INSTRUCTION MANUAL

Continental Models A50, A65, A75 and A80 Aircraft Engines

OPERATION, MAINTENANCE OVERHAUL INSTRUCTIONS AND PARTS LIST

MARCH, 1944
REVISED JANUARY, 1946

MUSKEGON, MICHIGAN, U. S. A.

INTRODUCTION

THIS book is a combined Operator's Manual, Maintenance and Overhaul Manual and Illustrated Parts and Price List for the Continental A50, A65, A75, and A80 series 8 and 9 engines.

This manual is intended for use by operators and mechanics as a guide and reference book in the operation and servicing of these engines.

The book is divided into five main groups: Operating and Maintenance Instructions, Overhaul Instructions, Table of Limits, the Illustrated Parts List, and Accessories.

It is suggested that a careful study be made of this manual. A strict adherence to the instructions outlined herein will assure a fine operating record. However, if any point is not entirely clear, do not hesitate to contact the nearest Authorized Continental Service Station or the factory Service Department.

In the event of failure of any engine part, notify the nearest Authorized Continental Service Station at once, giving the engine serial number, and full particulars. Do not attempt any repairs without factory permission if any adjustment is expected.

CONTINENTAL MOTORS CORPORATION
Muskegon, Michigan

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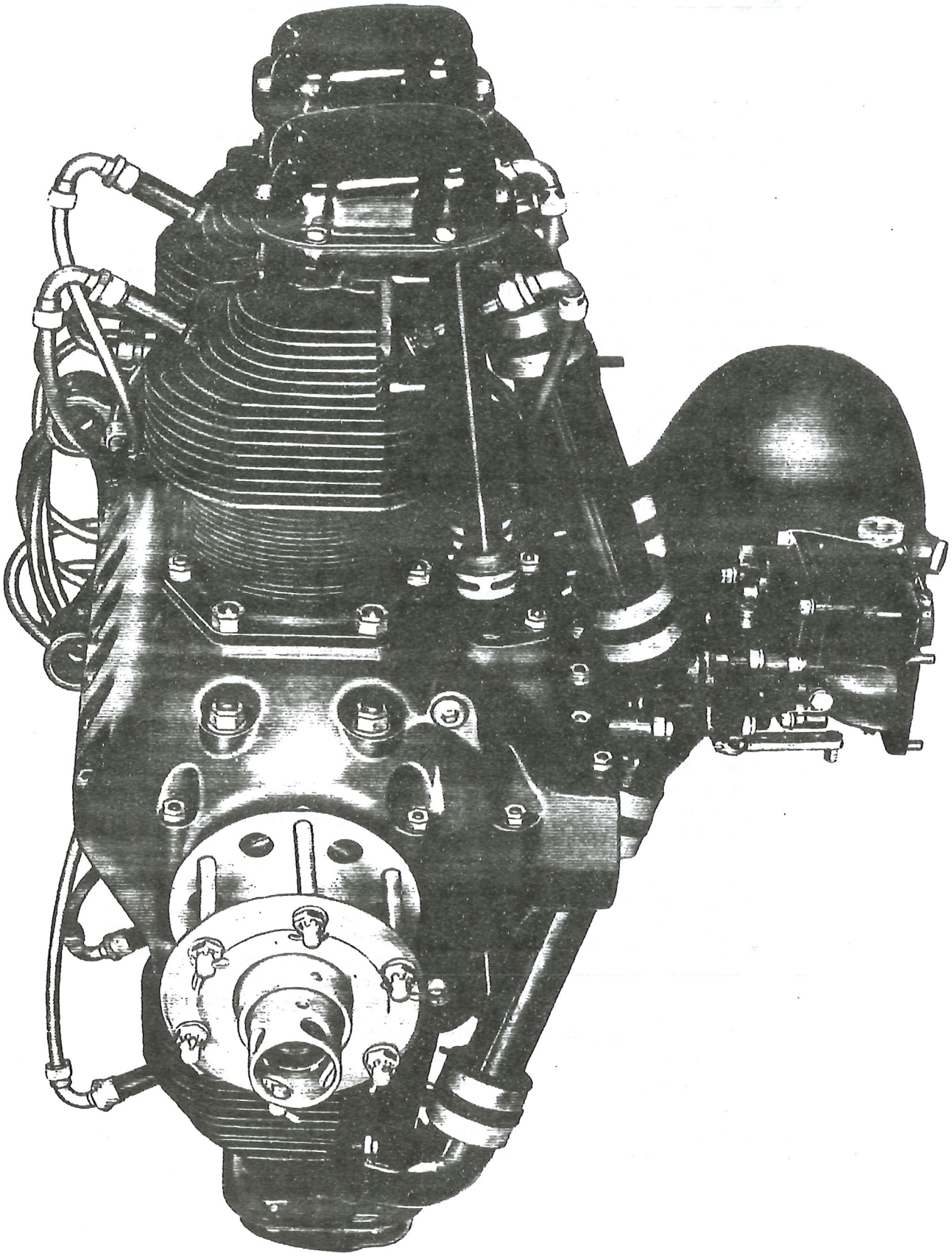
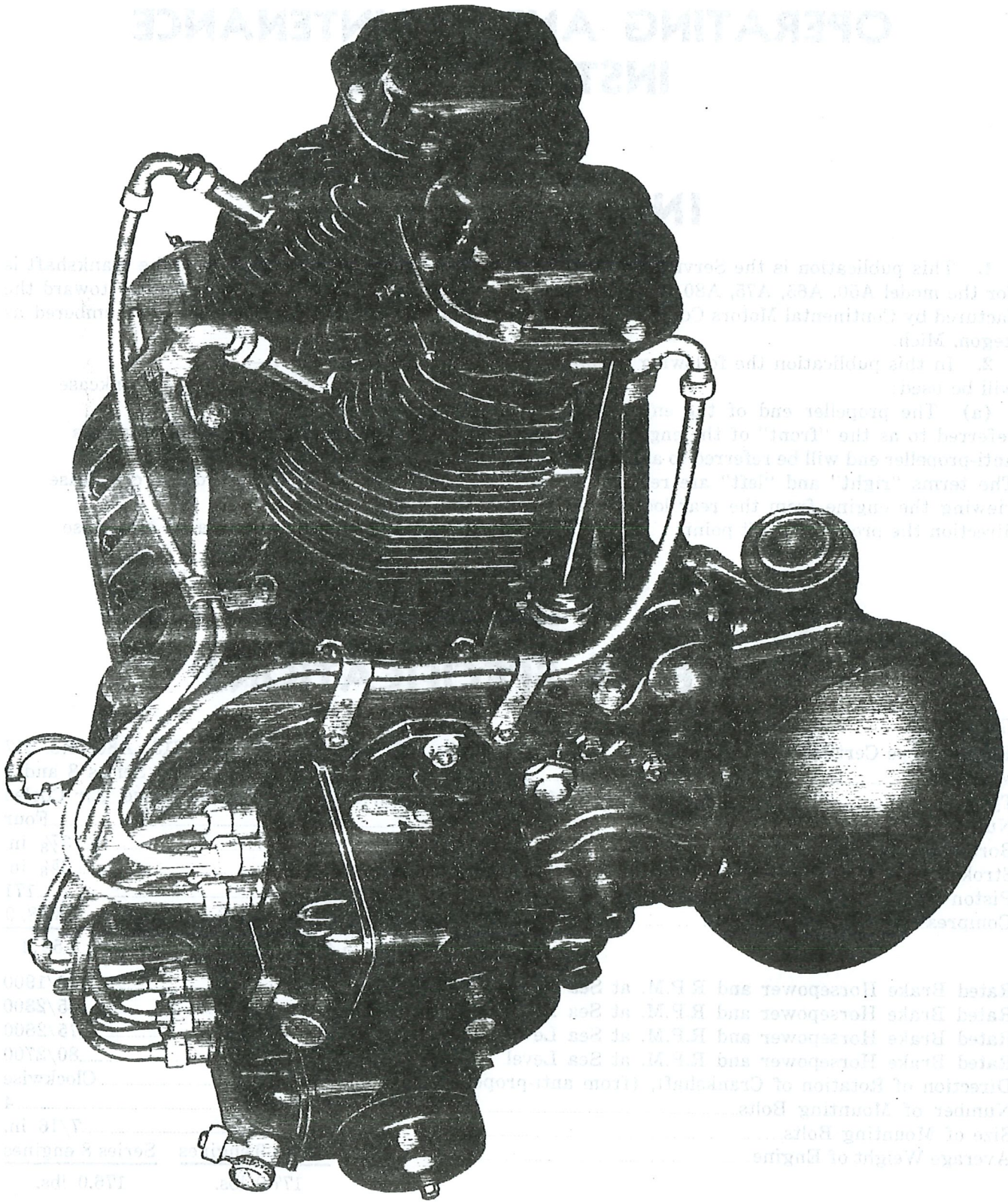


THREE-QUARTER LEFT FRONT (Series 8) — *Figure 1*



THREE-QUARTER RIGHT REAR VIEW (Series 8) — Figure 2

OPERATING AND MAINTENANCE INSTRUCTIONS

Section 1

INTRODUCTION

1. This publication is the Service Instructions for the model A50, A65, A75, A80 engines, manufactured by Continental Motors Corporation, Muskegon, Mich.

2. In this publication the following definitions will be used:

(a) The propeller end of the engine will be referred to as the "front" of the engine, and the anti-propeller end will be referred to as the "rear." The terms "right" and "left" are referred to as viewing the engine from the rear looking in the direction the propeller shaft points.

(b) Direction of rotation of the crankshaft is clockwise when looking from the rear toward the front of the engine. Cylinders are numbered as follows:

Cylinder No. 1 —
Right, rear side of crankcase
Cylinder No. 2 —
Left, rear side of crankcase
Cylinder No. 3 —
Right, front side of crankcase
Cylinder No. 4 —
Left, front side of crankcase

Section 2

TABLE OF SPECIFICATIONS

GENERAL

Engine Type Certificate	A50: No. 190; A65: No. 205; A75: No. 213; A80: No. 217
Models	A50, A65, A75, A80, Series 8 and 9
Type	Horizontally Opposed, 4 Cycle, Overhead Valve, Air Cooled
Number of Cylinders	Four
Bore	3⅞ in.
Stroke	3⅝ in.
Piston Displacement in Cu. In.	171

Compression Ratio	A50-8, 9	A65-8, 9	A75-8, 9	A80-8, 9
	5.4:1	6.3:1	6.3:1	7.55:1

Rated Brake Horsepower and R.P.M. at Sea Level (A50-8, 9)	50/1900
Rated Brake Horsepower and R.P.M. at Sea Level (A65-8, 9)	65/2300
Rated Brake Horsepower and R.P.M. at Sea Level (A75-8, 9)	75/2600
Rated Brake Horsepower and R.P.M. at Sea Level (A80-8, 9)	80/2700
Direction of Rotation of Crankshaft, (from anti-propeller end)	Clockwise
Number of Mounting Bolts	4
Size of Mounting Bolts	7/16 in.

Average Weight of Engine	Series 9 engines	Series 8 engines
	177.0 lbs.	176.0 lbs.

Overall Width of Engine	31-11/16 in.

Overall Length of Engine	Series 9 engines	Series 8 engines
	33-11/32 in.	30-13/32 in.

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

	Series 8	Series 9
Position of Center of Gravity:		
Distance from crankcase cover mounting face to center of gravity of engine	6-1/4 in.	4-7/8 in.
Distance from center line of crankshaft	1-11/32 in.	1-1/16 in.

IGNITION

Magneto — Scintilla, Type	SF4R		
Rotation	Counterclockwise		
Speed Ratio to Crankshaft	1:1		
	A50-8, 9	A75 and A80-8, 9	A65-8, 9
Right Magneto Fires (Upper Plugs), Degrees B.T.C.	25°	29°	30°
Left Magneto Fires (Lower Plugs), Degrees B.T.C.	28°	32°	30°
Spark Plug, Champion, Type (.012 to .016 gap)	Unshielded C26; Radio Shielded; C26S		

VALVES AND TIMING

Intake Opens, Degrees B.T.C.	10
Intake Closes, Degrees A.B.C.	50
Exhaust Opens, Degrees B.B.C.	50
Exhaust Closes, Degrees A.T.C.	15
Intake Remains Open, Crankangle Degrees	240
Exhaust Remains Open, Crankangle Degrees	245
Valve Lift	.400 in.

Valve Rocker Clearance — Cold — Zero lash (hydraulic tappets) — no adjusting necessary.

FUEL SYSTEM

Carburetor — Stromberg, Model	NA-S3A1
Fuel required in Flight	A80 Engines — 80 Octane, A50, A65, A75 Engines — 73 Octane
Priming System Inlet Conn. Thread	1/8 in. Std. Pipe

LUBRICATION SYSTEM

Grade of Oil Required in Flight	See Chart on Page 22
Speed of Oil Pump	0.5:1
Oil Pump Drive Shaft — Direction of Rotation	Counterclockwise

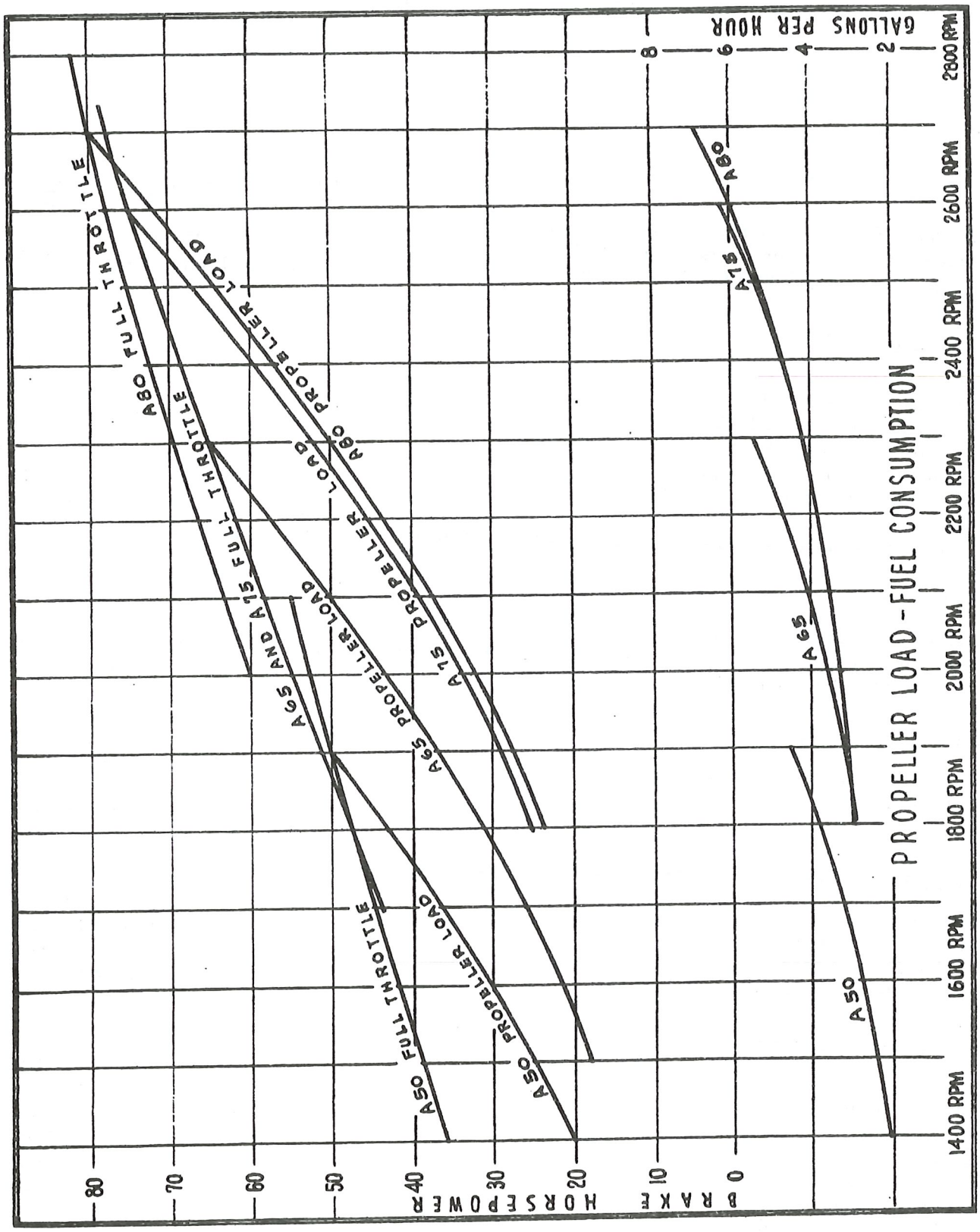
ACCESSORY DRIVES AND INSTRUMENT CONNECTIONS

Oil Pressure (thread)	1/8-in. Pipe
Tachometer Drive Shaft	Standard S.A.E.
Tachometer Drive Speed	0.5:1
Tachometer Drive Direction of Rotation	Counterclockwise

ACCESSORIES AND WEIGHTS

Carburetor	2.500#
Domestic Shipping Box	137.000#
Exhaust Flanges	.550#
Magnetos	15.560#
Radio Shielded Ignition	2.500#
Spark Plugs — Shielded	1.376#
Spark Plugs — Unshielded	1.070#

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued



PERFORMANCE AND FUEL CONSUMPTION CURVES FOR A50, A65, A75, A80 ENGINES — *Figure 3*

Section 3

GENERAL DESCRIPTION

1. DIFFERENCES IN ENGINE MODELS

a. DIFFERENCES BETWEEN THE CONTINENTAL SERIES 8 AND THE CONTINENTAL SERIES 9 ENGINES.

(1) GENERAL DIFFERENCES.

(a) The Series 8 engine and the Series 9 engine are very similar in general construction with the exception of differences in the machining of the crankcase, the crankcase cover assembly, magneto mounting and gears, and the ignition cable assembly.

(2) CRANKCASE.

(a) The crankcase of the Series 9 engine is the same as the crankcase for the Series 8 engine except that the journal for the starter gear has been machined, a dowel hole for the starter gear bushing and an oil passage hole for the starter gear bushing has been provided. A thicker crankshaft gear is required which meshes with the starter gear. The tapped holes for the studs attaching the crankcase cover to the crankcase are different and require longer studs to accommodate the crankcase cover.

(3) CRANKCASE COVER.

(a) The crankcase cover on the Series 9 engine is provided with an S.A.E. Standard small type starter mounting pad. The magneto mounting pads are standard two-bolt flange type but are machined to permit installing the magnetos horizontally.

(b) The tachometer drive housing and oil screen housing on the Series 9 engine are not cast integral with the crankcase cover as they are for the Series 8. The oil pressure relief valve is located on the right side of the crankcase cover on the Series 9.

(4) MAGNETO MOUNTING AND GEARS.

(a) As mentioned above, the Series 9 magnetos are installed in a horizontal position to prevent interference with a starter installation.

(b) The magnetos used on the Series 9 engines are identical to those on the Series 8. However, when the magnetos are installed on the engine, a plug and gasket must be installed into the upper ventilator screen of each magneto to prevent moisture from entering. A different magneto drive gear is also required on the Series 9 engine.

b. DIFFERENCES BETWEEN THE A50, A65, A75, A80 MODELS.

(1) GENERAL DIFFERENCES.

(a) All the engine models are identical in general construction with differences in the rating of the engine, compression ratio, number of piston rings, exhaust valves, and connecting rods.

(2) ENGINE RATINGS.

(a) The engines are rated as follows:

A50 Engines — 50 B.H.P. at 1900 R.P.M.
A65 Engines — 65 B.H.P. at 2300 R.P.M.
A75 Engines — 75 B.H.P. at 2600 R.P.M.
A80 Engines — 80 B.H.P. at 2700 R.P.M.

(3) ENGINE COMPRESSION RATIO.

(a) The engines have the following compression ratios:

A50 Engines — 5.4 Compression Ratio (73 min. Fuel Octane)
A65 Engines — 6.3 Compression Ratio (73 min. Fuel Octane)
A75 Engines — 6.3 Compression Ratio (73 min. Fuel Octane)
A80 Engines — 7.55 Compression Ratio (80 min. Fuel Octane)

(4) NUMBER OF PISTON RINGS.

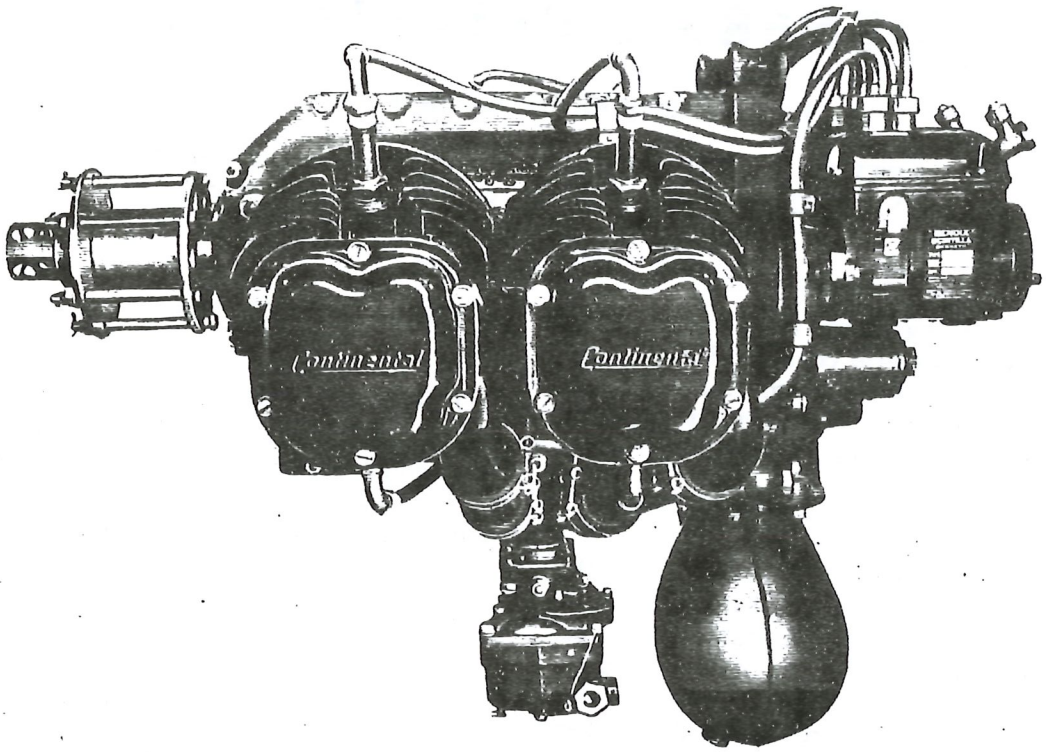
(a) The A50 and A65 engines have a total of four rings per piston; one bevelled compression ring in the top groove, one plain compression ring in the second groove, and two oil rings in the lower two grooves.

(b) The A75 and A80 engines have a total of five rings per piston, having two bevelled compression rings in the first two grooves, with the remaining rings the same as the A50 and A65 engines.

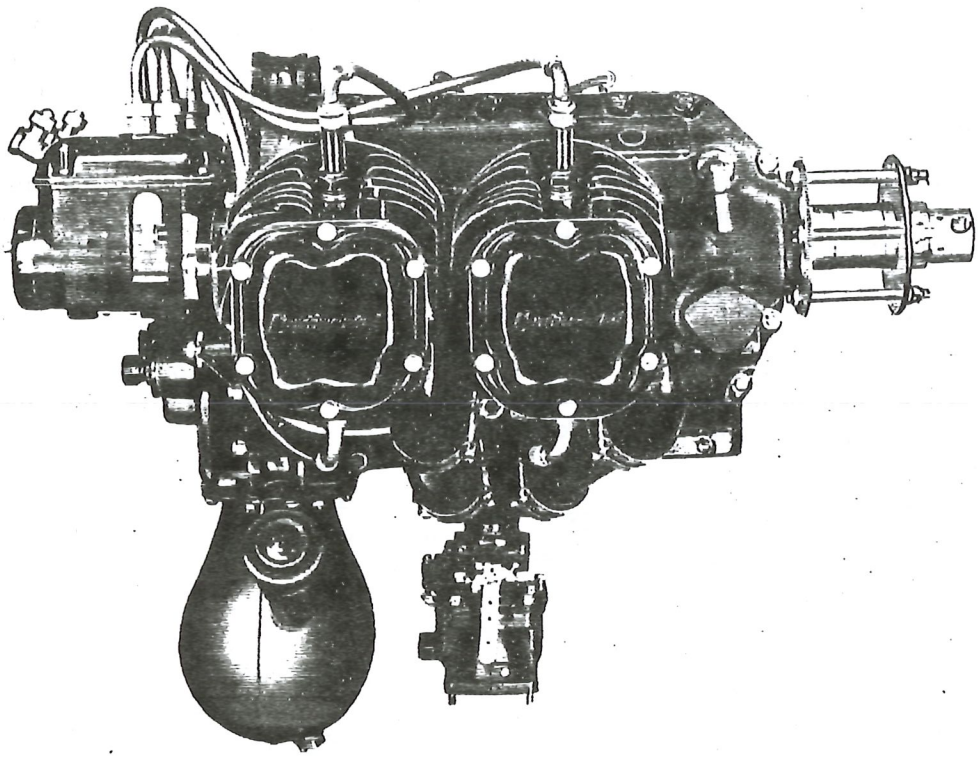
(5) EXHAUST VALVES.

(a) The exhaust valves on these models are identical in construction with the exception that

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued



LEFT SIDE VIEW — *Figure 4*



RIGHT SIDE— *Figure 5*

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

the valves used on the A75 and A80 engines have stellite faces to eliminate the greater wear experienced at the increased engine speeds.

(6) CONNECTING RODS.

(a) The connecting rods on these engines are identical in construction except that the rods used on the A75 and A80 engines have a 1/16 diameter drilled oil squirt hole in the cap end of the rod to provide increased lubrication to the cylinder walls.

2. CYLINDER CONSTRUCTION

Heat-treated, aluminum alloy cylinder heads are screwed and shrunk to steel barrels. Close-spaced cooling fins are provided on barrels and cylinder heads to provide ample and efficient radiation surface. Cylinder bores are ground to a smooth finish and held within extremely close limits. Aluminum bronze spark plug inserts are screwed and pinned in, while aluminum bronze intake and steel exhaust valve seats are shrunk into the cylinder heads. Rocker boxes are cast integral with cylinder heads and are provided with oil sealed covers made of deep drawing sheet metal. They are scavenged by the drainage of oil back to the crankcase through the push rod housings. Cylinder heads have underside exhaust ports to permit more positive exhaust scavenging.

3. VALVE OPERATING MECHANISM

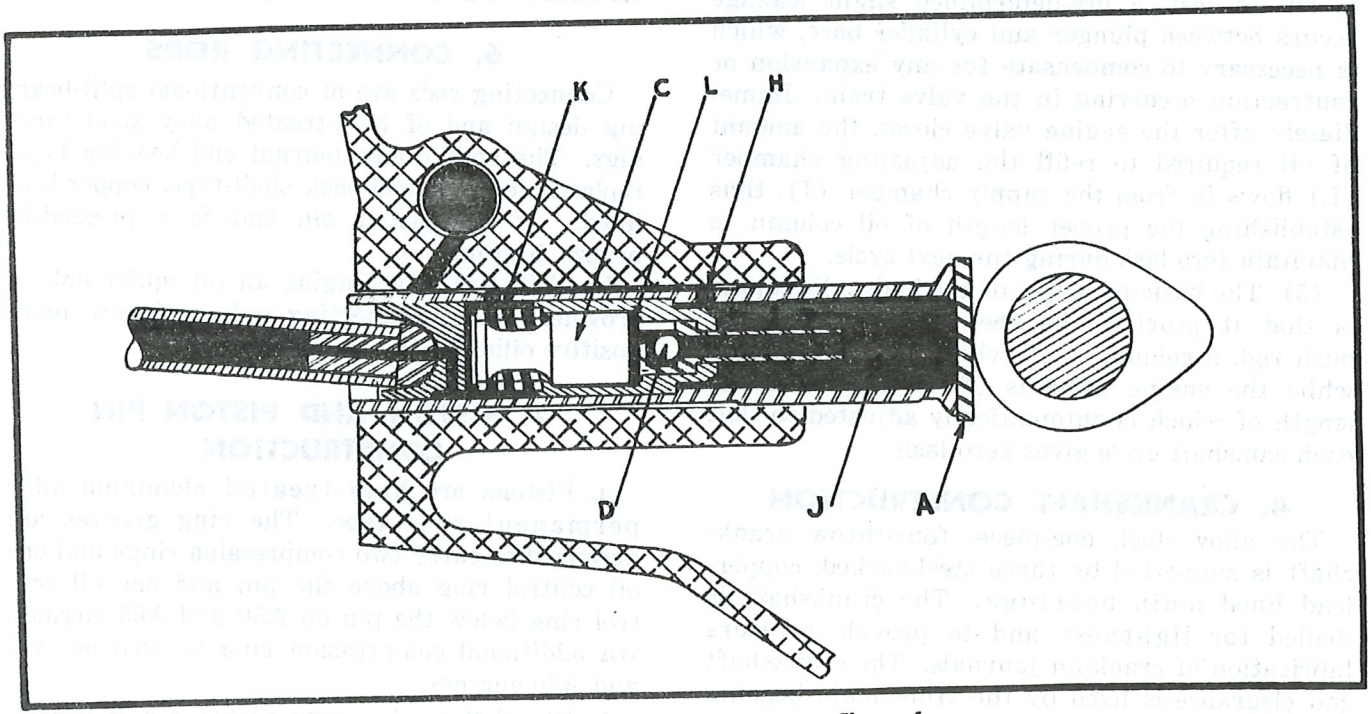
a. General. Zero lash hydraulic tappets fit aluminum alloy guides machined in the crankcase and so sealed as positively to prevent oil leakage. Tappets are drilled in such a manner that an oil passage is provided from the tappets to the push rods, rocker arm bearings, and rocker end. Push rods are made of light steel tubing with pressed-in ball ends, hardened and ground, and drilled their entire length to provide an oil passage to the overhead mechanism. The push rod is fully enclosed, and the outer end fits into a socket in the rear of the valve rocker. The rocker acts directly on the valve through a specially designed "foot" so constructed as to prevent side-thrust on the valve stem. Splash and spray lubrication keeps valve guides oiled at all times. Oil is returned to the crankcase by the push rod housing.

b. Hydraulic Tappets.

(1) The tappets are composed of only four parts which can be disassembled: the cup, cylinder, piston, and cam follower body.

(2) They are automatically adjusted to function properly with clearances ranging from .030 inch to .110 inch. At the factory, clearances are set from .050 inch to .080 inch.

(3) Oil lines to tappets operate on full engine



Section Through Hydraulic Tappet — Figure 6

pressure and are located in such a way that they register with tappet when valves are open.

(4) Oil under pressure from the lubricating system of the engine is supplied to the hydraulic lifter through hole (H) to supply chamber (J). (See figure 6.)

(a) With face of the lifter on the base circle of the cam and the engine valve seated as shown in figure 6, the light plunger spring (K) lifts the hydraulic plunger (C) so that its outer end contacts the push rod, taking up the clearance at this point and all along the valve train, giving zero lash. As the plunger (C) moves outward, increasing the volume in the pressure adjusting chamber (L), the ball check valve (D) moves off its seat and oil from the supply chamber (J) flows in and fills chamber (L).

(b) As the camshaft rotates, the cam pushes the lifter body outward, tending to decrease the volume of chamber (L) and forcing the ball check onto its seat. Further rotation of the camshaft moves the lifter body (A) outward and the confined body of oil in chamber (L) acts as a member in the valve operating mechanism, the engine valve being lifted on a column of oil. So long as the engine valve is off its seat, the load is carried by this column of oil.

(c) During the interval when the engine valve is off its seat, a pre-determined slight leakage occurs between plunger and cylinder bore, which is necessary to compensate for any expansion or contraction occurring in the valve train. Immediately after the engine valve closes, the amount of oil required to refill the adjusting chamber (L) flows in from the supply chamber (J), thus establishing the proper length of oil column to maintain zero lash during the next cycle.

(5) The basic principle of the hydraulic tappet is that it provides, between the cam and the push rod, a column of oil which carries the load, while the engine valve is off its seat, and the length of which is automatically adjusted so that each camshaft cycle gives zero lash.

4. CRANKSHAFT CONSTRUCTION

The alloy steel, one-piece, four-throw crankshaft is supported by three steel-backed, copper-lead lined main bearings. The crankshaft is drilled for lightness and to provide pressure lubrication of crankpin journals. The crankshaft end clearance is fixed by the front main bearing setting between the forward crank cheek and a collar machined on the shaft.

5. CRANKCASE AND OIL SUMP CONSTRUCTION

a. The crankcase is a two-piece heat-treated aluminum alloy casting, bolted together at the vertical lengthwise plane through the crank and camshafts. Rigid transverse webs hold the three main crankshaft bearings and the three camshaft journals. A specially designed oil seal prevents oil leakage at the propeller. Large tappet guides are formed in the crankcase in a plane below and parallel to the cylinders. Cast-in tubes are used to provide pressure lubrication of the tappet guides, camshaft, and main bearings. Circumferential stiffening ribs under the cylinder pads give additional strength and stiffness to the cylinder hold-down bosses. Four engine mount bosses for 7/16-inch bolts are provided at the rear of the crankcase for mounting similar to that of radial engines. To the rear and on the bottom of the crankcase there is a large flange for supporting the oil sump.

b. The oil sump is a two-piece deep drawing sheet steel stamping, welded together at the flange. A heavy sheet steel mounting flange is securely welded at the top of the sump. A steel filler tube with mounting bracket is welded to the oil sump body. A bayonet-type oil gauge rod is combined with the oil filler cap.

6. CONNECTING RODS

Connecting rods are of conventional split-bearing design and of heat-treated alloy steel forgings. The split crank journal end bearing is of replaceable thin steel-back shell-type, copper-lead lined. At the piston pin end is a pressed-in bronze bushing.

On A75 and A80 Engine an oil squirt hole is provided in the connecting rods to insure more positive oiling of the cylinder walls.

7. PISTON AND PISTON PIN CONSTRUCTION

a. Pistons are heat-treated aluminum alloy permanent mold type. The ring grooves are arranged to carry two compression rings and one oil control ring above the pin and one oil control ring below the pin on A50 and A65 engines. An additional compression ring is used on A75 and A80 engines.

b. The full-floating type piston pin is a case-hardened, seamless steel alloy tubing, machined

and ground. Each end is fitted with an aluminum plug to prevent scoring of the cylinder walls.

8. CRANKCASE COVER

The aluminum alloy crankcase cover casting at the rear end of the engine provides support for ignition units, oil pump, and tachometer drive. The gear case has the oil suction tube, the oil drain oil screen, the pressure relief valve and oil lines to match the several crankcase oil lines. The entire assembly with accessories is removable as a unit.

9. LUBRICATING SYSTEM

To reduce the number of external oil lines, an oil sump is attached directly to the crankcase. Oil is drawn from the oil sump through a suction tube extending down into the sump and delivered under pressure to a screen from which it goes through drilled passages in the crankcase cover and crankcase to all drive bearings, through the crankshaft, and to the crankpins. Engine oil from the pressure pump is carried through drilled passages in the crankcase to the hydraulic tappets. After entering the tappets, it travels out through the overhead mechanism through hollow push rods, and is spilled over the rocker arm and valve mechanism. As it drains away, it thoroughly oils the valve stems and valve guides. The oil is returned to the crankcase by way of the push rod housings, and drains back into the oil sump through the opening at the rear of the crankcase. The cylinder walls and piston pins are lubricated by spray. The excess oil in the crankcase is returned to the oil sump. The pressure relief valve is set to give approximately 35 pounds of pressure at speeds of from 1900 to 2300 R.P.M.

Refer to the Section on Table of Limits for Charts showing the lubrication system.

10. FUEL INJECTION

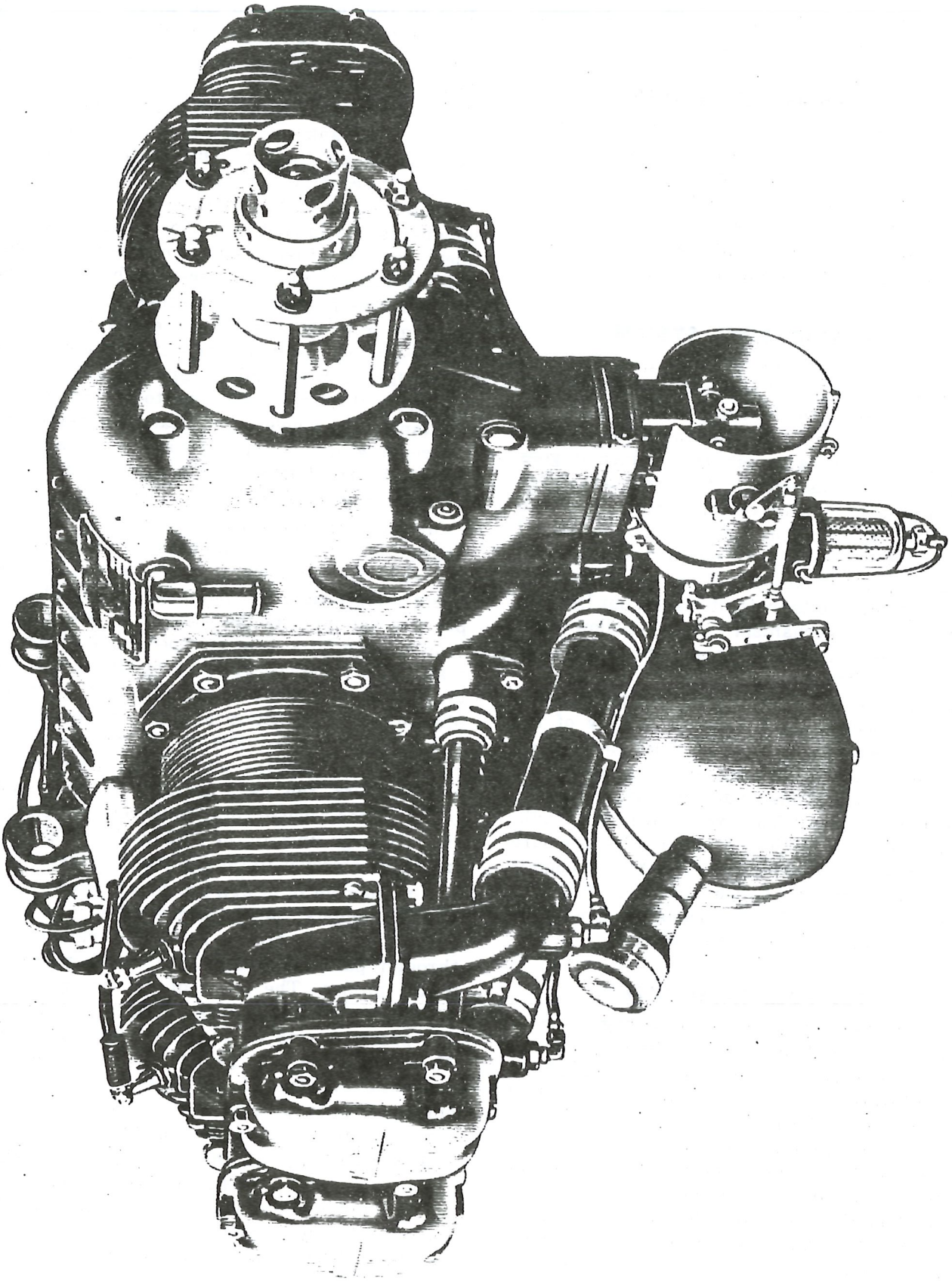
The injector mounting on these engines is at the forward end of the crankcase and the injector drive is taken from the front end of the camshaft. The air throttle assembly is mounted just back of the injector, on the lower side of the crankcase, and standard air intake pipes lead from the throttle assembly to the intake ports. Tubes from the injector are firmly clamped to the air intake pipes and conduct the fuel from the injector to spray jets mounted in the induction pipes just outside the intake ports. The valve which meters the fuel to the injector and the throttle controlling the air to the engine are linked together so that any degree of opening or closing simultaneously affects them both.

The mounting of the injector at the forward end of the crankcase, just back of the propeller, is ideal for air cooling. The injector is enclosed in an air scoop, which conducts the air blast to the air intake unit, and thus the induction air augments the impact blast for cooling. A sediment bowl and fuel strainer, mounted just below the air intake unit, also receives the cooling air as does the fuel line connecting the two. The installation in the airplane merely calls for a fuel line from the fuel tank connected to the rear of the sediment bowl and an upward sloping vent line from the top of the bowl to a high point in the tank. The whole unit streamlines neatly into the cowling of the airplane with merely an opening at the front to accommodate the opening of the air scoop.

Mechanically the injection system is of simple design. The injector unit consists of cylindrical plungers fitted into pumping bores, the plungers being reciprocated for pumpage and rotated for positive valving. As the rotation of the plungers is at one half the injector speed, one plunger is made to serve two cylinders by alternately discharging first to one and then to the other. Motion of reciprocation and of rotation is positive and applies equally to all plungers, with return springs on the plungers to keep them in contact with the cam surface. If the engine backfires the reverse rotation merely pumps from the discharge lines to the fuel intake without any injury whatsoever to the injection device.

A refinement of design provides for two grooves on the plungers, the one nearest the tip to arrest all fuel which works down the plunger, and through passages and a tube vents it into the intake piping. The lower of the two grooves is connected through drilled passages and ducts to the pressure side of the engine oiling system. The cam drive and gearing is also lubricated from the overflow of the pressure oiling of the engine. The surplus oil is returned to the engine crankcase to be recirculated again.

The function of the injector is to supply metered quantities of fuel to each cylinder, each cycle. This is accomplished by making the injector a positively driven pump of constant stroke to which the fuel is metered on its intake side.



FUEL INJECTOR ENGINE — *Figure 7*

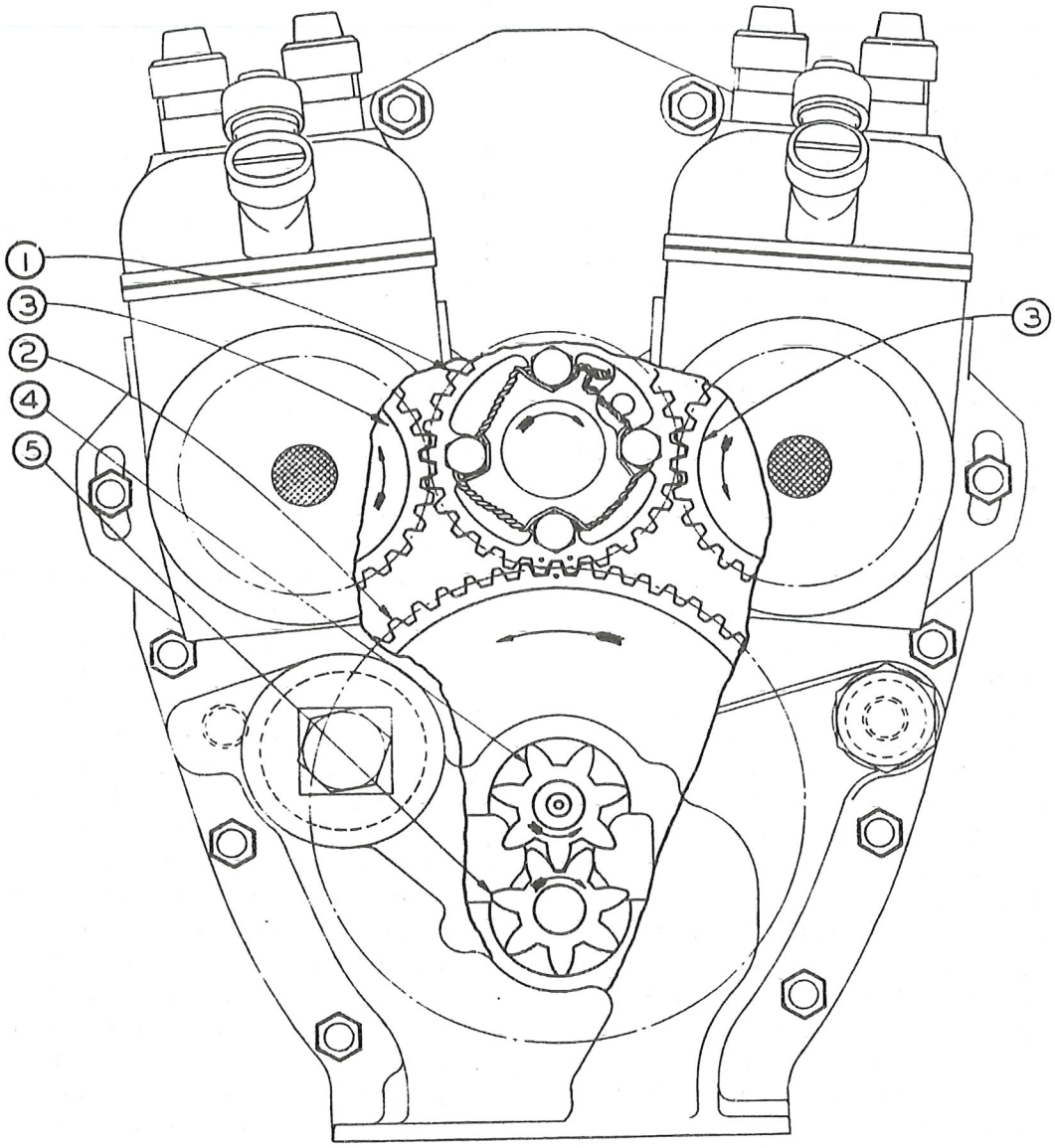
OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

The actual metering of fuel is into some eighteen or twenty inches of vacuum produced by the pump plungers, the plungers positively forcing to the engine the fuel which is metered. The fact that the fuel is metered on the intake side, as is the air throttled on the intake side of the engine, makes the fuel and air inherently self compensating for variable load. Thus with the fuel metering valve and the air throttle linked to it held in any fixed position, if the load is reduced and the speed increases, substantially the same amount of fuel and air is divided among more cylinder inductions and each individual charge is correspondingly smaller. Inversely, if the speed is pulled down with load, again substantially the same amount of fuel and air is divided among less cylinder inductions and each charge is correspondingly larger. This is of vital importance for an injector engine must be capable of both a power dive and also function perfectly when the speed is reduced by the extra load of a climb. The use of a variable pitch propeller is also made possible by this ability to compensate for load which is inherent in this injection system.

