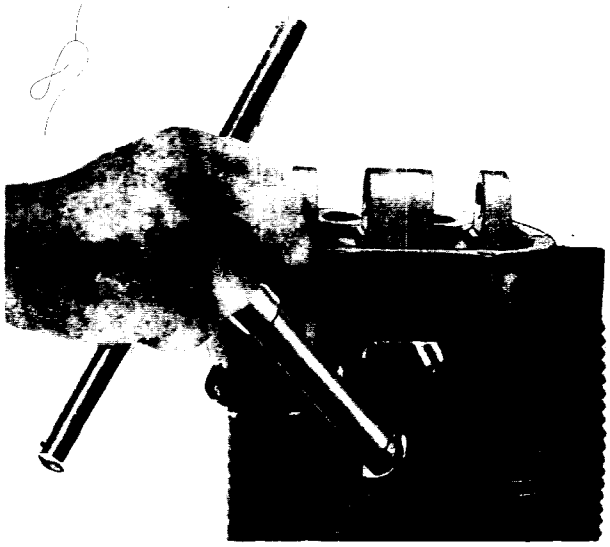


Figure 33. Expanding Spark Plug Hole Heli-Coil Insert

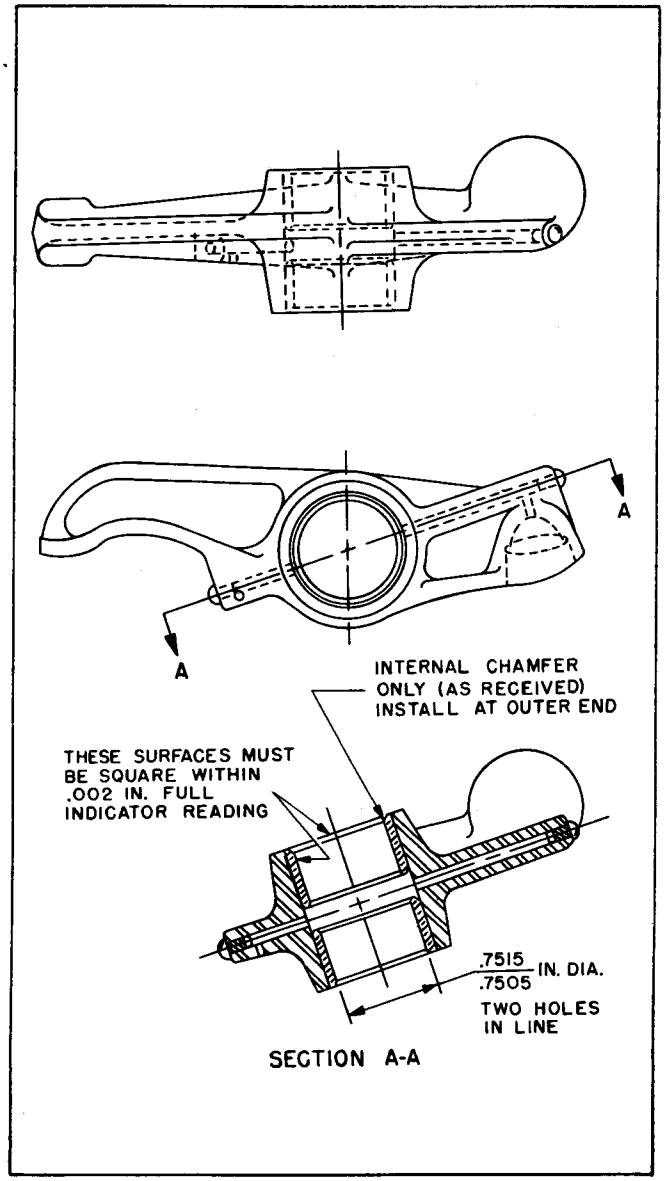


Figure 34. Valve Rocker Bearing Dimensions

f. Break sharp edges at the outside of the valve faces with a hard Arkansas stone or a fine India stone. The face must never run into the rounded edge of the head. Discard valves which must be ground to this condition to clean up.

10-11. After the valve seat has been ground, the concentricity, angle and angular relationship of the seat to the valve guide may be determined by the use of a blueing gauge. Coat the cone surface with a very thin film of Prussian blue, oil base pigment, and insert the gauge end into the valve guide until the cone surface can be rotated in contact with the valve seat. The tool should have a flat, marking the limiting diameter of the seat. If regrinding has excessively enlarged the seat, it may be reduced once only with a stone which makes an angle of 68° - 78° with the stem axis.

10-12. After grinding all valve seats, insert two refaced valves in the guides of each cylinder, with a light spring under each valve and a film of fine grade valve lapping compound on each valve face. Use an automatic type valve lapping tool with an extended stem equipped with a suction cup, to lap the refaced valves and reground seats to line contact at the outer edge only, lifting the tool every few seconds to redistribute the compound. Carefully wash off all abrasive particles after this operation; then keep the valves with the cylinders in which they were lapped.

10-13. CYLINDER WALLS. Glazed cylinder walls will not seat new chromefaced piston rings quickly; therefore, they should be roughened by honing with No. 400 grit stones in a spring-loaded honing head or by abrasion with Aloxite cloth of No. 100 grit. The fine scratches produced should be crossed and those running in each direction should form an angle of 35° - 55° with the end of the barrel.

NOTE

Due to the choke specified for the cylinder barrel bore, a cam-controlled grinder is required to regrind worn barrels to the allowable 0.015 in. oversize dimension. Since this type of grinder is not usually available in overhaul shops and job machine shops, it is suggested that cylinder assemblies with serviceable heads but in need of regrinding or rebarreling be returned to the factory through any Continental Authorized Distributor of aircraft engine parts on the long-established exchange basis. The service also includes replacement of valve guides and seat inserts.

10-14. VALVE ROCKERS. Worn bushings may be driven out with a suitable drift, and if properly designed the same tool may be used to drive in new bushings. The rocker must be supported on a ring which will allow the old bushing to pass through. Press the new bushing in flush with the rocker hub after dipping it in clean lubricating oil. Ream the new bushing to the diameter specified in paragraph 9-12. It is advisable to plug the oil holes with beeswax before reaming. Be sure to remove the wax after reaming. Lightly break the sharp edge at each end.

10-15. CONNECTING RODS.

CAUTION

In order to assure good dynamic balance, connecting rod assemblies for new engines are selected in sets with a maximum weight variation of 1/4 ounce. This limit cannot be maintained if material is removed from any of the original in a set. If a connecting rod must be replaced, specify the weight limits when ordering.

10-16. PISTON PIN BUSHING REPLACEMENT. The connecting rod does not need to be heated for this operation. Press out the old bushing in an arbor press, using a drift only slightly smaller than the bushing O.D. Make sure that the rod bore is smooth. Dip the new bushing in engine lubricating oil before placing it in position, and locate the split as illustrated in figure 36. (The position number is stamped on the rod and cap bosses on the far side.) Ream or bore the new bushing to the size limits given in paragraph 9-12, and check alignment as described in paragraph 9-17. The center-to-center distance given in paragraph 9-12 will be held automatically if the bore is centered in the new bushing.

10-17. CRANKSHAFT ASSEMBLY. Lightly scored crankpins and journals may be smoothed with a hard Arkansas stone. Do not use a coarser abrasive. Do not attempt to remove deep scoring or indications of overheating which render the crankshaft unserviceable. Remove the upstanding edges of small nicks on softer surfaces with a hard Arkansas stone. Polish crankpins and main journals with long strips of crocus cloth, preferably while the shaft is rotated about 100 R.P.M. in a lathe. Due to the fact that No. 536421 gears are shrunk fit to the crankshaft, it may be necessary to dip the gear in oil heated to 300° F, before removal can be accomplished. These operations should precede Magnaflux inspection.

10-18. Hardened steel bushings in the crankshaft blades and in the counterweights may be removed and replaced if excessively worn. It may be necessary to chill the old bushings to free them. New bushings must be chilled before installation with a suitable drift, and the holes must be smooth. No finishing operation is required for the new bushings, since they are made to final dimensions. They must be driven in to the same positions as the original parts.

NOTE

Regrinding of crankpins and crankshaft main journals to the allowable 0.010 inch undersize by

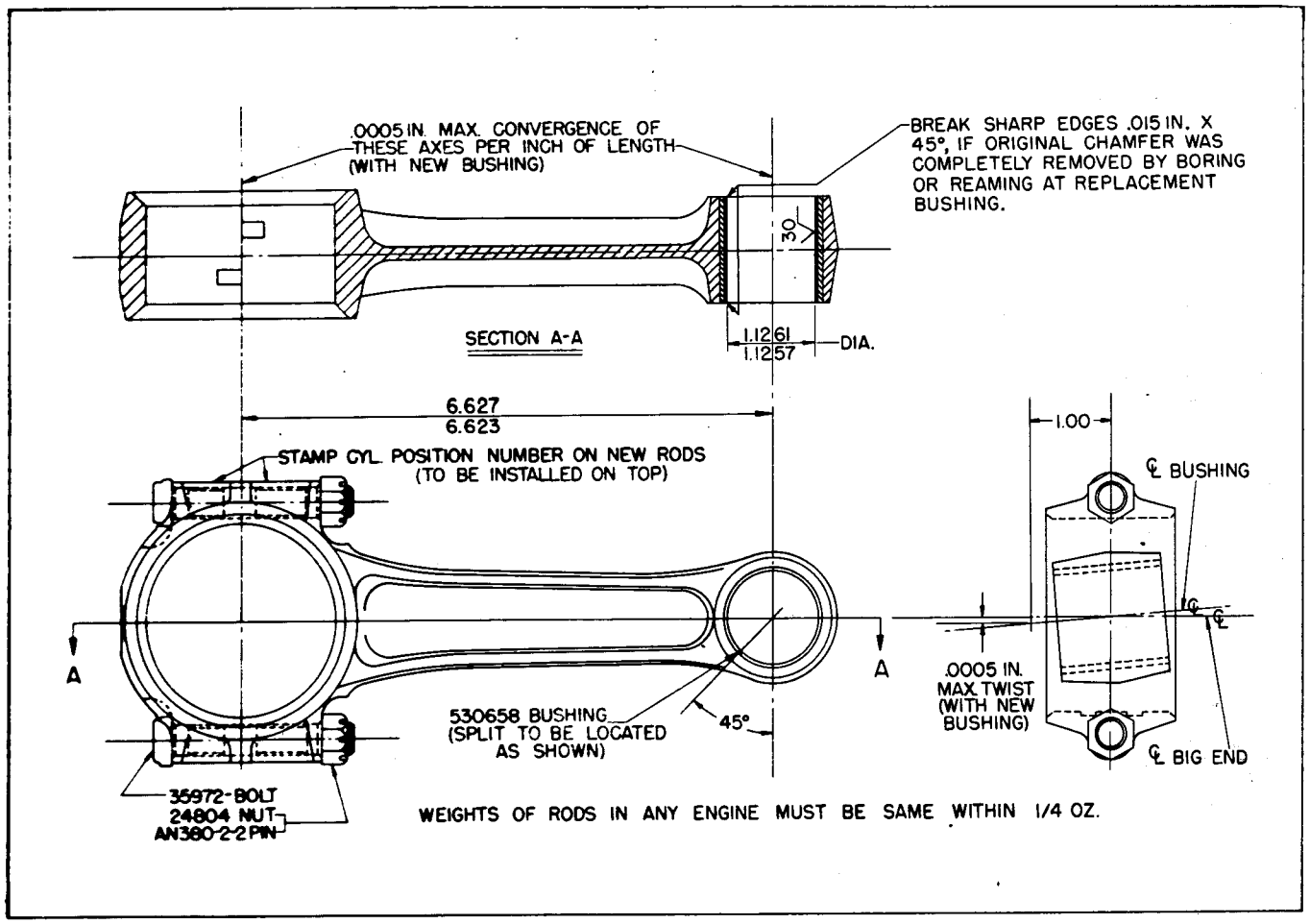


Figure 35. Connecting Rod and Bushing Dimensions

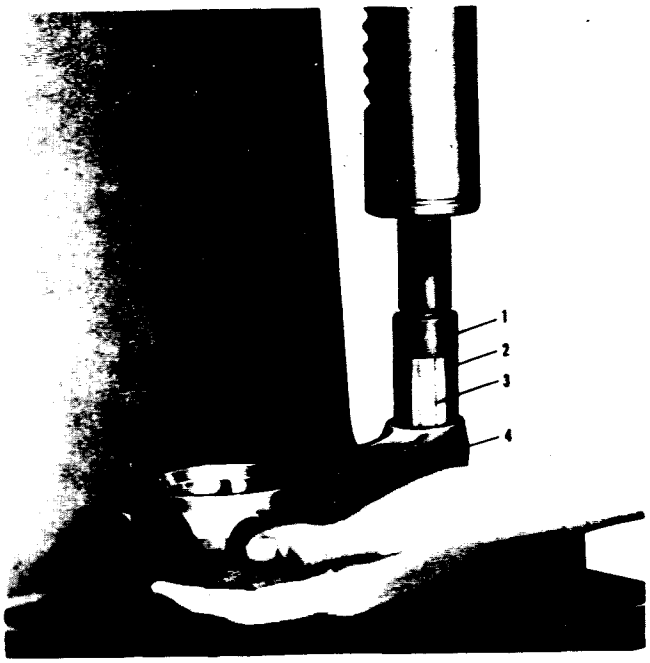
repair agencies is not recommended because of the high degree of precision required in dimensions and finish, and because reground crankpins and journals must be renitrided. Crankshafts which have not been bent or otherwise damaged may be returned to the factory through any Continental Authorized Distributor of aircraft engines and parts for regrinding.

CAUTION

Crankshaft counterweights are matched in pairs with a maximum weight variation of 2 grams, and the complete crankshaft and counterweights assembly is dynamically balanced. As a result, if either counterweight is damaged it will be necessary to discard both on that cheek and to procure a matched pair for replacement.

10-19. IDLER GEAR. Replacement of excessively worn idler gear bushings is not recommended, because a special fixture is required to hold the gear during the boring operation, in order to maintain the necessary concentricity of the bushing hole and the gear pitch circle.

10-20. MAGNETO AND ACCESSORY DRIVE ADAPTER ASSEMBLY. If the magneto and accessory drive adapter bushing must be replaced, it may be driven out with a 0.92 in. diameter drift while the adapter boss is supported on a 1.12 in. I.D. ring; however, this procedure involves some chance of scoring the adapter bore. A safer, though more laborious procedure is to turn down the bushing flange to the body diameter (0.942 in.) and to bore out the bushing to a thin shell which can be collapsed. If this method is used, take care not to cut into the end of the adapter boss or to mark the adapter bore. Press in a new bushing with an arbor press after dipping it in clean engine lubricating oil. The rear pad of the adapter, rather than the studs, should be supported on a parallel block and a flat block should be used to exert pressure, unless the arbor has a perfect end. Ream or bore the bushing to the diameter specified in paragraph 9-12; then face the flange until it projects forward 1.454 - 1.458 in. from the adapter parting surface. Chamfer the bore at the flange end 1/16 in. deep on a 45° angle, and slightly break sharp edges at both ends. The bushing hole must be concentric with the adapter pilot shoulder within 0.002 in. and square with the parting surface within 0.002 in. per inch of length. Its flange thrust face must be parallel to the parting surface within 0.002 in. (full indicator reading).



1. Connecting rod bushing removal and replacing tool
2. New bushing
3. Bushing split line
4. Connecting rod and cap assembly

Figure 36. Installing Connecting Rod Bushings

CAUTION

Before boring a new bushing, plug its oil holes with beeswax to exclude chips from the adapter oil groove. Be sure to remove the wax completely after the operation.

10-21. In most instances the old seal may be driven out with a 1/8 in. diameter pin punch inserted through the four oblique oil holes in the bushing boss alternately. If the seal is too tight for that method, drill and tap two opposite machine screw holes in the exposed flange of the seal case to match two screw clearance holes in a pressure plate which can be laid on the adapter studs. Run nuts on two long machine screws; then insert the screws through the pressure plate holes, and screw them into the holes tapped in the seal. To avoid unnecessary stoning of the seal bore, tighten the nuts against the plate to pull the seal squarely from its recess. Smooth any scores in the vacant adapter counterbore. Coat the periphery of a new oil seal with Lubriplate No. 107 grease (Fiske Bros, Ref. Co., Lockwood and Watts Sts., Newark 5, N.J., and Distributors in principal cities), and press it into the adapter with an arbor press and a flat end block of 1-3/8 dia. x 1-1/4 in. length.

10-22. TACHOMETER DRIVE HOUSING. Remove the oil seal with a suitable oil seal puller. If the housing counterbore is scored, smooth it with crocus cloth. Spread a film of Lubriplate grease on the periphery of a new seal. Then press the seal squarely into the housing with its lip pointed outward, facing the oil source.

10-23. STARTER DRIVE ADAPTER. The clutch spring sleeve is shrunk and doweled in the housing. If it is excessively worn, scored or burned, the adapter and sleeve assembly should be returned to factory for replacement. If it is necessary to remove the needle bearing in the adapter, a removing driver may be made similar to the driver illustrated in figure 38. The dimensions called for in figure 38 will apply for the remover except the 13/16 in. dimension. For the remover this dimension will be 1-1/2 in. Hold the adapter as shown in figure 39. Fill the needle bearing cavity with a heavyweight (SAE 50 or similar grade) oil within 1/4 in. of the top. Insert the tip of the remover into the bearing, and keep it aligned while driving with a medium weight hammer. The pressure exerted on the oil by the remover will force the bearing from the adapter. The installing driver may be constructed from in-

