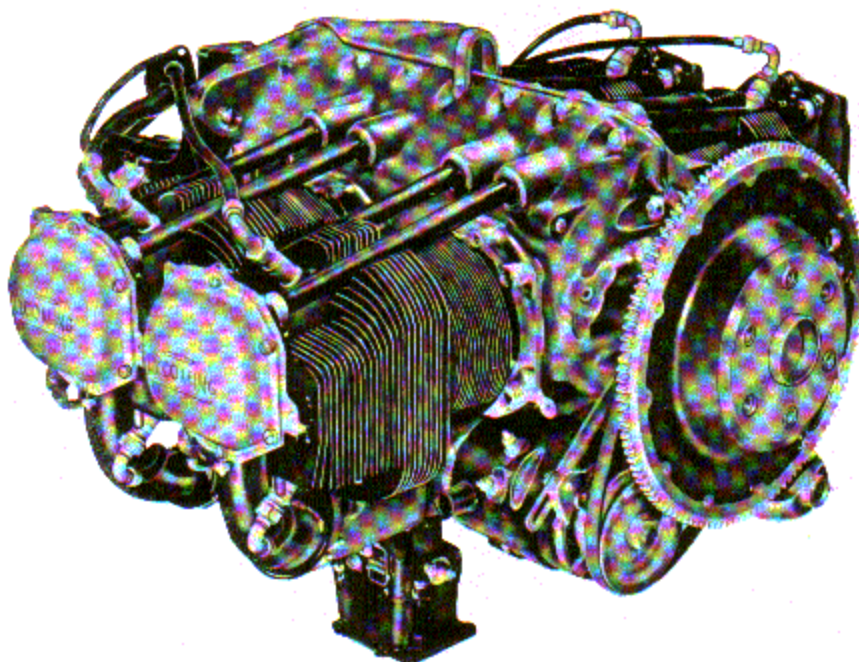


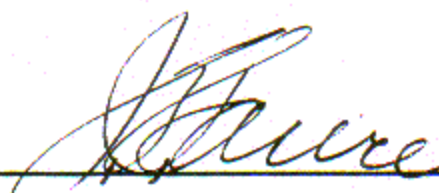
# OVERHAUL MANUAL

## LYCOMING

### 0-360 & 0-540 Series Aircraft Engines



Approved by :-



Chief of Aircraft Engineering Division  
Federal Aviation Agency

Date :- Jan. 19, 1960

### Lycoming

DIVISION **Arco** CORPORATION  
WILLIAMSPORT, PA., U. S. A.

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LYCOMING Division — AVCO Corporation warrants each new engine to be free from defects in material and workmanship, when properly installed and used under normal conditions, for ninety days after the shipment of each engine from the plant or one hundred hours of operation, whichever event takes place sooner. This warranty is limited to replacing or repairing at its shops any part or parts which have been returned to LYCOMING Division — AVCO Corporation, with transportation charges prepaid and which, in its opinion, are defective, and LYCOMING shall have no responsibility for any consequential damages. This warranty is expressly in lieu of all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of LYCOMING Division — AVCO Corporation.

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\* - The term "premium packaged" shall mean packaging in accordance with LYCOMING Standard packaging specifications for export shipment.

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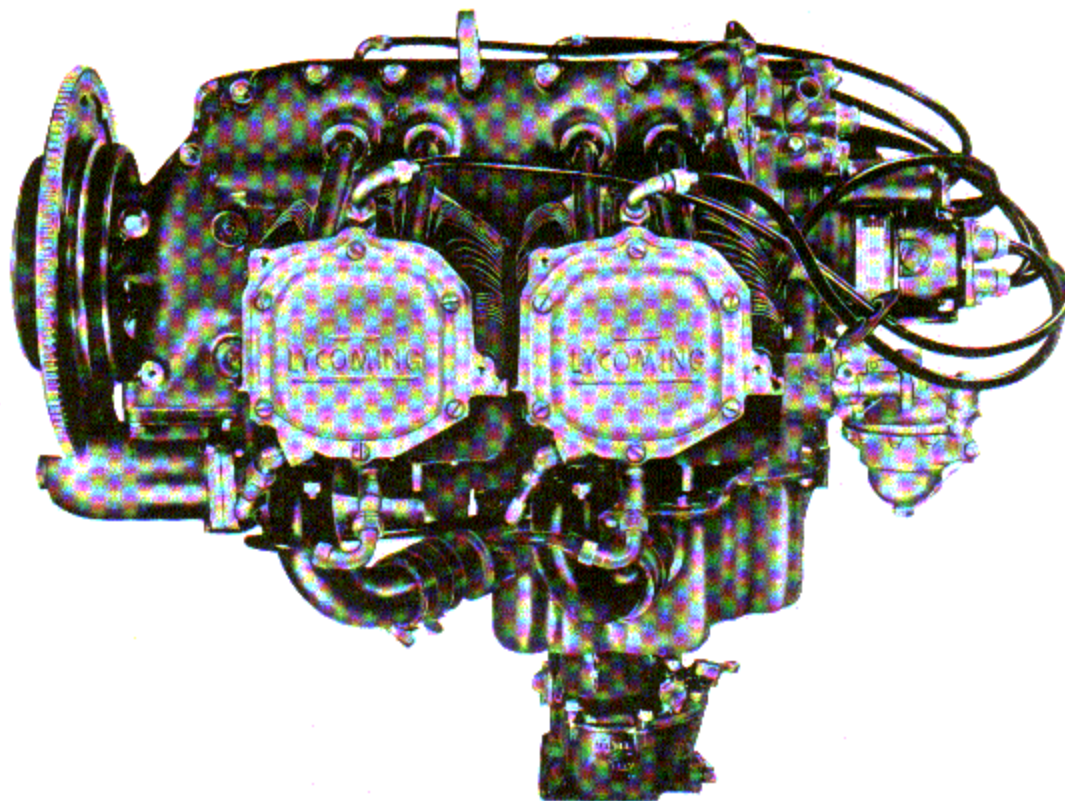


Figure 1. Left Side View, O-360-A

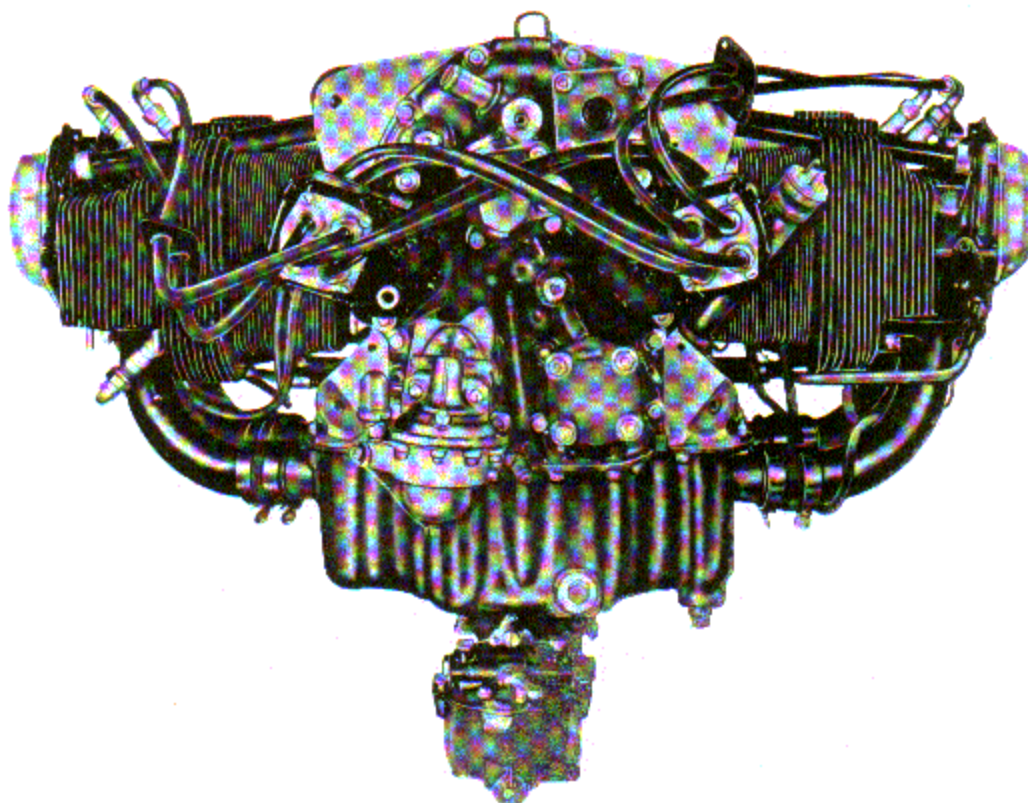


Figure 2. Rear View, O-360-A

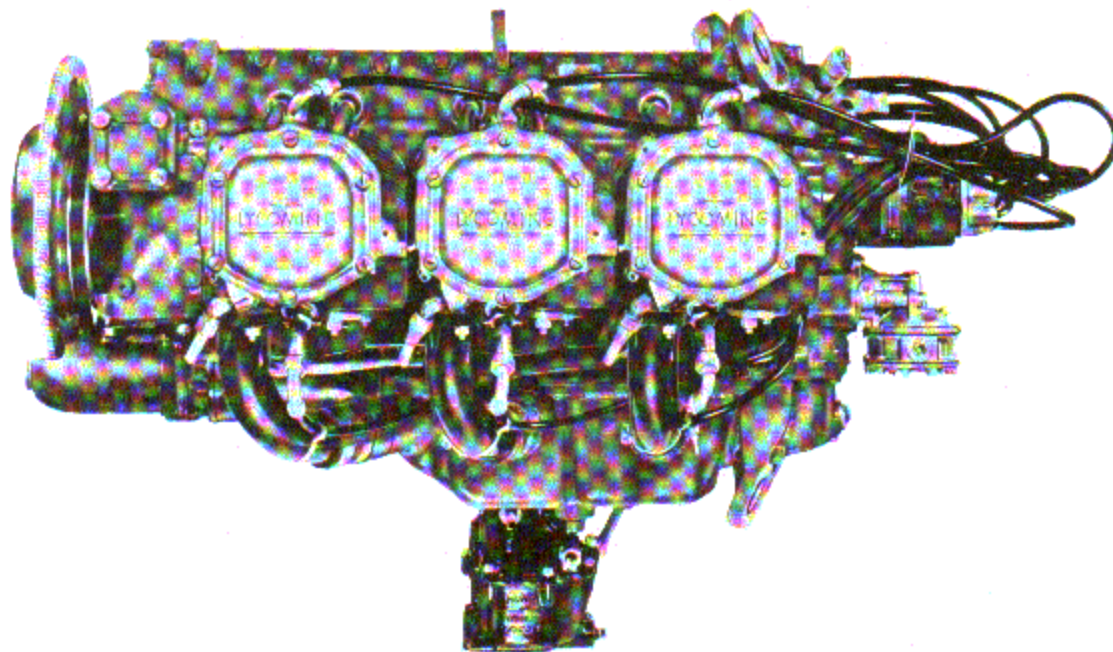


Figure 3. Left Side View, O-540-A

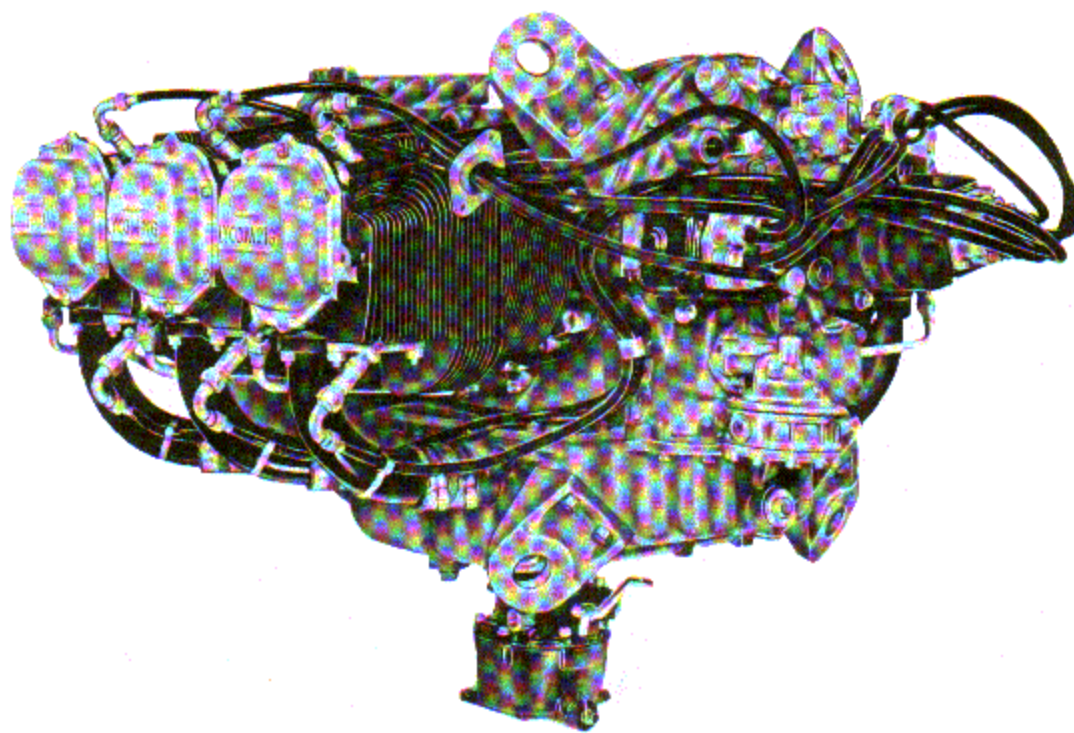


Figure 4. Three-quarter Rear View, O-540-A

## SECTION I

### INTRODUCTION

1-1. This manual contains the necessary information for the complete major overhaul of the Lycoming O-360-A Series, O-360-C Series and O-540-A Series Aircraft Engines.

1-2. The main portion of the text is divided into sections corresponding to the basic engine components; that is, cylinders, sump, accessory housing, ignition system, etc. Each of these sections will deal in complete detail with all phases of the overhaul procedure (Disassembly, Cleaning, Inspection, Repair and Replacement, and Reassembly), thus constituting a complete manual in itself with respect to the component being discussed. Additional sections are included covering such subjects as Test Procedure, Preparation for Storage, General Overhaul Procedures, and other items of a non-specific nature.

1-3. The tools used for overhauling this engine (excluding the ordinary mechanic's tools found in most overhaul shops) are listed in Section XI. When requesting information concerning one of these tools, refer to the tool by number and name, and not merely by name. Inspection gages are included in the tool lists.

1-4. It should be noted that when overhauling an engine, it may be necessary to order standard or over-size parts. A Parts Catalog, with the engine parts

listed numerically and alphabetically, may be obtained by writing to the Service Department, Lycoming Division—AVCO Corporation, Williamsport, Pennsylvania. If for any reason parts are returned to the factory, the following information should accompany them; engine serial number and model, number of hours service, the reason for the parts being returned, and any other facts concerning the parts.

1-5. Service Bulletins are also issued from time to time whenever the engine is modified or the overhaul procedure is revised. When received, these bulletins should be inserted in the rear of this manual.

1-6. In this manual, the term "front" of the engine shall refer to the propeller end of the engine. The term "rear" of the engine shall refer to the anti-propeller or accessory housing end of the engine. The terms "right" and "left" shall apply when the engine is viewed by an observer standing at the rear of the engine, that is, facing the accessory housing. The oil sump is considered the lower section of the engine. When reference is made to individual cylinders and pistons, the section nearest the crankshaft will be referred to as the lower section and the section most remote from the crankshaft (nearest the rocker box cover) will be referred to as the upper section. The right front cylinder is No. 1 and the cylinders on the right side are designated by odd number (1 and 3 on

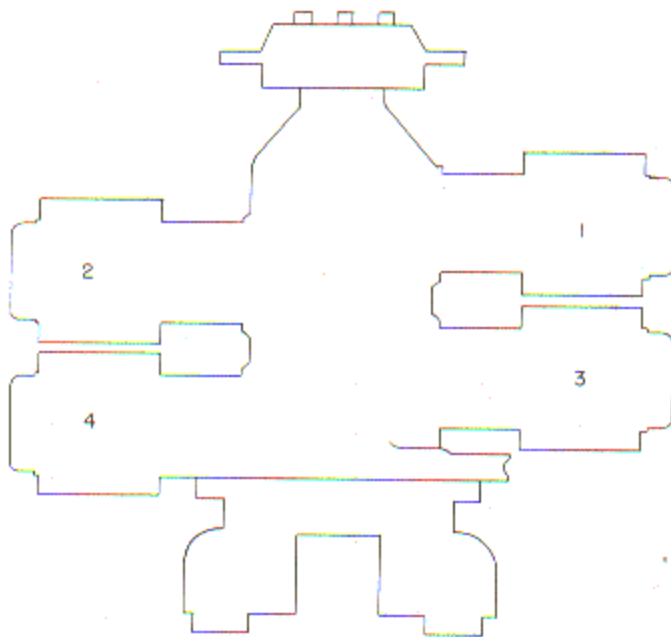


Figure 1-1. Cylinder Numbering Diagram, O-360

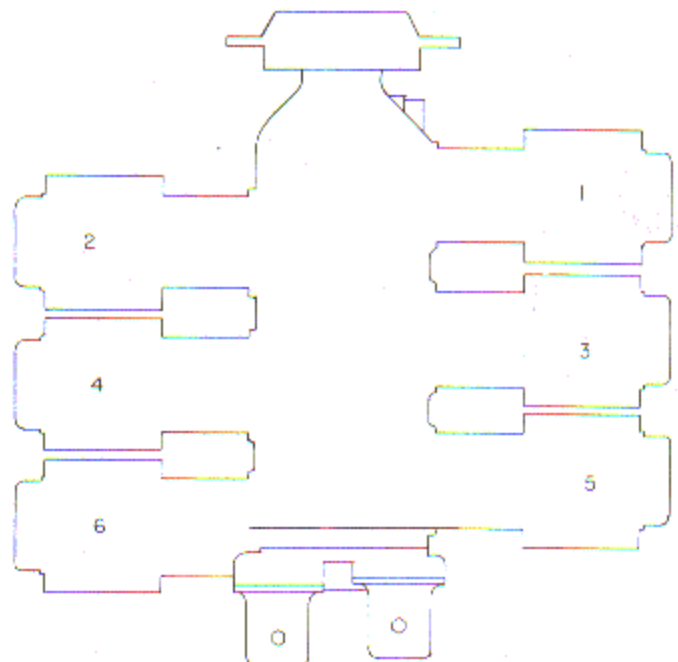


Figure 1-2. Cylinder Numbering Diagram, O-540

O-360 engines; 1, 3, and 5 on O-540 engines). The left front cylinder is No. 2 and the cylinders on the left side are designated by even numbers (2 and 4 on O-360 engines; 2, 4, and 6 on O-540 engines). (See figures 1-1 and 1-2.) The direction of rotation of the crankshaft, looking at the propeller end of the engine,

is counter-clockwise. In this manual, any reference to the direction of rotation of the crankshaft shall apply only when the engine is viewed from the propeller end. All references to direction of rotation of accessory drives apply only when facing the drives or the drive mounting pads.



## SECTION II GENERAL DESCRIPTION

2-1. The Lycoming O-360 series is a four cylinder engine and the O-540 is a six cylinder engine. Both models are air cooled, horizontally opposed, direct drive models incorporating a wet sump. The O-360 engines have a total displacement of 361 cubic inches and O-540-A engines have a displacement of 541.5 cubic inches. Table II-I provides information on the individual features incorporated in the various engine models.

2-2. CYLINDERS. Instead of being directly opposite each other, the cylinders are staggered, thus permitting a separate throw on the crankshaft for each con-

necting rod. The cylinders are of conventional air-cooled construction, with the two major parts, barrel and head, screwed and shrunk together. The heads are made from an aluminum alloy casting with a fully machined combustion chamber. The barrels are machined from chrome nickel molybdenum steel forgings with deep integral cooling fins; the interior walls of the barrel are ground and honed to a specified finish. The standard engine is equipped with unplated barrels and chrome faced piston rings; chrome plated barrels (which require the use of plain rings) are available as optional equipment.

TABLE II - I  
INDIVIDUAL CHARACTERISTICS OF VARIOUS ENGINE MODELS

|            | Carburetor |        | Magnetos |                   |                  |                    | Mounts            |                   | Number of Cylinders | Propeller Operation | Counter-weights    |            |         | Propeller Governor Studs |          |      |     |             |                    |               |               |               |       |
|------------|------------|--------|----------|-------------------|------------------|--------------------|-------------------|-------------------|---------------------|---------------------|--------------------|------------|---------|--------------------------|----------|------|-----|-------------|--------------------|---------------|---------------|---------------|-------|
|            | MA-4-5     | PS-5BD | PSH-5BD  | (1)S4LN-20(right) | (1)S4LN-21(left) | (1)S4LN-204(right) | (1)S6LN-200(left) | (1)S6LN-21(right) |                     |                     | (1)S6LN-204(right) | (2)S6LN-21 | Conical |                          | Dynafoal | Four | Six | Fixed Pitch | Controllable Pitch | (2) 6th Order | (1) 5th Order | (1) 6th Order | Short |
| O-360-A1A  | X          |        | X        |                   |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-A1B  |            | X      | X        |                   |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-A1C  |            | X      | X        |                   |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-A1D  | X          |        |          | X                 |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-A2A  | X          |        | X        |                   |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-A2D  | X          |        |          | X                 |                  |                    |                   | X                 | X                   |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C1A  | X          |        | X        |                   |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C1C  | X          |        |          | X                 |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C2A  | X          |        | X        |                   |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C2B  |            | X      | X        |                   |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C2C  | X          |        |          | X                 |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-360-C2D  |            | X      | X        |                   |                  |                    | X                 | X                 |                     |                     |                    | X          |         |                          |          |      |     |             |                    |               |               |               |       |
| O-540-A1A  | X          |        |          |                   | X                |                    |                   | X                 |                     | X                   |                    | X          | X       |                          |          |      |     |             |                    |               |               | X             |       |
| O-540-A1A5 | X          |        |          |                   | X                |                    |                   | X                 |                     | X                   |                    | X          |         | X                        |          |      |     |             |                    |               |               | X             |       |
| O-540-A1B5 | X          |        |          |                   |                  | X                  |                   | X                 |                     | X                   |                    | X          |         | X                        | X        |      |     |             |                    |               |               |               |       |
| O-540-A1C5 | X          |        |          |                   |                  | X                  |                   | X                 |                     | X                   |                    | X          |         | X                        |          |      |     |             |                    |               |               |               | X     |
| O-540-A1D5 | X          |        |          |                   | X                |                    |                   | X                 |                     | X                   |                    | X          |         | X                        |          |      |     |             |                    |               |               |               | X     |
| O-540-A2B  | X          |        |          |                   | X                |                    |                   | X                 |                     | X                   | X                  |            | X       |                          |          |      |     |             |                    |               |               | X             |       |
| O-540-A2D  | X          |        |          |                   | X                |                    |                   | X                 |                     | X                   | X                  |            | X       |                          |          |      |     |             |                    |               |               | X             |       |

**WARNING**

Do not under any circumstances assemble chrome plated piston rings in a chrome plated cylinder barrel. Chrome plated cylinders are identified by an orange band around the base of the cylinder barrel.

2-3. Rocker shaft bearing supports are cast integrally with the heads along with housings to form the rocker boxes for both the exhaust and intake valve rockers.

2-4. VALVE OPERATING MECHANISM. The valve operating mechanism is located on the upper side of the engine, thereby facilitating proper lubrication and accessibility. The camshaft is parallel to and above the crankshaft, and operates in aluminum bearings. Hardened and ground cam lobes actuate the valves by means of mushroom type hydraulic tappets which automatically keep the valve clearance at zero, thereby eliminating the necessity of any valve clearance adjustment mechanism. The valve springs bear against both lower and upper spring seats and are retained on the valve stems by means of tapered split keys. The valve rockers are supported on full floating steel pins.

2-5. HYDRAULIC VALVE TAPPETS. When the engine valve is closed, the face of the cam follower is on the base circle or back of the cam. The light plunger spring lifts the hydraulic plunger so that its outer end contacts the push rod, exerting a light pressure against it, thus eliminating any clearance in the valve linkage. As the plunger moves outward, the ball check valve moves off its seat. (See figure 2-1.) Oil from the supply chamber, which is directly connected with the engine lubrication system, flows in and fills the pressure chamber. As the camshaft rotates, the cam pushes the cam follower and the hydraulic lifter cylinder outward. This action forces the ball check valve onto its seat; thus, the body of

oil trapped in the pressure chamber acts as a cushion. During the interval when the engine valve is off its seat, a predetermined leakage occurs between plunger and cylinder bore which compensates for any expansion or contraction occurring in the valve train. Immediately after the engine valve closes, the amount of oil required to fill the pressure chamber flows in from the supply chamber, thereby preparing for another cycle of operation.

2-6. CRANKSHAFT. The crankshaft is made from a chrome nickel molybdenum steel forging. All bearing journal surfaces are nitrided and centrifugal sludge removers are provided in the form of oil tubes at each crankpin journal. These tubes are removed during overhaul and replaced with new ones; this enables thorough cleaning of the internal oil passages in the crankshaft.

**NOTE**

Crankshafts on engines equipped for constant speed operation are not interchangeable with crankshafts on engines equipped for fixed pitch operation unless the plug installed in the rear of the hollow front section of the crankshaft is removed. In addition, two special (short) propeller flange bushings are used on constant-speed installations to accommodate a controllable pitch propeller. (See figure 7-9 and applicable Parts Lists.)

2-7. CRANKCASE. The crankcase assembly consists of two reinforced aluminum alloy castings divided vertically at the centerline of the engine and fastened together by means of a series of studs and nuts. The mating surfaces of the crankcase are joined without the use of a gasket, and the main bearing bores are machined for the use of precision type main bearing inserts. Machined mounting pads are incorporated into the crankcase for attaching the accessory housings, cylinders, and oil sump.

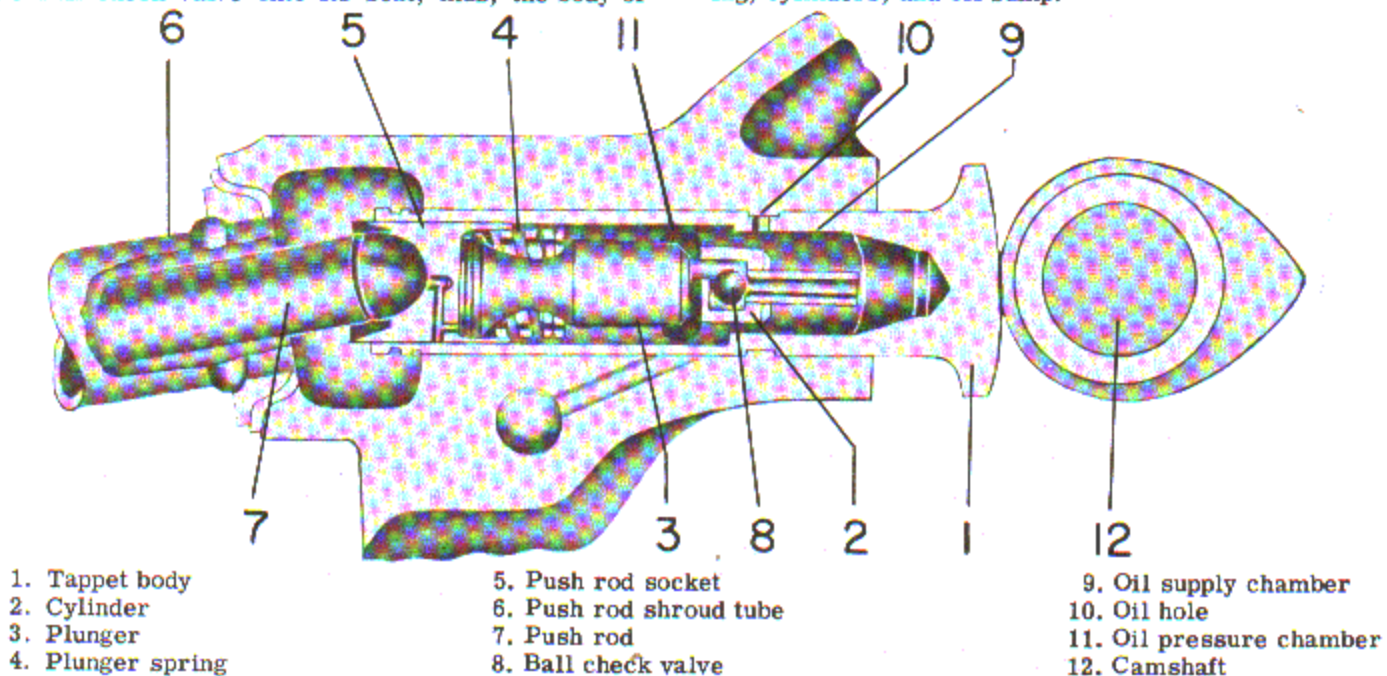


Figure 2-1. Diagram of Hydraulic Tappet

2-8. SUMP. The engines covered in this manual are of the wet sump type. The oil sump incorporates a carburetor mounting pad, the intake riser, and the intake pipe connections. The fuel-air mixture, as it passes through the riser, is vaporized by the heated oil in the sump that surrounds the riser. Drilled passages are provided in the sump for conveying oil to the oil pump.

2-9. CONNECTING RODS. The connecting rods are made in the form of "H" sections from alloy steel forgings. They have replaceable bearing inserts in the crankshaft ends and split type bronze bushings in the piston ends. The bearing caps on the crankshaft ends of the rods are retained by means of two bolts through each cap, secured by slotted nuts and cotter pins.

2-10. PISTONS. The full skirt type piston is machined from an aluminum alloy forging and is provided with grooves for three rings; two compression rings and an expander type oil regulating ring. The piston pin is of the full floating type with an aluminum plug located at each end to prevent the pin from touching the cylinder wall.

2-11. ACCESSORY HOUSING. The accessory housing is machined from an aluminum alloy casting and is fastened to the rear of the crankcase assembly and the top rear of the sump by hex head bolts. A gear train (see figures 2-2 and 2-3) mounted inside the housing, transmits power from the crankshaft to the camshaft, oil pump, magnetos, tachometer drive, and accessories. The gears, which are of the conventional spur type, are precision ground and hardened to insure long life and satisfactory operating qualities. Mounting pads are provided on the rear of the housing for the oil pressure screen chamber, magnetos, and accessories.

2-12. COOLING SYSTEM. The air pressure cooling system is actuated by the forward speed of the airplane. Baffles are provided to build up a pressure between the cowling and the cylinders, thus forcing the cool air through the cylinder fins. The air is then exhausted through augments tubes or gills located at the rear of the engine cowling.

2-13. LUBRICATION SYSTEM. (See figures 2-4 and 2-5.) Lubrication is of the full pressure wet sump type. The main bearings, connecting rod bearings, camshaft bearings, valve tappets, and push rods are lubricated by positive pressure. The pistons, piston pins, cams, cylinder walls, valve rockers, valve stems, and other parts are lubricated by means of oil collectors and spray.

2-14. The oil pump, which is located in the accessory housing, draws oil through a drilled passage which is connected to a similar drilled passage in the rear of the sump. The oil from the pump then enters a drilled passage in the accessory housing which feeds the oil to a threaded connection on the rear face of the accessory housing, where a flexible line leads the oil to the external full flow oil cooler. (See figure 5-1.) Pressure oil from the cooler returns to a second threaded connection on the accessory housing, from which point a drilled passage conducts the oil to the oil pressure screen which is contained in a cast cham-

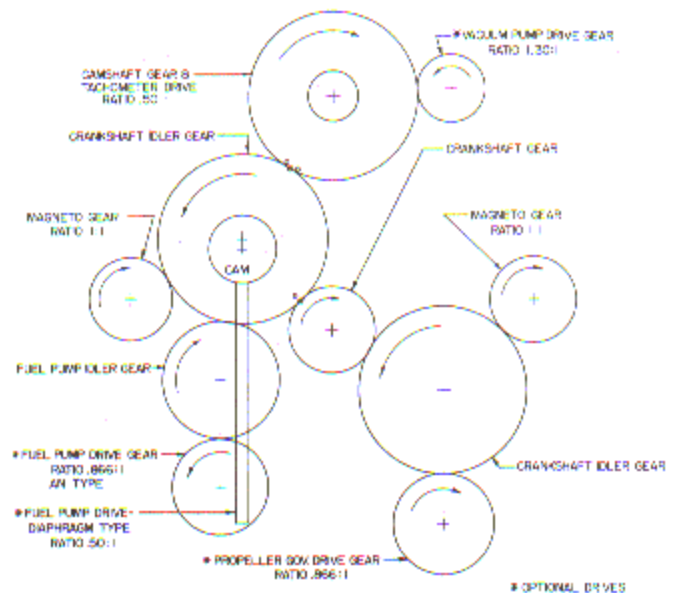


Figure 2-2. Gear Train Diagram, O-360

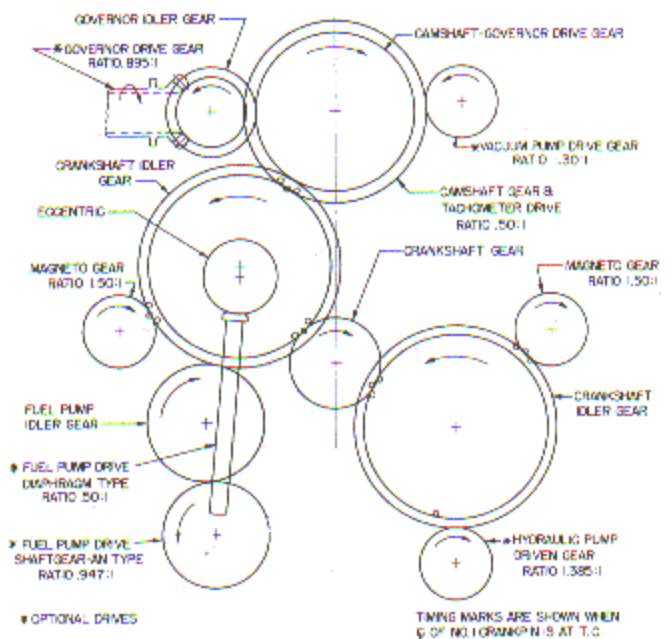


Figure 2-3. Gear Train Diagram, O-540

ber mounted on the accessory housing. In the event that cold oil or an obstruction should restrict the flow of oil to the cooler, an oil cooler by-pass valve is provided to pass the pressure oil directly from the oil pump to the oil pressure screen chamber. The oil pressure screen is provided as a means to filter any solid particles from the oil. After being filtered in the pressure screen chamber, the oil is fed through a drilled passage to the oil pressure relief valve, located in the upper right side of the crankcase in front of the accessory housing.

2-15. The oil pressure relief valve regulates the engine oil pressure by allowing excessive oil to return to the sump, while the balance of the pressure oil is

fed to the main oil gallery in the right half of the crankcase. During its travel through the main gallery, the oil is distributed by means of separate drilled passages to the main bearings of the crankshaft. The drilled passages to the bearings are located in such a manner as to form an inertia type filter. Thus, only the cleanest oil will be fed to the bearings. Angular holes are drilled through the main bearings to the rod journals where sludge removal tubes are located. Here the centrifugal force of the crankshaft removes any sludge or heavy matter that may be present in the oil. Drilled passages from the rear main bearings supply oil to the crankshaft idler gear shafts. Oil from the main oil gallery also flows to the cam and valve gear passages, and is then conducted through branch passages to the hydraulic tappets and camshaft bearings. Oil enters the tappets through indexing holes and travels out through the hollow push rods to the valve mechanism, lubricating the valve rocker bearings and valve stems. Residual oil from the bearings, accessory drives, and rocker boxes is returned by gravity to the sump, from where it is again circulated through the engine.

2-16. Pressure build up within the crankcase is held to a minimum by means of a centrifugal type breather (see figure 5-1) mounted on the upper section of the accessory housing.