Another advantage of this fuel injection system, which is inherent, is the ability to compensate for the varying atmospheric pressure encountered when flying to altitude. This is accomplished by restricting the fuel in the injector to the maximum required by the engine, as is the maximum air inducted by the engine dependent upon the valves or other breathing restrictions. With these restrictions of fuel and air comparable on the ground, and the maximum output of the engine dependent upon them, they will be comparable at other atmospheric pressures where the total output is correspondingly reduced. Likewise, any part-throttle fuel and air which is in proportion on the ground will be in proportion at any altitude for atmospheric pressure applies to them both at any and all altitudes in which the airplane is flown.

From the injector mounted on the crankcase, neoprene covered tubes conduct the fuel to the spray jets at the intake ports of the cylinders. The order in which the fuel is discharged from the fuel outlets of the injector is in accordance with the firing order of the engine. As these four cylinder engines fire in the sequence of 1, 3, 2, 4 the plunger ports serve the outlets connected to the cylinders in that respective order. Thus the discharge duct of number one plunger is set to first serve the outlet to number one cylinder, and 180 degrees later the discharge port in number two cylinder serves the outlet to number three cylinder. On the second rotation of the injector the number one plunger has rotated until the discharge duct serves the outlet to number two cylinder, and 180 degrees later the discharge duct to the number two plunger serves the outlet to the number four cylinder. With the third rotation of the injector the cycle is repeated.

In this low pressure system the fuel is injected into the inducted air during the suction stroke of the engine. The metered quantity of fuel, which is conducted through the fuel discharge tubes, is atomized by the spray jets mounted at the intake ports of the engine. In the spray jets the fuel is passed through ducts tangent to a central depression, or whirl-chamber, which causes the fuel to revolve so rapidly that it is torn asunder or finely atomized as it is discharged from the final orifice. The final orifice, and the ducts leading to the whirl-chamber, are each a number of times larger than is the free opening in an 80 mesh screen, so only an 80 mesh screen in the sediment bowl is needed to guard against foreign matter carried by the fuel. Light, hydraulically operated, valves in each spray jet seal the fuel in the discharge lines against the intake manifold depression and keep the fuel lines solidly filled with fuel between each spray discharge. This fog of finely atomized fuel, which is discharged in the shape of a solid cone, is picked up by the inducted air and vaporized as it is carried into the cylinder. It is the vaporizing of this fuel in the intake port, or as it is carried into the cylinder, which absorbs heat and causes a greater weight of charge to be inducted.



Cutaway View Showing Gear Train — Figure 8

GEAR TRAIN ANALYSIS

Figure 8 shows the complete gearing arrangement from the crankshaft power take-off to all accessories. The arrow on each gear indicates direction of rotation as viewed from the rear of the engine, and the following analysis describes each gear function with its speed in relation to the crankshaft.

(1) The crankshaft gear is driven from the crankshaft attached to the rear end of the crankshaft by cap screws and turns in a clockwise direction at crankshaft speed.

(2) The cam gear is driven by the crankshaft gear (1) at 1/2 crankshaft speed in a counter-clockwise direction.

(3) The right and left magneto drive gears, driven by the crankshaft gear, turn in a counter-clockwise direction at crankshaft speed.

(4) The oil pressure pump driver gear is driven by cam gear (2) through a male-female square coupling, and turns in a counterclockwise direction at 1/2 crankshaft speed.

(5) The oil pressure pump driven gear is driven by gear (4), and turns in a clockwise direction at 1/2 crankshaft speed.

Section 4

PACKING, UNPACKING, AND PREPARATION FOR STORAGE

1. SHIPPING BOXES

The engines are packed for domestic and overseas shipment in a shipping box of the following general dimensions:

Overall length	39"
Overall width	36"
Overall height	27½"
Empty weight	137 lbs.
Gross weight	320 lbs.
Volume	22.2 cu. ft.

2. PACKING

The engines are packed for shipment in their standard wooden shipping boxes in an inverted position, with the rear of the engine resting on the two mounting pads bolted to the angle iron brackets provided in the base, and the front of the crankshaft resting in the cradle provided for it in the base of the shipping box. The propeller hub and the carburetor air intake are securely fastened to the bottom of the shipping box, and the mounting cones and washers are wired together and fastened to a mounting arm.

3. UNPACKING THE ENGINE

a. Drive out the four hinge pins that secure the shipping box sides and cover to its base. Lift cover and sides off. Care must be taken to lift the cover straight up so that it will not touch any part of the engine.

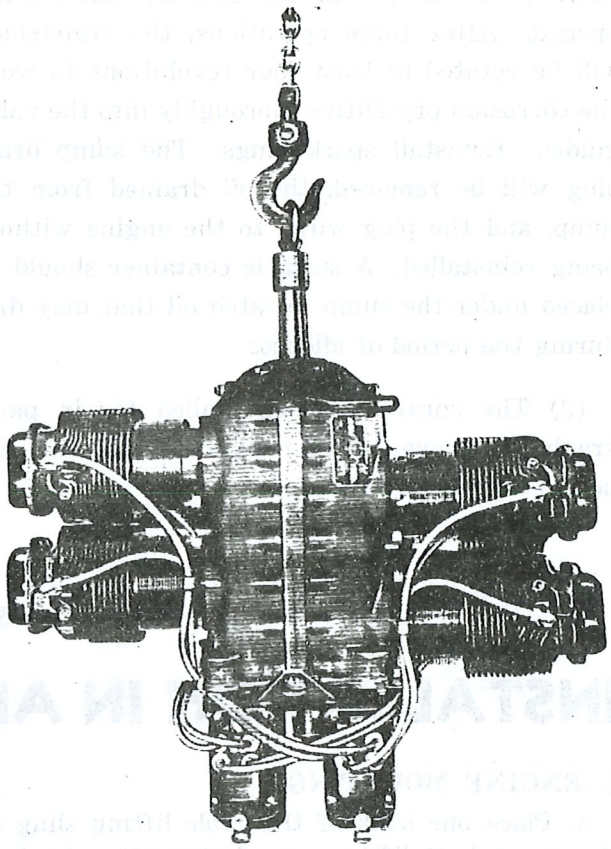
b. Remove the two nuts which hold the wooden block securing the crankshaft to the base. Remove wooden block from top of crankshaft.

c. Attach lifting eye, part No. A23162, to the crankshaft. With a man on each side of the engine, take up weight of engine. Remove bolts which secure mounting arms to the base.

d. Take up slack in the cable attached to lifting eye as the men lift the engine straight up. Remove shipping box base from beneath engine.

e. Take up weight of engine on lifting hoist until engine is suspended from the ground by the lifting eye attached to the crankshaft (Fig. 9).

f. Lower engine to appropriate engine stand and bolt it securely.



Hoisting Engine with Crankshaft Lifting Eye — Figure 9

g. Remove the propeller hub and carburetor air intake which are fastened to the base of the shipping box. Remove rubber mounting cones and washers which are tied to a mounting arm.

4. TREATMENT OF ENGINES FOR PERIODS OF IDLENESS

a. **Temporary** — Engines installed in aircraft that are not to be operated for a period of more than seven days, but less than 60 days, shall be considered in temporary storage. As soon as the period of inactivity is known, the engine will be treated as follows:

(1) Spray the exhaust valves thoroughly with a suitable corrosion preventive compound. This

spraying will be done through the exhaust ports, with the exhaust valves fully opened. On installations having exhaust collectors that are difficult to remove, the spraying may be done through the spark plug holes, with the exhaust valves fully opened. After these operations, the crankshaft will be rotated at least four revolutions to work the corrosion preventive thoroughly into the valve guides. Reinstall spark plugs. The sump drain plug will be removed, the oil drained from the sump, and the plug wired to the engine without being reinstalled. A suitable container should be placed under the sump to catch oil that may drip during the period of idleness.

(2) The spray treatment called for in paragraph (1) above will be repeated at the end of a period of 30 days of idleness.

5. PREPARATION OF ENGINES FOR SERVICE AFTER TREATMENT.

(a) **Engines in Temporary Storage.** — Engines treated for temporary periods of idleness can be placed in service immediately after making the following checks:

(1) Turn the propeller slowly by hand at least four or five revolutions to determine that the cylinders are free of any accumulation of water, oil, or fuel and that the valves operate freely. The stems of any valves that are sticking will be lubricated generously with a mixture of gasoline and lubricating oil. Continue to turn the engine over by hand until all evidence of sticking valves has been eliminated. If the mixture of gasoline and lubricating oil does not free all the valves, the necessary repairs will be made before the engine is placed in service.

(2) After starting the engine, if the spark plugs are found to be fouled from excessive engine oil, they will be removed and washed with Acetone.

Section 5

INSTALLATION IN AIRPLANE AND REMOVAL

1. ENGINE MOUNTING.

a. Place one hook of the cable lifting sling on the crankshaft lifting eye; fasten other hook of sling to rear lifting eye, part No. 23164, which is installed on the upper two studs holding crankcase cover to crankcase. (Refer to figure 10.)

b. Fasten hook of hoist to engine sling and raise engine to level which will permit the bolting of the mounting arms to the mounting bracket. Seven-sixteenths inch mounting bolts are used with cone type rubber mounting washers, which prevents any direct metal-to-metal contact between the engine and its mounting frame. These washers make the tension of the mounting bolts of prime importance, and these bolts must be adjusted from time to time in service to compensate for any permanent compression which may take place during usage.

c. Remove cardboard thread protector of crankshaft, cardboard exhaust port covers, and wood plug from carburetor inlet.

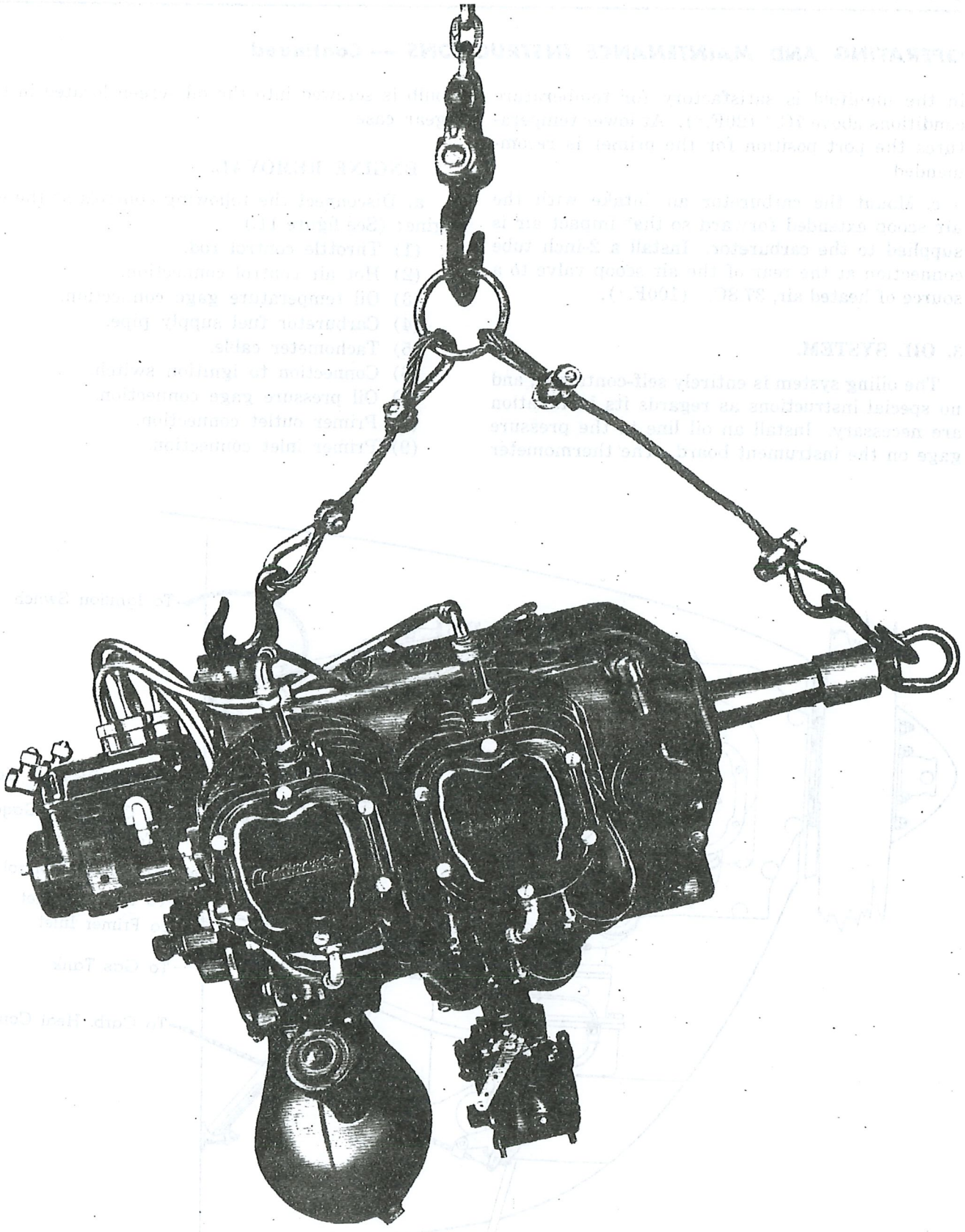
d. Connect the following controls at the engine: (See figure 11.)

(1) Throttle control rod.
(2) Hot air control connection.
(3) Oil temperature gage connection.
(4) Carburetor fuel supply pipe.
(5) Tachometer cable.
(6) Connection to ignition switch.
(7) Oil pressure gage connection.
(8) Primer outlet connection.
(9) Primer inlet connection.

2. FUEL AND CARBURETION SYSTEM.

a. Arrange the fuel tank so that the head, under extreme conditions of climb, does not fall below two inches. The head required to flood the carburetor in nose-down position is about 90 inches and provision should be made not to exceed this head in a steep glide.

b. The primer may be connected either at the intake manifold above the carburetor, or at the intake port of each cylinder. The primer installed



HOISTING ENGINE WITH LIFTING SLING — *Figure 10*

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

in the manifold is satisfactory for temperature conditions above 7C.° (20F.°). At lower temperatures the port position for the primer is recommended.

c. Mount the carburetor air intake with the air scoop extended forward so that impact air is supplied to the carburetor. Install a 2-inch tube connection at the rear of the air scoop valve to a source of heated air, 37.8C.° (100F.°).

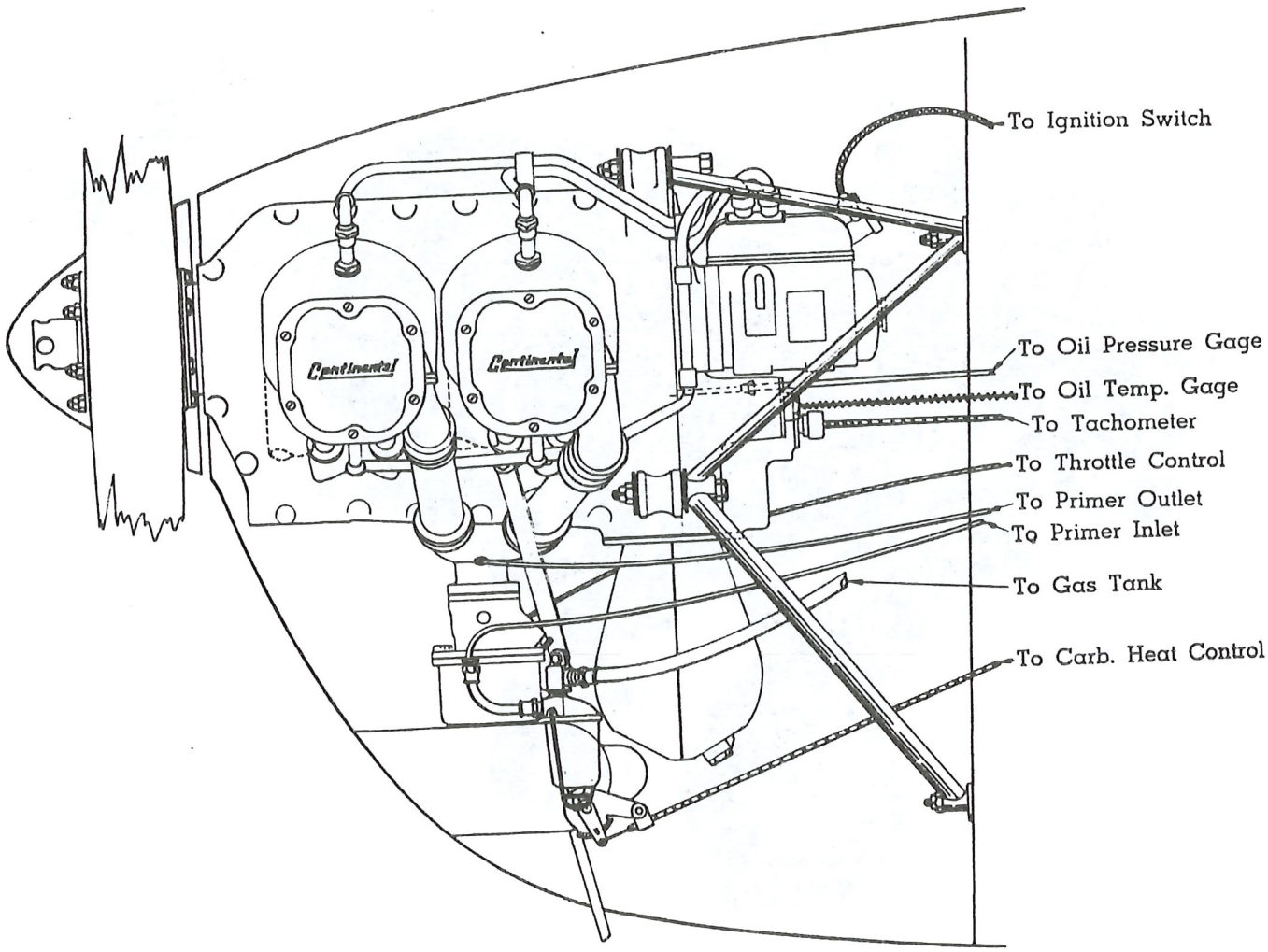
3. OIL SYSTEM.

The oiling system is entirely self-contained, and no special instructions as regards its installation are necessary. Install an oil line to the pressure gage on the instrument board. The thermometer bulb is screwed into the oil screen located in the gear case.

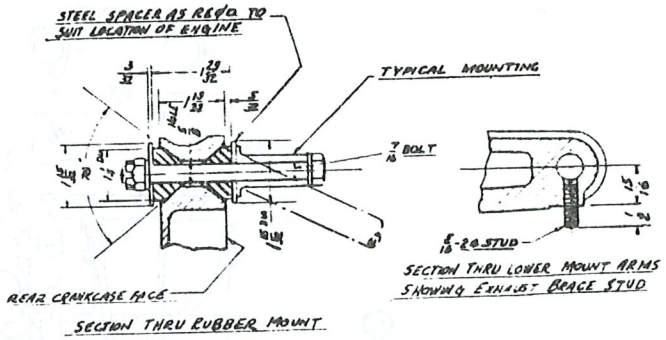
4. ENGINE REMOVAL.

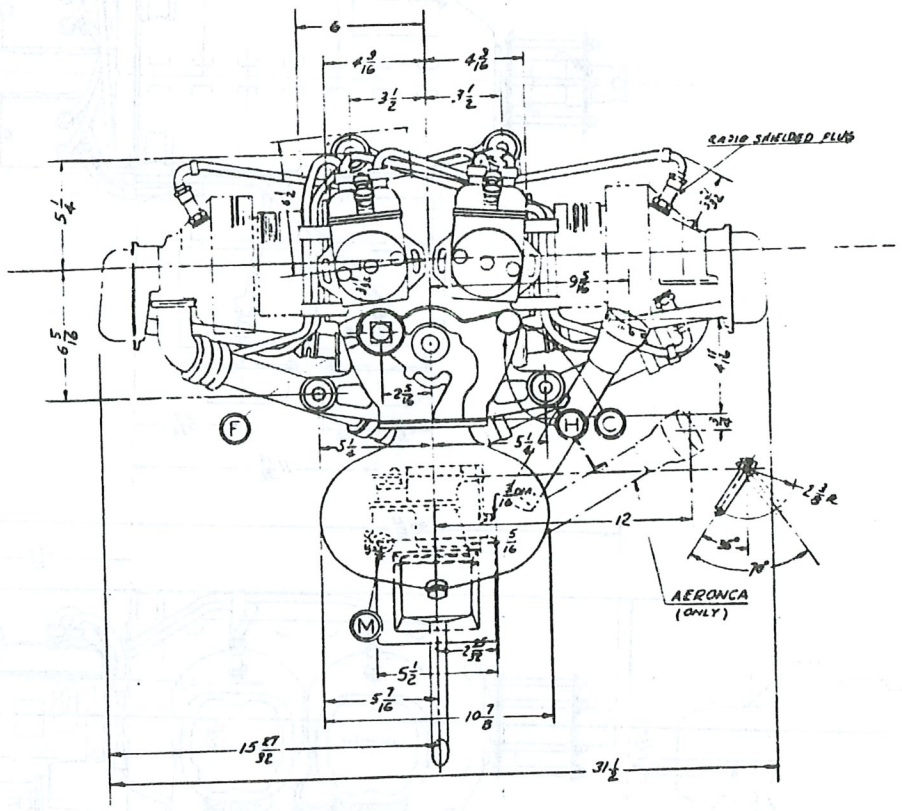
a. Disconnect the following controls at the engine: (See figure 11.)

(1) Throttle control rod.
(2) Hot air control connection.
(3) Oil temperature gage connection.
(4) Carburetor fuel supply pipe.
(5) Tachometer cable.
(6) Connection to ignition switch.
(7) Oil pressure gage connection.
(8) Primer outlet connection.
(9) Primer inlet connection.



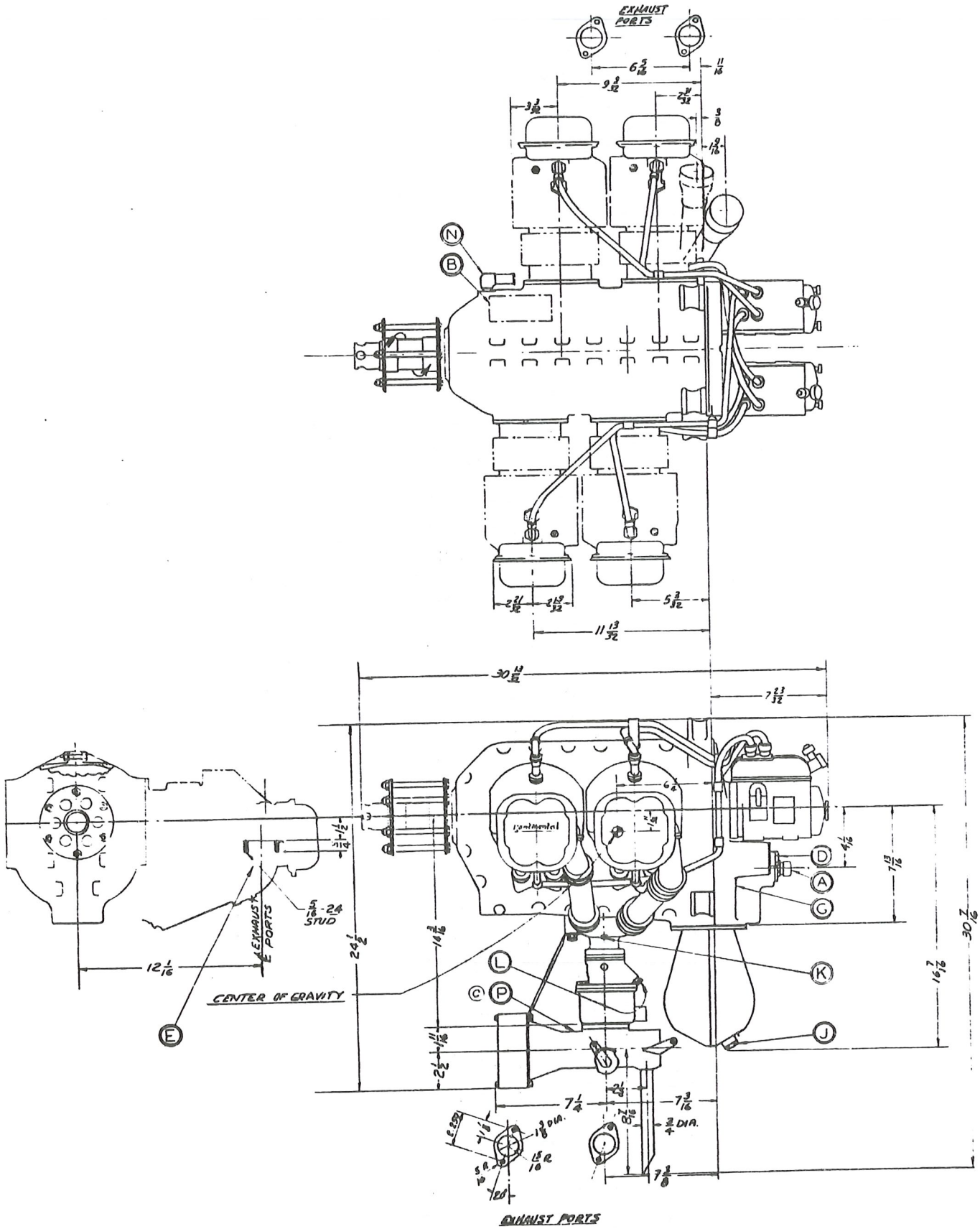
Typical Installation Diagram — Figure 11





A — TACHOMETER DRIVE SAE STD ½ ENGINE SPEED CCW ROT
B — NAME PLATE
C — OIL PRESSURE GAUGE CONNECTION ⅛ PIPE TAP
D — OIL THERMOMETER CONNECTION SAE STD
E — EXHAUST MOUNTING FACE
F — OIL SCREEN
G — OIL PUMP
H — OIL PPRESSURE RELIEF VALVE
J — OIL DRAIN
K — PRIMER JET CONNECTION ⅛ PIPE TAP
L — CARBURETOR MIXTURE CONTROL
M — FUEL INLET CONNECTION
N — BREATHER CONNECTION ⅝ I. DIA. HOSE
O — OIL QUANTITY GAUGE
P — AIR INTAKE
FOUR CYLINDER OPPOSED
3⅞ BORE 3⅝ STROKE 171 CU. IN.
LOWER EXHAUST
INSTALLATION DRAWING

INSTALLATION DRAWING — Figure 12



INSTALLATION DRAWING — Figure 12a

b. Remove ignition wires from magneto, and change position of magnetos, if necessary, to clear mounting frame.

c. Attach chain hoist to engine sling which is attached to engine as described in paragraph 1.a. above, and relieve mount of engine weight.

d. Remove engine mounting bolts, starting with those at the bottom.

CAUTION: Two men are required for this operation, one to remove the mounting bolts and the other to operate the chain hoist.

e. Cover portions of the rear section and accessories which may strike the mount when engine is removed.

f. Carefully remove engine from mount; lower, and fasten engine to stand.

Section 6

GENERAL OPERATING INSTRUCTIONS

1. PROCEDURE PRELIMINARY TO STARTING.

a. If the engine has been idle for over 2 hours, or if excessive priming has been used during starting attempts, make certain that ignition is turned to the "OFF" position, open the throttle wide and pull the engine through by hand four or five complete revolutions. If fuel or oil is present in any combustion chamber, as evidenced by excessive compression, remove the spark plugs from that cylinder, drain all liquid from the cylinder and intake pipes, and dry spark plugs thoroughly before replacing.

CAUTION: Starting the engine with excessive oil or fuel in the cylinders may result in bent or broken rods.

b. Set mixture control at "FULL RICH."

c. Open cowling flaps (if installed), except in extreme cold weather.

d. Place carburetor heat control in COLD position.

2. STARTING.

a. With throttle "CLOSED," switch "OFF," and gasoline supply valve turned "ON," prime the engine three or four strokes (depending on weather conditions, warm engine, etc.) as the engine is turned over by hand five or six times. Avoid overpriming.

b. Turn ignition switch "ON" and open throttle slightly. Start engine by pulling propeller through.

c. If engine fires on one or two cylinders with weak exhaust report and resultant black smoke, it is overprimed and should be unloaded in the following manner:

(1) Turn ignition switch "OFF."

(2) Open throttle and turn the engine backwards five or six times.

d. For cold weather starting, a half or quarter stroke on the primer when the motor fires once or twice will enable it to keep running. In extremely cold weather the oil should be preheated.

e. If the engine fails to start after a reasonable number of attempts, consult paragraph 1 of Section 7 for possible cause.

3. WARM-UP AND GROUND TEST.

a. As soon as engine is started, check oil pressure gage. If the gage does not indicate pressure within 30 seconds, the engine should be shut down and investigation made.

b. All ground testing and running of engine will be accomplished with carburetor set at "FULL RICH" position and all controllable cowling flaps, gills, etc., (if installed) will be in the full "OPEN" position.

c. After engine has run approximately 3 minutes between 700 and 800 rpm, increase throttle gradually until tachometer shows from 1200 to 1500 rpm and run for an additional 5 to 7 minutes.

d. Test magnetos separately for proper firing. Speed of engine with steady throttle should not drop off more than 75 rpm on either single magneto from a "BOTH" magneto operating position.

NOTE: Prolonged running of the engine at or near "FULL THROTTLE" position should be avoided on the ground. Under average conditions, for continuous operation on the ground, speeds up to 1850 rpm are permissible. However, due to

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

variations in the wooden propellers used, it is extremely difficult to give definite permissible and top ground rpm.

4. TAKE-OFF.

a. Immediately before take-off, set brakes. Open to "FULL THROTTLE" for approximately 10 seconds and check individual magneto operation. Check oil pressure, oil temperature gages and carburetor air heater control.

b. During take-off and climb the engine should be kept at "FULL THROTTLE." When a safe altitude has been attained the engine can be throttled down.

5. FLIGHT.

a. The rpm, cylinder head temperatures, oil pressure, and temperature give the most satisfactory indication of the engine's performance. If any of these appears irregular, the engine should be throttled and, if the cause cannot be eliminated, a landing should be made to investigate and remove the trouble.

b. In flight the mixture control can be leaned out only when a higher rpm can be obtained, i.e., a higher rpm must result from any leaning of the mixture, otherwise the mixture control must be returned to the "FULL RICH" position.

6. LANDING.

a. The mixture control must be replaced in its "FULL RICH" position prior to landing.

b. From cruising operation, slowly close throttle to 1000 rpm.

c. The carburetor air heater should be used in long glides.

d. When throttle is closed while making long glides from high altitude, open throttle periodically to clear the cylinders and to prevent spark plug fouling.

7. STOPPING.

a. **Preliminary Procedure.**

(1) Set mixture control at "FULL RICH" position.

(2) Set throttle at normal idling position.

(3) Allow the engine to run at normal idling speed with the nose cowl or radiator shutters (if installed) fully opened until the engine has cooled appreciably below cruising temperature. Cylinder and oil temperature will normally reach values below cruising temperatures during the gliding for landing and taxiing. The resulting temperature during this idling period will vary according to climate and the amount of power that was required for taxiing.

b. **Regular Procedure.** — The following procedure will be followed upon completion of preliminary procedure outlined in paragraph (a).
stop from idling speed.

(1) Close the fuel valve and allow engine to stop from idling speed.

(2) Place the throttle in the "OPEN" position after stopping the engine, as this lessens the possibility of accidental starting while the engine is hot.

8. CARBURETOR HEAT CONTROL.

The engine should be operated on "COLD" air at all times, except when operating under conditions where icing is likely, in which case the carburetor air control should be placed in the "FULL HOT" position. If improved engine operation is not obtained the heat control should be returned to the "COLD" position.

9. MIXTURE CONTROL.

The following expressions are applicable to manual adjustment of the mixture control:

a. "FULL RICH" is the setting of the mixture control lever in the position giving maximum fuel flow.

b. "BEST POWER" is the setting of the mixture control lever which, with a given throttle setting, results in obtaining a higher rpm., i.e., higher rpm must result from any leaning of th. mixture, otherwise the mixture control must be returned to the "FULL RICH" position.

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

10. GASOLINE AND OIL RECOMMENDATIONS

Engine Model	Recommended Gasoline Octane Rating	OPERATING TEMPERATURE OF OIL — °F. Below 120°F.	120° — 160°	160° — 190°	Above 190°F.
		APPROXIMATE EQUIVALENT IN OUTSIDE AIR TEMPERATURE — °F. Below + 32°	32° — 70°	70° — 100°	Above 100°
A50	73	SAE 20	Aero grade No. 60	Aero grade No. 80	Aero Grade No. 100
A65	73	SAE 20	Aero grade No. 60	Aero grade No. 80	Aero Grade No. 100
A75	73	SAE 20	Aero grade No. 60	Aero grade No. 80	Aero Grade No. 100
A80	80	SAE 20	Aero grade No. 60	Aero grade No. 80	Aero Grade No. 100

Recommended oil changes in all models — each 20 to 30 hours of operation. When operating oil temperatures overlap above column ranges, use the lighter oil.

Section 7

ENGINE TROUBLES AND SERVICE REPAIRS

1. FAILURE OF ENGINE TO START.

a. **Lack of Fuel.**

(1) Check whether there is a sufficient level of gasoline in airplane tank to flow to the carburetor.

(2) Check the gasoline flow at the carburetor; see that the carburetor float is not stuck, and that the jets are not clogged.

(3) Make certain that the vent holes in the gasoline tank caps are open.

b. **Under-priming or Over-priming.**

(1) If engine is under-primed, close throttle; with gasoline supply valve turned on, prime the engine two or three strokes.

(2) If the engine is over-primed, turn the ignition switch off, open the throttle, and turn the engine backward to unload the cylinders.

c. **Defective Ignition.**

(1) Examine ignition wiring for breaks in the insulation.

(2) Check all spark plugs for correct gap setting. Whenever the gap is found to exceed .020 inch, the electrodes will be regapped .012 to .016 inch.

(3) Check magneto points for clearance and possible pitted or oily condition.

(4) Examine the magnetos for correct timing to the engine. (Refer to section 12, paragragh i, (3). (5) Check ground terminal for possible shorting inside terminal housing.

d. **Valve Action.**

(1) Check valve stems to be sure they are not gummed with carbon and sticking open.

(2) Check condition of valve springs and see that they are assembled to the valve stem correctly.

(3) Check the working order of the rocker arm assemblies.

(4) Check for worn or bent push rods.

e. **Cold Oil** — With the ignition switch off, turn propeller over by hand to break the drag created by cold oil between the pistons, piston rings, and cylinder walls. If the engine is very stiff, it will be necessary to free the pistons in the cylinders either by applying heat or injecting small quantities of very light oil through the spark plug holes.

f. **Hot Engine** — Do not prime. The engine will frequently start without an additional prime over that left in the cylinders when the engine was shut off. It may be necessary to unload the cylinders by turning the propeller opposite to the direction of rotation.

2. LOW OIL PRESSURE.

a. Check for dirt in the oil screen. Remove screen and clean thoroughly.

b. Check for poor connections in the oil suction line, causing the pump to draw air.

c. Check the quantity of oil in sump. A minimum of two quarts of oil must be used.

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

d. Inspect relief valve to see whether plunger is operating smoothly in its guide and seating well, and the control spring is functioning properly. Clean.

e. Inspect and clean oil screen at end of oil suction tube.

3. HIGH OIL TEMPERATURE.

a. This condition may be due to the following:

(1) Insufficient amount of oil in sump.
(2) Dirty oil.
(3) Failure to remove winter baffles, or interference of loose baffles.
(4) Excessively lean carburetor mixture.
(5) Worn or stuck rings, indicating piston score.
(6) Altitude control mixture not adjusted properly.
(7) Worn or scratched bearings.

4. LOW POWER.

a. Check propeller for track and balance.

b. Check ignition system.

c. Check for air leaks at all connections of carburetor and intake manifold.

d. Check for full opening of throttle valve.

e. Check for unrestricted flow of fuel to carburetor inlet and for proper operation of carburetor.

f. Check carburetor for icing conditions.

g. Check carburetor air temperature. Check for proper operation of carburetor heat control.

h. Check tachometer to see that it is registering correctly.

5. ROUGH RUNNING.

a. Check propeller for balance, track and correct installation on the propeller hub and shaft.

b. Remove, clean, set gaps, and bomb test spark plugs.

c. Check magneto operation. Check whether ignition cables are breaking down at high speeds.

d. Check valve operation, especially evidence of sticking, or any lag in valve operating mechanism.

e. Check engine mounting bolts for tightness.

f. Check engine mount for cracked or broken members.

g. Check carburetor air temperature. Check for proper operation of carburetor heat control.

6. ENGINE FAILS TO ACCELERATE PROPERLY.

a. Motor not sufficiently warm.

b. Heater control not on, or not functioning properly.

c. Engine idling jet set too lean or plugged.

d. High float level.

e. Worn intake valve guides and piston rings.

7. ENGINE FAILS TO IDLE PROPERLY.

a. Air leaks at joints of the carburetor and intake manifold can be located by squirting raw gasoline from a hand oil can around all connections and packing while the engine is running about 400 to 500 rpm. If gasoline is applied at a leaking connection, it will be drawn in, causing the engine to increase its rpm. As soon as this extra fuel is burned, the engine will again fall back to its former rpm.

b. Leaking primer jets.

c. Heater control not on, or not functioning properly.

d. Engine idling jet set too lean or plugged.

e. Worn intake valve guides and piston rings.

Section 8

SERVICE INSPECTION AND ASSOCIATED MAINTENANCE

1. GENERAL.

a. The work outlined in this section consists of the periodic inspection, cleaning, servicing, lubricating, adjusting, and such maintenance work as is associated with the routine Inspection System.

2. INSPECTION AND MAINTENANCE.

a. **Daily — Power Plant.**

(1) Check oil level. Replenish oil supply if necessary.

(2) Inspect for evidence of engine throwing oil.

(3) Check security of carburetor air intake and its control valve for operation.

(4) Inspect carburetor for fuel leakage at connections, drain plugs, and passage plug. Clean

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

fuel filter bowl and fuel tank sump if necessary. Make sure drains are properly safetied.

(5) Check throttle and mixture control connections to insure that no binding exists and they are tight and properly safetied.

(6) Check all wiring terminals for tightness and condition of wiring.

(7) Make visual inspection of entire engine for: missing or loose nuts, bolts, manifolds; proper safetying of all plugs.

(8) Clean carburetor air intake filter by flushing out dirt with hot water or steam. Spray front and rear with just enough oil to coat all wires.

b. **Ignition and Electrical.**

(1) **25-Hour.**

(a) Remove magneto breaker cover and clean breaker housing.

(b) Inspect magneto for damaged breaker felts or cushions.

(c) Check for excessive lubrication. Clean and dry the breaker mechanism to insure that oil will not touch the breaker contacts.

(d) Make certain all necessary safety wiring or pins are installed.

(e) Replace breaker assembly, if necessary.

(f) Check security of spark plug elbow terminal and shielding nuts on radio shielded engines.

NOTE: When checking the elbow assembly, extreme care must be exercised that the barrel is not rotated with respect to the shell. Discontinue the common practice of slightly tightening the elbow nut at each 24-hour inspection. Never check the tightness of the elbow by twisting the body of the elbow.

(2) **50-Hour** — Inspect all wiring for breaks in the insulation and proper securing of terminals. Replace, if necessary.

(3) **100-Hour.**

(a) Remove spark plugs and clean, or replace with new or reconditioned plugs of approved type.

(b) Install serviceable spark plug gaskets.

c. **Fuel System.**

(1) **25-Hour.**

(a) Lubricate throttle shaft bearings, using light machine oil.

(b) Remove fuel filter bowl. Clean screen and bowl. Replace bowl and refill. Check for leaks and bubbles. Tighten bowl and safety.

(c) Remove float chamber, fuel passage drain plug, fuel strainer plug and strainer. Clean strainer. Flush out water and sediment by allowing fuel to flow through strainer and drain plug opening.

d. **Oil System.**

(1) **25-Hour.**

(a) Drain engine oil after each approximate 24-hours' operation, unless service requirements indicate otherwise, and refill with the proper grade and quality of oil. The draining should be done while the engine is hot.

(b) Check oil sump for security of mounting and proper safetying of all nuts.

(d) The oil screen assembly located in accessory housing back of No. 2 cylinder will be cleaned at least once every 25 hours.

(2) **100-Hour** — Clean oil screen and oil suction tube screen.

(3) **At Engine Change** — Clean oil screens on newly installed engines at the following periods:

(a) At completion of ground installation test.

(b) At completion of flight test.

e. **Cooling System.**

(1) **50-Hour.**

(a) Check air deflectors for cracks, security of fastening, and to make sure they do not rub cylinder rings.

(b) Inspect cylinders for damaged or broken fins.

f. **Valves.**

(1) These engines have internal automatic lubrication of the valve mechanism which will be inspected in accordance with the following periods and instructions:

(a) **25-Hour** — A complete detailed inspection of the valve mechanism will be made at the first 25-hour inspection period after the engine is installed.

(b) **100-Hour** — Following the first 25-hour inspection, a complete inspection of the valve mechanism will be made at 100-hour intervals.

(2) In making the inspection set forth above, the following additional instructions will be observed:

(a) Remove rocker box covers. Inspect rocker arm for cracks, excessive side or end play, signs of interference with adjacent parts.

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

(b) Check for broken springs, condition of valve spring washers, and security of retaining valve spring seat locks.

(c) Make certain all oil passages are open before replacing rocker box cover. Interior of rocker boxes should show complete coverage with engine oil.

g. **Manifold and Hose Connections.**

(1) 25-Hour.

(a) Check intake manifold for proper mounting and for security of the two plain nuts and palnuts.

(b) Inspect rubber hose connections and clamps on the intake pipes and elbows for proper and secure adjustment.

h. **Propeller and Accessories.**

(1) 100-Hour.

(a) Check propeller hub bolts for tightness and check propeller for track, making corrections if necessary. The propeller should track within ⅛-inch.

i. **General.**

(1) Check engine mounting bolts for tightness.

(2) All unattached ignition cable ends will be covered with friction tape or other suitable protective covering and secured.

(3) New or overhauled engines installed in an airplane will be ground-tested as follows:

(a) Run for a period of approximately 30 minutes during which time the operation of the engine, engine instruments, and related accessories will be thoroughly checked for proper functioning.

(b) Care must be taken not to exceed maximum cylinder or oil temperatures during this running period. Continual operation at either low idling speeds or at manifold pressures approaching rated power must be held to a minimum. Engine cowling will not be installed during the ground running.

(c) Warming-up speeds of 800 to 1000 rpm are recommended. Operation with speeds and manifold pressures that will give rated power will be limited to short bursts of only sufficient duration to obtain instrument readings and to make certain that the acceleration of the engine is satisfactory.

(d) Upon completion of the installation ground test, each airplane in which a new or overhauled engine has been installed will be flight-tested as specified below:

1. A flight of one hour's minimum duration, the first 50 minutes of which will be at reduced power and the last 10 minutes at normal rated power, followed by a careful inspection for evidence of any visible defects, malfunctioning parts, etc. If inspection does not indicate any malfunctioning or defects, the airplane may be released for service.
2. The mixture control will be kept in the "Full Rich" position at all times during the flight tests.

Section 9

ADJUSTMENT, REPLACEMENT, AND MINOR REPAIRS

1. GENERAL.

a. The work outlined in this section can be performed without the facilities usually available at major overhaul activities.

b. This section of the manual contains all necessary instructions for the replacement (but not repair) of accessories and removal of external or readily removable parts.

2. CARBURETOR.

a. The carburetor is located at the bottom of the crankcase and is attached to the intake manifold, which in turn is assembled on the two studs provided in the crankcase.

b. The carburetor is installed to the mounting pad of the intake manifold with a gasket between the parting flanges, and is retained by four castle nuts.

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

c. The carburetor air intake and filter assembly is mounted on the base of the carburetor with a gasket on each side of the adapter or spacer, and is retained by four castle nuts with palnuts.

d. Controls connecting to the carburetor are as follows:

(1) The throttle control lever is at the right side of the carburetor as viewed from the rear of the engine.

(2) The mixture control lever is located on top of the float chamber on the left side as viewed from the rear of the engine.

(3) The fuel inlet is a ¼-inch pipe tap connection located at the back near the bottom of the main body.

e. The carburetor may be removed from the engine by detaching the fuel line, throttle and mixture controls, removing the air intake assembly and the four castle nuts at the mounting pads.