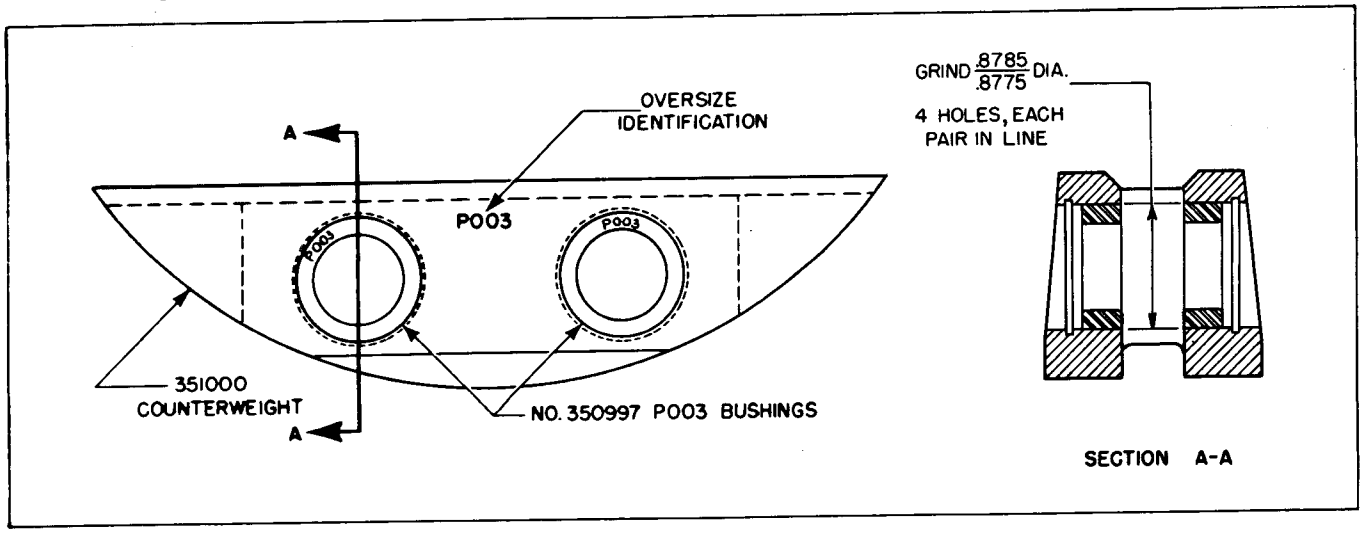


Figure 37. Counterweight with Oversize Bushings

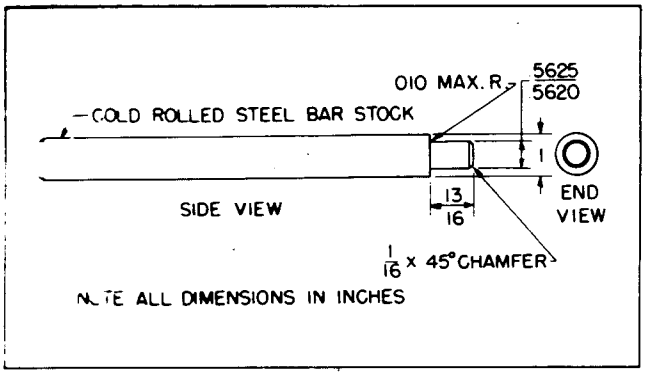


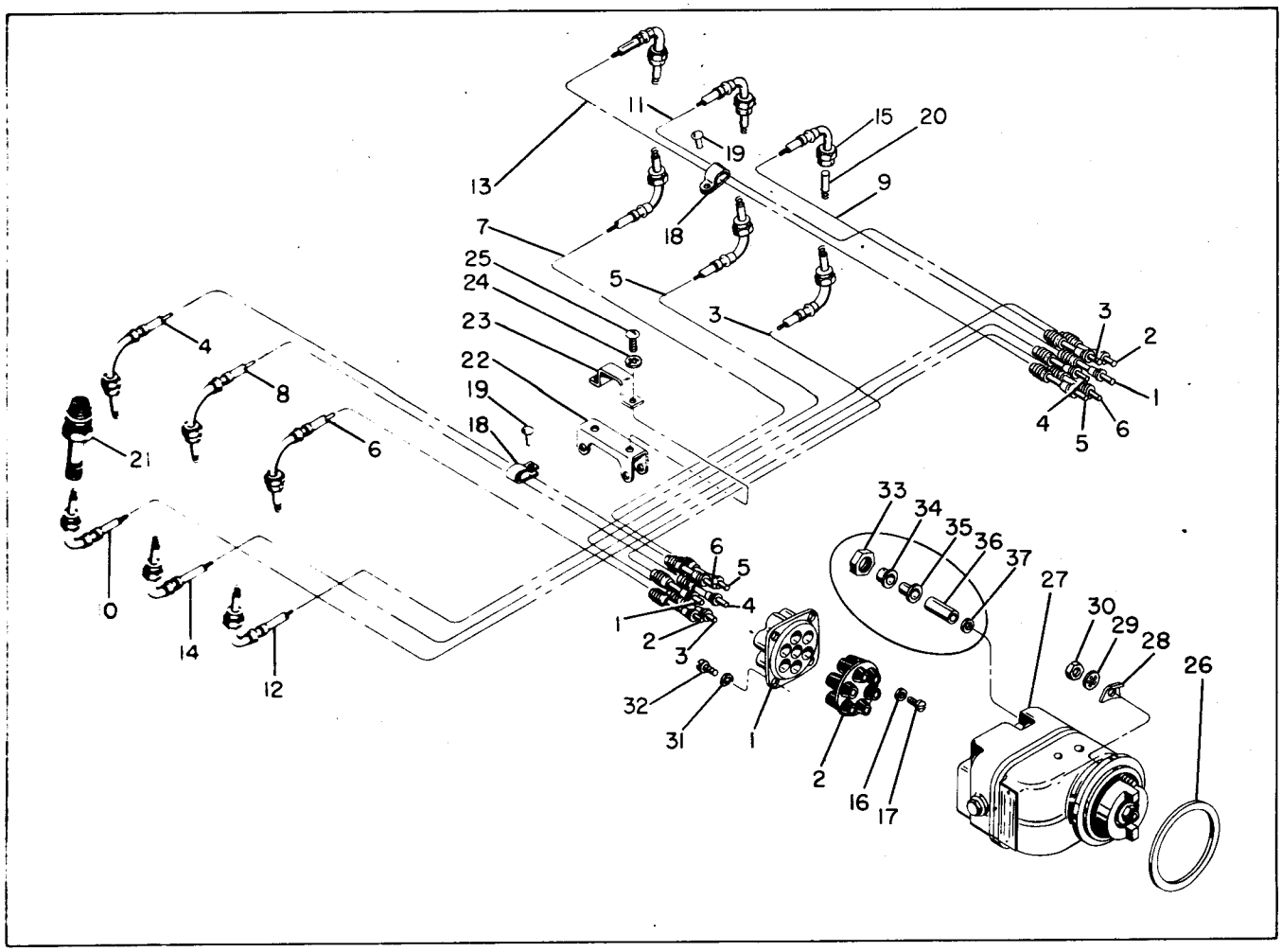
Figure 38. Starter Adapter Needle Bearing Installing Driver

Figure 39. Installing New Starter Adapter Needle Bearing

formation in figure 38. Its operation is illustrated in figure 39.

10-24. OIL PUMP ASSEMBLY. Except for stoning down nicks on parting flanges and replacement of studs and worn parts, no repairs to the pump assembly are contemplated. The pump driven gear shaft is pressed into the pump housing and cannot be replaced successfully. The pump gear chamber must not be enlarged; hence, if it is scored the housing must be discarded. Heavy scoring on the gear contact area of the tachometer drive and pump cover renders this part unserviceable, unless the parting surface can be lapped smooth and perfectly flat.

10-25. IGNITION CABLES. Normally, all ignition cable assemblies or both harness assemblies should be replaced at each overhaul. If the high tension outlet plates are in good condition, new cable assemblies and grommets may be installed on them and the cable ends secured to the grommet of each harness with a brass washer and a cable piercing screw, installed as in the original assembly. If only the cable assemblies and grommets are to be replaced, leave the cable clamping bracket on the original cables of each harness, and detach all cables from the high tension outlet plate by removing the cable piercing screws from their ends in the plate grommet. When the coupling nuts are unscrewed the cables may be withdrawn and the grommet removed from the plate. Observe the "1" mark on the exterior side of each outlet plate adjacent to the No. 1 cable outlet hole. Refer to figure 40 and observe that the numerals appearing at magneto ends of the high tension cables correspond to the consecutive order of outlet plate cable holes, while the relative positions of spark plug elbows indicate the installed positions of the cables. Install cable assemblies (3 through 14, figure 40) in the indicated positions in the two outlet plate and grommet assemblies (1 and 2), starting with the proper No. 1 cable assembly in the marked hole of each plate, and proceeding in consecutive order around the plates. As each cable end is inserted, screw in the cable coupling nut (5), and tighten it; then place one of the brass washers (16) and a cable piercing screw (17) at the grommet hole, and turn the screw in firmly but not enough to cut the wire strands. When all cables have been attached to the two outlet plates, locate a clamping bracket (18) on the proper cables of each harness in the same position as on the original cables, and install a rivet (19) to secure it. Parts indexed 21 through 32 will be installed at final assembly. This group should be collected and ready for installation. Parts indexed 33 through 37 are installed on the aircraft ignition switch wires.



1. High tension cable outlet plate
2. Outlet plate grommet
3. No. 539750-32 cable assembly to No. 1 lower spark plug
4. No. 539750-17 cable assembly to No. 6 upper spark plug
5. No. 539750-33 cable assembly to No. 3 lower spark plug
6. No. 539750-21 cable assembly to No. 2 upper spark plug
7. No. 539750-39 cable assembly to No. 5 lower spark plug
8. No. 539750-19 cable assembly to No. 4 upper spark plug
9. No. 539750-16 cable assembly to No. 1 upper spark plug
10. No. 539750-32 cable assembly to No. 6 lower spark plug
11. No. 539750-19 cable assembly to No. 3 upper spark plug
12. No. 539750-39 cable assembly to No. 2 lower spark plug
13. No. 539750-22 cable assembly to No. 5 upper spark plug
14. No. 539750-33 cable assembly to No. 4 lower spark plug
15. No. 25302 coupling nut
16. No. 25388 brass washer
17. No. 25387 cable piercing screw
18. No. 535042 two-wire cable bracket
19. No. 21264 7/32 dia. x 1/4 in. round-head rivet
20. No. 21440 spark plug terminal sleeve
21. No. 531132-1 Champion C27S or 530892-1 Champion RC26S spark plug
22. No. 535781 brace (assembled on crankcase)
23. No. 535557 clip
24. AN936A8 internal tooth lock washer
25. AN515-8-6 round-head screw (No. 8-32 x 3/8 in.) (2)
26. No. 534750 magneto gasket
27. Scintilla model S6RN-25 magneto
28. No. 535093 magneto holding washer
39. AN936A516 internal tooth lock washer
30. AN315-5R plain hex nut (5/16-24)
31. 25321 spring lock washer (No. 10)
32. No. 25320 fillister-head screw (No. 10-32 x 5/8 in.)
33. No. 25318 hex coupling nut
34. No. 25317 outer ferrule
35. No. 25316 inner ferrule
36. No. 530455 insulating sleeve
37. No. 25314 brass washer (5/16 in. O.D.)

Figure 40. Exploded View of Ignition System

SECTION XI
ASSEMBLY OF SUBASSEMBLIES

11-1. NEW PARTS.

Parts which require protection from atmospheric dust and moisture are wrapped or boxed individually or in sets. These should not be unpacked until they are to be installed. This is especially true of precision bearing inserts and anti-friction bearings. Check other new parts on receipt for damage done in transit. Refer to Section 4 of the Parts Catalog for part numbers of the complete gasket set, the main bearing set, the piston ring set and tubes of lightweight Tite-Seal gasket paste, all of which should be on hand when work is started. Use only new AN936 internal-tooth lock washers, spring lock washers, tab washers, palnuts, elastic stop nuts, cotter pins and 18 gauge, annealed, corrosion-resistant lock wire.

11-2. TIGHTENING TORQUES.

The accuracy of any torque-indicating wrench depends on a smooth application of force. Do not back up a nut or bolt and leave it in that condition. If a part is accidentally tightened too much, loosen it and retighten to a value within the specified limits. If a nut slot must be aligned with a cotter-pin hole, tighten the nut to the minimum specified torque, and check for alignment. If necessary, tighten further until alignment is achieved for the maximum allowable torque reached, whichever occurs first. If the alignment cannot be obtained within allowable torque limits substitute another serviceable part and tighten it in the same manner as before. If a cotter-pin hole in a stud lies beyond the nut slots when the nut has been tightened correctly, then either the stud has been improperly installed or has backed out, or the attached part has been reduced in thickness, or either the nut or its washer is not the correct part for that location. The situation must be corrected by whatever replacement is indicated by inspection.

NOTE

Tightening-torque limits specified in Section XV are based on oiled threads but are not applicable when special thread lubricant is applied.

11-3. FINAL CLEANING.

Immediately before assembling a group of parts they should be washed in or sprayed with clean solvent and dried with dehydrated compressed air.

11-4. LUBRICATION.

Immediately after final cleaning and before installation, coat all bare steel surfaces and journals with clean engine lubricating oil, except where special lubricants are mentioned in the text. In some instances where gears and other running parts are accessible after assembly in a housing, additional oil should be applied to assure full coverage. Before installing tapered pipe plugs or straight thread plugs, and to prevent seizure and leakage of oil, coat the first three male threads with Parker Fuelube No. 44 sealing lubricant. (Parker Appliance Co., 17325 Euclid Ave., Cleveland, Ohio.) This compound is fuel and oil resistant and has good lubricating properties. It may be used also to coat rubber-asbestos gaskets before installation to assure a perfect seal and to counteract the permanent "set" caused by compression. Lubriplate lubricants mentioned in the text are distributed by dealers in all principal cities.

11-5. SPECIFIC ASSEMBLY OPERATIONS.

11-6. OIL PUMP ASSEMBLY. (See figure 25.)

11-7. For oil pumps used on O-470-K and O-470-L engines the following steps are applicable:

a. Install the system pressure relief plunger (26), spring (25), new copper gasket (24) and cap (23) in the oil pump housing.

b. Install the oil filter bypass check ball (31), spring (30), new copper gasket (29) and cap (28).

c. Slide a new gasket (6) over the oil filter (5), and insert the filter into its chamber in the pump housing. Tighten it by hand only.

d. Install the pump driver and driven gears (19 and 21) in the housing chamber, and place one of the bevel gears (18) on the end of the driver gear shaft.

e. Slide the bronze thrust washer (14), flat side first, onto the tachometer drive shaft (16). On its shouldered side place a new copper-asbestos gasket (13); then carefully work the lip of the tachometer drive housing oil seal (12) (which is already in the housing) over the shaft end, and push the shaft through to seat the gasket on the housing end.

f. Place the second bevel gear (15) on the pinned end of the tachometer drive shaft, and, holding this end up, insert the shaft into the cover (10). Screw in the housing (11) by hand only, still keeping the bevel gear upward.

g. Place the cover and tachometer drive assembly on the pump housing, turning the driver gear to mesh the bevel gears, and attach it temporarily with two sets of parts (7, 8, 9).

NOTE

The pump cover must be removed during final assembly, as explained in Section XII. The oil filter cap and the left-hand threaded tachometer drive housing can best be tightened after installation on the engine.

11-8. The reassembly procedure described in paragraph 11-7, steps a, b and c, also apply to oil pumps used on O-470-M engines in conjunction with the following steps:

a. Install the tachometer driving gear (18) on the driver gearshaft (19).

b. Install the tachometer drive gear shaft (43) in the tachometer drive housing (32).

c. Align the two bevel gears and attach the tachometer drive housing to the oil pump.

d. Install the cover plates (36 and 41) using new gaskets (37 and 42) and lock washers.

11-9. STARTER AND DRIVE ASSEMBLY. (See figure 26.)

a. Place the depressed end of the spring (30) over the knurled end of the drum (36). Push the spring away from the depressed end sidewise, and work the end coil over the drum; then push the spring inward until the depressed end snaps into the drum groove next to the flange and install the retaining screw (28) and washer (29).

b. Insert the shaftgear (35) through the spring and drum. Place the ball bearing (31) on a steel support ring, sized to bear on its inner race only, in an arbor press, and press the shaftgear through until the bearing is seated on the inner shaft shoulder.

c. Install the worm wheel (34) on the drum flange, and push its two dowels through flange holes so that four bolt holes align. Attach the wheel with four screws (32) and secure them in pairs with lock wire.

d. With one leg hold the adapter (47), sleeve down, on the edges of the work bench, and insert the shaftgear and clutch assembly. Bear down on the worm wheel while turning it counterclockwise to wind up the clutch spring until it starts into the adapter sleeve. Push the spring fully into the sleeve.

e. Support the inner race only of the bearing (41) on a steel ring in an arbor press, and press the worm shaft (43) through until the bearing is seated against its flange.

f. Tap a serviceable Woodruff key (42) into the worm shaft key slot.

g. Install the spring (40) and the worm gear (39) on the shaft.

h. Holding the worm and shaft assembly vertical, slide it into the adapter and needle bearing. Invert the adapter. With Truarc pliers compress and install the retaining ring (38). Test by hand for perceptible end clearance.

i. With Truarc pliers compress and install in the groove of the cover (23) the retaining ring (27). Use a round block of slightly smaller diameter than the cover bore to press in a new oil seal (26) on the projecting side with its rubber lip toward the retaining ring and the seal case touching the ring.

j. Place a new gasket (24) and the cover (23) on the adapter, and attach with illustrated parts (19, 20 and 21).

k. Push the sleeve (25) over the shaftgear end and through the cover oil seal, flange outward.

l. Tap a serviceable Woodruff key (22) into the shaftgear key slot.

m. Install the sheave (18) and its attaching parts (15, 16, 17).

n. Spread on the pipe threads (45) a film of Alcoa thread lube, and screw the plug tightly into the adapter hole.

o. Install the gasket (14) on the adapter flange studs. Turn the starter shaft until its drive tongue aligns with the coupling slot in the mounting position, and mount the starter (3). Attach it with two sets of parts (1 and 2).

p. Install the remaining adapter attaching parts (5 through 13). If desired, the bolts and washers may be inserted in the proper holes and ready to screw in at final assembly.

11-10. CYLINDERS. Assemble parts to make up each of the six cylinder and valve assemblies in the manner outlined below. Each cylinder should have a different position number (1 through 6) stamped on the edge of its base flange, which will be on top when installed. These numbers should be found on original cylinders, but they must be stamped on new parts. After assembly, cylinders should be laid on the bench in a row in the order of position numbers, and the piston, pin and ring assemblies should be laid in front of them in the same order. Piston position numbers are stamped on the rims of their heads on the side which is to go toward the propeller. The part number is stamped on the rim at right angles to the pin hole and should be on top when installed. Mark new pistons thus:

a. Spread a film of Lubriplate No. 707 grease on the stems of the two valves previously lapped to the cylinder seats, and insert these into their guides.

b. Hold the valve stems, and lift the cylinder onto a post which will support the valve heads. Clamp the cylinder base flange to prevent it from rising. Again coat the valve stems with Lubriplate No. 707 grease.

c. Place the valve spring inner retainers over the guides, cupped sides up, then install two sets of inner and outer springs and the outer spring retainer.

d. Using the same type of spring compressor as for disassembly, compress, in turn, the sets of springs, and insert the stem keys. The springs should be depressed only enough to admit the keys to the stem grooves. If they drop too far, the keys may be cocked and may nick the stems when the springs are released. Make sure that the keys are seated in the stem grooves before releasing pressure. Do not allow the compressing tool to cock the outer retainers so as to contact the stems, since they can cause score marks.

e. Remove the cylinder from the assembly fixture. Set it base-down on the bench, and with a rawhide mallet strike each valve stem firmly to seat the keys.

f. Slide rocker shafts in the head bosses of numbers 3 and 4 cylinders but not in the others.

g. Lay all cylinders upside down on the bench, resting on the sloped head fins. Place a new base packing on the skirt of each cylinder, and push it against the flange. See that none are twisted.

h. Coat the cylinder bore walls thoroughly with Lubriplate No. 2, Sunoco way oil or castor oil.

11-11. PISTON AND CYLINDER ASSEMBLIES. Lubricate pistons, rings and pins. Space ring gaps 120° apart with the oil control ring gaps so that they will be on top.

11-12. PUSHROD HOUSINGS. Install on the cylinder end of the housings a No. 534609 washer and a No. 534610 red Silastic rubber seal. Install on the crankcase end a washer, a housing spring, another washer and a red Silastic seal. Lay two housings with each cylinder.

11-13. CRANKSHAFT AND CONNECTING RODS.

a. Lay the shaft on two notched 2 x 4 in. wood blocks under its front and rear journals.

b. Lay out the six connecting rods, caps, bolts and nuts opposite the crankpins according to stamped

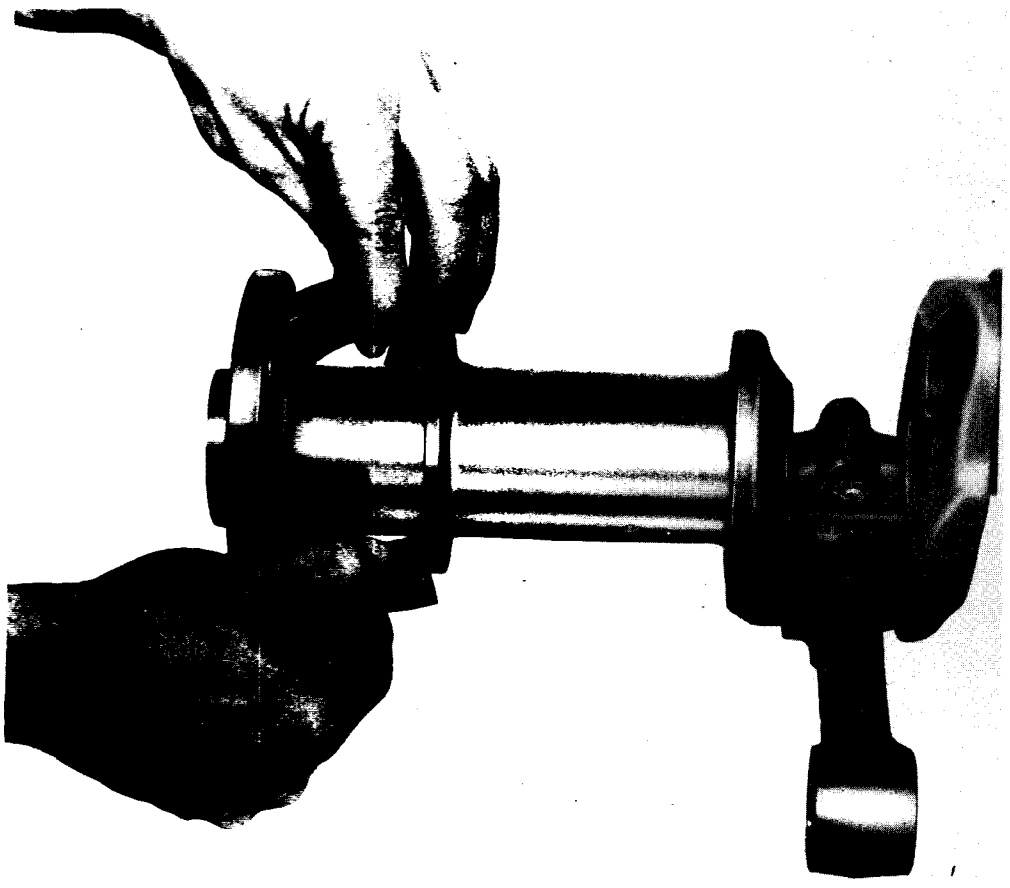


Figure 41. Installing Crankshaft Oil Seal

position numbers on bolt bosses, starting with No. 1 at the end opposite the flange and proceeding in numerical order.

c. Obtain a set of 12 new crankpin bearing inserts and make sure they are thoroughly clean. Snap an insert into each rod and each cap so that their ends project the same small distance.

d. Lubricate and install each connecting rod and cap with the position numbers on top when the odd-numbered rods are extended to the right and even numbers to the left. Attach them with the special bolts and hex nuts. Tighten the nuts to specified torque, and secure each with a 1/16 in. dia. x 1/2 in. cotter pin. Bend one leg of each pin down snug against the nut flat and the other over and against the bolt end.

e. Install retaining plates and Truarc rings in the pin holes in one side of each counterweight. Attach the counterweights to the crankshaft blades with two pins in each; then install the retaining plates and Truarc rings on the other sides.

f. Remove the spring from a new crankshaft oil seal assembly and unhook its ends.

g. Coat the lip of the seal with Gredag No. 44 or Lubriplate No. 707 grease.

h. Twist the seal and slide it over the crankshaft with its felt side toward the flange. (See figure 41.) Bring the ends back together.

i. Pass the oil seal spring around the crankshaft on the recessed side of the seal and hook its ends. Lift it into the seal recess at the split and work the remainder in progressively, move the fingers in both directions from the starting point. (See figure 42.) Make sure that the spring is in the deepest part of the recess all around. The hooked ends should be opposite the seal split.

j. Heat the crankshaft gear to 300°F prior to installation on the crankshaft. Align the dowel hole on the gear with the shaft dowel and then tap the gear on. Secure the gear to the shaft with six No. 536379 (5/16-24 x 15/16) hex drilled-head bolts and torque to the value specified in Section XV. Lock the screw heads together in pairs with lock wire. (See figure 43.)