2-17. INDUCTION SYSTEM. Carburetion is provided by either a Marvel-Schebler model MA-4-5 carburetor or a Bendix PS-5BD pressure carburetor. Particularly good distribution of the fuel-air mixture to each cylinder is obtained by the center zone induction system, which is integral with the sump and is submerged in oil, insuring a more uniform vaporization of fuel and aiding in cooling the oil in the sump. From the riser the fuel-air mixture is distributed to each cylinder by separate steel intake pipes.

2-18. IGNITION SYSTEM. Dual ignition is furnished by two Scintilla SN magnetos, which are mounted respectively on the upper right and left sides of the accessory drive housing. The shielded ignition wiring is so arranged that the left magneto fires the top plugs in the left-hand cylinders and the bottom plugs in the right-hand cylinders, while the right magneto fires the bottom plugs of the left-hand cylinders and the top plugs of the right-hand cylinders. (See figures 4-2 and 4-3.) This arrangement insures consistent drop off when switching from both magnetos to either the right or left magneto.

2-19. ACCESSORY DRIVES. The following accessory drives are furnished as standard equipment: starter, generator, and tachometer. Vacuum pump drives, fuel pump drives, and propeller governor drives are available as optional equipment.

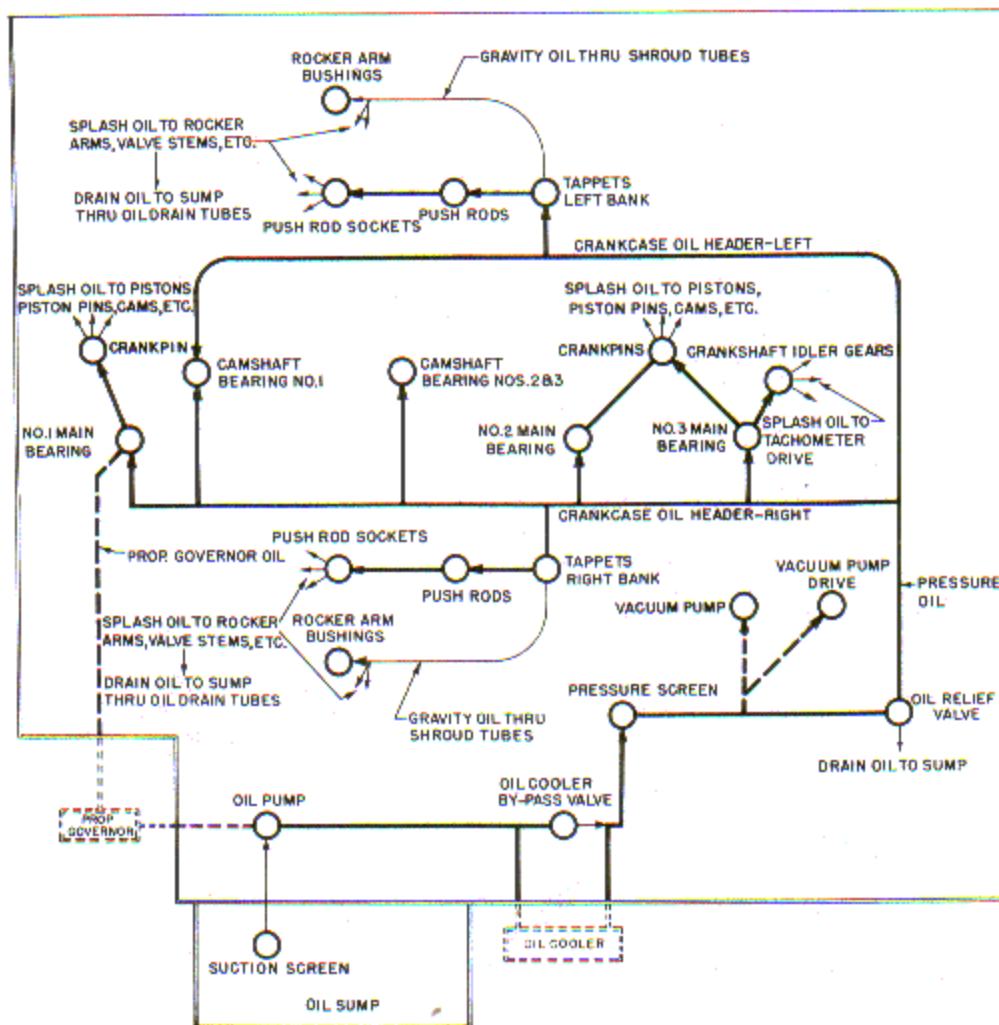


Figure 2-4. Lubrication Diagram, O-360

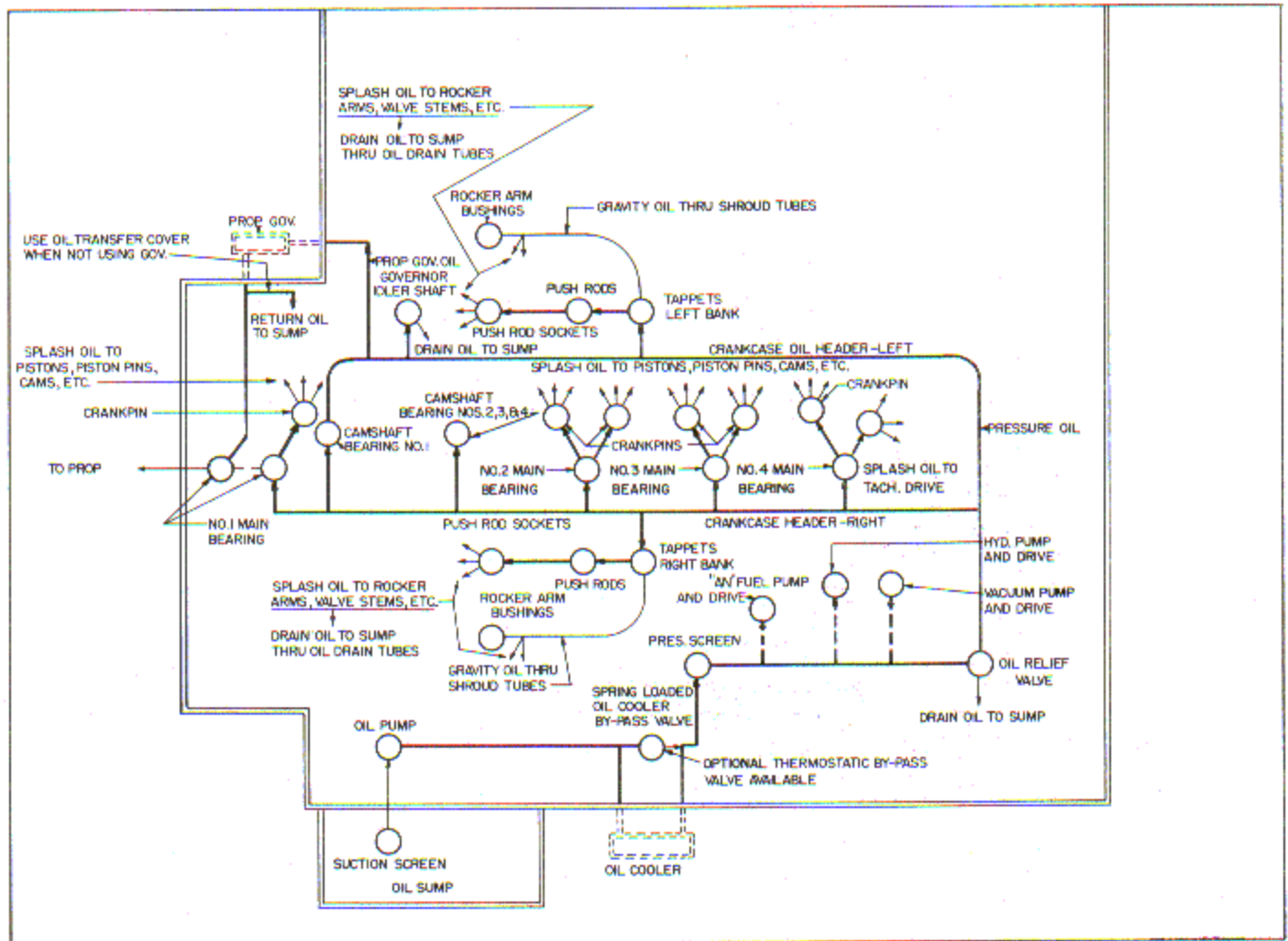


Figure 2-5. Lubrication Diagram, O-540

## SECTION III

### GENERAL OVERHAUL PROCEDURES

3-1. As mentioned in Section I, this manual will describe in separate chapters the complete overhaul of each individual section of the engine, thus dividing the manual, for all practical purposes, into a series of individual overhaul handbooks dealing in turn with the ignition system, accessory housing, cylinders, crankcase and crankshaft, and sump. Since there are various prescribed overhaul practices and instructions of a non-specific nature which apply equally to all basic engine components, these general instructions will be grouped together and described in Section III herein, thus eliminating repetition.

#### DISASSEMBLY

3-2. Inasmuch as visual inspection immediately follows disassembly, all individual parts should be laid out in an orderly manner on a workbench as they are removed from the engine. No cleaning operations should be performed until this initial visual inspection has been completed. All loose studs, cracked cooling fins, loose or damaged fittings, and the like, should be carefully tagged to prevent their being overlooked during inspection.

3-3. PREPARATION FOR OVERHAUL. By means of the engine lifting strap and a suitable chain hoist, remove the engine from the airframe. While the engine is supported in the air by the chain hoist, bolt the engine mounting ring (1, figure 1-1) to the engine mounts. The engine should then be lowered into position on the overhaul stand and dolly (2 and 3, figure 11-1) or other suitable rotary overhaul stand.

#### NOTE

If engine is equipped with dynafocal mounts, first attach dynafocal mount mounting ring adapters (4, figure 11-1) to the engine and then fasten mounting ring to adapters.

#### CLEANING

3-4. With certain limitations as described under Disassembly and Inspection headings of this section, it is imperative to clean all engine parts thoroughly to facilitate inspection. Two processes are involved in cleaning engine parts; degreasing and removal of dirt and sludge (soft carbon), and the removal of hard carbon deposits by decarbonizing, brushing or scraping, and grit-blasting.

3-5. DEGREASING. Degreasing is accomplished by immersing or spraying the part in a solution of carbon tetrachloride, white furnace oil (38-40 specific gravity), or a suitable commercial solvent such as Varsol

or Perm-A-Chlor. Operators are warned against the use of solvents with which they are unfamiliar, since there are products on the market which are injurious to aluminum and magnesium. Extreme care must be exercised if any water-mixed degreasing solutions containing caustic compounds or soap are used. Such compounds, in addition to being potentially dangerous to aluminum and magnesium, may become impregnated in the pores of the metal and cause oil foaming when the engine is returned to service. When using water-mixed solutions, therefore, it is imperative that the parts be completely and thoroughly rinsed in clear boiling water after degreasing. Regardless of the method and type of solution used, coat and spray all parts with lubricating oil immediately after cleaning in order to prevent corrosion.

3-6. REMOVAL OF HARD CARBON. While the degreasing solution will remove dirt, grease, and soft carbon, deposits of hard carbon will almost invariably remain on many interior surfaces. To facilitate removal, these deposits must first be loosened by immersion in a tank containing a decarbonizing solution (usually heated). A great variety of commercial decarbonizing agents are available, including such products as Gunk, Penetrol, Carbrax, Super-Chemaco, Gerlach No. 70 and many others. Decarbonizers, like the degreasing solutions previously mentioned, fall generally into two categories, water-soluble and hydro-carbons, and the same caution concerning the use of water-soluble degreasers is applicable to water-soluble decarbonizers.

#### CAUTION

Extreme caution should be exercised when using a decarbonizing solution on magnesium castings. It is recommended that the use of heated solutions be avoided unless the operator is thoroughly familiar with the particular solution being used. In addition, the operator is strongly advised against immersing steel and magnesium parts in the same decarbonizing tank, because this practice often results in damage to the magnesium parts from corrosion.

3-7. Decarbonizing will usually loosen most of the hard carbon deposits remaining after degreasing; the complete removal of all hard carbon, however, generally requires brushing, scraping, or grit-blasting. All of these operations demand care on the part of the mechanic to avoid damage to the machined surfaces. In particular, wire brushes and metal scrapers must never be used on any bearing or contact surface.

3-8. When grit-blasting parts, do not use sand or any metallic abrasives. It is recommended instead that

mildly abrasive organic substances such as rice, baked wheat, plastic pellets, or crushed walnut shells be used. All machined surfaces must, of course, be properly and adequately masked and all openings tightly plugged before blasting. The one exception to this, is the valve seats which may be left unprotected when blasting the cylinder head combustion chamber. It is often advantageous to grit blast the seats, since this will cut the glaze which tends to form (particularly on the exhaust valve seat), thus facilitating subsequent valve seat reconditioning. Piston ring grooves may be grit-blasted if necessary; extreme caution must be used, however, to avoid the removal of metal from the bottom and sides of the grooves. When grit-blasting housings, plug all drilled oil passages with rubber plugs or other suitable material to prevent the entrance of foreign matter.

3-9. The decarbonizing solution will generally remove most of the enamel on exterior surfaces. All remaining enamel should be removed by grit-blasting, particularly in the crevices between cylinder cooling fins.

3-10. At the conclusion of cleaning operations, rinse the part in petroleum solvent, dry and remove any loose particles of carbon or other foreign matter by air-blasting, and apply a liberal coating of preservative oil to all surfaces.

#### NOTE

A recommended preservative oil is Sinclair Rust-O-Lene 50, or equivalent.

### INSPECTION

3-11. The inspection of engine parts during overhaul is divided into three categories; visual, magnetic, and dimensional. The first two methods are aimed at determining structural failures in the parts, while the third and last method deals with the size and shape of each part. A "TABLE OF LIMITS" is shown in Section X. Structural failures can be determined by several different methods; the method employed depends on the part itself. Non-austenitic steel parts can readily be examined by the magnetic particle method. Other methods such as X-ray or etching can be used. During the inspection of an engine, it is a useful habit to have on hand several sets of inspection data sheets and, as each part is inspected, it can be checked off on the sheet with any discrepancies noted.

3-12. Visual inspection should precede all other inspection procedures. Do not clean any parts prior to visual inspection, since indications of a dangerous operating condition may often be detected from the residual deposits of metallic particles found in some particular recess in the engine.

3-13. Defects in non-ferro-magnetic parts are best found by careful visual inspection along with a suitable etching process. If it is thought that a fracture exists in an aluminum part, clean it with a fine wire brush (to remove any carbon, paint or gum) very carefully so as not to scratch the surface. Apply to the

part a solution made from 1-1/4 pounds of sodium hydroxide and one pint of water at room temperature. Rinse the part thoroughly with water after about one minute's contact with the solution. Immediately neutralize the part with a solution of one part of nitric acid and three parts of water heated to 38° C. (100° F.). Keep the part in this solution until the black deposit is dissolved. Dry the part with compressed air. If a crack exists, the edges will turn black after this treatment, thus aiding in its detection. For magnesium parts, the process of applying a ten percent solution of acetic acid at room temperature for a maximum time of one minute should be used, after which the part should be rinsed with a solution of one ounce of household ammonia in one gallon of water.

3-14. BEARING SURFACES. All bearing surfaces should be examined for scores, galling, and wear. Considerable scratching and light scoring of aluminum bearing surfaces in the engine will do no harm and should not be considered cause for rejection of the part, provided it falls within the clearances set forth in the Table of Limits. Even though the part comes within the specific clearance limits, however, it will not be satisfactory for reassembly into the engine unless inspection shows the part to be free from other serious defects. Ball bearings should be inspected visually and by feel for roughness, flat spots on balls, flaking or pitting of races, and for scoring on outside of races. All journals should be checked for galling, scores, misalignment and out-of-round condition. Shafts, pins, etc., should be checked for straightness. This may be done in most cases by using vee blocks and a dial indicator.

3-15. GEARS. All gears should be examined for evidence of pitting and excessive wear. These conditions are of particular importance when they occur on the involute of the teeth; deep pit marks in this area are sufficient cause to reject the gear. Bearing surfaces of all gears should be free from deep scratches. However, minor abrasions may be dressed out with a fine abrasive cloth.

3-16. CORROSION ON STRESSED AREAS. Pitted surfaces in highly stressed areas resulting from corrosion can cause ultimate failure of the part. The following areas should be carefully examined for evidence of such corrosion; interior surfaces of piston pins, the fillets at the edges of crankshaft main and crankpin journal surfaces, and thrust bearing races. If pitting exists on any of the surfaces mentioned to the extent that it cannot be removed by polishing with crocus cloth or other mild abrasive, the part must be rejected.

3-17. SCREWED FITTINGS. Screwed fittings (any parts such as threaded fastenings or plugs) should be inspected for condition of threads. Badly worn or mutilated threads must not be tolerated; the parts should be rejected. However, small defects such as slight nicks or burrs may be dressed out with a small file, fine abrasive cloth or stone. If the part appears to be distorted, badly galled, or mutilated by over-tightening, or from the use of improper tools, it must be replaced with a new one. Defective studs must be replaced with oversize studs.

Form 772

Sheet No. 1



**SERVICE ENGINE OVERHAUL RECORD AND INSPECTION FOR OPPOSED ENGINES**

Engine No. ....

Type .....

Carburetor No. ....

Magneto No. Rt. .... Lft. ....

SA No. .... RS No. ....

..... Date .....

Owner's Name ..... Address .....

Date Rec'd ..... Tot. Eng. Time ..... Time Since Last Overhaul .....

Reason For This Overhaul .....

Starter No. .... Fuel Pump No. .... Generator No. ....

Carburetor Int. Hsng. .... Prop. Parts Received .....

Oil Fittings ..... Spark Plugs .....

Special Equipment .....

|                               | Right | Left                    |
|-------------------------------|-------|-------------------------|
| Crankcase or                  |       | Crankshaft              |
| Crankcase — Cylinder Assembly |       | Thrust Bearing Journals |
| Finished Surfaces             |       | Main Bearing Journals   |
| Studs                         |       | Rod Bearing Journals    |
| Oil Passages                  |       | Oil Tubes               |
| Fins                          |       | Finished Surfaces       |
| Thrust Bearing                |       | Spline                  |
| Main Bearings                 |       | Threads                 |
| Cam Bearings                  |       | Counterweights          |
| Remarks                       |       | Rollers                 |
|                               |       | Plugs                   |
|                               |       | Remarks                 |
| Cam Follower                  |       |                         |
| Cam Follower Body             |       |                         |
| Hydraulic Unit                |       |                         |
| Finished Surfaces             |       | Camshaft                |
| Remarks                       |       | Cam Bearing Journals    |
|                               |       | Cam Lobes               |
|                               |       | Finished Surfaces       |
| Oil Sump                      |       | Remarks                 |
| Screen                        |       |                         |
| Plugs                         |       |                         |
| Studs                         |       |                         |
| Finished Surfaces             |       | Oil Relief Valves       |
| Remarks                       |       | Spring                  |
|                               |       | Seats                   |
|                               |       | Plungers                |
| Top Cover Plate               |       | Body                    |
| Finished Surfaces             |       | Remarks                 |
| Remarks                       |       |                         |

Figure 3-1. Typical Overhaul Record and Inspection Forms



3-18. **MAGNETIC INSPECTION.** All ferro-magnetic steel parts should be inspected by the magnetic particle method. The successful detection of structural failure by magnetic inspection demands skill and experience on the part of operating personnel. It must be remembered that almost any fabricated steel part will show indications of some kind, and it is important that the operator exercise good judgment in evaluating the indications. Too rigid an interpretation may result in the rejection of a sound part, while on the other hand, a part showing a dangerous indication may be returned to service as a result of a too casual diagnosis. In general, areas of stress concentration must be watched closely for fatigue cracks. These areas include such locations as keyways, gear teeth, splines, roots of threads, small holes, and fillets.

3-19. Proper judgment must also be used in determining the amount of current (amperage) applied; too little current will not sufficiently magnetize the part, while too heavy an application will permanently damage the part by overheating and burning thin areas adjacent to the electrodes. Again, skill and experience on the part of the operator are of the utmost importance.

3-20. **CORROSION-PREVENTION.** Upon completion of inspection, coat all steel parts with preservative oil. See text under "Cleaning" in this section for recommended mixture.

## REPAIR AND REPLACEMENT

3-21. **DAMAGED PARTS.** Abnormal damage such as burrs, nicks, scratches, scoring, or galling should be removed with a fine oil stone, crocus cloth, or any similar abrasive substance. Following any repairs of this type, the part should be carefully cleaned in order to be certain that all abrasive has been removed, and then checked with its mating part to assure that the clearances are not excessive. Flanged surfaces that are bent, warped, or nicked may be repaired by lapping to a true surface on a surface plate. Again the part should be cleaned to be certain that all abrasive has been removed. Defective threads can sometimes be repaired with a suitable die or tap. Small nicks can be removed satisfactorily with Swiss pattern files or small, edged stones. Pipe tapped threads should not be tapped deeper in order to clean them up, because this practice will invariably result in an oversized tapped hole. If scratches or galling are removed from a bearing surface of a journal, it should be buffed to a high finish. Generally it is impossible to repair cracks; however, welding operations may be performed in some parts of housings, provided the area is not a stressed section of the part. For example, almost any area of a rocker box may be welded, but no part of the cylinder head, except the fins, may be welded.

3-22. **PAINTED PARTS.** Following repair of parts requiring use of paint for protection or appearance parts should be repainted according to the following recommendations:

3-23. Aluminum-alloy parts should have original exterior painted surfaces rubbed smooth to provide a proper paint base. See that surfaces to be painted are thoroughly cleaned. Care must be taken to avoid painting mating surfaces. Exterior aluminum parts should be primed first with a thin coat of zinc chromate primer. Each coat should be either air dried for two hours or baked at 177° C. (350° F.) for one-half hour. After the primer is dry, parts should be painted with gray engine enamel, which should be air dried until hard or baked for one-half hour at 82° C. (180° F.). Aluminum parts from which the paint has not been removed may be repainted without the use of a priming coat, provided no bare aluminum is exposed.

3-24. Parts requiring a black gloss finish should be primed first with zinc chromate primer and then painted with glossy black cylinder enamel. Each coat should be baked for 1-1/2 hours at 177° C (350° F). If baking facilities are not available, cylinder enamel may be air dried; however, an inferior finish will result. All paint applied in the above operations preferably should be sprayed; however, if it is necessary to use a brush, exercise care to avoid an accumulation of paint pockets.

3-25. Shroud tubes should be refinished inside and out by dipping in zinc chromate primer thinned to spraying consistency. After the zinc chromate primer is dried, the outside of the shroud tubes should be refinished with glossy black enamel.

3-26. Magnesium parts should be cleaned thoroughly with a dichromate treatment prior to painting. This treatment consists of cleaning all traces of grease and oil from the part by using a neutral, non-corrosive degreasing medium followed by a rinse, after which the part is immersed for at least 45 minutes in a hot dichromate solution (3/4 pounds of sodium dichromate to one gallon of water at 180-200° F—quantity as required). Then the part should be washed thoroughly in cold running water, dipped in hot water, and dried in an air blast. Immediately thereafter, the part should be painted with a prime coat and grey engine enamel in the same manner as that prescribed for aluminum parts.

3-27. **STUD REPLACEMENT.** Any studs which are bent, broken, damaged, or loose must be replaced. After a stud has been removed, the tapped stud hole should be examined for size and condition of threads. If it is necessary to retap the stud hole, it will also be necessary to use a suitable oversize stud. Oversize studs are furnished 0.003, 0.007 and 0.012-inch oversize. Studs that have been broken off flush with the case must be drilled and removed with an "Easy-Out" or other suitable stud remover. Be careful not to damage threads. When replacing studs, coat the coarse threads of the stud with anti-seize compound.

3-28. **CORROSION-PREVENTION.** At the conclusion of all repair operations and subsequent inspection, coat all steel parts with preservative oil. See text under "Cleaning" in this section for recommended mixture.

## REASSEMBLY

3-29. CORROSION-PREVENTION. Prior to assembly of subassemblies, all parts should be cleaned to remove all traces of preservative oil and accumulated foreign matter. During assembly, cover all steel parts with a heavy coat of preservative oil (Sinclair Rust-O-Lene 50 or equivalent). This preservative should be used on all machined surfaces, especially on bearing surfaces, cylinder bores, and piston rings. The practice of using plain lubricating oil during assembly is not recommended.

3-30. TABLE OF LIMITS. The Table of Limits (Section X) should be consulted whenever it is desired to determine the backlash and end clearance of gears, the clearance between mating machined parts, the clearance between moving parts which are in close contact with each other, and the torque limits for various nuts, screws, and fastenings.

3-31. OIL SEALS AND GASKETS. When building up an engine during major overhaul, replace all oil seals and gaskets throughout the engine. For complete re-

placement sets of seals and gaskets available for these engines, consult applicable Parts Catalog.

3-32. ARBITRARY REPLACEMENT OF PARTS. It is recommended that certain parts throughout the engine be replaced at normal overhaul regardless of their apparent condition. Included among these are the following:

- All engine oil hose
- All oil seals
- All gaskets
- All circlips, lockplates, and retaining rings
- Piston rings
- All exhaust valves
- All bearing inserts (main and crankpins)
- Magneto drive cushions
- Stressed bolts and fastenings
  - Camshaft gear attaching bolts
  - Connecting rod bolts and nuts
  - Crankshaft flange bolts
- Ignition cables
- All laminated shims
- Crankshaft sludge tubes
- Exhaust valve keys

## SECTION IV

## IGNITION SYSTEM

4-1. There are eight different magnetos used on the various engine models incorporated in this overhaul manual. The O-360 Series engines incorporate S4LN magnetos and the O-540 Series engines incorporate S6LN magnetos. In each of these two groups there are four different models. The -20 magnetos are standard magnetos employing two-pole rotating type magnets. The -21 magnetos are like the -20 magnetos but employ an impulse coupling. The purpose of the impulse coupling is: (1) to rotate the magnet faster than engine cranking speed, thus generating a better spark for starting (2) to automatically retard the spark when starting the engine. When the engine is running the impulse coupling acts as a drive coupling for the magneto. Magnetos with the -200 suffix incorporate a retard breaker and are used with a starting vibrator to facilitate better starting. The -200 magnetos also contain a noise filter. All -204 magnetos are like -20 magnetos except that they, too, incorporate noise filters.

4-2. Table II-I in Section II provides information as to which magnetos are incorporated on the various model engines. There is little difference between the various model magnetos where timing and disassembly and assembly to the engine are concerned.

## DISASSEMBLY

4-3. IGNITION CABLES. Remove all elbow terminals from the top and bottom spark plugs. Remove the clamps which secure the lower ignition cables to each intake pipe and remove the clamps from both the right and left sides of the engine near the lower engine mounting lugs. Do not remove the clamps which encircle the cables at this time. Disengage all ignition cables from the engine. Place a suitable covering over the terminal holes in the magnetos to prevent any foreign substance from entering therein, and unscrew the spark plugs from each cylinder with spark plug wrench socket (1, figure 11-2) and offset handle (4, figure 11-2).

4-4. MAGNETOS. Remove the magnetos, adapter and gaskets from the engine by unscrewing the two 5/16-18 plain nuts and washers from the studs which secure the magnetos to the engine. Reach through the openings in the magneto drive pads of O-540 engines and remove the drive cushions, drive cushion retainers and gears. No further disassembly of magnetos is needed other than the removal of the drive coupling from the right magneto of the O-540 engine. Place shouldered bushing, washer and nut, which are magneto parts, back on S6LN magneto shafts after removing drive coupling; this is to prevent threads from being damaged.

## REPAIR AND REPLACEMENT

4-5. IGNITION CABLES. Unless the ignition cable assembly is obviously in new condition and is known to have been installed recently, it is recommended that the ignition cables be replaced at normal overhaul. Note, however, that the following parts may be re-used at the discretion of inspection personnel; outlet plate, 4 or 6-wire grommet, coupling nut, and the grommets and clips attaching the ignition cables to the engine.

4-6. MAGNETOS. For information concerning the inspection and overhaul of Scintilla magnetos, refer to manufacturer's applicable publications.

## REASSEMBLY

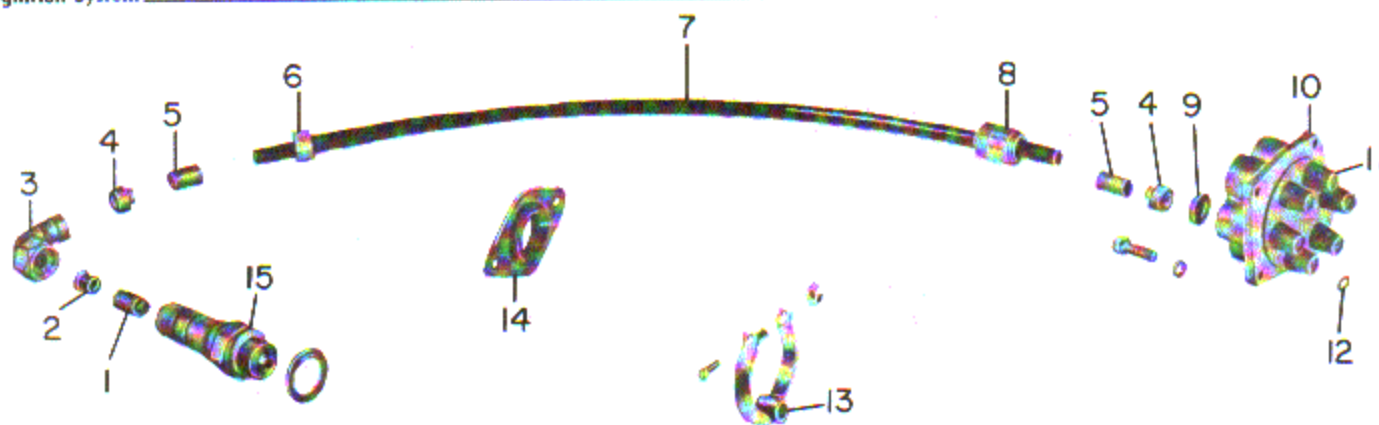
## NOTE

The following instructions for reassembly are for engines incorporating -20 or -204 magnetos on the right side and -21 or -200 magnetos on the left. When assembling O-540-A1B5 or O-540-A1C5 engines which have two S6LN-21 magnetos, one on each side, simply use instructions given for left magneto, to assemble and install both right and left magnetos.

4-7. MAGNETOS (O-360 Engines). Install a Woodruff key in the keyway of the magneto shaft and assemble the magneto gear in place on the shaft. Place a spacer over the shaft and screw on a castellated nut. The magneto gear may be held in a vise while the nut is being tightened. Secure nut with a cotter pin.

4-8. MAGNETOS (O-540 Engines). Assemble the magneto drive coupling on tapered shaft of S6LN-20 (right) magneto. Be certain the Woodruff key is in the slot of the magneto shaft. Assemble magneto drive bushing on the magneto shaft and again be certain a Woodruff key is in the slot in the shaft. Assemble the magneto washer and nut on the shaft. Tighten the nut to 15 to 25 foot pounds torque and secure with cotter pin. Assemble two magneto drive cushions and a drive cushion retainer over the bushing on each magneto.

4-9. MAGNETO DRIVE (O-540 Engines). Install the magneto gears by reaching through the openings in the magneto drive pads and inserting the gears into the bearings. It will be noted that each of the gears has a timing mark etched on one of its gear teeth and the crankshaft idler gears each have marks



### COMPLETE IGNITION CABLE ASSY.

- |                      |                                 |                             |
|----------------------|---------------------------------|-----------------------------|
| 1. Spark plug sleeve | 6. Spark plug union nut         | 11. 6-wire grommet          |
| 2. Spark plug collar | 7. Ignition cable               | 12. Slotted contact washer  |
| 3. Spark plug elbow  | 8. Coupling nut                 | 13. Ignition cable sleeve   |
| 4. Ferrule           | 9. Contour washer               | 14. Cable plate and grommet |
| 5. Sleeve            | 10. Ignition cable outlet plate | 15. Spark plug              |

Figure 4-1. Ignition Cable Assembly, Exploded

etched on two adjacent teeth. The marked tooth of the magneto gear must mesh with the space between the marked teeth of the crankshaft idler gear.

#### 4-10. MAGNETO TIMING.

4-11. When the engine buildup has progressed to the point where all major subassemblies are assembled and in place on the engine, the magnetos should be installed and timed. The following paragraphs describe the recommended procedure.

4-12. Turn the crankshaft opposite to its normal direction of rotation until it is approximately 35 degrees BTC on the compression stroke of number one cylinder. Clamp the ignition timing pointer (2, figure 11-2) on the 25 degrees mark on the starter ring gear. Rotate the crankshaft in its normal direction of rotation until the pointer and the crankcase parting flange are aligned. In this position both valves on number one cylinder should be closed. If the exhaust valve of number one cylinder is open, the engine is on the exhaust stroke of number one cylinder and the crankshaft must be turned one complete revolution before it is in proper position to install the magnetos. Leave the crankshaft in this position until right magneto is installed in place on the engine.

4-13. Rotate the drive coupling (S6LN magnetos) or magneto gear (S4LN magnetos) on the right magneto until the chamfered tooth on the distributor gear inside the magneto aligns with the white pointer as seen through the window in the magneto cover. Without allowing gear to turn from this position, assemble the magneto and gasket; on O-540 engines also assemble adapter and second gasket. Secure magneto in place with washers and nuts; tighten the nuts only finger tight.

4-14. Fasten ground wire on electric timing light to any unpainted metallic portion of the engine, and one of the positive wires of the timing light to a suitable terminal connected to the ground terminal connection of the right magneto. Turn engine crankshaft several degrees from BTC in direction opposite to that of normal rotation.

4-15. Turn on the switch of the timing light. The light should be lit. Turn the crankshaft very slowly in direction of normal rotation until the ignition timing pointer aligns with the mark on the camshaft gear, at which point the light should dim (or go out on battery-operated models). If it does not, turn the magneto in its mounting flange slots and repeat the procedure until the light dims at 25 degrees before dead center. Tighten the two mounting nuts and replace magneto inspection plug.

4-16. Install the impulse coupling magneto adapter and gasket on the left magneto mounting pad of the accessory housing.

#### CAUTION

The impulse coupling magneto (-21) or the -200 magneto can be used only on the left side of the engine (as viewed from rear) when used in conjunction with -20 or -204 magnetos.

4-17. Remove inspection plug, depress pawl on impulse coupling shaft and turn impulse coupling on left magneto until the white beveled tooth (or middle tooth, if timing gear has three beveled teeth) aligns with the timing pointer. Without allowing the magneto gear to turn from this position, assemble the left magneto to the accessory housing and secure with washers and nuts. Tighten nuts only finger tight.

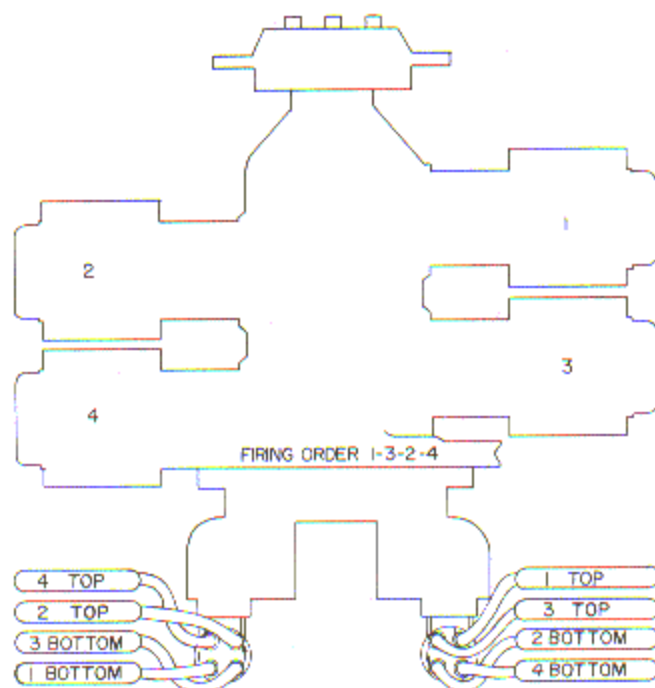


Figure 4-2. Ignition Wiring Diagram, O-360

## NOTE

If retard breaker (-200) magneto is used on left side of engine, the chamfered tooth marked with red dye must align with the white timing mark on the distributor block before magneto is installed on engine.