3. MAGNETOS — The engine's two magnetos are mounted one on the right, and one on the left side of the crankcase cover. The mounting flange of each magneto is oval in shape.

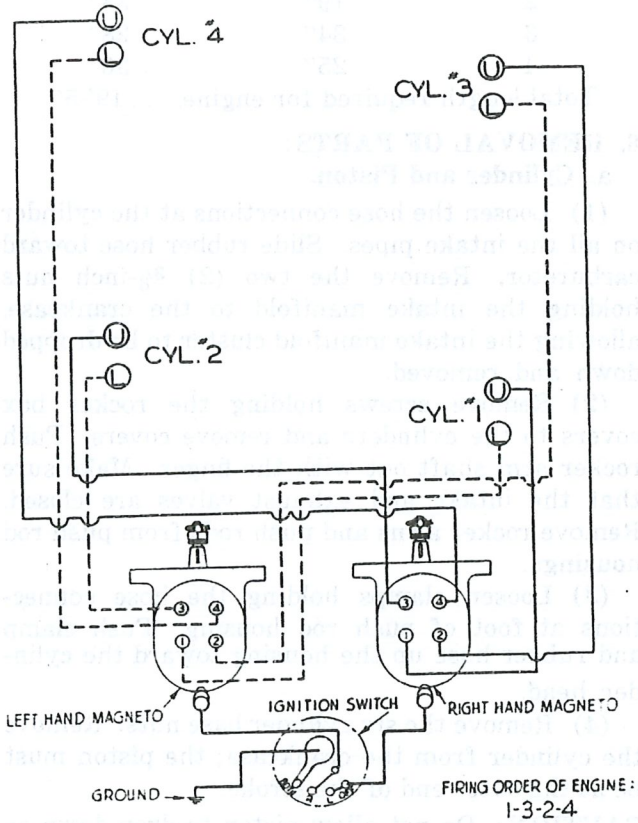
4. MAGNETO INSTALLATION AND TIMING TO THE ENGINE.

a. Rotate the magneto until the mark on the gear, visible through the inspection window, is in line with small pointer, which is also visible. This places the magneto in firing position for cylinder No. 1. Rotate engine in counterclockwise direction until the firing stroke of No. 1 cylinder is reached.

b. Installing the left and right magneto, set the engine as follows:

A50 Series 8, 9....	Right Magneto:	25° B.T.C.
	Left Magneto:	28° B.T.C.
A65 Series 8, 9....	Right and Left Magneto:	30° B.T.C.
A75 Series 8, 9 ..	Right Magneto:	29° B.T.C.
A80 Series 8, 9 ..	Left Magneto:	32° B.T.C.

c. Tighten the mounting nuts enough to hold magneto in position against the accessory case. Before checking exact breaker opening position, rotate magneto in a clockwise direction by tapping the mounting flange until it is near the end of travel permitted by the slots. Turn crankshaft backward slightly, and bring slowly up to firing position to take backlash out of the driving gear train. Insert a .0015-inch feeler between breaker points and tap magneto flange in a counterclockwise direction until the exact point of release is reached. Tighten mounting nuts and recheck timing by backing up crankshaft and turning it slowly forward to determine if the feeler is released the instant the disc reaches the 30 degree mark.



Ignition Wiring Diagram — Figure 13

5. IGNITION WIRING.

a. Refer to figure 13 where the complete ignition wire system is diagrammed and firing order given.

b. The following table shows the individual ignition cable lengths in inches and the total amount required for the Series 8 engines:

CYLINDER NUMBER	LEFT MAGNETO TO LOWER PLUG	RIGHT MAGNETO TO UPPER PLUG
1	36″	23″
2	26″	29″
3	36″	24″
4	34″	32″

Total length required per engine.....20′

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

c. The following table shows individual ignition cable lengths in inches and the total amount required for the Series 9 engine:

CYLINDER NUMBER	LEFT MAGNETO TO LOWER PLUG	RIGHT MAGNETO TO UPPER PLUG
1	33″	23″
2	19″	33″
3	34″	28″
4	25″	36″

Total length required for engine.....19′-5″

6. REMOVAL OF PARTS:

a. Cylinder and Piston.

(1) Loosen the hose connections at the cylinder on all the intake pipes. Slide rubber hose toward carburetor. Remove the two (2) 3/8-inch nuts holding the intake manifold to the crankcase, allowing the intake manifold cluster to be dropped down and removed.

(2) Remove screws holding the rocker box covers to the cylinders and remove covers. Push rocker arm shaft out with the finger. Make sure that the intake and exhaust valves are closed. Remove rocker arms and push rods from push rod housings.

(3) Loosen clamps holding the hose connections at foot of push rod housing. Push clamp and rubber hose up the housing toward the cylinder head.

(4) Remove the six cylinder base nuts. Remove the cylinder from the crankcase; the piston must be at the outer end of the stroke.

CAUTION: Do not allow piston to drop down as cylinder is removed from it, or damage will result.

(5) Push piston pin out and remove piston from the connecting rod.

b. Valves — Compress the valve springs in the rocker box, using valve spring compressor, tool No. 23480. Remove valve spring locks from valve stem. Remove spring seat, springs, and spring retainer. In removing valves from guides extreme caution must be exercised that they do not scratch or mar the cylinder walls.

7. GENERAL INSPECTION.

a. Replace all spark plugs with new or reconditioned plugs. Carefully inspect the entire ignition harness for serviceable condition.

b. Remove all cylinder hold-down studs that are loose, broken, or have damaged threads, and install proper replacements. Available oversize replacements are listed in the Illustrated Parts List.

c. Check entire engine and make sure all nuts are tight in accordance with torque values set forth in the Table of Limits, and see that all safetying is complete and tight. Palnuts will be tightened as follows: After the regular nuts are tightened to the desired torque, install palnuts with the smooth face against the plain nuts. Tighten the palnuts with the fingers, then turn with a wrench until the nut is locked, or approximately one-sixth of a turn. Never tighten palnuts more than one-quarter of a turn, as the threads on the stud may be damaged.

CAUTION: Do not attempt to tighten or loosen the palnut and plain nut at the same time.

d. Inspect, tighten, and safety all engine mounting bolts.

8. REASSEMBLY.

a. General — In this operation it will be assumed that all parts and assemblies are in a serviceable condition, thoroughly clean, and have been lubricated with engine oil on their bearing surfaces. When assembling the engine, use new gaskets and packing throughout.

b. Valves — Clean and oil valve guides and stems. Insert valve stems in guides.

c. Valve Springs.

(1) Insert valve spring retainer, valve outer and inner springs in rocker box housing.

(2) Fit spring seat over springs.

(3) Observe the following instructions before compressing valve springs for installation:

(a) Place a block (having the same contour as the inside of the head) against the dome of the combustion chamber to prevent the valve stems from descending in the guides when the springs are compressed for installation.

(b) Compress valve springs and install locks.

d. Piston Pins, Pistons, and Cylinders.

(1) Install new rings on piston. Fit assembly to its respective connecting rod with numbered side facing the propeller end of the crankshaft. Push piston pin carefully into position. Be sure piston pin plugs remain in place.

CAUTION: Piston must be carefully supported to avoid coming into contact with other metallic surfaces.

(2) Turn crankshaft until its position is brought to the outer end of the stroke. Carefully

OPERATING AND MAINTENANCE INSTRUCTIONS — Continued

wipe off cylinder with clean cloth. Oil both cylinder and piston. Use new cylinder base packing between the cylinder base flange and crankcase with small amount of sealing compound on the flat surface that contacts the crankcase.

(3) Install push rod housing rubber hoses on the housing and push back toward the cylinder head for clearance.

(4) Before placing cylinder on the crankcase section, all of the cylinder studs and hold-down nuts will be examined for cracks, damaged threads, or other visible defects. Any stud or nut that is defective will be disposed of. The threads of the studs and hold-down nuts will be thoroughly cleaned, using a hand wire brush for the purpose. Both faces of the stud washers and the recesses in the cylinder flange for the washers will also be cleaned, and any roughness or burrs removed.

(5) Assemble cylinder over piston. Rotate rings until gaps are evenly spaced about the piston, compress rings and slide the cylinder over them.

(6) Tightening of cylinder hold-down nuts will be accomplished in the following manner: Tighten all hold-down nuts to a snug position to insure that the cylinder is seated on the crankcase section. Loosen one nut at a time and retighten until contact is just made with the cylinder flange or washer. From this position, tighten the nut to the desired torque (400- to 500-inch pounds for 3/8-inch studs and 700- to 800-inch pounds for 7/16-inch studs). It is very important that the position of the wrench be maintained so that the turning axis of the wrench always coincides with the vertical center line of the hold-down nut which is being tightened. All nuts will be tightened slowly and smoothly until the proper torque has been applied.

CAUTION: Jerking of the torque wrench will always be avoided. Care will be exercised at all times to insure that the socket of the wrench does not contact the cylinder wall during the tightening procedure as such contact will cause an incorrect torque reading.

(7) Cylinder hold-down nuts will be checked by installing the torque wrench on the particular nut and gradually turning to the desired torque limit. If any movement is noted during this check, the nut will be loosened and retightened in accordance with instructions in paragraph (6) above.

(8) Upon completion of the check specified in paragraph (7) above, the cylinder hold-down nuts will be appropriately safetied. No further inspection of cylinder stud hold-down nuts will be necessary between engine overhauls.

(9) Slip rubber hose connections down in place on the push rod housing and tighten with metal hose clamp.

(10) Attach intake manifold and install intake pipes and hose connections.

(11) Attach and safety the carburetor.

e. Rocker Arms and Push Rods.

(1) Rotate crankshaft so that intake and exhaust valves are closed.

(2) Insert push rods in the housings, hold rocker arms in place, and push in rocker arm shaft.

f. Rocker Box Cover.

(1) Fit gasket on mounting face of rocker box cover.

(2) Fasten cover on rocker box housing with 1/4-inch screws.

g. Spark Plugs.

(1) Apply a small quantity of anti-freeze compound, on the threads of the spark plugs.

CAUTION: Do not allow any of the compound to collect on the electrodes, as subsequent fouling of the spark plug may result.

(2) Screw spark plugs in cylinder head and tighten.

NOTE: Spark plugs will be tightened to a maximum torque of 360-inch pounds.

h. Adjustment of Valve Tappet Clearances — As these engines are equipped with hydraulic tappets, no method of adjusting clearances is provided. Tappets will function properly with clearances ranging from .030 inch to .110 inch.

OVERHAUL INSTRUCTIONS

Section 10

DISASSEMBLY, CLEANING, AND INSPECTION

1. GENERAL.

a. Before proceeding with the operations of engine overhaul as outlined in this section, remove the engine from its packing box or the airplane in which it is installed, as outlined in Section 4 and 5. Mount engine on an engine overhaul stand.

b. Spray the exterior of the engine with an approved cleaner to remove all traces of dirt and grease.

c. Remove all safety wiring, palnuts and cotter pins where necessary before each part is disassembled from the engine.

2. PRELIMINARY OPERATIONS.

a. **Ignition Wiring Assembly** — Unfasten at spark plugs, magnetos, remove nuts securing brackets and remove ignition wires from engine.

b. **Spark Plugs**—Remove upper and lower plugs.

c. **Magnetos** — Remove nuts that fasten magnetos to crankcase cover and remove magnetos.

d. **Carburetor Air Intake** — Remove the four nuts that hold the carburetor air intake to the carburetor and remove air intake.

e. **Carburetor** — Remove four nuts which fasten the carburetor to the intake manifold and remove carburetor.

3. DISASSEMBLY.

a. **Oil Sump and Suction Tube** — Remove the six nuts that hold the oil sump to the crankcase, and the nut that fastens the oil filter bracket to the crankcase and remove oil sump. The oil suction tube inside the oil sump and attached to the crankcase cover can be removed by unscrewing the hex portion at the top, using a 7/8-inch open-end wrench.

b. **Intake Pipes and Manifold**—Unfasten clamps which secure hose connections to intake elbow at cylinder. Slide the rubber hose down toward carburetor. Remove the two 3/8-inch nuts holding intake manifold to crankcase. Remove intake manifold and pipes by dropping straight down.

c. **Rocker Box Covers** — Remove the 1/4-inch screws that fasten the rocker box covers to the cylinder head and remove covers.

d. **Push Rods and Rocker Arms** — After covers are removed, put out rocker arm shaft with the finger, or, if necessary, use aluminum drift and lightly tap out. Remove rocker arms from cylinder head and push rods from their housings.

CAUTION: Make certain that the cam is in such a position that the intake and exhaust valves are completely closed.

e. **Cylinder and Pistons.**

(1) Loosen clamps holding hose connections at foot of the push rod housing. Push clamp and rubber hose back up on the housing toward cylinder head.

(2) Turn crankshaft until piston within cylinder to be removed is at top of the stroke.

(3) Remove the six cylinder hold-down nuts and pull off cylinder from the crankcase.

CAUTION: Do not allow piston and connecting rod to drop down when cylinder is removed, as damage will result.

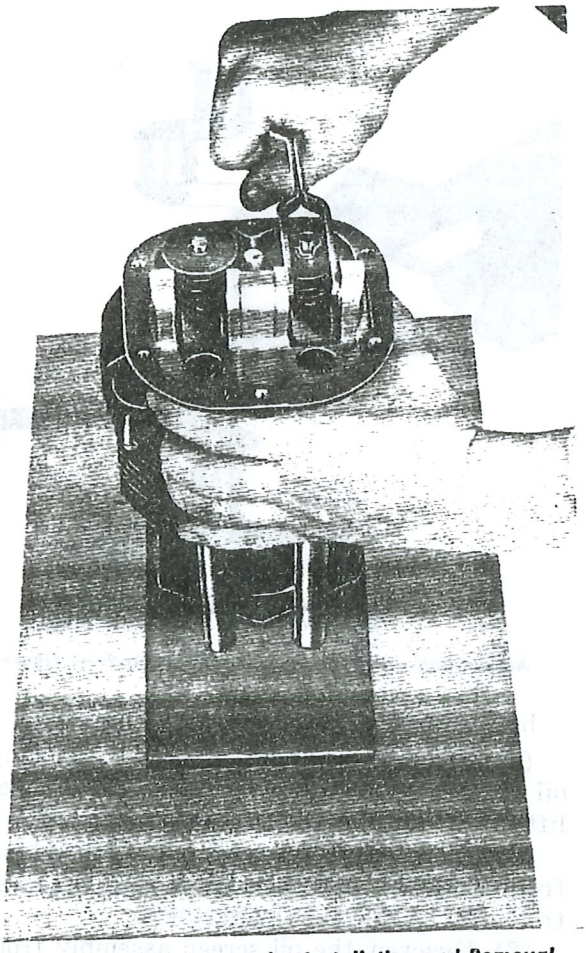
(4) After removal, place cylinders on wood or appropriate carrier to prevent damage at bottom end of barrels. Cover crankcase openings to prevent dust or grit from entering the crankcase.

(5) Push piston pin out and remove piston from connecting rod. If necessary, use aluminum drift to drive out piston pin, being careful to support the piston in the hand during this operation to prevent damage to the connecting rod.

(6) Remove the piston rings from the ring grooves of all pistons. Tie the set of rings for each piston together and tag. Number each tag with the number of the piston from which the rings were removed.

(7) Placing the cylinder over a wooden stand, shaped to fit the inside of the cylinder head, compress valve springs in rocker box, using valve

OVERHAUL INSTRUCTIONS — Continued



Compressing Valve Springs for Installation and Removal of Locks — Figure 14

spring compressor, tool No. 23480 (figure 14), remove the seat locks with thin-nosed pliers, release the compressor, and remove the spring seat, inner and outer springs, spring retainers and valves.

CAUTION: In removing valves, care must be taken that they do not scratch or mar cylinder walls.

f. **Crankcase.**

(1) Remove the four push rod housing flanges by unscrewing the nuts which secure them to the crankcase.

(2) Remove the valve tappet cups on the push rod end of the hydraulic valve tappets. Remove the hydraulic units of each tappet with the aid of a small wire hook. (Figure 15). Keep tappets numbered according to the order removed — keeping assemblies grouped together.

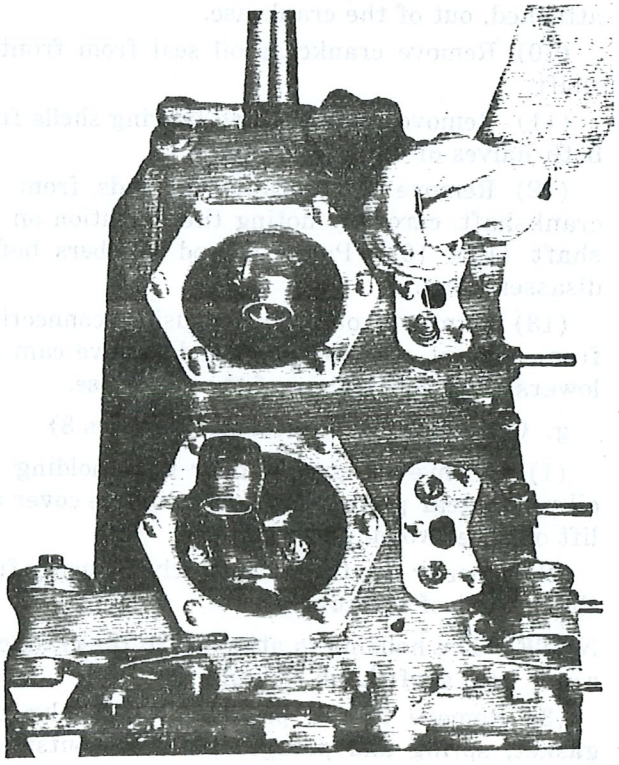
NOTE: If the cylinder and piston of the hydraulic units do not come out together, it may be necessary to wedge a wooden plug into the cylinder of the hydraulic unit and remove cylinder in this manner. Care must be taken that the wooden plug does not damage cylinder.

NOTE: The valve tappet cam follower body cannot be removed until the crankcase is disassembled. Place push rod housing connections over ends of cam follower to prevent their falling into crankcase when crankcase is lifted off. See Fig. 22, page 40.

(3) Remove the ten 5/16 inch nuts holding the crankcase cover to the crankcase. Lift the cover off as a complete unit — the oil pump, relief valve and tachometer drive units remain intact in the crankcase cover.

(4) Remove the four ¼ inch cap screws holding the cam gear to the camshaft and remove gear.

(5) Remove the four ¼ inch cap screws holding the crankshaft gear to crankshaft and remove gear.



Removal of Hydraulic Unit from Cam Follower Body — Figure 15

OVERHAUL INSTRUCTIONS — Continued

On Series 9 engines, remove the castle nut holding the starter gear to the crankcase and remove the washer, retainer screw, retainer, and starter gear.

(6) Remove all ¼ inch nuts from the bolts holding halves of crankcase together, located on centerline of crankcase on both top and bottom of the engine.

(7) Remove two 7/16 inch nuts attached to long studs at front of crankcase on the No. 2–4 cylinder side, two 7/16 inch nuts on the No. 1–3 cylinder side above the intake pipes between the cylinders.

(8) Rotate the engine stand until No. 2–4 crankcase is lying on its side, check all crankcase-to-crankcase studs to see that all nuts have been removed, and carefully lift the No. 1–3 crankcase off and lay aside with contact surface up. Do not pry the parting faces of the crankcase apart with a screw driver as the contact surfaces may be damaged.

On Series 9 engines, after removing the 1–3 crankcase from the 2–4 crankcase, remove the starter gear bushing.

(9) Lift crankshaft, with connecting rods attached, out of the crankcase.

(10) Remove crankcase oil seal from front of shaft.

(11) Remove camshaft and bearing shells from both halves of the crankcase.

(12) Remove all connecting rods from the crankshaft, carefully noting their position on the shaft (Fig. 16). Point up rod numbers before disassembling.

(13) Remove push rod housing connections from ends of cam followers and remove cam followers from both halves of the crankcase.

g. **Crankcase Cover Assembly (Series 8)**

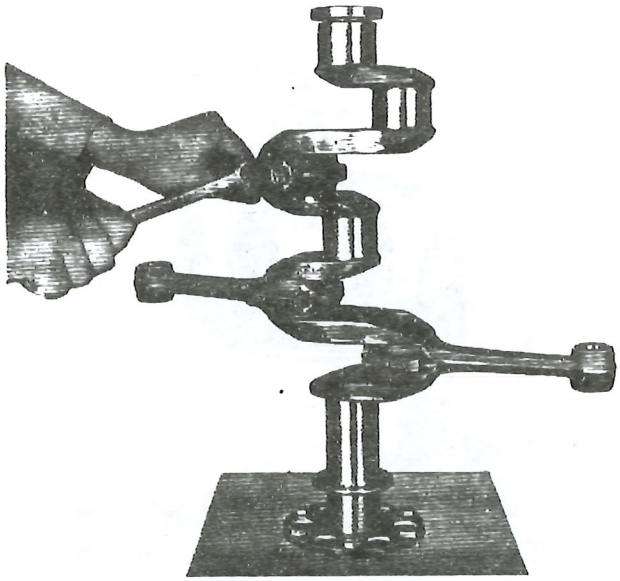
(1) Remove oil pump cover nuts holding the oil pump gear plate to the inside of the cover and lift out the two oil pump gears.

(2) Uncrew the tachometer drive housing from the outside of the cover.

NOTE: The housing is attached to the crankcase cover with a **left-hand** thread.

(3) Remove the oil pressure relief valve cap, gasket, spring and plunger from the outside of the cover.

(4) Remove oil screen and gasket from outside of cover.



Assembling and Removing Connecting Rods — Figure 16

h. Crankcase Cover Assembly (Series 9)

(1) Remove oil pump cover nuts holding the oil pump gear plate to the inside of the cover and lift out the two oil pump gears.

(2) Remove the three ¼ inch nuts and palnuts from the tachometer drive housing and remove the housing, oil seal, and gasket.

(3) Unscrew the oil screen assembly from the oil screen housing and remove.

(4) Remove the ¼ inch nut holding the oil screen housing to the crankcase cover. (It is necessary to remove two ¼-inch nuts when crankcase cover is removed from the crankcase.)

4. CLEANING.

a. **General.**

(1) After the engine has been dismantled, clean the major sub-assemblies and miscellaneous parts in accordance with the instructions below.

(2) The cleaning fluids prescribed herein must be of such a type that will not attack metals — particularly bronze and aluminum alloy parts.

(3) After the sub-assemblies and miscellaneous parts have been cleaned, thoroughly drain of excess cleaning fluid and dry with compressed air.

(4) Treat steel parts with a rust preventive after they have been cleaned and dried.

b. **Cleaning of Engine Parts** — Spray the following assemblies and parts with kerosene. Particular attention will be given to the special cleaning instructions which are prescribed for each of the sub-assemblies and parts.

OVERHAUL INSTRUCTIONS — Continued

(1) **Crankcase** — Clean out both halves of crankcase; blow out oil passage tubes in both halves. Examine cam journal supports for scores or deep scratches and smooth out with crocus cloth if necessary.

(2) **Cylinders** — Remove accumulation of oil and dirt from between the cooling fins. Remove carbon from inside of cylinder head with wire brush.

(3) **Valve Mechanism** — Clean thoroughly of accumulated oil the rocker arms, rocker shaft, spring seat, springs, retainer and intake and exhaust valves.

(4) **Oil Sump** — Unscrew drain plug and flush out the sump, removing all accumulated sludge.

(5) **Crankshaft and Connecting Rods** — Clean thoroughly with kerosene, blowing out all oil lines.

CAUTION: The cleaning fluid must be free from grit and foreign particles.

(6) **Pistons and Piston Pins**

a. Wash off oil from pistons with kerosene.

b. Immerse pistons in a carbon-removing compound. The purpose of this operation is to facilitate cleaning by loosening the carbon deposits on the pistons.

c. Scrape carbon out of ring grooves, using every precaution not to distort, cut or damage the lands.

d. Remove carbon from inner and outer walls of the piston heads by scraping. Do not scratch or cut piston heads.

e. Clean out the oil bleed holes with an undersized drill.

f. Clean piston pins and plugs thoroughly with kerosene.

(7) **Gears** — Clean cam, magneto drive and crankshaft gears thoroughly with kerosene, and dry with compressed air.

5. INSPECTION.

a. **General.**

(1) After the sub-assemblies and parts of the engine have been cleaned and dried, place on a table for visual inspection. This inspection will be a basis for determining which parts have been defective or damaged in the course of operation. Parts that are damaged beyond repair, or worn in excess of the permissible tolerances, must be replaced.

b. **Inspection of Engine Parts.**

(1) **Crankcase.**

a. Check thoroughly for fatigue cracks.

b. Examine bearing seats for cracks and scratches and excessive wear.

c. Check studs for damaged threads and straightness.

(2) **Cylinders.**

a. **Cylinder Heads** — Examine cylinder head for cracks. Small cracks found at head fins are not cause for rejection. However, if cracks are of appreciable size and indicate ultimate failure, replace the cylinder.

b. **Cylinder Barrels** — Inspect cylinder barrel flange for nicks, evenness and for condition of cylinder hold-down nut recesses. Inspect inside of cylinder barrel for dents and scoring, for corrosion as indicated by rust and pitting, and for ring wear as evidenced by a ridge near the top and bottom of the barrel. Also check inside of barrel for out-of-round and taper, using dial indicator.

c. **Spark Plug Inserts and Pins** — Examine for crossed or otherwise damaged threads and looseness of insert in head.

d. **Rocker Shaft Bosses** — Examine rocker shaft bosses for oversize and galling of bearing surfaces.

e. **Valve Seat Inserts** — Examine for signs of erosion, burning, pitting or warping.

f. **Valve Guides** — Examine for wear and looseness. If loose in cylinder head, or if excessive clearance is found between valve stem and guide, replace.

g. **Rocker Boxes** — Examine for smoothness of finished surfaces.

h. **Intake and Exhaust Flanges** — Examine for nicks and burrs and smoothness of surfaces.

(3) **Valve Mechanism.**

a. Inspect exhaust and intake rockers for cracks, particularly around lubrication holes. Also inspect rockers for straightness, nicks and condition of bushing. Check rocker shaft for wear.

b. Examine push rods for straightness by rolling them on a flat plate. See that lubrication holes on ball ends are not obstructed.

c. Check valve springs for fractures, corrosion and for proper pressure and length as specified in Table of Limits. Inspect ends of each spring for splitting and cracks.

OVERHAUL INSTRUCTIONS — Continued

d. Inspect valve spring retainers and seats for cracks and wear.

e. Inspect valve spring retainer locks for wear and galling on outside diameter, and for wear and fit on valve stem.

f. Inspect exhaust valves carefully, using a magnifying glass and magnaflux equipment, for cracks on end of valve stem, valve head and in grooves for retainer locks. Inspect valve stem and tip for scoring, pitting and wear. Check valve face for warpage, pitting and burning.

g. Inspect intake valves as described in preceding paragraph.

h. Check hydraulic tappets in accordance with instructions given in accessory section.

(4) **Oil Sump** — Examine body of sump for excessive dents and possible fractures or cracks. Inspect oil filler body. Check drain hole for damaged threads.

(5) **Crankshaft and Connecting Rods.**

a. Carefully inspect crankshaft, using magnaflux equipment. A fractured shaft must be replaced.

b. Check keyway on front of shaft for nicks or burrs.

c. Inspect connecting rod bearing surfaces for galling, scoring and for proper clearance with connecting rods in accordance with the Table of Limits.

d. Inspect oil tubes for tightness in shaft and for freedom from obstructions.

e. Inspect oil plug and propeller hub nut threads at front of crankshaft.

f. Inspect all connecting rods and caps for cracks. Check alignment of crankshaft bushing with piston pin bushing. The crankshaft hole and the piston pin hole must be parallel with each other within .001 per inch of bearing length.

(6) **Pistons and Piston Pins.**

a. Check piston pin plugs for smoothness, wear and proper fit in the piston pins. Discard piston pin plugs which are cracked or show excessive wear.

b. Check piston pins carefully for cracks, using magnaflux equipment. Also check piston pins for scoring, flat spots, out-of-round, straightness and for proper fit in piston. Piston pins which are cracked, out-of-round, bent, scored, or excessively worn must be replaced.

c. Carefully inspect pistons for cracks, scores, corrosion and for proper size of skirt. Check ring lands for cracks by applying a light side pressure. Also check ring grooves and lands for proper width. Inspect bearing surfaces in piston pin bosses for wear and scoring.

d. Replace cracked or badly-corroded pistons. Piston rings must be replaced at each overhaul. If cylinder barrels have been reground, or if piston ring grooves have been remachined, exercise care that proper oversize piston rings are installed.

(7) **Crankcase Cover.**

a. Inspect cover for cracks, particularly around stud holes and using a magnifying glass and, if necessary, by etching any doubtful portions for possible cracks. Inspect magneto mounting flanges for corrosion, burrs, scratches and flatness.

b. Check all studs on cover for cracks and tightness. Stretched or loose studs must be replaced.

c. Inspect threads for oil pressure relief cap, oil suction tube, oil screen and tachometer housing.

(8) **Camshaft.**

a. Inspect cam lobes for scoring, wear and pitting. Crankcase bearing surfaces for camshaft should be checked for out-of-round condition, for cracks and scoring.

(9) **Gears.**

a. Check magneto drive, cam and crankshaft gears for cracks, nicks, burrs, wear and proper fit.

Section 11

REPAIR AND REPLACEMENT

1. GENERAL.

a. Repair such damage to finished surfaces as scores, nicks, burrs and roughness by careful hand stoning, using a fine stone and gasoline. Polish with crocus cloth and gasoline.

b. Lap flanged surfaces which are bent or uneven to a flat surface.

c. Repair slightly-damaged threads with proper thread chasers.

d. All loose, bent or otherwise damaged studs will be replaced by the next oversize stud. Replacement of steel studs driven in aluminum alloy parts requires good judgment as well as a great deal of care on the part of the mechanic. Unless the replacement is properly made, more difficulties may be encountered than would have been evident had no attempt been made to correct the original difficulty.

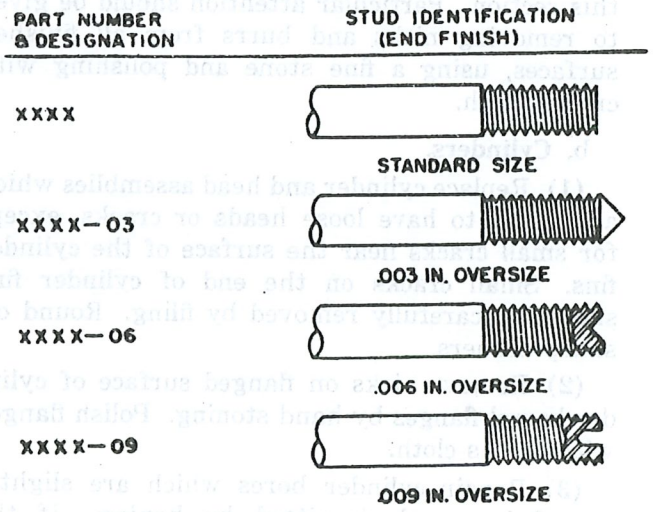
(1) The first problem is not just to get the broken or damaged stud out, but to get it out without injury to the part in which it has been set. If the outside threads have been stripped, it is usually a simple matter to remove the stud. A stud driver or a small pipe wrench, if necessary, may be used. Apply pressure on the handle of whatever tool is used in such a manner that there will be no tendency to bend the stud. Back the stud out slowly to avoid overheating of the threads. It should be remembered that any thread lubricant or sealing material used when the part was originally installed has probably congealed, and rapid withdrawal of the parts may cause damage to the housing threads. Either of two methods has been used successfully to remove studs broken off at or near the base. The center section of the stud may be drilled out and a square shanked stud remover installed. Use a wrench of the proper size and back the stud out carefully. If this method does not work satisfactorily, it may be possible to electric weld a short piece of steel bar stock or a steel nut to the broken stud. The bar stock or the nut may then be used to withdraw the broken piece. The welding must be done carefully to avoid melting or damaging the metal around the base of the stud.

(2) The threads in whatever part the stud is to be replaced should be cleaned up before attempting to drive a new stud. Be sure that the tap to be used is the correct size. New taps usually cut oversize, and the mechanic should handle them carefully. If the tap appears to be cutting material away instead of just cleaning out the threads, withdraw it and use an older tool. Rough edges or burrs on a tap may also cause it to cut oversize. Carefully inspect all taps for evidence of this difficulty before they are used.

(3) If a stud was removed because it was loose, the next oversize stud should be installed. Oversizes of .003 inch, .006 inch, and .009 inch are supplied to replace the standard studs. These studs may be identified by the machining on the end that is driven into the housing. Refer to figure 17 for section drawings showing the identifying shapes on the ends of the studs. Examine the stud removed to determine what size it is, and install the next oversize stud available. If the stud being removed was broken and is not being replaced merely because it fit loosely, install the same size stud that was taken out.

(4) An approved lubricant should be applied to the threads on all studs before they are installed. The lubricant should be stirred before using and applied in conservative quantities.

(5) Before installing a stud, make certain that it is the correct part and that the right end will



Stud Identification — Figure 17

OVERHAUL INSTRUCTIONS — Continued

be inserted in the housing. Examine the new stud carefully, since these parts easily become mixed in stock.

(6) There is a definite height that each stud in the engine must protrude when it has been installed. Check this height with the blueprint when such information is available.

(7) When driving the stud, feed it in carefully until reasonably sure the threads are meshing properly. Then turn in slowly and steadily until the stud is approximately in position. A T-handle stud driver should always be used.

(8) Do not turn the studs in rapidly, or it is possible that the threads may overheat and either seize or be damaged.

e. Dress washers, nuts, lock nuts and screw heads to remove burrs, nicks, or scratches from outside surfaces. Nuts, washers and screws used externally should be zinc or cadmium plated to prevent corrosion.

f. Replace any part found to be cracked unless it is an unstressed part that can be repaired by welding without further damage of distortion to it.

g. Replace all gaskets and packings at the time of a major overhaul.

2. REPAIR AND REPLACEMENT OF ENGINE PARTS.

a. Crankcase.

(1) Make repairs to the crankcase in accordance with instructions given in paragraph 1 of this section. Particular attention should be given to removing nicks and burrs from all finished surfaces, using a fine stone and polishing with crocus cloth.

b. Cylinders.

(1) Replace cylinder and head assemblies which are found to have loose heads or cracks, except for small cracks near the surface of the cylinder fins. Small cracks on the end of cylinder fins should be carefully removed by filing. Round off sharp corners.

(2) Remove nicks on flanged surface of cylinder barrel flanges by hand stoning. Polish flanges with crocus cloth.

(3) Repair cylinder bores which are slightly corroded, scored or pitted by honing. If the maximum permissible out-of-round condition, the maximum permissible taper, or the average maximum barrel diameter is exceeded, the cylinder bore should be reground and honed to the first standard oversize that will remove all out-of-round and taper. If cylinders are ground oversize, it will be necessary to fit oversize pistons and piston rings. Pistons are available to fit cylinders .015 inch oversize.

(4) Reface valve seats which are pitted, burned or worn by removing the least amount of metal possible. Following the repair of valves, the valve seats may then be lapped in with suitable valve-grinding compound.

CAUTION: After the valves have been ground and checked for proper seating, remove all traces of grinding compound with an approved cleaner.

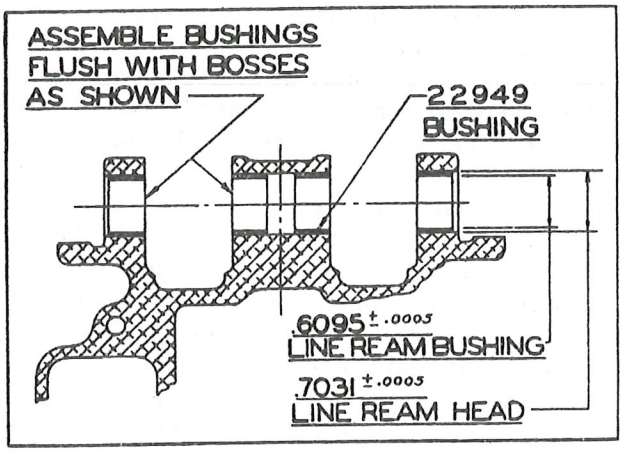
(5) Replace valve guides if loose in cylinder head or if excessive clearance is found between valve stem and guide. If guides are scored, they should be replaced. Remove guides with the use of tool No. 23505 and an arbor press.

(6) Remove and replace spark plug inserts which are loose or leaking. Remove hard carbon from threads in inserts with a tap, being careful not to remove any metal.

(7) Remove burrs, nicks and roughness from exhaust flanges with a fine file or scraper.

(8) Repair intake flanges by removing nicks with a stone. Polish flange with crocus cloth. Tighten studs on intake flange, if necessary, and dress threads, using thread chaser.

(9) Stone finished surfaces of rocker boxes for nicks and scores. Polish surface with crocus cloth. Check rocker box covers for true flatness by rubbing on a sheet of sandpaper placed on a surface plate.



Assembling Rocker Shaft Bushings — Figure 18

OVERHAUL INSTRUCTIONS — Continued

NOTE: If rocker shaft bosses are excessively worn, bushings (No. 22949) may be installed as shown in Fig. 18.

c. Valve Mechanism.

(1) Remove nicks and scores from exhaust and intake rockers and polish finished surfaces with crocus cloth.

(2) Polish valve rocker bushings for slight scores and roughness.

(3) Straighten push rods which are slightly bent by tapping into proper shape, using a light mallet. Polish ball ends with crocus cloth. Loose or badly worn ball ends must be replaced by complete push rod assembly.

(4) Valve springs which are broken at flat ends cannot be repaired satisfactorily and therefore should be replaced.

(5) Remove scores or burrs from valve spring seats by stoning and polishing.

(6) Polish valve spring seat locks with crocus cloth inside and outside diameter.

(7) Stone valves to remove burrs and scores in the lock grooves and on stem tips. If tips are worn, they should be dressed with a fine emery wheel to secure a flat surface, square with valve stem. Replace warped or badly pitted valves. Use a standard valve refacing machine for conditioning valve contact faces and lap into valve seats as described in paragraph 2. (b). (4) above.

d. Crankshaft and Connecting Rods.

(1) Dress with proper dies damaged threads on front end of crankshaft. Remove all nicks and scores on bearing surfaces by careful stoning and polishing with crocus cloth. Stone keyway on front of shaft to remove scores, nicks, and burrs.

(2) If main and connecting-rod bearings are worn, or if checks or cracks are visible, make replacement.

(3) Remove all nicks and scores from connecting rods by stoning and polishing with crocus cloth. Remove slight scores in piston pin bushing by polishing with crocus cloth. If bushing appears burned or rough, replace. Repair slightly damaged threads on connecting rod bolts, using proper dies.

e. Pistons and Piston Pins.

(1) Repair pistons, pins and plugs which are slightly scored or burred by careful use of a fine stone and by polishing with crocus cloth.

CAUTION: Stone only enough to remove the metal which has piled up — deep scratches cannot be removed. If scoring is heavy, piston and piston pin must be replaced. Do not at any time use a wire brush or buffer wheel on the pistons.

(2) Replace piston rings at the time of a major overhaul. If cylinder barrels have been reground or if piston ring grooves have been remachined, care should be exercised in securing the proper oversize piston rings.

(3) Replace cracked or badly eroded pistons with pistons which are within ¼ ounce of the same weight.

f. Crankcase Cover Assembly.

(1) Make repairs to crankcase cover in accordance with instructions given in paragraph 1. (d) and (f) of this section. Particular attention should be given to removing nicks and burrs from all finished surfaces, using a fine stone and polishing with crocus cloth.

(2) Carefully dress and chase with proper dies damaged threads in cover for the oil screen assembly, oil pressure relief valve cap and tachometer drive housing.

(3) Repair with proper thread chasers damaged threads on oil screen assembly, oil pressure relief valve cap and tachometer drive housing.

(4) If oil pump gears are nicked or scratched, stone lightly. Remove all burrs. If the gears are badly dented or worn, replace.

(5) Replace tachometer drive oil seal at the time of a major overhaul.

g. Camshaft and Hydraulic Tappets.

(1) If lobes on the cam are scuffed, stone lightly.

(2) If cam followers are scuffed, stone light. Examine the tappets for wear and damage. If either the piston or cylinder is damaged, replace both parts. For complete information on Hydraulic Tappets refer to section 19.

CAUTION: Do not drop hydraulic tappets or allow them to come in contact with other metallic objects, as damage will result.

h. Gears — Stone lightly crankshaft, magneto drive and cam gears if nicked or scratched. Remove all burrs. If the gears are badly dented or worn, they should be replaced. Cap screws should be replaced if heads or threads are damaged.

i. Intake Pipes, Connections and Clamps.

(1) Remove small dents from intake pipes by careful hammering on a suitable mandrel and without reducing the wall thickness of the pipe,

OVERHAUL INSTRUCTIONS — Continued

to obtain a smooth and even surface. Replace cracked or leaking intake pipes.

(2) Replace rubber hose connections for intake pipes at the time of a major overhaul.

(3) Replace intake hose clamps if broken or cracked.

j. **Push Rod Housing Flanges, Connections and Clamps.**

(1) Stone lightly all finished surfaces of the flanges to remove all nicks and scratches. If flange is cracked, it must be replaced.

(2) Replace the rubber push rod housing connections at the time of a major overhaul.

(3) Replace push rod housing clamps if broken or cracked. If threads of tightening screws are damaged, replace.

k. **Ignition System** — Replace all ignition cables at overhaul. For instructions on repair and replacement of ignition cables refer to Section 12, page 45.

SECTION 12

REASSEMBLY, FINAL ASSEMBLY, TIMING AND TESTING

1. GENERAL.

This section covers the procedure of the reassembly of the major sub-assemblies, the final assembly of the complete engine, the timing of magnetos to the engine and the final testing of the engine following the overhaul of each major sub-assembly and separate parts as described in the previous section.

2. REASSEMBLY OF MAJOR SUB-ASSEMBLIES.

a. **Cylinder and Valve Assembly Procedure.**

(1) Apply a light coat of oil on valve stems. From inside of cylinder and head assembly, assemble intake valve through intake valve guide. In same manner, assemble exhaust valve through exhaust valve guide.

(2) Holding both valve stems so that head of each valve is against valve seat, mount cylinder and head assembly over suitable holding block on bench. Assemble intake and exhaust valve spring retainers over valve guides.

(3) Assemble inner and outer valve springs over exhaust valve and guide and onto the valve spring retainer. Assemble valve spring seat over valve stem with spring lands toward springs.

(4) Using valve-spring compressor, special tool No. 23480 (Fig. 14), assemble valve-spring seat-locks in groove on valve stem so that large diameter of locks is toward end of valve stem.

(5) Assemble valve spring over intake valve and guide in same manner as described above.

(6) Assemble new rubber push rod housing connections and clamps on the push rod housings, pushing them toward the cylinder head for clearance when cylinder is assembled to crankcase.

(7) Install new cylinder base packing on cylinder barrel base, using a very thin film of sealing compound on the cylinder flange on the flat surface that will contact the crankcase.

CAUTION: Do not pick up cylinders by push rod housings as they are only pressed into the rocker box and are easily bent. Any bending or misalignment will result in an oil leak.

b. **Connecting Rods to Crankshaft.**

(1) Snap both halves of the connecting rod bushings into the connecting rod and cap.

(2) Assemble connecting rods in their proper positions on the crankshaft with the connecting rod numbers pointing up. (Fig. 16.)

NOTE: The connecting rod bolts must be assembled on the connecting rods with the threaded end pointed toward the piston pin bushing. Fasten securely with castle nuts and cotter pins.

c. **Pistons and Piston Pins.**

(1) With top of piston downward on bench, assemble one oil scraper ring **with undercut edge toward open end of piston,** in the ring groove nearest the open end of piston. Turn piston with top up on the bench, assemble the other oil scraper ring **with undercut edge down** in the third ring groove from top of piston. Assemble plain ring in second groove and compression ring **with beveled edge** toward top of piston in the top groove.

OVERHAUL INSTRUCTIONS — Continued

(2) Assemble the piston pin and plugs temporarily into pistons.

d. **Crankcase Cover Assembly (Series 8).**

(1) Install oil screen assembly into crankcase cover.

(2) Install oil pressure relief valve plunger, spring, gasket and cap into crankcase cover. See that the plunger works freely in its cage without sticking.

(3) Press tachometer drive oil seal into tachometer housing. Assemble oil pump drive gear into cover with square coupling on the inside of the cover. Insert driven gear into mesh with drive gear. Assemble oil pump cover over studs and gear shaft on inside of cover. Holding cover in place with one hand, assemble tachometer drive housing (with oil seal pressed in place) and gasket over end of drive gear shaft on outside of cover, pushing the shaft through the oil seal. It is advisable to use a ⅜ inch rod to lead the shaft through the packing in order that it will not be pushed out of position. Screw tachometer drive housing securely to cover.

NOTE: The tachometer drive housing has a **left-hand thread** which secures it to the crankcase cover.

(4) Test the oil pump gears for free running in the case. If they are free from binding, assemble washers and nuts to the pump cover and safety wire.

e. **Crankcase Cover Assembly (Series 9).**

(1) Press tachometer drive oil seal into tachometer housing. Assemble oil pump drive gear into cover with square coupling on the inside of the cover. Insert driven gear into mesh with drive gear. Assemble oil pump cover over studs and gear shaft on inside of cover. Holding cover in place with one hand, assemble tachometer drive housing (with oil seal pressed in place) and gasket over end of drive gear shaft on outside of cover, pushing the shaft through the oil seal. It is advisable to use a ⅜ inch rod to lead the shaft through the packing in order that it will not be pushed out of position.