11-14. CAMSHAFT. Tap a 5/8 in. dia. x 1/8 in. Woodruff key into the key slot at the front end of the camshaft. The gear can be installed on the camshaft flange in only one position, due to the offset position of one screw hole. Attach the gear with four 5/16-24 hex drilled-head bolts, and secure these in pairs with lock wire. (See figure 45.)

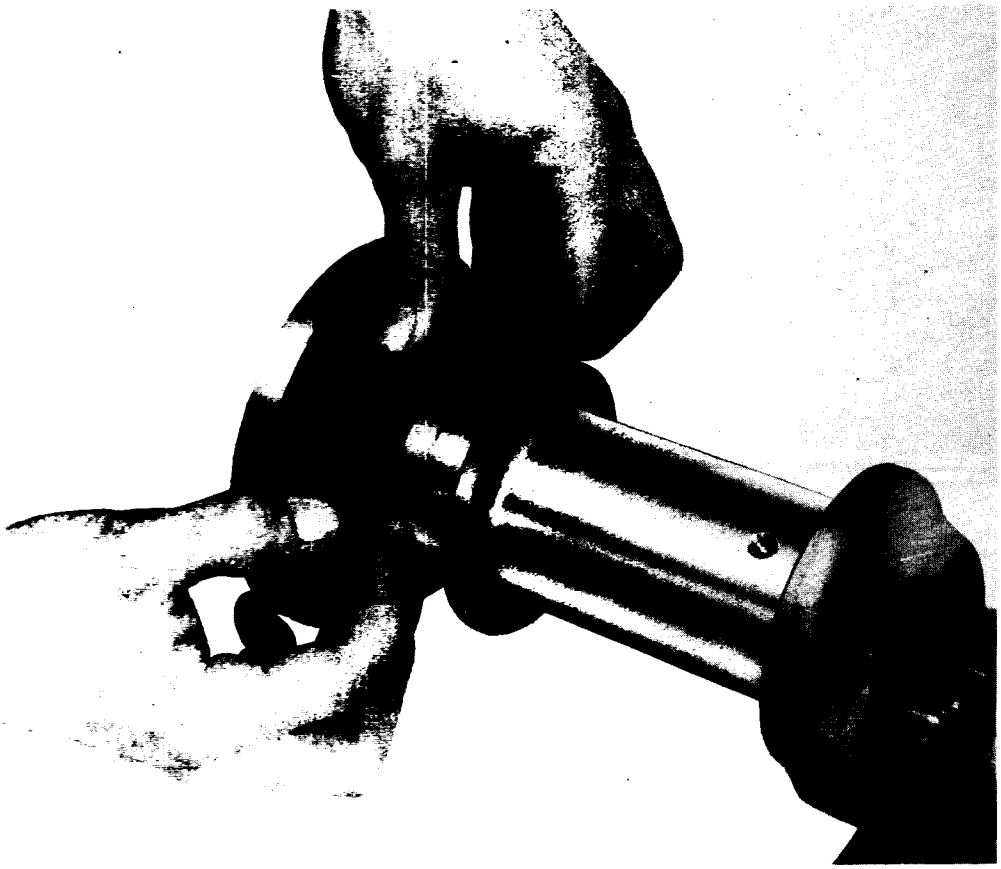


Figure 42. Installing Crankshaft Oil Seal Spring

11-15. CRANKCASE. (See figure 23.)

a. If any of the 3/8 in. pipe plugs were removed from the castings install serviceable plugs in the open holes. Make sure that a 1/8 in. pipe plug is installed below the 3/8 in. plug in the side of the right crankcase. Install new gaskets and plugs in the right crankcase.

b. Screw the Vernatherm control valve (67) into its chamber at the front of the right crankcase, and tighten it. Tie it with lock wire to the plug below the oil cooler pad.

c. Install the pad cover and attaching parts (53 through 58) on the left crankcase, unless a governor is to be installed at final assembly.

d. If the engine mount brackets (46 or 47) were removed, reinstall them and their attaching parts.

e. Install the fuel pump pad cover, gasket and attaching parts (48 through 52) on the rear side of the left crankcase, unless a fuel pump is to be installed at final assembly.

f. Make sure that the gasket in the filler cap (62) is serviceable; then lock the cap on the filler neck.

g. Turn both crankcase castings open side up. Clean thoroughly the new main bearing set, and snap the inserts into the crankcase seats so that their ends project very slightly and equally, and install the nylon inserts in the front bearings.

SECTION XII
FINAL ASSEMBLY

12-1. GENERAL INSTRUCTIONS.

12-2. LUBRICATION. Apply clean engine lubricating oil liberally to all bare steel surfaces, journals, bearings and bushings before and/or after installation, depending on accessibility, except where special lubricants are mentioned.

12-3. TIGHTENING TORQUES. Instructions in paragraph 11-2 are applicable to final assembly work.

12-4. PALNUTS. After tightening a palnut with the fingers, tighten it only 1/6 to 1/4 turn with a wrench. Excessive tightening will deform the spring teeth, making the nut difficult to remove and ineffective as a safety device.

12-5. CLEARANCES. When possible, measure clearances of running parts as they are installed. When end clearances, side clearances and backlashes cannot be measured with normal thickness gauges due to the inaccessible positions of the parts, test for binding and excessive looseness as well as possible by moving the running part.

12-6. COVERS. Unless the atmosphere is unusually free of dust and airborne grit, it is advisable to cover openings as soon as possible and to cover assemblies and the partial engine assembly whenever they are not in the process of being assembled. Cover all openings into which small parts might be dropped.

12-7. CRANKCASE. (See figure 24.)

a. Install the oil filler neck and attach the mount brackets on the left crankcase to the assembly stand in the same way as during disassembly, and place the pipe support (1) under the casting.

b. Spread a film of lightweight Tite-Seal compound in the crankshaft oil seal recess at the front end of each crankcase casting. Do not apply enough that it will be squeezed into the assembled case.

c. Lubricate all main bearing inserts and crankshaft journals. Lift the shaft assembly by the number 1 connecting rod and the propeller mount flange. While a second person holds up the number 3 and 5 connecting rods, lower the assembly into position in the left crankcase bearings with the oil seal positioned so as to enter its case recess. The connecting rod position numbers should automatically be toward the upper case flange if properly installed. If the oil seal split is elsewhere, rotate the seal to replace it about 5/8 in. below the case parting surface toward the upper case flange while holding up the front end of the shaft. Lay the odd-numbered connecting rods on the upper case flange.

d. Insert the governor driven gear (5) into its bearing.

e. Slide the governor driver gear on the front end of the camshaft. Lay the camshaft assembly in its bearings in the left case, meshing the spur gear teeth with those of the crankshaft gear, so that the timing marks will align as illustrated in figure 43, and turning the governor driven gear to mesh it with the driver gear.

f. With a feeler gauge, measure the crankshaft end clearance at either end of the thrust bearing with the shaft pushed toward that end. Similarly, measure the camshaft end clearance at either end of its rear bearing. Check for perceptible backlash between spur

gears and bevel gears.

g. Install the idler gear assembly and support pin in the left crankcase as illustrated (bushing thrust flange to rear).

h. Use lightweight Tite-Seal and spread in a thin but continuous film all around the left crankcase parting flange, taking care not to get it on other parts. Lay lengths of No. 50 silk thread on the parting flange where illustrated (9, 10, 11 and 12). The thread should be inside the bolt holes but never on the edge.

i. Stand up the odd-numbered connecting rods.

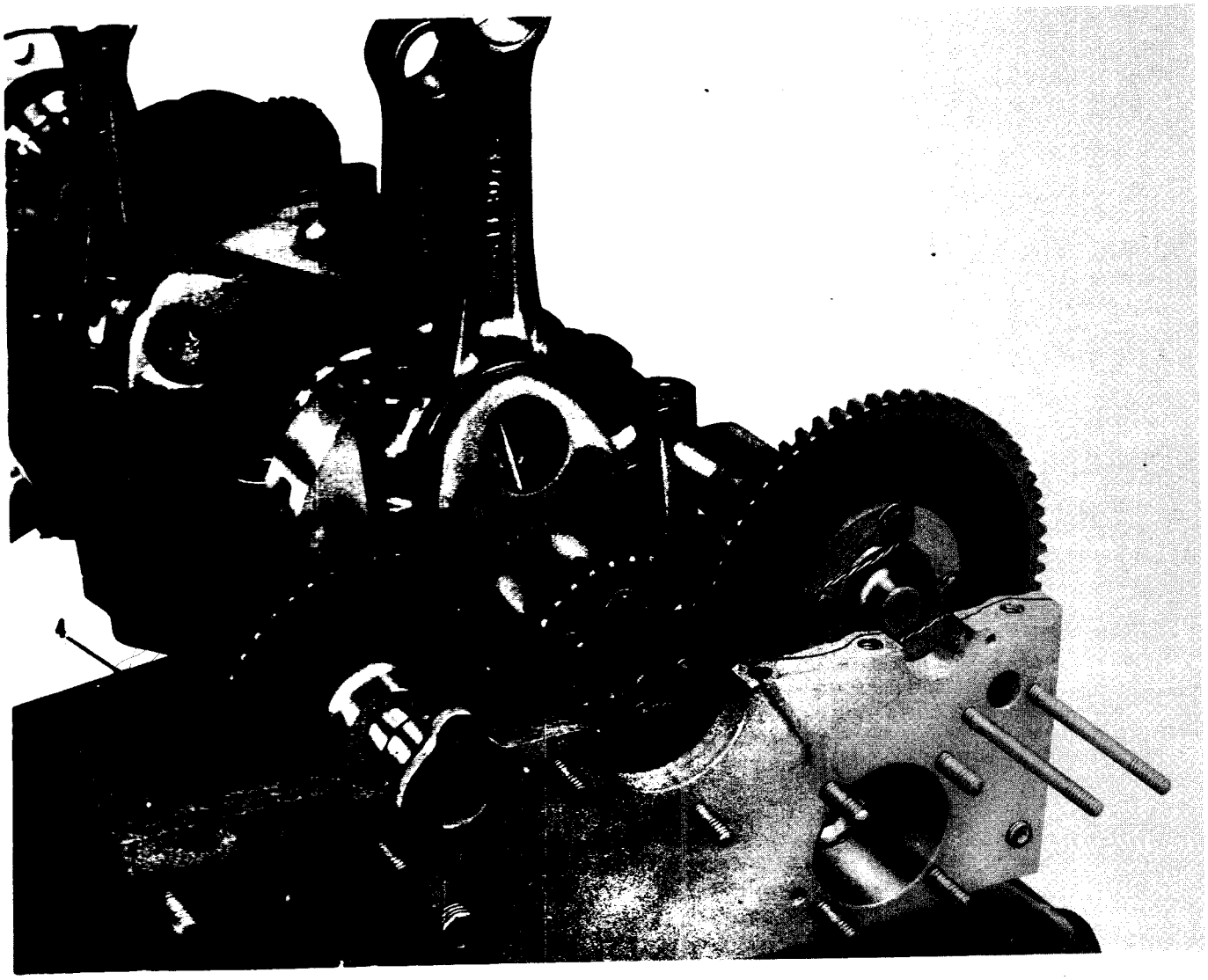
j. Lay the right crankcase subassembly on the left case. Take care not to displace or damage the crankshaft oil seal and nylon inserts.

12-8. (See figure 23.)

a. Insert (from above) the two 8-7/8 in. through bolts (36) at the front of the crankcase, the 9-13/16 in. through bolt (38) in front of No. 5 cylinder mount pad, the seven 10-3/4 in. through bolts (39) through the cylinder mount pads and the four 10-1/2 in. through bolts (37) below the camshaft level. Tap all of these through to centered positions with a non-marring hammer. These bolts align the crankcase castings and thrust bearings.

b. Install a spacer and a flanged nut on each end of the two front through bolts, a spacer and flanged nut on the top end of the two through bolts ahead of No. 5 cylinder and on the bottom end of the upper rear through bolt nearest to the magneto mount pad.

c. Install two spacers (12), the lifting eye (11) and



1. Camshaft timing mark
2. Crankshaft timing mark
3. Idler gear support pin
4. Idler gear

Figure 43. Idler gear Support Pin and Timing Marks

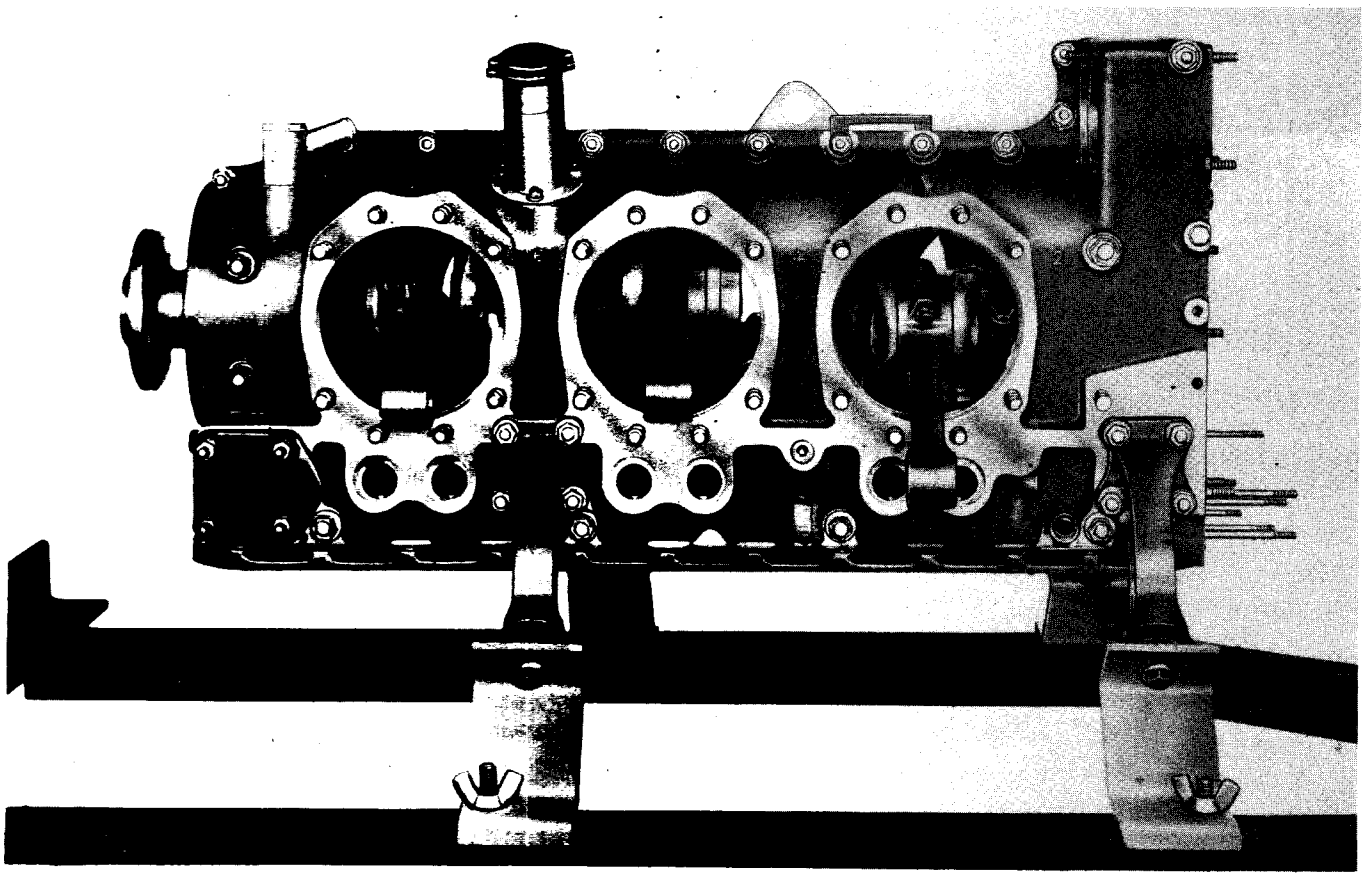


Figure 44. Left Side of Completed Crankcase Assembly

its attaching parts (10, 9, 8, 7, 6).

d. Immediately behind the lifting eye install the brace (22, figure 40), then install the upper flange attaching parts (5, 4, 3, 2, 1), and install washers and a nut (3, 2, 1) on the bolt (71) already in place. Do not tighten any of these attaching parts yet.

e. Install one bolt and washers (18, 19, 20) at the left rear, one O-ring and two bolts and washers (18 through 21) at right rear and one bolt and washers (18, 19, 20) at right front. Do not tighten any of the attaching parts in this group yet.

f. Seat the idler gear support pin. The eccentric shoulder must be away from the crankshaft. Do not install the attaching parts yet.

g. Tighten all attaching parts installed in steps "d" and "e".

h. Install two O-rings, one bolt and attaching parts (13 through 17) in the upper rear case hole, and tighten the nut.

i. Attach the right crankcase mount brackets to the assembly stand; then rotate the engine bed until the crankcase is upright.

j. Install the generator mount bracket on the lower rear through bolt, and attach it with a nut and spacer. Do not install the palnut yet.

k. Install and tighten the support pin attaching parts (29, 30). Figure 44 shows the completed crankcase assembly.