4-18. Connect the other positive wire of the timing light to a suitable terminal connected to the ground terminal connection of the left magneto and time the magneto in the same manner as described for the right magneto.

## NOTE

The crankshaft should not be rotated more than 10 degrees in direction opposite normal rotation; because the pawl on the impulse coupling will engage with the stoppin and late timing will be indicated through the impulse coupling mechanism. If this should happen, rotate engine in normal direction until sharp click is heard; this will indicate that the impulse coupling has passed through firing position. Turn crankshaft in direction opposite normal rotation to approximately 35 degrees BTC and proceed with timing check.

4-19. After both magnetos have been timed, leave the timing light wires connected and re-check magneto timing as previously described to make sure that both magnetos are set to fire together. If timing is correct, both timing lights will dim simultaneously when the timing pointer aligns with the centerline of the crankcase. If the breaker points open too early, loosen the mounting nuts and rotate the magneto clockwise. If the breaker points open too late, rotate the magneto counter-clockwise. Remove timing light

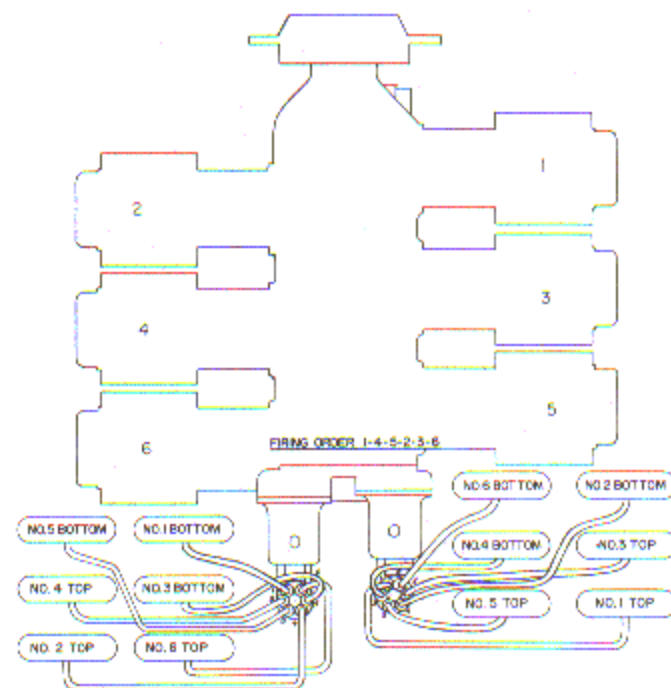


Figure 4-3. Ignition Wiring Diagram, O-540

and ignition timing pointer, and replace timing inspection plug in magneto.

4-20. After the magnetos have been properly timed, clean the breaker points to remove any trace of oil or dirt. Replace breaker cover and lock the retaining screws together with lockwire.

## 4-21. IGNITION CABLE ASSEMBLY AND INSTALLATION.

4-22. ASSEMBLY OF IGNITION HARNESS (AUTO-LITE OR PACKARD). To assemble the ignition cables, first cut the individual cables to the lengths shown in TABLES IV-I, IV-II, or IV-III. Assemble each harness (right and left) using a special crimping tool and wire stripper (Aircraft-Marine Products, Inc., Harrisburg, Pa., Part No's. 59249 and 47665 or equivalent). The procedure for assembly of the harness is as follows:

4-23. See figure 4-4. Make a mark 1-1/4 inches back from the magneto end of the cable, and using the middle cutter (marked "shield") provided on the cutting tool, proceed to cut through the outer cover and the wire braiding, being careful not to cut the inside cable. The cutting can be facilitated by using a pendulum motion with the cutter. Remove the cut material by sliding it off the end of the cable. Make a mark 1-3/4 inches from the end of the cable. Turn the cutting head over and using the uppermost cutter, cut through the outer shielding and remove by sliding off cable. Make a mark, 1/4 inch from the end of the cable; and using the lower cutter provided on the cutting tool, strip the cable to the wire, leaving the wire strands exposed.

4-24. Prepare the spark plug ends of the cables in the same manner as described in the preceding paragraph; except that the first cut is taken three inches from the

end of the cable and the second cut is 3-1/2 inches from the cable end. See figure 4-4.

4-25. Slide a coupling nut (8, figure 4-1) and sleeve (5, figure 4-1) (tapered end toward cable end) over the magneto end of the cable. Select the proper ferrule (4, figure 4-1) to provide minimum clearance when assembled, and slip it up under the braiding that is exposed. Slide the sleeve (5, figure 4-1) into the recess provided in the ferrule. Open the crimping tool jaws to their maximum by opening the lever provided on the tool and insert the assembled ferrule and sleeve into the hole provided in the jaws. Apply a firm pressure on the handles of the tool to crimp the ferrule in order to make a firm tight grip on the cable.

4-26. Refer to the ignition wiring diagram (figure 4-2 or 4-3) and arrange the cables in the proper sequence. Install a contour washer (9, figure 4-1) over the end of each cable; then slide the magneto ends of the six cables into the holes in the ignition outlet plate (10, figure 4-1), making sure that the number one cable enters the marked hole in the plate and that the remaining cables follow in their proper order. Slide the 6-wire (or 4-wire) grommet (11, figure 4-1) onto the cable ends protruding from the outlet plate. Insert the bared ends of the cable strands through the hole in the center of the slotted contact washer, (12, figure 4-1). Divide the strands and bend them over the face, through the slots and under the rim of the washer.

4-27. Slide the cable plates (14, figure 4-1) onto their respective cables; on an O-540 harness a single grommet plate is installed over each of the three top leads of each harness and on the O-360 harnesses a dual grommet plate is installed over the two top leads of each harness.

TABLE IV — II  
LENGTH OF INDIVIDUAL AUTOLITE  
OR PACKARD CABLES  
(O-540 AIRCRAFT ENGINES\*)

| Cylinder No. and Plug Location | Magneto No. | Cable Length (Inches) |
|--------------------------------|-------------|-----------------------|
| 1 Bottom                       | Left 1      | 53.5                  |
| 4 Top                          | Left 2      | 32.5                  |
| 5 Bottom                       | Left 3      | 41                    |
| 2 Top                          | Left 4      | 41                    |
| 3 Bottom                       | Left 5      | 47.5                  |
| 6 Top                          | Left 6      | 27.5                  |
| 1 Top                          | Right 1     | 42.5                  |
| 4 Bottom                       | Right 2     | 47.5                  |
| 5 Top                          | Right 3     | 32                    |
| 2 Bottom                       | Right 4     | 53.5                  |
| 3 Top                          | Right 5     | 35                    |
| 6 Bottom                       | Right 6     | 43                    |

\* All O-540 engines except those installed in aircraft manufactured by Piper Aircraft Corporation.

TABLE IV — III  
LENGTH OF INDIVIDUAL AUTOLITE  
OR PACKARD CABLES  
(O-540 ENGINES INSTALLED IN PIPER AIRCRAFT)

TABLE IV — I  
LENGTH OF INDIVIDUAL AUTOLITE  
OR PACKARD CABLES  
(O-360 AIRCRAFT ENGINES)

| Cylinder No. and Plug Location | Magneto No. | Cable Length (Inches) |
|--------------------------------|-------------|-----------------------|
| 1 Bottom                       | Left 1      | 47                    |
| 3 Bottom                       | Left 2      | 41                    |
| 2 Top                          | Left 3      | 29.25                 |
| 4 Top                          | Left 4      | 21.75                 |
| 1 Top                          | Right 1     | 30.50                 |
| 3 Top                          | Right 2     | 24.50                 |
| 2 Bottom                       | Right 3     | 44.50                 |
| 4 Bottom                       | Right 4     | 39.50                 |

| Cylinder No. and Plug Location | Magneto No. | Cable Length (Inches) |
|--------------------------------|-------------|-----------------------|
| 1 Bottom                       | Left 1      | 53.5                  |
| 4 Top                          | Left 2      | 34.5                  |
| 5 Bottom                       | Left 3      | 41                    |
| 2 Top                          | Left 4      | 42                    |
| 3 Bottom                       | Left 5      | 47.5                  |
| 6 Top                          | Left 6      | 30.5                  |
| 1 Top                          | Right 1     | 42.5                  |
| 4 Bottom                       | Right 2     | 47.5                  |
| 5 Top                          | Right 3     | 36                    |
| 2 Bottom                       | Right 4     | 53.5                  |
| 3 Top                          | Right 5     | 40                    |
| 6 Bottom                       | Right 6     | 43                    |

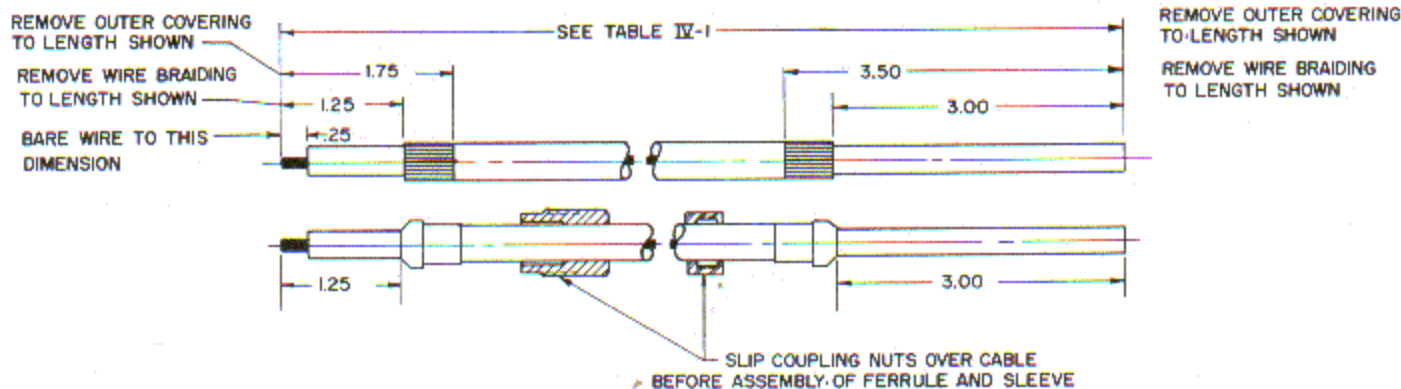


Figure 4-4. Preparation of Autolite Cables for Assembly

4-28. Slide an ignition cable sleeve (13, figure 4-1) over each bottom spark plug lead, then slide a spark plug union nut (6, figure 4-1) over the spark plug end of each lead. Install a sleeve and ferrule (5 and 4, figure 4-1) on each lead in the same manner as described in paragraph 4-24. Install a spark plug elbow (3, figure 4-1) and secure in place with the spark plug union nut. Strip the cable back 1/4 inch from the end, slide the spark plug collar (2, figure 4-1), then the spark plug sleeve (1, figure 4-1) over the cable and secure the sleeve by dividing the conductor strands into two groups and bending each group back over the end of the sleeve; repeat for all cables.

4-29. INSTALLATION OF AUTOLITE OR PACKARD HARNESES. (See figure 4-1.) Secure each harness to its respective magneto by screwing the outlet plate (10) to the plate mounting flange on the magneto. Install cable clips at sides and on rear of accessory housing to secure bottom ignition leads to engine. (See installation drawings at end of Section IX for location of clips.) Attach each bottom lead to its adjacent intake pipe with an offset clamp and screw the elbow into the spark plug. All upper leads run directly from the magnetos to the plugs without intermediate clamps. Refer to the ignition wiring diagrams (figures 4-2 and 4-3) for correct terminal connections when installing all leads.

4-30. ASSEMBLY OF BREEZE AND CO-OP HARNESES (O-360 ONLY). Make certain the cable at the magneto ends of the ignition harness leads is trimmed 1.31 - 1.37 inches from the face of the ferrule. The spark plug end of the leads must be trimmed 1.12 - 1.18 inches from the ferrule face. Trim the insulation from both ends of each cable, cutting the

insulation back .32 inch. Assemble each harness right and left as follows:

4-31. Refer to the ignition wiring diagram (figure 4-2) and arrange the lead assemblies in the proper sequence. Insert the magneto ends of the lead assemblies into the outlet plate making sure that the No. 1 cable enters the marked hole in the plate and that the remaining cables follow in the proper order. Slide the terminal block onto the cable ends protruding from the outlet plate. Insert the bared ends of the cable strands of each lead through the hole in the center of a slotted cable fastening washer. Divide the strands into two groups of three and four, and bend them over the face, through the slots and under the rim of the washer. Complete the assembly of the magneto end of the harness by screwing the bushing nuts into the outlet plate using the magneto bushing wrench (3, figure 11-2).

4-32. Slide a rubber collar and terminal over the end of each cable and secure the terminal by bending the exposed conductor strands back over the end of the terminal.

4-33. INSTALLATION OF BREEZE AND CO-OP HARNESS (O-360 ONLY). Secure each harness to its respective magneto by screwing the outlet plate to the plate mounting flange on the magneto. Install cable clips at sides and on rear of accessory housing to secure bottom ignition leads to engine. (See installation drawings at end of Section IX for location of clips.) Attach each bottom lead to its adjacent intake pipe with an offset clamp and screw the elbow into the spark plug. All upper leads run directly from the magnetos to the plugs without intermediate clips. Refer to ignition wiring diagram (figure 4-2) for correct terminal connections when installing all leads.

## SECTION V

## ACCESSORY HOUSING

5-1. It is assumed that all accessories, such as fuel pump, vacuum pump, etc., with which the engine is equipped, will have been removed from the accessory housing before the disassembly of the housing, as described in the following paragraphs, is begun. For overhaul procedures covering the various accessories themselves, consult the applicable manufacturer's handbook.

## DISASSEMBLY

## 5-2. INITIAL DISASSEMBLY.

5-3. OIL PRESSURE SCREEN HOUSING. (See figure 5-1.) Remove this unit from the engine by unscrewing the four 1/4-inch hex head bolts which secure the housing to the rear of the accessory housing.

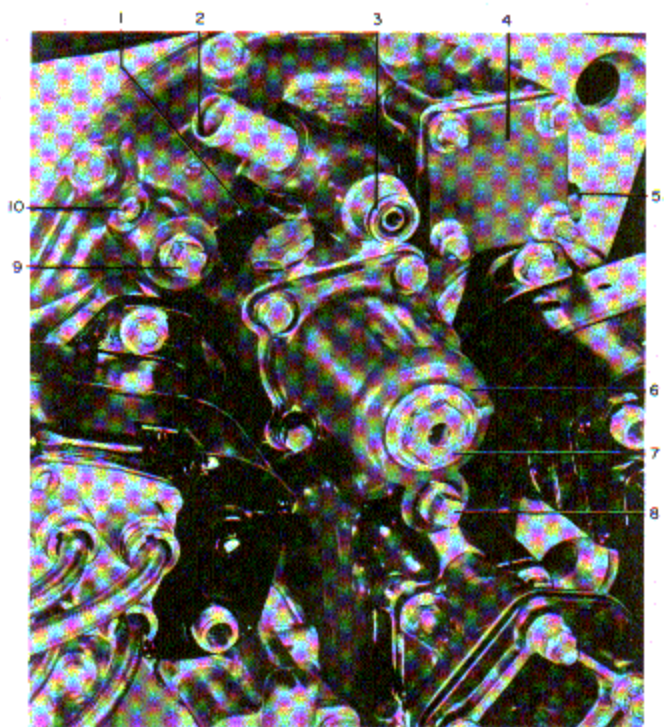
5-4. REMOVAL FROM ENGINE. The accessory housing is removed from engine by unscrewing the twelve

1/4-inch hex head bolts securing the housing to the crankcase.

## 5-5. FINAL DISASSEMBLY.

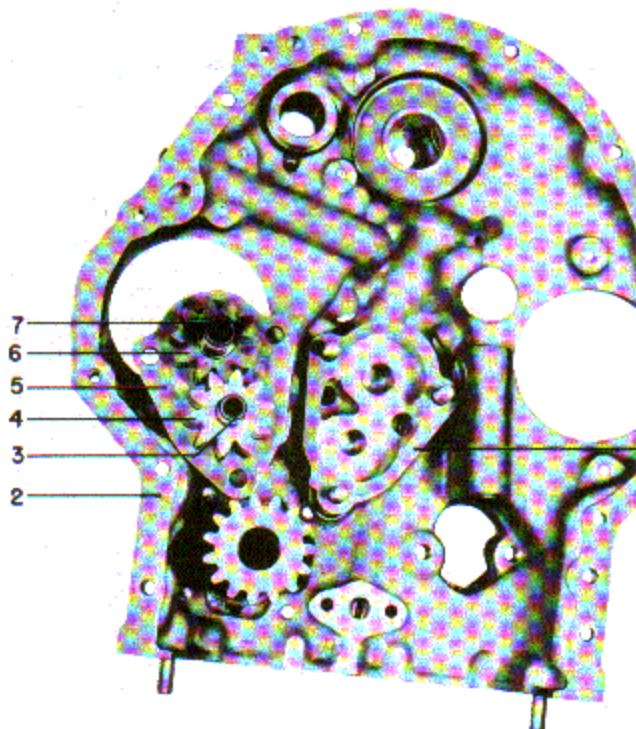
5-6. OIL PUMP. (See figure 5-2.) Remove the 0.040 diameter lockwire from the three 5/16-inch slotted nuts around the oil pump cover and remove the nuts with a 1/2-inch socket wrench. Remove the oil pump cover (5) and body (1) from the accessory housing and then detach the oil pump impellers (4) and (6). Pull the oil pump drive shaft (7) out of the cover, but do not remove the oil pump idler shaft (3) unless it is damaged.

5-7. ACCESSORY HOUSING. Remove any accessory drive adapters, such as vacuum pump, propeller governor or hydraulic pump, that are still remaining on the housing. If the engine is equipped with an "AN" fuel pump drive, remove the fuel pump idler gear from the idler gear shaft and remove the idler gear shaft from the housing by removing the two 1/4-20 hex head screws that hold it in place. Unscrew the



- |                                |                                     |
|--------------------------------|-------------------------------------|
| 1. Oil Cooler by-pass valve    | 7. Oil temperature thermometer well |
| 2. Crankcase breather          | 8. Oil connection to cooler         |
| 3. Tachometer drive            | 9. Oil connection from cooler       |
| 4. Vacuum pump mounting pad    | 10. 1/8-inch pipe plug              |
| 5. 1/8-inch pipe plug          |                                     |
| 6. Oil pressure screen housing |                                     |

Figure 5-1. Location of Oil Pressure Screen Housing



- |                         |                     |
|-------------------------|---------------------|
| 1. Oil pump body        | 4. Driven impeller  |
| 2. Accessory housing    | 5. Oil pump cover   |
| 3. Oil pump idler shaft | 6. Driving impeller |
| 7. Oil pump drive shaft |                     |

Figure 5-2. Interior View of Accessory Housing with Oil Pump Cover Removed



1/8-inch Allen head pipe plug (5, figure 5-1) from the upper right side of the accessory housing and remove a similar plug (10, figure 5-1) from the upper left side of the housing. Unscrew the oil cooler by-pass plug and remove the gasket spring and plunger.

## CLEANING

5-8. Clean all accessory housing parts in accordance with general instructions outlined in Section III of this manual. Specific instructions will be found in the following paragraphs.

5-9. DRILLED OIL PASSAGES. Particular care must be given when cleaning the accessory housing to see that accumulations of sludge and foreign matter are completely removed from the drilled oil passages. Make absolutely certain all threaded plugs have been removed, and then use a finger brush of suitable size with stiff bristles to clean the various oil passages. After cleaning, blow out all passages with petroleum solvent and air.

## INSPECTION

5-10. Inspect all accessory housing parts in accordance with the general instructions outlined in Section III of this manual. Specific instructions will be found in the following paragraph.

5-11. SHAFTS AND IMPELLERS. Check the mating fits between oil pump shafts and impellers, comparing the clearance in each case with the fit listed in the Table of Limits.

## REPAIR AND REPLACEMENT

5-12. Repair all accessory housing parts in accordance with the general instructions in Section III of this manual.

## REASSEMBLY

5-13. All semi-permanent fittings on the accessory housing should have been replaced during inspection and repair. However, before beginning assembly of the accessory housing, check the three oil passage openings in the housing to determine if they have been properly sealed. One opening is located on the upper side of the oil screen chamber mounting pad and it should be closed with a 1/8-inch Allen head pipe plug (10, figure 5-1). An identical pipe plug (5, figure 5-1) should also be located in the oil passage on the right side of the accessory housing near the magneto mounting pad. If any of these pipe plugs were not inserted during inspection and repair of the accessory housing, the oil passages should be carefully checked to ascertain if any foreign substance has accumulated in them. Immediately following this inspection, coat the threads of the pipe plugs with a suitable thread lubricant and screw them tightly in their proper locations.

5-14. OIL PUMP. (See figure 5-2.) Assemble the oil pump body (1) over the studs on the interior of the accessory housing (2). (No gasket or shim is used with any part of the oil pump.) Then insert the oil pump impellers into the body. The driving impeller (6) is made of steel and must be assembled in the upper compartment of the oil pump body. The driven impeller (4) is made from aluminum and must be assembled in the lower compartment of the oil pump body.

5-15. Check the side clearance between the oil pump cover and the impellers, also the diameter clearance between the oil pump body and the impellers. (See Table of Limits.)

5-16. After the impellers have been inserted in the oil pump body, the oil pump cover (5) may be placed over the studs and fitted against the oil pump body. (This cover should have the oil pump idler shaft (3) assembled with it and secured with a 0.13-inch diameter cotter pin.)

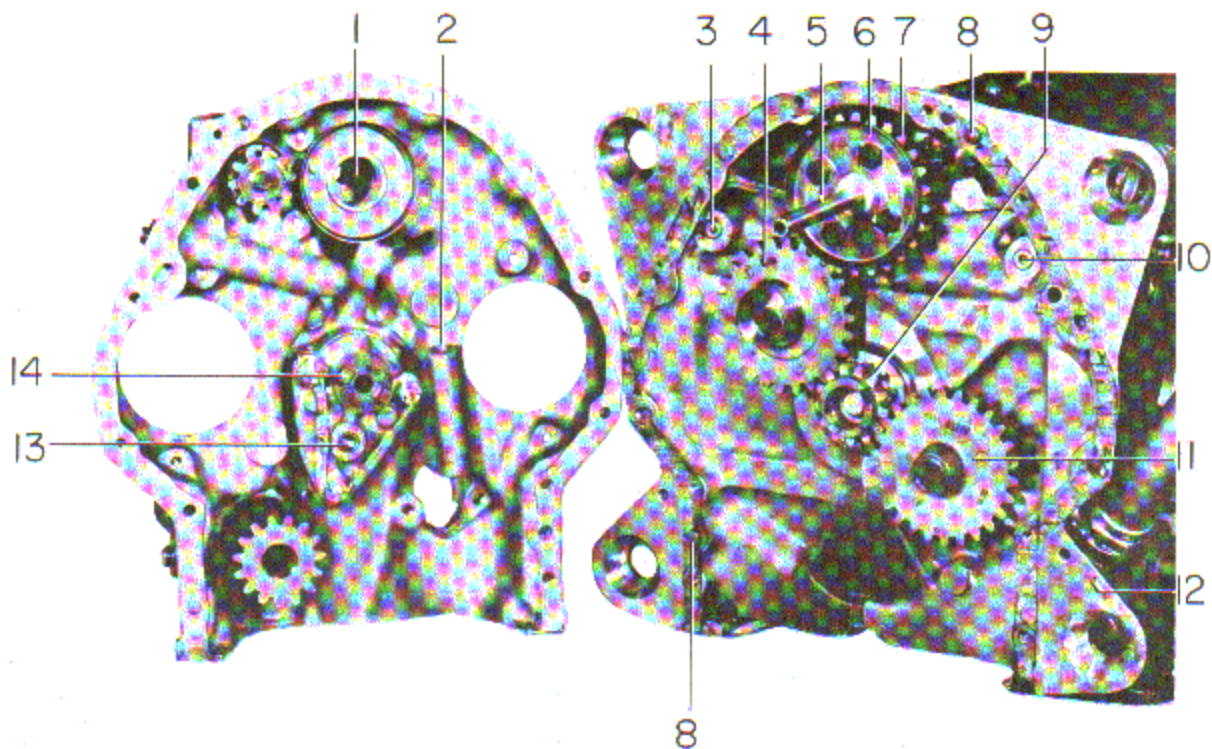
5-17. Insert the oil pump drive shaft (7) into the oil pump drive impeller. Place a 5/16-inch plain washer over each of the oil pump studs; assemble 5/16-inch slotted nuts onto the studs and tighten evenly and gradually, turning the oil pump drive shaft at the same time to make sure that the shaft turns freely. Should the shaft stick, or not turn freely, tap the side of the cover lightly with a soft hammer to get proper alignment. When it is determined that the shaft will turn freely, the nuts may be tightened to 150 inch-pounds torque and secured with 0.040-inch diameter lockwire as shown in figure 5-3.

5-18. OIL PRESSURE SCREEN HOUSING. Insert the oil pressure screen into the oil pressure screen housing. Using a new gasket, secure the housing to its mounting pad with four 1/4-inch hex head, self-locking screws. (See figure 5-1.)

5-19. OIL COOLER BY-PASS VALVE. Insert the valve plunger and spring in the oil cooler by-pass valve recess in top of the oil pressure screen chamber mounting boss. Place a copper asbestos gasket on the valve plug, screw the plug in place, and secure with 0.040-inch diameter lockwire.

5-20. THERMOSTATIC OIL COOLER BY-PASS VALVE. On engines equipped with this device, all parts of the standard oil cooler by-pass valve are eliminated. In place of the valve, an oil cooler connection adapter is used and should be assembled, with a new gasket, into place at this time. Insert the oil pressure screen into the valve and screen chamber and attach the chamber to the housing in the same manner as the standard chamber described above. Using a new gasket, screw the thermostatic by-pass valve into the chamber.

5-21. ACCESSORY HOUSING. (See figure 5-3.) Place a new accessory housing gasket over the locating dowels (8) on the rear of the crankcase. Check the assembly of the two crankshaft idler gears; if the engine is equipped with a diaphragm type fuel pump, the hub of the left-hand gear should incorporate a cam, and the fuel pump plunger (2) should be inserted in the



- |                                     |   |
|-------------------------------------|---|
| 1. Breather oil shield              | 8. Locating dowels                          |
| 2. Fuel pump plunger                | 9. Crankshaft gear                          |
| 3. Rear of left main oil passage    | 10. Rear of right main oil passage          |
| 4. Crankshaft idler gear (with cam) | 11. Crankshaft idler gear (plain)           |
| 5. Tachometer drive shaft           | 12. Lockwire hole (for oil level gage tube) |
| 6. Breather slinger                 | 13. Oil pump idler shaft                    |
| 7. Camshaft gear                    | 14. Oil pump drive shaft                    |

Figure 5-3. Accessory Housing and Rear of Assembled Crankcase

accessory housing as shown. Make certain that if the engine incorporates an "AN" fuel pump drive, the fuel pump idler gear shaft is in place on the inside of the accessory housing cover and secured with two 1/4-20 hex head screws and a lockplate. Place the fuel pump gear on the idler shaft; on O-540 engines, install the thrust washer and retaining ring that hold the idler gear in place on the shaft. Make sure that a new oil seal has been inserted in the tachometer drive shaft bore. Rotate the oil pump drive shaft (14) so that the lobes on the shaft align with the slots in the crankshaft gear (9) as shown. Apply a liberal coating of preservative oil to the tachometer drive shaft (5) and all other contact surfaces, such as gear teeth and hub of left idler gear. Carefully fit the accessory housing in place on the rear of the crankcase, guiding the housing first over the tachometer drive shaft and then onto the locating dowels (8). Secure the housing in place with ten 1/4-20 x 15/16 hex head bolts and two 1/4-20 x 1-3/4-inch bolts. The latter two fastenings are inserted from the crankcase side through the holes adjacent to the right magneto. Assemble all fastenings with plain washers and lockwashers.

**5-22. VACUUM PUMP AND DRIVE.** If the engine is equipped with a vacuum pump drive, assemble the unit

as follows: Insert a new oil seal into the recess in the pump side of the vacuum pump adapter assembly; make sure that the seal is inserted with the grooved side toward the adapter. Place a new accessory driven gear washer over the shaft of the vacuum pump driven gear and insert the gear into the adapter, being careful not to push the oil seal out of its seat. Using a new gasket, attach the adapter to the accessory housing with four 1/4-20 plain nuts, plain washers, and lockwashers. If the engine is equipped with vacuum pump drive only, place a cover over the exposed end of the drive to prevent entrance of dirt and foreign matter. If engine is equipped with vacuum pump and drive, install the vacuum pump on the adapter instead of the cover.

**5-23. PROPELLER GOVERNOR DRIVE LOCATED ON ACCESSORY HOUSING (O-360 ONLY).** On engines equipped with a propeller governor drive, insert the propeller governor drive shaft gear into the adapter; place a new accessory driven gear washer over the drive end of the shaft and secure the shaft in place with a 13/16 diameter external retaining ring. Using a new gasket, attach the adapter to the housing with four 5/16-18 plain nuts, plain washers, and lockwashers. Attach a cover on the exposed end of the drive as protection against dirt and foreign matter.

5-24. VACUUM PUMP AND PROPELLER GOVERNOR DUAL DRIVE (O-360 ONLY).

5-25. If the engine is equipped with a vacuum pump and propeller governor dual drive, mount the drive assembly on the vacuum pump mounting pad and fasten with a 1/4-20 nut, three 1/4-20 socket head capscrews, and the required plain washers and lockwashers. Mount the vacuum pump and propeller governor on the dual drive housing, using new gaskets, and install the bracket between vacuum pump pad and pressure screen housing mounting flange.

5-26. If it is desired to install a vacuum pump and propeller governor dual drive on the engine, a dual drive kit is available. The kit, Lycoming Part No.

70385, is intended primarily for use on those installations where engine cowling or other restrictions prevent the use of the governor drive provided on the lower right-hand corner of the accessory housing. The kit, which consists of a cast aluminum housing assembly, together with the required gears, attaching parts, and gaskets, is packed assembled and ready to install on the vacuum pump mounting pad. Instructions for installing the kit are as follows:

a. Remove vacuum pump from accessory housing.

b. Remove all four studs from the vacuum pump mounting pad and install one 69943 (P03) stud to a driven height of 0.83 inch in the upper left-hand hole; the other three holes are left as is. (See figure 5-4.)

c. Mount the drive assembly on the vacuum pump mounting pad as shown in figure 5-5, securing the assembly in place as follows: Install a 1/4-20 nut, plain washer, and lockwasher on the stud installed in the accessory housing in step b. above. Install three 1/4-20 socket head capscrews, plain washers, and lockwashers in the three holes ("B", figure 5-5) in the governor drive mounting pad.

d. Install the vacuum pump and propeller governor on the dual drive housing. Use the gasket provided in the kit and the nuts and washers removed from the original vacuum pump drive on the accessory housing to attach the vacuum pump to the mounting pad. Secure one end of the dual drive support bracket (Lyc. P/N 71023) to the lower left-hand stud on the vacuum pump pad and attach the other end to the upper left-hand corner of the pressure screen housing mounting flange as shown in figure 5-5, using the STD-1215 bolt provided. Make sure the hole in the support brace aligns with the hole in the pressure screen

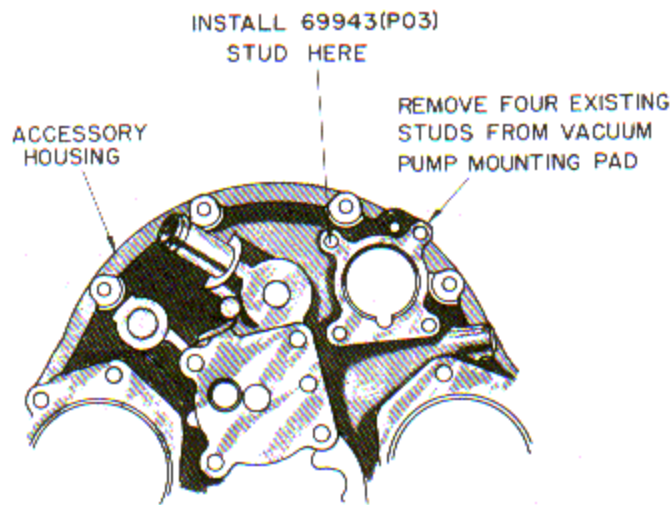


Figure 5-4. Vacuum Pump Pad Stud Modification

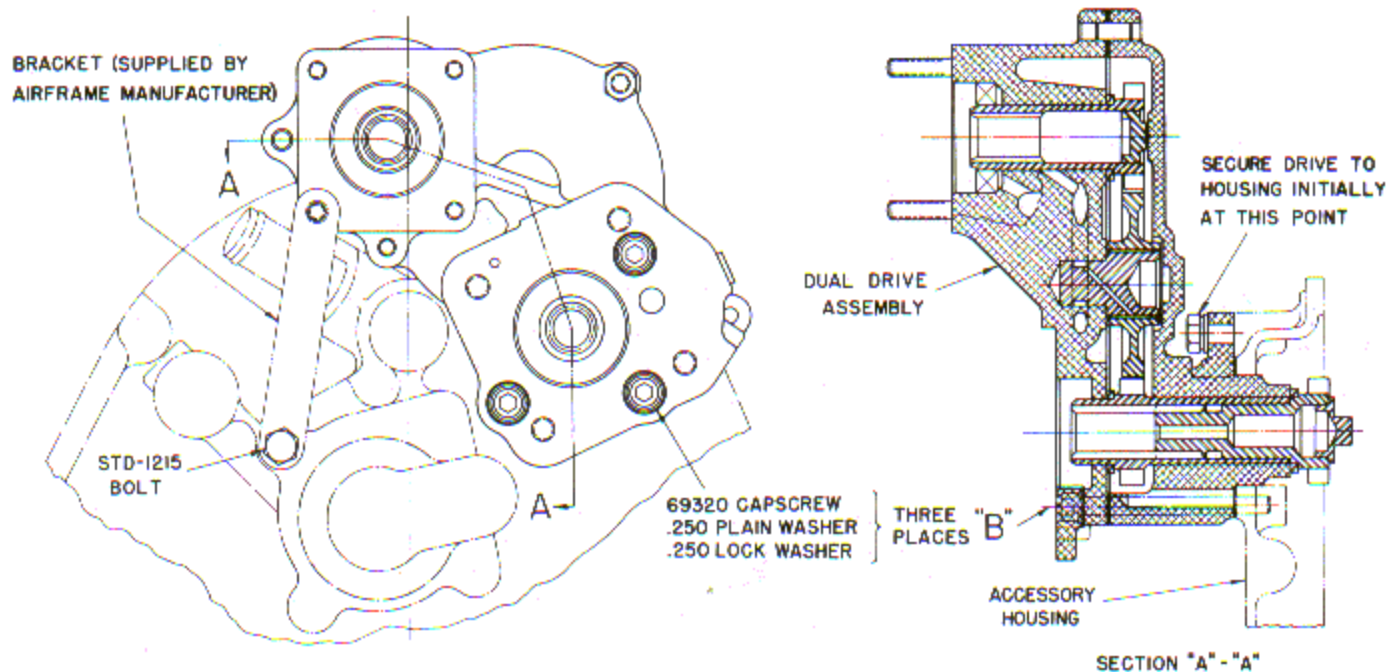


Figure 5-5. Dual Drive Assembly, Vacuum Pump and Propeller Governor

housing mounting flange. Use spacer washers under ends of brace if required for proper seating. (See figure 5-8.) Check the bracket for fit after the vacuum pump is installed.