(2) Push tachometer drive housing on the studs and fasten securely with washer, nut and palnuts.

(3) Test the oil pump gears for free running in the case. If they are free from binding, assemble washers and nuts to the pump cover and safety. See that wire is pressed tightly against the oil pump plate to prevent interference.

(4) Install oil pressure relief valve plunger, spring, gasket and cap into crankcase cover. See that the plunger works freely in its cage without sticking.

(5) Install oil screen housing on the one ¼ stud provided on the crankcase cover. See that the housing is properly located on the pad and secured with nut and palnut.

f. **Intake Pipes and Hose Connections.**

(1) Push one 1½ inch hose and one 1¾ inch hose (one inserted into the other) over one end of intake pipe.

(2) Run four hose clamps over end of intake pipe.

(3) Push another set of hose connections over other end of intake pipe. (See (1) above.)

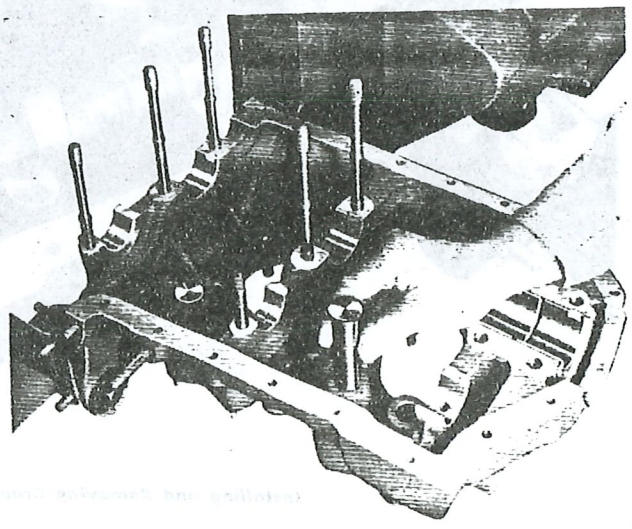
3. FINAL ASSEMBLY PROCEDURE.

a. **Preliminary.**

(1) Mount No. 2–4 crankcase (referring to cylinder numbers) with contact face, or inside of crankcase, up, on a suitable engine stand which will permit tilting the crankcase to horizontal and upright position. Lay crankcase No. 1–3 with contact face up on bench. Put a very thin film of sealing compound on the contact face of crankcase No. 2–4 and on the front of the No. 1–3 crankcase where the oil seal is pressed in.

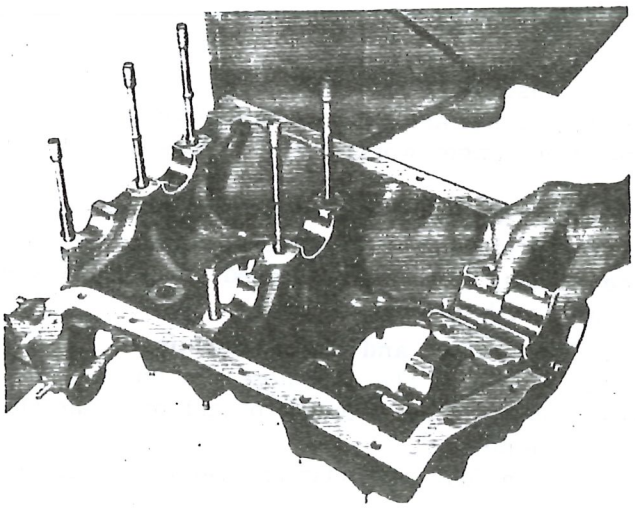
(2) Dip cam followers in light oil and insert into the push rod housing pads from the inside of the crankcase (Fig. 19). Install in both halves of the crankcase.

NOTE: Insert push rod hose connections over the ends of the cam followers installed in the



Installing Cam Follower Body into Crankcase — Figure 19

OVERHAUL INSTRUCTIONS — Continued



Installing Crankshaft Bearings Into Crankcase — Figure 20

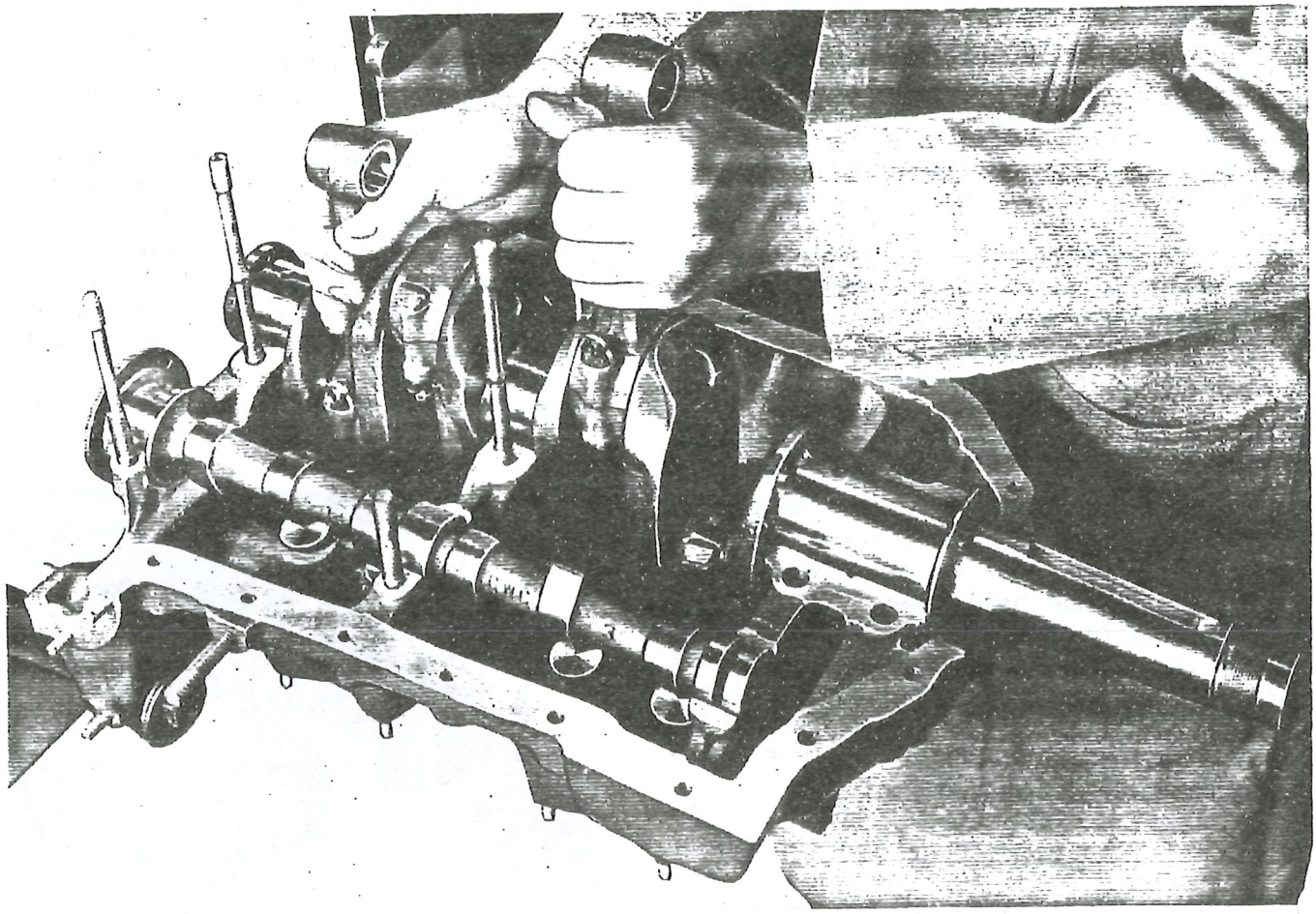
No. 1–3 crankcase to prevent them from slipping out when crankcases are assembled together.

(3) Insert bearings in both cases and gently tap into place, (Fig. 20). The shell-type bearings have "tangs" and can only be replaced in their proper positions. On Series 9 engines lay starter gear bushing in position on the No. 2–4 crankcase with flange on outside of the crankcase and with the oil hole in the bushing in line with the oil passage in the crankcase.

(4) Oil camshaft and lay in No. 2–4 crankcase. Check camshaft for end clearance in accordance with limits as set forth in the Table of Limits.

b. **Installing Crankshaft and Connecting Rods.**

(1) Oil bearings thoroughly. Lay crankshaft, with connecting rods assembled, into place in the No. 2–4 crankcase. (Fig. 21.) The No. 2 and No. 4 connecting rods must be carefully guided through the No. 2 and No. 4 cylinder ports of



Installing and Removing Crankshaft and Connecting Rods — Figure 21

OVERHAUL INSTRUCTIONS — Continued

the crankcase, taking care that they do not strike and damage the openings.

(2) Check end clearance of crankshaft in the crankcase as specified in the Table of Limits.

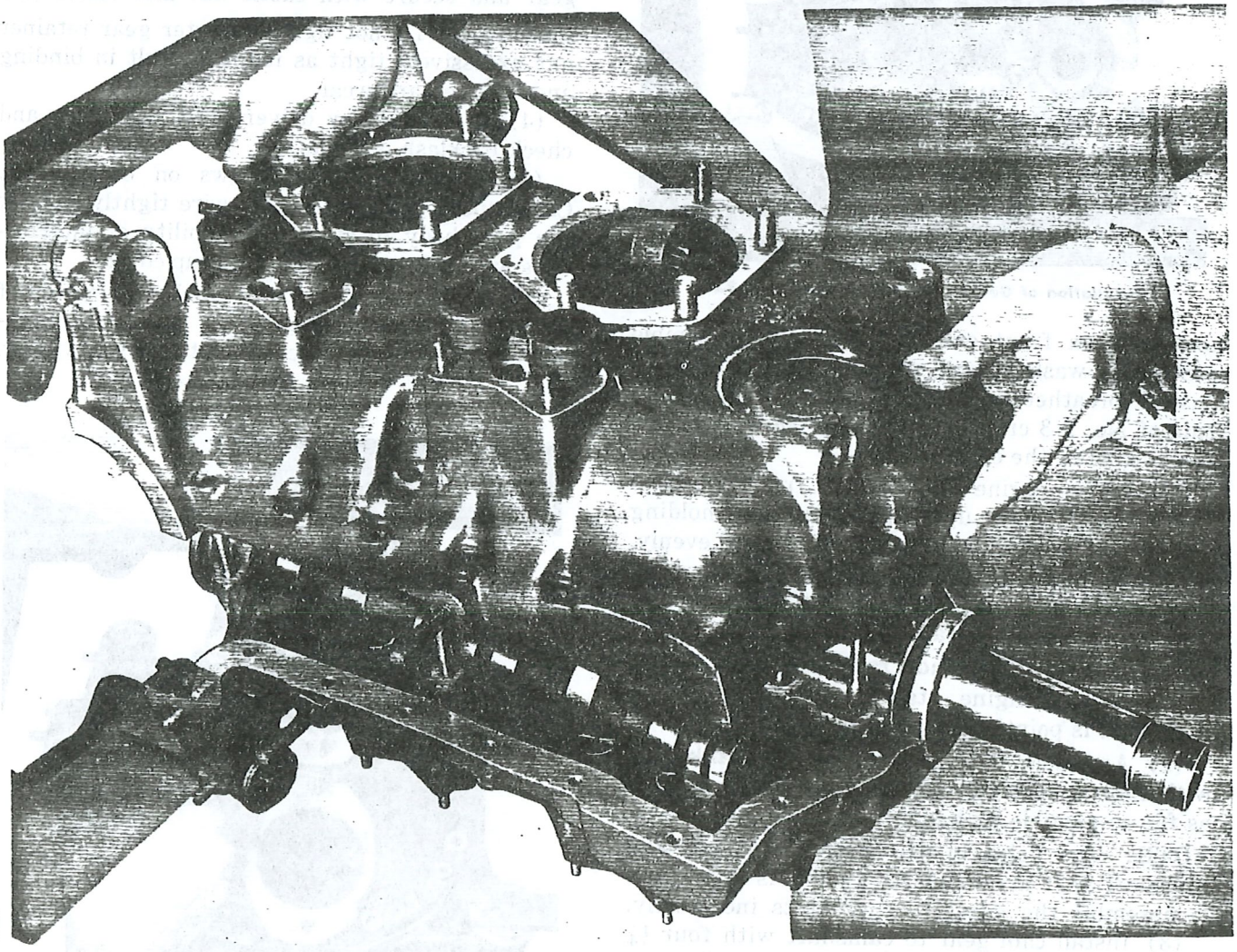
c. **Assembly of Crankcases and Component Parts.**

(1) Install oil seal on front of crankshaft, pushing securely into place on the No. 2–4 crankcase.

(2) Lay No. 1–3 crankcase in place on No. 2–4 crankcase, carefully guiding connecting rods No. 1 and No. 3 through cylinder ports. (Fig. 22.) Be sure dowel bolts are in their proper locations. Check camshaft and crankshaft for free running to see that crankcases are installed in their proper positions. Remove push rod hose connections from cam followers on No. 1–3 crankcase.

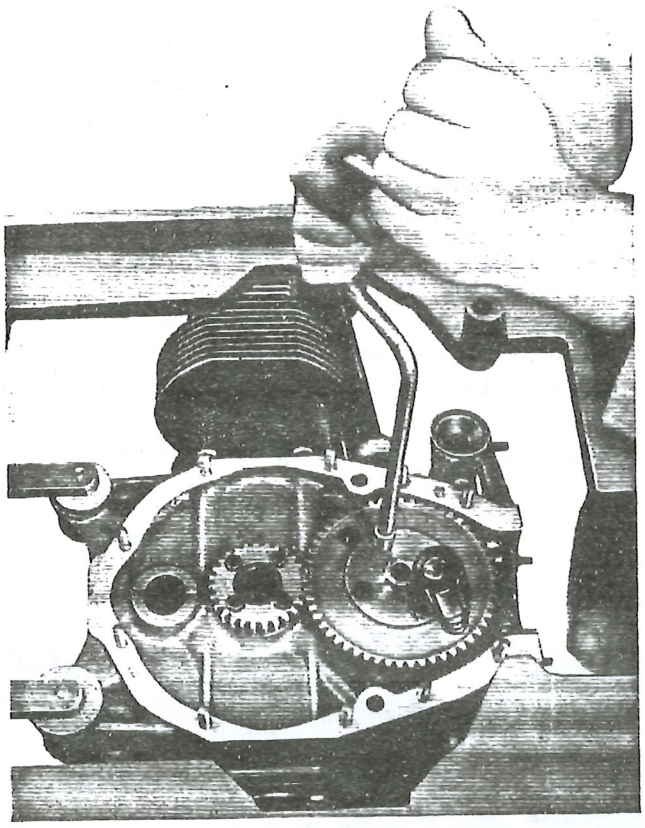
NOTE: On Series 9 engines when the No. 1–3 crankcase is laid in place over No. 2–4 crankcase, extreme care must be taken to insure that the starter gear bushing is in its proper position. A shouldered dowel is provided in the journal on the crankcase which fits into the dowel hole in the starter gear bushing, locking the bushing in position and preventing it from turning.

(3) Assemble the six (6) ¼ inch cap screws, washers and nuts at top of the crankcase. Assemble the five (5) ¼ inch cap screws, washers, and nuts at bottom of crankcase. Three dowel cap screws are used for properly lining up the crankcases. Assemble remaining cap screws, washers,



Installation of Crankcase 1-3 over Crankcase 2-4 — Figure 22

OVERHAUL INSTRUCTIONS — Continued



Installation of Gears in Crankcase — Figure 23

and nuts on front end of crankcase. Assemble remaining washers and nuts to crankcase studs. Install breather connection in tap provided in side of No. 1–3 crankcase opening pointed toward the bottom of the crankcase.

(4) Rotate engine stand so that front of engine is pointing straight up. Tighten all nuts holding the two halves of the crankcase firmly and evenly. Install propeller hub key in keyway — tapping carefully in place with mallet. Install palnuts on all nuts holding crankcase together.

d. Installing Gears and Crankcase Cover.

(1) Rotate engine stand until rear end of crankcase is pointing straight up.

(2) Assemble crankshaft gear to crankshaft with four ¼ inch cap screws, turning them down as far as possible by hand.

NOTE: The holes in the crankshaft gear and camshaft gear are so spaced that it is impossible to assemble the gears to the shafts incorrectly.

(3) Install cam gear to camshaft with four ¼ inch cap screws. **The timing mark on the cam** gear must mesh between the two timing marks on the crankshaft gear (Fig. 8). Place a screw driver in one of the lightening holes in the cam gear and rotate gear until screw driver is blocked against the crankcase, preventing gears from turning when cap screws are tightened. Tighten cap screws on cam gear and crankshaft gear with standard ¼ inch wrench (Fig. 23).

NOTE: For Series 9 engines proceed as follows:

a. Install starter gear into starter gear bushing in mesh with crankshaft gear.

b. Place the starter gear retainer over the 5/16 inch screw.

c. Reaching through the No. 1 Cylinder port. install the screw (with retainer) into the starter gear. Make certain that the retainer shoulder is seated properly on the starter gear.

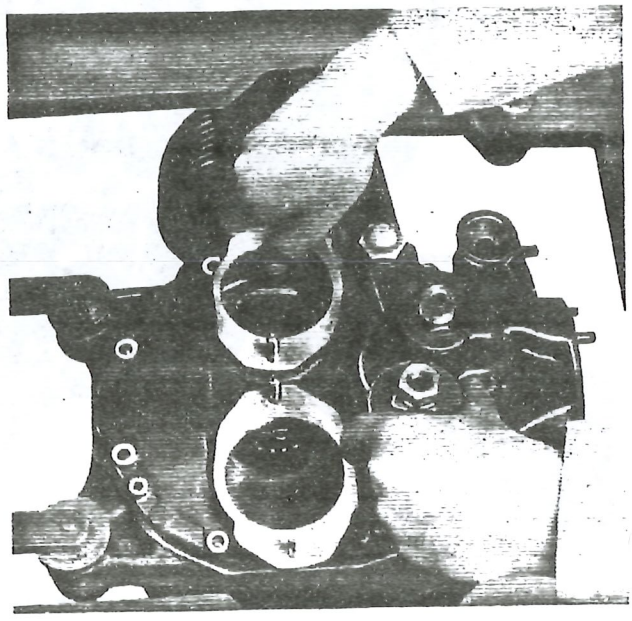
d. Install 1¼ inch washer in place on starter gear and secure with castle nut and cotter pin.

CAUTION: Do not tighten starter gear retainer nut excessively tight as it may result in binding and unnecessary wear.

(4) Remove screw driver from cam gear and check backlash of gears.

(5) Safety wire cap screws on both gears. Care must be taken to press wire tightly against the gear body to avoid a possibility of interference with the studs of the oil pump cover.

(6) Place crankcase cover gasket over end of crankcase and mounting studs. Assemble crankcase cover assembly over gasket and studs (Fig. 24).



Installation of Crankcase Cover to Crankcase — Figure 24

OVERHAUL INSTRUCTIONS — Continued

NOTE: For Series 9 Engines: Place crankcase cover gasket in position over end of crankcase and mounting studs. Install crankcase cover assembly over gasket and studs, properly meshing the oil pump drive gear into the cam gear. It will be noted that two studs secure both the crankcase cover and oil screen housing to the crankcase.

(7) Rotate engine stand so that crankshaft is horizontal. Install washers and nuts to studs. Tighten nuts securely and install palnuts.

NOTE: Safety wire oil pressure relief valve cap to nearest stud holding crankcase cover to crankcase, and secure with palnut.

e. **Installing Oil Sump and Oil Suction Tube.**

(1) Rotate engine stand so that the crankcase cover is facing up.

(2) Cut off the portion of the crankcase cover gasket which crosses the oil sump opening.

(3) Install oil suction tube in the tapped hole in the bottom of the crankcase cover, tightening with a 7/8 inch wrench. Safety wire suction tube to crankcase cover in holes provided.

(4) Install oil sump gasket to mounting studs on bottom of crankcase and cover. Mount oil sump on the six mounting studs on the case and cover and fit oil filler bracket over stud in crankcase mounting arm. Secure sump with washers and castle nuts on the case and cover and install nut and palnut on stud holding oil filler bracket.

f. **Installing Hydraulic Units and Push Rod Housing Flanges.**

(1) Rotate engine stand so that crankshaft is horizontal. Oil hydraulic units with thin coat of light oil.

NOTE: Be sure that the hydraulic unit is working properly and smoothly by depressing the piston with the thumb several times. Units should be partially deflated of trapped air and oil by releasing the ball check by inserting a 3/32 inch diameter rod tapered for approximately 1/2 inch to dull point on the end that will contact ball check. This will prevent damage to ball check seat. Refer to page 103 for complete information.

(2) Insert hydraulic units, tube end first, into the cam follower body. Insert tappet cups on top of hydraulic units in the cam follower body.

(3) Place push rod housing flange gaskets over studs on housing pads in crankcase. Install push rod housing flanges over studs and gaskets.

(4) Secure flanges to crankcase with washers and nuts.

NOTE: Tighten middle nut of flange first. Do not tighten nuts excessively, as the flange may be cracked.

(5) Install palnuts on all nuts holding push rod housing flanges to the crankcase.

g. **Installing Cylinders.**

(1) Rotate engine stand so that the front of the engine is facing up.

(2) Oil piston pin bushing on connecting rods. Install piston pin plugs into piston pin. Oil piston thoroughly and work oil into piston ring grooves. Oil piston pin and install piston (with rings assembled) to the connecting rod. Install piston with the numbers toward the front of the engine. The connecting rod must be fully extended through the port.

(3) Stagger gaps in piston rings on the piston so that they are evenly distributed around the piston to prevent blow-by. Assemble steel clamping band around the piston, compressing the piston rings and also retaining the piston pin and plugs in the piston.

(4) Coat inside cylinder barrel with a thin coat of engine oil.

(5) With one hand compressing the steel clamping band around the rings, insert the cylinder barrel over the top of the piston. (Fig. 25.)

CAUTION: Do not pick up cylinders by push rod housings as they are only pressed into the rocker boxes and are easily bent. Any bending or misalignment will result in an oil leak.

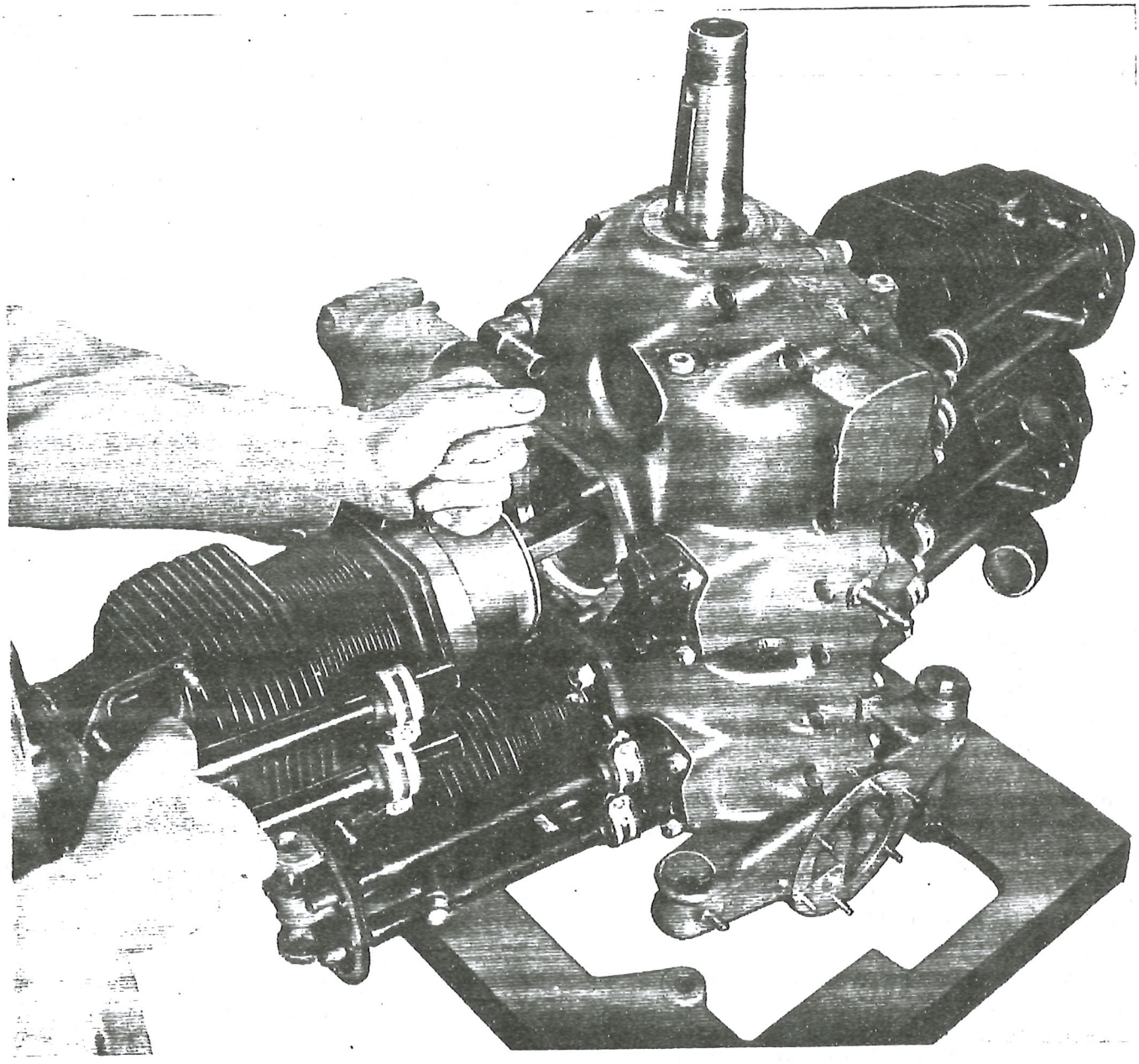
(6) Steady the cylinder with the body, push the cylinder carefully back to the mounting studs, moving the steel band back on the piston. Remove steel band when cylinder is pushed on the full length of the piston.

(7) Assemble cylinder flange over studs on crankcase. Be sure that cylinder base packing is properly in place and not twisted. Assemble nuts on studs and tighten slowly and evenly. Install palnuts.

CAUTION: Do not tighten nuts excessively as the studs may be stretched or broken. See Table of Limits for the proper amount of torque to be applied on nuts.

(8) Rotate crankshaft so that intake and exhaust valves are closed. Insert push rods into the

OVERHAUL INSTRUCTIONS — Continued



Installation of Cylinder on Crankcase — Figure 25

housings, hold rocker arms in place, and push in the rocker arm shaft.

(9) Assemble gaskets on rocker box flanges and install valve rocker box covers and secure with fillister screws.

(10) Slip push rod connections and clamps down over push rod housing flange, and tighten clamp moderately.

(11) Assemble remaining cylinders in the same manner as described above.

h. **Installing Air Intake System.**

(1) Assemble carburetor to intake manifold securing with four elastic stop nuts. The nut nearest the altitude control of the carburetor should be installed first to facilitate assembly.

(2) Assemble intake manifold (with carbureto attached) to the crankcase on the two studs provided at the bottom. Secure with nuts and palnuts. Tighten nuts moderately.

OVERHAUL INSTRUCTIONS — Continued

(3) Place gaskets on intake flanges. Attach intake elbows on the two studs on the flange, and secure with nuts and palnuts.

(4) Assemble intake pipes (with hose connections and clamps installed) to intake manifold and elbow, pushing outer hose connections over ends of manifold and intake elbows. Install clamps on both ends of each connection and tighten securely.

i. Installing Ignition System.

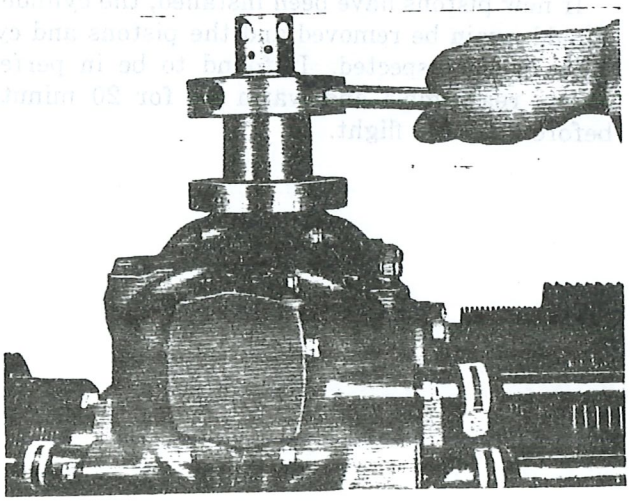
(1) Assemble lower spark plugs with gasket in each cylinder.

(2) Determine the firing position of cylinder No. 1 in the following manner:

(a) Place timing disc on the tapered crankshaft so that the slot in the hub fits over the key on the shaft. The top center (T.C.) mark stamped on the timing disc must line up with the split of the two crankcases on the **top dead center of the compression stroke.**

(b) To determine that the piston is on the compression stroke, place thumb over upper spark plug hole and turn crankshaft **in direction of rotation.** The intensity of the pressure will indicate that the piston is on the compression stroke.

(c) When the piston is on top dead center with the top center (T.C.) mark in line with the split of the crankcases, turn crankshaft in a **clockwise direction** until the timing disc is set as specified in the Table of Specification, Section 2, for the particular engine being timed. The piston is then set at its firing position. (See figure 26.)



Determining Firing Position — Figure 26

(3) Installing and Timing Magneto to the Engine.

(a) Before installing magnetos, insure that they have been correctly timed and checked in accordance with the section covering the accessories.

(b) Rotate the magneto drive gear, attached to the magneto, until the timing marks on the chamfered tooth of gear and timing pointer are opposite each other as seen through the timing window in the magneto cover. At this position the breaker contacts should begin to open.

(c) All adjustments for exact timing to the engine are made at the drive end and not by altering the position of the contact points. See that the mounting faces are clean and smooth. With the timing marks (as described in (b) above) opposite each other, install the magneto on the engine and secure with its mounting nuts. Exact timing is obtained by turning the magneto through the angle provided by the slots in the magneto flange. (Figure 42, page 96.)

(d) Before checking the exact breaker opening position, rotate magneto in a clockwise direction by tapping the mounting flange until it is near the end of the travel permitted by the slots.

(e) Turn crankshaft backward a quarter turn, then bring up slowly to firing position to take the backlash out of driving gear train.

(f) Insert a .0015 inch feeler between breaker points (cellophane may be used as a substitute), and tap mounting flange in a counter clockwise direction until the exact point of release is obtained. (Figure 42, page 96.)

NOTE

If a Bendix Scintilla No. 11-851 timing light or equivalent is available, it should be used to determine the opening of the contacts rather than using a feeler gage or cellophane strip. The use of shim stock or cellophane feeler strips invariably introduces a possibility of fouling the points, since oil and dirt is nearly always present on such feeler strips. If the strip is of soft material such as cellophane, brass, or foil, particles of the strip itself are likely to remain between the contacts, causing unsatisfactory magneto operation.

(g) Tighten the mounting nuts. Check timing

OVERHAUL INSTRUCTIONS — Continued

by backing up the crankshaft and turning it slowly forward to determine if the feeler is released the instant the timing disc reaches the mark specified on the particular engine being timed.

NOTE: If cellophane is used instead of a feeler or a timing light all traces of the cellophane must be removed before replacing the breaker cover.

(h) Install other magneto on the engine following the procedure outlined above.

(i) Remove timing disc from the crankshaft.

(4) Assemble upper spark plugs with gasket in each cylinder.

j. **Installing Radio Shielded Ignition Wires.**

Refer to figure 13 where the complete ignition wire system is diagrammed and firing order given.

(1) When it is necessary to install new ignition wiring (i. e., at an overhaul period), refer to section 9, paragraph 5, for length of cables.

(2) Slip the knurled nut, brown bakelite ferrule, and the rubber gland over cable in the order named.

(3) Strip insulation from cable end about ¼ inch and attach terminal clip by inserting bare cable strands through the hole of the clip and secure with solder.

(4) Fit spark plug elbows over the end of the cable and secure it by means of the union nut and cone.

(5) Check wiring by a recognized standard electrical test.

(6) Reassemble brackets to ignition cables.

k. **Testing Engine After Overhaul.**

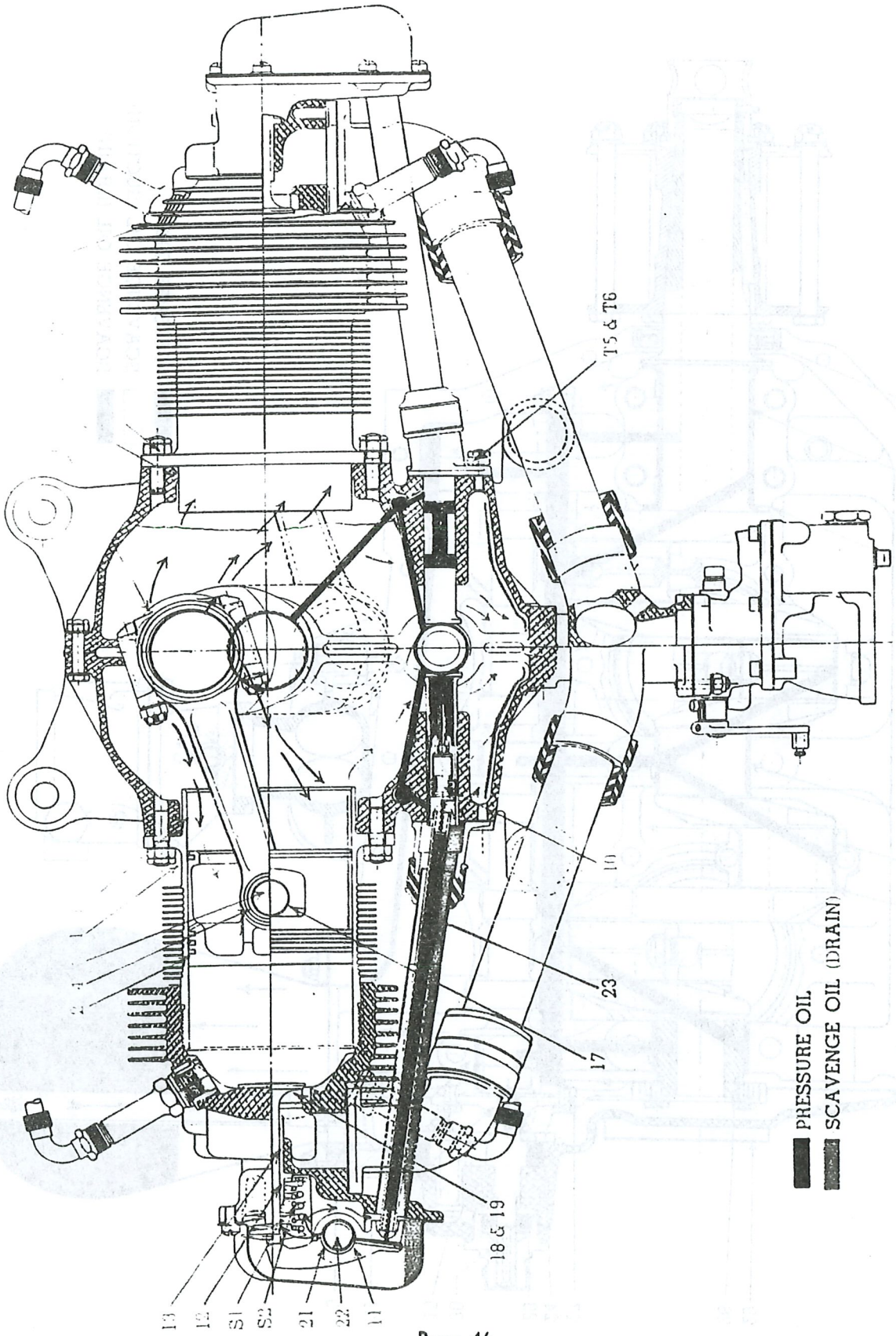
It is very important that an engine be carefully run-in after a complete or top overhaul. The length of time necessary for this depends upon the new parts installed during the overhaul and the facilities available for the running-in process. A flying propeller does not cool the engine properly if the airplane is not in flight, and any continued full-throttle operation should be avoided on the run-in unless a special cooling propeller is used. It is also advisable to have a thermocouple attached at the base of the spark plugs and not allow the cylinder head temperature to exceed 500°F.

When new pistons or bearings are installed, at least 5 hours of run-in time should be put on the engine. New rings may be broken in sufficiently for flight in possibly 3 to 4 hours.

The engine should be filled with a light grade of oil and run at approximately 800 r.p.m. until the oil is thoroughly warm. Then at intervals of 15 to 20 minutes, the speed should be increased by 100 r.p.m. If a special propeller is not being used, a speed of approximately 1400 r.p.m. should not be exceeded for more than a few minutes at a time with the airplane on the ground. If a thermocouple is used, speeds may be increased until the cylinder head temperature reaches 500°F. The remainder of the run-in may be put on in cruising flight, with a final run of about 30 minutes at a speed approximately 100 r.p.m. less than full-throttle. Any flight run-in should be made over the airport in order that a quick landing may be made if any trouble develops.

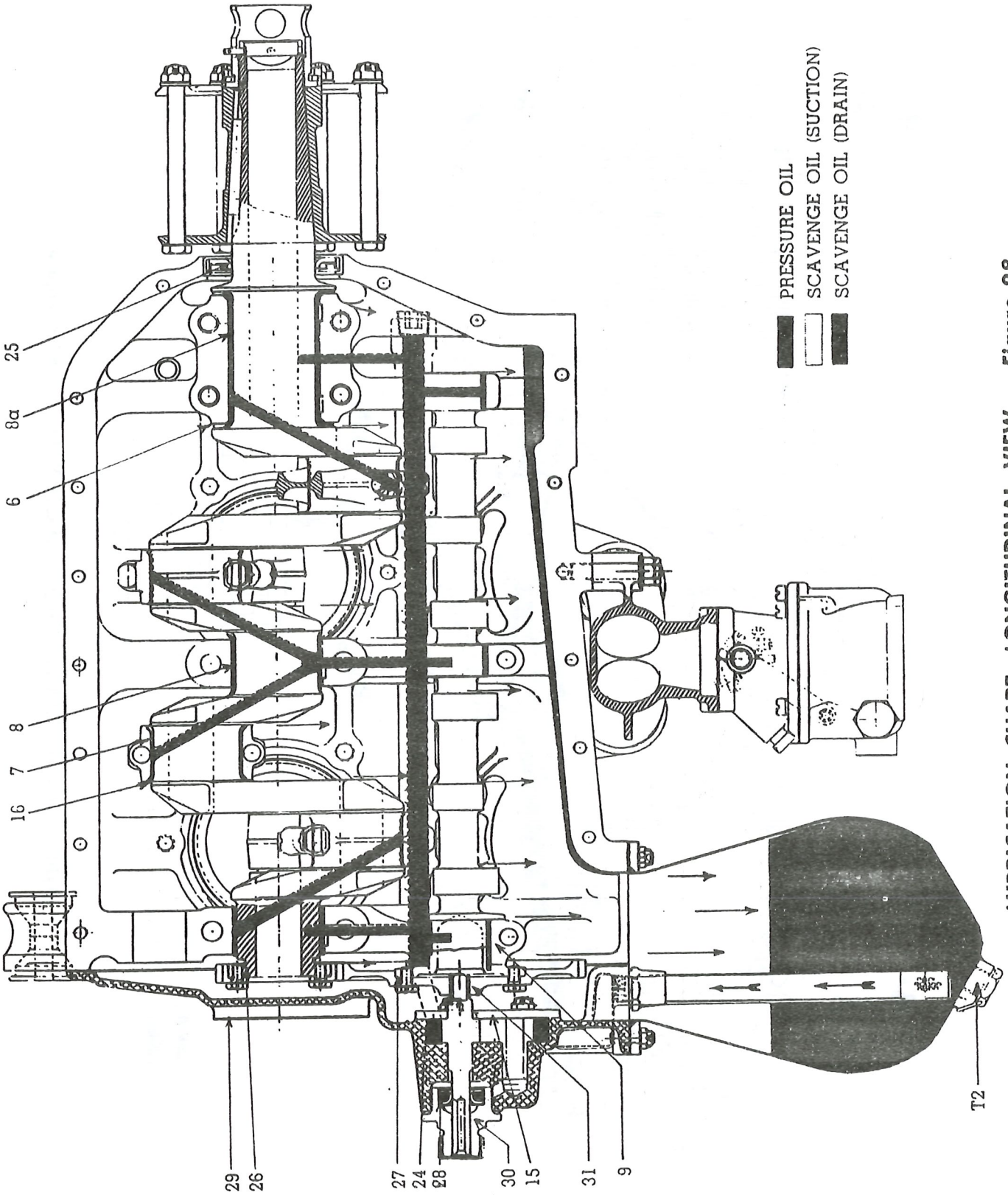
If new pistons have been installed, the cylinders should again be removed and the pistons and cylinder walls inspected. If found to be in perfect order, reassemble and warm up for 20 minutes before final test flight.