12-9. CYLINDERS AND PISTONS. (See figure 45.)

a. Before installing each piston and cylinder, turn the crankshaft until the corresponding rod is at T.D.C.

b. Place the piston over the connecting rod with the position number on its head forward, and push the pin through until it is centered.

c. Lubricate the piston and rings liberally with engine oil.

d. Hang a piston ring compressor on the piston skirt. Then hold the cylinder in the left arm, center the compressor over the piston rings, compress them fully. Push the cylinder onto the piston, forcing the compressor off the piston.

e. Remove the ring compressor and start the cyl-

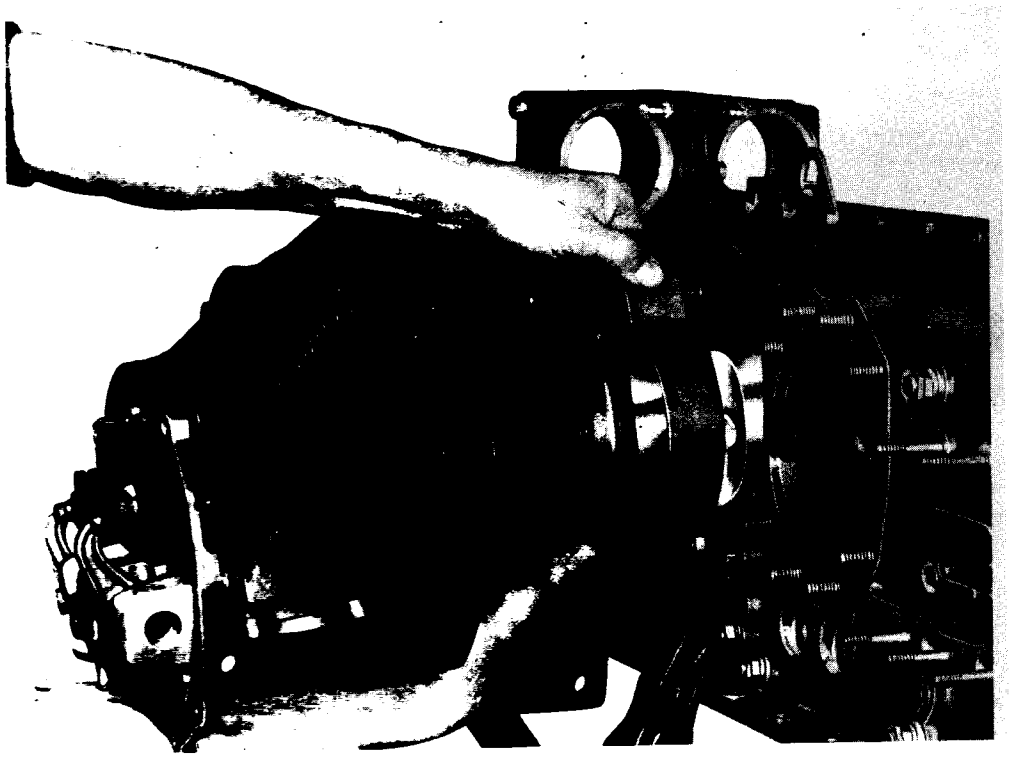


Figure 45. Installing No. 5 Cylinder and Piston Assembly

inder base flange onto the hold-down studs.

f. After making sure the base flange packing ring is in place and not twisted, seat the flange on the crankcase cylinder pad.

g. Install pistons and cylinders in any desired order. In order to minimize turning of the crankshaft and to prevent excessive unbalance, it is suggested that No's 1 and 2 be installed first, then the shaft turned for No's 3 and 4 and these assemblies installed; then the shaft positioned for No's 5 and 6 and the last two installed in those positions.

h. As soon as a cylinder has been installed, attach it first with the upper four nuts, then with the lower four. Tighten these moderately.

i. Tighten the flanged nuts in the sequence of index numbers of figure 46 to a torque between 490 and 510 in.lb. Beginning with index number 1 (figure 46), and in a clockwise sequence, tighten the nuts to a torque between 490 and 510 in. lb.

j. Install a palnut over the flanged nut on each end of each through bolt.

k. Equip six spark plugs with serviceable gaskets, and screw them into the upper cylinder holes.

12-10. FUEL PUMP. For O-470-M engines, lubricate the fuel pump drive gear, install a new gasket on the

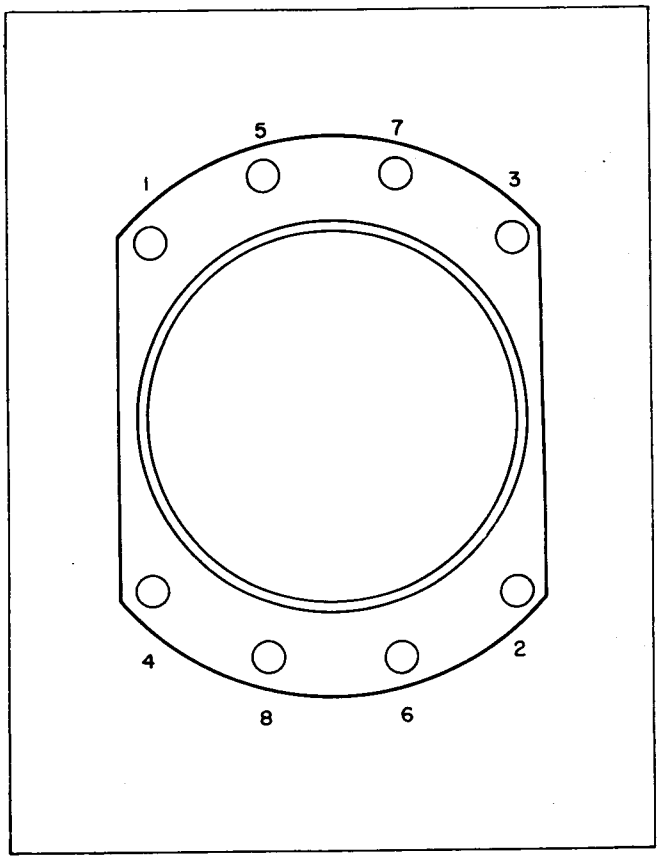


Figure 46. Cylinder Base Nut Torque Diagram

four lower left rear crankcase studs, install the fuel pump adapter, insulator, gasket. Coat the pump shaft splines with a light film of Lubriplate and install the pump. Secure the pump to the crankcase with four each plain washers, shakeproof lock washers and plain nuts.

12-11. OIL PUMP.

a. Remove the two nuts and washers which attach the tachometer drive and pump cover, and, holding the assembly so that the tachometer driven bevel gear will be above the shaft, remove the cover assembly. Prop it up on the bench in the same position.

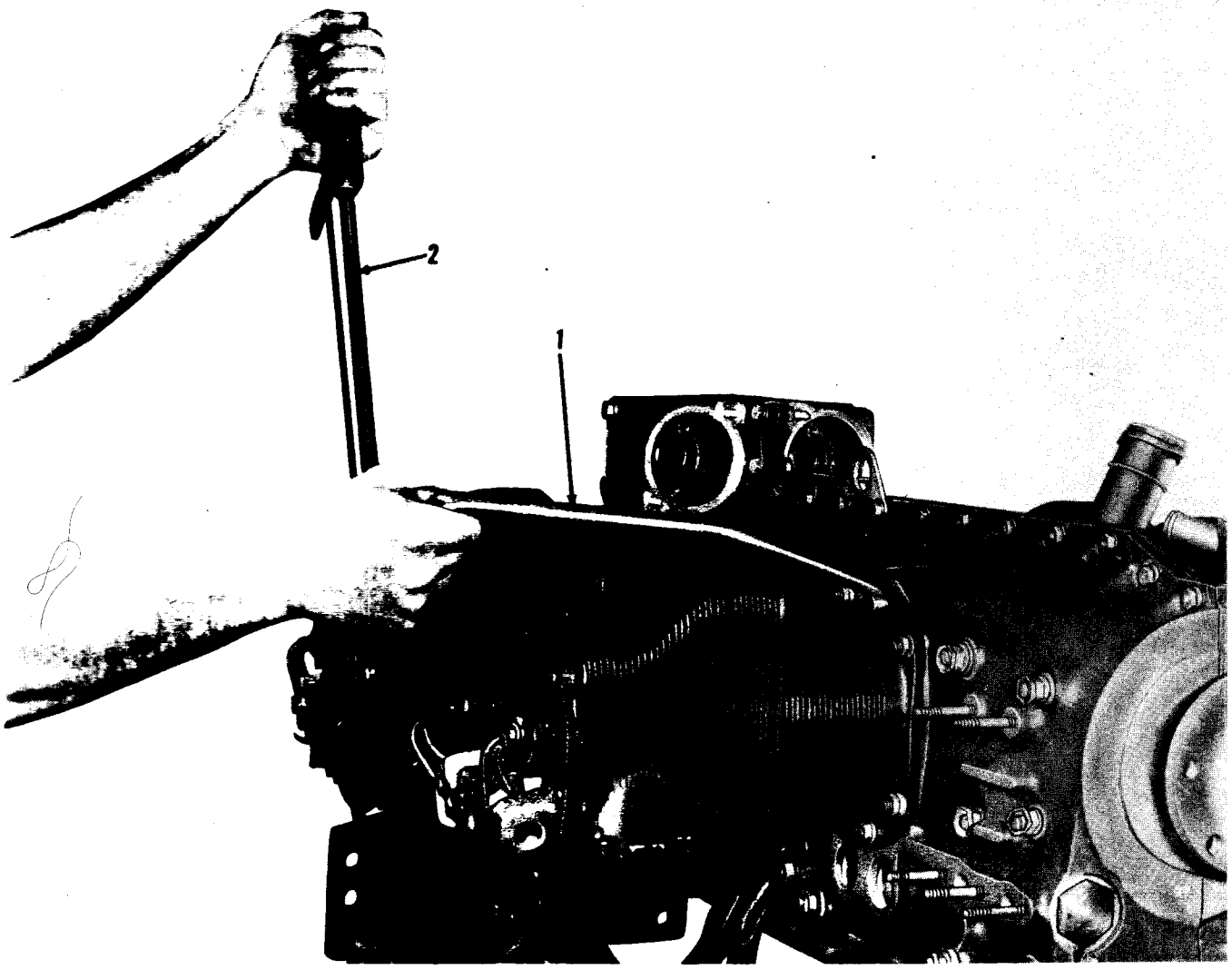
b. With a small, round brush, spread a very thin, uniform film of gasket shellac on the rear parting surface of the pump housing.

c. Lay No. 50 silk thread around the rear housing surface inside the bolt holes and studs, but clear of the edge. Overlap the ends.

d. Before the shellac has set, install the cover assembly, keeping the tachometer driven gear in place, and attach it with two sets of washers and nuts, as before.

e. Without delay, lubricate the pump shaft splines with Lubriplate grease, and install the pump assembly on the crankcase studs. Install plain washers, internal tooth shakeproof washers and plain hex nuts on the ten studs; then tighten those and the cover attaching nuts consecutively around the housing, making two or three circuits to reach specified torque on all nuts. (See figure 48.)

f. Tighten the oil filter cap and the left-hand threaded tachometer drive housing.



1. Cylinder base nut wrench

2. Torque indicating wrench

Figure 47. Tightening Cylinder Base Nut With Torque Wrench

12-12. STARTER DRIVE ADAPTER.

a. Place a new gasket on the crankcase dowels of the adapter mount pad.

b. Lubricate the spur gear, and mesh it with the crankshaft gear as the adapter assembly is placed in position. Seat the adapter on its gasket and secure it with washers, shakeproof lock washers and plain nuts, on the crankcase-to-adapter studs (S of figure 21).

c. Remove the adapter cover attaching bolts (A and C of figure 21) and install the generator support bracket.

d. After installing the generator support bracket, install a shakeproof lock washer and plain washer on each of the three bolts (B of figure 21); then install and tighten the bolts.

12-13. GENERATOR. (See figure 49.)

a. Position the generator (2) on the mount and support brackets (1), and install the attaching parts (3 through 7, 10 and 11).

b. If the generator sheave (8) has not been installed remove the shaft nut and install a Woodruff key in the shaft key slot; then install the sheave and nut.

c. Install the drive belt (9) on the starter adapter and generator sheaves, and hold the generator outward while tightening its clamp bolt (11) so that the belt can be moved up or down from its natural position about 1/2 in. Tighten and check for security all starter-adapter, carburetor-support and generator bolts.

12-14. MAGNETO AND ACCESSORY DRIVE ADAPTERS. Place new gaskets on the two upper four-stud mount pads at the rear of the crankcase with their oil holes aligned with crankcase oil outlet holes. Install the two adapter assemblies with oil holes aligned with the crankcase oil outlet holes. Attach both with plain and shakeproof washers and plain hex nuts. (See figure 48.)

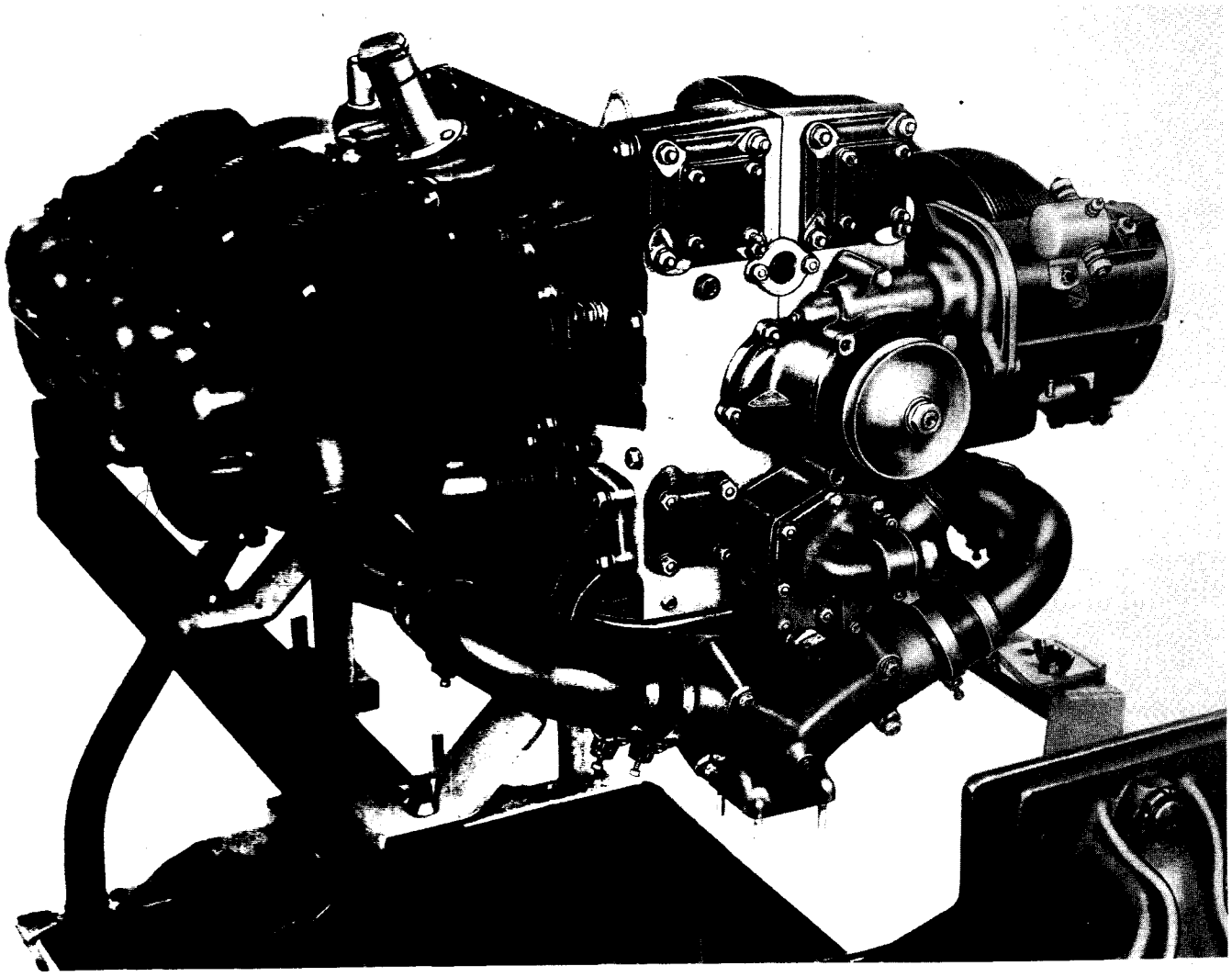
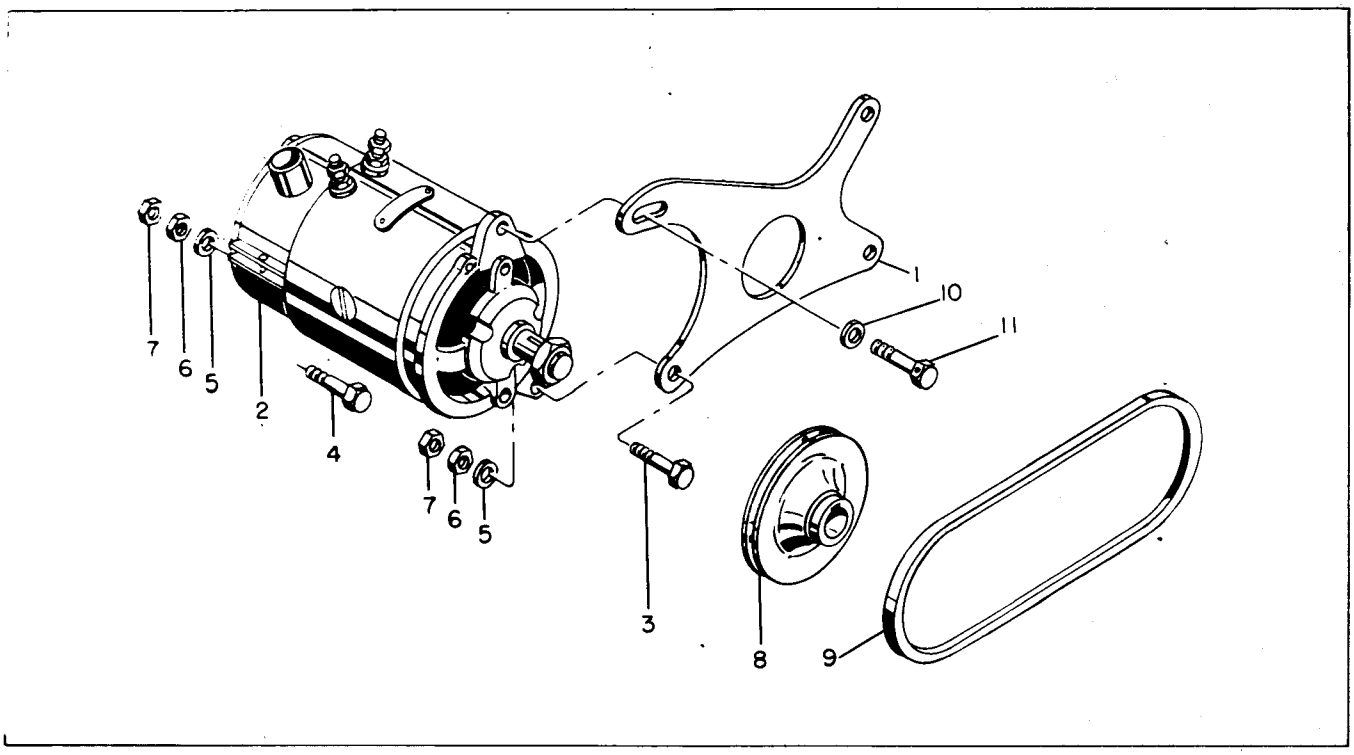


Figure 48. Crankcase with Cylinders, Oil Pumps, Starter Adapter and Accessory Adapters



1. Generator support bracket
2. Generator
3. Bolt
4. Bolt
5. Plain washer
6. Plain hex nut
7. Lock nut
8. Generator sheave
9. Generator drive belt
10. Plain washer
11. Bolt

Figure 49. Generator and Attaching Parts

12-15. VALVE MECHANISM.

a. Turn the engine upside down.

b. Figure 50 illustrates the use of a locally manufactured spring compressor to facilitate installation of pushrod housings.

c. Lubricate the exterior surface of each tappet just before installing it in one of the crankcase guides. Apply oil to the socket, but not into the body oil holes. Install all tappets.

d. To install each pushrod housing, compress the spring and place on that end of the housing a sandwich of one red Silastic seal between two steel washers (see figure 50). Insert this end of the housing into the crankcase tappet guide until the other end and its seal ring can be aligned with the cylinder head opening. Move the assembly outward until the seal has entered the cylinder hole; then release the spring slowly until it is free, and remove the compressor.

e. Install first the six pushrod housings nearest to the engine mount brackets, since the compressor must lie close to the horizontal in order to clear the crankcase flange; then install all others.

f. Before installing the valve-actuating parts on each cylinder, turn the crankshaft until cam lobes for that pair of tappets are pointed to the opposite side of the engine.

g. Install lubricated pushrods and seat them in the tappet sockets. Push the rocker shaft endwise to clear either rocker position, and place the proper type of rocker in the opening and on the pushrod end. Hold it inward to align its bearing with the shaft hole, and push the shaft through to its working position. Install the second rocker in the same manner. Install and safety, with lock wire, the rocker shaft retaining bolts.

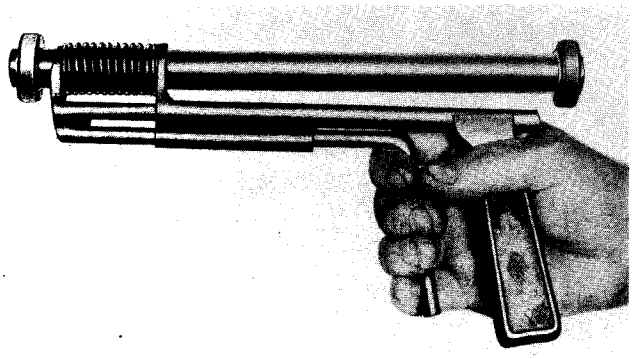


Figure 50. Pushrod Housing and Spring Compressor

h. Install pushrods and rockers in the other cylinders in the same manner as in the preceding step.

i. Install all valve rocker covers and new gaskets and attach each with seven sets of parts (2, figure 51).