**CAUTION**

Brace must be seated properly so there is no stress at either end of bracket when nuts are tightened.

e. Before mounting the governor, install a 69827 gasket, 69737 spacer, and 69723 gasket on the mounting pad in the order named. Attach governor with the 5/16-18 bolts, plain washers, and lockwashers provided.

f. The conversion of an O-360-A engine from fixed pitch to constant speed operation requires the installation of an external high pressure line from the governor to an elbow fitting at the front of the right crankcase. Two clips (68604) are provided in the kit for supporting the high pressure line; one clip is attached to the bottom of the crankcase by the same crankcase flange bolt that secures the rear of the generator mounting bracket, and the other is fastened to the sump-crankcase parting flange along the right side of the engine. A 1/4-20 x 1-3/4 bolt (STD-1415) is furnished to replace the 1-1/2 inch length bolt (STD-1414) furnished at the generator bracket location on other series engines. This bolt is not required on the O-360-A engine.

**5-27. VACUUM PUMP AND HYDRAULIC PUMP DUAL DRIVE.**

5-28. If the engine is equipped with a vacuum pump and hydraulic pump drive, mount the drive assembly on the vacuum pump mounting pad and fasten with a 1/4-20 nut, plain washer, and lockwasher on the short stud

in accessory housing. Install the vacuum pump and hydraulic pump on the dual drive housing and fasten with the required nuts and washers; then install the bracket between the vacuum pump pad and the pressure screen housing mounting flange.

5-29. If it is desired to install a vacuum pump and hydraulic pump dual drive on O-360-A engines equipped for constant speed operation, a dual drive kit is available. The kit, Lycoming Part No. 69912, which consists of a cast aluminum housing assembly, together with the required gears, attaching parts, and gaskets, is packed assembled and ready to install on the vacuum pump mounting pad on the accessory housing. Instructions for installing the kit are as follows:

a. Remove vacuum pump from accessory housing.

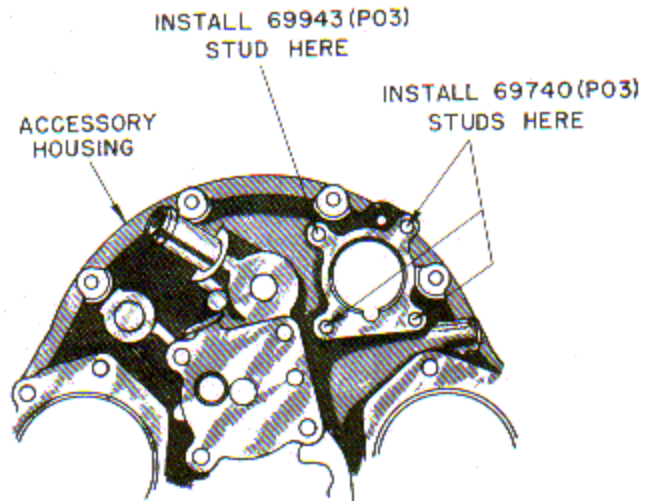


Figure 5-6. Vacuum Pump Pad Stud Modification

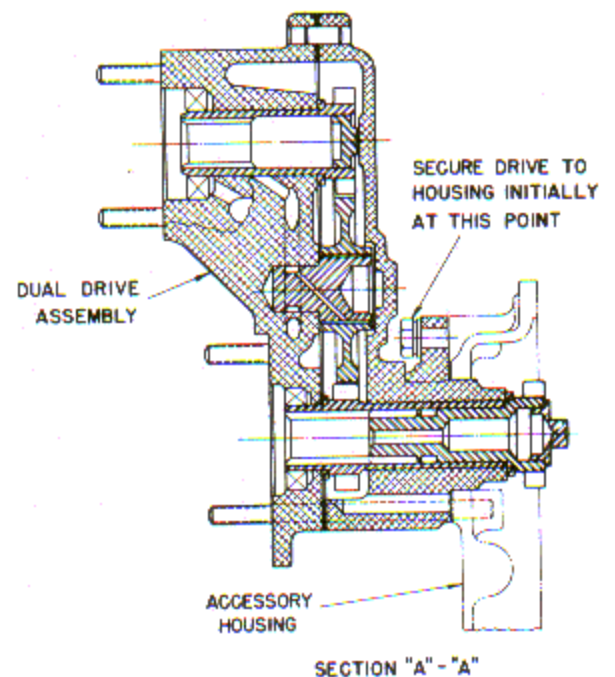
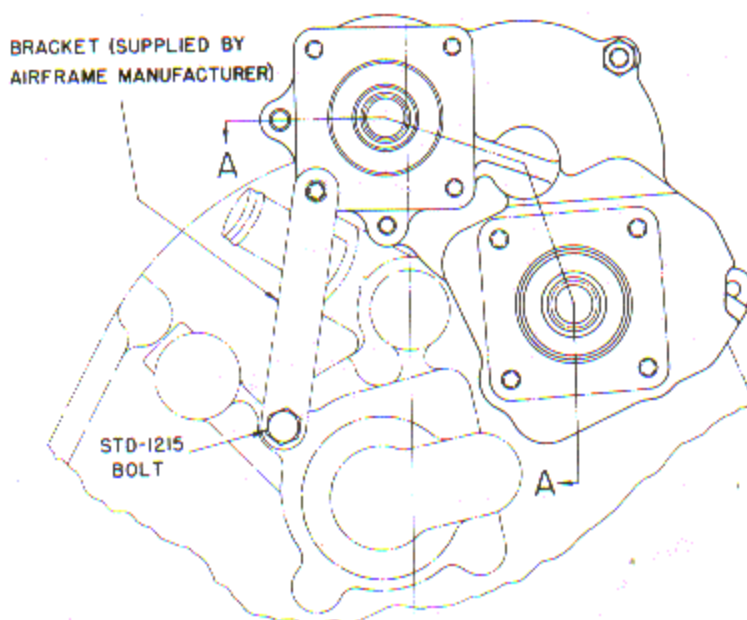


Figure 5-7. Dual Drive Assembly, Vacuum Pump and Hydraulic Pump

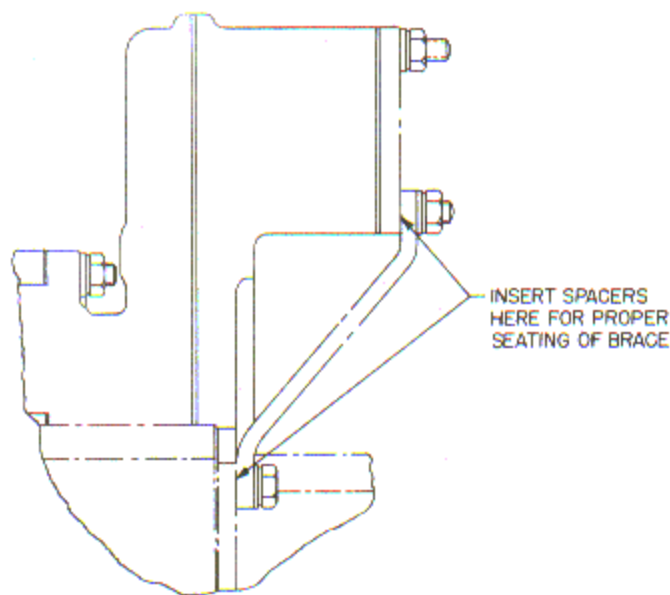


Figure 5-8. Proper Seating of Support Brace

b. Remove all four studs from the vacuum pump mounting pad and install three 69740 (P03) studs, to a height of 3.34 inches, and one 69943 (P03) stud, to a height of 0.83 inch in the pad at the locations shown in figure 5-6.

**WARNING**

Be sure that larger end of stud (nut fits freely on smaller end) is driven into the accessory housing and fits tightly to prevent rotation of stud when nuts are assembled. Studs must be correct height after installation so that there is no possibility of interference between studs and gears or oil slinger inside accessory housing.

c. Install the drive assembly on the vacuum pump mounting pad on the accessory housing as shown in figure 5-7, securing the assembly in place with a 1/4-20 nut, plain washer, and lockwasher on the short stud installed in the accessory housing in step b. above.

d. Install the vacuum pump and hydraulic pump on the dual drive housing, using the remaining four sets of

nuts and washers in the kit plus the four sets removed from the accessory housing in step a. above. Secure one end of the dual drive support brace (Lyc. P/N 71023) to the lower left-hand stud on the vacuum pump pad and attach the other end to the upper left-hand corner of the pressure screen housing mounting flange as shown in figure 5-7, using the STD-1215 bolt provided. Make sure that the hole in the support brace aligns with the hole in the pressure screen housing mounting flange. Use spacer washers under ends of brace if required for proper seating of both ends. See figure 5-8. Check the bracket for fit after vacuum pump is installed.

**CAUTION**

Brace must be seated properly so there is no stress at either end of bracket when nuts are tightened.

5-30. **HYDRAULIC PUMP DRIVE (O-540 ONLY).** If the engine is equipped with a hydraulic pump drive, assemble the unit as follows: Insert a new seal into the recess in the pump side of the hydraulic pump adapter assembly; make sure that the seal is inserted with the grooved side toward the adapter. Place a new accessory driven gear washer over the shaft of the hydraulic pump driven gear and insert the gear into the adapter, being careful not to push the oil seal out of its seat. Using a new gasket, attach the adapter to the housing with four 5/16-18 plain nuts, plain washers and lockwashers. Attach a cover on the exposed end of the drive as protection against dirt and foreign matter.

5-31. **"AN" FUEL PUMP DRIVE.** If the engine is equipped with an "AN" fuel pump drive, assemble the unit as follows: Insert a new seal into the recess on the pump side of the fuel pump drive adapter assembly; make sure the seal is inserted with the grooved side toward the adapter. Insert the fuel pump drive shaft gear into the adapter, being careful not to push the oil seal out of its seat. Using a new fuel pump drive adapter gasket, attach the adapter to the accessory housing with four 5/16-18 plain nuts, plain washers and lockwashers. Using a new fuel pump gasket, install a drive cover over the exposed end of the drive as protection against dirt and foreign matter.

## SECTION VI

## CYLINDERS, PISTONS, AND VALVE TRAIN

6-1. Identical cylinder assemblies are furnished with the O-360 and O-540 Series engines. These cylinders are manufactured with plain barrels, however, chrome plated barrels are available. Engines are equipped with sodium-cooled exhaust valves and exhaust valve rotators.

6-2. The piston, being a reciprocating part, is normally grouped with the crankshaft in a theoretical breakdown of the engine into basic components. From a practical standpoint, however, it is felt that the piston should be considered with the cylinders insofar as overhaul procedure is concerned. For example, the basic configuration of the engine requires the removal — and reassembly — of the pistons at the same time that the cylinders are removed or replaced.

6-3. For the purpose of this manual, the valve train will be considered as all parts of the valve operating mechanism beyond the camshaft, beginning with the hydraulic tappet assembly.

## DISASSEMBLY

6-4. PRIMER LINES. Rotate the overhaul stand so that the engine is in a horizontal, inverted position. Remove the priming lines (figure 6-1) by detaching the clamps on the crankcase and the union nuts holding the priming lines to the primer nipples in the cylinders. The primer nipples should not be removed from the cylinders unless they are damaged. The lower spark plugs can now be removed.

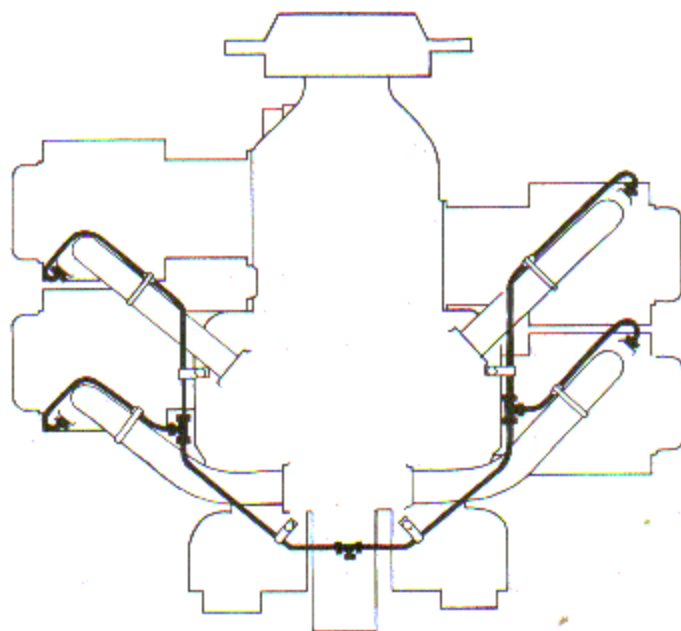


Figure 6-1. Primer System, O-360

6-5. OIL DRAIN TUBES. Loosen both hose clamps at lower end of each rocker box drain tube and slide hose out on tube; then identify the tubes to correspond with the cylinder from which they are removed. Loosen gland nut at rocker box end of each tube and remove the tubes. Do not remove the elbow drain fittings from the cylinder heads or the 3/8-inch nipples from the crankcase.

6-6. INTAKE PIPES. Remove the 1/4-inch nuts and washers that secure the pipe flanges to the studs at the cylinder ports and pull the flanges away from the cylinders. Loosen the hose clamps nearest the sump, pull the hose connections away from the sump, and remove the intake pipes. Keep all component parts of each intake pipe with each individual pipe, also tag or otherwise identify each pipe as it is removed, because only those for number one and number two cylinders are alike. See Section VIII for further information on intake pipes.

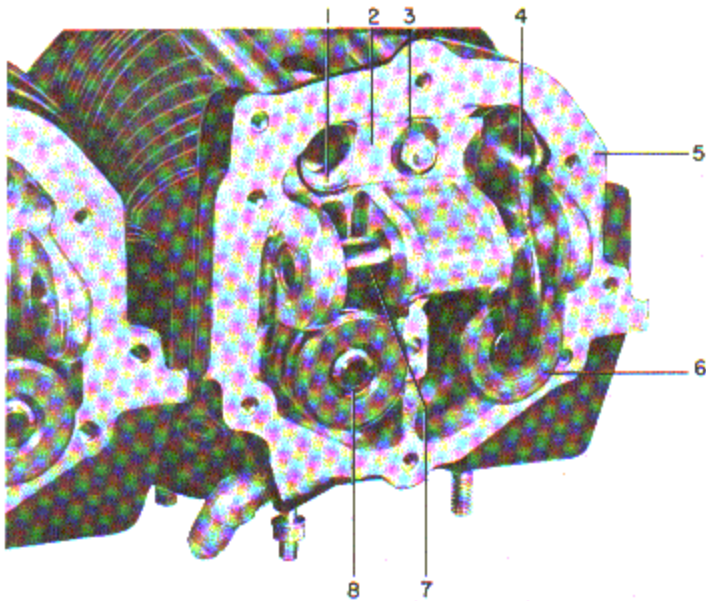
6-7. Remove the self-locking nut from the upper baffle clamp and pull the baffle down and away from the cylinder fins. Remove baffle assemblies, which are attached to the engines by a retainer and an "S-type" hook, by using a piece of drill rod, bent to a right angle, to turn the hook so that it disengages the retainer.

6-8. CYLINDER REMOVAL. Rotate the crankshaft to place the piston of No. 1 cylinder at top center of the compression stroke. (With the piston in this position, both valves will be closed and the piston extended away from the crankcase to avoid damage when the cylinder is removed.) Remove rocker box cover and remove valve rocker shaft, valve rockers, exhaust valve caps (rotators), and push rods. The valve rocker shaft is full floating and may be pushed out of cylinder head with finger pressure. If it is not possible to push it out in this manner, the shaft may be driven out by tapping lightly with a fiber drift. Place each valve rocker and push rod in its proper compartment in cleaning basket.

## NOTE

The cleaning basket (3, figure 11-3) provides individual compartments for keeping the valve operating parts segregated. Parts as they are removed should be placed in their proper compartments as marked on the basket. This applies to valves, valve rockers, push rods, and all parts of the hydraulic tappets.

6-9. Release and remove the push rod shroud tubes by removing the 1/4-inch plain nut and shroud tube lockplate which hold the two shroud tube springs and spacer in position. (See figure 6-2.)



- |                          |                       |
|--------------------------|-----------------------|
| 1. Shroud tube           | 5. Rocker box         |
| 2. Shroud tube spring    | 6. Valve spring seat  |
| 3. Shroud tube lockplate | 7. Valve rocker shaft |
| 4. Valve rocker          | 8. Valve keys         |

Figure 6-2. Method of Securing Shroud Tubes

6-10. Using the applicable wrench (7 or 8, figure 11-3) and handle (4, figure 11-3), remove the four 3/8-inch and four 1/2-inch cylinder base nuts attaching the cylinder to the crankcase. Remove the cylinder from the engine by pulling straight away from the crankcase. As the cylinder is pulled away, catch and hold the piston to prevent it from falling against the cylinder pad of the crankcase. Discard the cylinder base oil seal ring.

6-11. PISTON. Remove the piston pin plugs from their location in the piston by applying compressed air to each relief hole (one located in the bottom of each piston pin boss). If compressed air is not

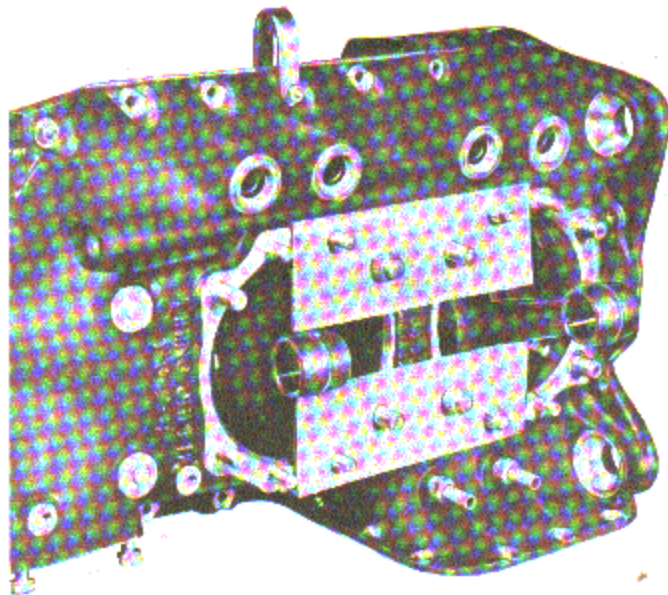


Figure 6-3. Method of Supporting Connecting Rods

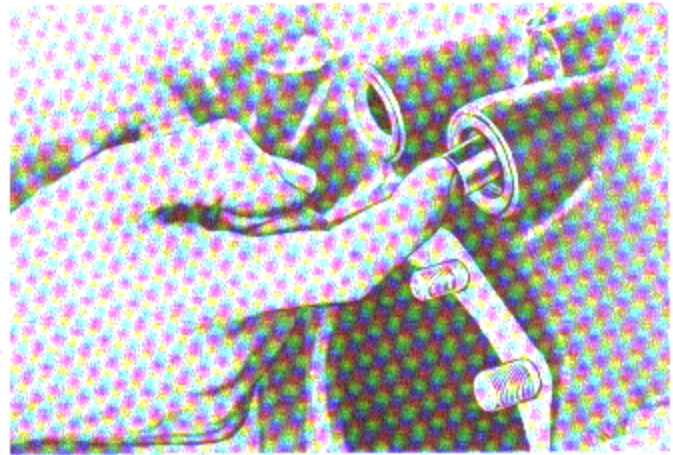


Figure 6-4. Removing Push Rod Sockets

available, carefully tap out piston pin plugs with suitable drifts. Insert piston pin puller (9, figure 11-3) through piston pin; assemble puller nut, then proceed to remove piston pin.

**CAUTION**

Do not allow the connecting rods to rest on the cylinder pads of the crankcase; the rods should be supported by heavy rubber bands (removed cylinder base oil seal rings) looped around the cylinder base studs, or by two plates made of steel or wood as shown in figure 6-3.

6-12. Removal of the remaining cylinders and pistons may be done in any desired order, but less turning of the crankshaft is involved if the cylinders are removed successively in the engine's firing order which is 1-3-2-4 for O-360 engines and 1-4-5-2-3-6 for O-540 engines.

6-13. HYDRAULIC TAPPET PLUNGERS. Remove the push rod sockets from the hydraulic tappets with fingers or by using a pair of needle-nosed pliers. (See figure 6-4.) Bend a right angle in one end of a piece of wire and insert this end into the space between the plunger assembly and the tappet body. Turn

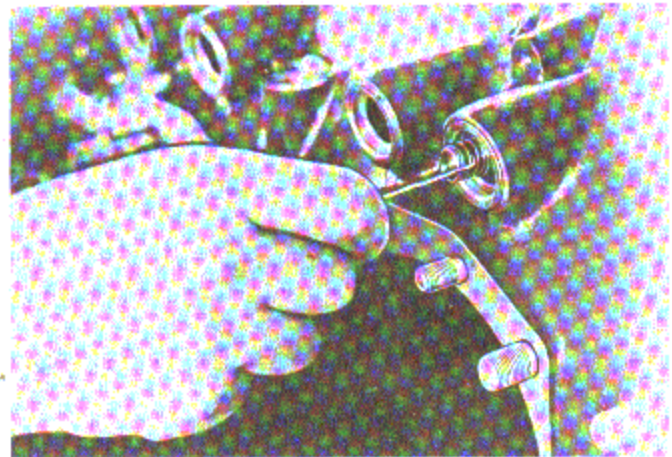
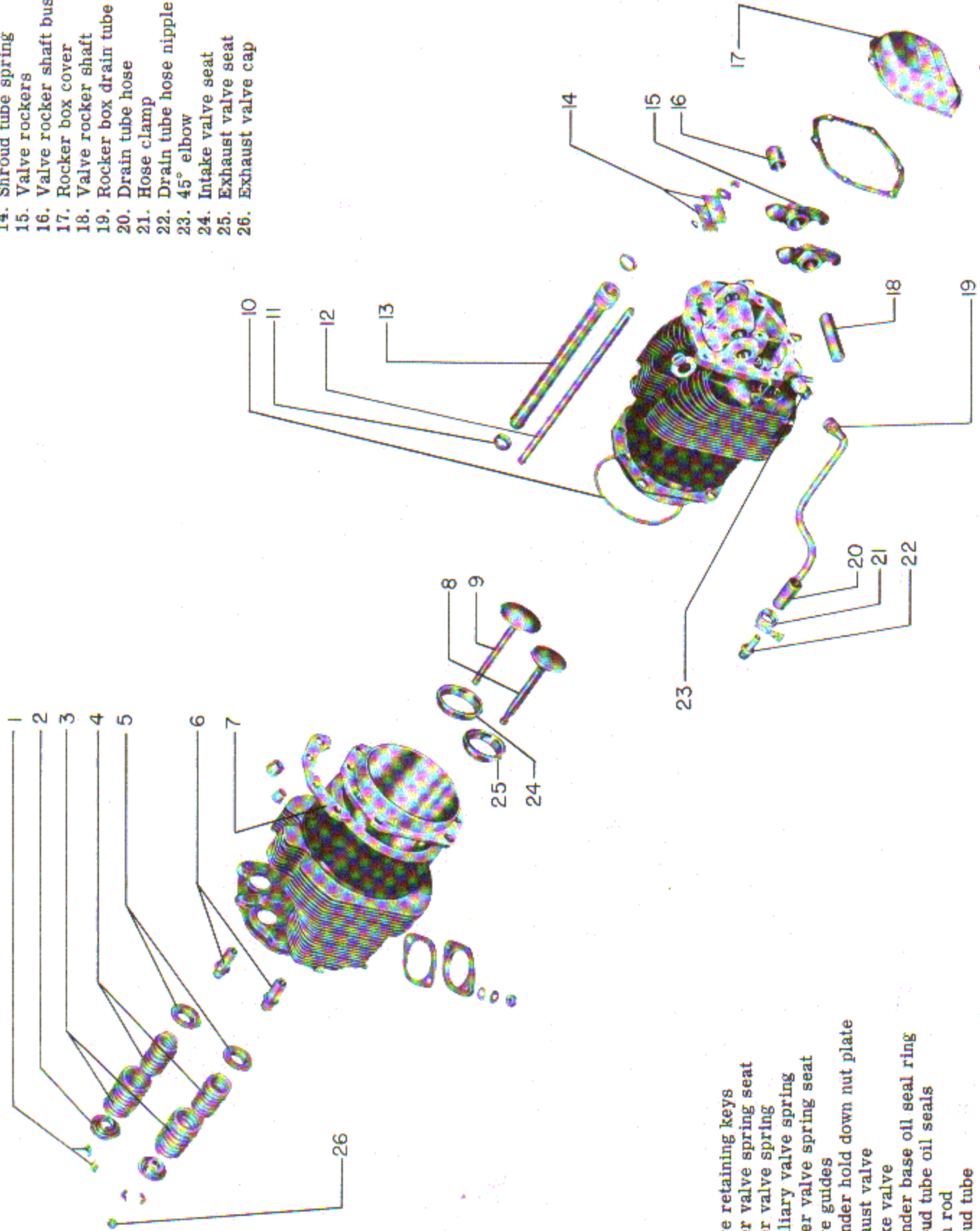


Figure 6-5. Removing Hydraulic Tappet Plunger Assembly

- 14. Shroud tube spring
- 15. Valve rockers
- 16. Valve rocker shaft bushing
- 17. Rocker box cover
- 18. Valve rocker shaft
- 19. Rocker box drain tube
- 20. Drain tube hose
- 21. Hose clamp
- 22. Drain tube hose nipple
- 23. 45° elbow
- 24. Intake valve seat
- 25. Exhaust valve seat
- 26. Exhaust valve cap



- 1. Valve retaining keys
- 2. Outer valve spring seat
- 3. Outer valve spring
- 4. Auxiliary valve spring
- 5. Lower valve spring seat
- 6. Valve guides
- 7. Cylinder hold down nut plate
- 8. Exhaust valve
- 9. Intake valve
- 10. Cylinder base oil seal ring
- 11. Shroud tube oil seals
- 12. Push rod
- 13. Shroud tube

Figure 6-6. Exploded View of Cylinder Assembly



the wire 90° to engage a coil of the spring and draw out the hydraulic tappet plunger assembly as shown in figure 6-5. Place all parts in their proper compartment in the cleaning basket. Never use a magnet to remove the cylinder and plunger assemblies from the crankcase.

#### CAUTION

It is imperative that the various parts of each tappet assembly be kept together during all overhaul operations, in order that all component parts may be reassembled with their original mating parts and each completed assembly inserted in its original location in the crankcase.

6-14. **DISASSEMBLY OF CYLINDERS.** Place cylinder over the cylinder holding block (2, figure 11-3), assemble valve spring compressor (1, figure 11-3) on cylinder and compress valve springs far enough to remove the valve retaining keys.

#### NOTE

If springs are stuck tight in spring seat, a light blow with a soft hammer on top of compressor will release keys.

6-15. Remove all valve spring seats and springs from rocker box, keeping parts for each valve separate. Hold valves by the stems to keep them from dropping out of the cylinder, and remove cylinder from holding block. Now reach inside of cylinders and remove valves. If difficulty is experienced in pulling the tops of the valve stems through the valve guides, push the valves back in position and clean the carbon from the stems.

#### CAUTION

Do not drive the valves through the guides.

6-16. Place each valve, with its springs, seats, cap (exhaust valves only), and keys, in its proper compartment of the cleaning and inspection basket. No further disassembly of the cylinder is necessary unless inspection warrants the replacement of valve guides, valve seats, rocker box drain tube elbow, or primer nipple.

6-17. **PISTON RING DISASSEMBLY.** Using the piston ring expander (6, figure 11-3), remove the rings from all pistons. Remove the rings in order, starting with the top ring and working down.

6-18. **HYDRAULIC TAPPETS.** Push in on spring end of hydraulic tappet plunger, turn approximately one-quarter turn in a clockwise direction, and pull it from the cylinder. Do not further disassemble any parts of the tappet assembly.

#### CAUTION

Keep plunger and cylinder of each assembly together. They are very closely and selectively fitted during manufacture and are not interchangeable.

## CLEANING

6-19. Clean all cylinder, piston, and valve train parts in accordance with the general instructions described in Section III, specific instructions follow:

6-20. **HYDRAULIC TAPPETS.** Use the cleaning basket (3, figure 11-3) in order to keep the valve operating mechanism parts separate. Dip the basket, with all parts contained in their proper compartments, in petroleum solvent. Hold the ball check valve in each plunger cylinder off its seat by inserting a light copper wire or other relatively soft material through the tube on the cylinder and wash thoroughly, so that any dirt particles that may be under the ball seat will be washed out. After washing the parts of each hydraulic tappet assembly; replace the parts in the proper compartment of the cleaning basket.

#### CAUTION

It is imperative that the various parts of each tappet assembly be kept together during all overhaul operations, in order that all component parts may be reassembled with their original mating parts and each completed assembly inserted in its original location in the crankcase.

## INSPECTION

6-21. Inspect all cylinder, piston, and valve train parts in accordance with the general instructions described in Section III. Specific instructions will be found in the following paragraphs.

6-22. **CYLINDER HEAD (VISUAL INSPECTION).** Examine the cylinder head thoroughly, checking for the following possible defects:

a. Loose, scored, pitted, or otherwise damaged valve seats. (Mark for replacement.)

b. Loose or damaged studs. (Replace with 0.003, 0.007, or 0.012 oversized studs.)

c. Cracked or broken cooling fins. Any crack extending into the base of the fin is cause for rejection of the head. Small cracks in the outer edge of the fin, however, may be profiled with a hand grinder or file.

d. Loose or damaged spark plug thread inserts. (Mark for replacement.)

e. Loose, cracked, or scored valve guides.

f. Nicked, scored, or dented mounting pads (intake and exhaust ports and rocker box cover.)

g. Damaged oil drain tube fittings. (Usually these fittings are not removed from the cylinder head during reconditioning unless they are to be replaced.)

h. Etch any local areas of the head where it is suspected that a crack may exist. This is done and carried out in accordance with the instructions in Section III.

6-23. **CYLINDER HEAD (DIMENSIONAL INSPECTION).** Check the ID of each valve guide at both ends with the valve guide replacement flat plug rejection gage (23 or 30, figure 11-3.) Test for diameter and out-of-roundness of the guide bore by checking with the gage at a minimum of two positions 90° apart. If the gage enters the guide at any of the positions tested, mark the guide for replacement. Check the ID of the four rocker shaft bushings in the cylinder head, using the flat plug rejection gage (53, figure 11-3). Be sure to use the end of the gage marked "Cyl. Head." The opposite end, marked "Rocker Bushing," is 0.0015 inch larger in diameter by virtue of the greater wear limit allowed on the valve rocker bushing. As in the case of the valve guides, check for out-of-roundness by trying the gage at several different points on each diameter being checked.

6-24. **CYLINDER BARREL (VISUAL INSPECTION).** In addition to a thorough inspection of the cylinder barrel to ascertain its general condition, make the following specific checks:

- Cooling fins, see subparagraph c. under "Cylinder Head (Visual Inspection)."
- Cylinder skirt. Replace any cylinder having a bent, cracked, or broken skirt.
- Check mounting flange for cracks, nicks, or warping.
- Inspect interior of barrel for scoring or corrosion. Minor damage can be repaired by regrinding or honing; deep scoring or pitting, however, is cause for rejection of the cylinder.

6-25. **CYLINDER BARREL (DIMENSIONAL INSPECTION).** Dimensional inspection of the barrel consists of the following measurements (the numbers in parentheses refer to the applicable reference numbers in the Table of Limits):

- Fit between piston skirt and cylinder (519).

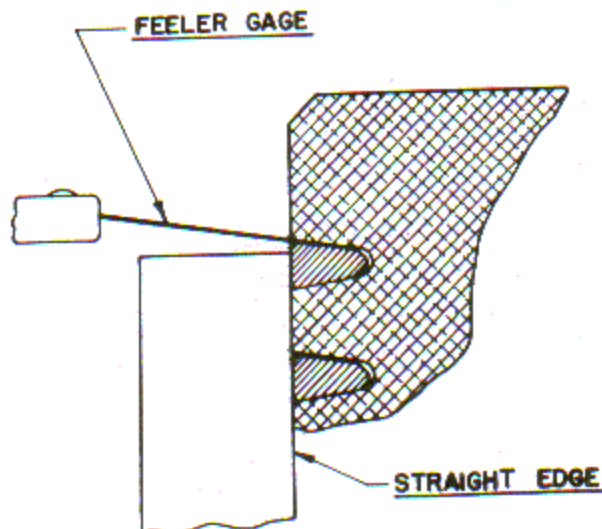


Figure 6-7. Method of Checking Piston Ring Side Clearance

- Maximum taper of cylinder wall (520).
- Maximum out-of-roundness (521).
- Bore diameter (522).

**NOTE**

All measurements involving cylinder barrel diameters must be taken at a minimum of two positions 90° apart in the particular plane being measured.

6-26. **PISTON (VISUAL INSPECTION).** Examine the top of the piston for excessive pitting, cavities, or surface distortion. The latter may be evidence of detonation, particularly if the piston has been in service for a relatively short time. Other critical points which must receive thorough visual examination are the piston ring bands and grooves, piston pin holes, and piston pin hole bosses. Etch all suspicious areas, using method described in Section III.

6-27. **PISTON (DIMENSIONAL INSPECTION).** Make the following dimensional checks on each piston (the numbers in parentheses refer to the applicable reference numbers in the Table of Limits):

- Side clearance between piston ring and piston (514, 515, 516 and 517). Pistons for Lycoming opposed engines are ground with a slight taper from the skirt to the head, with the exception of the lands between the top compression and oil control rings, which are ground parallel. The clearance on wedge type compression rings, therefore, must be measured as shown in figure 6-7 in order to obtain a true check of the side clearance.

- Inside diameter of piston pin hole (512).

- Clearance between piston skirt and cylinder and piston diameter at top and bottom (519).

6-28. **PISTON PIN AND PISTON PIN PLUGS.** Check OD of piston pin against ID of hole in piston (reference 512, Table of Limits). Measure fit between piston and plugs and check OD of plugs (reference 513, Table of Limits). Examine interior surfaces of piston pin for corrosion or pitting.

6-29. **VALVE ROCKERS.** Damaged, badly worn, pitted or scored tips and push rod sockets warrant replacement of the rocker. Check the ID of the rocker bushing at several different positions with flat plug rejection gage (53, figure 11-3). This is a double-end gage; be sure to use the end marked "Rocker Bushing." If the gage enters the bushing at any point, mark the bushing for replacement.

6-30. **PUSH RODS.** Inspect push rods for wear or looseness of ball ends. If ball ends are loose, replace the rod; manufacturing limits call for a drive fit. (See reference 535, Table of Limits.)

6-31. **VALVES.** Critical areas include the face and tip, both of which should be examined for pitting and excessive wear. The head of the exhaust valve is par-

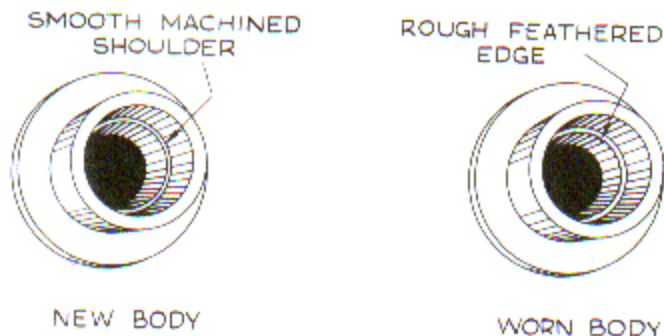


Figure 6-8. Appearance of Interior Shoulder in New and Worn Tappet Bodies

ticularly subject to pitting and corrosion because of the excessive heat to which it is exposed during operation. Minor pitting on valve faces can sometimes be removed by regrinding; otherwise the valve should be rejected. Replace any valve that has operated with a collapsed hydraulic tappet, regardless of the number of hours on the valve. (See inspection of hydraulic tappets.) Check the clearance between the valve stem and guide (reference 528, Table of Limits for exhaust valves, and reference 529, for intake valves.)

6-32. HYDRAULIC TAPPET BODIES. The following specific checks must be made during inspection of the hydraulic tappet body:

NOTE

Discard any hydraulic tappet bodies that have neither identification grooves on the end of the stem, three pimples under the head of the body nor one groove under the head.

a. Examine the interior of the bore in the tappet body, using a small flashlight or other suitable means to illuminate the interior surfaces. If any appreciable amount of wear has occurred at the interior shoulder (which serves as a seat for the cylinder and plunger assembly), a feathered edge of worked metal will be visible around the shoulder as shown in figure 6-8. The existence of this feathered edge is sufficient cause for rejection of the entire tappet assembly.

b. Use a magnifying glass (min., 10 power) to check the face of the tappet body for signs of spalling or pitting as shown in figure 6-9. Any tappet body face which shows this condition is cause for rejection, and the tappet body must be replaced.