OVERHAUL INSTRUCTIONS — Continued



LUBRICATION CHART, CROSS-SECTIONAL VIEW — Figure 27

OVERHAUL INSTRUCTIONS — Continued



LUBRICATION CHART, LONGITUDINAL VIEW — Figure 28

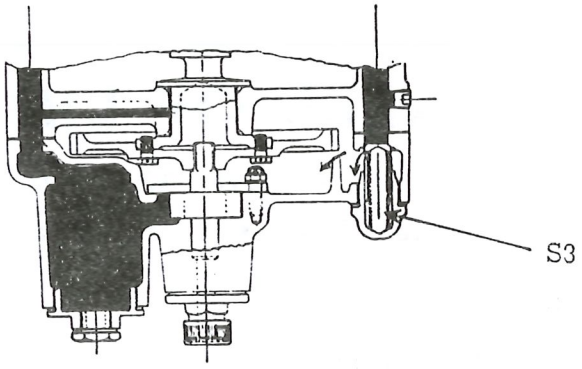
TABLE OF LIMITS

A50, A65, A75, A80

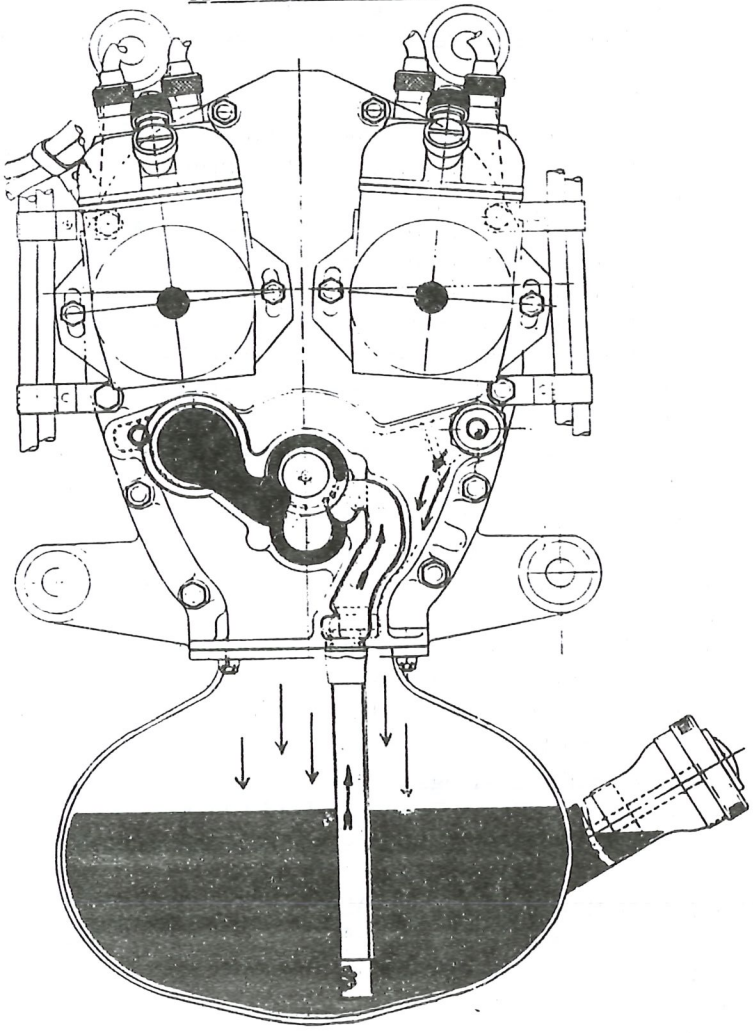
Series 8 and Series 9 Engines

Ref. No.	Fig. No.	Description of Limits	Min.	Max.
1	27	**Piston**		
		Piston in Cylinder (Skirt)	.014L	.017L
2	27	**Piston Ring**		
		Piston Ring in Groove (Top Compression) — A50	.0025L	.0045L
		Piston Ring in Groove (Top Compression) — A65	.005L	.007L
		Piston Ring in Groove (Top Compression) — A75 and A80	.005L	.007L
		Piston Ring in Second Groove (Plain) — A50	.002L	.005L
		Piston Ring in Second Groove (Plain) — A65	.0025L	.0055L
		Piston Ring in Second Groove (Compression) — A75 and A80	.0025L	.0055L
		Piston Ring in Third Groove (Scraper) — A50	.001L	.004L
		Piston Ring in Third Groove (Scraper) — A65	.0025L	.0055L
		Piston Ring in Third Groove (Plain) — A75 and A80	.0025L	.0055L
		Piston Ring in Fourth Groove (Scraper) — A50	.001L	.004L
		Piston Ring in Fourth Groove (Scraper) — A65	.001L	.004L
		Piston Ring in Fourth Groove (Scraper) — A75 and A80	.0025L	.0055L
		Piston Ring in Fifth Groove (Scraper) — A75 and A80	.001L	.004L
		Gap Clearance	.012L	.025L
		Compression Ring Tension, Gap Closed	12½ lb.	
		Scraper Ring Tension, Gap Closed	9 lb.	
3	27	Plug in Piston Pin	Size	.004L
4	27	**Piston Pin**		
		Piston Pin and Plug in Cylinder (End Clearance)	.010L	.050L
		Piston Pin in Piston (Diameter)	.0001L	.001L
		Piston Pin in Connecting Rod Bushing	.0013L	.003L
5	27	Connecting Rod Bearing to Shaft	.0008L	.0035
6	28	**Crankshaft Main Bearings**		
		Crankshaft in Front Bearing (End Clearance)	.005L	.020L
		Crankshaft in Main Bearings	.002L	.0045
7	28	Crankpins Out-of-Round		.0015
8	28	Crankshaft Run-Out (Center Main)		.005
8a	28	Maximum Allowable Crankshaft Wear Before Regrinding is Necessary (Or 1.8720 in. or less)		.002
9	28	**Camshaft Journal**		
		Journals in Crankcase	.001L	.005L
		Rear Journal in Crankcase (End Clearance)	.004L	.010L
10	27	Valve Tappet in Crankcase	.0005L	.003L
11	27	**Rocker Shaft**		
		Rocker Shaft in Rocker Bearing	.0011L	.004L
		Rocker Shaft in Cylinder Head	.0007L	.003L
12	27	**Valves in Guides**		
		Exhaust Valve in Guide	.0027L	.006L
		Intake Valve in Guide	.001L	.005L

OVERHAUL INSTRUCTIONS — Continued



VIEW SHOWING OIL STRAINER
OIL PRESSURE RELIEF VALVE &
OIL GAGE PRESSURE TAKEOFF



PRESSURE OIL
SCAVENGE OIL (SUCTION)
SCAVENGE OIL (DRAIN)

LUBRICATION CHART, REAR VIEW — *Figure 29*

TABLE OF LIMITS — Continued

Ref. No.	Fig. No.	Description of Limits	Min.	Max.
13	27	Valve Guide in Cylinder Head	.001T	.003T
		Spark Plug Insert in Cylinder Head	.002T	.004T
14	27	Cylinder Barrel Bore Maximum Allowable Taper		.002
		Wear and Out-of-Round		.015
		Cylinder Barrel Rebore Maximum Allowable Oversize		
15	28	**Oil Pump**		
		Oil Pump Drive Shaft in Cover	.0015L	.004L
		Oil Pump Drive Shaft in Cover	.0015L	.004L
		Oil Pump Drive Shaft in Plate	.0015L	.004L
		Gears in Oil Pump Housing (End Play)	.002L	.010L
16	28	Connecting Rod to Crankshaft (End Clearance)	.006L	.012L
17	27	Piston-Pin Bushing in Connecting Rod	.002T	.004T
18	27	Intake Valve Insert in Cylinder Head	.005T	.008T
19	27	Exhaust Valve Insert in Cylinder Head	.0045T	.0075T
20	27	Cylinder Barrel in Crankcase	.003L	.007L
21	27	Valve Rocker Bushing in Valve Rocker	.002T	.004T
22	27	Valve Rocker (Side Clearance)	.004L	.011L
23	27	Push Rod — Over-all Length	10.807	10.817
24	28	Gears in Oil Pump Housing Diameter	.004L	.010L
25	28	Front Crankshaft Oil Seal in Crankcase	.001T	.007T
26	28	Crankshaft Gear on Crankshaft Pilot	.0005T	.002L
27	28	Camshaft Gear on Camshaft Pilot	.0005T	.0015L
28	28	Oil Seal in Tachometer Housing	.001T	.007T
29	28	Magneto Pilot in Accessory Case	.001L	.005L
30	28	Tachometer Drive Shaft in Housing	.015L	.045L
31	28	**Oil Pump Drive Shaft in Camshaft Gear**		
		Across Flats	.008L	.011L
		Across Corners	.0175L	.022L

GEAR TEETH BACKLASH

Ref. No.	Fig. No.	Description of Limits	Min. and Desired	Replacement
1 & 2	7	Crankshaft Gear to Cam Gear	.004	.025
3 & 1	7	Magneto Drive Gears to Crankshaft Gear	.004	.025
4 & 5	7	Oil Pump Gears	.004	.025

TORQUE LIMITS

T1	27	Spark Plug	300-360 in.-lbs.
T2	28	Plug — Oil Sump Drain	Oiltight
T3	27	Nut — $\frac{7}{16}$-20, Cylinder to Crankcase	700-800 in.-lb.
T4	27	Nut — $\frac{3}{8}$-24 Cylinder to Crankcase	400-500 in.-lb.
T5	27	Nut — $\frac{7}{16}$-20, Crankcase to Crankcase	700-800 in.-lb.
T6	27	Nut — $\frac{3}{8}$-24, Crankcase to Crankcase	400-500 in.-lb.

SPRING PRESSURES

			Part No.	Wire Dia.	Compress to	Lbs. Minm.	Lbs. Max.
S1	27	Spring, Valve Inner	21365	.105 in.	55/64	31½	34½
S2	27	Spring, Valve Outer	21366	.135 in.	61/64	52	56
S3	29	Spring, Oil-pressure Relief Valve	21352	.041 in.	1-9/16	5⅛	5⅜

ILLUSTRATED PARTS LIST
A50, A65, A75 AND A80 ENGINES

Section 13

INTRODUCTION

GENERAL

This catalog lists and describes the parts for the models A50, A65, A75 and A80 series 8 and 9 engines manufactured by the Continental Motors Corporation, Muskegon, Michigan.

The Group Assembly Parts List consists of the complete engine divided into twelve (12) main groups. Each assembly listed is followed immediately by its component parts, properly indented thereunder, to show their relationship to the assembly. Component parts of the complete engine which are not included in any assembly but which are used in conjunction with, attach, or attach to a certain assembly, are listed immediately following the last detail of that assembly and in line with the major assembly.

The quantities specified in the Assembly Parts List are those used at the location shown, and not necessarily the total number used per engine. Refer to the Numerical Parts List for the total quantities used per engine.

Parts which may be obtained in oversize or undersize are indicated throughout the catalog by an asterisk (*) preceding the part number. Refer to the "Oversize and Undersize Parts List" for the sizes available.

The reference numbers appearing on the illustrations are numerically arranged in the Assembly Parts List and are used mainly to assist in locating a part in the Group Assembly Parts List after it has been found on an illustration.

To secure the most rapid service and lowest transportation charges, parts should be ordered from your nearest Authorized Continental Service Station. When ordering be sure to give **name and address** of person or organization to whom parts are to be shipped, the **part number**, the **exact description** as listed, the **quantity required**, and the **engine model and serial number.**

All parts and service shipments will be sent C.O.D., or sight draft against bill of lading unless credit has previously been established.

We will make any shipment by any means of transportation specified, subject to the transportation company's regulations. All shipments will be carefully packed before leaving the Factory. Continental Motors Corporation shall not be held liable for damages to engines or parts incurred while in transit — our liability ceasing when shipment is delivered to the transportation agency. If damage is evident on receipt of shipment, see that a notation is made on the shipping bill and file a claim with the transportation agency. If the contents do not show damage until after the container is opened, have the carrier's claim agent make an inspection before unpacking, then file a claim for damages.

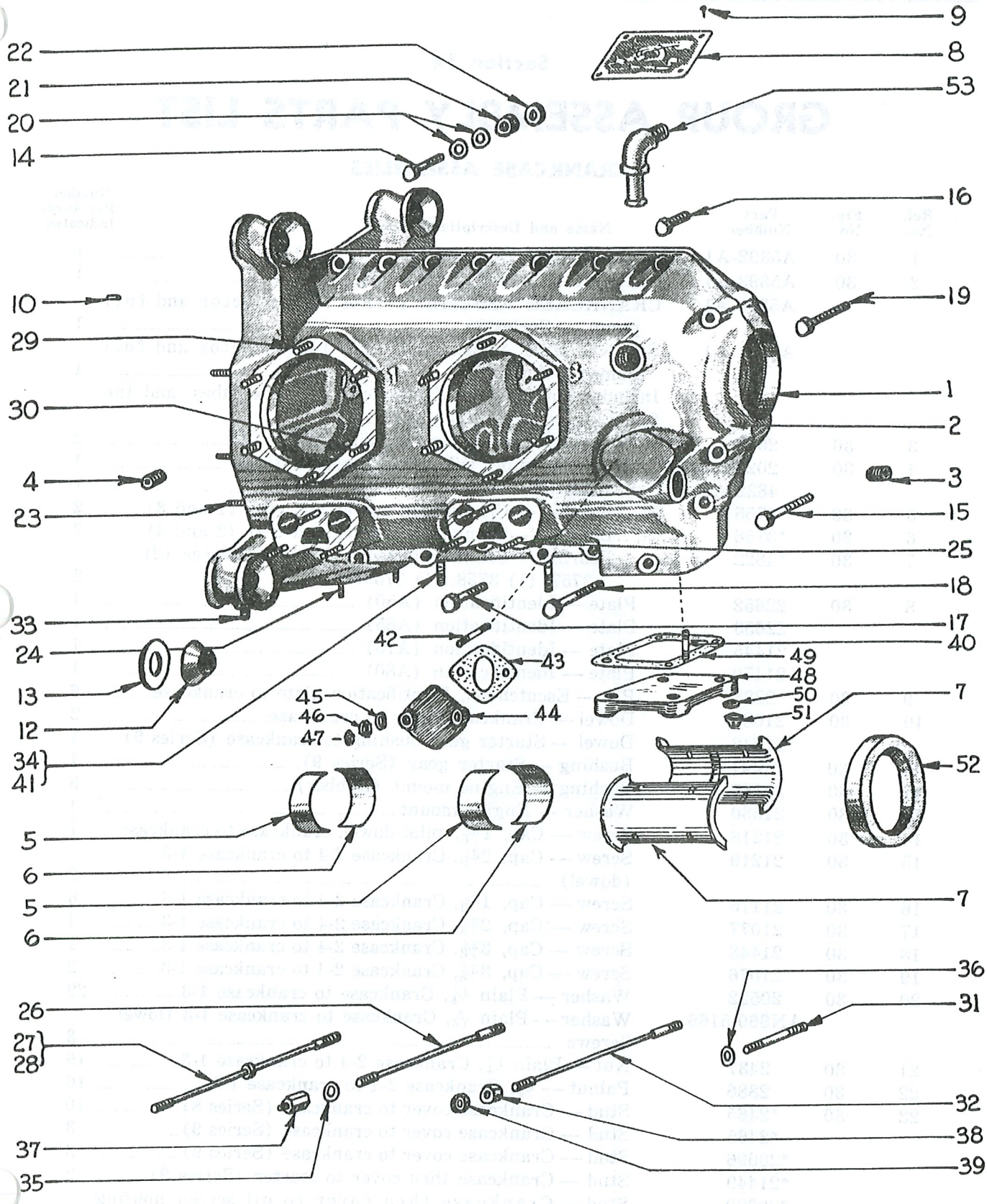
Telegraphic orders will be accepted and immediate shipment will be made. However, all telegraphic orders should be confirmed by mail. Care should be exercised in composing telegraphic orders that sufficient words are used to clearly indicate the intended meaning.

EXCHANGE SERVICE

Upon return to factory, freight prepaid, of old crankshafts in usable condition, **subject to inspection at factory,** we will exchange a factory reconditioned .010" undersize crankshafts for $10.50 each.

Upon return to factory, freight prepaid, of old cylinder assemblies in usable condition, **subject to inspection at factory,** including valve guides, seats, spark plug inserts, we will exchange one factory-conditioned cylinder assembly, including valve guides and seats for $22.50 each.

Connecting rod bushings will be replaced for $0.75 per rod.



CRANKCASE — *Figure 30*

Section 14

GROUP ASSEMBLY PARTS LIST

CRANKCASE ASSEMBLIES

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
1	30	A5392-A1	CRANKCASE ASSEMBLY (Series 8)	1
2	30	A5393-A1	CRANKCASE ASSEMBLY (Series 9)	1
		A5390-A1	CRANKCASE ASSEMBLY (For fuel injector and fuel pump — Series 8)	1
		A5391-A1	CRANKCASE ASSEMBLY (For fuel injector and fuel pump — Series 9)	1
			Includes both halves of crankcase, oil line tubes, and the following corresponding parts:	
3	30	2025	Plug — 3/8 pipe, Crankcase oil lines	2
4	30	2024	Plug — 1/8 pipe, Oil pressure gage outlet	1
		4822-A1	Bearing Set	1
5	30	*3755	Bearing — Crankshaft, center and rear (1 and 3)	2
6	30	*3756	Bearing — Crankshaft, center and rear (2 and 4)	2
7	30	*4822	Bearing — Crankshaft front thrust (Replaces (2) 3757, (1) 3758, (1) 3759)	2
8	30	22652	Plate — Identification (A50)	1
		22653	Plate — Identification (A65)	1
		21445	Plate — Identification (A75)	1
		21470	Plate — Identification (A80)	1
9	30	2223	Pin — Escutcheon, Identification plate to crankcase	6
10	30	21080	Dowel — Crankcase cover to crankcase	2
		21442	Dowel — Starter gear bushing to crankcase (Series 9)	1
11	30	21441	Bushing — Starter gear (Series 9)	1
12	30	22387	Bushing — Engine mount (Rubber)	8
13	30	21530	Washer — Engine mount	4
14	30	21218	Screw — Cap, 1 3/8, pilot dowel, crankcase to crankcase	1
15	30	21219	Screw — Cap, 2 3/8, Crankcase 2-4 to crankcase 1-3 (dowel)	2
16	30	21176	Screw — Cap, 1 3/8, Crankcase 2-4 to crankcase 1-3	6
17	30	21077	Screw — Cap, 2 3/8, Crankcase 2-4 to crankcase 1-3	4
18	30	21448	Screw — Cap, 3 5/8, Crankcase 2-4 to crankcase 1-3	1
19	30	21076	Screw — Cap, 3 3/8, Crankcase 2-4 to crankcase 1-3	2
20	30	20522	Washer — Plain 1/4, Crankcase to crankcase 1-3	29
		AN960-5166	Washer — Plain 5/16, Crankcase to crankcase 1-3 Dowel Screws	3
21	30	2437	Nut — Plain 1/4, Crankcase 2-4 to crankcase 1-3	16
22	30	2886	Palnut — 1/4, Crankcase 2-4 to crankcase 1-3	16
23	30	*2465	Stud — Crankcase cover to crankcase (Series 8)	10
		*2465	Stud — Crankcase cover to crankcase (Series 9)	3
		*20096	Stud — Crankcase cover to crankcase (Series 9)	3
		*21449	Stud — Crankcase thru cover to starter (Series 9)	2
		*20020	Stud — Crankcase thru cover to oil screen housing (Series 9)	2

*Available in oversize or undersize. See oversize and undersize parts list.

GROUP ASSEMBLY PARTS LIST — Continued

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
24	30	*21167	Stud — Oil sump to crankcase	3
25	30	*2018	Stud — Push rod housing flange to crankcase	12
26	30	*21055	Stud — Crankcase 1-3 to crankcase 2-4	2
27	30	*21054	Stud — Crankcase 1-3 thru crankcase 2-4 to cylinder barrel	2
28	30	*21054	Stud — Crankcase 2-4 thru crankcase 1-3 to cylinder barrel	4
29	30	*2416	Stud — Cylinder barrel to crankcase	8
30	30	*21053	Stud — Cylinder barrel to crankcase	10
31	30	*2985	Stud — Crankcase 2-4 to crankcase 1-3	1
32	30	*21075	Stud — Crankcase 2-4 to crankcase 1-3	1
33	30	*2390	Stud — Oil sump bracket to crankcase arms	2
34	30	*20303	Stud — Intake manifold to crankcase (with A5892-A1 and A5395-A1)	2
35	30	2475	Washer — $\frac{7}{16}$, Crankcase 2-4 to crankcase 1-3	2
36	30	2474	Washer — $\frac{3}{8}$, Crankcase 2-4 to crankcase 1-3	2
37	30	23130	Nut — Spacer, Crankcase 1-3 to crankcase 2-4	2
38	30	2557	Nut — Plain $\frac{3}{8}$, Crankcase 2-4 to crankcase 1-3	2
39	30	2561	Palnut — $\frac{3}{8}$, Crankcase 2-4 to crankcase 1-3	2
40	30	*22172	Stud — Fuel injector to crankcase (with A5390-A1 and A5391-A1)	4
41	30	*21480	Stud — Intake manifold to crankcase (with A5390-A1 and A5391-A1)	2
42	30	*20001	Stud — Fuel pump to crankcase (with A5390-A1)	2
43	34	21064	Gasket — Fuel pump (with A5390-A1)	1
44	30	21059	Cover — Fuel pump (with A5390-A1)	1
45	30	2473	Washer — Fuel pump or cover (with A5390-A1)	2
46	30	2439	Nut — $\frac{5}{16}$, Fuel pump or cover (with A5390-A1)	2
47	30	2560	Palnut — $\frac{5}{16}$, Fuel pump or cover (with A5390-A1)	2
48	30	21350	Cover — Fuel injector flange (with A5390-A1 and A5391-A1)	1
49	30	21404	Gasket — Fuel injector to crankcase (with A5390-A1 and A5391-A1)	1
50	30	20522	Washer — $\frac{1}{4}$, Fuel injector to crankcase (with A5390-A1 and A5391-A1)	4
51	30	2456	Nut — $\frac{1}{4}$, castle, Fuel injector to crankcase (with A5390-A1 and A5391-A1)	4

ASSOCIATED PARTS

52	30	24321	Oil Seal — Crankshaft	1
53	30	842-10D	Elbow — $\frac{1}{2}$, Breather hole	1

*Available in oversize or undersize. See oversize and undersize parts list.

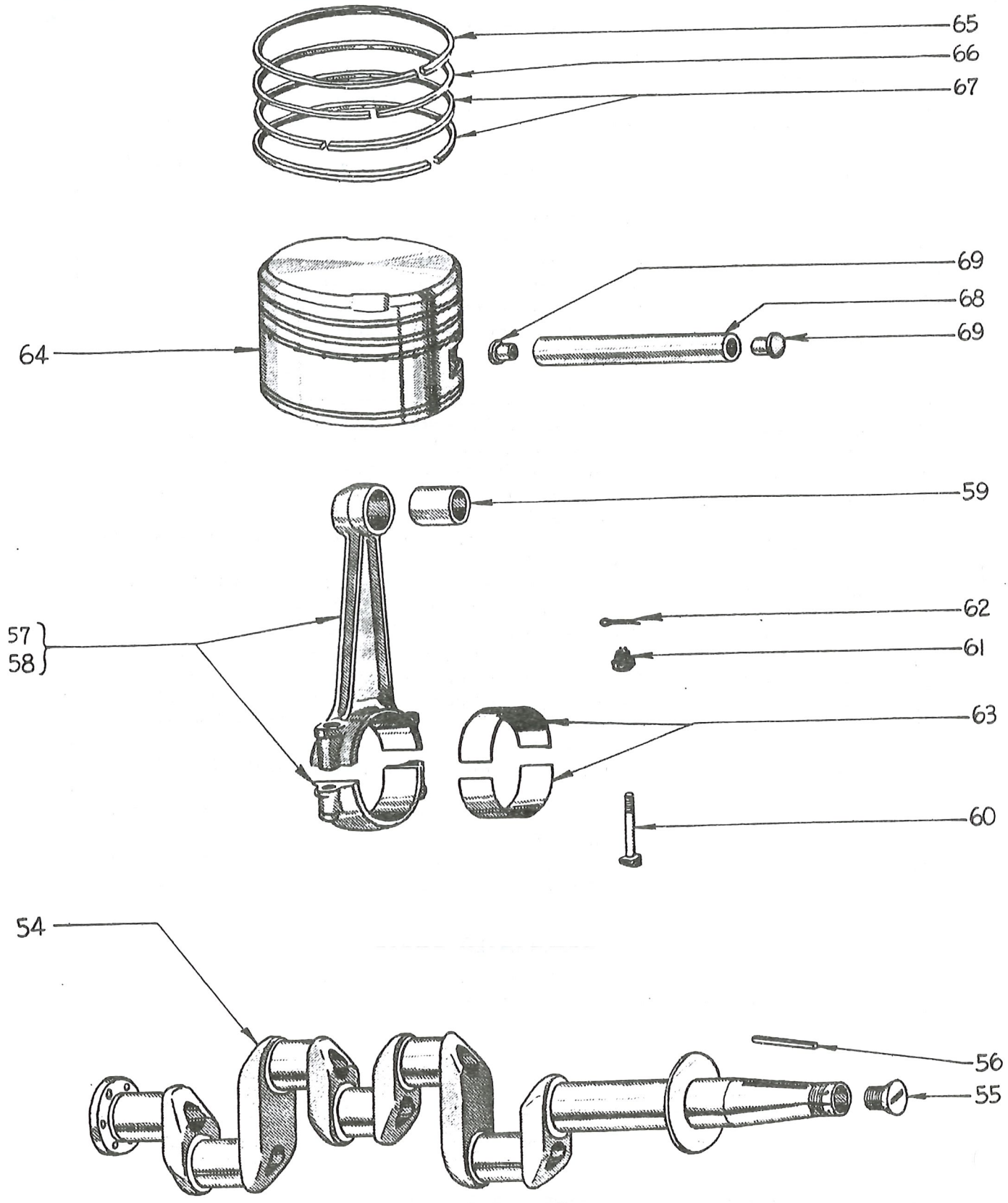


Figure 31
CRANKSHAFT, CONNECTING RODS AND PISTONS

GROUP ASSEMBLY PARTS LIST — Continued

CRANKSHAFT, CONNECTING RODS AND PISTONS

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
54	31	A5334	CRANKSHAFT ASSEMBLY	1
			Includes the shaft, oil passage tubes, and the following part:	
55	31	500398	Plug — Oil, crankshaft front end	1
			ASSOCIATED PARTS	
56	31	500400	Key — Propeller hub	1
		A35158-A1	CONNECTING ROD ASSEMBLY — COMPLETE (A50 & A65)	4
		A35159-A1	CONNECTING ROD ASSEMBLY — COMPLETE (A75 & A80)	4
57	31	A35158-A2	CONNECTING ROD ASSEMBLY (A50 & A65)	1
58	31	A35159-A2	CONNECTING ROD ASSEMBLY (A75 & A80)	1
			Each assembly includes the rod, cap, and the following parts:	
59	31	21003	Bushing — Piston pin	1
60	31	21004	Bolt — Connecting rod	2
61	31	2458	Nut — Castle, 3/8-24	2
62	31	2506	Cotter pin	2
63	31	*3698	Bushing — Connecting rod, upper and lower	2
		A4544	Piston Assembly — Complete (A50)	4
		A40577	Piston Assembly — Complete (A65 and A75) (Replacing A4557, A4648, A40312, A4625, A4638)	4
		A4701	Piston Assembly — Complete (A80)	4
64	31	*4544	Piston (A50)	1
		*40577	Piston (A65 and A75) (Replacing 4557, 4648, 40312, 4625, 4638)	1
		*4701	Piston (A80)	1
65	31	*35551	Ring — Piston, Compression, Beveled, Top Groove (A50 and A65 with Pistons 4544, 4557, or 4648)	1
65 & 66	31	*35551	Ring — Piston, Compression, Beveled, 1st and 2nd Grooves (A65, A75, and A80 with pistons 4625, 4638, 4701, 40312 or 40577)	2
66	31	*35597	Ring — Piston, Compression, Plain, 2nd Groove (A50 and A65 with pistons 4544, 4557 or 4648)	1
		*35597	Ring — Piston, Compression, Plain, 3rd Groove (A75 and and A80 with pistons 4625, 4638, or 4701)	1
67	31	*35595	Ring — Piston, Oil Control, 3rd and 4th Grooves (A50 and A65 with pistons 4544, 4557 or 4648)	2
		*35595	Ring — Piston, Oil Control, 4th and 5th Grooves (A75 and A80 with pistons 4625, 4638 or 4701)	2
67	31	*35741	Ring — Piston, Oil Control (A65 and A75 with pistons 40312 and 40577)	2

*Available in oversize or undersize. See oversize and undersize parts list.

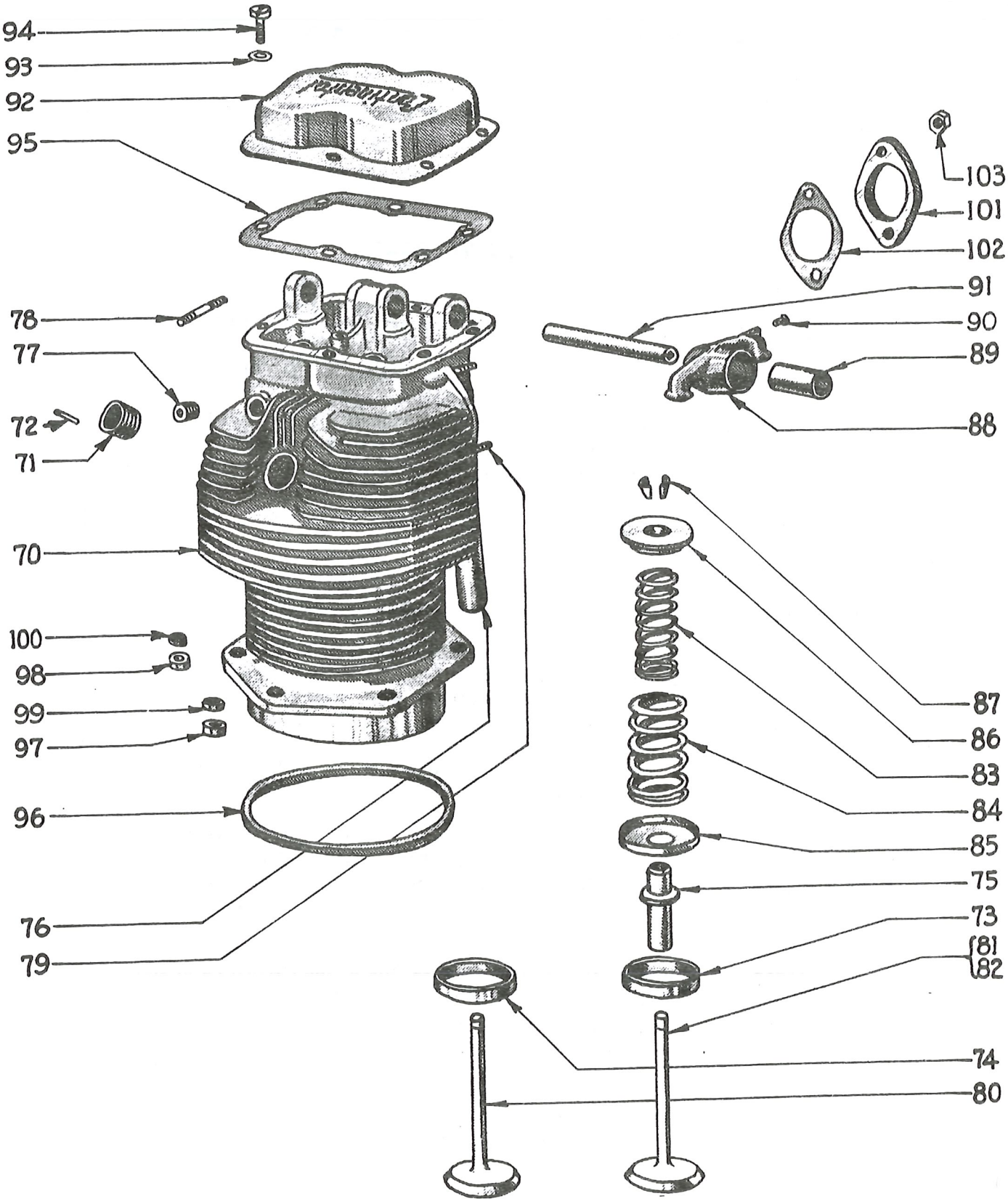


Figure 32
CYLINDER AND VALVES

GROUP ASSEMBLY PARTS LIST — Continued

CRANKSHAFT, CONNECTING RODS AND PISTONS — (Continued)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
		A21422	Piston Pin Assembly	1
			Pin — Piston	1
68	31	*21422		
69	31	21159	Plug — Piston Pin	2
		A22205	Ring Set — Piston (A50 and A65 with pistons 4544, 4557 or 4648)	1
		35551	Ring — Piston, Compression, Beveled	4
		35597	Ring — Piston, Compression, Plain	4
		35595	Ring — Piston, Oil Control	8
		B22205	Ring Set — Piston (A75 and A80 with pistons 4625 or 4638)	1
		35551	Ring — Piston, Compression, Beveled	8
		35597	Ring — Piston, Compression, Plain	4
		35595	Ring — Piston, Oil Control	8
		35670-A1	Ring Set — Piston (A65 and A75 with pistons 40312 or 40577)	1
		35551	Ring — Piston, Compression, Beveled	8
		35741	Ring — Piston, Oil Control	4

CYLINDER AND VALVES

		B3762-A2	CYLINDER ASSEMBLY — COMPLETE (A50 and A65)	4
		B3762-B	CYLINDER ASSEMBLY — COMPLETE (A75 and A80)	4
		B3762-A1	CYLINDER AND VALVE ASSEMBLY (A50 and A65)	1
		B-3762-B1	CYLINDER AND VALVE ASSEMBLY (A75 and A80)	1
		B3762	CYLINDER ASSEMBLY	1
			Includes the head, barrel, and the following parts:	
71	32	*2002	Insert — Spark plug	2
72	32	22676	Pin — Spark plug insert	2
73	32	21478	Insert — Valve seat, exhaust	1
74	32	21031	Insert — Valve seat, intake	1
75	32	*21419	Guide — Valve	2
76	32	21284	Housing — Push rod	2
77	32	2024	Plug — ⅛ pipe, Primer jet hole in head	1
78	32	*2018	Stud — Intake elbow to cylinder	2
79	32	*2389	Stud — Exhaust flange to cylinder	2
80	32	21359	Valve — Intake	1
81	32	22211	Valve — Exhaust (A50 and A65)	1
82	32	21479	Valve — Exhaust (A75 and A80)	1
83	32	21365	Spring — Valve, inner	2
84	32	21366	Spring — Valve, outer	2
85	32	21025	Retainer — Valve spring	2
86	32	21119	Seat — Valve spring	2
87	32	21361	Lock — Valve spring seat	4
88	32	A24122	VALVE ROCKER ASSEMBLY	2
			Includes the rocker arm, and the following parts:	
89	32	24122	Bushing — Valve rocker arm	1
90	32	21007	Plug — Oil passage	1

*Available in oversize or undersize. See oversize and undersize parts list.

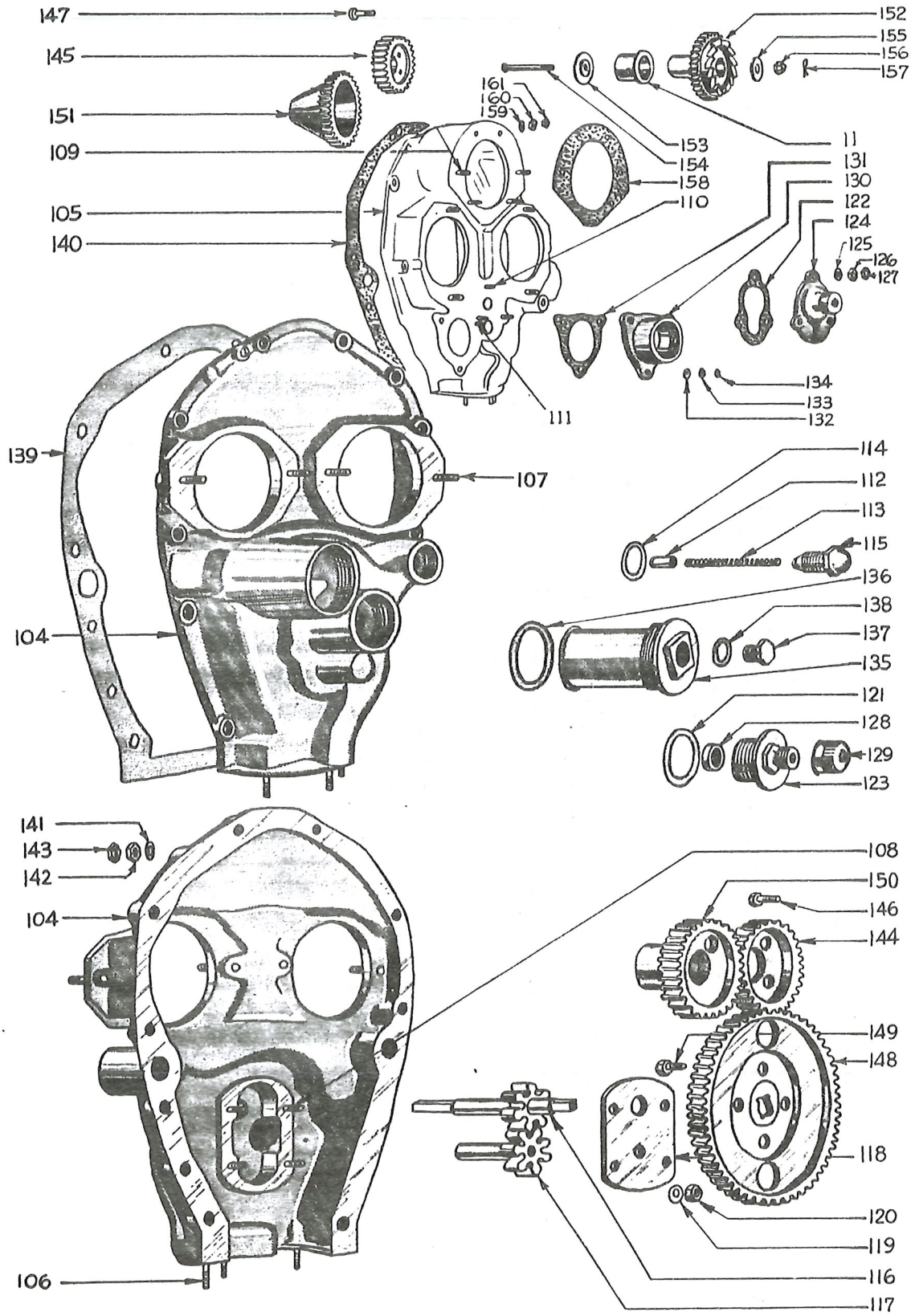


Figure 33

REAR CRANKCASE COVER AND GEAR TRAIN

GROUP ASSEMBLY PARTS LIST — Continued

CYLINDER AND VALVES — (Continued)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
91	32	21153	Shaft — Valve rocker	1
92	32	4806	Cover — Valve rocker	1
93	32	936-A-416	Washer — ¼ shakeproof, Rocker cover to cylinder	6
94	32	500-A416-8	Screw — ¼, Valve rocker cover to cylinder	6
95	32	3500	Gasket — Rocker cover	1
96	32	21477	Packing — Cylinder base	1
		**22949	Bushing — Valve Rocker Shaft Boss	4

ASSOCIATED PARTS

97	32	2443	Nut — $\frac{7}{16}$ plain, Crankcase thru crankcase to cylinder	16
98	32	2557	Nut — ⅜ plain, Cylinder barrel to crankcase	8
99	32	2958	Palnut — $\frac{7}{16}$, Cylinder barrel to crankcase	16
100	32	2561	Palnut — ⅜, Cylinder barrel to crankcase	8
101	32	21492	Flange — Exhaust	4
102	32	21493	Gasket — Exhaust flange	4
103	32	22022	Nut — Plain (Brass) Exhaust flange to cylinder	8
		21485	Gasket — Exh. Manifold Flange (for up-exhaust cylinder only)	1
		4528	Cover — Valve Rocker (Aluminum — Optional)	1
		22004	Stud — (For aluminum rocker cover — Optional)	6
		20522	Washer — (For aluminum rocker cover — Optional)	6
		2437	Nut — (For aluminum rocker cover — Optional)	6
		2886	Palnut — (For aluminum rocker cover — Optional)	6

REAR CRANKCASE COVER AND GEAR TRAIN

		A4587-A	CRANKCASE COVER ASSEMBLY — COMPLETE (Series 8)	1
		A6234-A	CRANKCASE COVER ASSEMBLY — COMPLETE (Series 9)	1
104	33	A4587	CRANKCASE COVER ASSEMBLY (Series 8)	1
105	33	A6234	CRANKCASE COVER ASSEMBLY (Series 9)	1
			Includes the cover and following corresponding parts:	
106	33	*21167	Stud — Oil sump to crankcase cover	3
107	33	*2465	Stud — Magneto to crankcase cover	4
108	33	*21393	Stud — Oil pump cover to crankcase cover	4
109	33	21463	Stud — Starter to crankcase cover (Series 9)	4
110	33	*2018	Stud — Tachometer housing to crankcase cover (Series 9)	3
111	33	*2018	Stud — Oil screen housing to crankcase cover (Series 9)	1
112	33	21114	Plunger — Oil pressure relief valve	1
113	33	21352	Spring — Oil pressure relief valve	1

*Available in oversize or undersize. See oversize and undersize parts list.

**NOTE: Valve rocker shaft bushing, Part No 22949 is a replacement part only and is used to bush worn rocker shaft bosses in the cylinder head, these bosses are not bushed on the new engine.

GROUP ASSEMBLY PARTS LIST — Continued

REAR CRANKCASE COVER AND GEAR TRAIN — (Continued)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
114	33	AN900-14	Gasket — Oil relief valve	1
115	33	21113	Cap — Oil pressure relief valve	1
116	33	3562	Gear and drive shaft — Oil pressure pump	1
117	33	21343	Gear and shaft — Oil pressure pump (driven)	1
118	33	21160	Cover — Oil pressure pump	1
119	33	20522	Washer — Oil pump cover to crankcase cover	4
120	33	2456	Nut — Castle, oil pump cover	4
		2220	Wire — Lock, oil pump cover to crankcase cover	UAR
121	33	AN900-22	Gasket — Tachometer drive housing (Series 8)	1
122	33	21429	Gasket — Tachometer drive housing (Series 9)	1
123	33	21208	Housing — Tachometer drive (Series 8)	1
124	33	3701	Housing — Tachometer drive (Series 9)	1
125	33	20522	Washer — Tachometer drive housing (Series 9)	3
126	33	2437	Nut — Tachometer drive housing (Series 9)	3
127	33	2886	Palnut — Tachometer drive housing (Series 9)	3
128	33	21163	Oil seal — Tachometer drive	1
		2220	Wire — Lock, Tachometer housing to cover (Series 8)	UAR
129	33	2716	Nut — Tachometer drive cover	1
130	33	3773	Housing — Oil screen housing (Series 9)	1
131	33	21510	Gasket — Oil screen housing (Series 9)	1
132	33	20522	Washer — Oil screen housing to cover (Series 9)	1
133	33	2437	Nut — 1/4, Oil screen housing to cover (Series 9)	1
134	33	2886	Palnut — 1/4, Oil screen housing to cover (Series 9)	1
135	33	A3568	OIL SCREEN ASSEMBLY	1
136	33	AN900-28	Gasket — Oil screen	1
137	33	2265	Plug — Thermometer hole in oil screen	1
138	33	AN900-10	Gasket — Thermometer hole in oil screen	1

ASSOCIATED PARTS

139	33	4577	Gasket — Crankcase cover to crankcase (Series 8)	1
140	33	4617	Gasket — Crankcase cover to crankcase (Series 9)	1
141	33	2473	Washer — 5/16, Crankcase cover to crankcase (Series 8)	10
		2473	Washer — 5/16, Crankcase cover to crankcase (Series 9)	8
		2473	Washer — 5/16, Oil screen housing to crankcase cover to crankcase (Series 9)	2
142	33	2439	Nut — 5/16, Crankcase cover to crankcase (Series 8)	10
		2439	Nut — 5/16, Crankcase cover to crankcase (Series 9)	8
143	33	2560	Palnut — 5/16, Crankcase cover to crankcase (Series 8)	10
		2560	Palnut — 5/16, Crankcase cover to crankcase (Series 9)	8
		2560	Palnut — 5/16, Oil screen housing to crankcase cover to crankcase (Series 9)	2
144	33	21083	Gear — Crankshaft (Series 8)	1
145	33	3699	Gear — Crankshaft (Series 9)	1
146	33	21346	Screw — 1/4 cap, Crankshaft gear to crankshaft (Series 8)	4
147	33	21447	Screw — 1/4 cap, Crankshaft gear to crankshaft (Series 9)	4
		2220	Wire — Lock, Crankshaft gear to crankshaft	UAR
148	33	3506	Gear — Camshaft	1

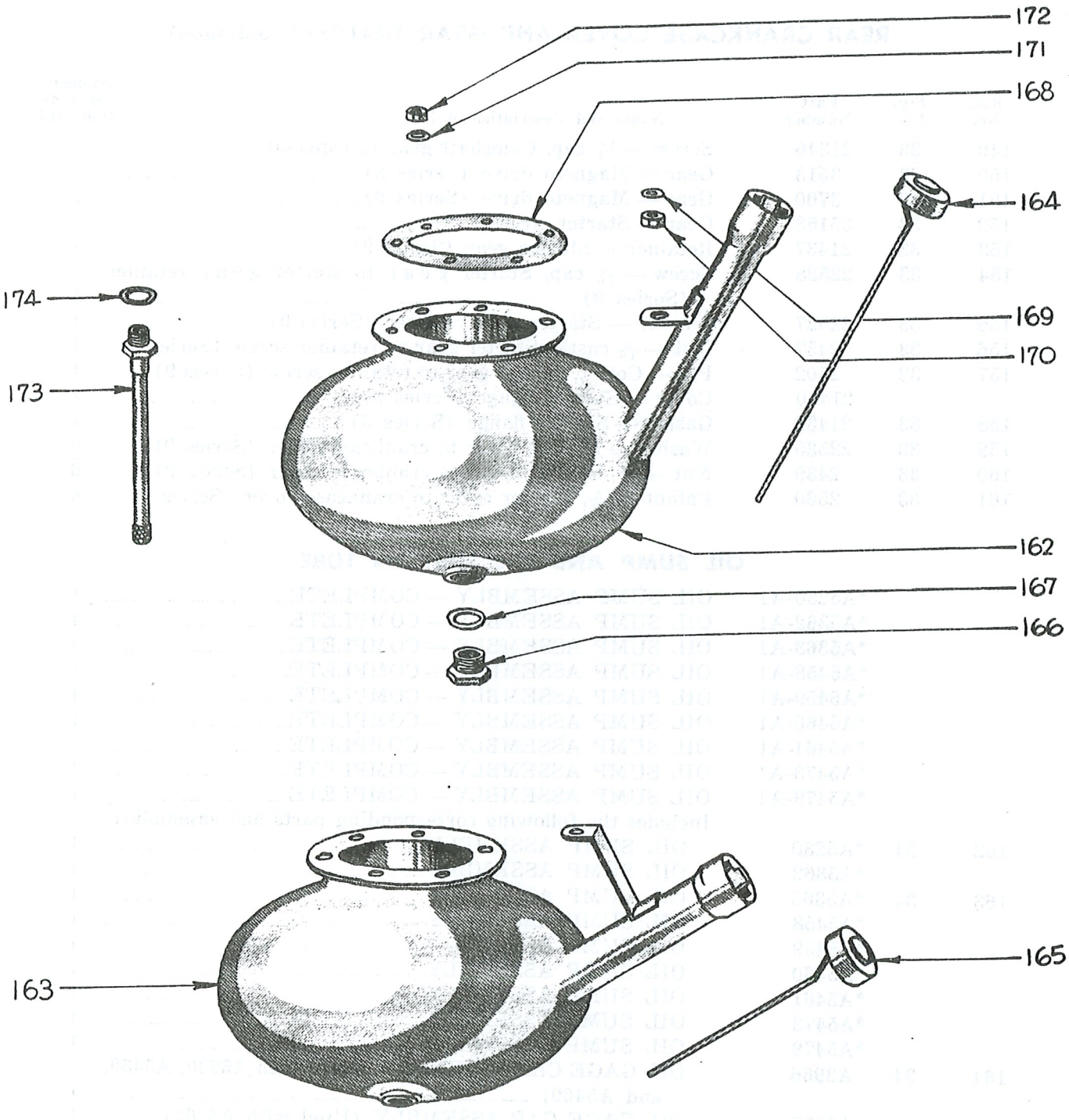


Figure 34
OIL SUMP AND OIL SUCTION TUBE

GROUP ASSEMBLY PARTS LIST — Continued

REAR CRANKCASE COVER AND GEAR TRAIN — (Continued)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
149	33	21346	Screw — 1/4 cap, Camshaft gear to camshaft	4
150	33	3513	Gear — Magneto drive (Series 8)	2
151	33	3700	Gear — Magneto drive (Series 9)	2
152	33	35153	Gear — Starter (Series 9)	1
153	33	21437	Retainer — Starter gear (Series 9)	1
154	33	22528	Screw — 5/16 cap, Starter gear to starter gear retainer (Series 9)	1
155	33	22527	Washer — Starter gear retainer (Series 9)	1
156	33	2457	Nut — 5/16 castle, Starter gear to retainer screw (Series 9)	1
157	33	2502	Pin — Cotter, starter gear to retainer screw (Series 9)	1
		21430	Cover — Starter flange (Series 9)	1
158	33	21432	Gasket — Starter flange (Series 9)	1
159	33	22535	Washer — Starter cover to crankcase cover (Series 9)	6
160	33	2439	Nut — 5/16, Starter cover to crankcase cover (Series 9)	6
161	33	2560	Palnut — 5/16, Starter cover to crankcase cover (Series 9)	6

OIL SUMP AND OIL SUCTION TUBE

		*A5230-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5362-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5363-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5458-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5459-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5460-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5461-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5473-A1	OIL SUMP ASSEMBLY — COMPLETE	1
		*A5479-A1	OIL SUMP ASSEMBLY — COMPLETE	1
			Includes the following corresponding parts and assemblies:	
162	34	*A5230	OIL SUMP ASSEMBLY	1
		*A5362	OIL SUMP ASSEMBLY	1
163	34	*A5363	OIL SUMP ASSEMBLY	1
		*A5458	OIL SUMP ASSEMBLY	1
		*A5459	OIL SUMP ASSEMBLY	1
		*A5460	OIL SUMP ASSEMBLY	1
		*A5461	OIL SUMP ASSEMBLY	1
		*A5473	OIL SUMP ASSEMBLY	1
		*A5479	OIL SUMP ASSEMBLY	1
164	34	A3966	OIL GAGE CAP ASSEMBLY (Used with A5230, A5459, and A5460)	1
		A3657	OIL GAGE CAP ASSEMBLY (Used with A5362)	1
165	34	A3680	OIL GAGE CAP ASSEMBLY (Used with A5363)	1
		A3896	OIL GAGE CAP ASSEMBLY (Used with A5458)	1
		A3970	OIL GAGE CAP ASSEMBLY (Used with A5461)	1

NOTE: For Crankcase Cover Assembly Use on Series 7 Engines (Discontinued), Order Part No. A-6226-A

*NOTE: When ordering oil sumps specify the number stamped on the flange. If no number is found, be sure to advise airplane make and model.