12-16. OIL PUMP SUCTION TUBE. (See figure 51.)

a. Place a new gasket on the crankcase suction tube pad and position the suction tube assembly as illustrated.

b. Attach the suction tube assembly with four drilled head bolts to the crankcase. A plain washer is installed under each head of the flange attaching bolts.

c. Tighten the attaching parts to the torque specified in Section XV and secure with lock wire as illustrated in figure 51.

12-17. OIL PUMP. (See figure 52.)

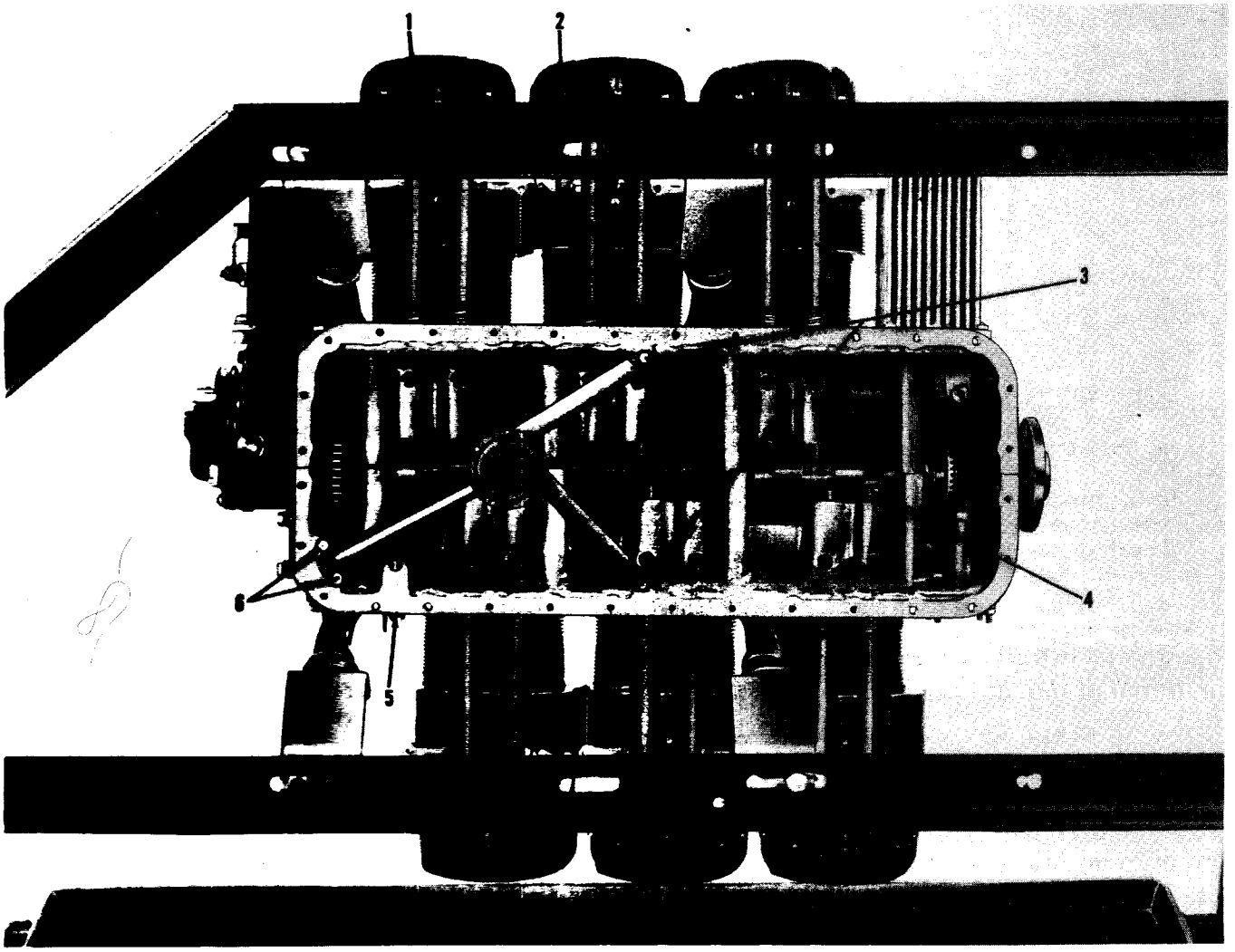
a. Spread a thin uniform film of Tite-Seal or gasket shellac on both sides of the sump gasket and position it on the crankcase.

b. Lay the sump on the crankcase, install the manifold riser brackets, the sump attaching parts and for O-470-M engines, the manifold balance tube brackets.

c. Install and safety the sump drain plugs.

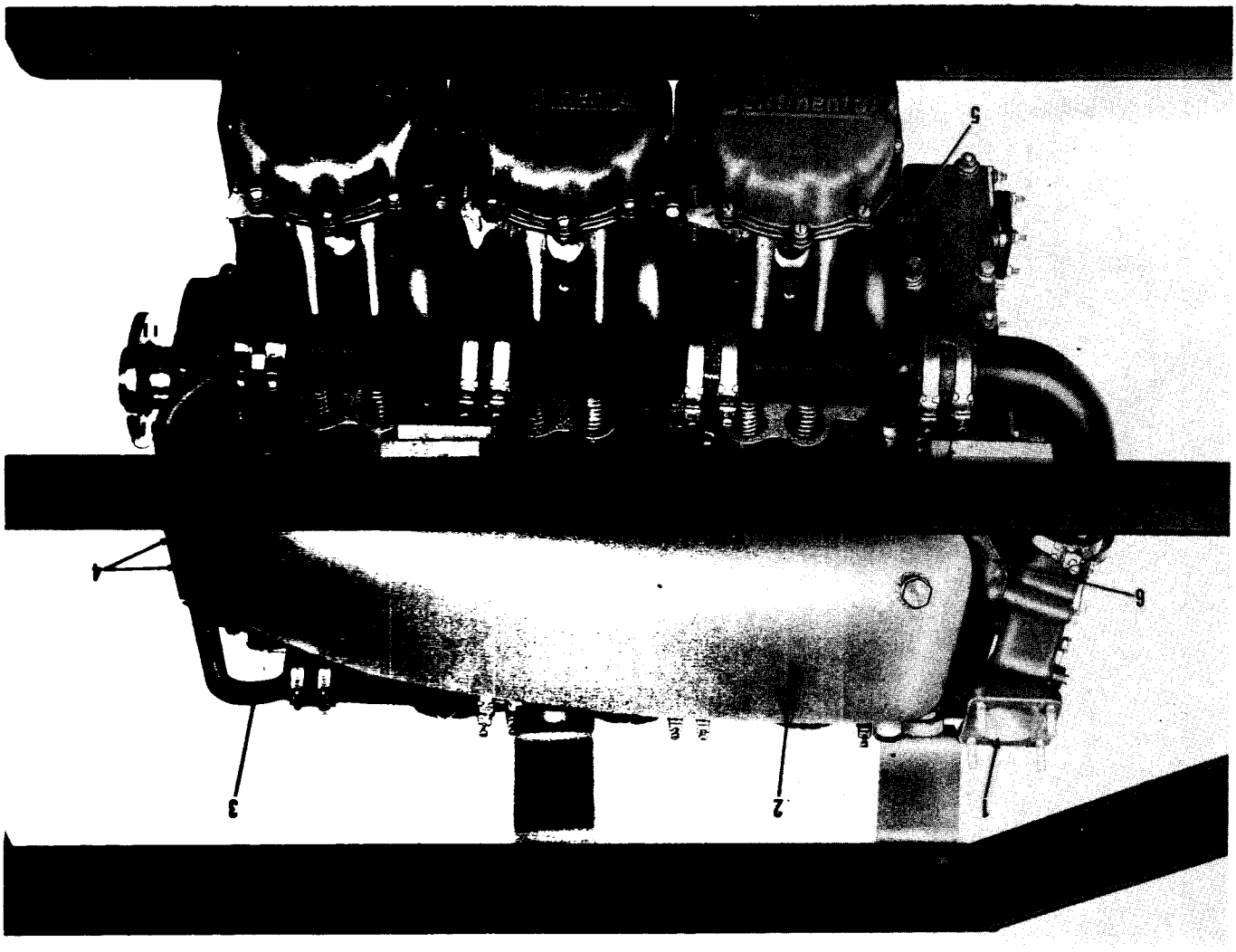
12-18. INDUCTION SYSTEM. (See figure 53.)

a. Push one of the hose connectors on each end of each center intake tube until they cover a length of 1-1/8 inches. Slide one hose clamp on each hose to a position midway on the overlapping portion. Turn each clamp so that a screwdriver can be aligned with



1. Valve rocker cover
2. Plain washer, lock washer and 1/4-20 x 3/4 in. screw
3. Plain washer, 1/4-20 x 15/32 in. screw and lock wire
4. Valve lifter
5. Oil gauge guide
6. Plain washer, 1/4-20 x 19/32 in. screw and lock wire

Figure 51. Bottom View with Valve Mechanism and Oil Suction Tube Installed



1. Riser manifold
2. Oil sump
3. Balance tube
4. Balance tube attaching bolts
5. Intake pipe attaching bolts
6. Riser manifold support bracket

Figure 52. Oil Sump and Riser Manifold Installed, O-470-K

its screw and yet clear of the stand when the tube is installed. Tighten the clamp screw only enough to hold the hose in position.

b. Place a hose clamp on one end of each end cylinder intake tube so as to face the center tube, and push the end tubes into the hoses already installed. Work the hose clamps over the ends of the hoses, but not past the beads. Do not tighten these clamps.

c. Push a hose on the front end of each side manifold assembly, and install a clamp on the overlapping portion inside the tube bead. Tighten both clamps.

d. Lay a new gasket on the intake flange of each cylinder. Position each side manifold assembly on the proper bank of cylinders, and adjust the individual tubes so as to seat squarely on the cylinder intake ports. The end tube must be located above No. 2 cylinder.

e. Attach each of the six intake tube flanges to its cylinder with four sets of attaching parts.

f. Tighten the clamps on the two center hoses on each side so that they lay inside the tube beads.

g. For models O-470-K and O-470-L engines, it is first necessary to remove the two front center sump bolts. Place a hose clamp on each end of the balance tube and then push the ends into the previously installed connecting hoses. Install the sump bolts through the balance tube bracket and screw back into the crankcase flange.

h. For model O-470-M, place a hose clamp on each

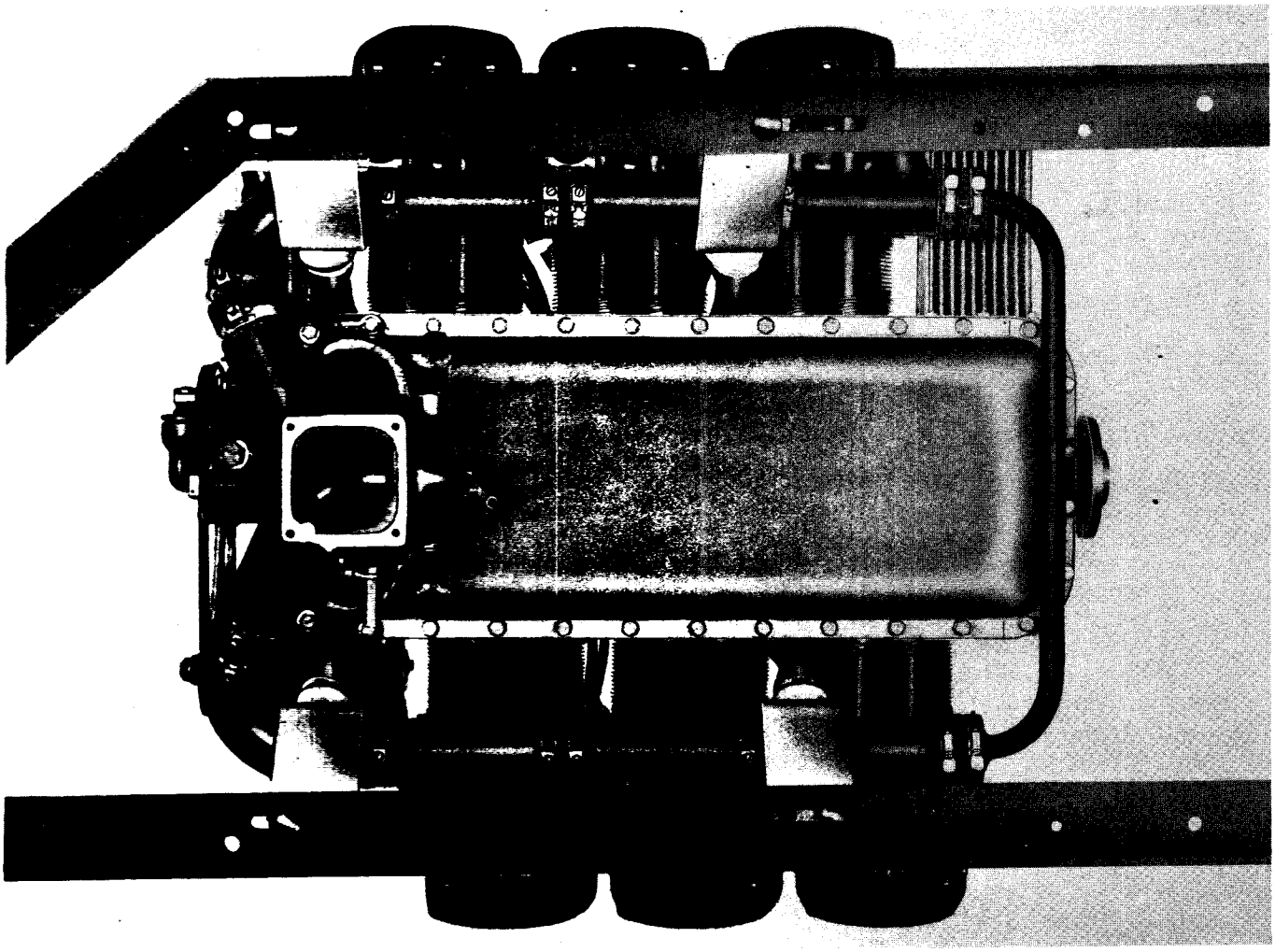


Figure 53. Induction System and Carburetor Installed, O-470-L

Figure 54. Position of Magneto Couplings

end of the balance tube and lay the tube in its bracket. Push the tube ends into the connecting hoses installed on the manifold. Secure the balance tube to the brackets with the clamps and their attaching parts. Push the hose clamps over the hose ends and tighten.

i. On models O-470-K and O-470-L engines, attach the riser manifold to its support brackets and safety the bolts in pairs with lock wire. Install a new gasket and the carburetor on the riser manifold's bottom flange and secure with four plain washers, shakeproof lock washers and plain nuts.

j. Install the riser to elbow connecting hoses in such a manner as to clear the joint. Insert the elbow into the manifold connecting hose. After positioning the hoses tighten the clamps in place. Check all attaching parts for sufficient and proper torque. The engine may now be rotated on the stand to its upright position.

k. For O-470-M engines, attach the carburetor top support bracket to the idler pin studs on the crankcase rear. Attach the carburetor to its top support. Install a new gasket on the riser manifold and insert

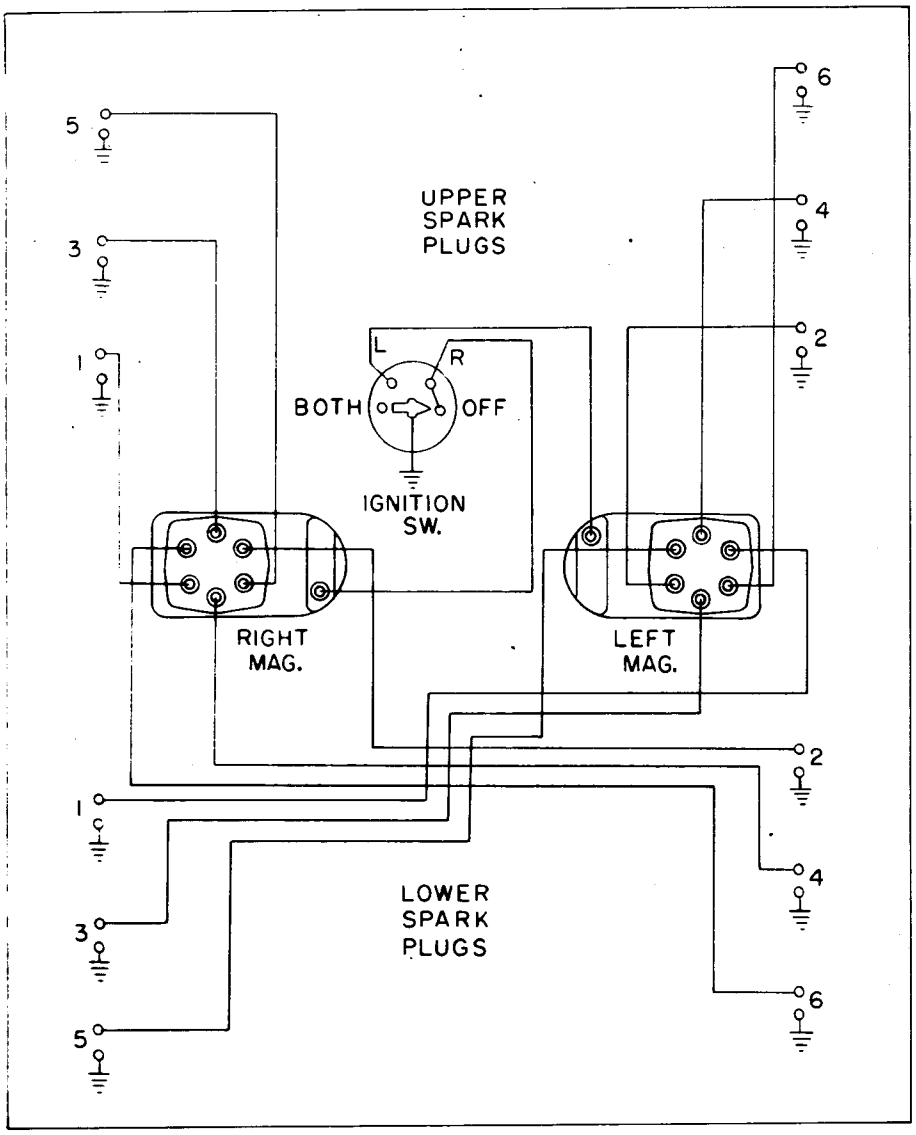


Figure 55. Ignition Wiring Diagram

the studs through the carburetor's bottom flange and the lower support brackets. After securing the riser to the carburetor and brackets, with five sets of attaching parts, work the elbow to the riser connecting hose onto the riser, position and tighten the hose clamps.

12-19. OIL COOLER. For model O-470-K engine:

a. Install a new oil cooler gasket on the crankcase studs in front of No. 5 cylinder.

b. Position the oil cooler on the crankcase-to-cooler studs and attach it with five plain and shakeproof washers and plain hex nuts.

For model O-470-L engines:

a. Install a new gasket on the crankcase studs, install the cooler adapter and secure it with plain washers, lock washers and nuts on the two upper studs.

b. Install the cooler with a new gasket on the adapter and secure it with plain washers, lock washers, three plain nuts and five hex head screws.

For model O-470-M engines:

a. Install a new oil cooler adapter-to-crankcase gasket on the crankcase studs in front of No. 5 cylinder.

b. Install the crankcase-to-oil cooler adapter and secure it with five each plain washers, shakeproof lock washers and plain nuts.

c. Install a new oil cooler-to-adapter gasket and oil cooler. Secure it with twelve plain washers and drilled hex-head bolts. Safety the bolts together in pairs with lock wire.

12-20. MAGNETO DRIVE GEARS. (See figure 54.)

a. Insert one of the pressed-steel coupling retainers

into each gear hub slot.

b. Cover each of four new rubber coupling bushings with a film of Lubriplate grease. Insert two bushings into each retainer, rounded long edges first.

c. Turn the crankshaft to the No. 1 cylinder advance firing angle as described in the following paragraph, then lubricate each magneto drive gear shaft and teeth, and insert both gears into their bushings. Observe the shaft ends from the rear as they are carefully pushed through the adapter oil seals to make sure that the seal lips are not reversed or damaged. Mesh the magneto drive gears with the idler gear so that the coupling bushing slots assume approximately the illustrated positions. These positions will vary slightly due to differences in magnetos and gears.