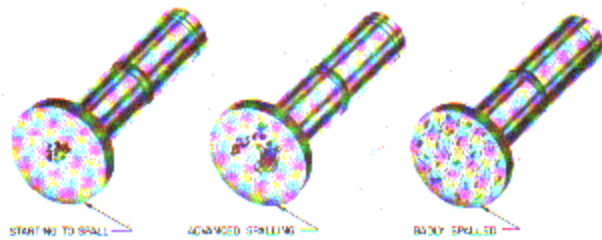


Figure 6-9. Appearance of Spalling Marks on Face of Hydraulic Tappet Bodies

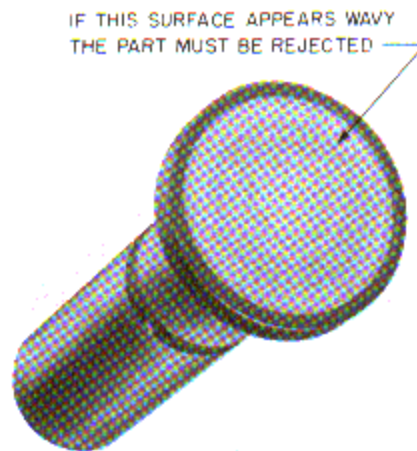


Figure 6-10. Circular Wear Pattern on Face of Hydraulic Tappet Body

NOTE

The presence of one or two Brinnell marks on the tappet body face is not a cause for rejection of the tappet body. Brinnell marks, which should not be confused with spalling or pitting marks, are near the center of the face and appear to be round; spalling marks are irregular.

c. Check face of the tappet body for circular wear patterns. The tappet body face may have circular discoloration due to rotation of the body but this is not cause for rejection. Circular wear patterns, give the surface of the face a wavy appearance and any hydraulic tappet body whose face shows indications of circular wear, must be rejected. (See figure 6-10.)

d. Test the tappet body for structural failure through use of the magnetic particle or magnaflux method. Use a magnaflux machine which uses 440 line volts, a copper adapter (11, figure 11-3) and a holding fixture which may be fabricated according to the dimensions

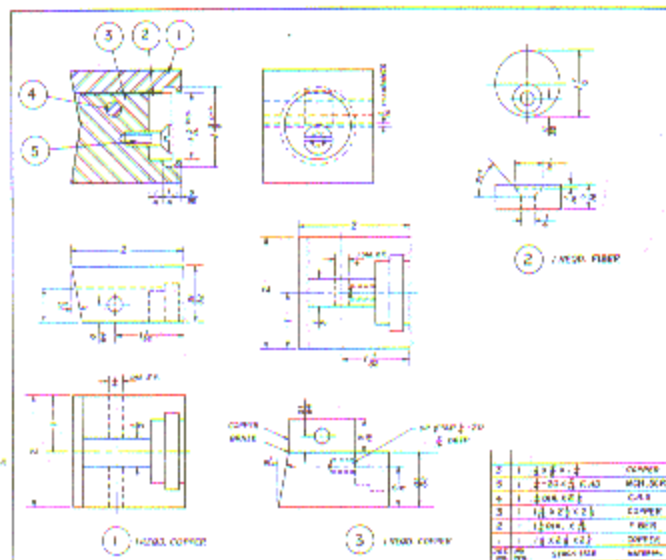


Figure 6-11. Dimensions for Making Holding Fixture

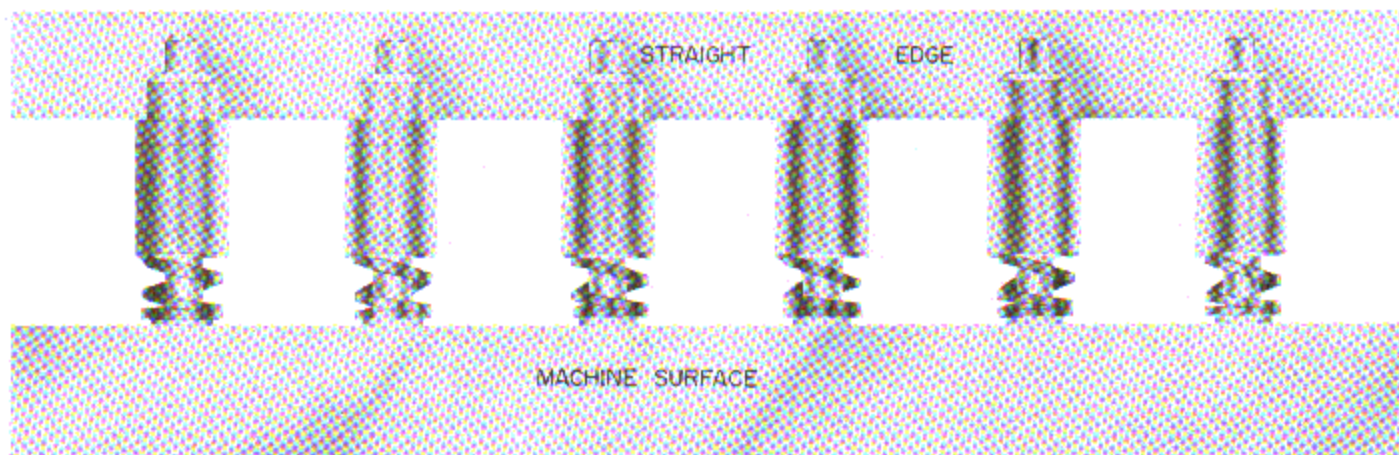


Figure 6-12. Checking Cylinder and Plunger Assembly with Straight Edge

and instructions given in figure 6-11. Use a medium grade of sand paper to clean the edge of the head of any Ferrox coating. Make sure the adapter and tappet body are secure in the holding fixture, which must be secure in the magnaflux machine, and that no electrodes touch the face of the tappet. Pass a current of 500 amps through the tappet body for 1/2 to 3/4 of a second while the magnaflux solution is running over the tappet body. Seams and cracks in the body will be coated black and can be easily identified.

#### NOTE

Use 1 to 1-1/4 oz. of magnaflux 7B paste to one gallon of Bay Oil D to make the liquid solution when using the "continuous method" of magnafluxing. Use 1/10 to 1/4 oz. of paste per gallon when using the "magnaglow" method of magnafluxing.

6-33. HYDRAULIC TAPPET CYLINDER AND PLUNGER ASSEMBLY. The following paragraphs set forth the various procedures to be followed during inspection of the cylinder and plunger assemblies:

#### NOTE

Discard all Lycoming Part No. 68312 assemblies; these are to be replaced with Part No. 71791 assemblies. It is permissible to reuse 68324 assemblies, in sets, in O-360 engines which incorporate a 68769 camshaft assembly.

- Check each plunger and cylinder assembly for chipping of the seating shoulder.
- Stand the cylinder and plunger assemblies side by side on a machine surface, plunger side down, and lay a straight edge across the top. (See figure 6-12.) Any plunger assembly that is more than 1/32-inch below the straight edge is "collapsed" and must be rejected.
- Inspect the cylinder bodies visually for cracks.

#### CAUTION

Never check any part of the hydraulic tappet cylinder and plunger assembly by means of the magnetic particle, or magnaflux, method.

- Clean the plunger assemblies with clean solvent and then back-flush each assembly, again using clean solvent.

- Check each hydraulic tappet cylinder and plunger assembly to see that the ball check valve is not leaking. A leaking ball check valve will make itself evident when the unit is checked as follows: dip the plunger in light machine or engine oil; hold the lifter cylinder between the thumb and middle finger in a vertical position with one hand; then place the plunger in position so that the plunger just enters the lifter cylinder. (See figure 6-13.) Depress the plunger

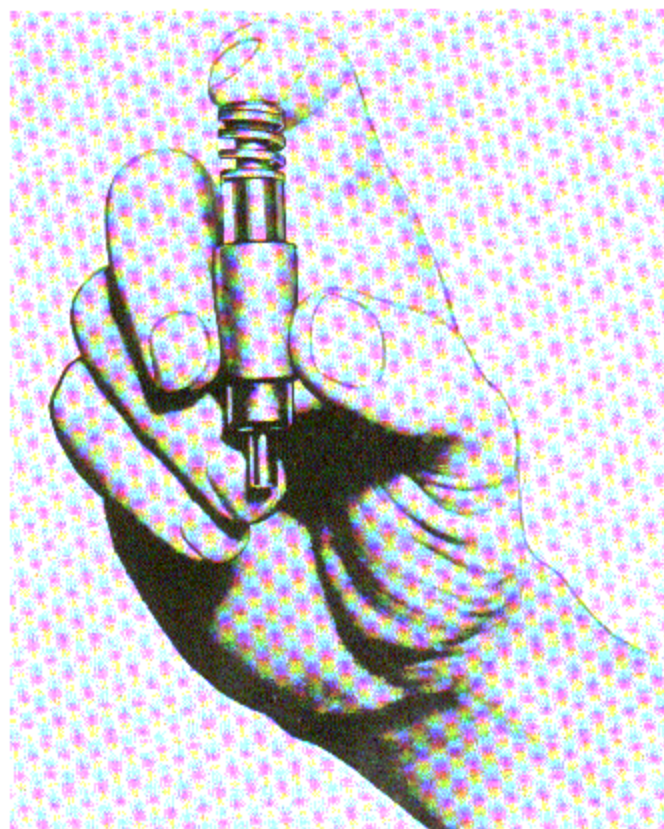


Figure 6-13. Checking Hydraulic Tappet Plunger and Cylinder Assembly for Leaks

quickly with index finger, if plunger bounces back to its original position, the unit may be considered to be satisfactory. If, however, the plunger does not bounce back to its original position, but remains in a collapsed position, this indicates that the ball check valve is not seating properly. When this condition exists, the plunger assembly is defective and both the cylinder and plunger must be replaced.

NOTE

If a valve tappet assembly should prove defective, the valve itself must be replaced as well as the tappet cylinder and plunger.

6-34. VALVE SPRINGS. Check the condition of all valve springs on a suitable spring tester, using the loads and deflections as given in reference 801 and 802, Table of Limits.

## REPAIR AND REPLACEMENT

6-35. General instructions for the repair of cylinder, piston, and valve train parts will be found in Section III. Specific instructions follow.

6-36. SPARK PLUG THREAD INSERTS. Spark plug thread inserts which were rejected during inspection are removed and replaced as described in the following paragraphs.

6-37. Insert the extracting tool (15, figure 11-3) in the spark plug hole so that the edges of the tool cut into the top thread of the insert. Then rotate the tool in a counterclockwise direction, unscrewing the insert from the hole.

6-38. A new insert may be installed by use of the inserting tool (14, figure 11-3). Withdraw the mandrel part of the tool beyond the recessed section of its sleeve. The insert may then be assembled into the recess and the mandrel advanced to engage its slotted end with the tang of the insert. Rotate the mandrel

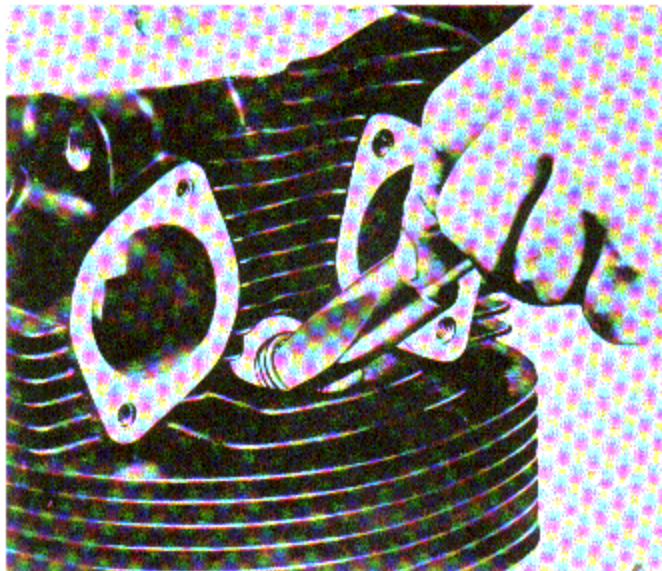


Figure 6-14. Removing Heli-Coil Insert

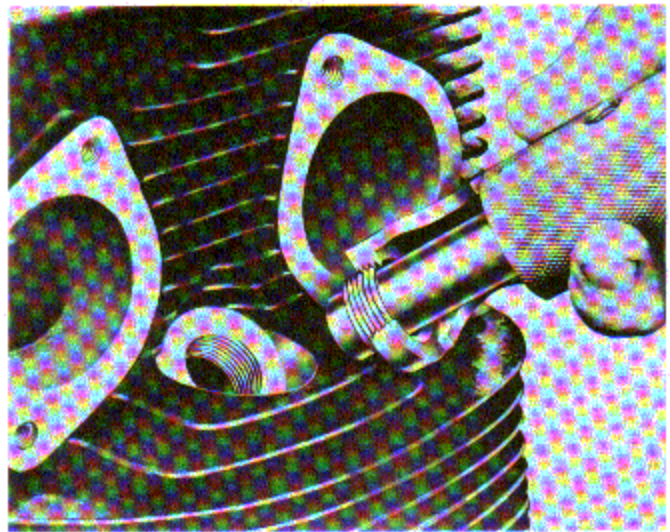


Figure 6-15. Heli-Coil Insert Assembled on Inserting Tool

clockwise and press forward slightly; this will engage the insert in the threaded end of the sleeve. Continue to rotate the mandrel while holding the sleeve, thus securing the insert firmly on the inserting tool. The insert may then be wound through the threaded portion of the sleeve within one-half turn from the end of the coil.

6-39. The adjustable brass screw on the sleeve tends to act as a brake, preventing the insert from unwinding. It is important that the insert be kept tight on the

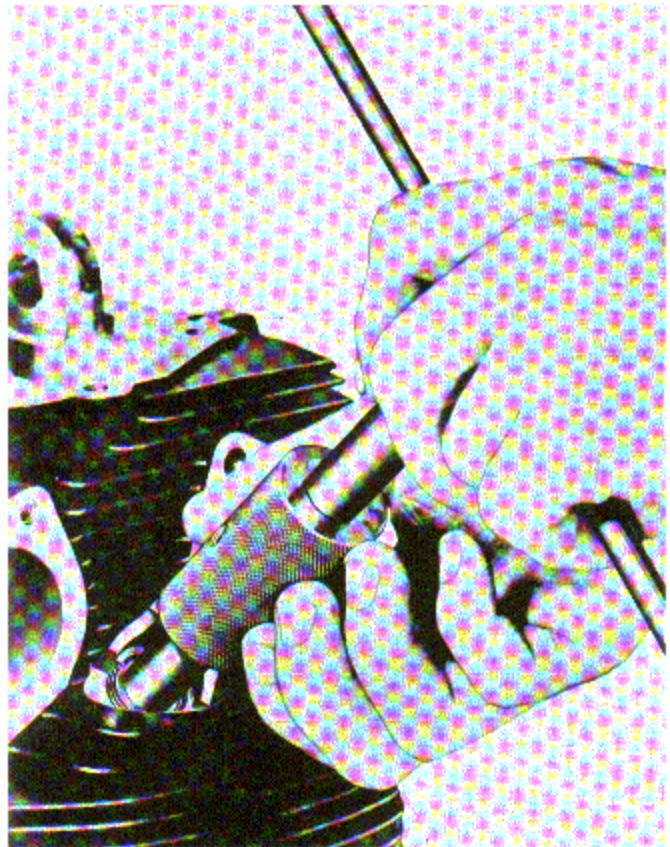


Figure 6-16. Installing Heli-Coil Insert



Figure 6-17. Expanding Heli-Coil Insert

mandrel to facilitate its assembly in the threads of the cylinder head. The insert should be wound so that the adjacent turns of the insert are in contact with each other. This will eliminate the possibility of crossed threads.

6-40. When screwing the insert into the hole in the cylinder head, be sure that the first coil picks up the first thread. As the tool is turned, the insert will advance into the hole. When the face of the sleeve is approximately  $1/16$  inch from the face of the boss, the inserting tool should be held tightly by the handle and the sleeve rotated counterclockwise with the other hand, freeing the last half-turn of the insert. By sliding the sleeve toward the top of the mandrel, the end of the insert can be seen projecting above the boss. The mandrel should then be rotated in a clockwise direction until the insert disappears from sight. When this position is reached, the turning action should be stopped and the tool withdrawn. The top of the insert will be approximately one-half turn from the face of the boss. However, if it is not, the tool should be re-assembled and the insert turned until it is about one-half turn from the face of the boss.

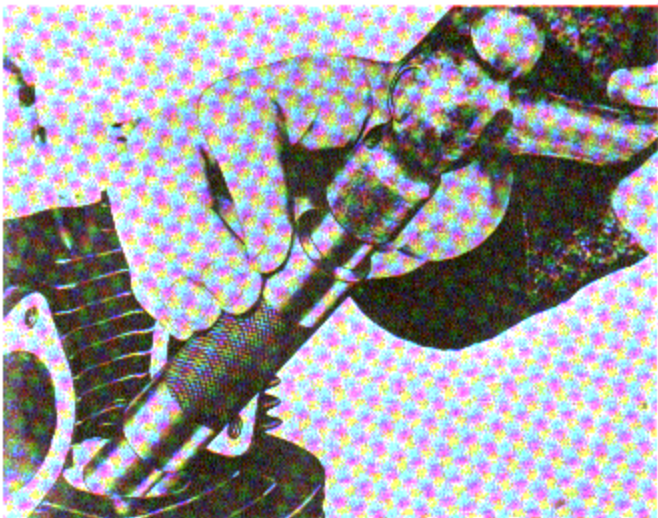


Figure 6-18. Staking Heli-Coil Insert

6-41. The tang of the insert can be broken off with needle nosed pliers at the location of the notch. Then using the expanding tool (13, figure 11-3), secure the insert firmly in the spark plug holes. The limit of expansion can be kept within thread gage limits by fixing the stop nut on the expanding tool at the correct position. After expanding the insert, it may be staked by assembling the staking sleeve over the mandrel until the sleeve meets the boss. A slight blow on the top of the sleeve will impress a slight chamfered edge around the periphery of the tapped hole. The staking sleeve may then be removed, the adjusting screw released, and the expanding mandrel removed from the insert.

6-42. VALVE GUIDE REMOVAL AND REPLACEMENT. Damaged valve guides are removed and new guides are installed according to the procedures described in paragraph 6-43 through 6-47.

6-43. Place valve guide puller (24, figure 11-3) over guide inside of rocker box and with nut at extreme outer end, insert puller bolt down through guide. Place

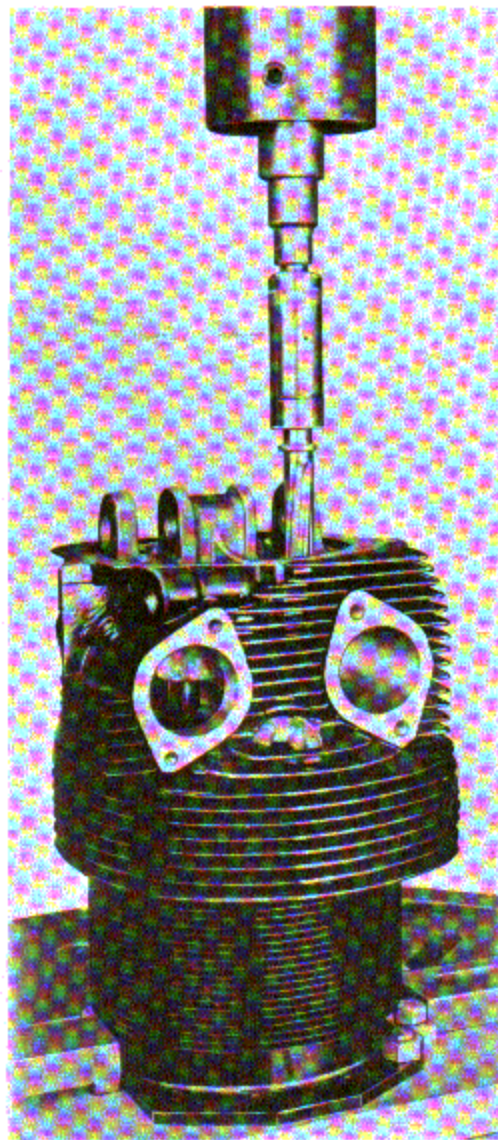


Figure 6-19. Reaming Valve Guide Hole in Cylinder Head

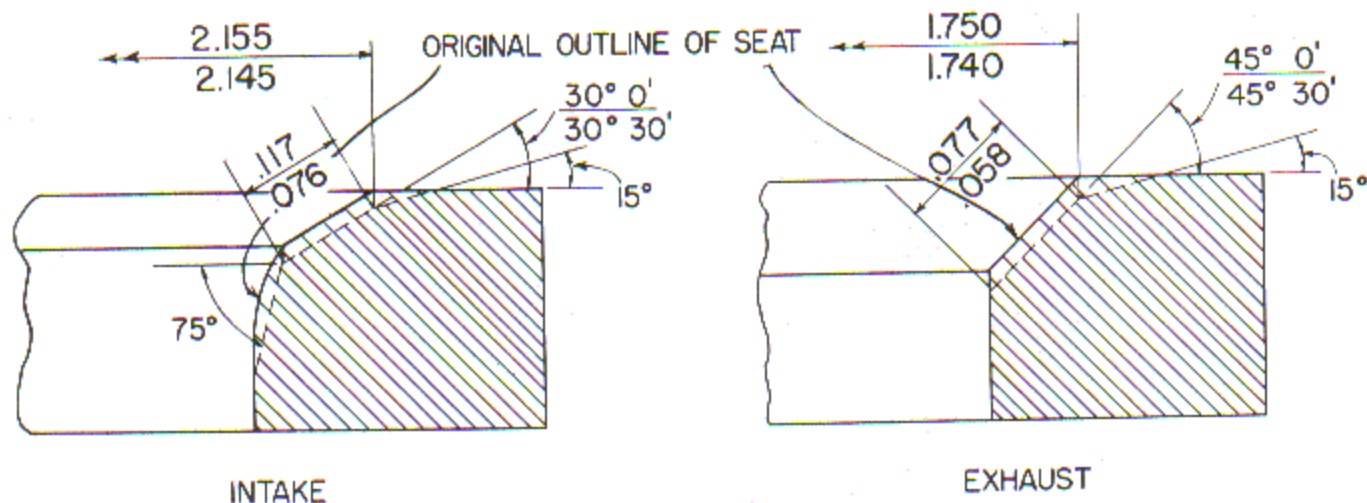


Figure 6-20. Valve Seat Reconditioning Dimensions

horseshoe puller retainer on end of puller bolt with small pilot of retainer toward open end of guide. Lock puller bolt nut by inserting nut between sides of large slot across top of puller body. Tighten screw gently until pilot of horseshoe puller retainer is felt by fingers to enter the lower or post end of the guide; then pull guide out of cylinder head by turning puller screw clockwise.

6-44. Check each valve guide hole in cylinder head with standard valve guide hole plug gage (22, figure 11-3). If the gage enters the hole more than 1/8 inch, it will be necessary to ream the hole and install an oversize guide. If the gage enters the hole easily or seems loose in the hole, it is evident that an oversize guide has already been installed and the next larger size guide must be used. Refer to Table VI-I for the selection of the proper size guide and reamer.

6-45. Mount valve guide replacement fixture on drill press table and mount cylinder on the fixture.

6-46. Having determined the proper size reamer, mount the reamer in the drill press spindle and ream the valve guide hole in the cylinder head. (See figure 6-19.) Check the reamed hole with the corresponding gage. (See Table VI-I.)

TABLE VI — I  
VALVE GUIDE REPLACEMENT TOOLS

| Nominal<br>Oversize | Reamer          | Gage            |
|---------------------|-----------------|-----------------|
| Standard            | -----           | 22, figure 11-3 |
| 0.005               | 25, figure 11-3 | 18, figure 11-3 |
| 0.010               | 26, figure 11-3 | 19, figure 11-3 |
| 0.020               | 27, figure 11-3 | 20, figure 11-3 |

6-47. Heat the cylinder to 600° - 650° F (316° - 343° C) Place the new guide on the valve guide installing drift (17 or 33, figure 11-3) and insert the guide in the hole in the cylinder head. Drive the guide to a firm seat with sharp hammer blows on the end of the drift. After the cylinder has cooled, ream the hole in the

guide with the valve guide ID reamer (28 or 32 figure 11-3). Check the finished ID of the guide with the valve guide ID plug gage (21 or 31, figure 11-3).

6-48. GRINDING VALVE SEATS. Grind valve seats using suitable grinding equipment, to 30° angle on intake valve seats and 45° angle on exhaust valve seats. (See figure 6-20.) Narrow the faces of the valve seats in the following manner:

6-49. On intake valves, use a 15° grinding wheel to grind the top surface of the valve seat to produce an outer face diameter of 2.155/2.145 inches. Bring the face of the intake valve to the specified width of .117/.076 inch by narrowing the throat with a 75° wheel. (See figure 6-20.)

6-50. On exhaust valve seats, use a 15° wheel to grind the top surface of the exhaust valve seat enough to bring face of seat to a specified width of .077/.058 inch. The outer face diameter of the exhaust valve seat should now measure 1.750/1.740 inches in diameter. (See figure 6-20.)

6-51. If seat wear has progressed to the extent that the entire face of the 15° narrowing wheel must be brought into contact with the seat in order to achieve the specified diameter, the seat must be replaced. (See figure 6-21.)

6-52. VALVE SEAT REMOVAL AND REPLACEMENT. Valve seats that are loose, damaged or worn

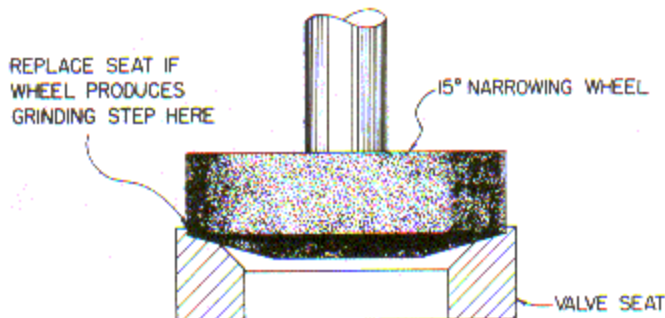


Figure 6-21. Rejection of Valve Seat

to the extent that they cannot be reground to the dimensions shown in figure 6-20 must be replaced.

#### NOTE

The removal of a valve seat requires the installation of an oversize replacement seat. The replacement seat must be at least 0.010 inch larger than the removed seat.

6-53. Mount the valve seat removal pilot (34 or 35, figure 11-3), cutter (39 or 40, figure 11-3), and holder (36, figure 11-3) in the spindle of a suitable drill press.

6-54. Place valve seat removal fixture (37, figure 11-3) on the drill press table. Locate cylinder on fixture, fasten cylinder securely in place, and set fixture for proper angle. Locate fixture on table so that counter-bore pilot enters valve guide.

6-55. Fasten fixture securely in place and bore out valve seat. Collapse seat and remove from cylinder head.

6-56. Measure the ID of the valve seat recess in the cylinder head. Compare the measurement against the original manufactured diameter of the recess (see Table of Limits) and decide which oversize seat (0.010, 0.020, or 0.030) is to be installed. Select the corresponding cutter (45, 46 or 47, figure 11-3 for intake seat recesses; 48, 49 or 50, figure 11-3 for exhaust seat recesses) and the proper pilot (43, figure 11-3 for intake valve guides; 44, figure 11-3 for exhaust valve guides). Install the pilot in the cutter and secure with setscrew, insert the cutter into the handle (42, figure 11-3) and proceed to cut the recess in the cylinder head to proper size. Remove no more metal from the bottom of the recess than is necessary to clean up the surface.

6-57. Heat cylinder to 600° - 650° F (316° - 343° C). Place new valve seat on replacement drift (38 or 41 figure 11-3), and drive seat into recess in head by tapping end of drift firmly with a hammer.

6-58. Grind, or seat the faces of all newly-installed valve seats as described in paragraph 6-48.

6-59. VALVE REFACING. Reface valves in valve refacing machine. Remove no more metal than is necessary to clean up pits in valve face or to correct any apparent warping condition. Set refacer to 30° for intake valves and to 45° for exhaust valves. Round off with a hand stone any sharp or burred edges left around the valve face after refacing; this is best done while valve is turning in the refacing machine.

6-60. ROCKER SHAFT BUSHING REMOVAL AND REPLACEMENT. Rocker shaft bushings are removed and new bushings replaced in the following manner:

6-61. Secure the cylinder to a suitable fixture on a workbench. Remove both outer and inner rocker shaft bushings, using the rocker shaft bushing removal drift (56, figure 11-3).

6-62. After the rocker shaft bushings have been removed, check each rocker shaft bushing hole in cylin-

der head with rocker shaft bushing hole in cylinder head plug gage (54, figure 11-3). If plug gage enters hole more than 1/8 inch, an oversize rocker shaft bushing will be required. If the fit of the plug gage in the hole is quite loose, it is evident that the rocker shaft bushing that was removed was an oversize bushing. Use the 0.005 inch oversize rocker shaft bushing hole in cylinder head plug gage (55, figure 11-3) to determine what oversize bushings should be used for replacement.

6-63. When the proper sizes of replacement rocker shaft bushings have been determined, proceed to ream the bushing holes in cylinder head. Place the pilot of the 0.005 or 0.010-inch oversize rocker shaft bushing hole in cylinder head reamer (61 or 62, figure 11-3) through the outer bushing hole and ream the four rocker shaft bushing holes in cylinder head. Clean the cylinder and reamed holes thoroughly.

6-64. Place a new bushing on the driver of the inner rocker shaft bushing installation drift (59, figure 11-3) and locate bushing and driver in front of inner rocker shaft bushing hole in cylinder head. Insert the pilot of the inner rocker shaft bushing installation drift through the outer bushing hole and tap inner bushing in place. When installing the outer rocker shaft bushing, install the stop of the outer rocker shaft bushing installation drift (58, figure 11-3) between the inner and outer rocker shaft bushing holes in cylinder head. Place a new bushing on the outer rocker shaft bushing installation drift and tap into place.

6-65. After installing new rocker shaft bushings in cylinder head, place the pilot of the inner and outer rocker shaft bushing ID finish reamer (60, figure 11-3) through the outer bushing hole and ream the four bushings. Check the finished ID holes of the rocker shaft bushings with the rocker shaft bushing ID plug gage (57, figure 11-3). Clean the cylinder and reamed holes thoroughly.

#### NOTE

After bushings have been reamed, they must be impregnated by immersing them for at least 15 minutes in engine oil that has been heated to 140° F (60° C).

6-66. REPLACEMENT OF VALVE ROCKER BUSHINGS. If valve rocker bushings are damaged or worn, they can be replaced in the following manner:

6-67. Place the valve rocker in position in the valve rocker holding fixture (51, figure 11-3) and, using a suitable drift, remove the bushing from the valve rocker.

6-68. Using a suitable arbor press, install a new bushing in the valve rocker. Make sure the oil hole in the bushing is aligned with the oil hole in the valve rocker.

6-69. Burnish the bushing by using an arbor press to pass the valve rocker bushing burnisher (52, figure 11-3) completely through the bushing.



6-70. REGRINDING UNPLATED CYLINDER BARRELS. All unplated cylinder barrels which exceed allowable service limits in diameter, taper, or out-of-roundness must be reground to 0.010 or 0.020 inch oversize. This work must be done by a competent operator on a suitable internal grinding machine; do not attempt to regrind a barrel on a lightweight grinder such as a block-mounted automotive type or other similar machine.

6-71. The oversize to which the cylinder is to be ground is determined by adding 0.004 inch cleaning-up allowance (0.002 inch per wall) to the barrel diameter measured at the point of the greatest wear; the barrel is then ground to the next oversize above this figure. Barrels with wear at any point exceeding .020 inch over the basic manufactured diameter must be replaced. (See reference 522, Table of Limits.)

6-72. The following data is included as a guide in selecting an efficient wheel and set-up:

a. Wheel

Grain Size — 60 or 70 (medium to fine)  
Grade — I or J (medium)  
Structure — 8 (porous)  
Diameter — 3-1/2 to 4 inches.

b. Wheel speed — 5600 to 6000 surface feet per minute (5350 to 5730 rpm for 4-inch diameter wheel.)

c. Work speed — 120 rpm.

6-73. It is recommended that barrels be ground to a surface finish of 30–45 micro-inches minimum. Providing that suitable equipment is used, such a finish can be obtained by grinding if the barrel diameter is brought to within 0.0005 to 0.0010 inch of the desired ID by roughing cuts, after which the wheel is redressed and the finish pass made. The wheel should then be allowed to run out over the work four or five times. When setting up the job, make sure that the stops are arranged to prevent the edge of wheel from running past the top of the barrel more than 1/8 inch. This will protect the interior of the combustion chamber from damage.

6-74. Cylinders with barrels ground 0.010 or 0.020 oversize must be fitted with corresponding oversize rings and pistons.

6-75. It is feasible under certain circumstances to rebarrel a cylinder; this operation is strictly a factory job, however, and the cylinder must be returned to Lycoming.

6-76. RECONDITIONING BARRELS BY CHROME PLATING. The restoration of worn cylinder barrels by chrome plating can be done, provided the barrels can be ground prior to chrome plating to not more than 0.015-inch diameter over the maximum standard cylinder bore diameter. The barrel diameter after plating will be within the limits established for standard cylinders. Barrels that have been chrome plated develop wear steps only under extreme operating conditions; although it is not practical to remove wear steps by regrinding, such barrels can be restored at subsequent overhaul periods by a stripping and replating process.

6-77. BROKEN FINS. If any of the fins are found to be cracked, the area surrounding the crack should be ground out so that the crack is entirely removed. If several fins are cracked and considerable material has been removed so that the cooling properties of the fins are impaired, the cylinder should be discarded. Any nicks that are found on the fins should be carefully stoned or removed with a small file, because even the smallest nick can develop into a crack. If a crack has progressed beyond the base of the fin into the head, the cylinder must be rejected.

## REASSEMBLY

6-78. INITIAL ASSEMBLY.

6-79. ASSEMBLY OF CYLINDER. (See figure 6-6) Coat the stems of intake and exhaust valves (8 and 9) with preservative oil and insert the valves in their respective guides. The intake valves can be identified by the fact that they are slightly larger than the exhaust valves. In addition, the sodium-cooled exhaust valves have a larger diameter stem than the conventional solid-stem valve. Hold the ends of the valve stems and place the cylinder on the holding block (2, figure 11-3). Install on each valve a lower spring seat (5), inner and outer valve spring (4 and 3) and an upper spring seat (2).

### NOTE

Assemble the dampener ends of springs (close-wound coils marked with red dye or lacquer) downward or next to the lower spring seats.

8-80. Compress the springs with the valve spring compressor (1, figure 11-3) and assemble the valve retaining keys.

### NOTE

Exhaust valves are assembled with special keys.

6-81. ASSEMBLY OF PISTONS. Using the piston ring expander (6, figure 11-3), assemble new rings on each piston in the order described below.

8-82. With the piston lying top up on the workbench, install the oil regulating ring equalizer in the third groove from the top of the piston. Then assemble the regulating ring over the equalizer with its gap 180° opposite the equalizer gap. Compress the assembly several times with the fingers to make sure the ring lies free and loose in the groove.

### NOTE

Both the equalizer and the regulating ring are symmetrical and may be installed with either side upward.

6-83. Install a compression ring in the second groove and then install the other compression ring in the top groove. The compression rings are etched on one side with the word "top," and this side of the ring must be facing toward the head of the piston.

**WARNING**

Do not under any circumstances assemble chrome plated piston rings in a chrome plated cylinder barrel. If in doubt as to the proper combination of rings to be used, contact the Service Department, LYCOMING Division.