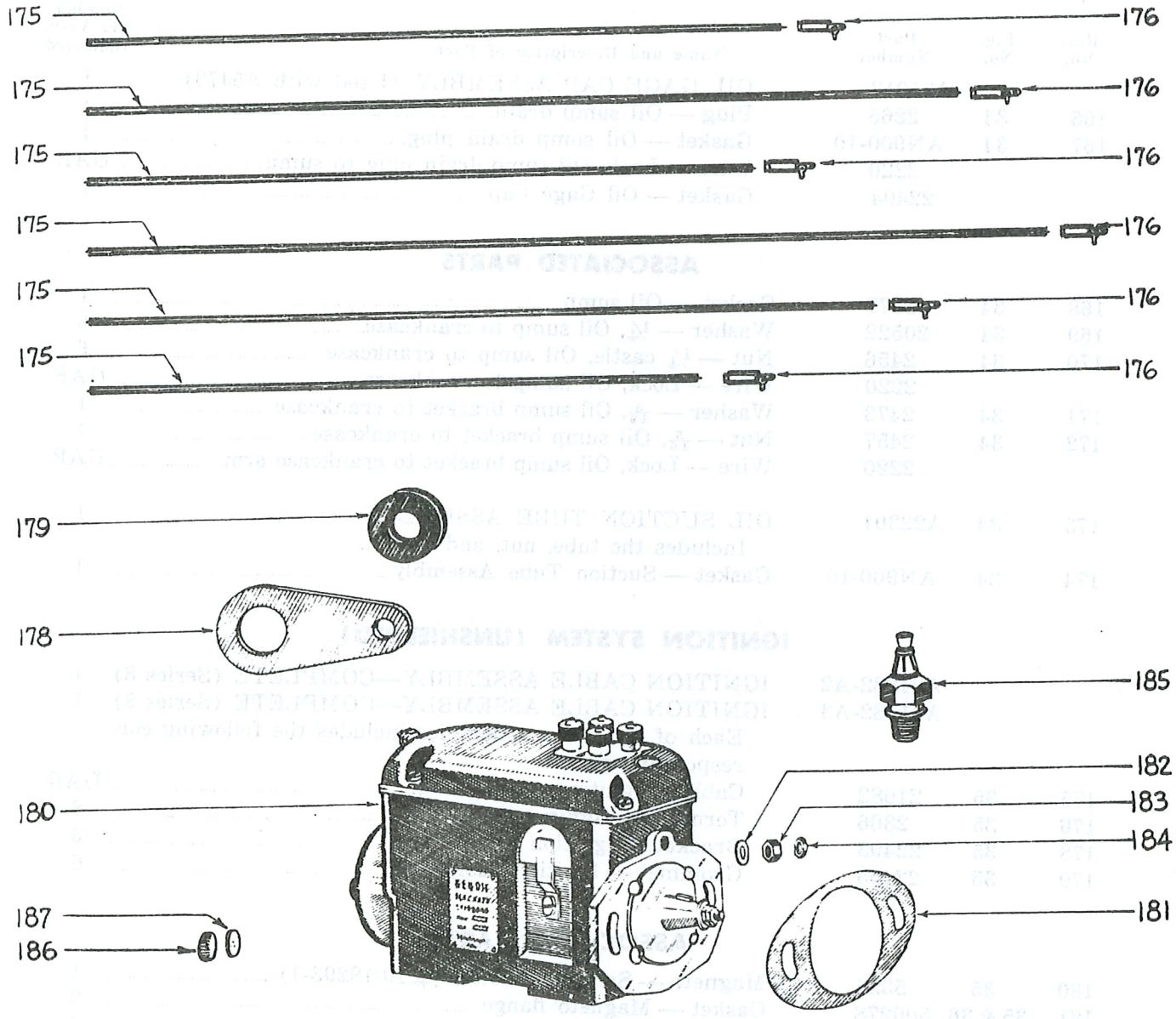


Figure 35

IGNITION SYSTEM — UNSHIELDED

GROUP ASSEMBLY PARTS LIST — Continued

OIL SUMP AND OIL SUCTION TUBE — (Continued)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
		A35017	OIL GAGE CAP ASSEMBLY (Used with A5479)	1
166	34	2265	Plug — Oil sump drain	1
167	34	AN900-10	Gasket — Oil sump drain plug	1
		2220	Wire — Lock, Oil sump drain plug to sump	UAR
		22404	Gasket — Oil Gage Cap	1

ASSOCIATED PARTS

168	34	3577	Gasket — Oil sump	1
169	34	20522	Washer — ¼, Oil sump to crankcase	6
170	34	2456	Nut — ¼ castle, Oil sump to crankcase	6
		2220	Wire — Lock, Oil sump to crankcase	UAR
171	34	2473	Washer — $\frac{5}{16}$, Oil sump bracket to crankcase	1
172	34	2457	Nut — $\frac{5}{16}$, Oil sump bracket to crankcase	1
		2220	Wire — Lock, Oil sump bracket to crankcase arm	UAR
173	34	A22301	OIL SUCTION TUBE ASSEMBLY Includes the tube, nut, and screen.	1
174	34	AN900-10	Gasket — Suction Tube Assembly	1

IGNITION SYSTEM (UNSHIELDED)

		A21082-A2	IGNITION CABLE ASSEMBLY—COMPLETE (Series 8)	1
		A21082-A3	IGNITION CABLE ASSEMBLY—COMPLETE (Series 9)	1
			Each of the above assemblies includes the following corresponding parts:	
175	35	21082	Cable — Ignition	UAR
176	35	2306	Terminal — Ignition	8
178	35	22493	Bracket — Ignition cable	6
179	35	22495	Grommet — Ignition cable	6

ASSOCIATED PARTS

180	35	5394	Magneto — Scintilla SF4R-8 (#10-19293-1)	1
181	35 & 36	500278	Gasket — Magneto flange	2
182	35 & 36	2555	Washer — $\frac{5}{16}$, Magneto to crankcase cover	4
183	35	2439	Nut — $\frac{5}{16}$, Magneto to crankcase cover	4
184	35	2560	Palnut — $\frac{5}{16}$, Magneto to crankcase cover	4
185	35	22460	Spark Plug — Champion C26	8
186	35	21469	Plug — Magneto ventilator (Series 9)	2
187	35	21491	Gasket — Magneto ventilator (Series 9)	2

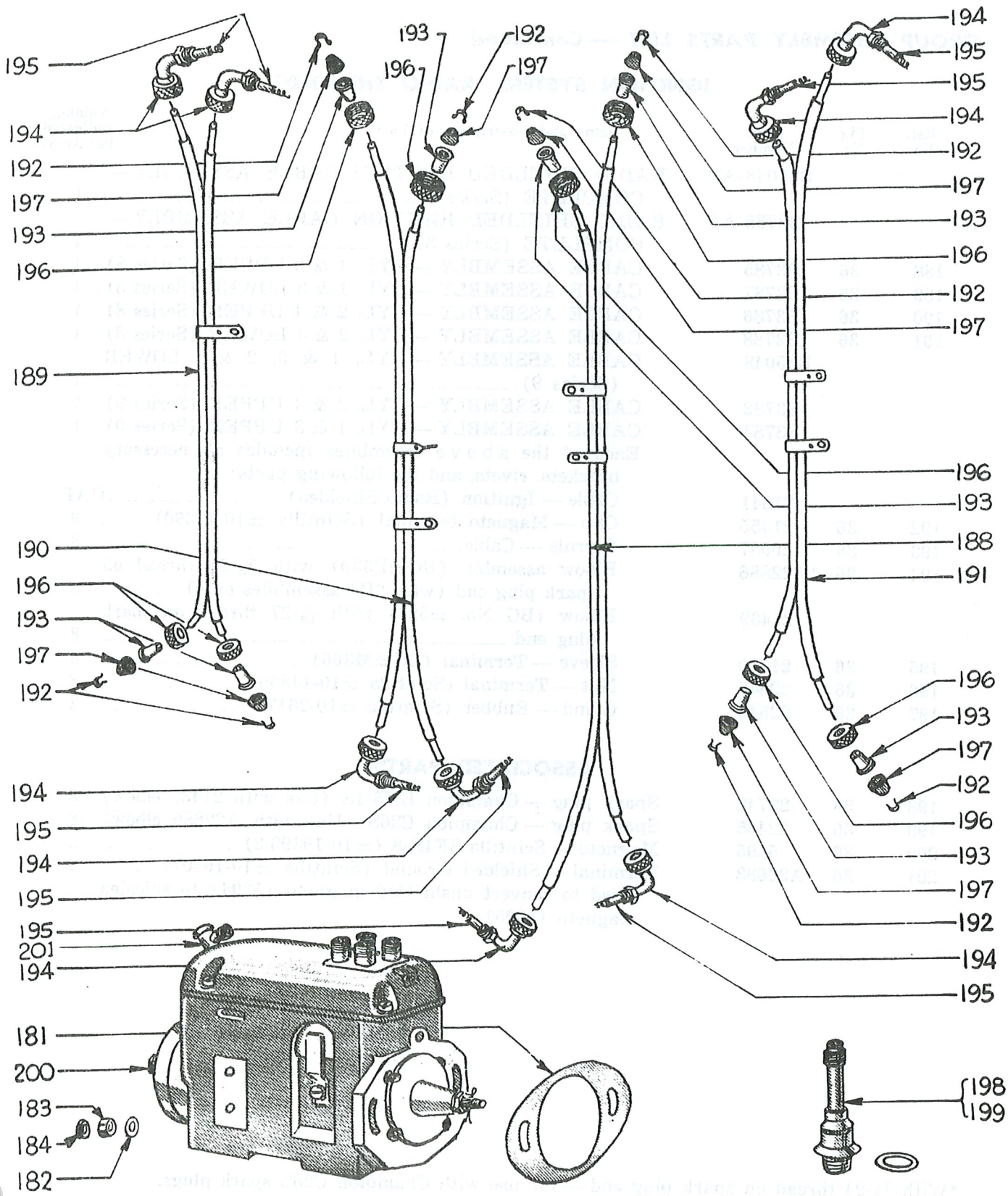


Figure 36

IGNITION SYSTEM — RADIO SHIELDED

GROUP ASSEMBLY PARTS LIST — Continued

IGNITION SYSTEM (RADIO SHIELDED)

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Indicated Per Assy.
		B35048-A1	RADIO SHIELDED IGNITION CABLE ASSEMBLY — COMPLETE (Series 9)	1
		B3785-A1	RADIO SHIELDED IGNITION CABLE ASSEMBLY — COMPLETE (Series 8)	1
188	36	B3785	CABLE ASSEMBLY — CYL. 1 & 3 UPPER (Series 8)	1
189	36	B3787	CABLE ASSEMBLY — CYL. 1 & 3 LOWER (Series 8)	1
190	36	B3786	CABLE ASSEMBLY — CYL. 2 & 4 UPPER (Series 8)	1
191	36	B3788	CABLE ASSEMBLY — CYL. 2 & 4 LOWER (Series 8)	1
		B35048	CABLE ASSEMBLY — CYL. 1 & 3, 2 & 4 LOWER (Series 9)	1
		B3782	CABLE ASSEMBLY — CYL. 2 & 4 UPPER (Series 9)	1
		B3783	CABLE ASSEMBLY — CYL. 1 & 3 UPPER (Series 9)	1
			Each of the above assemblies includes all necessary brackets, rivets, and the following parts:	
		21541	Cable — Ignition (Radio Shielded)	UAR
192	36	21455	Clip — Magneto terminal (Scintilla #10-12360)	8
193	36	20087	Ferrule — Cable	8
194	36	*A22886	Elbow assembly (BG#E530) with 5/8-24 thread on spark plug end (with "B" assemblies only)	8
		**21439	Elbow (BG No. #526) with 9/16-27 thread on spark plug end	8
195	36	21440	Sleeve — Terminal (BG#M366)	8
196	36	22548	Nut — Terminal (Scintilla #10-14855)	8
197	36	22549	Gland — Rubber (Scintilla #10-2617)	8

ASSOCIATED PARTS

198	36	22742	Spark plug — Champion LM3-1S (Use with 21439 elbow)	8
199	36	22465	Spark plug — Champion C26S (Use with A22886 elbow)	8
200	36	5395	Magneto — Scintilla SF4R-8 (#10-19393-2)	2
201	36	A23683	Terminal — Shielded Ground (Scintilla #10-16507) Used to convert unshielded magneto (5394) to shielded magneto (5395).	2

*With 5/8-24 thread on spark plug end — for use with Champion C26S spark plugs. All "B" assemblies (ignition cable) are equipped with this elbow.

**For Radio Shielded Ignition Assemblies equipped with this elbow (for use with 22742 spark plug) order same part number as shown above except that it must be preceded with an "A". Example: "A3785" instead of "B3785".

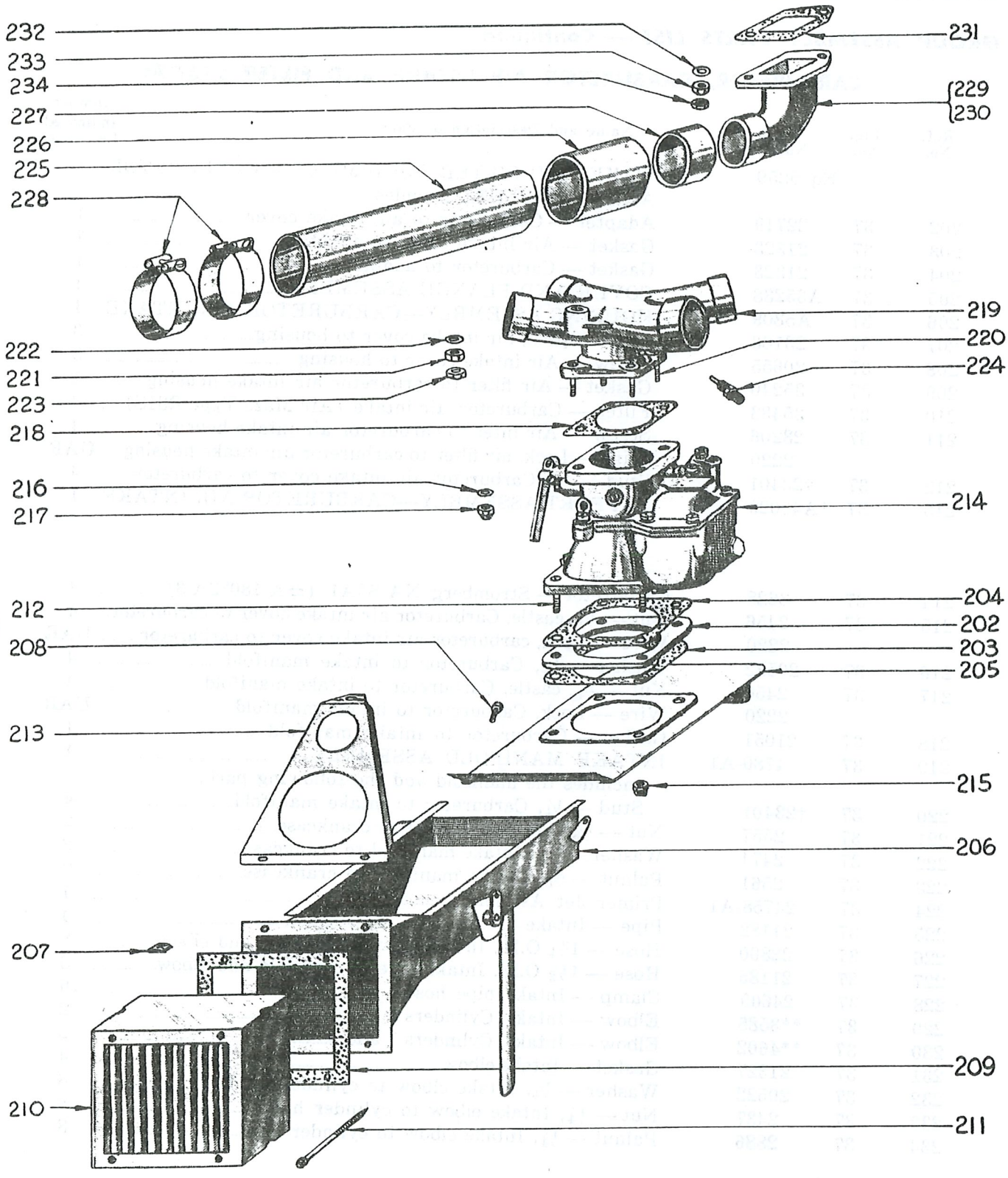


Figure 37

CARBURETOR, CARBURETOR AIR INTAKE AND FILTER SYSTEM

GROUP ASSEMBLY PARTS LIST — Continued

CARBURETOR, CARBURETOR AIR INTAKE AND FILTER SYSTEM

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Indicated Per Assy.
		Eq. 5259	INTAKE AND FILTER EQUIPMENT — CARBURETOR AIR — COMPLETE includes:	1
202	37	22719	Adapter — Carburetor to air intake cover	1
203	37	21323	Gasket — Air intake cover to adapter	1
204	37	21323	Gasket — Carburetor to adapter	1
205	37	A35238	COVER AND FLANGE ASSEMBLY	1
206	37	A5809	HOUSING ASSEMBLY—CARBURETOR AIR INTAKE	1
207	37	23166	Nut — Speed, air intake cover to housing	3
208	37	20655	Screw — Air intake cover to housing	3
209	37	35240	Gasket — Air filter to carburetor air intake housing	1
210	37	35433	Filter — Carburetor air intake (Air Maze Type R81S)	1
211	37	23206	Screw — Air filter to carburetor air intake housing	4
		2220	Wire — Lock, air filter to carburetor air intake housing	UAR
212	37	†23401	Stud — ¼, Carburetor air intake cover to carburetor	4
213	37	*A40029	SUPPORT ASSEMBLY—CARBURETOR AIR INTAKE	1
214	37	3628	Carburetor — Stromberg NA-S3A1 (≒A-18033A-3)	1
215	37	2456	Nut — ¼, castle, Carburetor air intake cover to carburetor	4
		2220	Wire — Lock, carburetor air intake cover to carburetor	UAR
216	37	20522	Washer — ¼, Carburetor to intake manifold	4
217	37	2456	Nut — ¼, castle, Carburetor to intake manifold	4
		2220	Wire — Lock, Carburetor to intake manifold	UAR
218	37	21051	Gasket — Carburetor to intake manifold	1
219	37	4780-A1	INTAKE MANIFOLD ASSEMBLY	1
			Includes the manifold and the following part:	
220	37	†23401	Stud — ¼, Carburetor to intake manifold	4
221	37	2557	Nut — ⅜, Intake manifold to crankcase	2
222	37	2474	Washer — ⅜, Intake manifold to crankcase	2
223	37	2561	Palnut — ⅜, Intake manifold to crankcase	2
224	37	24758-A1	Primer Jet Assembly	1
225	37	21182	Pipe — Intake	4
226	37	22800	Hose — 1¾ O.D., Intake pipe to manifold and elbow	8
227	37	21185	Hose — 1½ O.D., Intake pipe to manifold and elbow	8
228	37	24609	Clamp — Intake pipe hose	16
229	37	**3585	Elbow — Intake, Cylinders 2 and 3	2
230	37	**4602	Elbow — Intake, Cylinders 1 and 4	2
231	37	21327	Gasket — Intake elbow	4
232	37	20522	Washer — ¼, Intake elbow to cylinder head	8
233	37	2437	Nut — ¼, Intake elbow to cylinder head	8
234	37	2886	Palnut — ¼, Intake elbow to cylinder head	8

†Available in oversize or undersize. See oversize and undersize parts list.

*For special brackets for use when oil cooler is installed under engine. See Oil Cooler Equipmen, page 76.

**For Elbows for use on fuel injection engine refer to page 74, Fuel Injector Equipment.

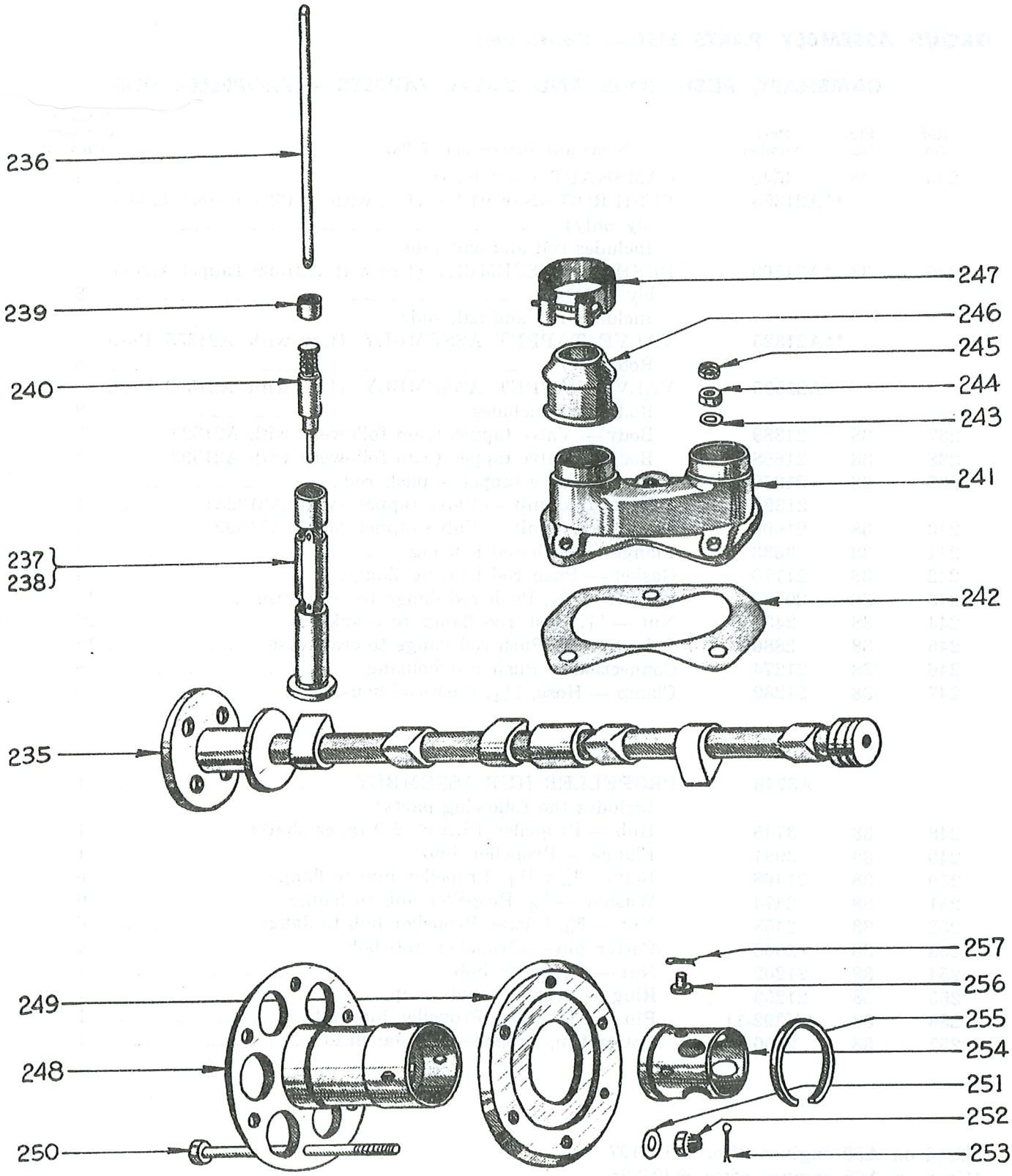


Figure 38

CAMSHAFT, PUSH RODS AND VALVE TAPPETS
PROPELLER HUB

GROUP ASSEMBLY PARTS LIST — Continued

CAMSHAFT, PUSH RODS AND VALVE TAPPETS — PROPELLER HUB

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
235	38	4546	CAMSHAFT (Standard)	1
		**A21355	PUSH ROD ASSEMBLY (Use with A21325 Tappet Assembly only)	8
			Includes rod and ball ends	
236	38	*A21509	PUSH ROD ASSEMBLY (Use with A21599 Tappet Assembly only)	8
			Includes rod and ball ends	
		**A21325	VALVE TAPPET ASSEMBLY (Use with A21355 Push Rod only)	8
		*A21599	VALVE TAPPET ASSEMBLY (Use with A21509 Push Rod only) includes	8
237	38	21389	Body — Valve tappet (cam follower) with A21325	1
238	38	21608	Body — Valve tappet (cam follower) with A21599	1
239	38	21378	Cup — Valve tappet — push rod	1
		21390	Hydraulic unit — Valve tappet (with A21325)	1
240	38	21609	Hydraulic unit — Valve tappet (with A21599)	1
241	38	3633	Flange — Push rod housing	1
242	38	21170	Gasket — Push rod housing flange	1
243	38	20522	Washer — 1/4, Push rod flange to crankcase	12
244	38	2437	Nut — 1/4, Push rod flange to crankcase	12
245	38	2886	Palnut — 1/4, Push rod flange to crankcase	12
246	38	21274	Connection — Push rod housing	8
247	38	21282	Clamp — Hose, 1 1/4, Push rod housing	8
		A3746	PROPELLER HUB ASSEMBLY	1
			Includes the following parts:	
248	38	3745	Hub — Propeller (S.A.E. #0 taper shaft)	1
249	38	3991	Flange — Propeller hub	1
250	38	21468	Bolt — 3/8 x 4 1/4, Propeller hub to flange	6
251	38	2474	Washer — 3/8, Propeller hub to flange	6
252	38	2458	Nut — 3/8, Castle, Propeller hub to flange	6
253	38	2506	Cotter pin — Propeller hub bolt	6
254	38	21202	Nut — Propeller hub	1
255	38	21203	Ring — Propeller hub snap	1
256	38	AN392-11	Pin — Flat head, Propeller hub nut	1
257	38	2500	Cotter Pin, Propeller nut flat head	1

*Used on A50 engines after #129197.
*Used on A65 engines after #404298.
*Used on A75 engines after #630698.
*Used on all A80 engines.
**Used on A50 engines through #12197.
**Used on A65 engines through #404298.
**Used on A75 engines through #630698.

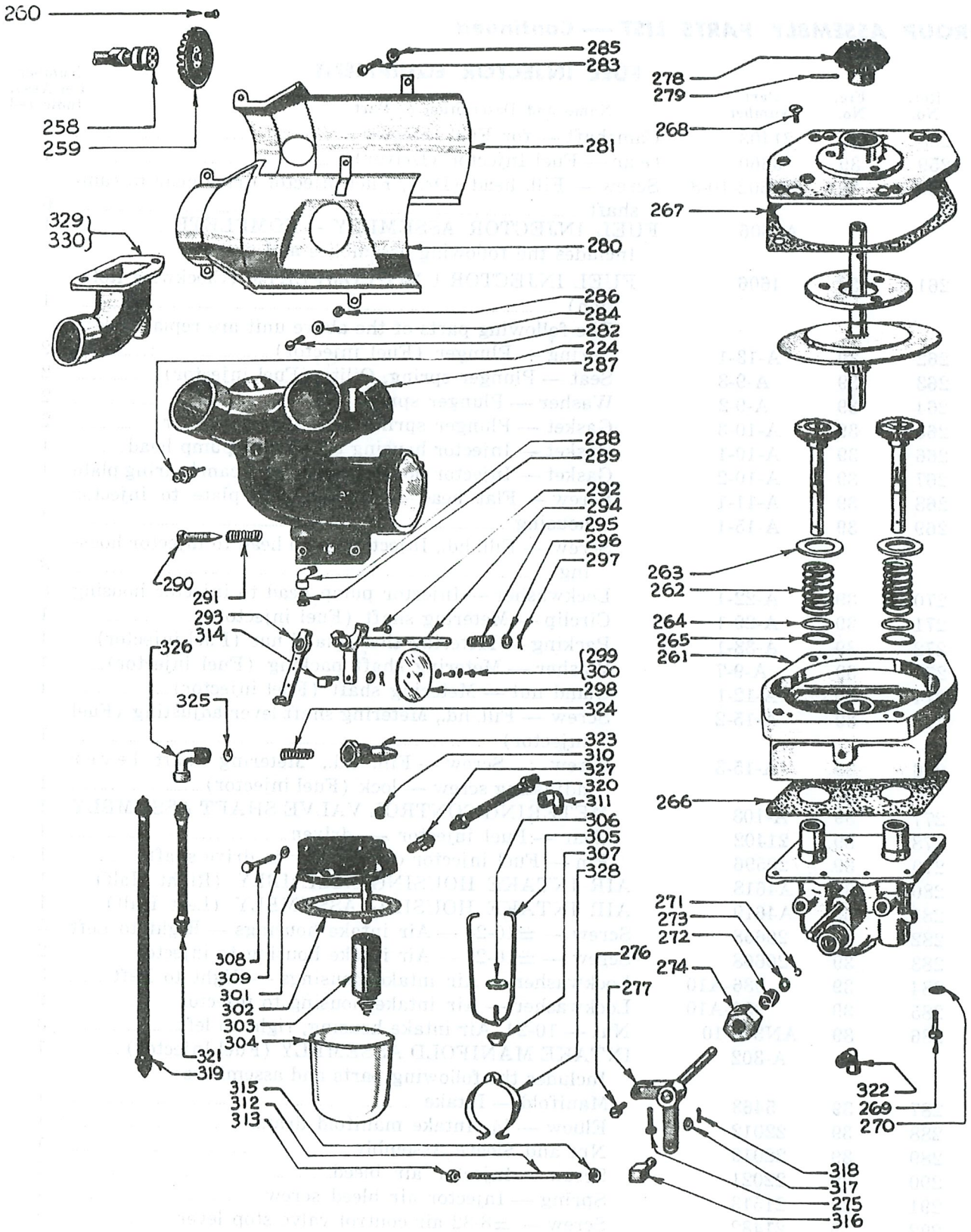


Figure 39

FUEL INJECTOR EQUIPMENT

GROUP ASSEMBLY PARTS LIST — Continued

FUEL INJECTOR EQUIPMENT

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
258	39	21403	Camshaft — for Fuel Injector	1
259	39	3660	Gear — Fuel Injector (Driver)	1
260	39	AN502-10-8	Screw — Fill. head (Dr.), Fuel injector drive gear to camshaft	6
		A4606	FUEL INJECTOR ASSEMBLY — COMPLETE	1
			Includes the following assemblies and parts:	
261	39	4606	FUEL INJECTOR UNIT COMPLETE (Clockwise Rotation)	1
			The following parts of the above unit are replaceable:	
262	39	A-13-1	Spring — Plunger (Fuel injector)	2
263	39	A-9-3	Seat — Plunger spring, Oilite (Fuel injector)	2
264	39	A-9-2	Washer — Plunger spring (Fuel injector)	2
265	39	A-10-3	Gasket — Plunger spring boss (Fuel injector)	2
266	39	A-10-1	Gasket — Injector housing to injector pump head	1
267	39	A-10-2	Gasket — Injector housing to injector cam bearing plate	1
268	39	A-11-1	Screw — Flat head — Cam bearing plate to injector housing	4
269	39	A-15-1	Screw — Fill. hd., Injector pump head to injector housing	8
270	39	A-22-1	Lockwasher — Injector pump head to injector housing	8
271	39	A-29-1	Circlip — Metering shaft (Fuel injector)	1
272	39	A-33-1	Packing — Metering shaft gland nut (Fuel injector)	1
273	39	A-9-7	Washer — Metering shaft packing (Fuel injector)	1
274	39	A-12-1	Gland nut — Metering shaft (Fuel injector)	1
275	39	A-15-2	Screw — Fill. hd., Metering shaft lever-adjusting (Fuel injector)	1
276	39	A-15-3	Screw Screw — Fill. hd., Metering shaft lever adjusting screw — lock (Fuel injector)	1
277	39	A-103	METERING CONTROL VALVE SHAFT ASSEMBLY	1
278	39	21402	Gear — Fuel injector — driven	1
279	39	20596	Pin — Fuel injector driven gear to drive shaft	1
280	39	A4618	AIR INTAKE HOUSING ASSEMBLY (Right Half)	1
281	39	A4619	AIR INTAKE HOUSING ASSEMBLY (Left Half)	1
282	39	20668	Screw — #10-24 — Air intake housings — Right to Left	3
283	39	20668	Screw — #10-24 — Air intake housing to injector	2
284	39	936-A10	Lockwasher — Air intake housings — Right to Left	3
285	39	936-A10	Lockwasher — Air intake housing to injector	2
286	39	AN340-10	Nut — 10-24, Air intake housing, right to left	3
		A-302	INTAKE MANIFOLD ASSEMBLY (Fuel Injector)	1
			Includes the following parts and assemblies:	
287	39	5463	Manifold — Intake	1
288	39	22012	Elbow — ¼, Intake manifold drain	1
289	39	22019	Nut and Sleeve Assembly	1
290	39	22021	Screw — Injector air bleed	1
291	39	21513	Spring — Injector air bleed screw	1
292	39	21482	Screw — #8-32 air control valve stop lever	4
293	39	A21423	LEVER ASSEMBLY — THROTTLE	1
294	39	A-1011	AIR CONTROL VALVE SHAFT ASSEMBLY (Fuel injector)	1
			Consists of a shaft, stop lever and pin.	

GROUP ASSEMBLY PARTS LIST — Continued

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
295	39	21481	Spring — Air control valve shaft	1
296	39	2473	Washer — Air control valve shaft spring	1
297	39	AN380-3-2	Cotter pin — Air control valve shaft	1
298	39	21424	Valve — Throttle	1
299	39	21431	Screw — #8-32, Throttle valve to shaft	2
300	39	21597	Lockwasher — Throttle valve to shaft screw	2
		A3934	SEDIMENT BOWL ASSEMBLY	1
			Includes the following parts and assemblies:	
301	39	A-31-2	Cover — Sediment — Bowl (Fuel injector)	1
302	39	A-1005	Gasket — Sediment Bowl (Fuel injector)	1
303	39	A-37-A-1	STRAINER ASSEMBLY (Fuel injector)	1
304	39	A-1006	Bowl — Glass, sediment (Fuel injector)	1
305	39	A-1	CLAMP AND SCREW ASSEMBLY — BOWL (Fuel injector)	1
306	39	A-105-1	Nut — Bowl screw (Fuel injector)	1
307	39	A-1007	Seat — Sediment bowl (Fuel injector)	1
308	39	22051	Screw — ¼, Sediment Bowl Assembly to Intake Manifold	2
309	39	20522	Washer—¼, Sediment Bowl Assembly to Intake Manifold	2
310	39	2024	Plug — ½ pipe, Sediment bowl cover vent hole	1
311	39	22012	Elbow — 14, Sediment bowl to injector tube	1
		A-108	ROD ASSEMBLY COMPLETE — INJECTOR LEVER TO THROTTLE LEVER (Fuel injector)	1
			Includes the following parts:	
312	39	21427	Rod — Injector lever to throttle lever	1
313	39	21475	Nut — #10-32 (Left hand thread) Injector Rod—Lock	1
314	39	21476	Rod End — (Left hand thread) Injector lever to throttle lever	1
315	39	2436	Nut—#10-32 (Right hand thread) Injector Rod—Lock	1
316	39	21428	Rod End (Right hand thread) Injector lever to throttle lever	1
317	39	2471	Washer — #10 Rod end, Air control	2
318	39	2501	Cotter pin — Rod end, Air control	2
319	39	A22014	TUBE ASSEMBLY — FUEL INJECTOR TO INTAKE ELBOW	4
320	39	A22020	TUBE ASSEMBLY — SEDIMENT BOWL TO FUEL INJECTOR	1
321	39	A22008	TUBE ASSEMBLY — FUEL INJECTOR VENT	1
322	39	A22017	Elbow — Fuel injector vent	1
323	39	35832	JET — ENGINE INTAKE ELBOW	4
326	39	21375	Elbow — Injector jet	1
327	39	22011	Coupling — Female, Sediment bowl to ¼" O.D. tube	1
328	39	22010	Clip — Injector tube to intake pipe	4
		21404	Gasket — Injector to crankcase	1

ASSOCIATED PARTS

329	39	22524	Elbow — Intake (Cyl. 1 and 4)	2
330	39	22525	Elbow — Intake (Cyl. 2 and 3)	2

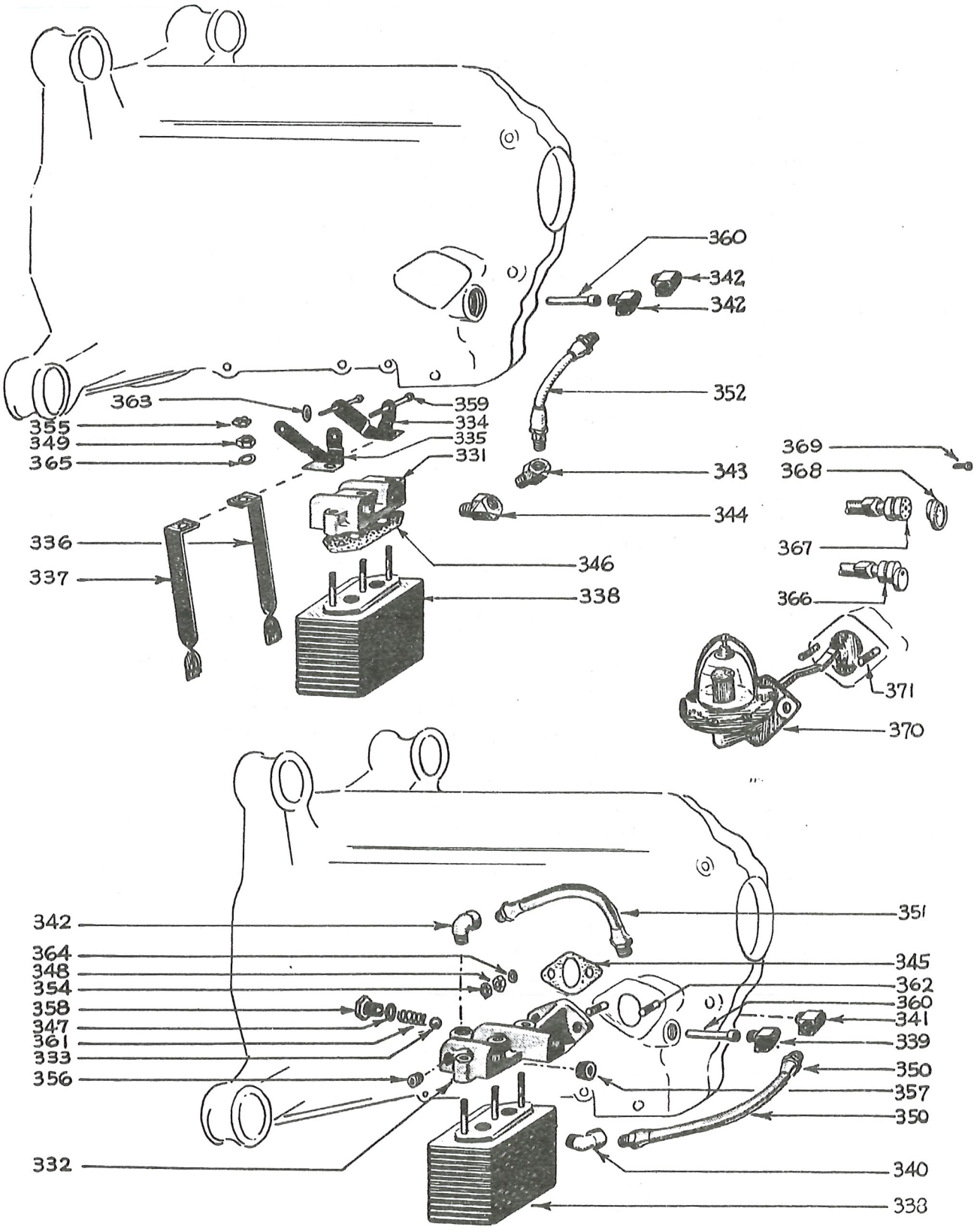


Figure 40

FUEL PUMP AND OIL COOLER EQUIPMENT

GROUP ASSEMBLY PARTS LIST — Continued

OIL COOLER EQUIPMENT

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
331	40	*3875	Adapter — Oil cooler	1
332	40	**4732	Adapter — Oil cooler	1
333	40	2849	Ball — 5/16 steel, By-pass valve	1
334	40	*22131	Bracket — Oil cooler adapter (Crankcase 2-4)	1
335	40	*22132	Bracket — Oil cooler adapter (Crankcase 1-3)	1
336	40	*A23655	Bracket — Carburetor air intake housing to oil cooler bracket (2 and 4 side)	1
337	40	*A23657	Bracket — Carburetor air intake housing to oil cooler bracket (1 and 3 side)	1
338	40	3883	Cooler — Oil (Harrison)	1
339	40	**22140	Elbow — Inverted Male — Oil tube to crankcase 1-3	1
340	40	**22140	Elbow — Inverted Male — Oil tube to adapter	1
341	40	**22271	Elbow — 90 — 3/8 M. to F. pipe thread, Oil tube to crankcase 2-4	1
342	40	*22271	Elbow — 90 — 3/8 M. to F. pipe thread	2
343	40	*22296	Elbow — 45 — 3/8 M. to F., Oil tube to 45 elbow (ret. 344)	2
344	40	*22295	Elbow — 45 — 3/8 M. to F., Crankcase to 45 elbow (ret. 343)	2
345	40	**21064	Gasket — Adapter to crankcase	1
346	40	22133	Gasket — Oil cooler to adapter	1
347	40	AN900-10	Gasket — By-pass valve plug	1
		2220	Lockwire — (50 ft. roll)	UAR
348	40	**2439	Nut — 5/16-24 — Adapter to crankcase studs	2
349	40	2441	Nut — 3/8-24, Oil cooler studs	3
350	40	**22198	OIL TUBE ASSEMBLY (10 1/4 in. long) — OIL COOLER TO CRANKCASE 2-4	1
351	40	**22199	OIL TUBE ASSEMBLY (6 1/4 in. long) — OIL COOLER TO CRANKCASE 1-3	1
352	40	*22293	OIL TUBE ASSEMBLY — OIL COOLER TO CRANKCASE (Both sides)	2
354	40	**2560	Palnut — 5/16, Adapter to crankcase studs	2
355	40	2561	Palnut — 3/8, Oil cooler stud	3
		*20882	Plug — 1/8 pipe, Square head (drilled)	1
356	40	**20288	Plug — 1/4 pipe, Countersunk head — Oil cooler adapter	1
357	40	**2025	Plug — 3/8 pipe, Countersunk head — Oil cooler adapter	1
358	40	2265	Plug — 5/8, hex head — By-pass valve	1
359	40	*22134	Screw — 1/4-28 hex. head, Oil cooler adapter to crankcase	2
360	40	22130	Sleeve — Oil line — crankcase 1-3 side	1
361	40	2848	Spring — By-pass valve	1
362	40	**20001	Stud — 5/16 x 1 1/4, crankcase 1-3 to adapter	2
363	40	*22139	Washer — 29/32 x 5/8 x 1/8 thick, Bracket to crankcase—spacing	4
364	40	**2473	Washer — 5/16 — Adapter to crankcase studs	2
365	40	2474	Washer — 3/8, Oil cooler studs	3

*For *under-engine mount* only (Equip. 5198).