12-21. PLACING CRANKSHAFT IN TIMING POSITION. The magnetos are timed to the engine in the full advance firing position of No. 1 piston, i.e., the magnetos must be installed with their timing marks aligned while the No. 1 crankpin is 22° B.T.C. for O-470-K and O-470-L engines, or 24°B.T.C. for O-470-M engines, on its compression stroke. The No. 1 crankpin will be at this angle when the mark on the edge of the propeller mount flange representing 22° B.T.C., for O-470-K and O-470-L engines, is in line with the crankcase parting line below the crankshaft. It is also necessary to be sure that the No. 1 piston is on its compression stroke. Observe piston position with the No. 1 upper spark plug removed. (Lower plugs should not be installed yet.) To locate the compression stroke, install a plug in the No. 1 cylinder lower hole, and plug the upper hole with a thumb. If the crankshaft is turned backward a suction will be felt, or if forward, air in the cylinder will be compressed. Having located the proper stroke, the firing angle may be located with the aid of a sliding depth gauge or other squaring tool placed on the propeller flange with one edge over the 22° mark for O-470-K and O-470-L engines, or the 24° mark for O-470-M.

12-22. MAGNETOS.

a. Unscrew the timing inspection hole plugs.

b. To place either magneto in its timing position, turn the impulse coupling backward so that the latches will not engage until the timing pointer inside the inspection hole is aligned with the white distributor gear tooth.

c. Without turning the magneto coupling, hold the magneto in the horizontal position it will occupy when installed, and see that the gear coupling slot is aligned with the impulse coupling lugs. If it isn't, pull the gear out of mesh (but not out of the oil seal), and turn it to the aligned angle; then push it back into mesh.

d. Install the magneto and secure it with the clamp washers, shakeproof washers and nuts, but only tighten enough to permit turning the magneto for final timing without looseness.

12-23. IGNITION HARNESS. (See figure 40.)

a. The high tension cable outlet plate of each cable assembly can be attached to either magneto in only one position, due to the unequal screw spacing. The very shortest ignition cable is for No. 1 upper spark plug, and identifies the proper assembly for the right magneto. The wiring may be traced with the aid of either figure 40 or figure 55. Notice the "1" on the outlet plates next to the No. 1 cylinder cable outlet holes.

b. Attach each cable outlet plate to its magneto with four sets of parts (32, 33).

c. Lay the lower spark plug cables from each magneto across the brace (22) on the crankcase top flange in two layers of three cables each. Install the clamp and its attaching parts (23, 24, 25).

d. Install all spark plugs not already in place with smooth copper gaskets. Tighten all plugs to specified torque.

NOTE

Before final installation, coat spark plug 18 mm. threads with a film of BG mica thread lubricant.

e. Insert cable terminal sleeves into the proper plugs, and screw on the elbow coupling nuts only tight enough to keep the elbows from turning. Keep the lower spark plug cables above the intake manifold and inside the intake elbows.

12-24. FINAL PARTS.

a. Unless optional accessories are to be installed on the mount pads behind the magneto drive gears before the test run, install gaskets and covers. Attach each with four plain and shakeproof washers and plain hex nuts.

b. Install a new "O" ring on the oil level gauge, and insert the gauge in the support sleeve at the left side of the crankcase.

SECTION XIII
REPAIR AND TESTING OF ACCESSORIES

13-1. HYDRAULIC VALVE TAPPETS.

Select a clean bench space in a location where there is adequate light and a minimum of air circulation and air-borne dust. If the bench top is wood or metal, spread over it a clean sheet of heavy brown wrapping paper. A bench covered with linoleum or tempered Masonite is preferable. In any event, the work surface should be absolutely clean. If the volume of tappet work permits, it will be advisable to provide a rack of varnished wood or of sheet aluminum to hold the parts while they are disassembled. If such a rack is not available, the disassembled parts of each tappet should be placed in a row on the clean work surface so as to avoid interchanging them between assemblies. Particularly, it is essential that bodies, sockets and plungers, be kept in original relationship, since they are selectively fitted to obtain the specified "leak-down" rate (the rate at which oil escapes past the plunger). Obtain a supply of cleaning solvent of a type which leaves no perceptible solid residue when it evaporates. Cleaners' Naptha and the various trade-named mineral spirit solvents used in regular cleaning of engine parts will be satisfactory. The solvent must be previously unused, and the supply should be kept in a tightly-covered can. Pour out a sufficient quantity of solvent into a clean pan, such as a tinned cake pan, for use, and discard the working bath whenever it becomes discolored or contains an appreciable amount of sediment. No special tools are required, though a new paint brush may be used to loosen sludge deposits.

13-2. DISASSEMBLY.

a. Clean the assembled tappet, then stand it on its flat end.

b. Use a small screwdriver carefully to pry the snap ring's flat sides inward, in turn, until the ends are disengaged from the body groove. Hold down the socket with a pushrod or other ball end tool until the snap ring has been removed.

c. Invert the tappet, and catch the socket as it drops out.

d. Invert a finger into the plunger, and withdraw it and the attached spring and check valve assembly. If the socket was not held out against the snap ring, the plunger will be stuck tightly in the body. This may be due to the formation of a ring of hard carbon around the upper oil groove. It may be possible to scrape off such a deposit with a blunt-edged knife, holding the plunger fully down in the body. If so, the carbon should be blown out with a watchmaker's blowgun or a small rubber ball-type syringe as it is scraped loose. If such an obstruction cannot be removed, or if the plunger is seized by score marks, the entire assembly must be discarded.

e. After removing the plunger, detach the spring by turning it so as to unwind it while pulling outward. Sometimes the spring will come off without twisting, but do not stretch it out of shape.

f. To remove the check valve cage from the edge of the plunger, use a very small screwdriver or a cotter pin inserted only far enough to pry against the plunger shoulder just inside the cage slots. Do not flip the cage off: just loosen it; then lift it off while the plunger stands on its open end. Take off the check valve spring and the valve plate.

13-3. CLEANING AND INSPECTION.

a. Clean the tappet parts individually in the solvent, and inspect all oil grooves, oil holes and corners for deposits. Each part must be thoroughly clean, all oil holes unobstructed and all particles of carbon and other foreign matter removed from all surfaces.

b. Inspect the body for nicks, scores and other roughness on all machined surfaces. Inspect the cam follower face for pitting, radial scores and groove wear. The latter indicates that the tappet did not rotate as it is intended to do. This may be due to excessive wear on the tapered toe of the cam lobe. None of these defects may be allowed.

c. Inspect the socket for scoring in the concave area. If properly lubricated, the socket should wear to a mirror polish at the bottom. The size of the worn area is not a true indication of the extent of wear, since there is some variation in pushrod ball-end radius and hardness, as well as in socket hardness. If the worn area is small in diameter it may appear to be rather deep. This, too, is deceptive. Unless there is indication that wear has gone beneath the hard case depth, the socket will be serviceable, unless it is rough. Inspect each of the right-angle socket oil holes while aiming the other at a strong light to check for restrictions. Remove any deposit with a 1/16 inch brass rod cut square and flat on the end.

d. Inspect the plunger exterior wall for scores and other roughness. (Do not attempt to smooth these surfaces. If they are rough the plunger is not repairable.) Make sure that its side oil hole and check-valve oil hole are clear. Inspect the check-valve seat

for nicks, pitting and scratches, using a magnifying glass in good light. The seat must be perfectly flat.

e. Inspect the check-valve plate for bending and roughness. It is possible to lap the valve plate to restore perfect flatness; however, this is not usually an economical procedure. Inspect the check-valve spring for distortion. It should stand about 1/4 inch high. Look for dirt in the valve cage, and see that it is not deformed so as to be loose on the plunger shoulder.

13-4. TESTING. Since proper leak-down past the plunger and perfect seating of the check valve are essential for maintenance of zero lash in the valve train, and since bodies and plungers are not interchangeable, it is essential to ascertain whether the original body and plunger are worn too much to operate satisfactorily and whether the check valve will seal perfectly. It is not necessary to determine the exact leak-down rate. A quick but sufficient check may be made immediately after cleaning the parts and without special equipment. For the first test assemble the plunger, check-valve plate, check valve spring and cage (refer to paragraph 13-5). Do not install the large expanding spring on the plunger. Stand the dry body on its flat end, and start the dry plunger and valve assembly into its bore. The plunger will go in easily until its inner end has passed the lower body oil hole. Unless it is very badly worn or the check valve is leaking, it will stop there. In order not obstruct the check-valve oil hole, use a screwdriver to push down on the bottom of the plunger bore. Push only a short way, and release at once - a tapping motion. The plunger should kick back promptly due to the compression of trapped air under it. It may not come quite back to the starting point, and by successive taps it can be pushed eventually to the bottom as air slowly escapes around it, but the kick back should indicate good compression. If it shows rapid leakage, this may be due to dirt on the check valve or seat or to irregularities in either part, or it may be due to wear of the plunger. A second test for valve leakage may be made by plugging the top of the plunger either with the smallest finger or with a rubber cork into which a small screw has been driven and pushing the plunger in while plugging the body oil holes by holding the body between thumb and forefinger. If the plunger resists inward and outward motion, indicating good compression and vacuum, respectively, then the check valve is not seating perfectly. In this event, clean the sealing surfaces again and inspect for possible scratches and other damage. If the valve cannot be made to seat perfectly, or if the second test indicated excessive plunger wear, discard the entire tappet. On the other hand, if the first test produced a satisfactory kickback the unit should operate well enough in the engine and, in the absence of other kinds of damage to the parts, it should be considered acceptable.

13-5. REASSEMBLY.

a. Coat the inside of the tappet body with only a film of clean engine lubricating oil. Stand it on its flat end.

b. Stand the plunger on its open end. Lubricate the check-valve plate, and lay it on the seat at the top of the plunger. Center it by eye. In the center of the valve stand the small valve spring. Place the valve cage over the spring, and push it down onto the plunger shoulder. Use a screwdriver and a small hammer or hand-tap the cage down firmly against the plunger all around.

c. Place the large expanding spring on over the valve cage. Lubricate the outside of the plunger and the spring sparingly. Insert this assembly into the body core, spring first.

d. Lubricate the socket. Place it, flat side down, on top of the plunger. Hold it inward below the body snap ring groove with a pushrod or other ball-end tool, and insert the ends of the snap ring into the groove, then with a screwdriver push the snap ring center curve into the groove.

e. Lubricate the outside of the body and its flat end with clean engine oil, but do not squirt oil into the plunger or body oil holes. Store assembled tappets under cover, or wrap them in waxed paper until ready for installation in the engine.

13-6. HARRISON OIL COOLER.

13-7. CLEANING.

a. Soak the assembly in a tank of mineral spirit solvent or cleaners' naptha to loosen and wash out heavy sludge deposits and oil.

b. Blow out the cooling fins and dry the exterior with a jet of dry compressed air after draining the cooler.

c. For a final cleaning operation, a tank of at least 10 gallons capacity with a solution-circulating pump system of approximately 35 gallons per minute delivery at 75 - 150 p.s.i. pressure should be used to circulate through the cooler core a solution of an inhibited, mild alkaline cleaning compound, such as Oakite No. 61 (6 oz. Oakite per gallon of water), maintained at a temperature between 160°F. and 180° F. A pressure gauge should be installed in the supply line and another in the return line to measure the pressure drop through the cooler. The pressure drop will decrease, i.e., the gauge readings will come closer together as the solid deposits are flushed out An adapter for attachment of the hoses must be made locally and sealed to the cooler mount flange with a gasket and three bolts, washers and nuts. The adapter may incorporate the two gauges. It may be made of steel plate and standard iron pipe fittings. The cleaning solution should enter through the normal cooler outlet port (front in installed position). A filter must be interposed in the supply hose between

STATIC FLOW

AIR		OIL	
Flow - Lbs/Min.	42	Flow - Lbs/Min.	40
Inlet Temperature	100°F	Inlet Temperature	225°F
Static Drop "H_2O"	5.0	Outlet Temperature	200°F
		Pressure Drop P. S. P.	16.0
Heat Rejection (Includes 10% F F) B.T.U./Min.			

the pump and the cooler. Circulate the solution until the discharge appears clean and the pressure drop across the cooler has stabilized at the lowest value obtained. This may require 30 minutes or so.

d. Flush the cooler core thoroughly with clean, hot water, and drain it as completely as possible. Blow off the exterior with dry compressed air.

CAUTION

Use only an inhibited, mild alkaline cleaning compound intended for cleaning aluminum parts. Strong alkaline materials intended for use on other metals will destroy the cooler by corrosive action. If such a compound has been used in the circulating equipment it must be washed out thoroughly before filling with the solution to be pumped through the oil cooler. It is essential that all alkaline material be removed from all exterior and interior surfaces of the cooler. Residues left inside the core will react with acids in the engine oil to form soap, and this will cause violent foaming in the oil system.

After a cleaning operation, empty the solution filter, and examine the filtering element for metallic particles. If any significant volume of such particles is found, the cooler from which they came should be destroyed, since there is no way of determining when all such particles have been removed.

13-8. INSPECTION.

a. Look for obstructions between the air fins.

b. Inspect the flat tubes, fins and headers for dents and bending. The assembly is allowed to be out of square 1/16 inch per foot in any direction. Any distortion will indicate the possibility of cracks and broken joints. Fins must not be bent so as to restrict the cooling air flow.

c. Inspect the mounting surface for deep scratches and cracks which would cause oil leakage.

d. To test for invisible leaks, block either oil port with a gasket and adapter plate through which compressed air may be introduced into the other port, and attach a compressed air hose to the adapter inlet. The air line should be equipped with a pressure gauge and, between the gauge and the pump, a manual shutoff valve. Lower the cooler into a water tank until it is completely immersed; then slowly open the air line valve until the pressure has risen to 100 p.s.i. Close the valve, and watch for air bubbles escaping from the cooler, accompanied by a drop in gauge reading. If necessary to maintain pressure, open the air line valve long enough to locate the source of bubbles at the cooler surface, and if the point is accessible, circle the leak with a crayon mark to identify points which may be repairable.

13-9. REPAIR.

a. Because of the welded constructions, repairs are not recommended by the oil cooler manufacturer; however, emergency repairs may be made to stop leaks in accessible locations, such as tube seams and header surfaces, when a new cooler is not available. Do not attempt to repair an oil cooler with blown or bulged tubes.

b. Clean thoroughly the area surrounding the crack or hole.

c. Apply a thin coat of a solution of Alcoa No. 33 flux in water.

d. To repair tube leaks, heat the metal with an acetylene torch equipped with a No. 3 tip, and apply Alcoa No. 716 welding wire 1/16 inch in diameter.

e. To repair header leaks or mounting pad cracks, heat the metal with an acetylene or hydrogen torch equipped with a No. 5 tip, and apply Alcoa No. 718 welding wire of 3/32 inch diameter or Alcoa No. 43S welding rod.

f. Remove all traces of welding flux by wiping all accessible areas with a clean cloth wet with hot water; then scrub with a stiff bristle brush and hot water, and wipe again with a wet, hot cloth. Flush all inaccessible areas thoroughly with hot water and dry with compressed air. Repeat the flushing and drying operation several times.

g. Repeat the air test described in paragraph 13-8d.

CAUTION

All aluminum welding flexes are highly corrosive. Exercise care to prevent the flux from entering the cooler core. Complete removal of the flux residues is essential for the same reason.

h. If a crack in the mounting surface was repaired by welding, the flatness of the surface must be restored by machining or by careful filing and lapping. Before machining or filing, plug the oil ports with a hard grease which is soluble in lubricating oil. Remove the plugs after machining or lapping and thorough cleaning.

13-10. TESTING. Seal the flushing adapter to the cooler, and connect to a high pressure hose leading through a valve to a source capable of supplying a low viscosity lubricating oil at a static pressure of 200 p.s.i. Fill the cooler by circulating oil until all air has been displaced. Then block the cooler, and apply a pressure of 200 p.s.i. Close the supply-line valve, and allow the cooler to stand under this pressure for 20 minutes, during which time there should be no oil leakage, and the gauge pressure should remain constant.

13-11. LUBRICATION. Following completion of cleaning, testing and repair work, if any, and pending installation of the cooler, flush the core with clean, low viscosity lubricating oil at a temperature of approximately 160°F. Drain out the bulk of the flushing oil, leaving a coating on the interior surfaces, and store the cooler in a tightly-covered container.

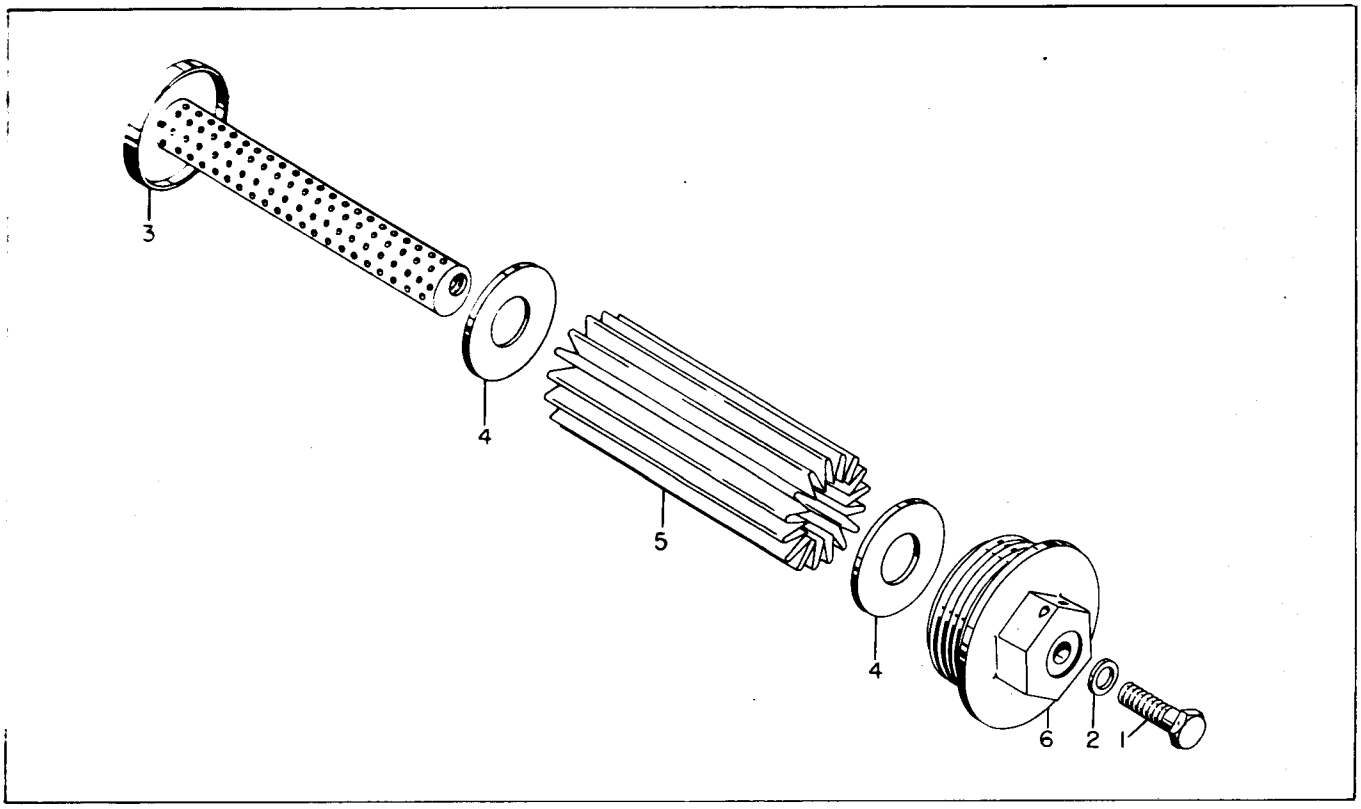
13-12. AIR-MAZE NO. Q9T116 OIL FILTER. (See figure 56.)

13-13. DISASSEMBLY.

a. Remove the lock wire from the bolt head. Unscrew and remove the bolt (1) and its washer (2).

b. Lift off the head casting (6), the upper element gasket (4), the element assembly (5) and the lower element gasket (4) from the perforated tube assembly (3).

13-14. CLEANING. Soak the corrugated screen as-



1. Air-Maze No. Q9S580-212 special bolt
2. Air-Maze No. Q9S552-06 washer
3. Air-Maze No. Q9T116-218 perforated tube subassembly
4. Air-Maze No. Q9S471-66 element gasket
5. Air-Maze No. Q9T116-07 element subassembly
6. Air-Maze No. Q9S580-140 head casting

Figure 56. Air-Maze No. Q9T116 Oil Filter Assembly

sembly in a mineral spirit solvent to loosen sludge; then swish it through the solvent and allow it to drain dry. Do not use any forceful method to clean this assembly. Clean all other parts with a solvent applied by brush or spray, and dry them with dehydrated compressed air.

13-15. INSPECTION. Discard and replace any damaged parts. Replace with new parts, the washer (2) and both element gaskets (4) each time the filter is disassembled.

13-16. ASSEMBLY. Reverse the disassembly procedure (paragraph 13-13) to reassemble the filter, tighten the bolt (1) to 80 in. lbs. torque, and safety with lock wire.