6-84. Upon completion of assembly of rings to piston check the side clearance of the rings in the piston grooves. Use feeler gages and a straight edge as shown in figure 6-7. Draw ring into groove against feeler gage: if face of ring protrudes beyond edge of piston land when using minimum thickness gage, the clearance is too small. If face of ring is inside edge of piston land when using maximum thickness gage, the clearance is too great. The clearance should fall within the dimensions given in References 514 through 517, Table of Limits. If prior inspection of the ring grooves or cylinder barrel has indicated that over-size rings are required, be sure that the proper over-size rings are selected.

**6-85. INSTALLATION OF PISTONS AND CYLINDERS.**

6-86. See that all oil accumulations on cylinder and piston assemblies are washed off and thoroughly dried with compressed air. Insert all valve rocker shafts (18, figure 6-6) in their bearings in the rocker boxes. Immediately prior to assembly of each cylinder and piston to the engine, space the rings correctly and apply a generous coating of preservative oil to inside of cylinder barrel and to piston and rings, working the oil well around the rings and into ring grooves. Starting with No. 1 cylinder, proceed to assemble as follows:

6-87. Rotate crankshaft so that No. 1 piston, when installed, will be approximately at top dead center on its firing stroke; this is determined by both tappets for No. 1 cylinder being on the base circle of the cam lobes.

**CAUTION**

Before any attempt is made to rotate the crankshaft, support the connecting rods with rubber bands (discarded cylinder base oil seal rings) looped around the cylinder base studs or metal plates as shown in figure 6-3.

6-88. Assemble piston on connecting rod with piston number, which is stamped on bottom of piston head, toward the front of the engine. The piston pin should be palm or hand push fit. If the original piston pin is tighter than a palm push fit, it is probably caused by nicks or slight carbon in the piston pin bore of the piston. If a new piston pin or piston is to be installed, select the pin to give a palm push fit at room temperature of 15° to 20° C (60° to 70° F). After piston pin is in place and centrally located, insert a piston pin plug at each end of the piston pin.

**NOTE**

When assembling piston on engines with chrome plated cylinder barrels, use aluminum bronze piston pin plugs.

6-89. Place a rubber cylinder base oil seal ring (10, figure 6-6) around the cylinder base, assemble the piston ring compressor (5, figure 11-3) over the top three piston rings and install the cylinder over the piston, pushing the piston ring compressor ahead with the cylinder barrel skirt to encircle and compress the oil scraper ring at the piston skirt. As the cylinder barrel approaches the crankcase, catch the piston ring compressor as it drops off the piston skirt. When base of cylinder is seated on crankcase pad install cylinder hold-down nut plate over the cylinder base studs and secure the cylinder with 3/8-inch and 1/2-inch cylinder base nuts, tightening the nuts finger-tight only. Before tightening any of the nuts to final torque, complete the assembly of the three remaining cylinders as described above. This can be done in any order desired, but less turning of the crankshaft is involved if the cylinders are installed successively in the engine firing order.

6-90. To assure proper assembly of the crankcase halves and to eliminate the possibility of subsequent loosening of cylinder base nuts, a definite and specific sequence of tightening all crankcase and cylinder fastenings must be followed. As noted in the description in Section VII of crankcase assembly, the peripheral crankcase fastenings are initially tightened finger-tight only, final torque not being applied until after the cylinder base nuts are installed as described in the following paragraphs.

6-91. When all cylinders have been initially installed on the crankcase as described in paragraph 6-89 above, begin tightening all cylinder base nuts in the following sequence, using the proper cylinder base nut wrenches (7 and 8, figure 11-3) and handle (4, figure 11-3) in conjunction with a suitable torque indicator.

**NOTE**

Torque wrenches employing the flexible beam design are recommended in preference to those using the hydraulic principle as a dial indicator with rack and pinion.

a. Tighten all 3/8-inch cylinder base nuts to 200 inch-pounds torque. The order of cylinder is immaterial, but the nuts on each individual cylinder should be tightened in the sequence shown in figure 6-22.

b. On O-360 engines, tighten all 1/2-inch cylinder base nuts on No. 2 cylinder to 300 inch-pounds

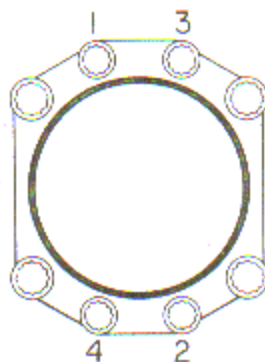


Figure 6-22. Sequence of Tightening 3/8-Inch Cylinder Base Nuts

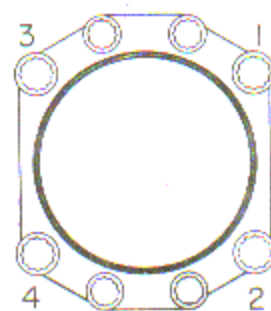


Figure 6-23. Sequence of Tightening 1/2-Inch Cylinder Base Nuts

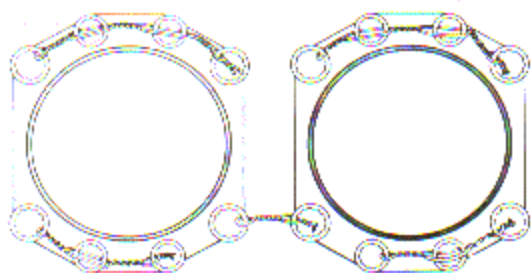


Figure 6-24. Method of Lockwiring Cylinder Base Nuts on Four Cylinder Engines

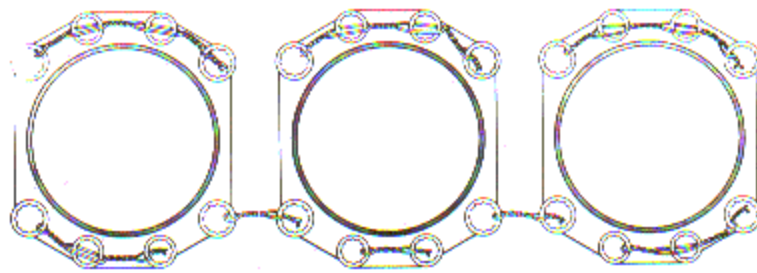


Figure 6-25. Method of Lockwiring Cylinder Base Nuts on Six Cylinder Engines

torque in the sequence shown in figure 6-23. Then, using the same sequence, proceed to tighten the 1/2-inch nuts on cylinders 3,4 and 1, in that order. Figure 6-23 also shows the sequence for tightening 1/2-inch cylinder base nuts on O-540 engines. These nuts are to be tightened to 300 inch-pounds torque, first on cylinder No. 4, then on cylinders 5,3, 2, 6 and 1, in that order.

c. Repeat step a. above, this time tightening the 3/8 inch nuts to 300 inch-pound torque.

d. Repeat step b. above, this time tightening the 1/2 inch nuts to 550 inch-pound torque.

e. During the final tightening procedure, bearing crush or crankcase shift may have occurred, relieving the load on certain of the 1/2-inch stud nuts. Therefore, as a final check, repeat step d. This may be done by holding the wrench on each nut for about five seconds at 550 inch-pounds. If the nut does not turn it may be presumed to be tightened to the proper torque.

6-92. Secure cylinder base nuts by lockwiring as shown in figure 6-24 and 6-25, using 0.032 diameter wire.

6-93. When all cylinder base nuts have been tightened, checked, and locked, as described in paragraphs 6-91 and 6-92, proceed with the final tightening of the peripheral crankcase fastenings as described in Section VII.

6-94. Install some type of vented plug in each spark plug hole after assembly of cylinder to prevent entrance of foreign matter and at same time to permit the engine to be turned easily by hand.

6-95. Install hydraulic tappet plunger and cylinder assemblies with spring end outward and sockets with concave end outward in the two hydraulic tappet bodies for No. 1 cylinder.

6-96. Assemble new shroud tube oil seals (11, figure 6-6) in both shroud tube oil seal retainers in crankcase and on outer end of the two push rod shroud tubes; then assemble a shroud tube seal sleeve over each of these seals, centering the sleeve on the seal.

6-97. Install each shroud tube (13, figure 6-6) through its hole in the rocker box and seat the end firmly in the crankcase. Place a spacer, two springs (14, figure 6-6) a lockplate, and a plain 1/4-20 nut over the stud provided in the rocker box. Tighten the nut to proper

torque and secure by bending the lockplate over nut and springs. (See figure 6-2.)

6-98. After applying a liberal coating of preservative oil to all parts to be assembled, insert a push rod in each shroud tube, placing the grooved end of the rod outward (away from the crankcase). Next, install a valve cap (26, figure 6-6) on exhaust valve and start a valve rocker shaft (18, figure 6-6) into one of the outer rocker shaft mounting bosses in the cylinder head. While holding a valve rocker (15, figure 6-6) in place, push the rocker shaft through the valve rocker and into the hole in the middle boss. Repeat with the other rocker, pushing the shaft through until it protrudes equally from both outside mounting bosses. After the rockers are installed, check the clearance between the valve stem tip or cap and the valve rocker. This is done by inserting the valve clearance gage (12, figure 11-3) into the gap between rocker and valve stem or cap while pushing down on the push rod end of the valve rocker. If the valve clearance exceeds the minimum or maximum limits (see Table IX-I, General Specifications) it must be adjusted by inserting a push rod of different length. These lengths may be identified by the number of grooves turned into the tappet end of the rod (see figure 6-26); the shortest rods have two grooves, the next longer rods have one groove and the longest rods are unmarked. Inserting a longer rod will decrease the clearance. After the proper clearance has been obtained, attach the rocker box cover temporarily to prevent displacement of valve rocker shafts.

6-99. After completing the assembly of No. 1 cylinder to the crankcase, proceed in the same manner with the assembly of the remaining cylinders; assemble the cylinders in the same sequence as the firing order (1-3-2-4 for O-360 engines; 1-4-5-2-3-6 for O-540 engines).

6-100. At completion of valve clearance check on each cylinder, recheck clearance on all cylinders and make

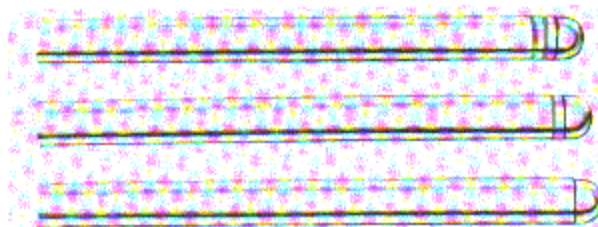


Figure 6-26. Identification of Push Rod Length

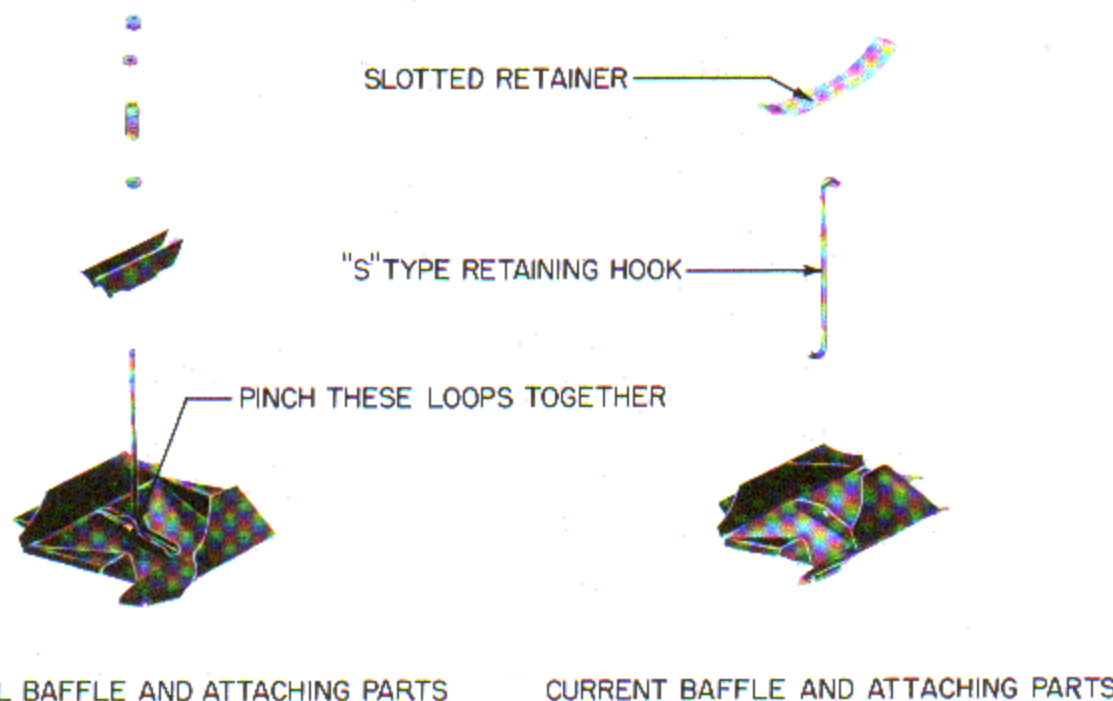


Figure 6-27. Intercylinder Baffle Assembly, Exploded View

any necessary corrections. Coat all exposed valve mechanism parts within rocker boxes with a liberal amount of preservative oil and assemble all four rocker box cover gaskets and covers. Secure covers with screws and plain washers.

**6-101. INTERCYLINDER BAFFLES.** All intercyylinder baffle assemblies must be attached with an "S" type retaining hook and slotted retainer. Modify baffle assemblies, if this has not already been done, by pinching loops together as shown in figure 6-27. Hook the baffle retaining hook through the loops in the baffle. Place the baffle in position beneath and between the cylinder, running the hook up between the cylinder barrels. Place a baffle retainer in position between the cylinders and use the L-shaped baffle assembly tool (10, figure 11-3) to bring the end of the retainer hook through the slot in the retainer. During this operation the retainer is forced down until the hook comes above the surface of the retainer far enough to be turned and hooked over the bridge between the slots in the retainer.

**6-102. INTAKE PIPES.** See Section VIII for installation of intake pipes.

**6-103. ROCKER BOX DRAIN TUBES.** (See figure 6-6.) Assemble a new rocker box drain tube hose (20) and two hose clamps (21) over the crankcase end of each drain tube. Connect the end of the hose to the nipple in the crankcase. Then connect the gland on the other end of the tube to the 45° elbow in the cylinder head. Tighten the hose clamps and attach the remaining drain tubes.

**6-104. PRIMER LINES.** Primer lines are available for cylinders 1, 2 and 4 on O-360 engines and cylinders 3, 4, 5 and 6 on O-540 engines. The primer system is assembled by connecting the lines from each cylinder to tee connections. (See figure 6-1.) Each individual line is supported by a loom and offset clamp attached to the adjacent intake pipe, while the entire system is supported by two clips fastened to the rear of the crankcase. The lines from each cylinder terminate in a tee at the rear of the engine.

## SECTION VII

CRANKCASE, CRANKSHAFT, AND  
RECIPROCATING PARTS

7-1. As explained in Section VI, paragraph 6-2, the piston assembly, which actually is a reciprocating part, has been included with the cylinder for the purposes of this manual in order to reduce cross-referencing and resulting confusion.

## 7-2. REMOVAL OF ACCESSORIES.

7-3. GENERATOR. Unfasten the two 5/16-inch hex head bolts which attach the generator to its mounting bracket but do not remove the bracket, which is attached to the crankcase. Unfasten the 5/16-inch hex head bolt which attaches the generator to its adjusting link and remove the generator. The adjusting link may now be removed from the crankcase.

7-4. On engines equipped with propeller governor on the accessory housing, remove the external oil line from the governor drive adapter to the right front of the crankcase by unscrewing the threaded fittings at both ends and pulling the line out toward the rear of the engine.

7-5. STARTER. Remove the starter ring gear support from the crankshaft propeller flange by tapping lightly on the rear face of the support with a hammer. The generator drive belt should also be disassembled from the engine with this unit.

7-6. Remove the four 5/16-inch hex head bolts which attach the starter to the lower left front of the crankcase and remove the starter from the engine by pulling it downward to avoid damage to the two dowels which locate the starter on its mounting.

## DISASSEMBLY

7-7. Remove the crankshaft idler gears from the crankshaft idler gear shafts attached to the rear of

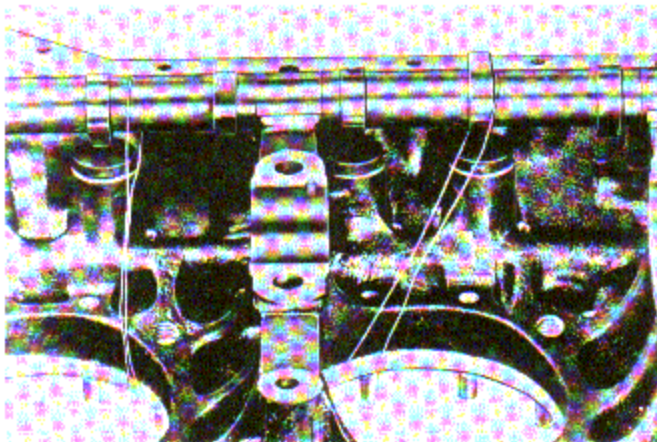


Figure 7-1. Camshaft Wired to Crankcase

the crankcase; also remove the breather slinger and camshaft gear from the rear of the camshaft, by removing the four 5/16-inch hex head bolts and two lockplates that secure them to the camshaft. Remove the tachometer shaft from the rear of the camshaft by removing the 3/16-inch dia. x 1-1/8-inch long pin that secures it to the camshaft.

7-8. Remove all nuts, from around the dividing line of the crankcase, that hold the two halves of the crankcase assembly together; keep in mind that there are fastenings on the bottom and one on the rear of the crankcase. Support the crankcase by the lifting strap and a suitable chain hoist and detach the engine mounting bolts. Lift the crankcase from the overhaul stand and place it on a suitable bench with the right side down. Prevent the tappets in the left side of the crankcase from falling out by wiring the camshaft to the left crankcase. (See figure 7-1.) Separate the crankcases a distance of one inch apart by tapping the through bolts gently with a soft hammer. Reach down through the cylinder mounting pads and push the left half of each main bearing down onto the crankshaft so it will not fall from the crankcase while the crankcase is being removed. Separate the cases by hand and remove the main bearings, tappets, camshaft, and crankshaft assembly. Place each tappet body, as it is removed, in its proper compartment of the cleaning basket.

## NOTE

In the left crankcase the intake tappet for its corresponding cylinder is located nearest the front of the engine, while in the right crankcase, the intake tappet is located nearest the rear of the engine.

7-9. PROPELLER GOVERNOR DRIVE (O-540 ONLY). (See figure 7-2.) Loosen the lockwire and remove the hex head plug (6) from the propeller governor drive housing. Remove the idler shaft (5) through the opening in the housing, at the same time supporting the idler gear (2) to prevent it from being dropped and damaged. Pull the governor drive gear (3) from the housing on the inside.

7-10. CRANKCASE. Remove all threaded plugs to facilitate cleaning. These plugs include five 1/8-inch Allen head plugs; one is located at the end of the main oil gallery near the front of each half of the crankcase, another is on the rear of the left half, and two more are on the rear of the right half of the crankcase.

7-11. Remove the front, center and rear main bearing inserts from both halves of the crankcase. Remove and discard the rubber oil seals encircling the studs and stud holes near each main bearing.

7-12. Remove the two crankshaft idler gear shafts located on the rear of the two crankcase halves by removing the 1/4-inch hex head screws and lockplates on O-360 engines and 5/16-inch hex head screws and lockplates on O-540 engines. No further disassembly of the crankcase is necessary.

7-13. CAMSHAFT. Remove the camshaft governor drive gear by removing the two external retaining rings that hold it in place.

7-14. CRANKSHAFT. With the crankshaft properly supported at front and rear main bearings, remove the roll (or cotter) pins from the 3/8-inch slotted nuts on the connecting rod bearing caps. Remove the nuts and connecting rods from crankshaft by tapping on ends of bolts with a soft hammer. After noting any evidence of damage or failure of the bearing inserts, discard inserts and reassemble each cap with its corresponding rod, as the caps and rods are not interchangeable.

7-15. Flatten out the bent edge of the lockplate from the hex head screw which is located within the inside diameter of the gear on rear end of crankshaft. Use a 1/2-inch socket wrench to remove this 5/16-inch hex head screw. Tap gear gently with a fibre drift to remove. Do not remove the dowel from the rear end of the crankshaft unless damaged.

7-16. Remove the crankshaft oil seal from around front of crankshaft by slipping it out from its retaining spring and then off the shaft. To remove the retaining spring, locate on its circumference the place where its two ends are joined; then by twisting at this point (in the same manner as removing a nut from a bolt), the spring can be opened.

7-17. Do not remove the propeller flange bushings from the flange of the crankshaft unless they are damaged or loose. However, if it is necessary to replace the bushings, they may be removed with the crankshaft flange bushing removal and replacement tool (16, figure 11-4).

7-18. CRANKSHAFT COUNTERWEIGHTS (O-540 ONLY). Disassemble the counterweights from the crankshaft by first removing the retaining rings and washers which hold them in place; after this the rollers and counterweights may be removed.

#### NOTE

All counterweights and their related parts should be reassembled in the same location they occupied on the crankshaft before disassembly. For example, the retaining washers used with the counterweights are fitted to the washer seats in the counterweights during manufacture of the crankshaft. It is advisable, therefore, to mark all counterweight parts during disassembly to insure proper identification. Note that these markings must be impermanent; no scoring, scratching, etching or other permanent markings of any kind are permissible on these parts.

7-19. CRANKPIN OIL TUBES (O-360). Remove the four crankpin journal sludge tubes with the oil tube removal drift (6, figure 11-4), by placing the drift part of the tool in the oil tube and driving out the

tube with the bar portion of the tool. Do not clean the tubes but lay them aside for examination to determine if metal chips will be found in the sludge deposits. Do not re-use crankshaft oil tubes.

#### NOTE

All crankpin journal sludge tubes must be removed from the crankshaft; otherwise accumulated sludge loosened during cleaning will clog the crankshaft oil passages and cause subsequent bearing failures. The oil transfer tubes, however, which conduct oil from the main bearings to the crankpin journals must not be removed under any circumstances.

7-20. CRANKPIN OIL TUBES (O-540). When removing the six crankpin journal oil tubes, use the slide hammer puller (13, figure 11-4) and crankshaft sludge tube puller adapter (15, figure 11-4). Remove the jaws from the slide hammer and assemble the puller adapter on the slide hammer puller. Remove the collar from the adapter and insert the adapter through the crankpin sludge tube. Screw the collar tightly in place on the threaded end of the adapter which protrudes through the sludge tube. Pull the tube out of the crankshaft with a series of quick hard strokes of the hammer. Remove all crankpin oil tubes in the same manner. Do not clean tubes, but set them aside for examination to determine if metal chips will be found in the sludge deposits. Do not re-use crankshaft oil tubes.

## CLEANING

7-21. All crankcase, crankshaft, and reciprocating parts are cleaned in accordance with the general instructions outlined in Section III. When cleaning the crankshaft, clean the inside of all crankpin and main bearing journals and all oil passages with suitable brushes, after which flush thoroughly with cleaning solvent and compressed air.

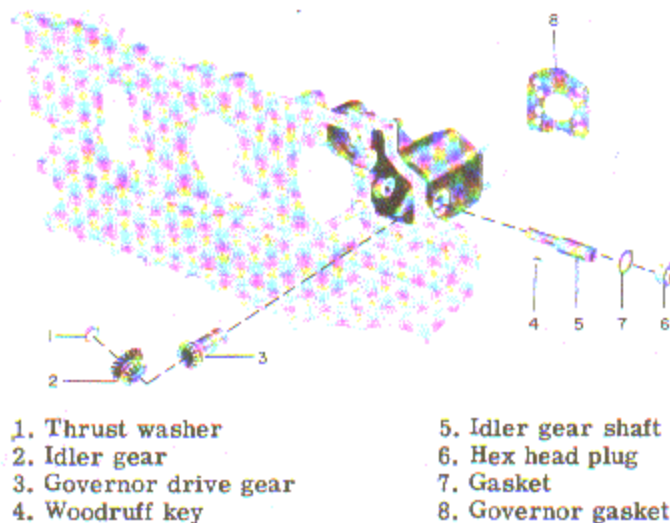


Figure 7-2. Exploded View of Propeller Governor Drive (O-540 only)

**CAUTION**

Do not attempt under any circumstances to clean the crankshaft without first removing the crankshaft oil tubes, as solvent will loosen but not remove accumulated sludge. This loose sludge is certain either to form a stoppage in the nearest oil passage or to wash through and cause a bearing failure.

**INSPECTION**

7-22. Inspect all crankcase, crankshaft, and reciprocating parts in accordance with the general instructions contained in Section III. Specific instructions follow:

7-23. CAMSHAFT (VISUAL INSPECTION). Carefully inspect all surfaces of the camshaft for cracks, scoring, galling, corrosion, pitting, or other damage; be particularly careful when inspecting bearing surfaces. If a hydraulic tappet body has been rejected for spalling, inspect the corresponding cam lobe with a magnifying glass (10 power, min.); any indication of distress, surface irregularity, or feathering at the edge of the cam lobe is cause for rejection of camshaft.

7-24. CRANKSHAFT (VISUAL INSPECTION). Carefully inspect all surfaces of the shaft for cracks; check the bearing surface with particular care for scoring, galling, corrosion, pitting, or other damage. Check propeller flange bushings for tightness; mark for replacement any that are loose. Inspect all plugs and oil transfer tubes for tightness and condition.

7-25. BEARING INSERTS. All steelbacked precision type bearing inserts used for main crankshaft bearings and connecting rod bearings should be replaced with new inserts at each overhaul.

7-26. CAMSHAFT (DIMENSIONAL INSPECTION). Check the camshaft for run-out and out-of-roundness. Using vee blocks (5, figure 11-4) on a surface plate, measure the run-out with a dial indicator at the center main bearing journals (see reference 539, Table of Limits). Slight bending operations are permissible on the camshaft provided careful magnetic inspection follows bending operations.

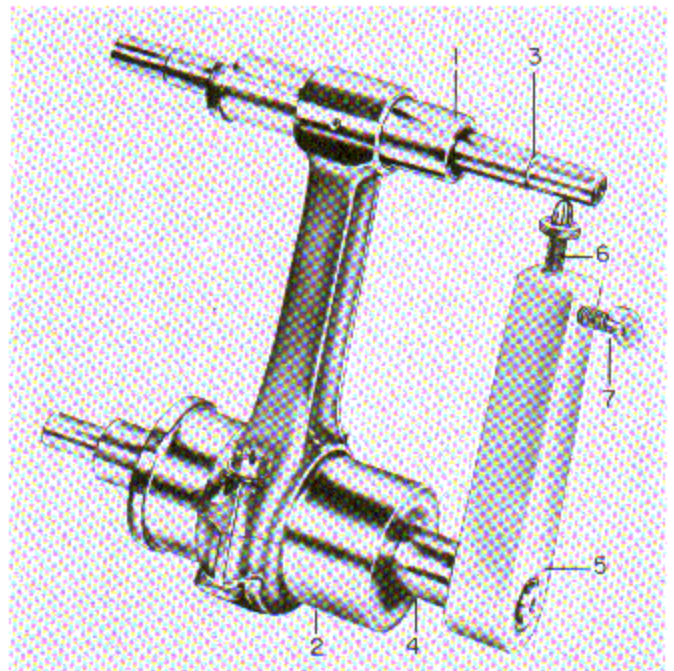
7-27. CRANKSHAFT (DIMENSIONAL INSPECTION). Mount the front and rear bearing journals of the crankshaft in vee blocks (5, figure 11-4) on a surface plate. Use a dial indicator to measure for run-out and out-of-roundness. Maximum allowable run-out for journal No. 2 is 0.002 inch and the maximum run-out allowed for journal No. 3 (and journal 4 on O-540 engines only) is 0.005 inch. The maximum run-out of pilot diameter in relation to front and rear main bearings is 0.003 inch and the maximum permissible run-out on the crankshaft flange is 0.018. If the run-out on any surface checked should exceed the limits given, the crankshaft must be rejected. If the flange run-out falls between 0.005 and 0.018 and the rest of the surfaces of the crankshaft are within limits, the crankshaft may be straightened.

7-28. Using new inserts at all main bearing locations, assemble crankcase halves together temporarily and measure the ID of the bearings. Measure the OD of the main bearing journals and compare the resulting clearances with Table of Limits (reference 501). Assemble the connecting rods temporarily (using new bearing inserts) and check the crankpin journal clearances in the same manner (reference 502, Table of Limits). If clearances do not fall within prescribed limits, the shaft must be reground for 0.003 or 0.010 inch undersize bearings. Measure the diameter of the camshaft bearing journals and check them against the bearings formed by the crankcase (see reference 537, Table of Limits).

7-29. COUNTERWEIGHT ROLLER BUSHING (O-540 ONLY). Under normal conditions, wear on the steel bushings in the crankshaft counterweight lugs is confined to a localized area of the bushing ID opposite the longitudinal centerline of the crankshaft. Any wear sustained by the bushing, therefore, will appear as an out-of-round condition which can readily be detected with standard measuring equipment. Since wear of this nature directly affects the dampening action of the counterweight itself, bushings showing wear must be replaced.

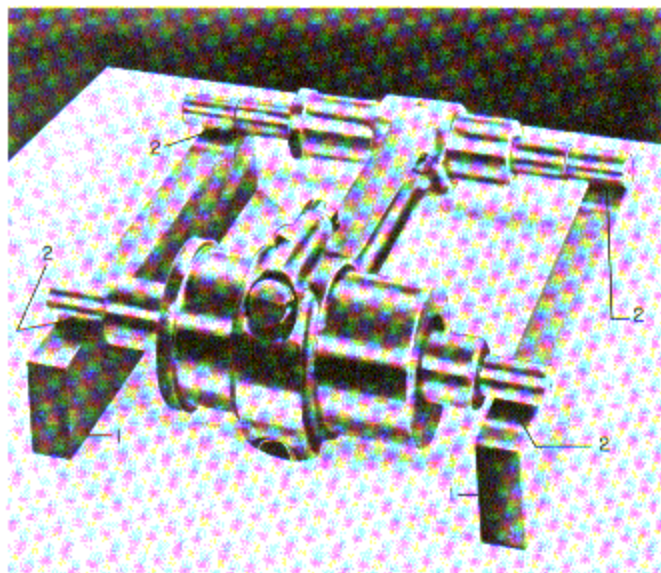
**7-30. CONNECTING RODS.**

7-31. Discard all connecting rod bolts and nuts; new bolts and nuts are to be used on assembly. Check condition of bore in large end for seating of the bearing inserts. Check ID of bushing in small end with flat plug rejection gage (4, figure 11-4). If the gage enters the bushing, replace the connecting rod bushing.



- |                               |                             |
|-------------------------------|-----------------------------|
| 1. Tapered sleeve (small end) | 4. Arbor (large end sleeve) |
| 2. Tapered sleeve (large end) | 5. Gage arm                 |
| 3. Arbor (small end sleeve)   | 6. Adjusting screw          |
|                               | 7. Wing nut                 |

Figure 7-3. Checking Parallelism of Connecting Rods



1. Parallel blocks                      2. Points to be checked

Figure 7-4. Checking Squareness of Connecting Rods

**7-32. CONNECTING ROD PARALLELISM CHECK.** (See figure 7-3.) Using connecting rod parallelism and squareness gage (1, figure 11-4), insert tapered sleeves (1 and 2), in bearing holes in connecting rod. Be sure that bearing cap is assembled properly and tightened securely. Place arbors (3 and 4) through sleeves (1 and 2, respectively) and place gage arm (5) on arbor (3). Set adjusting screw (6) on gage arm to exact distance between arbors and lock the adjusting screw with wing nut (7). Then remove gage arm, place it on other end of arbor (3), and check distance between arbors. For exact parallelism or alignment, the distances checked on both sides will be the same (see reference 566, Table of Limits).

**7-33. CONNECTING ROD SQUARENESS CHECK.** (See figure 7-4.) Using the same gage that was used in the parallelism check described above, place parallel blocks (1) on surface plate and with sleeves and arbors still in place in connecting rod, place ends of arbors on parallel blocks. Check clearance at points (2) where arbors rest on parallel blocks using a feeler gage. For exact squareness or zero twist, no clearance will exist at the designated points (see reference 567, Table of Limits).

**7-34. CRANKCASE.** Check carefully for nicks and burrs and for cracks around bearing support webbing. Pay particular attention to check of bearing bores and insert tang slots for any roughness that might cause improper seating of bearing inserts. Check all drilled holes. The procedure for checking main bearing dimensions will be found in final assembly.

## REPAIR AND REPLACEMENT

**7-35.** Repair all crankcase, crankshaft, and reciprocating parts in accordance with the general instructions contained in Section III. Specific instructions follow.

## 7-36. CRANKSHAFT.

**7-37.** Be careful not to damage the bearing surfaces of the crankshaft during repair and assembly operations. A crankshaft that has been scratched and scored may be polished with crocus cloth or some other fine abrasive to remove the scratches or scores, provided the maximum service allowance limits are not exceeded. If maximum service allowance is exceeded the crankshaft must be lapped to 0.002 undersize and fitted with 0.003 inch undersize bearing inserts.

**7-38. REGRINDING.** If the crankshaft is to be lapped, do not allow lathe speed to exceed 150 rpm during the lapping procedure. It may be necessary to renew the lapping compound several times during the operations; in any event, the compound must not be allowed to become dry. Following the lapping operations, the journals must be polished with crocus cloth or some other fine abrasive material. After removing crankshaft from the lathe, be sure all lapping compound is washed away, particularly from the oil holes and passages.

**7-39.** If it is necessary to make the journals more than 0.003 inch undersize, the crankshaft must be ground to 0.010 inch undersize. The grinding operation is a very delicate one, requiring adequate grinding facilities and a high degree of skill on the part of the operator. A properly dressed wheel, Carborundum GA54-J5-V10 or one of corresponding grade, must be used in conjunction with generous quantities of coolant. The wheel must be fed to the journal or pin very slowly and the final ground finish maintained during the complete operation. This procedure must be followed to eliminate possibility of grinding cracks. After grinding, the crankshaft must be carefully inspected by the magnetic particle method and examined for cracks or checks. If any cracks or checks are found the shaft must be rejected.

### NOTE

Crankshafts which have been reground must be renitrided; it is recommended that crankshaft be returned to LYCOMING for regrinding and renitriding.

**7-40.** No attempt should be made to remove the oil transfer tubes or propeller oil tube from the crankshaft. If for any reason these tubes must be replaced, the crankshaft should be returned to LYCOMING for their removal and replacement.

**7-41.** The crankshaft oil plug installed in the rear of the hollow front section of crankshafts fitted for constant speed operation, will not require replacement under ordinary circumstances. In the event that replacement of this plug is necessary, the crankshaft should be returned to LYCOMING.

**7-42. STRAIGHTENING FLANGE.** (See figure 7-5.) If crankshaft flange run-out exceeds the maximum service limit of 0.005 inch but does not exceed 0.018 inch and the rest of the shaft is within the limits given in the Table of Limits, the crankshaft flange may be straightened.



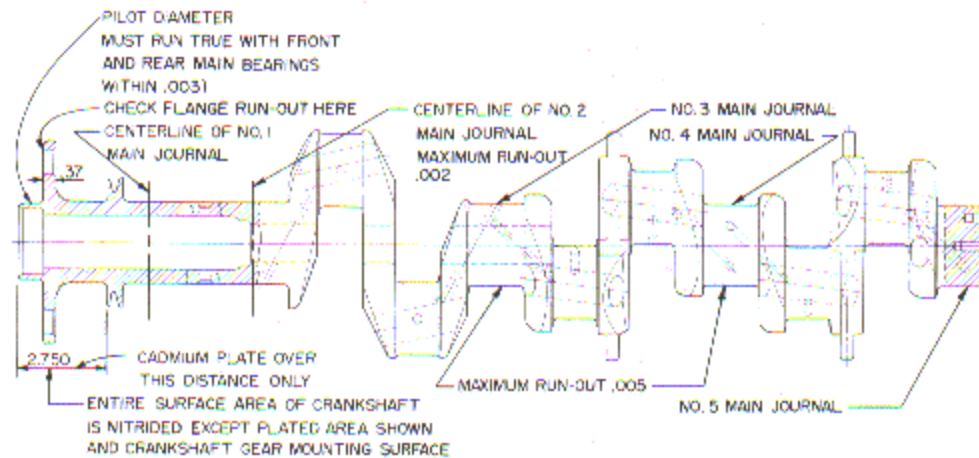


Figure 7-5. O-540 Crankshaft, Limits Allowed When Straightening Bent Flange

7-43. When surface distortion of the flange has been reduced as much as possible, the front face of the flange should then be trued by grinding. This operation is permissible, however, only if the minimum width of the flange after grinding is not less than 0.370 inch.