**For *crankcase 1-3 side mount* only (Equip. ≒5199). This installation cannot be made on engines equipped with fuel pump.

GROUP ASSEMBLY PARTS LIST — Continued

FUEL PUMP EQUIPMENT

Ref. No.	Fig. No.	Part Number	Name and Description of Part	Number Per Assy. Indicated
366	40	*4608	Camshaft (Fuel pump)	1
367	40	**21521	Camshaft (Fuel pump with Fuel Injector)	1
368	40	**21525	Eccentric — Fuel pump (with 21521)	1
369	40	**AN502-10-12	Screw — 10-32, Fuel pump thru fuel injection drive gear to camshaft	3
		**21527	Dowel — Fuel pump eccentric (with 21521 camshaft	1
370	40	4552	Fuel pump (A. C.)	1
		21064	Gasket — Fuel pump	1
371	40	†20001	Stud — $\frac{5}{16}$ x 1¼, Fuel pump to crankcase	2
		2473	Washer — $\frac{5}{16}$, Fuel pump to crankcase	2
		2439	Nut — $\frac{5}{16}$-24, Fuel pump to crankcase	2
		2560	Palnut — $\frac{5}{16}$, Fuel pump to crankcase	2
		*21598	TUBE ASSEMBLY — FUEL PUMP TO CARBURETOR	1
		*21619	Elbow — ¼ O.D., Fuel pump inlet	1
		**21619	Elbow — ¼ O.D., Fuel pump inlet and outlet — and Fuel injector inlet	3
		**A3828	TUBE ASSEMBLY — Fuel pump to fuel injector	1

*For use on Carburetor Equipped Engines.
**For use on Fuel Injection Equipped Engines.

	A3972	Gasket Set (Engine) — 1
	B3973	Gasket and Hose Connection Set — 1

†Available in oversize or undersize. See oversize and undersize parts list.

Section 15

NUMERICAL PARTS LIST

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
71	*2002	Insert — Spark plug	8	8
25	*2018	Stud — Push rod housing flange to crankcase (12)		
78		Stud — Intake elbow to cylinder (2)		
110		Stud — Tachometer housing to crankcase cover (Series 9) (3)		
111		Stud — Oil screen housing to crankcase cover (Series 9) (1)	18	18
4	2024	Plug — 1/8 pipe, Oil pressure gage outlet (1)		
77		Plug — 1/8 pipe, Primer jet hole in head (4)		
310		Plug — 1/2 pipe, Sediment bowl cover vent hole (1)	5	5
3	2025	Plug — 3/8 pipe, Crankcase oil lines (2)		
357		Plug — 3/8 pipe, Countersunk head—Oil cooler adapter (1)	3	3
	2220	Wire — Lock, oil pump cover to crankcase cover		
		Wire — Lock, tachometer housing to cover (Series 8)		
		Wire — Lock, crankshaft gear to crankshaft		
		Wire — Lock, oil sump drain to plug to sump		
		Wire — Lock, oil sump to crankcase		
		Wire — Lock, oil sump bracket to crankcase arm		
		Wire — Lock, air filter to carburetor air intake housing		
		Wire — Lock, carburetor air intake cover to carburetor		
		Wire — Lock, carburetor to intake manifold		
		Lockwire — (50 ft. roll)	UAR	UAR
9	2223	Pin — Escutcheon, Identification plate to crankcase	6	6
137	2265	Plug — Thermometer hole in oil screen (1)		
166		Plug — Oil sump drain (1)		
358		Plug — 5/8 hex. head — By-pass valve (1)	3	3
176	2306	Terminal — Ignition	8	8
79	*2389	Stud — Exhaust flange to cylinder	2	2
33	*2390	Stud — Oil sump bracket to crankcase arms	2	2
29	*2416	Stud — Cylinder barrel to crankcase	8	8
315	2436	Nut — #10-32 (Right hand thread), Injector rod-lock	1	1
21	2437	Nut — Plain 1/4, crankcase 2-4 to crankcase 1-3 (16)		
126		Nut — Tachometer drive housing (Series 9) (3)		
133		Nut — 3/4, Oil screen housing to cover (Series 9) (1)		
233		Nut — 1/4, Intake elbow to cylinder head (8)		
244		Nut — 3/4, Push rod flange to crankcase (1)	36	40
		Nut — 3/4, (For aluminum rocker cover—optional) (24)		
46	2439	Nut — 5/16, Fuel pump or cover (with A5390-A1) (2)		
142		Nut — 5/16, Crankcase cover to crankcase (Series 2) (10)		
		Nut — 5/16, Crankcase cover to crankcase (Series 9) (8)		
		Nut — 5/16, Oil screen housing to crankcase cover to crankcase (Series 9) (2)		
160		Nut — 5/16, Starter cover to crankcase cover (Series 9) (6)		
183		Nut — 5/16, Magneto to crankcase cover (4)		
348		Nut — 5/16-24, Adapter to crankcase studs (2)		
		Nut — 5/16-24, Fuel pump to crankcase (2)	18	24

*Available in oversize or undersize — See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
349	2441	Nut — 3/8-24, Oil cooler studs	3	3
97	2443	Nut — 7/16 plain, Crankcase thru crankcase to cylinder	16	16
51	2456	Nut — 1/4, castle, Fuel injector to crankcase (with A5390-A1 and A5391-A1) (4)		
120		Nut — Castle, oil pump cover (4)		
170		Nut — 1/4 castle, Oil sump to crankcase (6)		
215		Nut — 1/4 castle, Carburetor air intake cover to carburetor (4)		
217		Nut — 1/4, Carburetor to intake manifold (4)	22	22
156	2457	Nut — 5/16 castle, Starter gear to retainer screw (Series 9) (1)	2	2
172		Nut — 5/16, Oil sump bracket to crankcase (1)	2	2
61	2458	Nut — Castle, 3/8-24 (2)		
252		Nut — 3/8 castle, Propeller hub to flange (6)	8	8
23	*2465	Stud — Crankcase cover to crankcase (Series 8) (10) Stud — Crankcase cover to crankcase (Series 9) (3)		
107		Stud — Magneto to crankcase cover (4)	14	17
317	2471	Washer — #10 — Rod end, air control	2	2
45	2473	Washer — Fuel pump or cover (with A5390-A1) (2)		
141		Washer — 5/16, Crankcase cover to crankcase (Series 8) (10) Washer — 5/16, Crankcase cover to crankcase (Series 9) (8) Washer — 5/16, Oil screen housing to crankcase cover to crankcase (Series 9) (2)		
171		Washer — 5/16, Oil sump bracket to crankcase (1)		
296		Washer — Air control valve shaft spring (1)		
364		Washer — 5/16, Adapter to crankcase studs (2) Washer — 5/16, Fuel pump to crankcase (2)	11	11
36	2474	Washer — 3/8, Crankcase 2-4 to crankcase 1-3 (2)		
222		Washer — 3/8, Intake manifold to crankcase (2)		
251		Washer — 3/8, Propeller hub to flange (6)		
365		Washer — 3/8, Oil cooler studs (3)	13	13
35	2475	Washer — 7/16, Crankcase 2-4 to crankcase 1-3	2	2
257	2500	Cotter pin — Propeller nut flat head	1	1
318	2501	Cotter pin — Rod end, air control	2	2
157	2502	Pin — Cotter, starter gear to retainer screw (Series 9)	1	1
62	2506	Cotter pin (2)		
253		Cotter pin — Propeller hub bolt (6)	8	8
182	2555	Washer — 5/16, Magneto to crankcase cover	4	4
38	2557	Nut — Plain 3/8, crankcase 2-4 to crankcase 1-3 (2)		
98		Nut — 3/8 Plain, cylinder barrel to crankcase (8)		
221		Nut — 3/8, Intake manifold to crankcase (2)	12	12
47	2560	Palnut — 5/16, Fuel pump or cover (with A5390-A1) (2)		
143		Palnut — 5/16, Crankcase cover to crankcase (Series 8) (10) Palnut — 7/16, Crankcase cover to crankcase (Series 9) (8) Palnut — 5/16, Oil screen housing to crankcase cover to crankcase (Series 9) (2)		
161		Palnut — 5/16, Starter cover to crankcase cover (Series 9) (6)		

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
184		Palnut — $\frac{5}{16}$, Magneto to crankcase cover (4)		
354		Palnut — $\frac{5}{16}$, Adapter to crankcase studs (2)		
		Palnut — $\frac{5}{16}$, Fuel pump to crankcase (2)	20	26
39	2561	Palnut — $\frac{3}{8}$, crankcase 2-4 to crankcase 1-3 (2)		
100		Palnut — $\frac{3}{8}$, Cylinder barrel to crankcase (8)		
223		Palnut — $\frac{3}{8}$, Intake manifold to crankcase (2)		
355		Palnut — $\frac{3}{8}$, Oil cooler stud (3)	15	15
129	2716	Nut — Tachometer drive cover	1	1
361	2848	Spring — By-pass valve	1	1
333	2849	Ball — $\frac{7}{16}$ steel, By-pass valve	1	1
22	2886	Palnut — $\frac{1}{4}$, crankcase 2-4 to crankcase 1-3 (16)		
127		Palnut — Tachometer drive housing (Series 9) (3)		
134		Palnut — $\frac{1}{4}$, Oil screen housing to cover (Series 9) (1)		
234		Palnut — $\frac{1}{4}$, Intake elbow to cylinder head (8)		
245		Palnut — $\frac{1}{4}$, Push rod flange to crankcase (12)	36	40
		Palnut — $\frac{1}{4}$, (For aluminum rocker cover (optional) (24)		
99	2958	Palnut — $\frac{7}{16}$, Cylinder barrel to crankcase	16	16
31	*2985	Stud — Crankcase 2-4 to crankcase 1-3	1	1
95	3500	Gasket — Rocker cover	4	4
148	3506	Gear — Camshaft	1	1
150	3513	Gear — Magneto drive (Series 8)	2	
116	3562	Gear and drive shaft — Oil pressure pump	1	1
135	A3568	Oil Screen Assembly	1	1
168	3577	Gasket — Oil sump	1	1
229	3585	Elbow — Intake, cylinders 2 and 3	2	2
214	3628	Carburetor — Stromberg NA-S3A1 (±A-18033A-3)	1	1
241	3633	Flange — Push rod housing	4	4
	A3657	Oil Gage Cap Assembly (Used with A5362)	1	1
259	3660	Gear — Fuel injector (driven)	1	1
165	A3680	Oil Gage Cap Assembly (Used with A5363)	1	1
63	*3698	Bushing — Connecting rod, upper and lower	8	8
145	3699	Gear — Crankshaft (Series 9)		1
151	3700	Gear — Magneto drive (Series 9)		2
124	3701	Housing — Tachometer drive (Series 9)		1
248	3745	Hub — Propeller (S.A.E. ±0 taper shaft)	1	1
	A3746	Propeller Hub Assembly	1	1
5	*3755	Bearing — Crankshaft, center and rear (1 and 3)	2	2
6	*3756	Bearing — Crankshaft, center and rear (2 and 4)	2	2
	B3762-B1	Cylinder and Valve Assembly (A75 and A80)	4	4
	B3762-B	Cylinder Assembly — Complete (A75 and A80)	4	4
	B3762-A2	Cylinder Assembly — Complete (A50 and A65)	4	4
	B3762-A1	Cylinder and Valve Assembly (A50 and A65)	4	4
70	B3762	Cylinder Assembly	4	4
130	3773	Housing — Oil Screen (Series 9)		1
	B3782	Cable Assembly — Cylinder 2 and 4, Upper (Series 9)		1
	B3783	Cable Assembly — Cylinder 1 and 3, Upper (Series 9)		1
	B3785-A1	Radio Shielded Ignition Cable Assembly — Complete (Series 8)	1	
188	B3785	Cable Assembly — Cylinder 1 and 3, Upper (Series 8)	1	

*Available in oversize or undersize — See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
190	B3786	Cable Assembly — Cylinder 2 and 4, Upper (Series 8)	1	
189	B3787	Cable Assembly — Cylinder 1 and 3, Lower (Series 8)	1	
191	B3788	Cable Assembly — Cylinder 2 and 4, Lower (Series 8)	1	
	A3828	Tube Assembly — Fuel pump to fuel injector	1	1
331	3875	Adapter — Oil cooler	1	1
338	3883	Cooler — Oil (Harrison)	1	1
164	A3966	Oil Gage Cap Assembly (Used with A5230, A5459, and A5460)	1	1
	A3896	Oil Gage Cap Assembly (Used with A5448)	1	1
	A3934	Sediment Bowl Assembly	1	1
	A3970	Oil Gage Cap Assembly (Used with A5461 and A5473)	1	1
249	3991	Flange — Propeller hub	1	1
	4528	Cover — Rocker (aluminum—Optional)	4	4
	A4544	Piston Assembly — Complete (A50)	4	4
64	*4544	Piston (A50)	4	4
235	4546	Camshaft (Standard)	1	1
	4552	Fuel Pump (A.C.)	1	1
139	4577	Gasket — Crankcase cover to crankcase (Series 8)	1	
	A4587-A	Crankcase Cover Assembly — Complete (Series 8)	1	
104	A4587	Crankcase Cover Assembly (Series 8)	1	
230	4602	Elbow — Intake, cylinders 1 and 4	2	2
	A4606	Fuel Injector Assembly — Complete	1	1
261	4606	Fuel Injector Unit Complete (clockwise rotation)	1	1
	4608	Camshaft (Fuel pump)	1	1
140	4617	Gasket — Crankcase cover to crankcase (Series 9)		1
280	A4618	Air Intake Housing Assembly (Right Half)	1	1
281	A4619	Air Intake Housing Assembly (Left Half)	1	1
	A4701	Piston Assembly — Complete (A80)	4	4
	*4701	Piston (A80)	4	4
	4732	Adapter — Oil cooler	1	1
219	4780-A1	Intake Manifold Assembly	1	1
92	4806	Cover — Valve rocker	4	4
	4822-A1	Bearing Set	1	1
7	*4822	Bearing — Crankshaft front thrust (Replaces (2) 3757, (1) 3758, (1) 3759)	2	2
	A5230-A1	Oil Sump Assembly — Complete	1	1
162	A5230-A	Oil Sump Assembly	1	1
	Eq. 5259	Intake and Filter Equipment—Carburetor Air—Complete	1	1
54	A5334	Crankshaft Assembly	1	1
	A5362-A1	Oil Sump Assembly — Complete	1	1
	A5362	Oil Sump Assembly	1	1
	A5363-A1	Oil Sump Assembly — Complete	1	1
	A5363	Oil Sump Assembly	1	1
	A5390-A1	Crankcase Assembly for fuel injector and fuel pump (Series 8)	1	
	A5391-A1	Crankcase Assembly for fuel injector and fuel pump (Series 9)		1
1	A5392-A1	Crankcase Assembly (Series 8)	1	
2	A5393-A1	Crankcase Assembly (Series 9)		1

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
180	5394	Magneto — Scintilla SF4R-8 (#10-19293-1)	2	2
200	5395	Magneto — Scintilla SF4R-8 (#10-19393-2)	2	2
	A5458-A1	Oil Sump Assembly — Complete	1	1
	A5458	Oil Sump Assembly	1	1
	A5459-A1	Oil Sump Assembly — Complete	1	1
	A5459	Oil Sump Assembly	1	1
	A5460-A1	Oil Sump Assembly — Complete	1	1
	A5460	Oil Sump Assembly	1	1
	A5461-A1	Oil Sump Assembly — Complete	1	1
	A5461	Oil Sump Assembly	1	1
287	5463	Manifold — Intake	1	1
	A5473-A1	Oil Sump Assembly — Complete	1	1
	A5473	Oil Sump Assembly	1	1
	A5479-A1	Oil Sump Assembly — Complete	1	1
	A5479	Oil Sump Assembly	1	1
	A5809	Housing Assembly — Carburetor Air Intake	1	1
	A6234-A	Crankcase Cover Assembly — Complete (Series 9)		1
	A6234	Crankcase Cover Assembly (Series 9)		1
42	*20001	Stud — Fuel pump to crankcase (with A5390-A1)	2	2
362	20001	Stud — 5/16 x 1¼, crankcase 1-3 to adapter	2	2
	*20001	Stud — 5/16 x 1¼, Fuel pump to crankcase	2	2
	*20020	Stud — Crankcase thru cover to oil screen housing (Series 9)		2
193	20087	Ferrule — Cable	8	8
	*20096	Stud — Crankcase cover to crankcase (Series 9)		3
356	20288	Plug — ¼ pipe, Countersunk head — Oil cooler adapter	1	1
34	*20303	Stud — Intake manifold to crankcase (with A5892-A1 and A5395-A1)	2	2
20	20522	Washer — Plain ¼, crankcase 2-4 to crankcase 1-3 (29)		
50		Washer — ¼, Fuel injector to crankcase (with A5390-A1 and A5391-A1) (4)		
119		Washer — Oil pump cover to crankcase cover (4)		
125		Washer — Tachometer drive housing (Series 9) (3)		
132		Washer — Oil screen housing to cover (Series 9) (1)		
169		Washer — ¼, Oil sump to crankcase (6)		
216		Washer — ¼, Carburetor to intake manifold (4)		
232		Washer — ¼, Intake elbow to cylinder head (8)		
243		Washer — ¼, Push rod flange to crankcase (12)		
309		Washer — ¼, Sediment bowl assembly to intake manifold (2)	69	73
		Washer — ¼, (For aluminum rocker cover—optional) (24)		
279	20596	Pin — Fuel injector driven gear to drive shaft	1	1
208	20655	Screw — Air intake cover to housing	3	3
282	20668	Screw — #10-24, Air intake housing — Right to Left (3)		
283		Screw — #10-24, Air intake housing to injector (2)	5	5
	20882	Plug — ⅛ pipe, Square head (drilled)	1	1
59	21003	Bushing — Piston pin	4	4
60	21004	Bolt — Connecting rod	8	8
90	21007	Plug — Oil passage	1	1

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
86	21025	Retainer — Valve spring	8	8
74	21031	Insert — Valve seat, intake	4	4
218	21051	Gasket — Carburetor to intake manifold	1	1
30	*21053	Stud — Cylinder barrel to crankcase	10	10
27	*21054	Stud — Crankcase 1-3 thru crankcase 2-4 to cylinder barrel	2	2
28	*21054	Stud — Crankcase 2-4 thru crankcase 1-3 to cylinder barrel	4	4
26	*21055	Stud — Crankcase 1-3 to crankcase 2-4	2	2
44	21059	Cover — Fuel pump (with A5390-A1)	1	1
43	21064	Gasket — Fuel pump (with A5390-A1)	1	1
30	*21075	Stud — Crankcase 2-4 to crankcase 1-3	1	1
19	21076	Screw — Cap, 3⅜, crankcase 2-4 to crankcase 1-3	2	2
17	21077	Screw — Cap, 2⅜, crankcase 2-4 to crankcase 1-3	4	4
10	21080	Dowel — Crankcase cover to crankcase	2	2
175	21082	Cable — Ignition	UAR	UAR
	A21082-A2	Ignition Cable Assembly — Complete (Series 8)	1	
	A21082-A3	Ignition Cable Assembly — Complete (Series 9)		1
144	21083	Gear — Crankshaft (Series 8)	1	
115	21113	Cap — Oil pressure relief valve	1	1
112	21114	Plunger — Oil pressure relief valve	1	1
85	21119	Seat — Valve spring	8	8
91	21153	Shaft — Valve rocker	4	4
69	21159	Plug — Piston	8	8
118	21160	Cover — Oil pressure pump	1	1
128	21163	Oil Seal — Tachometer drive	1	1
24	*21167	Stud — Oil sump to crankcase	6	6
242	21170	Gasket — Push rod housing flange	4	4
16	21176	Screw — Cap, 1⅜, crankcase 2-4 to crankcase 1-3	6	6
225	21182	Pipe — Intake	4	4
227	21185	Hose — 1½ O.D., Intake pipe to manifold and elbow	8	8
254	21202	Nut — Propeller hub	1	1
255	21203	Ring — Propeller hub snap	1	1
123	21208	Housing — Tachometer drive (Series 8)	1	
14	21218	Screw — Cap, 1⅜, pilot dowel, crankcase to crankcase	1	1
15	21219	Screw — Cap, 2⅜, pilot dowl, crankcase 2-4 to crankcase 1-3	2	2
246	21274	Connection — Push rod housing	8	8
247	21282	Clamp — Hose, 1¼, Push rod housing	8	8
76	21284	Housing — Push rod	8	8
203	21323	Gasket — Air intake cover to adapter (1)		
204		Gasket — Carburetor to adapter (1)	2	2
	A21325	Valve Tappet Assembly (Use with A21355 Push rod only)	8	8
231	21327	Gasket — Intake elbow	4	4
117	21343	Gear and shaft — Oil pressure pump (driven)	1	1
146	21346	Screw — ¼ cap, Crankshaft gear to crankshaft (Series 8) (4)		
149		Screw — ¼ cap, Camshaft gear to camshaft (4)	8	8
48	21350	Cover — Fuel injector flange (with A5390-A1 and A5391-A1)	1	1
113	21352	Spring — Oil pressure relief valve	1	1

*Available in oversize or undersize — See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
	A21355	Push Rod Assembly (Use with A21325 Tappet Assembly only)	8	8
80	21359	Valve — Intake	4	4
87	21361	Lock — Valve spring seat	16	16
83	21365	Spring — Valve, inner	8	8
84	21366	Spring — Valve, outer	8	8
326	21375	Elbow — Injector jet	4	4
239	21378	Cup — Valve tappet — push rod	8	8
237	21389	Body — Valve tappet (cam follower) with A21325	8	8
	21390	Hydraulic unit—Valve tappet (with A21325)	8	8
108	*21393	Stud — Oil pump cover to crankcase cover	4	4
278	21402	Gear — Fuel injector, driven	1	1
258	21403	Camshaft — for Fuel Injector	1	1
49	21404	Gasket — Fuel injector to crankcase (with A5390-A1 and A5391-A1)	1	1
75	*21419	Guide — Valve	8	8
68	21422	Pin — Piston	4	4
	A21422	Piston Pin Assembly	4	4
293	A21423	Lever Assembly — Throttle	1	1
298	21424	Valve — Throttle	1	1
312	21427	Rod — Injector lever to throttle lever	1	1
316	21428	Rod End (Right hand thread), Injector lever to throttle lever	1	1
122	21429	Gasket — Tachometer drive housing (Series 9)		1
	21430	Cover — Starter flange (Series 9)		1
299	21431	Screw — #8-32, Throttle valve shaft	2	2
158	21432	Gasket — Starter flange (Series 9)		1
153	21437	Retainer — Starter gear (Series 9)		1
	21439	Elbow (BG No. 526) with $\frac{9}{16}$-27 thread on spark plug end	8	8
195	21440	Sleeve — Terminal (BG =M366)	8	8
11	21441	Bushing — Starter gear (Series 9)		1
	21442	Dowel — Starter gear bushing to crankcase (Series 9)		1
	21445	Plate — Identification (A75)	1	1
147	21447	Screw — ¼ cap, Crankshaft gear to crankshaft (Series 9)		4
18	21448	Screw — Cap, 3⅝, crankcase 2-4 to crankcase 1-3	1	1
	*21449	Stud — Crankcase thru cover to starter (Series 9)		2
192	21455	Clip — Magneto terminal (Scintilla #10-12360)	8	8
109	*21463	Stud — Starter to crankcase cover (Series 9)		4
250	21468	Bolt — ⅜ x 4¼, Propeller hub to flange	6	6
186	21469	Plug — Magneto ventilator (Series 9)		2
	21470	Plate — Identification (A80)	1	1
313	21475	Nut — #10-32 (Left hand thread), Injector rod-lock	1	1
314	21476	Rod end (Left hand thread), Injector lever to throttle lever	1	1
96	21477	Packing — Cylinder base	4	4
73	21478	Insert — Valve seat, exhaust	4	4
82	21479	Valve — Exhaust (A75 and A80)	4	4
41	*21480	Stud — Intake manifold to crankcase (with A5390-A1 and A5391-A1)	2	2
295	21481	Spring — Air control valve shaft	1	1

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
292	21482	Screw — #8-32, Air control valve stop lever	4	4
	21485	Gasket — Exhaust manifold flange (for up-exhaust cylinders only)	4	4
187	21491	Gasket — Magneto ventilator (Series 9)		2
101	21492	Flange — Exhaust	4	4
102	21493	Gasket — Exhaust flanges	4	4
236	A21509	Push Rod Assembly (Use with A21599 Tappet Assembly only)	8	8
131	21510	Gasket — Oil screen housing (Series 9)		1
291	21513	Spring — Injector air bleed screw	1	1
	21521	Camshaft (Fuel Pump)	1	1
	21525	Eccentric — Fuel pump (with 21521)	1	1
	21527	Dowel — Fuel pump eccentric (with 21521 camshaft)	1	1
13	21530	Washer — Engine mount	4	4
	21541	Cable — Ignition (Radio Shielded)	UAR	UAR
300	21597	Lockwasher — Throttle valve to shaft screw	2	2
	21598	Tube Assembly — Fuel Pump to Carburetor	1	1
	A21599	Valve Tappet Assembly (Use with A21509 Push rod only)	8	8
238	21608	Body — Valve tappet (cam follower) with A21599	8	8
240	21609	Hydraulic unit — Valve tappet (with A21599)	8	8
	21619	Elbow — ¼ O.D., Fuel pump inlet	1	1
	21619	Elbow — ¼ O.D., Fuel pump inlet and outlet and fuel injector inlet	3	3
	22004	Stud — (For aluminum roller cover—optional)	24	24
321	A22008	Tube Assembly — Fuel Injector Vent	1	1
328	22010	Clip — Injector tube to intake pipe	4	4
327	22011	Coupling — Female, Sediment bowl to ¼" O.D. tube	1	1
228	22012	Elbow — ¼, Intake manifold drain	1	1
319	A22014	Tube Asembly — Fuel injector to intake elbow	4	4
322	A22017	Elbow — Fuel injector vent	1	1
289	22019	Nut and sleeve assembly	1	1
320	A22020	Tube Assembly — Sediment bowl to fuel injector	1	1
290	22021	Screw — Injector air bleed	1	1
103	22022	Nut — Plain (Brass) Exhaust flange to cylinder	8	8
308	22051	Screw — ¼, Sediment bowl assembly to intake manifold	2	2
360	22130	Sleeve — Oil line, crankcase 1-3	1	1
334	22131	Bracket — Oil cooler adapter (Crankcase 2-4)	1	1
335	22132	Bracket — Oil cooler adapter (Crankcase 1-3)	1	1
346	22133	Gasket — Oil cooler to adapter	1	1
359	22134	Screw — ¼-28 hex. head, Oil cooler adapter to crankcase	2	2
363	22139	Washer — $\frac{9}{32}$ x ⅝ x ⅛ thick, Bracket to crankcase-spacing	4	4
339	22140	Elbow — Inverted Male — Oil tube to crankcase 1-3 (1)		
340		Elbow — Inverted Male — Oil tube to adapter (1)		
343		Elbow — Inverted Male — Oil tubes to crankcase (2)	4	4
40	22172	Stud — Fuel injector to crankcase (with A5390-A1 and A5391-A1)	4	4
350	22198	Oil Tube Assembly (Long) — Oil cooler to crankcase 2-4	1	1
351	22199	Oil Tube Assembly (Short) — Oil cooler to crankcase 1-3	1	1
	A22205	Ring Set — Piston (A50 and A65)	1	1

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
	B22205	Ring Set — Piston (A75 and A80)	1	1
65	*35551	Ring — Piston-Compression, bevelled, top groove (A50 and A65)	4	4
		Ring — Piston-Compression, bevelled, top 2 grooves (A75 and A80)	8	8
66	*35597	Ring — Piston-Compression, plain	4	4
67	*35595	Ring — Piston, oil control, bottom 2 grooves	8	8
81	22211	Valve — Exhaust (A50 and A65)	4	4
341	22271	Elbow — 90 — 3/8 M. to F. pipe thread, Oil tube to crankcase 2-4	1	1
342		Elbow — 90 — 3/8 M. to F. pipe thread, Oil tube to adapter		
352	22293	Oil Tube Assembly — Oil cooler to crankcase 2-4	1	1
344	22295	Elbow — 45 — 3/8 M. to F., crankcase to 45 elbow	2	2
344	22296	Elbow — 3/8 tube, Oil tubes to oil cooler	2	2
173	A22301	Oil Suction Tube Assembly	1	1
12	22387	Bushing — Engine mount (Rubber)	8	8
	22404	Gasket — Oil Filler Cap	1	1
185	22460	Spark Plug — Champion C26	8	8
199	22465	Spark plug — Champion C26S (Use with A22886 elbow)	8	8
178	22493	Bracket — Ignition cable	6	6
179	22495	Grommet — Ignition cable	6	6
329	22524	Elbow — Intake (Cylinder 1 and 4)	2	2
330	22525	Elbow — Intake (Cylinder 2 and 3)	2	2
155	22527	Washer — Starter gear retainer (Series 9)		1
154	22528	Screw — 5/16 cap, Starter gear to starter gear retainer (Series 9)		1
159	22535	Washer — Starter cover to crankcase cover (Series 9)		6
196	22548	Nut — Terminal (Scintilla #10-14855)	8	8
197	22549	Gland — Rubber (Scintilla #10-2617)	8	8
8	22652	Plate — Identification (A50)	1	1
	22653	Plate — Identification (A65)	1	1
72	22676	Pin — Spark plug insert	8	8
202	22719	Adapter — Carburetor to air intake cover	1	1
198	22742	Spark plug — Champion LM3-1S (Use with 21439 elbow)	8	8
226	22800	Hose — 1 3/4 O.D., Intake pipe to manifold and elbow	8	8
194	A22886	Elbow Assembly (BG #E530) with 5/8-24 thread on spark plug end (with "B" assemblies only)	8	8
	22949	Bushing — Valve rocker shaft boss	16	16
37	23130	Nut — Spacer, crankcase 1-3 to crankcase 2-4	2	2
207	23166	Nut — Speed, air intake cover to housing	3	3
211	23206	Screw — Air filter to carburetor air intake housing	4	4
212	*23401	Stud — 1 1/4 Carburetor air to intake cover to carburetor		
220		Stud — 1/4, Carburetor to intake manifold	8	8
336	A23655	Bracket — Carburetor air intake housing to oil cooler bracket (2 and 4 side)	1	1
337	A23657	Bracket — Carburetor air intake housing to oil cooler bracket (1 and 3 side)	1	1
201	A23683	Terminal — Shielded Ground (Scintilla #10-16507) Used to convert unshielded magneto (5394) to shielded (5395)	2	2

*Available in oversize or undersize. See oversize and undersize parts list.

NUMERICAL PARTS LIST — Continued

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
88	A24122	Valve Rocker Assembly	8	8
89	24122	Bushing — Valve rocker arm	8	8
52	24321	Oil Seal — Crankshaft	1	1
228	24609	Clamp — Intake pipe hose	16	16
224	24758-A1	Primer Jet	1	1
	A35017	Oil Gage Cap Assembly (Used with A5479)	1	1
	B35048	Cable Assembly — Cylinder 1 and 3, 2 and 4 Lower (Series 9)	1	1
	B35048-A1	Radio Shielded Ignition Cable Assembly — Complete (Series 9)	1	1
152	35153	Gear — Starter (Series 9)		1
57	A35158-A1	Connecting Rod Assembly — Complete (A50 and A65)	4	4
	A35158-A2	Connecting Rod Assembly — (A50 and A65)	4	4
58	A35159-A1	Connecting Rod Assembly — Complete (A75 and A80)	4	4
	A35159-A2	Connecting Rod Assembly — (A75 and A80)	4	4
205	A35238	Cover and Flange Assembly	1	1
209	35240	Gasket — Air filter to carburetor air intake housing	1	1
210	35433	Filter — Carburetor air intake (Air Maze Type R-72)	1	1
65	*35551	Ring — Piston, compression, beveled	4	4
67	*35595	Ring — Piston, oil control	8	8
66	*35597	Ring — Piston, compression, plain	4	4
	*35670-A1	Ring Set — Piston	1	1
67	*35741	Ring — Piston, oil control	4	4
323	35832	Jet Assembly — Engine Intake Elbow	4	4
	A40577	Piston Assembly — Complete (A65 and A75)	4	4
	40577	Piston (A65 and A75)	4	4
213	A40029	Support Assembly — Carburetor Air Intake	1	1
181	500278	Gasket — Magneto flange	2	2
55	500398	Plug — Oil, crankshaft front end	1	1
56	500400	Key — Propeller hub	1	1
286	AN340-10	Nut — 10-24, Air intake housing, right to left	3	3
297	AN380-3-2	Cotter pin — Air control valve shaft	1	1
256	AN392-11	Pin — Flat head, Propeller hub nut	1	1
94	500-A416-8	Screw, — ¾, Valve rocker cover to cylinder	24	24
260	AN502-10-8	Screw — Fillister head (dr.), Fuel injector drive gear to camshaft	6	6
	AN502-10-12	Screw — 10-32, Fuel pump thru fuel injector drive gear to camshaft	3	3
53	842-10D	Elbow — ½, Breather hole	1	1
138	AN900-10	Gasket — Thermometer hole in oil screen (1)		
167		Gasket — Oil sump drain plug (1)		
174		Gasket — Suction Tube Assembly (1)		
347		Gasket — By-pass valve plug (1)	4	4
114	AN900-14	Gasket — Oil relief valve	1	1
121	AN900-22	Gasket — Tachometer drive housing (Series 8)	1	1
136	AN900-28	Gasket — Oil screen	1	1
284	936-A10	Lockwasher — Air intake housing — Right to left (3)		
285		Lockwasher — Air intake housing to injector (2)	5	5
93	936-A416	Washer — ¼ shakeproof, Rocker cover to cylinder	24	24

*Available in Undersize or Oversize. See Oversize and Undersize Parts List.

NUMERICAL PARTS LIST — Continued

FUEL INJECTOR EQUIPMENT

Ref. No.	Part No.	Part Name	QUANTITY PER ENGINE Series 8	Series 9
264	A-9-2	Washer — Plunger spring (Fuel injector)	2	2
263	A-9-3	Seat — Plunger spring — Oilite (Fuel injector)	2	2
273	A-9-7	Washer — Metering shaft packing (Fuel injector)	1	1
266	A-10-1	Gasket — Injector housing to injector pump head	1	1
267	A-10-2	Gasket — Injector housing to injector cam bearing plate	1	1
265	A-10-3	Gasket — Plunger spring boss (Fuel injector)	2	2
268	A-11-1	Screw — Flat head, Cam bearing plate to injector housing	4	4
274	A-12-1	Gland nut — Metering shaft (Fuel injector)	1	1
262	A-13-1	Spring — Plunger (Fuel injector)	2	2
269	A-15-1	Screw — Fillister head, Injector pump head to injector housing	8	8
275	A-15-2	Screw — Fillister head, Metering shaft lever-adjusting (Fuel injector)	1	1
276	A-15-3	Screw — Fillister head, Metering shaft adjusting screw-lock (Fuel injector)	1	1
270	A-22-1	Lockwasher — Injector pump head to injector housing	8	8
271	A-29-1	Circlip — Metering shaft (Fuel injector)	1	1
301	A-31-2	Cover — Sediment-Bowl (Fuel injector)	1	1
272	A-33-1	Packing — Metering shaft gland nut (Fuel injector)	1	1
303	A-37-A-1	Strainer Assembly (Fuel injector)	1	1
277	A-103	Metering Control Valve Shaft Assembly	1	1
305	A-105	Clamp and Screw Assembly — Bowl (Fuel injector)	1	1
306	A-105-1	Nut — Bowl screw (Fuel injector)	1	1
	A-108	Rod Assembly Complete — Injector Lever to Throttle Lever (Fuel injector)	1	1
	A-302	Intake Manifold Assembly (Fuel injector)	1	1
302	A-1005	Gasket — Sediment Bowl (Fuel injector)	1	1
304	A-1006	Bowl — Glass, sediment (Fuel injector)	1	1
307	A-1007	Seat — Sediment Bowl (Fuel injector)	1	1
294	A-1011	Air Control Valve Shaft Assembly (Fuel injector)	1	1

Section 16

OVERSIZE AND UNDERSIZE PARTS

Oversize or Undersize Part No.	Standard Part No.	Name	Amount Undersize or Oversize
2002-03	2002	INSERT — Spark plug	.003 O.S. on O.D.
2002-06	2002	INSERT — Spark plug	.006 O.S. on O.D.
2002-09	2002	INSERT — Spark plug	.009 O.S. on O.D.
2018-03	2018	STUD — 1/4-20 x 1/4-28 x 1	.003 O.S. on O.D.
2018-06	2018	STUD — 1/4-20 x 1/4-28 x 1	.006 O.S. on O.D.
2018-09	2018	STUD — 1/4-20 x 1/4-28 x 1	.009 O.S. on O.D.
2389-03	2389	STUD — 5/16-18 x 5/16-24 x 1 1/4	.003 O.S. on O.D.
2389-06	2389	STUD — 5/16-18 x 5/16-24 x 1 1/4	.006 O.S. on O.D.
2389-09	2389	STUD — 5/16-18 x 5/16-24 x 1 1/4	.009 O.S. on O.D.
2390-03	2390	STUD — 5/16-18 x 5/16-24 x 1	.003 O.S. on O.D.
2390-06	2390	STUD — 5/16-18 x 5/16-24 x 1	.006 O.S. on O.D.
2309-09	2390	STUD — 5/16-18 x 5/16-24 x 1	.009 O.S. on O.D.
2416-03	2416	STUD — 3/8-16 x 3/8-24 x 1 3/8	.003 O.S. on O.D.
2416-06	2416	STUD — 3/8-16 x 3/8-24 x 1 3/8	.006 O.S. on O.D.
2416-09	2416	STUD — 3/8-16 x 3/8-24 x 1 3/8	.009 O.S. on O.D.
2465-03	2465	STUD — 5/16-18 x 5/16-24 x 1 3/8	.003 O.S. on O.D.
2465-06	2465	STUD — 5/16-18 x 5/16-24 x 1 3/8	.006 O.S. on O.D.
2465-09	2465	STUD — 5/16-18 x 5/16-24 x 1 3/8	.009 O.S. on O.D.
2985-03	2985	STUD — 3/8-16 x 3/8-24 x 2 7/8	.003 O.S. on O.D.
2985-06	2985	STUD — 3/8-16 x 3/8-24 x 2 7/8	.003 O.S. on O.D.
2985-09	2985	STUD — 3/8-16 x 3/8-24 x 2 7/8	.009 O.S. on O.D.
3698-U10	3698	BUSHING — Connecting rod	.010 U.S. on I.D.
3755-U10	3755	BEARING — Crankshaft (3/8" width tang)	.010 U.S. on I.D.
3756-U10	3756	BEARING — Crankshaft (3/8" width tang)	.010 U.S. on I.D.
4544-015	4544	PISTON (A50)	.015 O.S. on O.D.
4701-015	4701	PISTON (A80)	.015 O.S. on O.D.
4822-U10	4822	BEARING — Crankshaft, Front (3/8" width tang)	.010 U.S. on I.D.
20001-03	20001	STUD — 5/16-18 x 5/16-24 x 1 1/4	.003 O.S. on O.D.
20001-06	20001	STUD — 5/16-18 x 5/16-24 x 1 1/4	.006 O.S. on O.D.
20001-09	20001	STUD — 5/16-18 x 5/16-24 x 1 1/4	.009 O.S. on O.D.
20020-03	20020	STUD — 5/16-18 x 5/16-24 x 3 7/8	.003 O.S. on O.D.
20020-06	20020	STUD — 5/16-18 x 5/16-24 x 3 7/8	.006 O.S. on O.D.
20020-09	20020	STUD — 5/16-18 x 5/16-24 x 3 7/8	.009 O.S. on O.D.
20096-03	20096	STUD — 5/16-18 x 5/16-24 x 2 1/2	.003 O.S. on O.D.
20096-06	20096	STUD — 5/16-18 x 5/16-24 x 2 1/2	.006 O.S. on O.D.
20096-09	20096	STUD — 5/16-18 x 5/16-24 x 2 1/2	.009 O.S. on O.D.
20303-03	20303	STUD — 3/8-16; 3/8-24 x 2 1/8	.003 O.S. on O.D.
20303-06	20303	STUD — 3/8-16; 3/8-24 x 2 1/8	.006 O.S. on O.D.
20303-09	20303	STUD — 3/8-16; 3/8-24 x 2 1/8	.009 O.S. on O.D.
21031-02	21031	INSERT — Intake valve seat	.002 O.S. on O.D.
21031-010	21031	INSERT — Intake valve seat	.010 O.S. on O.D.
21031-020	21031	INSERT — Intake valve seat	.020 O.S. on O.D.
21031-030	21031	INSERT — Intake valve seat	.030 O.S. on O.D.

NOTE: Order by Oversize or Undersize Part number only and not by Standard Part number.

OVERSIZE AND UNDERSIZE PARTS — Continued

Oversize or Undersize Part No.	Standard Part No.	Name	Amount Undersize or Oversize
21053-03	21053	STUD — 7/16-14 x 7/16-20 x 1 1/2	.003 O.S. on O.D.
21053-06	21053	STUD — 7/16-14 x 7/16-20 x 1 1/2	.006 O.S. on O.D.
21053-09	21053	STUD — 7/16-14 x 7/16-20 x 1 1/2	.009 O.S. on O.D.
21054-03	21054	STUD — 7/16-14 x 7/16-20 x 6 3/32	.003 O.S. on O.D.
21054-06	21054	STUD — 7/16-14 x 7/16-20 x 6 3/32	.006 O.S. on O.D.
21054-09	21054	STUD — 7/16-14 x 7/16-20 x 6 3/32	.009 O.S. on O.D.
21055-03	21055	STUD — 7/16-14 x 7/16-20 x 4 3/4	.003 O.S. on O.D.
21055-06	21055	STUD — 7/16-14 x 7/16-20 x 4 3/4	.006 O.S. on O.D.
21055-09	21055	STUD — 7/16-14 x 7/16-20 x 4 3/4	.009 O.S. on O.D.
21075-03	21075	STUD — 3/8-16 x 3/8-24 x 5	.003 O.S. on O.D.
21075-06	21075	STUD — 3/8-16 x 3/8-24 x 5	.006 O.S. on O.D.
21075-09	21075	STUD — 3/8-16 x 3/8-24 x 5	.009 O.S. on O.D.
21167-03	21167	STUD — 1/4-20 x 1/4-28 x 1	.003 O.S. on O.D.
21167-06	21167	STUD — 1/4-20 x 1/4-28 x 1	.006 O.S. on O.D.
21167-09	21167	STUD — 1/4-20 x 1/4-28 x 1	.009 O.S. on O.D.
21393-03	21393	STUD — 1/4-20 x 1/4-28 x 7/8	.003 O.S. on O.D.
21393-06	21393	STUD — 1/4-20 x 1/4-28 x 7/8	.006 O.S. on O.D.
21393-09	21393	STUD — 1/4-20 x 1/4-28 x 7/8	.009 O.S. on O.D.
21419-05	21419	GUIDE — Intake and Exhaust Valve	.005 O.S. on O.D.
21419-010	21419	GUIDE — Intake and Exhaust Valve	.010 O.S. on O.D.
21419-020	21419	GUIDE — Intake and Exhaust Valve	.020 O.S. on O.D.
21422-05	21422	PIN — Piston	.005 O.S. on O.D.
21449-03	21449	STUD — 5/16-18 x 5/16-24 x 1	.003 O.S. on O.D.
21449-06	21449	STUD — 5/16-18 x 5/16-24 x 1	.006 O.S. on O.D.
21449-09	21449	STUD — 5/16-18 x 5/16-24 x 1	.009 O.S. on O.D.
21463-03	21463	STUD — 5/16-18 x 5/16-24 x 1 3/8	.003 O.S. on O.D.
21463-06	21463	STUD — 5/16-18 x 5/16-24 x 1 3/8	.006 O.S. on O.D.
21463-09	21463	STUD — 5/16-18 x 5/16-24 x 1 3/8	.009 O.S. on O.D.
21478-02	21478	INSERT — Exhaust valve seat	.002 O.S. on O.D.
21478-010	21478	INSERT — Exhaust valve seat	.010 O.S. on O.D.
21478-020	21478	INSERT — Exhaust valve seat	.020 O.S. on O.D.
21478-030	21478	INSERT — Exhaust valve seat	.030 O.S. on O.D.
21480-03	21480	STUD — 3/8-16 x 3/8-24 x 1 13/16	.003 O.S. on O.D.
21480-06	21480	STUD — 3/8-16 x 3/8-24 x 1 13/16	.006 O.S. on O.D.
21480-09	21480	STUD — 3/8-16 x 3/8-24 x 1 13/16	.009 O.S. on O.D.
22172-03	22172	STUD — 1/4-20 x 1/4-28 x 1 5/8	.003 O.S. on O.D.
22172-06	22172	STUD — 1/4-20 x 1/4-28 x 1 5/8	.006 O.S. on O.D.
22172-09	22172	STUD — 1/4-20 x 1/4-28 x 1 5/8	.009 O.S. on O.D.
23401-03	23401	STUD — 1/4-20; 1/4-28 x 1 1/4	.003 O.S. on O.D.
23401-06	23401	STUD — 1/4-20; 1/4-28 x 1 1/4	.006 O.S. on O.D.
23401-09	23401	STUD — 1/4-20; 1/4-28 x 1 1/4	.009 O.S. on O.D.
35551-05	35551	RING — Compression, bevelled	.005 O.S. on O.D.
35551-015	35551	RING — Compression, bevelled	.015 O.S. on O.D.
35595-05	35595	RING — Oil control	.005 O.S. on O.D.
35595-015	35595	RING — Oil control	.015 O.S. on O.D.
35597-05	35597	RING — Compression, plain	.005 O.S. on O.D.
35597-015	35597	RING — Compression, plain	.015 O.S. on O.D.
40577-015	40577	PISTON — (A65 and A75)	.015 O.S. on O.D.