13-17. MAGNETOS. For overhaul instructions and parts list relative to Scintilla model S6RN-25 magnetos, address the Director of Service Publications, Scintilla Magneto Division of Bendix Aviation Corp., Sidney, N.Y. Magnetos installed on model O-470 engines are built to Scintilla Parts List No. 10-79020-1. Special tools for magneto overhaul work are listed separately by the manufacturer.

13-18. CARBURETOR. For parts list and overhaul instructions relative to Marvel-Schebler model MA-4-5 carburetors, address Service Department, Marvel-Schebler Division of Borg-Warner Corp., Flint, Michigan. O-470-K and O-470-L carburetors are identified by the manufacturer's part No. 10-3965. For parts list and overhaul instructions pertaining to Stromberg-Bendix model PSD-5C carburetors, address Service Department, Bendix Products Division of Bendix Aviation Corp., South Bend, Indiana. O-470-M carburetors are identified by the manufacturer's part No. 391572-1.

13-19. STARTER AND GENERATOR. Service information on these Delco-Remy products is distributed through United Motors Service, General Motors Building, Detroit, Michigan. The Delco-Remy part numbers for the starters are as follows:

12-volt	10816
24-volt	11046

For the generators, the following part numbers:

12-volt	X1428
24-volt	1101906

SECTION XIV
TESTING AFTER OVERHAUL

NOTE

Testing of overhauled engines after installation in aircraft is not recommended, because the cooling air flow induced by a static rotating propeller is usually inadequate for high speed operation. For this reason, and to assure the accuracy of test data, it is recommended that the run-in test be performed with the engine mounted on a rigid test stand within a cellular enclosure, which may be wide open at each end. A cell which is not too large in cross section and has sufficient length will induce a higher air flow and will help to prevent immediate recirculation of cooling air.

14-1. TEST EQUIPMENT.

14-2. TEST CLUB. Unless a dynamometer is used to apply controlled loads to the crankshaft, it will be necessary to install a wood test club such as those supplied by the Hartzell Propeller Fan Co. of Piqua, Ohio. Test clubs are customarily supplied in standard diameters, so that the blade length must be reduced by the "cut and try" method until the club will absorb 225 B.H.P. at 2600 R.P.M. when used in the cell, stand, and engine combination for which it was calibrated.

14-3. TEST STAND. Any rigid supporting stand of adequate strength and suitable shape and dimensions may be fitted with adapters to accept the engine mount bracket locations and shear rubber mount bushing dimensions shown in the installation drawings. The crankshaft should be at least five feet above the cell floor so that the test club will not cause excessive disturbance in the air at floor level. If the cell does not have a paved floor the ground beneath the stand and for a reasonable distance around it should be treated so as to hold the soil in place.

14-4. COOLING AIR SCOOP. In warm climates it will probably be necessary to construct a scoop of heavy-gauge sheet metal to fit over the tops of all cylinders, with pads to seal it to the rear cylinders and to all valve rocker covers, in order to direct an adequate flow of air downward through the cylinder fins. Vanes may be found necessary to direct a portion of the cooling air to the center cylinder and/or the oil cooler, therefore the temperatures of all cylinder heads should be measured until uniformity within 50°F has been obtained. It is advisable to provide a duct from the cylinder scoop to the generator vent tube or to provide a separate scoop for it.

14-5. CARBURETOR AIR INTAKE. An air filter and housing should be attached to the carburetor air inlet flange. The filter area must be sufficient to avoid excessive restriction of air flow, even when the filter is dirty, though it should be cleaned before each test. Calculations of filter area should be based on 356 c.f.m. of air required by the engine at full throttle at 2600 R.P.M. and on the filter capacity per unit of area. The calculated area of a clean filter should be increased by at least 50% to allow for dirt accumulation.

14-6. EXHAUST STACKS. For testing purposes the exhaust back pressure should be zero. Short stacks may be made locally to match the cylinder port diameter and the flange stud dimensions shown in applicable installation drawings.

14-7. CONTROLS. The only controls required are a carburetor throttle control, a starter switch and wiring and a standard twin magneto switch with connections to the Scintilla grounding terminals; however, the carburetor manual-mixture control lever may be connected to a suitable manual control in order to permit a very brief test of its operation and to permit stopping the engine with the idle cutoff feature. If the mixture control is not connected, it must be wired in the "RICH" (extreme right) position. For locations of all control connections and required throttle travel refer to the applicable installation drawing.

14-8. ELECTRICAL WIRING. A 6- or 12-volt storage battery, depending on the starter installed, must be connected by a No. O stranded copper cable from its positive terminal to the power terminal on the starter solenoid and the battery negative terminal must be connected to the engine, or both battery negative terminal and engine may be grounded. A small insulated wire should connect the starter solenoid coil terminal to a 5 Amp. pushbutton switch. The other switch terminal must be connected to the engine or both to a common ground. A Delco-Remy generator regulator designed for a 12-volt system should be connected to the generator "A" (armature) and "F" (field coil) terminals, the latter of which is nearest to the crankcase, and to the battery and the ammeter to check generator performance. If desired, an electrical load may be connected across the battery terminals to provide a constant or variable drain so as to check generator output throughout the test run.

14-9. INSTRUMENTS. The control panel should be equipped with the following engine instruments. (See installation drawings for connection points.)

a. A mechanically-driven (counterclockwise, 1/2 engine R.P.M.) tachometer and flexible shaft assembly is needed for model O-470-K and O-470-L engines. An electrically powered (1/2 engine R.P.M.) tachometer is necessary for model O-470-M engines.

b. An oil pressure gauge and tube connection.

c. An oil temperature gauge and capillary assembly.

d. A cylinder head temperature gauge, wiring and spark plug washer thermocouple. (Install under a lower spark plug.)

e. A water manometer with rubber hose connection to the vacuum pump oil-return hole at the rear of the crankcase.

f. An ammeter connected in the generator circuit.

14-10. BREATHER. A substantial hose of 3/4 inch I.D. should be securely clamped over the crankcase breather elbow and support so as to lead to a point above and to the rear of the engine.

14-11. FUEL SYSTEM. The fuel supply tank for O-470-K and O-470-L engines should be elevated so as to provide gravity feed of fuel through a 3/8 in. O.D. tube and shutoff valve to an AN816-6B flared tube fitting installed in the carburetor fuel inlet port at a pressure within the range specified in Table IV, Section II. For O-470-M engines, the fuel supply tank need not be elevated due to the fuel pump installed. Connect the fuel supply line to the fuel pump and install the line from the fuel pump to the carburetor. Remove the plug (No. 1 of figure 20) and connect the carburetor vapor vent to a return line to the fuel supply tank. Remove the plug (No. 6 of figure 20), install the fitting, and connect the fuel-pressure gauge line. For all models, if it is desired to measure the total fuel consumption per minute during the test run, a flow meter may be interposed in the supply line or a graduated alternate tank supported on a small platform scale may be connected to the supply line through a selector valve and the time required to trip with a known fuel overbalance at the switchover time may be timed by a stop watch.

14-12. TEST SCHEDULES.

a. Run the engine according to the schedule in Table XII after a top overhaul or after a major overhaul when no new running parts were installed.

b. Run the engine according to the schedule in Table XIII after a major overhaul which included

replacement of bushings, cylinders, pistons, and any gear or any assembly containing gears.

c. Extend the second period of each test schedule, if necessary, to raise the oil temperature to 100°F.

NOTE

If tests must be conducted in extremely cold weather, it may be necessary to shield the crankcase from the cooling air stream, since it takes some heat from the oil.

d. Take instrument readings at the beginning, in the middle, and at the end of the full-throttle period. Take one reading during each of the other periods as soon as conditions have stabilized.

e. Make one check on performance of each magneto alone at 2050 R.P.M. (Refer to Table II, Section II.) Clear spark plugs by operating with both magnetos on for a few seconds between checks.

NOTE

The maximum allowable cylinder head temperature and the maximum allowable oil temperature (Table V) must not be exceeded at any time during the test.

14-13. PRESERVATION. If the engine is not to be installed in an aircraft and placed in service immediately, the last 15 minutes of operation should be used to circulate a corrosion-preventive oil mixture (suitable for flight operation). This will be an additional period, since the engine must be stopped to change oil. During the same period, unleaded gasoline should be supplied to the carburetor.

TABLE XII. SHORT TEST SCHEDULE

Time (Minutes)	R.P.M.	Approx. B.H.P. *	Approx. % Power
5	800	-	-
10	1000	-	-
15	1200	-	-
15	1500	-	-
15	1650	-	-
15	1800	80	35
15	2050	112	50
15	2270	146	65
10	2380	168	75
15	2435	180	80
15	2530	202	90
20	2600	225+	100
15	1500 - 800	-	-

TABLE XIII. LONG TEST SCHEDULE

Time (Minutes)	R.P.M.	Approx. B.H.P *	Approx. % Power
5	800	-	-
10	1000	-	-
15	1200	-	-
15	1500	-	-
15	1650	-	-
15	1800	80	35
15	1950	93	40
15	2050	112	50
20	2200	134	60
30	2330	157	70
10	2380	168	75
30	2435	180	80
30	2530	202	90
30	2600	225+	100
15	1500 - 800	-	-

* Based on propeller load, corrected to standard Sea Level Atmospheric Pressure, 60°F. carburetor air temperature.

+ Full throttle. R.P.M. will be governed by test club and atmospheric conditions but should not exceed 2650.

SECTION XV
TABLE OF LIMITS

O-470-K, L, M

Ref. No.	Chart No.	Model	Description	Serviceable Limit	New Parts Min.	New Parts Max.
			CYLINDER AND HEAD ASSEMBLY			
1	1	K,L,M	Cylinder bore (lower 4-1/4" of barrel) . . . . diameter:	5.006	5.001	5.003
2	1	All	Cylinder bore (top of barrel) . . . . . diameter:	5.000	4.989	4.993
3	1	All	Cylinder bore choke (from 3.25" above flange to top) . . . . . taper:	.006	.010	.012
4	1	All	Cylinder bore out of round . . . . . :	.003	-	.002
5	1	All	Cylinder bore (reground .015) . . . . . allowable o' size:	5.021	5.016	5.018
6	1	All	Cylinder bore surface roughness . . . (micro in. RMS):	-	30	40
7	1	All	Cylinder barrel in crankcase . . . . . diameter:	-	.004L	.010L
8	1	All	Intake valve seat insert in cylinder head . . . diameter:	-	.009T	.012T
9	1	All	Intake valve guide in cylinder head . . . . . diameter:	-	.001T	.0025T
10	1	All	Exhaust valve guide in cylinder head . . . . . diameter:	-	.001T	.0025T
11	1	All	Exhaust valve seat insert in cylinder head . . diameter:	-	.007T	.010T
12	1	All	Intake valve seat . . . . . .width:	-	.107	.156
13	1	All	Exhaust valve seat . . . . . .width:	-	.120	.171
14	1	All	Valve seat (to valve guide axis) . . . . . .angle:	-	45°	45°30'
			ROCKER ARMS AND SHAFTS			
15	1	All	Rocker shaft in cylinder head bosses . . . . . diameter:	.003L	.000	.0015L
16	1	All	Rocker shaft in rocker arm bearing . . . . . diameter:	.004L	.001L	.0025L
17	1	All	Rocker arm bearing in rocker arm . . . . . diameter:	-	.002T	.004T
18	1	All	Rocker arm . . . . . side clearance:	.019	.005	.015
19	1	All	Intake valve in guide . . . . . diameter:	.005L	.0012L	.0032L
20	1	All	Exhaust valve in guide . . . . . diameter:	.008L	.003L	.005L
21	1	All	Intake valve face (to stem axis) . . . . . angle:	-	45°	45°30'
22	1	All	Exhaust valve face (to stem axis) . . . . . angle:	-	45°	45°30'
23	1	All	Intake valve (max. tip regrind .015) . . . . . length:	4.789	4.804	4.824
24	1	All	Exhaust valve (max. tip regrind .015) . . . . . length:	4.791	4.806	4.826
25	1	All	Intake and exhaust valve (full indicator reading) warpage . . . . . :	.004	.000	.002
			PISTONS, RINGS AND PINS			
26	1	K & L	Piston (bottom of skirt) in cylinder . . . . . diameter:	.021L	.006L	.009L
		M	Piston (bottom of skirt) in cylinder . . . . . diameter:	.022L	.007L	.010L
27	1	K & L	Piston (below third ring groove) in cylinder . diameter:	.026L	.016L	.019L
		M	Piston (below third ring groove) in cylinder . diameter:	.028L	.017L	.021L
28	1	All	Top piston ring in groove . . . . . side clearance:	.015	.007	.0085
29	1	All	Second piston ring in groove . . . . . side clearance:	.014	.0065	.008
30	1	All	Third piston ring in groove . . . . . side clearance:	.008	.0035	.005
31	1	All	Top and second ring (ring in cylinder barrel) . . . . gap:	.065	.0381	.0544
32	1	All	Third ring (ring in cylinder barrel) . . . . . gap:	.060	.0331	.0494
33	1	All	Top piston ring (standard gap) comp. ring . . .tension*:	12 lbs.	13 lbs.	17 lbs.
34	1	All	Second piston ring (standard gap) comp. ring. .tension*:	12 lbs.	13 lbs.	17 lbs.
35	1	All	Third piston ring (standard gap) . . . . . .tension†:	10 lbs.	11 lbs.	16 lbs.
36	1	All	Plug in piston pin (before swaging) . . . . . diameter:	-	.0005T	.001L
37	1	All	Piston pin in piston . . . . . diameter:	.002L	.0005L	.0012L
38	1	All	Piston pin and plug in cylinder . . . . . end clearance:	.090L	.036	.048L
39	1	All	Piston pin in connecting rod bushing . . . . . diameter:	.003L	.0012L	.0018L
40	1	All	Bushing in connecting rod . . . . . diameter:	-	.0025T	.0050T
41	1	All	Connecting rod bearing on crankpin (tri-metal bearing) . . . . . diameter:	.006L	.0009L	.0034L

† Measure piston ring (oil ring) tension on diameter perpendicular to gap when ring is compressed to .030 - .040 inch gap.

* Measure piston ring (top and second compression ring) tension on diameter perpendicular to gap when ring is compressed to .035 - .045 inch gap.

TABLE OF LIMITS (cont)

Ref. No.	Chart No.	Model	Description	Serviceable Limit	New Parts Min.	New Parts Max.
			PISTONS, RINGS AND PINS (cont)			
42	2	All	Connecting rod on crankpin . . . . . end clearance:	.016	.006	.010
43	1	All	Connecting bearing and bushing twist or convergence per inch of length . . . . . :	.001	.000	.0005
44	1	All	Bolt in connecting rod . . . . . diameter:	-	.0005T	.001L
			CRANKSHAFT			
45	2	All	Crankshaft in main bearings (tri-metal) . . . diameter:	.005L	.0005L	.0025L
46	2	All	Crankpins . . . . . out of round:	.0015**	.000	.0005
47	2	All	Main journals . . . . . out of round:	.0015**	.000	.0005
48	2	All	Crankshaft main and thrust journals . . . . . diameter:	2.372	2.374	2.375
49	2	All	Crankpins . . . . . diameter:	2.247	2.249	2.250
50	2	All	Crankshaft run-out at center main journals (shaft supported at thrust and rear journals) full indicator reading . . . . . :	.015	.000	.015
51	2	All	Crankshaft run-out at propeller flange when supported at front and rear main journals full indicator reading . . . . . :	.005	.000	.005
52	2	All	Damper pin bushing in crankcheek extension. diameter:	-	.0015T	.003T
53	2	All	Damper pin bushing in counterweight . . . . . diameter:	-	.0015T	.003T
54	2	All	Damper pin in bushing (6th order). . . . . diameter:	.082L	.0666L	.0706L
55	2	All	Damper pin in counterweight . . . . . end clearance:	.050	.011	.033
56	2	All	Crankcheek in counterweight . . . . . side clearance:	.020	.006	.012
57	2	All	Crankshaft gear on crankshaft . . . . . diameter:	-	.000	.002T
58	2	All	Crankshaft in thrust bearing . . . . . diameter:	.0055L	.0009L	.0039L
59	2	All	Crankshaft in thrust bearing . . . . . end clearance:	.024	.004	.014
			CAMSHAFT			
60	2	All	Camshaft journals in crankcase . . . . . diameter:	.005L	.001L	.003L
61	2	All	Camshaft in crankcase . . . . . end clearance:	.014	.005	.009
62	2	All	Camshaft run-out at center journals (shaft supported at end journals) full indicator reading . . . . . :	.001	.000	.001
63	2	All	Camshaft gear on camshaft flange. . . . . diameter:	-	.0005T	.0015L
64	2	All	Governor drive gear on camshaft . . . . . diameter:	.004L	.0005L	.003L
65	2	M	Cam cluster gear of cam gear pilot . . . . . diameter:	-	.0001T	.001L
			CRANKCASE AND ATTACHED PARTS			
66	2	All	Crankcase oil seal in crankcase (split seal) . . . . . diameter:	-	.012T	.016T
67	2	All	Through bolt (10.75") (.500-20) dowel bolt in crankcase . . . . . diameter:	-	.001L	.0005T
68	1	All	Hydraulic tappet in crankcase . . . . . diameter:	.0035L	.0005L	.002L
69	2	All	Governor drive shaft in crankcase . . . . . diameter:	.005L	.0014L	.0034L
70	2	All	Idler gear support pin in crankcase (front) . . diameter:	.005L	.0005L	.0025L
71	2	All	Idler gear support pin in crankcase (rear) . . diameter:	-	.0005L	.0025L
72	3	All	Magneto and accessory drive adapter pilot in left crankcase . . . . . diameter:	-	.000	.004L
73	3	All	Magneto and accessory drive adapter pilot in right crankcase . . . . . diameter:	-	.000	.004L
74	2	All	Oil pump housing pilot in crankcase . . . . . diameter:	-	.001L	.003L
75	3	All	Starter shaftgear needle bearing in crankcase . . . . . diameter:	-	.0005L	.0015T
			OIL PRESSURE RELIEF VALVE ASSEMBLY			
76	2	All	Oil pressure relief valve plunger in cap . . . diameter:	.009L	.003L	.006L
			ACCESSORY DRIVE IDLER ASSEMBLY			
77	2	All	Bushing in idler gear . . . . . diameter:	-	.001T	.003T
78	2	All	Idler gear support in bushing . . . . . diameter:	.005L	.0015L	.0035L

**If crankshafts are worn beyond these limits they may be repaired by grinding journals to .010 inch under new shaft limits and renitriding journals. Crankshafts may be returned to the factory for such repairs.