**CAUTION**

Exercise extreme care during straightening operations in order to avoid damage to the nitrided surfaces of the crankshaft. These surfaces, which extend without interruption from the front oil seal seat to the crankshaft gear position are glass-hard and will crack if the shaft is bent, dropped or carelessly handled in any way.

7-44. At the conclusion of straightening operations, the entire crankshaft must be inspected by the magnetic particle method, paying particular attention to bearing surfaces and the fillet areas at the base of the flange.

7-45. Cadmium plate the ground surfaces of the crankshaft flange. The plating, which should be 0.005 inch maximum thickness, should be permitted to extend along the crankshaft proper only 2.750 inches. (See figure 7-5.)

7-46. **CRANKSHAFT COUNTERWEIGHT BUSHING REPLACEMENT.** If the crankshaft counterweight bushings are out-of-round or otherwise damaged and need to be replaced, the procedure for removal and replacement, using the counterweight bushing puller (17, figure 11-4), is as follows:

7-47. Thread the bolt of the counterweight bushing puller through the puller plate, positioning the plate so that the recess in it will be next to the crankshaft when the puller bolt is inserted through the bushing in the crankshaft. Install the small puller bushing over the end of the bolt and then place the puller nut over the end of the bolt and tighten. As the nut is tightened on the bolt, the counterweight bushing will be pushed out of its recess in the crankshaft counterweight mounting ear and into the recess in the puller plate. See figure 7-6,

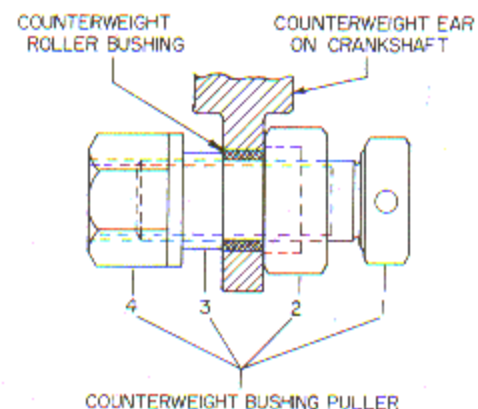
7-48. Measure the ID of the roller bushing hole in the crankshaft. If the hole measures 0.9369-0.9377, no reaming of the hole is necessary and a standard bushing may be installed. If the roller bushing hole measures more than 0.9377, the next oversize bushing must be installed and the hole reamed accordingly.

7-49. Determine the oversize reamer needed, (19, 20, or 21, figure 11-4) and assemble the reaming fixture (18, figure 11-4) over the crankshaft lug. Place the lower edge of the reaming fixture tight against the shoulder of the crankshaft and install the plug provided to line up the holes in the fixture with the holes in the crankshaft lug. Secure the fixture by tightening the Allen head set screw. Assemble the reamer to a suitable brace and proceed to hand ream the hole in the crankshaft lug to proper size.

7-50. Assemble the puller to the crankshaft in the same manner described in paragraph 7-47 except that the large puller bushing is used in place of the small puller bushing. Place the correct size crankshaft bushing on the puller bolt between the crankshaft lug and the large puller bushing. When the puller nut is tightened it will force the bushing into position in the crankshaft.

**CAUTION**

The inside diameter of these bushings is finished at the factory and no further machining of the bushing is necessary. Caution must be exercised when installing the bushings so that this finished ID is not damaged. Because of possible damage to the crankshaft, never, under any circumstances, remove or install the roller bushings by using a drift.



- |                 |                           |
|-----------------|---------------------------|
| 1. Puller bolt  | 3. Puller removal bushing |
| 2. Puller plate | 4. Puller nut             |

Figure 7-6. Removal of Counterweight Bushing from Crankshaft

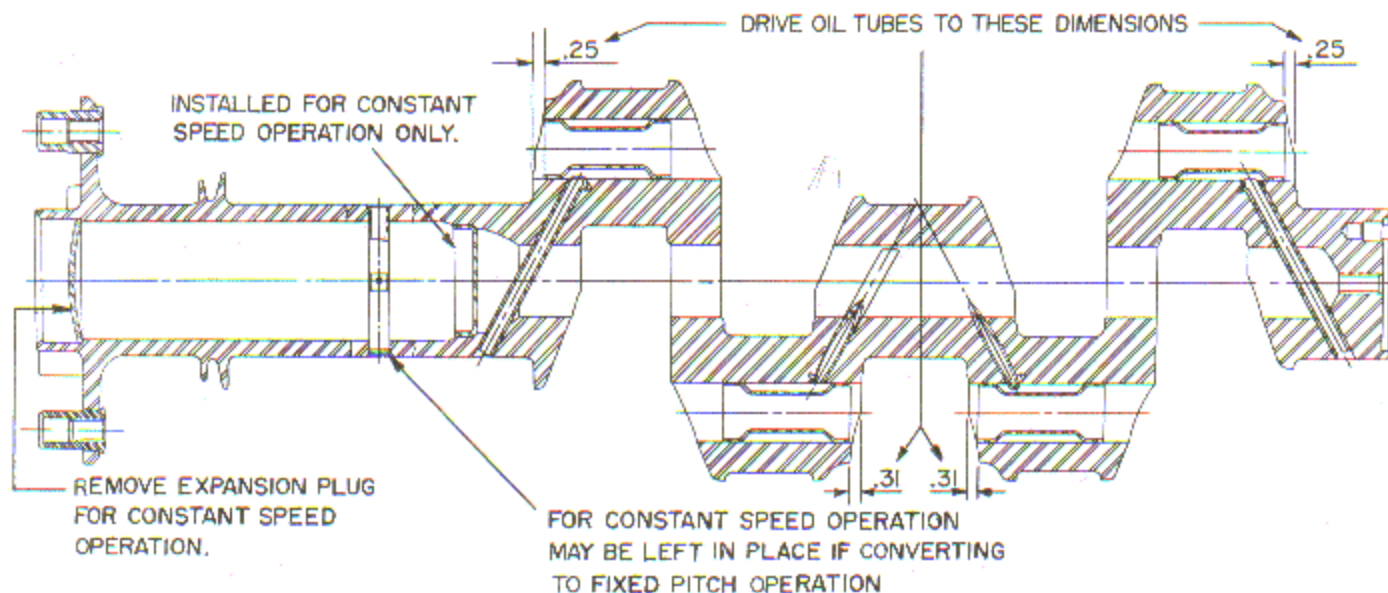


Figure 7-7. Installation Dimensions, O-360 Crankshaft Oil Tubes

7-51. **CONNECTING ROD BUSHINGS.** If the bushing in the small end of the connecting rod is worn beyond service limits, it can be replaced in the following manner:

7-52. Clamp the connecting rod on the connecting rod bushing replacement block. (8, figure 11-4) in such a manner that the small bushing in the rod is in alignment with the hole stamped "Remove Bushing". Use the connecting rod bushing removal drift (2, figure 11-4), drive the bushing out of the rod. Move the connecting rod to the "Install and Burnish" position and clamp it securely in place. Using the replacement drift (3, figure 11-4) drive the new bushing into place in the rod. Locate bushing so that split is toward the piston end of the rod and 45° off the centerline.

7-53. Use a suitable arbor press and the connecting rod burnisher (7, figure 11-4) to burnish the bushing in place. Pass the burnisher completely through the bushing. Remove the rod from the holding block and finish bore the bushing to the diameter shown in reference 510, Table of Limits. Check the bushing ID with finish ID gage (11, figure 11-4). Check alignment of the hole in bushing with the connecting rod parallelism and squareness gage (1, figure 11-4) as described in paragraphs 7-32 and 7-33. If the assembly does not meet the requirements shown in References 566 and 567, Table of Limits, the entire assembly must be replaced.

7-54. **CYLINDER ATTACHING STUDS.** In the event of failure of a cylinder base hold-down stud, all of the hold-down studs adjacent to the broken stud must be replaced; this applies to both through-studs and short studs anchored in the cylinder base pad.

7-55. **CRANKCASE.** The oil relief valve sleeve makes a 0.001 inch press fit with the relief valve bore in the crankcase. If the sleeve seat is badly scored or otherwise damaged, remove and replace the seat as follows:

7-56. Apply a liberal coating of heavy grease to the threads of a standard 1/2-20 bottoming hand tap. This

will aid in subsequent cleaning of the relief valve bore, since loose metal particles resulting from the action of the tap will tend to adhere to the tap when it is withdrawn from the bore. Insert the tap into the relief valve bore, making sure that the tap is centered in the ball seat of the sleeve. Screw the tap into the sleeve a maximum of four full turns.

#### CAUTION

Do not rotate tap in excess of four full turns, because the tap may damage the crankcase if it is inserted too far beyond the sleeve.

7-57. Draw the tap and sleeve straight out of the bore with a sharp quick pull.

7-58. Clean the relief valve bore thoroughly with petroleum solvent and a suitable bristle brush, taking care to see that all metal particles are removed. The sleeve seat in particular must be entirely free from foreign matter, or the new sleeve will not seat properly.

7-59. Place a new relief valve sleeve into the crankcase bore with the seat end of the sleeve toward the crankcase. Make sure that the sleeve is centered in the bore, insert the driver (10, figure 11-4) in the sleeve and drive the sleeve into place with light hammer blows.

7-60. If the sleeve does not make a 0.001 press fit with the crankcase, but is loose, remove the standard size sleeve and install a 0.003 oversize sleeve in the same manner as described in paragraphs 7-59.

#### CAUTION

In the event the hole in the crankcase is too small for installation of the 0.003 oversize sleeve, place the sleeve in a lathe and lap it sufficiently to fit the hole in the crankcase. Do not ream the oil relief valve sleeve hole in the crankcase.

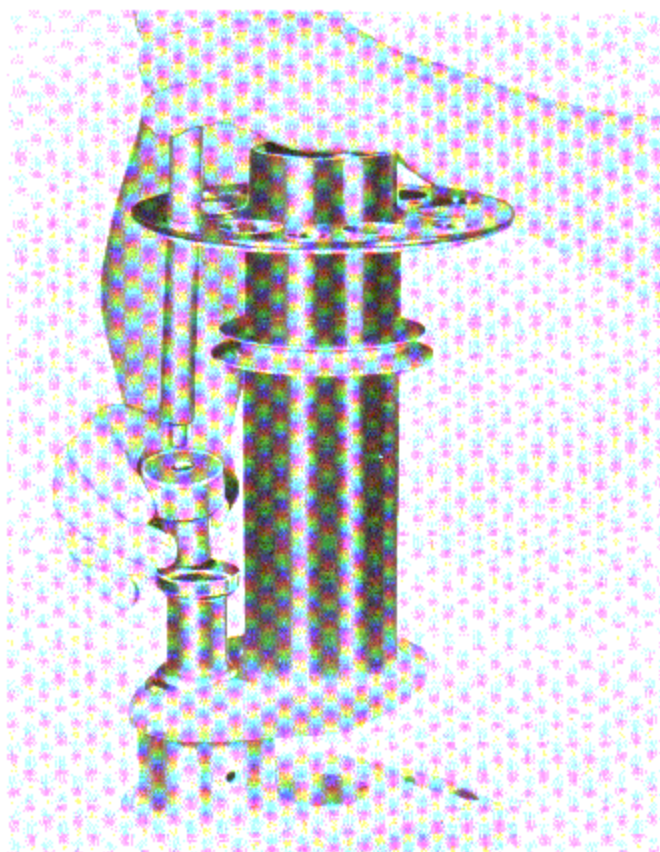


Figure 7-8. Installing Crankpin Oil Tubes (O-360 only)

## REASSEMBLY

### 7-61. INITIAL ASSEMBLY.

7-62. **CRANKSHAFT (O-360).** Support the crankshaft in a nearly vertical position and install new crankpin oil tubes in their proper location in each journal. (See figure 7-7.) Insert the crankpin oil tube drift (8, figure 11-4) in a new oil tube, insert the bar in the drift and drive the tube to its correct depth with a hammer. (See figures 7-7 and 7-8.)

7-63. On engines equipped for fixed pitch propeller use the expansion plug installation drift (23, figure 11-4)

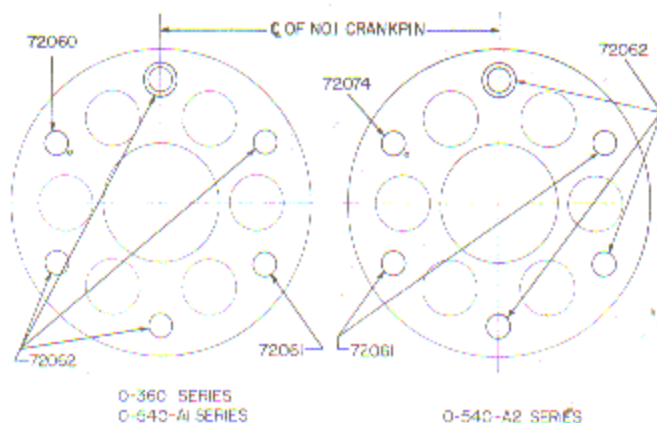


Figure 7-9. Location of Crankshaft Flange Bushings

to install a new expansion plug in place in the front of the crankshaft with the convex side toward the front. Be sure the plug fits firmly against the shoulder provided for it on the inside diameter of the crankshaft.

### NOTE

On engines used with controlled pitch propeller, no expansion plug is used. There is, instead, a plug located at the rear of the front bore of the crankshaft. This plug is not removed during overhaul.

7-64. On engines equipped for controllable pitch propeller, a 1.75 inch plug must be installed at the rear of the bore in the front of the crankshaft. If this plug has been removed during overhaul install a new plug by sliding it sideways past the crankshaft propeller oil tube. When the plug is properly positioned in the rear of the bore (flange frontward), insert the oil plug drift (12, figure 11-4) and seat the plug with several sharp hammer blows on the drift

7-65. If the propeller flange bushings have been removed from the crankshaft, new bushings must be installed. Use the crankshaft flange bushing replacement tool (16, figure 11-4) to install new bushings in the flange. See figure 7-9 for proper location of bushings.

7-66. The crankshaft oil seal assembly, consisting of a split oil seal and spring, should be replaced at overhaul. To assemble oil seal, loop the garter spring around the crankshaft and lock by twisting each end in opposite directions, placing the two ends together and allowing the torsion of the spring to lock the ends. (See figure 7-10.) Slip the seal around the crankshaft ahead of the spring, bevel side to the front; assemble spring in the groove in the seal.

7-67. Apply a small amount of grease (Master Lubricant Prod. Co., Lubriko M-6 or equivalent) to the outside diameter on the break side of the seal and apply a small amount of glue (Goodyear's Pliobond 20 or equivalent) on the opposite side of the seal and to the right half of the crankcase. Apply a small amount of

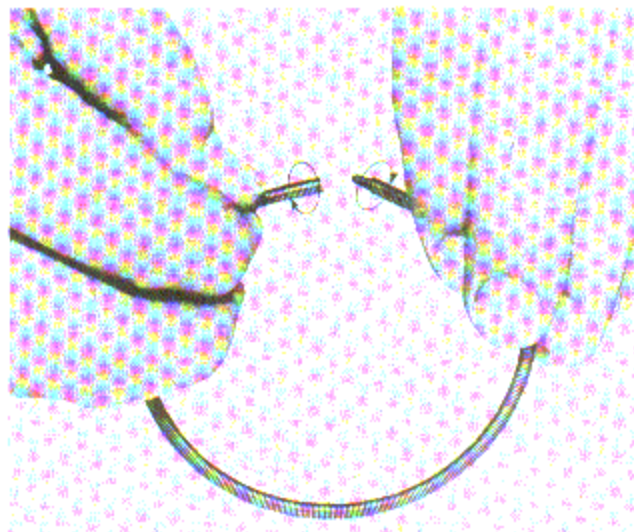


Figure 7-10. Method of Assembling Oil Seal Spring

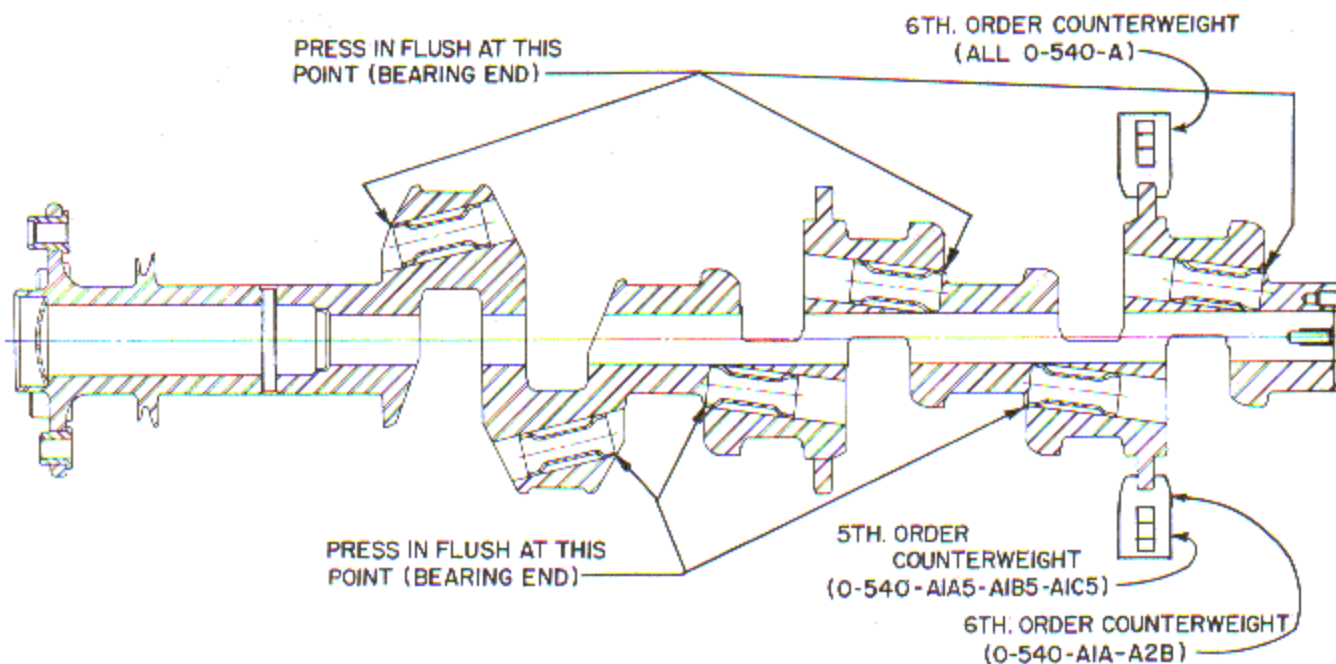


Figure 7-11. Locations of Crankshaft Oil Tubes and Counterweights, O-540 Engines

grease to the crankshaft and seal contact surface then press seal in place in crankcase. The break in the seal should be installed at the one o'clock position as viewed facing the front of the engine.

7-68. The crankshaft gear may now be installed on rear of crankshaft. Make sure the gear fits over the dowel and is located securely in the counterbored recess provided for it in the rear of the crankshaft. Secure the gear to the crankshaft with the crankshaft gear lockplate and screw.

7-69. CRANKSHAFT (O-540). Support the crankshaft in a nearly vertical position with the front end of the crankshaft upward. Place a new crankpin oil tube on the crankpin oil tube driver (9, figure 11-4), assemble the pilot on the driver and, with the tool rotated so the stop is out of the way, drive the tube into the bore in No. 6 crankpin journal until the tube is flush with the opening of the oil tube hole at its bearing end. See figure 7-11. Drive new tubes into journals 2 and 4 in like manner then invert the crankshaft and install tubes in journals 1, 3 and 5. The tubes must be driven flush with the bearing end of the crankpin oil tube hole as shown in figure 7-11; failure to do so may result in blocking the oil transfer tubes between main bearings and crankpin journals.

7-70. Using the identifying marks made on the various counterweight parts during disassembly, match each washer with the proper seat on the counterweight from which it was removed. Check the diameter of each washer against the diameter of its seat in the counterweight; any washer with a diameter smaller than the seat diameter less 0.001 must be replaced. Oversize washers are available. Upon completion of washer diameter check, install washers and new retaining rings on one side of the counterweight, place the counterweight on its proper ear on the crankshaft, insert the rollers, and secure the assembly by installing

the washers and retaining rings on the other side of the counterweight. Note that the washers are installed with the chamfered side in toward the roller and the retaining rings are inserted with the sharp edge outward (see figure 7-12) and gap in position as shown in figure 7-13. Insert one end of the counterweight retaining ring gap gage (22, figure 11-4) between the ends of the counterweight retaining ring, making sure the gage is resting on the bottom of the groove. The gage must pass between the ends of the retaining ring and, when rocked back and forth, must clear the inside edge of the top of the retaining ring. If the gage does not pass freely between the ends and under the top of the ring, the ring is not seated properly.

#### NOTE

Make sure counterweights are installed on the two rearmost crankshaft lugs located between No. 5 and No. 6 crankpins. (See figure 7-11.)

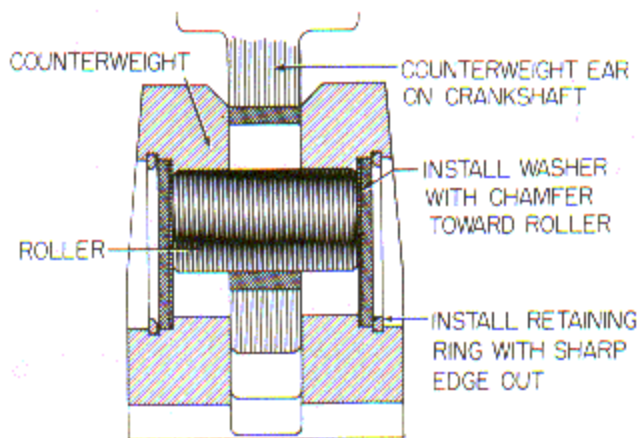


Figure 7-12. Installation of Counterweight Washers and Retaining Rings

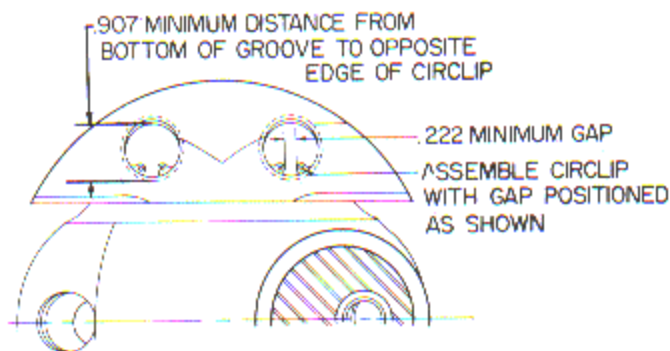


Figure 7-13. Location of Gap When Installing Counterweight Retaining Ring

7-71. Finish assembling the remaining parts of the O-540 crankshaft according to instructions given in paragraphs 7-63 to 7-68.

7-72. CAMSHAFT (O-540 only). Place a Woodruff key in the slot at front of camshaft and install camshaft governor drive gear, holding it in place by two external retaining rings.

7-73. CRANKCASE. Before beginning assembly, examine the right and left halves of the crankcase and make sure that the five 1/8-inch Allen head pipe plugs have been installed. One plug is located at the end of the main oil gallery near the front of each half of the crankcase, another is on the rear of the left half and two more are on the rear of the right half of the crankcase. If these plugs have not been installed, recheck the oil passages to ascertain if any foreign matter has lodged in them. Before the plugs are installed, the threads should be coated with the suitable thread lubricant.

#### 7-74. FINAL ASSEMBLY

#### 7-75. CRANKSHAFT AND CONNECTING RODS.

7-76. Assemble two new connecting rod bolts in each connecting rod cap and install new bearing inserts in the connecting rods and connecting rod caps, making sure the tang on each bearing insert enters locating slot in cap and connecting rod. Assemble each connecting rod assembly after installing inserts; tighten nuts moderately tight. Measure the ID of each bearing and check for clearance against measurements taken previously on diameter of crankpin journals. (See Table of Limits.)

7-77. Place crankshaft in suitable support on bench so that all crankpins are free for the installation of connecting rods. Dismantle connecting rods after checking bearing ID, thoroughly coat both the inserts and the crankpin journals with preservative oil, and assemble rods on their respective crankpins. The order of assembly should be such that the numbers stamped on the caps and on the rods will be down; that is, toward the oil sump when the crankshaft is assembled in the crankcase.

7-78. Assemble nuts on connecting rods and, using a torque indicating wrench, tighten the nuts to the

minimum specified torque and check alignment of the roll pin hole in the bolts with the castellation of the nuts; then, if the roll pin holes are in alignment, insert the roll pins. However, if, at minimum specified torque, the roll pin holes are not in alignment, tighten nuts further only sufficiently to allow pins to be inserted. Use a long needle-nose pliers to hold the small roll pin in line with the hole, making certain the slot faces outward. Tap the pin lightly with a small hammer until it is driven through the bolt. Make certain the slot in the pin has not turned. Use the roll pin spreader (14, figure 11-4) to spread the exposed ends of the roll pin as far apart as possible. Check connecting rod side clearance according to Table of Limits.

7-79. Place both crankcase halves on a suitable support with interior of each facing upward. Place new, main bearing inserts in the center and rear main bearings of both crankcase halves, making certain that the tang of each insert is fitted into the recess provided in the crankcase. Place the front main bearing temporarily in position in the left crankcase half, making sure that the bearing is properly seated on the two dowels. (Note that this bearing, unlike the center and rear bearings, splits on the horizontal center line of the engine.) Using a sharp pencil, trace on the assembled bearing both lines of intersection between the crankcase parting flanges and the bearing. Also make a vertical reference mark on both the bearing and the crankcase at any convenient point along the line of intersection, thus locating the bearing both radially and axially. These marks are necessary to insure proper seating of the bearing halves on the two locating dowels when the crankshaft is placed in position in the crankcase.

7-80. PROPELLER GOVERNOR DRIVE (O-540 Only). (See figure 7-2.) On O-540 engines equipped with a propeller governor drive, the drive must be assembled before the crankcase halves are assembled. Place the propeller governor drive gear (3) in its recess in the drive housing at the front of the left crankcase half. Insert the idler gear shaft (5) through the opening in the drive housing. Place the idler gear (2) and thrust washer (1) on the shaft, inside the housing. Use any of three washers (see Parts Catalog) to give proper backlash between drive gear and idler gear (see reference 669, Table of Limits). Check to make certain the shaft is inserted all the way into the housing. Assemble hex head plug (6) in place and secure with lockwire.

#### 7-81. CRANKCASE AND CRANKSHAFT.

7-82. Assemble an idler gear shaft to the rear of each half of the crankcase as follows: Insert the pilot of the shaft into the hole provided for it in the crankcase and turn the shaft until the holes of the pilot flange align with the drilled holes in the mounting pad of the crankcase. Place a lockplate over the flange. On O-360 engines, insert two 1/4-inch hex head screws into the mounting holes of the flange and, on O-540 engines, insert two 5/16-inch hex head screws into the holes.

7-83. The right half of an O-360 crankcase has four through-studs and the left half has two through-studs. O-540 crankcases have six through-studs in

the right half and two in the left half. A counter-bored recess is provided for an oil seal ring at each bolt and stud location. Install a new seal ring at the base of each stud.

7-84. Place the left crankcase half on a suitable support on the bench with the cylinder pads down. The support should be so constructed as to give approximately six inches clearance between bench and case. Lay the right crankcase half on bench with cylinder pads down.

7-85. Remove hydraulic tappet bodies from cleaning basket one at a time. Coat outside (but not inside) of each tappet body with 600-W oil and place body in proper hole in case.

#### NOTE

If a new or reconditioned camshaft is to be used in the engine, new tappet bodies must also be used.

7-86. Coat the camshaft lobes and the camshaft bearings in the crankcase with 600-W oil. Lay the camshaft in position in the right crankcase half. Loop a wire or rubber band around the camshaft and then around an adjacent cylinder pad stud in such a manner that the shaft will be held securely in place when the crankcase is turned over. (See figure 7-1.)

7-87. Coat the main bearing journals of the crankshaft and the rear and center main bearing inserts of the left crankcase half with 600-W lubricating oil. Remove the front main bearing halves from the left crankcase half, coat each bearing half liberally with 600-W oil and assemble the bearing on the crankshaft. Rotate the bearing on the journal so that the three oil transfer holes will be uppermost when the crankshaft is placed in the left crankcase half. Pick up the assembled crankshaft by numbers one and three (or five) connecting rods and lower the crankshaft into the left crankcase half, permitting numbers two and four (also six on O-540 engines) rods to protrude through their respective cylinder mounting pads. Using the reference marks made previously (see paragraph 7-79), adjust the main bearing so that the halves are seated squarely on the locating dowels. Protect the crankshaft oil seal from damage during assembly of the crankcase halves by pulling seal out to the propeller flange end of the crankshaft.

7-88. If either the crankcase or crankshaft has been replaced, the crankshaft end clearance must be checked. When crankshaft is located in left half of crankcase, push the crankshaft forward as far as possible. Check the clearance, at the rear of the front main bearing surface, between the crankcase and crankshaft shoulder. (See point "A", figure 7-14.) If clearance exists between crankcase and crankshaft shoulder (point "A"), regrind the front face of the crankshaft slinger (see point "B", figure 7-14) to remove the clearance. For example, if end clearance at point "A", figure 7-14, measures 0.002 grind 0.002 to 0.006 from face of slinger at point "B".

7-89. Coat the main bearing inserts of the right half of the crankcase with a generous amount of 600-W oil.

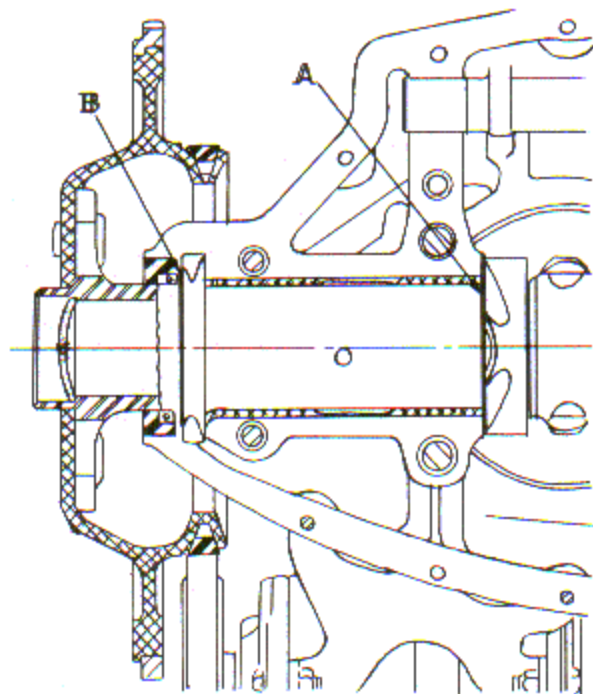


Figure 7-14. Crankshaft Located in Crankcase Half

Following this, apply a film of non-hardening gasket compound to the outside mating flanges of each half of the crankcase. The gasket compound must be confined to the outside mating flanges only, and must not be applied to any other mating surface of the crankcase halves such as the bearing support webs. Next, place a length of silk thread along the upper mating flange of the left crankcase, seating the thread securely in the gasket compound. The thread should extend all the way along the flange from front to rear. Before assembling the right half of the crankcase over the left, place the odd number connecting rods in a vertical position so that they will enter the cylinder holes of the right half of the crankcase.

7-90. Lower the right half of the crankcase carefully so that the studs align properly with the left half. If necessary, tap the right half gently with a soft hammer to facilitate assembly. However, no difficulty will be encountered if the two halves are kept parallel while the right is being lowered onto the left. After the cases are together, tap the right half with a soft hammer to seat it securely all around.

7-91. Install all fastenings. There are several sizes and types of bolts, capscrews, and nuts, and it is important that the correct fastening be used in its proper position.

#### CAUTION

Before any attempt is made to rotate the crankshaft, support all connecting rods either with heavy rubber bands (discarded cylinder base oil seal rings) or metal plates fitted over the cylinder studs as shown in figure 6-3.

7-92. Assemble the lifting strap, on O-360 engines, at the third crankcase fastening from the rear, at the top of the engine, with a 1/4-inch throughbolt and nut.

The lifting strap on O-540 engines is attached at the fourth fastening from the rear with a 1/4-inch through bolt and nut.

7-93. Assemble the generator mounting bracket on the lower right front of the crankcase of O-360 engines and fasten with two 1/4-inch capscrews and washers and 1/4-inch through bolts, nuts, and washers. On O-360 engines with propeller governor, assemble a governor oil line clip on the rear, or through bolt hole, of the generator bracket.

7-94. Assemble the two, generator mounting brackets to the machined mounting pads on the lower right front of the crankcase of O-540 engines. Fasten the brackets to the crankcase with four 5/16-inch capscrews and lockwire.

7-95. Assemble 3/8-24 hex head bolts, 3-1/2 inches long, through the right side of the crankcase near the propeller flange. Two bolts are used on O-360 engines and one is used on O-540 engines. These bolts will protrude through the left side of the crankcase and are fastened with 3/8-inch lockwashers, plain washers, and nuts.

7-96. Place the generator drive belt in the pulley groove of the starter ring gear support; then fit the starter ring gear assembly over the propeller flange bushings of the crankshaft. Make sure the bushing hole in the ring gear that is identified with an "O", is placed over the crankshaft flange bushing that is also identified by an "O" etched on the flange next to the bushing. The starter ring gear must be located correctly to assure proper alignment of the timing marks on the ring gear.

7-97. At this stage of assembly, a chain hoist may be attached to the lifting strap and the partially assembled engine raised to a convenient height, it may be mounted to an overhaul stand in the following manner: Remove the supporting braces from the mounting ring (1, figure 11-1) and attach to machined mounts on crankcase. Fasten only finger tight. Secure the mounting ring to the overhaul stand (2, figure 11-1) and then fasten engine by means of the supporting braces to the mounting ring. Tighten the bolts and nuts which secure the supporting braces to the engine and then tighten the fastenings which secure the braces to the mounting plate.

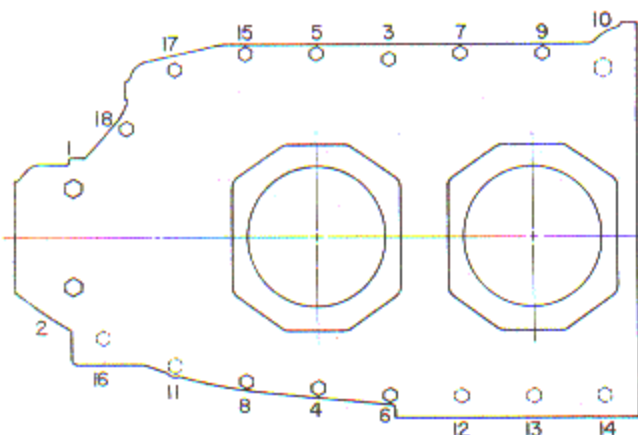


Figure 7-15. Proper Sequence for Tightening Crankcase Fastenings, O-360 Engines

NOTE

When mounting engines with dynafocal mounts, use special adapter (4, figure 11-1) to fit supporting braces of mounting ring to engine.