NOTE: Order by Oversize or Undersize Part number only and not by Standard Part number.

Section 17

CARBURETOR—STROMBERG NAS3A1

SERVICE INSTRUCTIONS

a. **Installation.**

(1) The carburetor should be so mounted on the engine that the float chamber is at the side of the throttle barrel, preferably with the fuel inlet to the rear. With the carburetor in this position, the throttle lever, which is adjustable to any radial position, is at the right side of the carburetor as viewed from the rear of the engine. The mixture control lever is located on top of the float chamber on the right hand side. The fuel inlet is a ¼" pipe tap connection located at the back near the bottom of the main body if the carburetor is installed as above. When the fuel level is set at the factory, a pressure of one-half pound per square inch at the carburetor is used. As these carburetors will undoubtedly be used on engines having a gravity feed system, it is recommended that the tanks be located so that the minimum head of fuel at the carburetor inlet is nineteen (19) inches under all normal conditions of flight.

b. **Starting.**

(1) As these carburetors are not equipped with a priming device, the following procedure is recommended for starting. With the mixture control in the full rich position and the throttle closed the engine should be turned over two or three times before the ignition is turned on. This will draw fuel up through the idle system and then if the ignition is turned on the engine will usually start on the next turn over. As soon as the engine starts to fire it is usually necessary to open the throttle slightly to keep the engine running and to warm it up sufficiently for normal operation.

c. **Adjustment.**

(1) The main metering jet used in the carburetor is of the fixed orifice type, and its size as well as the remainder of the carburetor specifications has been determined by test work as previously mentioned, so that no adjustment for cruising and full throttle speeds is required except at altitude when the mixture control may be used to obtain best power. An idle adjustment is provided to take care of slight production variations in the carburetors and engines. The small knurled screw on the throttle valve body, may be adjusted to control the richness of the mixture at idling speeds. Turning this screw in a clockwise direction closes off the passage leading to the upper idle discharge hole and leans out the idle mixture. Turning in the opposite direction of course gives a richer mixture. A throttle stop is provided on the throttle shaft next to the throttle control lever which should be adjusted to obtain the desired idling speed. Both the throttle stop and the idle adjustment should be set with the engine hot to obtain the proper idling speed and smooth operation.

d. **Servicing.**

(1) Once the carburetor is properly installed and the idle adjustment made, very little attention is required in service. A fuel strainer is provided near the fuel inlet of the carburetor, and may be removed by the removal of the large hexagon head plug on the side of the float chamber. A small square head plug is provided as a drain in the bottom of the carburetor. The strainer and drain plug should be removed frequently to get rid of any dirt or water which may have accumulated in the strainer chamber or the float chamber. The entire carburetor should also be inspected to see that all parts are tight and properly safety wired.

e. **Description and Functioning of Carburetors.**

(1) FLOAT MECHANISM: A conventional hinge type of float mechanism located in a float chamber having ample fuel capacity to operate in all ordinary maneuvers is used. This float mechanism is adjusted at the factory to obtain the proper fuel level, and requires no adjustment in service unless it is necessary after a long period of service to install new parts. For information concerning the proper level see the section of these instructions pertaining to "Overhaul."

CARBURETOR SERVICE INSTRUCTIONS — Continued

(2) MAIN METERING SYSTEM: The metering system used in the carburetor is of the plain tube type with an air bleed to the main discharge nozzle. The main discharge nozzle is located at the center of the venturi and is screwed into a boss projecting into the air intake. The main air bleeder is screwed into the air bleed arm which is held in place by the main discharge nozzle. The actual metering of the fuel is accomplished by the main metering jet which is assembled in the bottom of the float chamber in a channel through which the gas flows to the main discharge nozzle. The size of the main metering jet affects the fuel consumption at all speeds from approximately 1000 RPM to full throttle speed.

(3) MIXTURE CONTROL: The altitude or mixture control is of the back suction type which may be used to lean out the mixture by placing a portion of the venturi suction on the fuel in the float chamber so that it opposes the suction in the venturi on the main discharge nozzle. This control consists of a venturi suction channel from above the mixture control plates to the throttle bore at the upper edge of the venturi, a manually operated valve, and the necessary passages to the float chamber and venting system. The valve consists of a lower and upper valve plate, the former fastened in place and the latter free to move. When the control is in the full rich position, holes in both the upper and lower plates mate and air is allowed to flow through the plates from the space behind the venturi. As the mixture control is moved from the full rich position to the full lean position, a series of progressively smaller holes open up over the hole in the lower plate, thereby restricting the flow of air from the vent space behind the venturi and increasing the suction on top of the fuel in the float chamber and a leaner mixture is the result.

(4) IDLING SYSTEM: Inasmuch as the main metering system will not function at very low air flows (low engine speed), an idling system is provided. This consists of an idle tube with an idle metering orifice in the bottom and several air bleed holes in the wall, an idle air bleed, and two holes in the throttle barrel, which act as idle discharge nozzles. A needle valve type of adjustment is provided on the upper discharge nozzle, which regulates the quality of the idle mixture. Fuel for the idle system is taken from the annular space around the main discharge nozzle, passes through the idle metering jet and mixes with the air from the idle air bleed located in the main body behind the venturi. The air enters the tube through the bleed holes and the mixture then passes out of the upper or lower idle discharge hole. The relative quantities passing through the upper and lower idle hole depends upon the position of the throttle. At extreme idle, all the fuel passes through the upper hole and as the throttle opening is increased, more and more of it passes through the lower hole. The idle system operates up to an engine speed of approximately 900 to 1000 RPM.

f. Overhaul.

(1) DISASSEMBLY: The carburetor should be disassembled for cleaning and inspection each time the engine is given an overhaul. After the carburetor has been removed from the engine and the hot spot and air intake or heater taken off, the halves of the carburetors may be separated by the removal of the fillister head screws at the parting surface. The venturi is held in the lower half by a hexagon head screw.

Remove the set screw which holds the float fulcrum pin in place and the plug at the side of the carburetor, which will permit the removal of the float fulcrum pin. The float and the float needle valve will then come out and it will be possible to remove the main metering jet, which is located below the float. Remove the idle tube which is screwed into the main body. If there is any indication of dirt or foreign matter in the float chamber, it is advisable to remove the main discharge nozzle. The mixture control may be disassembled by removing the two fillister head screws holding the cover to the throttle body. The removal of the above parts will permit a thorough inspection and cleaning of the carburetor, and unless replacements are necessary, further disassembly is not recommended.

(2) INSPECTION AND CLEANING: The bodies and all parts should be thoroughly cleaned in gasoline, and all passages blown out with an air hose.

The float needle valve and seat should be inspected and if either part is worn both parts should be replaced as it is very difficult to fit a new needle to an old seat or a new seat to an old needle. The needle valve is made of stainless steel and the seat of naval brass so that under ordinary service these parts should last for many hundreds of hours. Check the main metering jet and float

CARBURETOR SERVICE INSTRUCTIONS — Continued

needle seat to make sure they are tight. It is important that the throttle valve fits in the barrel tightly when in the closed position and that the lower edge be flush with the top of the lower idle hole. If it was found necessary to replace either of the mixture control plates, they should be lapped in with a very fine lapping compound to eliminate any possibility of air leakage.

(3) REPLACEMENTS: If due to accident or wear after long service it is necessary to make replacements, the parts should be obtained from the Bendix Products Division, Stromberg Carburetor Section, South Bend, Indiana, or an authorized Stromberg aircraft carburetor service organization.

In ordering parts, be sure to state on what make and model engine the carburetor is being used as the sizes of some parts are different for different engines. Ordering by part numbers as shown in the service parts list and also giving the serial number of the carburetor will greatly facilitate service.

(4) REASSEMBLY: All headless screw plugs below the fuel level should be assembled with shellac, being careful not to get it on the end of the plug where it will come off and be carried by the fuel into one of the metering orifices. Headless screw plugs above the fuel level and all other threaded parts screwed into the bodies should have a compound of graphite and castor oil put on the threads.

The float level on these carburetors should be 13/32" below the parting surface and is dependent upon the thickness of the gasket under the needle valve seat. The level should be checked under the same conditions encountered in service as regards the fuel used and the fuel pressure or head at the carburetor. The levels are set at the factory with a pressure at the carburetor of one-half pound per sq. inch (19" gasoline at .710 Sp. Gr.), and this is recommended for setting the levels in the field. If, after fitting new parts, the level is not correct, remove the needle valve seat and put in thicker gaskets to lower the level and thinner gaskets to raise it. One-sixty-fourth inch change in gasket thickness will change the level approximately 5/64".

The mixture control lever should be correctly pinned to the stem so that when the stop is in the full rich position, the large hole in the upper plate lines up with the hole in the lower plate. The parts of the carburetor should be safety wired before installing on an engine.

STROMBERG NA-S3AI CARBURETOR

SERVICE PARTS LIST

RECOMMENDED MAINTENANCE PARTS

Item No.	Part No.	Part Name	Quan. per Acc.	Quan. for Maint.	Quan. for O'haul	Total Quan
1	174-S-22	Gasket, Strainer Plug	1	200	50	250
2	P-2266	Screw, Thro. Stop	2	.....	50	50
3	P-2885	Gasket, Main Air Bleed Arm	1	30	50	80
4	P-5015	Screw, Thro. Stop	1	.....	10	10
5	P-5329	Gasket, Disch. Nozzle	1	.....	50	50
6	P-6387	Plug, Fulcrum Pin	1	.....	30	30
7	P-6550	Screw, Body Attaching	6	.....	120	120
8	P-6588	Screw, Throttle Lever	1	.....	10	10
9	P-6668	Lockwasher, Thro. Lever Screw	1	.....	30	30
10	P-6670	Plug, Headless Screw	1	.....	5	5
11	P-7881	No. 49 Jet, Main Metering	1	.....	10	10
12	P-8770	Spring, Mixt. Cont.	1	.....	10	10
13	P-11556	Spring, Idle Needle	1	5	10	15
14	P-12167	Lockwasher, Throttle Valve Screw	2	.....	400	400
15	P-12375	Screw, Throttle Stop	2	.....	50	50
16	P-12958	Strainer Assy.	1	15	15	30
17	P-12999	Gasket, Fl. N. V. Seat and Vent. Set Screw (1/32")	2	.....	100	100
18	P-14220	Plug, Strainer	1	15	15	30
19	P-15225	Washer, Idle Needle Valve	1	5	10	15
20	P-15237	Stop Assy., Throttle	1	.....	10	10
21	P-15344	Washer, Body Attach. Screw	6	.....	120	120
22	P-15350	Washer, Mixt. Cont. Cover Screw	2	.....	80	80
23	P-15505	Gasket, Mixt. Cont. Stem	1	10	50	60
24	P-16151	Shaft Assy., Throttle	1	.....	10	10
25	P-16154	No. 68 Tube Assy., Idle	1	.....	10	10
26	P-16155	Gasket, Main Body	1	.....	50	50
27	P-16156	Float Assy.	1	.....	10	10
28	P-16160	Pin, Float Fulcrum	1	.....	5	5
29	P-16161	Screw, Fl. Fulcrum Set	1	.....	30	30
30	P-16165	Gasket, Float Needle Valve Seat (1/64")	1	.....	50	50
31	P-16166	Gasket, Float Needle Valve Seat (3/64")	1	.....	50	50
32	P-16167	Gasket, Float Needle Valve Seat (1/16")	1	.....	50	50
32A	P-16169	Bushing, Thro. Shaft (Std.)	2	.....	20	20
32B	P-16169-1	Bushing, Thro. Shaft (1st O. S.)	2	.....	40	40
32C	P-16169-2	Bushing, Thro. Shaft (2nd O. S.)	2	.....	20	20
33	P-16170	Washer, Thro. Shaft	1	.....	5	5
34	P-16171	Spring, Thro. Shaft	1	.....	5	5
35	P-16173	Screw, Thro. Valve Screw	2	.....	250	250
36	P-16176	1 1/4" Tube, Venturi	1	.....	3	3
37	P-16177	Valve Assy., Idle	1	.....	10	10

CARBURETOR SERVICE PARTS LIST — Continued

Item No.	Part No.	Part Name	Quan. per Acc.	Quan. for Maint.	Quan. for O'haul	Total Quan.
38	P-16178	Screw, Venturi Set	1	.....	3	3
39	P-16179	No. 65 Bleed, Main Air	1	.....	10	10
40	P-16289	Lever, Mixt. Cont.	1	.....	15	15
41	P-17247	Seat, Float Needle Valve	1	.....	5	5
42	P-20170	Palnut, Mixt. Cont.	1	.....	15	15
43	P-20364	Washer, Mixt. Cont. Palnut	1	.....	15	15
44	P-21244	Screw, Thro. Lever	1	.....	10	10
45	P-21247	Lever Assy., Throttle	1	15	35	50
46	P-21472	Plug, Headless Screw (8-32)	1	.....	1	1
47	P-21475	Plug, ¼" Pipe	1	5	20	25
48	P-21854	Screw, Mixt. Cont. Cover	2	.....	60	60
49	P-60138	Plug, Headless Screw (¼-28)	2	.....	2	2
50	P-60834	Nut, Mixt. Cont. Cover Lock	1	.....	15	15
51	P-61030	Plate, Mixt. Cont. (Upper)	1	.....	5	5
52	P-61031	Plate, Mixt. Cont. (Lower)	1	.....	5	5
53	P-61033	Gasket, Mixt. Cont. Cover	1	.....	50	50
54	P-61034	Stem, Mixt. Cont.	1	.....	5	5
55	P-61035	Gasket, Mixt. Cont. Plate (Lower)	1	.....	50	50
56	P-61037	Cover Assy., Mixt. Cont.	1	.....	2	2
57	P-61038	Screw, Mixt. Cont. Plate	1	.....	10	10
58	P-61057	Arm Assy., Main Air Bleed	1	.....	2	2
59	P-61166	Gasket Set	1	.....	100	100
60	P-61385	Valve, Throttle	1	.....	3	3
61	390077	Valve, Float Needle	1	.....	50	50
62	390222	No. 22 Nozzle, Main Disch	1	.....	5	5

Section 18

SCINTILLA MAGNETO TYPES SF4RN-8 AND SF4LN-8

SERVICE INSTRUCTIONS

a. **General.**

These new magnetos are characteristic of all Scintilla magnetos in principle and construction. The outstanding features incorporated are the new and powerful rotor and a coil of new design which increase their efficiency and ability to give dependable service for longer periods of time. Their general appearance is somewhat changed which is due mostly to the new feature incorporated for the distribution of the spark. In place of distributor blocks, separate terminals, which protrude from the main cover, are provided for the installation of the spark plug cables.

These magnetos are radio shielded and provision is made for attaching radio shielded cables. A screened ventilator on each side of the housing and one in the base insure adequate ventilation for the magneto.

b. **Installing and Timing to the Engine.**

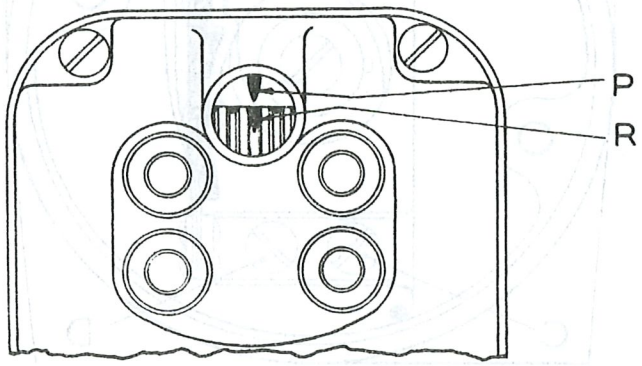
Before installing the magneto, insure that it has been correctly timed and checked in accordance with the section entitled "Adjustment of the Breaker Contact Points." It is installed to the engine in the following manner:

(1) Set the piston of cylinder No. 1 at its firing position.

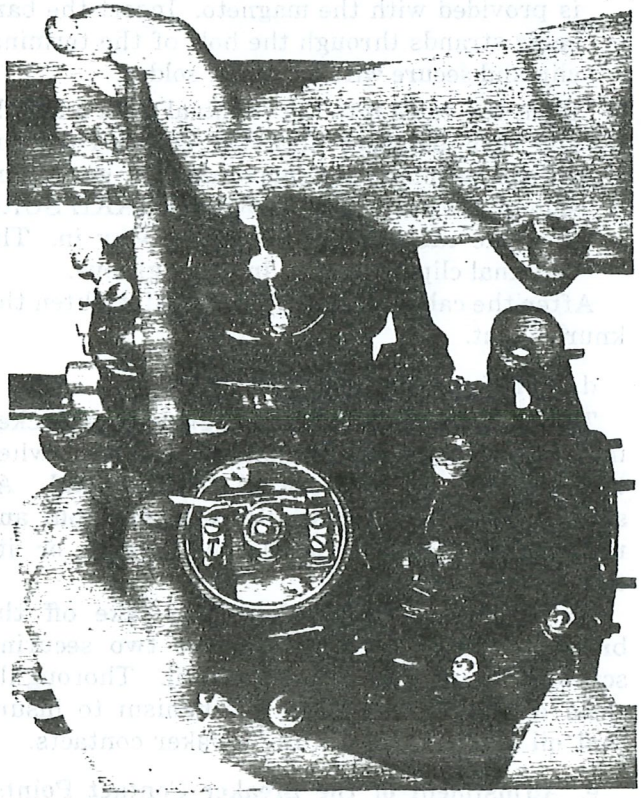
(2) Place the breaker in its full advance position (if variable spark magneto).

(3) Rotate the magneto drive shaft until the timing mark R on the chamfered tooth of gear, Fig. 41, and timing pointer P are opposite each other as seen through the timing window in the magneto cover. At this position the breaker contacts should begin to open.

(4) All adjustments for exact timing to the engine are made at the drive end and not by altering the position of the contact points. Insure that the mounting faces are clean and smooth. With the timing marks P and R (Fig. 41) opposite each other, install the magneto on the engine and secure with its mounting bolts. Exact timing is obtained by turning the magneto through the angle provided by the slots in the magneto flange. A convenient way of checking this adjustment is to place a strip of .0015" shim stock between the contact points and pull on it slightly. When the shim stock slips, the contact points are just opening. (Fig. 42.)



Showing Magneto Timing Markers — Figure 41



Timing Magneto — Figure 42

MAGNETO SERVICE INSTRUCTIONS — Continued

When the exact timing to the engine has been made, tighten and lock the mounting bolts and recheck the adjustment.

c. **Installation of the Cables.**

(1) The new type of individual high tension terminals for each cylinder used in these series magnetos eliminates the use of cable-piercing screws. It permits the use of a snap terminal clip on the cable end which can be quickly attached to or disconnected from the distributor terminals which protrude from the main cover. The cable outlets are water-tight and are separated sufficiently to prevent flashing between the cables.

The number discs adjacent to the high tension terminal bushings on the main cover indicate the serial firing order of the magneto and are not engine cylinder numbers.

Attach the high tension cables to the magneto as follows:

1. Slip the knurled nut, brown bakelite collar, and the rubber gland over the cable in the order named.
2. Strip the insulation from the cable end for about ¼" and attach the terminal clip which is provided with the magneto. Insert the bare cable strands through the hole of the terminal clip and secure with a drop of solder.
3. Push the cable into the terminal with a steady and firm pressure until the crimped portion on the terminal clip snaps into the groove inside of the terminal. ALWAYS MAKE SURE that the cable is pushed all the way in. The terminal clip must snap into the groove.

After the cable is properly installed, tighten the knurled nut.

d. **Care in Operation.**

The ball bearings of the magneto are packed in grease and require no lubrication except when the magneto is disassembled for overhaul. At such times the grease should be washed out and replaced with Keystone No. 44 grease or its equivalent.

At routine inspection intervals, take off the breaker cover by loosening the two securing screws and remove any excess oil. Thoroughly clean and dry the breaker mechanism to insure that oil will never touch the breaker contacts.

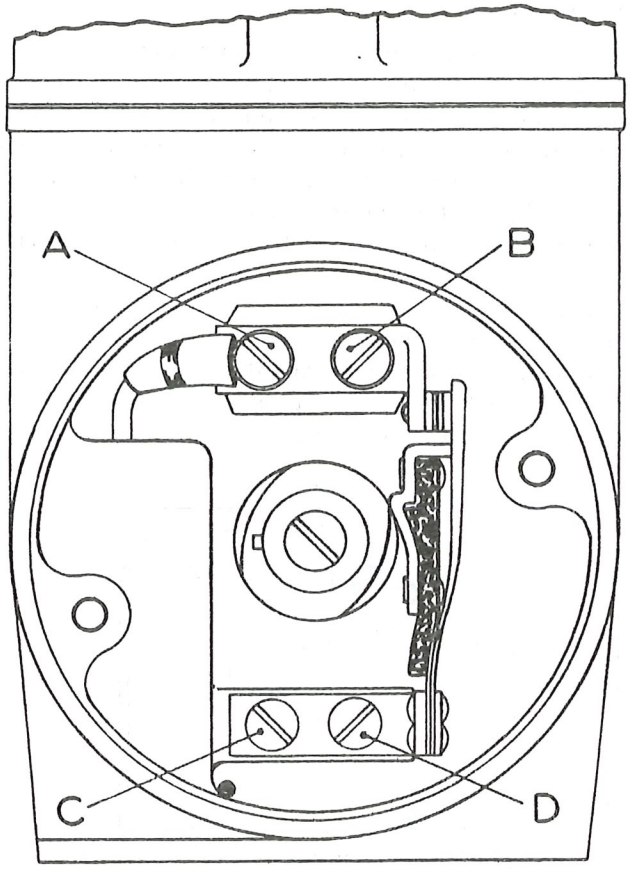
e. **Adjustment of the Breaker Contact Points.**

During major overhaul periods, at intervals which should not exceed 400 hours operating time, the contact points are adjusted in the following manner:

(1) Place the breaker in its full advance position (if variable spark magneto).

(2) Turn the drive shaft until the mark R (Fig. 41) on the chamfered tooth of the large distributor gear is opposite the timing pointer P inside the magneto cover as seen through the timing window. When these two marks are opposite each other, the breaker contacts should be just opening. A convenient way of checking this adjustment is to place a strip of .0015" shim stock between the contacts and pull against it slightly. When the shim stock slips, the contacts are separating.

(3) If the contacts do not open at the proper time, loosen the two screws, A and B (Fig. 43), which hold the adjustable contact assembly in place and move the adjustable contact assembly to right or left until the two contacts separate when the timing marks are opposite each other. It should be noted that the contact points are not adjusted for any fixed clearance between them.



Breaker Mechanism — Figure 43

MAGNETO SERVICE INSTRUCTIONS — Continued

(4) If the contacts do not line up properly, the location of the contact and cam follower assembly can be adjusted by loosening the two screws, C and D (Fig. 43), which secure the contact and cam follower assembly to the housing. The hole for screw D is slightly oversize to permit this adjustment. After retightening the screws, recheck this adjustment to insure that it is correct.

(5). Insure that the lubrication felt attached to the cam follower is soft and moist with oil. This felt supplies a very minute quantity of lubricant to the breaker cam. If oil appears on the surface when the felt is squeezed between the fingers, do not add any more oil. If the felt is dry, however, moisten with a few drops of medium bodied mineral lubricating oil, SAE 60 or equivalent. Do NOT give it all it will hold.

Before replacing the breaker, wipe out any dirt or excess oil which may have entered into the breaker compartment during adjustment.

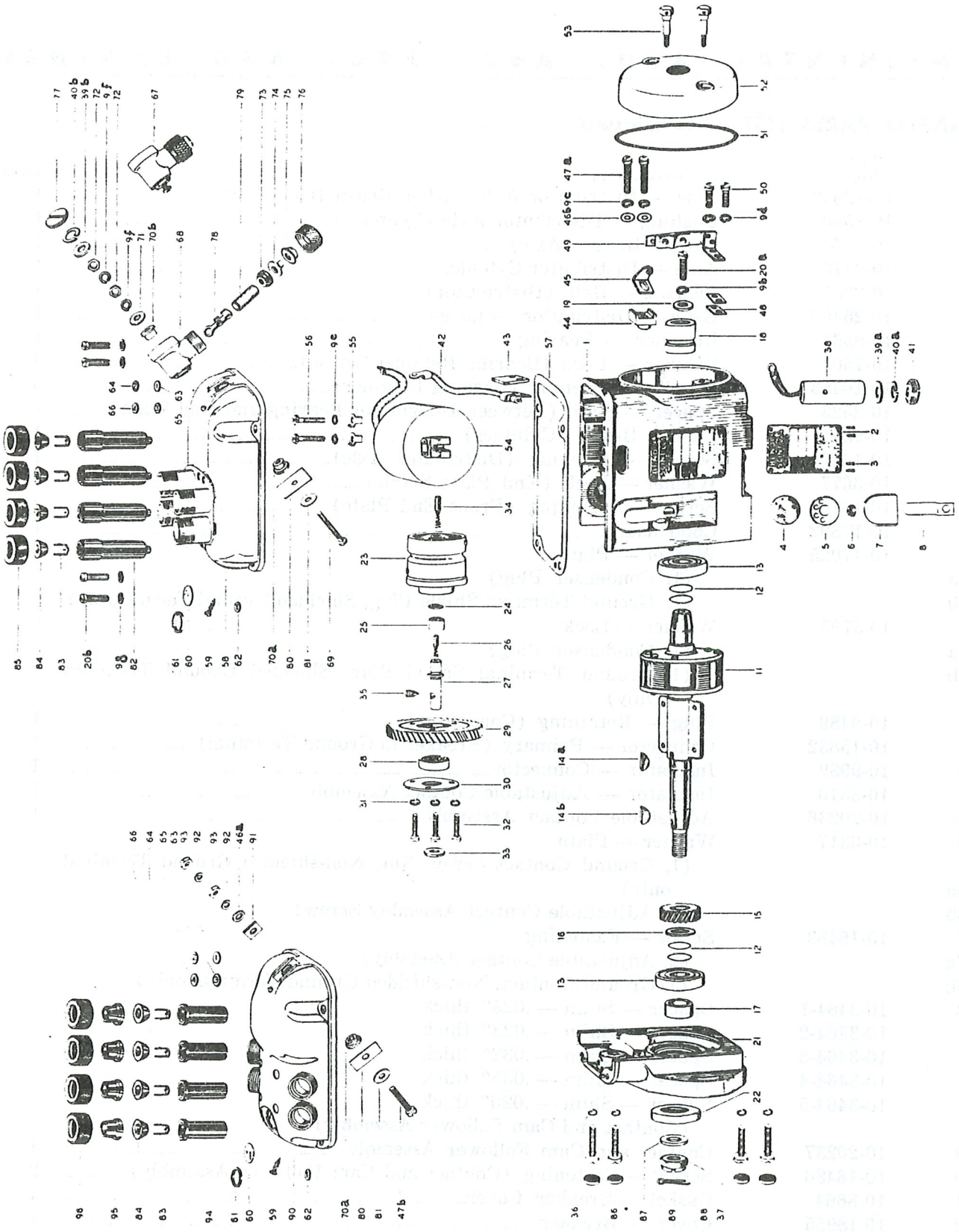
NOTE: On production magnetos now supplied, the breaker cam is staked in position on its shaft thereby eliminating the use of a cam key. The same cam is used for both clockwise and anti-clockwise magnetos, and therefore the directional arrow on the cam has been discontinued.

SCINTILLA MAGNETO TYPES SF4RN-8 AND SF4LN-8

SERVICE PARTS LIST

AIRCRAFT MAGNETOS

Ref. No.	Part No.	Description	No. Required
1	10-19805	Housing — Magneto	1
2	10-12042	Plate — Magneto Identification	1
3	2-783	Drive Screw (Identification Plate)	4
*	10-14673	Ventilator Assembly — Side	2
		(Includes 10-3132, 10-7441, 10-13795, 10-13796, 10-13797, 10-13798, 10-15444)	
4	10-13797	Screen — Side Ventilator	2
5	10-7441	Retainer — Side Ventilator Screen	2
6	10-13796	Spacer — Side Ventilator Shield	2
7	10-13795	Shield — Side Ventilator	2
8	10-13798	Clamp — Side Ventilator	2
9	10-3132	Washer — Lock	
9a		(2, Side Ventilator Clamp Screw)	
9b		(1, Cam Screw)	
9c		(2, Adjustable Contact Assembly Screw)	
9d		(2, Contact and Cam Follower Assembly Screw)	
9e		(2, Coil Core Screw)	
**9f		(2, Ground Terminal Shield Screw Nut, Shielded Ground terminal Only)	
9g		(4, Magneto Cover Screw)	
10	10-15444	Screw — Fastening (Side Ventilator Clamp)	2
11	10-15828Y	Magnet — Rotating	1
12	2-161-1	Washer — Shim — .0025" thick	
	2-161-2	Washer — Shim — .004" thick	
	2-161-3	Washer — Shim — .005" thick	
	2-161-4	Washer — Shim — .008" thick	
	2-161-5	Washer — Shim — .010" thick	
	2-161-6	Washer — Shim — .012" thick	
		(Magnet End Play Adjusting)	
13	10-3057	Bearing — Ball (Magnet, Drive and Breaker Ends)	2
14	2-295Z	Key — Woodruff	2
14a		(1, Small Gear)	
14b		(1, Drive Shaft)	
†15	10-25457	Gear — Distributor-Small-Clw.	1
	10-25458	Gear — Distributor-Small-Anti-Clw.	1
16	10-8672	Spacer — Plain (Between Small Gear and Bearing)	1
‡17	10-25788	Sleeve — Magnet Shaft (Bronze)	1
18	10-8524	Cam — Breaker	1
19	10-3659	Washer — Plain (Cam Screw)	1
20	10-16487	Screw — Fastening	5
20a		(1, Cam)	
20b		(4, Magneto Cover)	
‡21	10-29049	Plate — Front End	1
‡22	10-27448	Oil Seal — Drive Shaft	1
23	10-12046Y	Cylinder — Distributor	1



MAGNETO ILLUSTRATED PARTS — *Figure 44*

MAGNETO PARTS LIST — Continued

Ref. No.	Part No.	Description	No. Required
24	10-12643	Disc — Distributor Axle Carbon Brush (Cylinder)	1
25	10-8560	Bushing — Distributor Axle (Cylinder)	1
26	10-12647	Carbon Brush (Axle)	1
27	10-9476	Axle — Distributor Cylinder	1
28	10-2935	Bearing — Ball (Distributor)	1
†29	10-25459	Gear — Distributor — Large	1
30	10-8561	Retainer — Bearing	1
31	10-7501	Washer — Lock (Bearing Retainer Screw)	3
32	10-16483	Screw — Fastening (Bearing Retainer)	3
33	10-8523	Spacer — Plain (Between Distributor Bearing and End Plate)	1
34	10-9595	Carbon Brush (Cylinder)	1
35	10-13370	Screw — Fastening (Distributor Axle)	1
36	10-3677	Washer — Lock (End Plate Screw)	4
37	10-16768	Screw — Fastening (Front End Plate)	4
38	10-17892	Condenser	1
39	10-17025	Washer — Plain	
39a		(1, Condenser Plug)	
**39b		(1, Ground Terminal Shield Plug, Shielded Ground Term'l Only)	
40	10-3793	Washer — Lock	
40a		(1, Condenser Plug)	
**40b		(1, Ground Terminal Shield Plug, Shielded Ground Terminal Only)	
41	10-9489	Plug — Retaining (Condenser)	1
42	10-15832	Connector — Primary (Breaker to Ground Terminal)	1
43	10-9939	Insulator — Connector	1
44	10-3316	Insulator — Adjustable Contact Assembly	1
45	10-20236	Adjustable Contact Assembly	1
46	10-3317	Washer — Plain	
46a		(1, Ground Contact Screw Nut, Non-shielded Ground Terminal only)	
46b		(2, Adjustable Contact Assembly Screw)	
47	10-16489	Screw — Fastening	
47a		(2, Adjustable Contact Assembly)	
47b		(1, Ground Contact, Non-shielded Ground Terminal only)	
48	10-3464-1	Spacer — Shim — .025" thick	
	10-3464-2	Spacer — Shim — .028" thick	
	10-3464-3	Spacer — Shim — .032" thick	
	10-3464-4	Spacer — Shim — .035" thick	
	10-3464-5	Spacer — Shim — .020" thick	
		(Contact and Cam Follower Assembly)	
49	10-20237	Contact and Cam Follower Assembly	1
50	10-16486	Screw — Fastening (Contact and Cam Follower Assembly)	2
51	10-8664	Gasket — Breaker Cover	1
52	10-18955	Cover — Breaker	1
53	10-19722	Screw — Fastening (Breaker Cover)	2
54	10-15829V	Coil	1
55	10-3983	Washer — 2 Ear Lock (Coil Core Screw)	2
56	10-5600	Screw — Fastening (Coil Core)	2
57	10-8665	Gasket — Magneto Cover	1
58	10-13457Z	Cover — Magneto (Vertical Outlet)	1
59	10-9477	Pointer — Timing	1
60	10-9976	Window — Timing	1

MAGNETO PARTS LIST — Continued

Ref. No.	Part No.	Description	No. Required
61	10-9975	Washer — Plain (Timing Window Retaining)	1
62	2-319	Disc — Rotation Direction	1
63	2-321	Disc — No. 1	1
64	2-322	Disc — No. 2	1
65	2-323	Disc — No. 3	1
66	2-324	Disc — No. 4	1
67	10-16507	Shield Assembly — Ground Terminal (Shielded Ground Terminal only)	1
**68	10-16140Z	Shield — Ground Terminal	1
**69	10-16584	Screw — Fastening (Ground Terminal Shield)	1
70	10-8014	Bushing — Insulating, Round	
70a		(1, Ground Contact Screw)	
70b		**(1, Ground Contact Nuts)	
**71	10-5534	Washer — Plain (Ground Contact Nuts)	1
**72	10-14990	Nut (Ground Terminal Shield Screw)	2
**73	10-2674	Grommet — Rubber (Ground Terminal Cable)	1
**74	10-7029	Ferrule — Inner (Ground Terminal Cable)	1
**75	10-7030	Ferrule — Outer (Ground Terminal Cable)	1
**76	10-3657	Nut (Ground Terminal Shield)	1
**77	10-13242	Plug — Ground Terminal Shield	1
**78	10-19021	Terminal Clip — Ground Wire	1
**79	10-21847	Tube — Insulating (Ground Wire Terminal Clip)	1
80	10-16203	Insulator — Primary Connector	1
81	10-3220	Washer — Plain (Primary Connector Insulator)	1
82	10-13458	Terminal — High Tension (Vertical Outlet Cover)	4
83	10-12360	Clip — High Tension Cable	4
84	10-2617	Grommet — Rubber (High Tension Terminal)	4
85	10-14855	Nut — High Tension Terminal (Shielded Installations)	4
86	10-13182	Plug — Leather (End Plate Screw Hole)	4
87	10-4093	Washer — Plain (Drive Shaft Nut)	1
88	10-4092	Nut — Drive Shaft	1
89	2-393	Pin — Cotter (Drive Shaft Nut)	1
90	10-12945Z	Cover — Magneto (Angle Outlet)	1
91	10-9543	Plate — Insulating (Ground Contact Screw Nut, Non-shielded Ground Terminal only)	1
92	2-339	Washer — Lock (Ground Contact Screw Nut, Non-shielded Ground Terminal only)	2
93	10-16497	Nut (Ground Contact Screw, Non-shielded Ground Terminal only)	2
94	10-9994Y	Terminal — High Tension (Angle Outlet Cover)	4
95	10-9993	Collar — High Tension Cable (Non-shielded Installations)	4
96	10-9571	Nut — High Tension Terminals (Non-shielded Installations)	4

*Not illustrated.

**Included in 10-16507 Ground Terminal Shield Assembly.

†Current production magnetos incorporate distributor gears of the helical or angle-cut tooth design, where formerly they incorporated gears of the spur or straight-cut tooth design.

Therefore, when replacing either the large or small spur tooth gears, it is necessary to order both the large and small helical tooth gears as a set, the gears not being interchangeable individually.

‡When replacing the drive shaft oil seal (Ref. No. 22) on magnetos incorporating the "Garlock" seal inserted from the outside of the front end plate, the bronze bushing (Ref. No. 17) and the new type "Chicago Rawhide" seal must be used.

When replacing the Garlock seal on magnetos with the oil seal inserted from the inside of the front end plate, the front end plate must be reworked in accordance with Scintilla Service Bulletin No. 93.

Section 19

WILCOX-RICH HYDRAULIC LIFTERS

SERVICE INSTRUCTIONS

THINGS TO BE REMEMBERED IN HANDLING:

1. Plungers not interchangeable:

The plunger in the hydraulic unit is not interchangeable in the cylinder as tests are made after assembly for the rate of leak-down, which determines the quality of the unit rather than diametric clearances.

2. Plunger spring must be snapped in counterbore:

Any time the plunger is removed from the bore and replaced, the plunger spring should be snapped into the counterbore of the hydraulic cylinder. This can readily be done by a slight twisting motion in the direction to wind up the coil of the spring.

3. No grinding or machining to be done on unit:

It is not advisable to do any kind of grinding or machining on the hydraulic units. In cases where valves have been re-seated to a depth which would require increasing their mechanical clearance, the valve stems should be ground off to provide this clearance.

4. Shellac or gasket cement not to be used:

No shellac or gasket cement of any kind should be used at any point where it will be possible for it to get into the hydraulic lifters, as this will cause the check-ball to be glued to the seat and prevent operation.

ESSENTIALS OF OPERATION:

1. Body free in guide:

The tappet body, itself, must be a free fit in the guide. A proper test for this is to insure that the tappet will drop of its own weight in the guide.

2. Check-ball must not leak:

The check-ball must not leak more than about one drop per second when filled with kerosene, and the plunger loaded with 50 lbs. pressure.

3. Check-ball travel must not be too great:

The check-ball should not have more than .014" travel. This is provided for in manufacturing and it would be very seldom the travel would exceed this amount.

4. Plunger must be free in bore:

The plunger must be a free fit in the hydraulic cylinder and, at the same time, the leakdown rate must be right. The production limit is ¼" travel with 50 lbs. load in not less than four seconds when unit is filled with kerosene.

Fixtures are available for service inspection which compare a unit to be tested with a master unit. As there are a number of these fixtures, the method of testing is not given here, therefore reference should be made to the instructions provided with each fixture.

5. Lifters must have proper mechanical clearance:

The mechanical clearance should be checked each time installation is made. This check should be made without oil in the unit.

6. Proper oil supply must be maintained:

Oil must be supplied to the hydraulic lifters with at least three or four pounds of pressure at idle and twenty pounds of pressure at high speeds; and the maximum oil pressure should not exceed fifty-five pounds for any great period of time, as excessive oil pressure can cause the entire hydraulic unit to pump up and down in the body, preventing compensation, resulting in noise.

HANDLING:

The usual handling will be: Removal for valve grind or some other repair or replacement, in which case it is only necessary to wash-up the hydraulic lifters, removing the plunger from the hydraulic cylinders one at a time to prevent interchanging, washing them thoroughly in clean gasoline, kerosene, or any cleaning solution used for other parts and replacing them in the engine without any attempt being made to fill them with oil before assembly. After assembly, check clearance using a screwdriver to pry the plunger down. With valve in closed position, measure the clearance between the end of the plunger and the valve stem. Running the engine, the units should quiet themselves usually within forty-five minutes in a horizontal engine. The time required for any

HYDRAULIC LIFTERS SERVICE INSTRUCTIONS — Continued

given unit to quiet is not indicative of the quality but means only that the particular unit has a larger amount of air to dispose of.

The engine should be run at the lowest speed which produces maximum oil pressure, until all lifters have become quiet.

It often happens that when a hydraulic unit is operated in an engine for a considerable length of time, carbon may form on the inside of the cylinder above travel of the plunger during normal operation. If this takes place, the plunger will appear to be stuck in the cylinder. The following is the condition which actually occurs in this case:

Removal of the valve stem from the top of the plunger allows the plunger to move upwards and the hydraulic unit completely fills with oil. The carbon which has formed on the inside of cylinder above the shoulder on the plunger makes removal of the plunger very difficult and, since the unit has filled with oil, the plunger cannot be forced down because the oil is trapped by the check ball. This gives the impression of a stuck unit and, in order to free the plunger, the following can be applied:

Press the plunger all the way down while holding the check valve off its seat with a matchstick or other blunt instrument. This will allow the oil to escape and permit the unit to be checked with the leakdown tester. In most cases the carbon which has formed above the plunger can usually be broken by twisting the plunger and pulling outward at the same time. In case the carbon buildup is quite great and cannot be removed easily, it is advisable to place the unit in a solution which will dissolve the carbon ring. Once the plunger has been removed any carbon remaining on the cylinder should be cleaned off with a rough rag. The cylinder and the plunger should then be washed thoroughly before reassembling.

In replacing the plunger into the cylinder, give it a twist, while it is fully depressed; this will cause the end of the spring to snap into its seat.

TYPES OF FAILURE:

With respect to failure of hydraulic lifters, there are four general classifications:

1. Where very slight single or multiple noise is heard.
2. Where a single loud noise will be heard.
3. Where there is general noise in the entire set.
4. Intermittent or general noise in any particular section of the engine.

1. Slight Noise:

In the case of item 1, there is a variety of things other than the hydraulic lifter which can cause the trouble; such as, excessive clearance between the valve stem and the guide, eccentricity of the valve seat or anything which can cause the valve to contact the seat in closing at a point materially above the point where the valve sets on the seat.

In cases where this type of noise is made by the unit itself, it is due either to a leaky check valve or a plunger having too much clearance in the bore.

2. Loud Noise:

With reference to item 2 where single loud noise is heard in the valve gear: It is generally found that for some reason a hydraulic plunger has become sticky or tight in the bore to such an extent that the plunger spring will not move the plunger in the bore. This results in the plunger being forced all the way down so that the bottom of the plunger contacts the ball cage and the tappet clearance is approximately $\frac{1}{16}$".

The particular tappet causing the trouble can be located in the following manner: By using some kind of a listening rod and comparing the noise in each cylinder, it can readily be determined which cylinder the noisy tappet is in. Very often by listening directly over the exhaust or the intake, the individual tappet can be determined before disassembly. In any case, removal of these two tappets and examination will disclose which one has been sticking.

It will be found that the seating of the valve where a hydraulic unit is stuck produces a very perceptible shock to the valve spring at the instant of seating. This can readily be determined by either touch or sound. One readily accessible method is to push the end of a hammer handle against the valve spring keeper. If the tappet is noisy, a decided shock will be felt at the instant of closing. Whereas when the lifter is working properly there will be almost no shock felt. Once this comparison is made, there will be no question about its finality thereafter.

If it is found that one unit has a tendency to stick due to oil varnish, it is very likely that all units may need immediate attention to prevent a recurrence of sticking.

HYDRAULIC LIFTERS SERVICE INSTRUCTIONS — Continued

3. General Noise:

In cases of general noise in the entire set (item 3), it is a definite indication that insufficient oil is being delivered to the hydraulic units. As a general rule, in cases where engines run out of oil the hydraulic units will provide a warning before serious damage is done as air will periodically be taken into the intake side of the pump as soon as the level is very low. This, however, is not recommended as a means for determining when oil is needed in the engine. In any case where general noise is observed, it is advisable to determine oil pressures at the hydraulic lifters.

4. Intermittent or General Noise:

In the case of item 4, the general or intermittent noise in any particular section of the engine is usually an indication that air separation is inadequate at this point. This type of noise will usually occur when the engine is brought down to idle from high speed, or possibly in some cases on starting. This is usually a question of design and is not often encountered in the field.

However, there have been some examples of individual engines where some air-leak occurred on the intake side of the oil pump, providing excessive aeration, so that the air separation provided in the job may not be adequate — either for all or part of the engine. In any case, if this trouble should be found, the inlet side of the pump should first be examined for air leaks — particularly as excessive aeration is apt to cause trouble in bearings or other parts of the engine. If no air leak is found, any arrangement which will increase the capacity for air separation may remedy the trouble.

In some cases it has been found that the valves were definitely being held open, causing defective performance; but this has been found to be something other than the hydraulic lifters themselves — generally a camshaft with sufficient runout on the base circle of the cams to crack the valves off the seat when they should be closed. The maximum allowable runout on the base circle of a cam used with hydraulic lifters is .002" total indicator reading. It is not likely that many cases of this condition would be found.

5. To Summarize:

Noisy operation of hydraulic lifters is likely to result from inadequate oil supply, dirt, or air in the oil, etc., as outlined above and usually is not caused by any structural failure of the hydraulic unit itself.

Remember that no adjustment is necessary or possible on hydraulic lifters and that they are designed as a sturdy part of the engine to give long and trouble-free service — provided they are correctly handled and provided they are supplied with clean oil at the correct pressure. Therefore, it is advisable to leave them alone unless noisy operation is due to one of the causes mentioned above.

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