TABLE OF LIMITS (cont)

Ref. No.	Chart No.	Model	Description	Serviceable Limit	New Parts Min.	New Parts Max.
			ACCESSORY DRIVE IDLER ASSEMBLY (cont)			
79	2	All	Idler gear . . . . . end clearance:	.045	.004	.035
			LEFT AND RIGHT MAGNETO AND ACCESSORY DRIVE ASSEMBLY			
80	3	All	Bushing in magneto and accessory drive adapter . . . . . diameter:	-	.001T	.004T
81	3	All	Magneto and accessory drive gear in adapter bushing . . . . . diameter:	.005L	.0015L	.0035L
82	3	All	Oil seal in adapter . . . . . diameter:	-	.001T	.007T
83	3	All	Sleeve in magneto and accessory drive gear . diameter:	-	.001T	.004T
84	3	All	Magneto and accessory drive gear . . . . end clearance:	-	.0015L	.0865L
85	3	All	Magneto coupling retainer on magneto and accessory drive gear sleeve . . . . . diameter:	.055	.025L	.045L
86	3	All	Magneto coupling retainer in magneto drive gear slot . . . . . side clearance:	.040L	.002T	.028L
87	3	All	Magneto coupling rubber bushings on magneto drive lugs . . . . . side clearance:	-	.010L	.052T
88	3	All	Magneto pilot in crankcase . . . . . diameter:	-	.001L	.005L
			OIL PRESSURE PUMP ASSEMBLY			
89	2	All	Oil pump driver gear in pump housing . . . . . diameter:	.006L	.0015L	.004L
90	2	All	Oil pump driver gear shaft in pump housing. . diameter:	.0045L	.0015L	.003L
91	2	All	Oil pump driven gear in pump housing . end clearance:	.005L	.0005L	.003L
92	2	All	Oil pump driver gear in pump housing . end clearance:	.005L	.0005L	.003L
93	2	All	Oil pump driver gear shaft in cover of oil pump . . . . . diameter:	.0045L	.0015L	.003L
94	2	All	Oil pump driver gear shaft in tachometer drive bevel gear (tach. gear pinned to shaft) . . . . . diameter:	.004L	.0005L	.0025L
95	2	All	Oil pump driven gear shaft in oil pump housing . . . . . diameter:	-	.001T	.003T
96	2	All	Oil pump driven gear on shaft . . . . . diameter:	.004L	.005L	.0025L
97	2	All	Oil pump driven gear in housing . . . . . diameter:	.006L	.0015L	.004L
			TACHOMETER DRIVE ASSEMBLY			
98	2	All	Tachometer drive shaft in oil pump cover . . diameter:	.0045	.0015L	.003L
99	2	K & L	Driven bevel gear on tachometer drive shaft (gear pinned to drive shaft) . . . . . diameter:	.004L	.0005L	.0025L
100	2	K & L	Oil seal in tachometer drive housing . . . . . diameter:	-	.001T	.007T
101	2	M	Oil seal in tachometer drive housing . . . . . diameter:	-	.0015T	.0065T
102	2	K & L	Tachometer thrust washer . . . . . thickness:	.140	.150	.170
			STARTER DRIVE			
103	3	All	Starter shaftgear in bearing . . . . . diameter:	.0031L	.0005L	.0029L
104	3	All	Starter shaftgear front (bearing) journal . . . diameter:	.748	.7495	.750
105	3	All	Starter clutch drum on starter shaftgear . . . diameter:	.0055L	.001L	.004L
106	3	All	Clutch spring sleeve in starter adapter . . . diameter:	-	.003T	.005T
107	3	All	Starter shaftgear in ball bearing . . . . . diameter:	-	.0001L	.0005L
108	3	All	Starter shaftgear in oil seal sleeve . . . . . diameter:	-	.001L	.0025L
109	3	All	Bearing in starter adapter cover . . . . . diameter:	-	.001L	.0001T
110	3	All	Oil seal in starter adapter cover . . . . . diameter:	-	.0017T	.0063T
111	3	All	Starter adapter cover pilot in starter adapter . . . . . diameter:	-	.001L	.003L
112	3	All	Worm wheel gear . . . . . end clearance:	.080	.000	.0696
113	3	All	Clutch spring on clutch drum . . . . . diameter:	.012T	.017T	.020T
114	3	All	Clutch spring on starter shaftgear drum over "A" dia. (or high knurl) . . . . . diameter:	.009L	.002L	.005L
115	3	All	Clutch spring on starter shaftgear drum over "B" dia. (or low knurl) . . . . . diameter:	.013L	.006L	.009L
116	3	All	Clutch spring to sleeve (sandblasted dia. finish). When sandblasted finish is worn to 75 rms replace sleeve			

TABLE OF LIMITS (cont)

Ref No.	Chart No.	Model	Description	Serviceable Limit	New Parts Min.	New Parts Max.
			STARTER DRIVE (cont)			
117	3	All	From center line of worm gear shaft to starter adapter thrust pads:	.252	.246	.248
118	3	All	Needle bearing in starter adapter . . . . . diameter:	-	.001L	.001T
119	3	All	Ball bearing in starter adapter . . . . . diameter:	-	.001L	.0001T
120	3	All	Worm gear shaft in needle bearing . . . shaft diameter:	.5600	.5615	.5625
121	3	All	Worm gear shaft in ball bearing . . . . . diameter:	-	.0001L	.0007T
122	3	All	Starter worm gear on shaft . . . . . diameter:	.004L	.0005L	.0025L
123	3	All	Starter housing flange to worm gear thrust face:	4.520	4.496	4.500
124	3	All	Starter spring on worm drive shaft . . . . . diameter:	-	.005L	.025L
125	3	All	Starter pilot to starter drive adapter . . . . . diameter:	-	.002L	.005L
126	3	All	Starter drive tongue to worm shaft drive slot . . . . . side clearance:	.030L	.006L	.017L
127	3	All	Needle bearing to shaft worm gear . . . . . diameter:	.0031L	.0005L	.0029L
			FUEL PUMP ASSEMBLY			
128	3	M	Pilot (adapter fuel pump) in crankcase . . . . . diameter:	-	.001L	.005L
129	3	M	Gear fuel pump in adapter. . . . . diameter:	.004L	.0005L	.0025L
130	3	M	Gear fuel pump drive in crankcase. . . . .end clearance:	.054L	.002L	.034L
131	3	M	Seal in fuel pump adapter . . . . . diameter:	-	.001T	.007T
132	3	M	Insulator pilot in adapter . . . . . diameter:	-	.0005L	.0045L
			GEAR BACKLASH			
133	3	All	Crankshaft gear and camshaft gear . . . . . backlash:	.016	.008	.012
134	3	All	Crankshaft gear and idler gear . . . . . backlash:	.016	.008	.012
135		M	Cam gear cluster and fuel pump drive gear . . backlash:	.016	.008	.012
136	3	All	Idler gear and magneto drive gear (right and left) . . . . . backlash:	.016	.008	.012
137	2	All	Oil pump driver and driven gears . . . . . backlash:	.027	.014	.0218
138	2	K & L	Tachometer drive gear and tachometer driven gear . . . . . backlash:	.008	.002	.0033
139	2	M	Tachometer drive gear and tachometer driven gear . . . . . backlash:	.012	.004	.008
140	3	All	Starter shaftgear and crankshaft gear . . . . . backlash:	.016	.008	.012
141	3	All	Starter worm wheel gear and worm gear. . . . backlash:	.025	.009	.013
142	2	All	Governor drive gear and governor driven gear . . . . . backlash:	.009	.002	.006
			SPRING TEST DATA			
143	2	All	Oil pressure relief valve spring No. 538735 compressed to 1.58 in. length . . . . . load:	11.5 lbs	12.5 lbs	14.0 lbs
144	2	All	Vernatherm control valve 0.16 in. minimum travel at. . . . . temperature:	-	100°F	148°F
145	2	All	Vernatherm control valve to flow 4 to 6 GPM of oil between . . . . . oil pressure at:	-	-	25 psi
146	2	All	Vernatherm control valve must close between . . . . . oil temperature:	-	147°F	149°F
147	2	All	Vernatherm control valve at oil temperature 160° must not open below . . . . . pressure:	18 psi	-	-
148	2	All	Oil filter bypass valve spring in pump compressed to 0.53 in. length . . . . . load:	1.75lbs	2.25 lbs	2.75 lbs
149	1	All	Inner valve spring No. 520106 (compressed to 1.329 in. length) . . . . . load:	70 lbs	78 lbs	88 lbs
150	1	All	Inner valve spring No. 520106 (compressed to 1.809 in. length) . . . . . load:	37 lbs	43 lbs	49 lbs
151	1	All	Outer valve spring No. 520105 (compressed to 1.360 in. length) . . . . . load:	100 lbs	107 lbs	120 lbs
152	1	All	Outer valve spring No. 520105 (compressed to 1.840 in. length) . . . . . load:	62 lbs	65 lbs	71 lbs

TABLE OF TIGHTENING TORQUES

Ref. No.	Chart No.	Model	Special Applications	Thread Size	Qty	Torque In.-Lbs	Torque Ft.-Lbs
T-1	1	All	Crankcase sump flange	5/16-18	32	165 ± 10	13.7 ± .8
T-2	1	All	Crankcase flange bolts	5/16-24	13	200 ± 10	16.7 ± .8
T-3	2	All	Crankshaft gear screw	5/16-24	6	250 ± 10	20.8 ± .8
T-4	1	All	Crankcase through bolt	7/16-20	8	500 ± 10	42 ± .8
T-5	2	All	Crankcase to crankcase bolt at nose	7/16-20	2	500 ± 10	42 ± .8
T-6	2	All	Crankcase through bolt (dowel type) nuts.	1/2-20	4	650 ± 10	54 ± .8
T-7	1	All	Cylinder hold down nuts	7/16-20	36	500 ± 10	42 ± .8
		All	Cylinder hold down nuts	1/2-20	12	650 ± 10	54 ± .8
T-8	1	All	Connecting rod bolt nuts	3/8-24	12	350 ± 10	29.2 ± .8
T-9	1	All	Spark plugs	18 mm	12	350 ± 30	29.2 ± 2.5
T-10	3	All	Oil filter plug (with new gasket)	1-3/4-16	1	250 ± 10	20.8 ± .8
			Oil filter plug (with used gasket)	1-3/4-16	1	300 ± 10	25 ± .8

General Use Size	Torque: Driving Studs (In.-Lbs.)	Driving Studs (Ft.-Lbs.)	Nuts and Screws (In.-Lbs.)	Nuts and Screws (Ft.-Lbs.)
#10-32	-	-	43 ± 7	3.6 ± .6
1/4-20	60 ± 10	5 ± .8	-	-
1/4-28	-	-	100 ± 10	8.3 ± .8
5/16-18	125 ± 25	10.4 ± 2.1	-	-
5/16-24	-	-	200 ± 20	16.7 ± 1.7
3/8-16	237 ± 37	19.7 ± 3.1	240 ± 20	20.0 ± 1.7
3/8-24	-	-	300 ± 25	25.0 + 2.1
7/16-14	362 ± 62	30.2 ± 5.2	-	-
7/16-20	-	-	425 ± 25	35.5 ± 2.1
1/2-20	-	-	575 ± 25	47.9 ± 2.1

Note: All tightening torques listed are for use with oil on threads. Stud driving torques apply when studs are coated with lubricant or sealer, as specified in Section X.

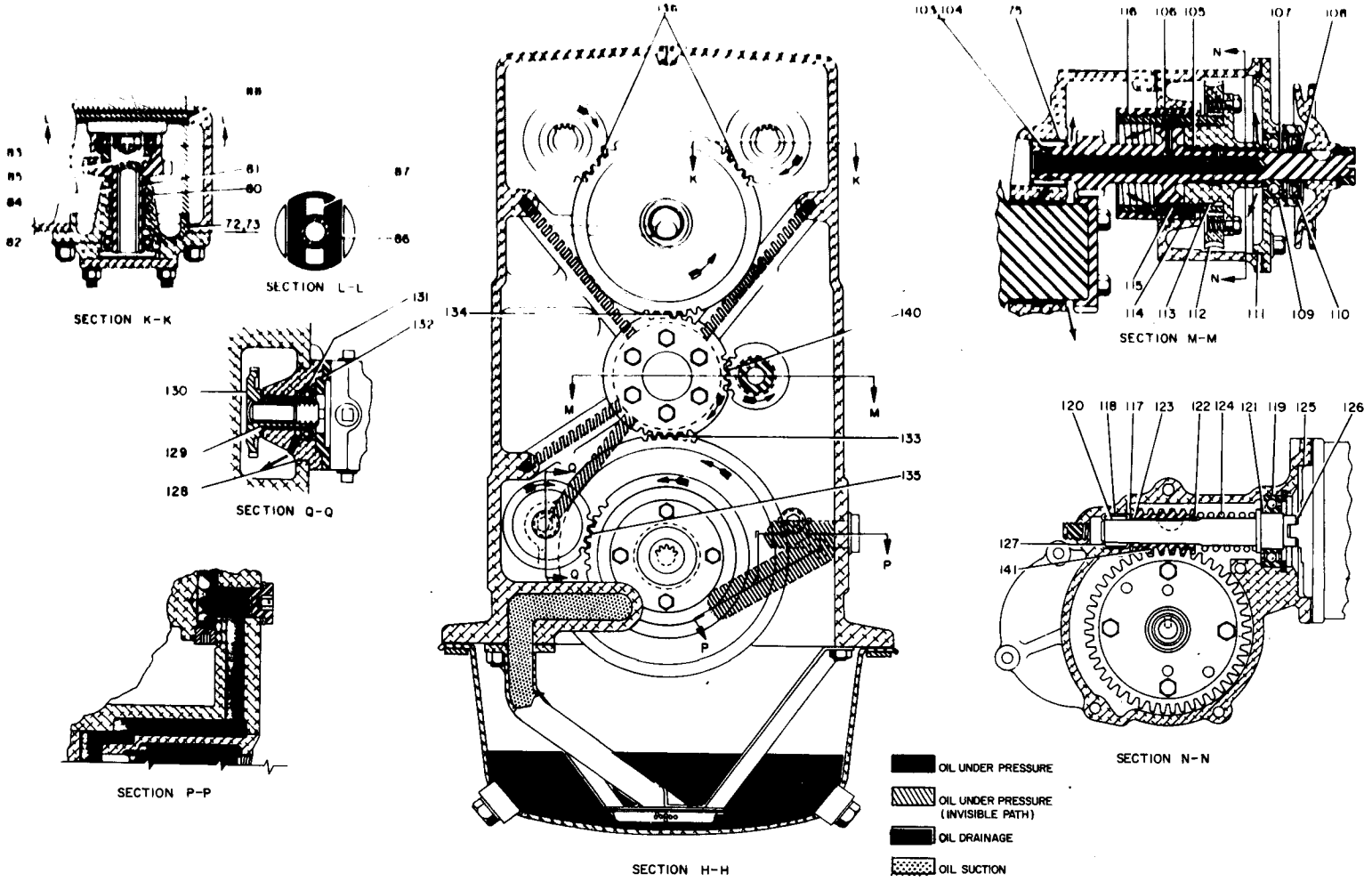


Figure 57. Limits and Lubrication Chart (Sheet 3 of 3)

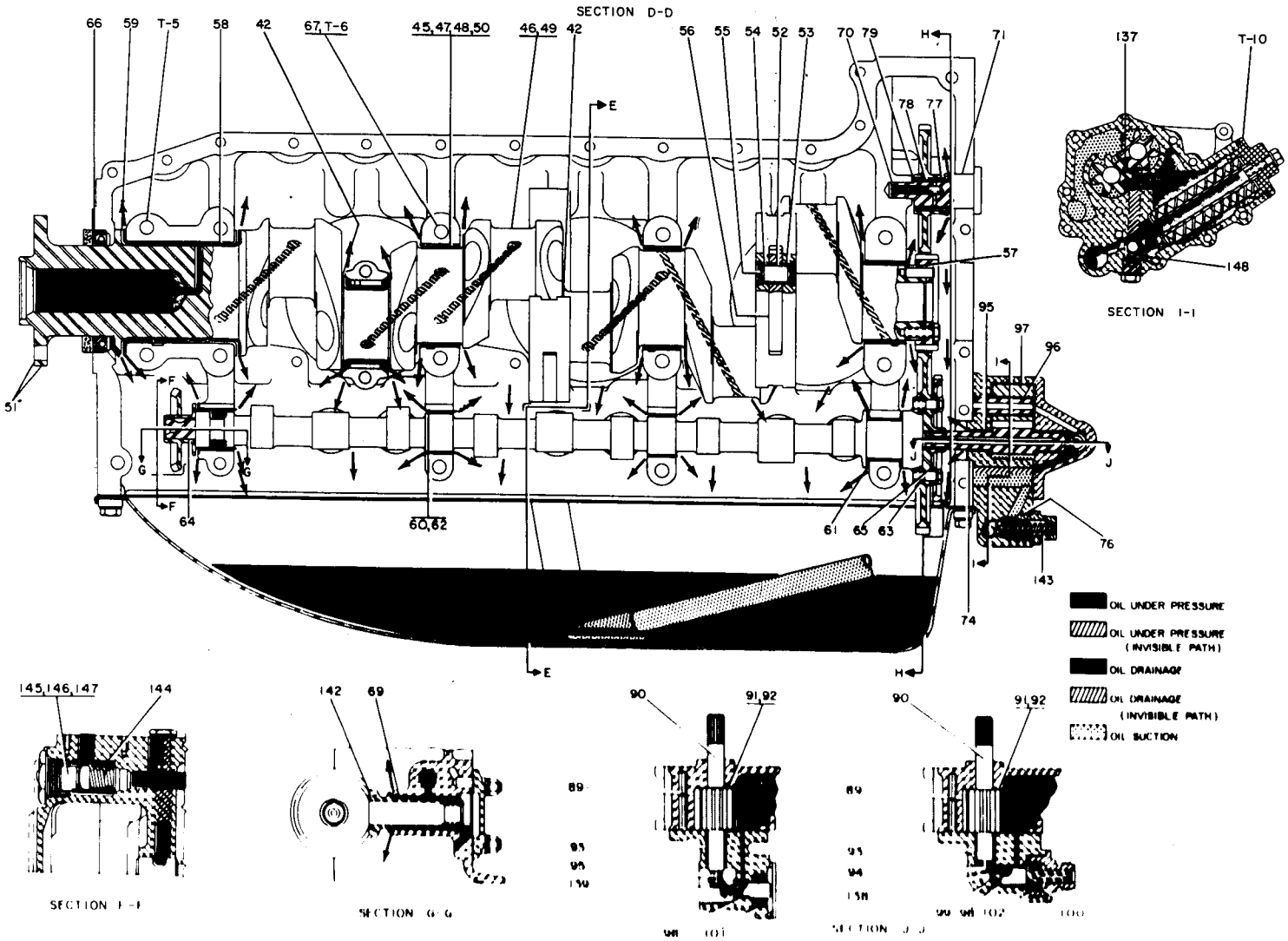


Figure 87. Limits and Lubrication Chart (Sheet 2 of 3)

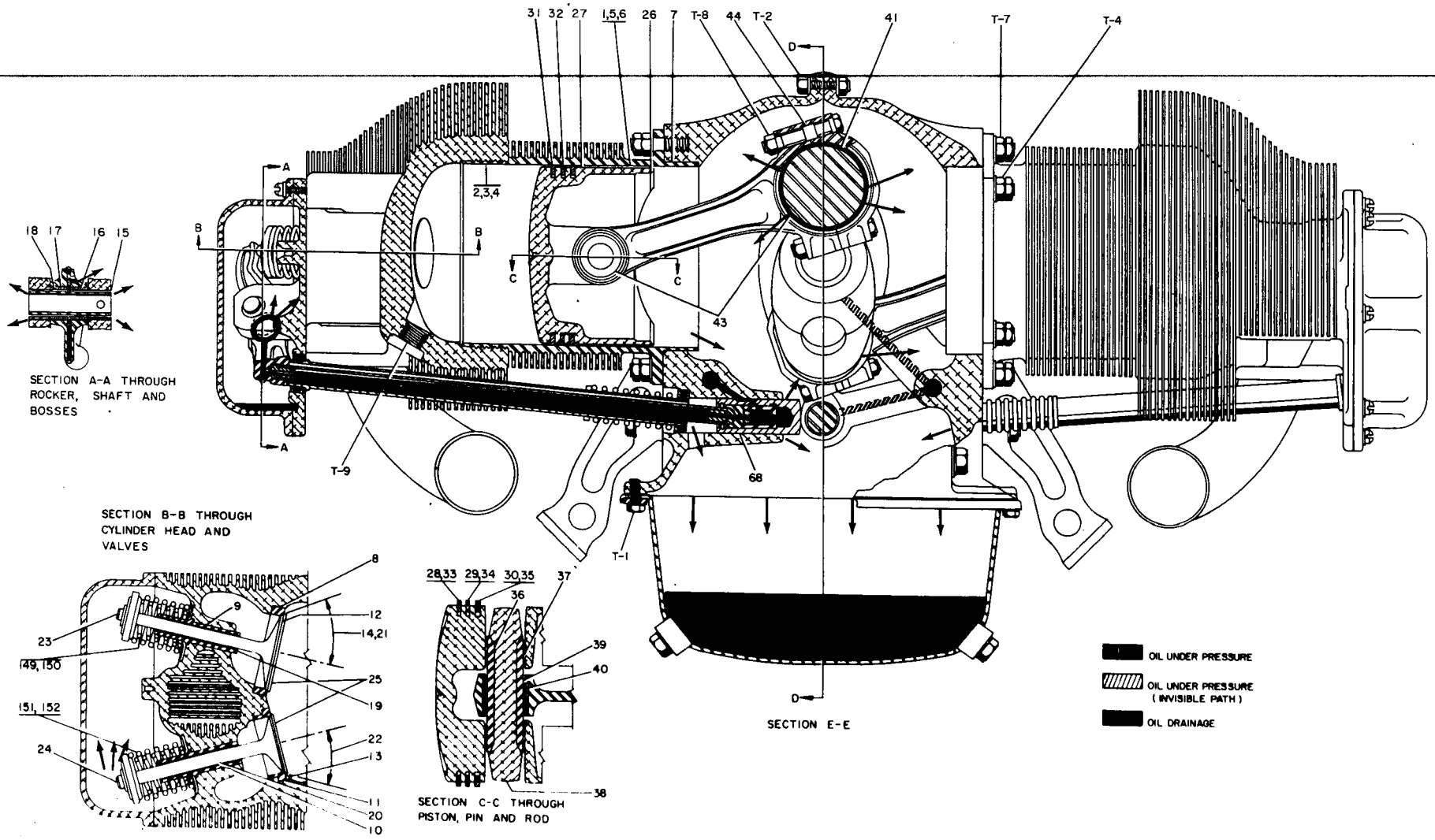


Figure 57. Limits and Lubrication Chart (Sheet 1 of 3)