7-98. Before further assembly of the engine is accomplished, all crankcase fastenings may be firmly, but not tightly, secured. When the cylinders have been assembled to the engine and all cylinder base nuts tightened to final torque (see Section VI), tighten all peripheral fastenings around the crankcase to specified torque. Apply final torque to each fastening in the sequence shown in figures 7-15 and 7-16. The 1/4-inch bolts located along the bottom of the crankcase near the rear and fastened with slotted shear nuts are secured with 1/16-inch diameter cotter pins. Also, the 3/8-inch bolt located at the rear of the crankcase above the camshaft flange is secured with a 3/32-inch diameter cotter pin.

7-99. TACHOMETER DRIVE SHAFT AND CAMSHAFT GEAR. Secure the tachometer shaft assembly in the end of the camshaft with a 3/16 diameter x 1-1/8-inch long pin. Fit the camshaft gear into place on the rear of the camshaft and insert the tachometer shaft centering spacer into the center recess of the camshaft gear.

7-100. Locate the breather slinger over the camshaft gear bolt holes, place two new lockplates in position, and secure the assembly to the camshaft with four 5/16-24 hex head bolts. Torque the bolts (see Table of Limits) and secure by bending up the ears of the lockplates.

NOTE

Before completing the assembly of the camshaft gear as described above, assemble the left (upper) crankshaft idler gear on its shaft. This is necessary because the idler gear cannot be moved on or off the shaft after the breather slinger is in place. Make sure that the idler gear is assembled with its timing marks in correct relationship with the crankshaft and camshaft gears as described in the following paragraphs.

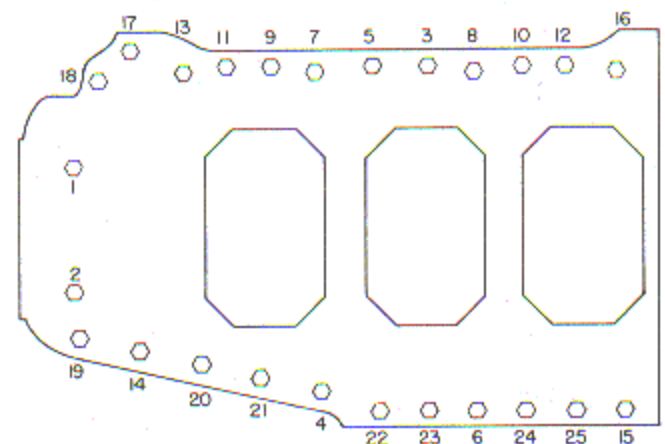


Figure 7-16. Proper Sequence for Tightening Crankcase Fastenings, O-540 Engines

## 7-101. CRANKSHAFT IDLER GEARS (O-360).

7-102. Place the crankshaft idler gear on the shaft located to the left between the camshaft and crankshaft gears. It will be noted that this gear is marked at two places with a small etched circle. One of these marks is located at the space between two gear teeth, while the other mark is located on a gear tooth. The camshaft gear is marked with small etched dots on two adjacent teeth, while the crankshaft gear is marked with a small etched dot on one of the gear teeth. The marked tooth on the idler gear must mesh with the space between the two marked teeth on the camshaft gear, while the marked space on the idler gear must mesh with the marked tooth of the crankshaft gear. (See figure 7-17.)

7-103. This idler gear must be assembled in its proper relationship with the crankshaft gear and camshaft gear, because no other combination of these three gears will permit the valve timing to be correct. The backlash between the camshaft gear and the crankshaft idler gear should not be less than 0.004 inch nor more than 0.020 inch. The same is true for the backlash between the crankshaft idler gear and the crankshaft gear; also, the backlash between the crankshaft idler gear and the magneto gear. (See Table of Limits.)

## 7-104. CRANKSHAFT IDLER GEARS (O-540).

7-105. Place the left crankshaft idler gear on the idler shaft located to the left and between the camshaft and crankshaft gears. It will be noted that this dual gear is marked in three different places with timing marks in the form of small etched circles. The smaller diameter gear is marked at one place with the etched circles on two adjacent teeth and at another place a single tooth is marked. The larger diameter gear is marked at one place with the etched circles on two adjacent teeth. The camshaft is marked with small etched dots on two adjacent teeth, while the magneto gear is marked with a small etched dot on one gear tooth and the crankshaft has small etched circles on single gear teeth at two different locations. The single marked tooth on the idler gear must mesh with the two marked teeth of the camshaft gear while the marked teeth on the crankshaft gear and the magneto gear must mesh with the marked teeth of the idler gear. (See figure 2-3.)

7-106. Install the right crankshaft idler gear in place on the idler shaft making sure that the second marked tooth on the crankshaft gear meshes with the space between the two marked teeth on the smaller gear surface of the idler gear. (See figure 2-3.)

7-107. Check the backlash between gears according to information given in paragraph 7-103 and the Table of Limits.

7-108. OIL RELIEF VALVE. Insert the ball in the sleeve of the oil relief valve chamber. Fit a copper asbestos gasket over the threads of the oil relief valve plug and insert the oil relief valve spring into the plug chamber. The assembled plug may now be screwed into the oil relief valve chamber.

7-109. OIL LEVEL GAGE TUBE (O-360). Assemble this part into its proper place on the right side of the crankcase, near the rear lower mounting lug. Secure tube by lockwiring one of the ears on the base to the small adjacent hole.

7-110. OIL LEVEL GAGE TUBE (O-540). This is an optional part on O-540 engines. If the engine incorporates the tube, assemble it in its correct place on the left side of the crankcase, above and between No. 4 and No. 6 cylinders. Secure tube by lockwiring one of the ears on the base to the small adjacent hole.

## 7-111. INSTALLATION OF ACCESSORIES.

7-112. Assemble the generator to its mounting bracket with two 5/16-inch bolts, nuts, and plain washers. Do not tighten until other assembly operations have been completed.

7-113. Fasten the generator adjusting lever to the crankcase with a 5/16 bolt and plain washer; then fasten the slotted end of the adjusting lever to the generator with a 5/16 bolt and plate washer. Fit the generator drive belt into the groove of the generator drive pulley and swing the generator to tighten the belt. When the belt is sufficiently tight, tighten all generator fastenings to specified torque. Secure bolts, used with generator adjusting lever with lockwire. Secure all nuts, used to fasten generator to mounting brackets, with cotter pins.

7-114. STARTER. Secure starter to its mounting pad with one 5/16 bolt, three 5/16 plain nuts, four plate washers and four lockwashers. Tighten nuts to specified torque.

7-115 On O-360 engines equipped with propeller governor, install external oil line to governor drive adapter and right front of crankcase and tighten the fittings.

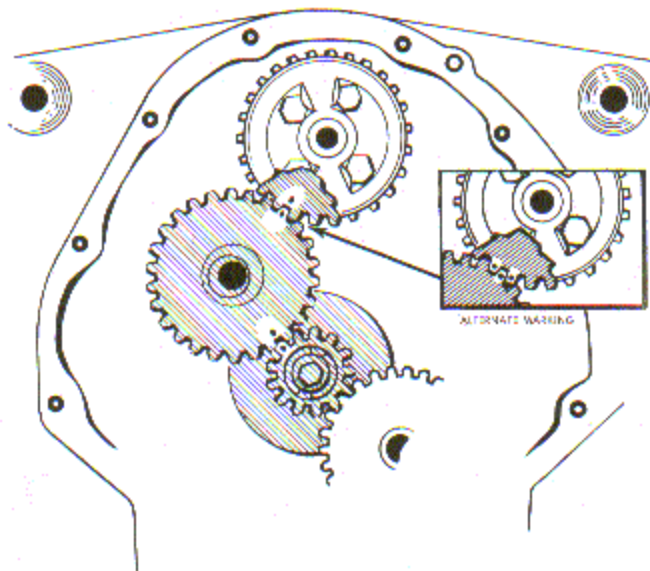


Figure 7-17. Proper Relationship of Timing Marks on Idler, Camshaft, and Crankshaft Gears



## SECTION VIII

### OIL SUMP

8-1. The engine may now be revolved on its overhaul stand so that the bottom (sump) side is uppermost.

#### DISASSEMBLY

8-2. Remove the sump from the engine following the removal of the cylinders as described in Section VI. The dismantling of the intake pipes is also described in Section VI. Remove the carburetor from its mounting pad on the sump. Then remove the 1/4-inch bolts and nuts from around the oil sump. Remove the sump and discard the gasket.

8-3. No further disassembly of the sump is necessary beyond the removal of any loose or damaged studs or intake pipe connections.

#### CLEANING

8-4. Clean the sump in accordance with the general instructions in Section III.

#### INSPECTION

8-5. Inspect the sump according to the general instructions in Section III.

#### REPAIR AND REPLACEMENT

8-6. Repair the sump in accordance with the general procedures described in Section III. In the event that

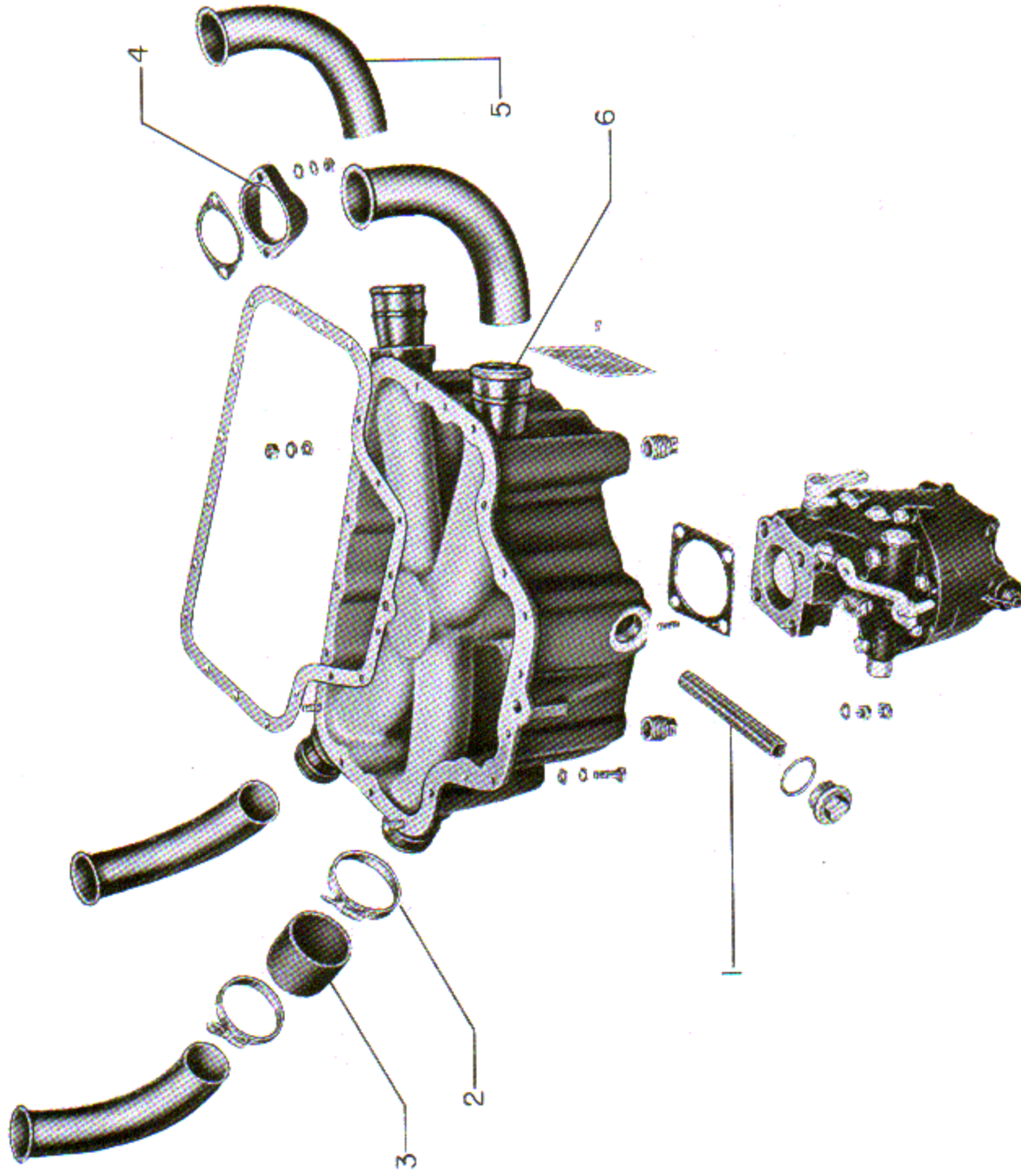
any of the intake pipe connections are loose or damaged, remove the defective connection by collapsing it with a chisel or punch and install a new connection.

#### REASSEMBLY

8-7. When engine buildup has progressed to the point where the crankcase and accessory housing are assembled and the cylinders installed, the sump may be assembled on the engine. Using a new gasket, attach the sump to the crankcase and accessory housing. (Consult Parts Catalog for proper fastenings.) Tighten all capscrews and nuts to specified torque.

8-8. In the event that the intake pipes were not marked during disassembly to indicate the cylinder from which each pipe was removed, determine now the proper location for each pipe. Then slide a flange onto each intake pipe, install two hose clamps on each hose, and slide the hose over the plain end of the intake pipe. With the engine in an inverted position, place a new gasket over each cylinder intake port and secure each flange to the cylinder studs with two 1/4-20 plain nuts, plain washers, and lockwashers. Before the nuts are screwed down tight, fit the sump end of each pipe to its proper sump connection and slide the hose down over the joint. Tighten all fastenings to specified torque.

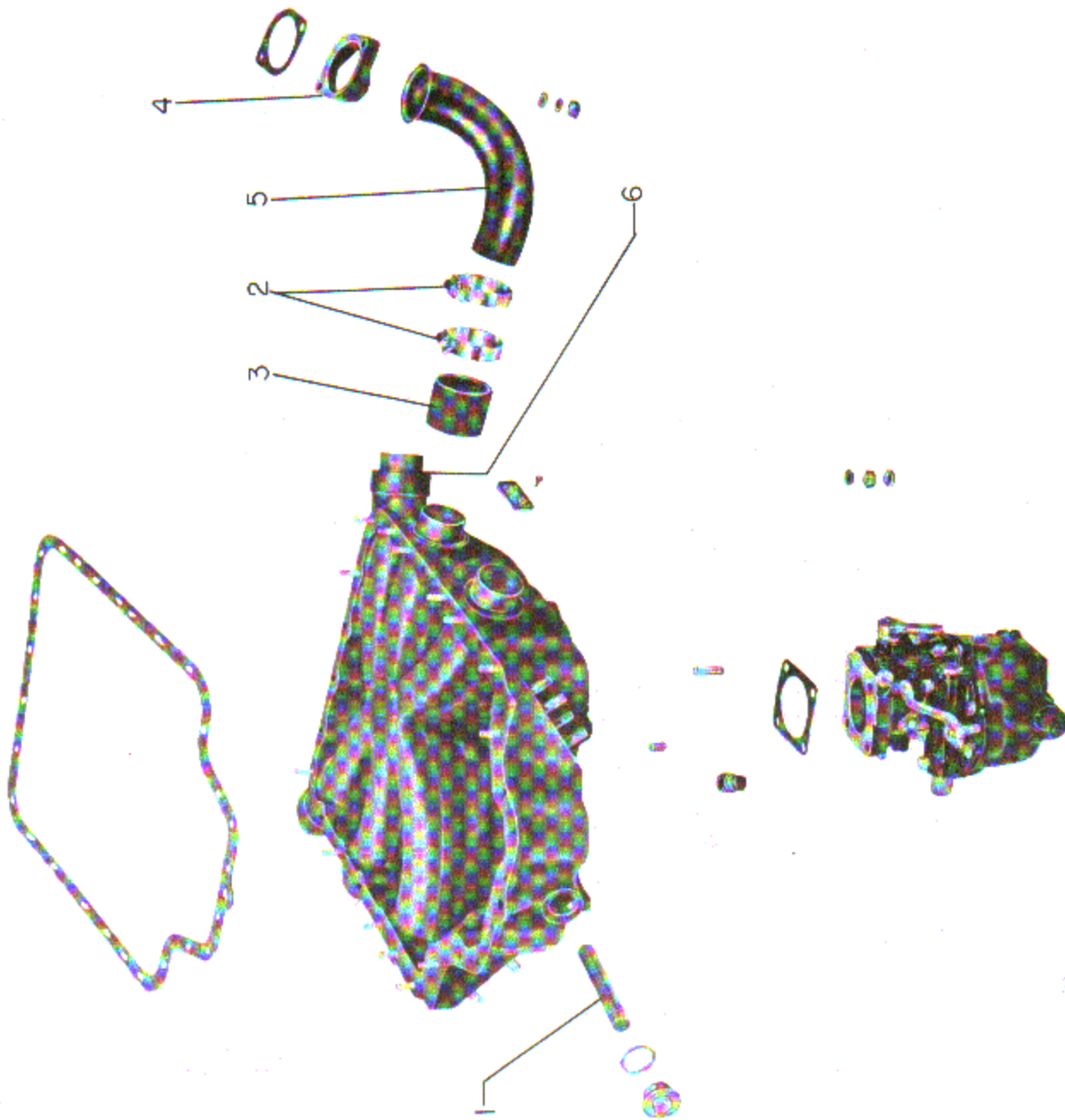
8-9. Install the carburetor on the sump.



1. Oil suction screen  
2. Hose clamp

3. Intake pipe hose  
4. Intake pipe flange  
Figure 8-1. Oil Sump, O-360

5. Intake pipe  
6. Intake pipe connections



1. Oil suction screen  
2. Hose clamp

3. Intake pipe hose  
4. Intake pipe flange

5. Intake pipe  
6. Intake pipe connections

Figure 8-2. Oil Sump, O-540

## SECTION IX

### TEST PROCEDURE

9-1. After the completion of assembly of the engine after overhaul, it is recommended that the engine be mounted upon a test stand for its initial or run-in operation. The run-in serves a two-fold purpose; first, to seat piston rings and burnish any new parts that have been installed, and secondly, to give the operator control over the first few critical hours of operation, during which time the operator can observe the functioning of the engine by means of the instruments in the test stand. The following instruments should be used, plus any additional instruments which are deemed essential by the operator. Cylinder head temperature gages, counter tachometer, fuel flow meters, fuel pressure gage, intake manifold vacuum gage, oil flow measuring devices, oil temperature gages and oil pressure gages.

#### 9-2. INSTALLATION.

9-3. The test stand should be mounted in a test cell that is clean and free of small, light articles that might be moved by the propeller blast. The engine should be

securely mounted on the test stand with the proper bolts, washers, lockwashers, and nuts. The engine should be equipped with a cooling shroud (1 or 3, figure 11-5) in order to provide proper cooling throughout all phases of the run-in. In order that the engine should receive the maximum of cooling air blast from the propeller, attach a test club (2, figure 11-5), using AN-104252 bolts.

9-4. After all instrument attachments and engine controls have been connected, fill the sump to normal capacity with lubricating oil. If the engine is to be installed in an airframe at the completion of the test run, it should be operated during the run with oil of the specified grade (see Table IX-1). If, however, the engine is to be stored upon completion of the run, it should be filled with preservative oil (Esso's "Rustban 622", Socony's "Avrex 901" or equivalent).

9-5. Make certain that the magneto switch is in the "OFF" position and then turn the engine over several

TABLE IX — I  
GENERAL SPECIFICATIONS

|  | O-360 Series | O-540 Series |
|--|--------------|--------------|
| CAA Type Certificate                       | 286          | 295          |
| Rated Horsepower                           | 180          | 250          |
| Rated Speed, RPM                           | 2700         | 2575         |
| Cruise Speed (Performance) in RPM          | 2450         | 2350         |
| Cruise Speed (Economy) in RPM              | 2350         | 2200         |
| Fuel Consumption (Economy Cruise), Gal/Hr. | 9            | 12.5         |
| Propeller Drive Ratio                      | 1:1          | ---          |
| Propeller Shaft Rotation                   | Clockwise    | ---          |
| Bore, Inches                               | 5.125        | ---          |
| Stroke, Inches                             | 4.375        | ---          |
| Displacement, Cubic Inches                 | 361          | 541.5        |
| Compression Ratio                          | 8.50:1       | ---          |
| Oil Viscosity                              |              |              |
| Above 40° F                                | 50           | ---          |
| Below 40° F                                | 30           | ---          |
| Below 10° F                                | 20           | ---          |
| Oil Sump Capacity, Quarts                  | 8            | 12           |
| Oil Pressure, psi                          |              |              |
| Normal                                     | 60-85        | ---          |
| Minimum Idling                             | 25           | ---          |
| Oil Inlet Temperature, °F                  | 180-245      | ---          |
| Fuel, Aviation Grade, Octane               | 91/96        | ---          |
| Fuel Pressure, psi                         | 3-6          | ---          |
| Cylinder Head Temperature, Maximum, °F     | 500          | ---          |
| Spark Advance, Degrees BTC                 | 25           | ---          |
| Tappet Setting, Cold Engine, Inches        | 0.028-0.080  | ---          |
| Magneto Drop-off, Maximum @1800 RPM        |              |              |
| (Each magneto alone)                       | 100          | ---          |
| (Difference between magnetos)              | 25           | ---          |

revolutions to ascertain if any interference exists within the arc of the propeller or within the engine itself. If it does not turn freely, do not try to force it or start the engine until the cause has been determined and corrected.

9-6. PS-5BD AND PSH-5BD CARBURETOR INSTALLATION. Initial preparation of pressure carburetors is required to fill, flush and vent the carburetor and to soak the diaphragms. This is accomplished as follows:

- a. Open the fuel supply valve.
- b. Set mixture control in "FULL RICH" position.
- c. Open the throttle halfway.
- d. Remove the 1/8 inch drain pipe plug located at the bottom of the regulator cover.
- e. Operate pump slowly until the fuel flowing from the drain plug is free of oil.
- f. Replace the drain plug in the bottom of the regulator cover and continue the pumping operation until a small amount of fuel discharges from the discharge nozzle. All included air must pass through the discharge nozzle on the vapor return line.

NOTE

If difficulty is experienced in keeping the engine running after it has started, remove the fill vent plug located near the top of the diagonal in the regulator cover, above and to the right of the fuel pressure gage connection. Operate the wobble pump until the fuel stands level with the plug opening. This will eliminate air which may be trapped in the line between the fuel tank and the carburetor. Replace the plug.

g. Place mixture control in "IDLE CUT-OFF" position. Because the carburetor has a closed fuel system, it will remain full of fuel as long as this lever is in the "IDLE CUT-OFF" position.

h. When a new carburetor or one that has been drained is installed on an engine, it is necessary to fill the carburetor with fuel and let it stand for an eight hour soaking period before starting the engine. It is recommended that the fuel lines to the carburetor be connected as soon as possible in making the carburetor installation. Fuel can then be pumped into the carburetor. This procedure will serve to reduce the elapsed time between the completion of the installation and the engine starting. The soaking period may be performed prior to the installation of the engine in an airframe.

9-7. Fuel should be supplied to the engine at a pressure of between 9 and 15 psi above carburetor entrance pressure. It is recommended that a wobble pump (hand operated pump) be used in conjunction with the engine fuel pump to supply the necessary pressure. In this manner the wobble pump builds up the initial pressure in the engine fuel pump and thereafter the engine fuel pump will maintain the pressure. It is also necessary to have a fuel drain line from the vapor vent connection

(near the main metering jet plug on the carburetor) back to the fuel supply. If the drain line is not attached to the carburetor, the excess fuel vapor blown out of the vapor vent connection will create a fire hazard and also will result in an inaccurate rate of fuel consumption.

9-8. TEST RUN.

9-9. Start the engine according to the following procedure:

- a. Turn fuel valve to "on" position.
- b. Set throttle at 1/10 open position.
- c. Set mixture control to "FULL RICH" position (MA-4-5 carburetors only).
- d. Turn ignition switch to "LEFT MAG" position.
- e. Engage starter.
- f. Place mixture control in "FULL RICH" position (PS-5BD and PSH-5BD carburetors only).
- g. When engine begins to fire, immediately move ignition switch to "BOTH".

CAUTION

If engine fails to start, immediately return mixture control lever to "IDLE CUT-OFF" position.

9-10. Check the oil pressure gage; if oil pressure does not build up within 30 seconds after the engine is started, shut down and investigate. Hold engine speed at approximately 1000 RPM for 5 minutes or until a minimum oil temperature of 140° F (60° C) is reached before increasing speed. Check oil pressure; if it is below the specified normal low limit (25 psi), the engine may be idled between 500 and 700 RPM while the cause is determined.

9-11. Reduce engine speed to idle (500 to 600 RPM) and observe oil pressure. Pressure should not be lower than 25 psi. Check ignition and general operation of the engine at approximately 1000 RPM and also idle speed. Any malfunctioning shall be cause to stop the engine to correct the trouble. The oil temperature should be maintained between 140° and 225° F (60° and 107° C). The maximum oil temperature 245° F (118° C), the maximum oil pressure (85 psi), and the maximum cylinder head temperature 500° F (260° C) should not be exceeded at any time during the test; and if these values are exceeded, the engine should be stopped immediately and the cause determined. The run-in test schedule is given in Table IX-II.

9-12. A log should be kept and the instrument readings recorded every 15 minutes. The log sheet should also include the date of the test, the engine number, type, and nature of test, along with the total number of hours of engine operation. All periods during the test run when the engine was not in operation should be recorded, along with the reason. If, for any reason,

it should be necessary to replace any part, the complete reason for the rejection of the part should also be noted.

9-13. OIL CONSUMPTION RUN. An oil consumption check run may be made at the end of the test if desired, in the following manner: Record oil temperature. Stop engine in usual manner. Place a previously weighed container under engine and remove oil drain plug. Turn engine until it is on approximately TDC of No. 1 cylinder and allow engine to drain for 15 minutes. Replace drain plug. Weigh oil and container. Record weight of oil, that is total weight less weight of container. Replace oil in engine. Start engine and warm up to 2350 RPM and operate at this speed for one hour. At the conclusion of one hour's operation and with the oil temperature the same as recorded at the time of previous draining (it is important to keep this oil temperature as constant as possible), again drain the oil in the same manner as above. The difference in oil weights at start and at end of run will give the amount of oil used during one hour's operation. The oil consumption for one hour on an overhauled engine with new rings installed should not exceed 0.8 pound for O-360 engines and 1.0 pounds for O-540 engines.

9-14. COMPLETION OF RUN. At completion of run-in, reduce engine speed slowly to idling. Adjust idling speed and mixture to give a smooth, steady idling speed of 550 RPM. The minimum oil pressure for idling should be 25 psi. Turn off the fuel supply and run the engine until it stops. Then cut off the ignition switch and drain the oil. Remove all oil screens to determine if any foreign matter is present, thus indicating some abnormal condition of the engine. Any replacement of any major engine parts (cylinder, piston, rings, and so forth) will be sufficient reason to re-run the engine through the entire test.

## NOTE

In the event that the engine is to be stored upon completion of the test run, certain operations must be performed before shutting down the engine at the end of the run. See instructions in the following paragraphs under "Preparation of Engine for Storage".

TABLE IX — II  
RUN-IN TEST SCHEDULE

| RPM                           | TIME<br>(Minutes) |
|-------------------------------|-------------------|
| 1000                          | 15                |
| 1200                          | 15                |
| 1400                          | 15                |
| 1600                          | 15                |
| 1800 Check Magneto drop-off   | 30                |
| 1900                          | 30                |
| 2000                          | 15                |
| 2100                          | 15                |
| 2200                          | 30                |
| 2300                          | 30                |
| Normal Rated                  | 15                |
| 2400 ± 20 Oil Consumption Run | 60                |

## 9-15. PREPARATION OF ENGINE FOR STORAGE.

9-16. The following procedure will provide protection from corrosion for a period of 30 to 60 days.

9-17. INTERIOR SURFACES. Upon completion of the test, drain the preservative oil from the engine and remove, clean and replace the oil pressure and oil suction screens. Perform any engine checks, such as valve clearance or ignition timing, which require rotation of the crankshaft. Disconnect the ignition harness and remove the spark plugs. While rotating the crankshaft five full turns for each cylinder (the engine starter may be used), spray each cylinder through the spark plug holes with approximately two ounces of preservative oil. Use the same oil as specified for the preservation run, maintaining the spray nozzle temperature between 200° F and 220° F (93°C and 104°C) for all spraying operations described herein. When all cylinders have been sprayed, remove the carburetor and spray approximately two ounces of preservative oil into the intake riser while rotating the crankshaft five full turns. Then spray the exhaust port and valve of each cylinder with the piston 1/4-turn before top center on the exhaust stroke. When absolutely certain that no further need exists for turning the crankshaft, again spray each cylinder through the spark plug hole, this time without moving the crankshaft.

## NOTE

Preservative oil drained from a single engine may be saved and returned to the stock tank, provided the oil is replenished to the original quantity after the preservation of each engine. Where the stock tank capacity is less than ten gallons, the re-use of the oil, although replenished, shall be limited to one engine for each two-gallon capacity. Where the tank capacity is more than ten gallons, the tank oil shall be completely replaced at least once every 30 hours operation time.

9-18. INSTALLATION OF SEALS AND PLUGS. Install a crankcase dehydrator plug (Lycoming Part No. 61487, or equivalent) in the oil sump drain hole and cylinder dehydrator plugs (Lycoming Part No. 40238, or equivalent) in the spark plug holes. Install ignition cable protectors (Lycoming Part No. 40239, or equivalent) over the spark plug terminal of each ignition cable and secure by attaching to the end of the dehydrator plug. Flush all accessory drives, for which oil seals are provided, with preservative oil before assembling the drive covers.

9-19. Make sure that all other openings in the engine are properly sealed. Suitable metal covers (Lycoming Part No. 66693, or equivalent) should be used in sealing the exhaust ports; moisture-resistant tape (Minnesota Mining and Manufacturing Co., 711 Acetate Fibre Tape, or equivalent) will be sufficient for the magneto ground connections and similar openings. Seal the intake riser opening with an oil and moisture-resistant cover (Lycoming Part No. 65329 or equivalent) and install sealing caps (Lycoming Part No. 61596, or equivalent) over the breather opening and the generator blast tube. Seal the tachometer drive

with a cap (Lycoming Part No. 61545 or equivalent) and install a plug (Lycoming Part No. 62744, or equivalent) in the thermometer well at the rear of the oil pressure screen housing.

9-20. EXTERIOR SURFACES AND ACCESSORIES. All exposed cadmium plated and machined surfaces should be coated with soft-film, corrosion-preventive compound (E.F. Houghton and Co., Cosmoline 1059, or equivalent). The starter ring gear and propeller mounting surfaces in particular should receive a liberal coating of compound.

9-21. Any other accessories or parts not attached to the engine must be preserved by dipping the part in preservative oil, draining it, wrapping it in greaseproof paper and packing it in a suitable container to be packed with the engine. This procedure applies to spark plugs and electrical components, with the exception that they are not to be dipped in the preservative oil.

9-22. CARBURETOR (MA-4-5). Drain all residual gasoline from the carburetor, fill with flushing oil (Esso Rust-Ban 392, or equivalent) and flush the interior surfaces by rocking the carburetor. After flushing, drain the carburetor, replace all plugs, lock the throttle in the closed position, and pack the carburetor in a cardboard carton.

9-23. CARBURETOR (PS-5BD AND PSH-5BD). Drain all residual gasoline from the carburetor by disconnecting the fuel pressure gage line, removing the 1/8 inch pipe plug located at the bottom of the regulator cover and removing the fuel strainer assembly. Replace the strainer plug and line when the carburetor has drained thoroughly. Any moisture in the air chamber of the regulator should be drained by removing the 1/8 inch pipe plug from the end of the manual mixture control assembly; replace the plug immediately after draining to prevent flushing oil from entering the air chamber.

9-24. Set the manual mixture control at "FULL RICH" and the throttle at "WIDE OPEN". Connect an oil supply line to the carburetor fuel inlet and inject flushing oil (Esso Turbo-Oil 1010 or equivalent) into the carburetor at 5 psi. Continue the injection until a flow of oil from the discharge bar is noted. Drain

the carburetor, replace all plugs, lock the throttle in the closed position and pack the carburetor in a suitable closed container.

#### CAUTION

The oil should never be injected into the carburetor at a greater pressure than 8 psi, and under no circumstances should oil be permitted to enter the air passages, regulator air chamber, or automatic mixture control; these locations must be kept dry at all times.

9-25. Upon completion of the above procedures, the engine should be secured in a suitable engine shipping container. The date of preservation and the following legend should be legibly marked on the side of the container:

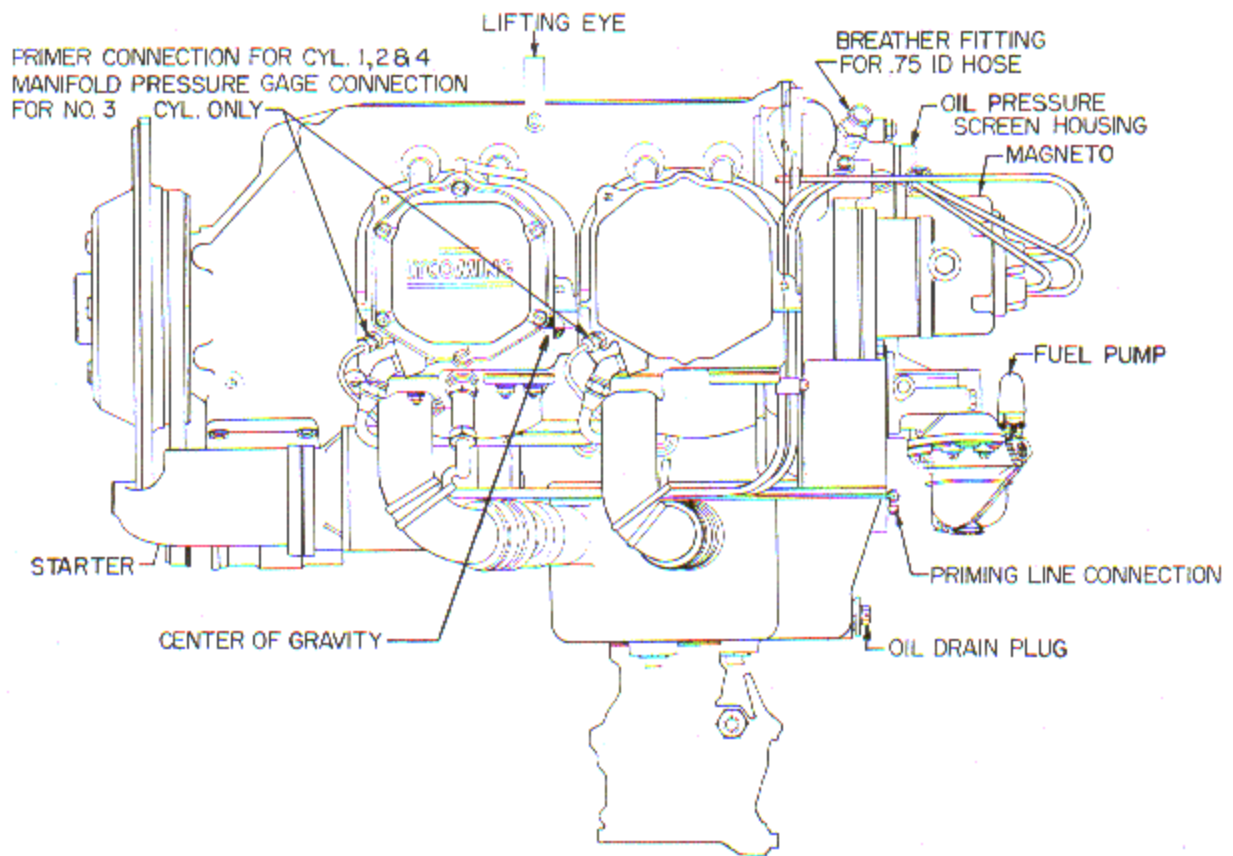
"On -----(Date)----- this engine was preserved for 60-day short term storage with preservative oil and cylinder and crankcase dehydrator plugs. The dehydrator plugs shall be inspected on arrival at destination or 30 days after the above date (whichever occurs sooner) to determine if renewal of the dehydrating agent is necessary."

9-26. The engine shall be examined every 30 days, depending on weather and locality. If corrosion appears to be starting, the corroded area shall be cleaned free of corrosion and the engine represerved.

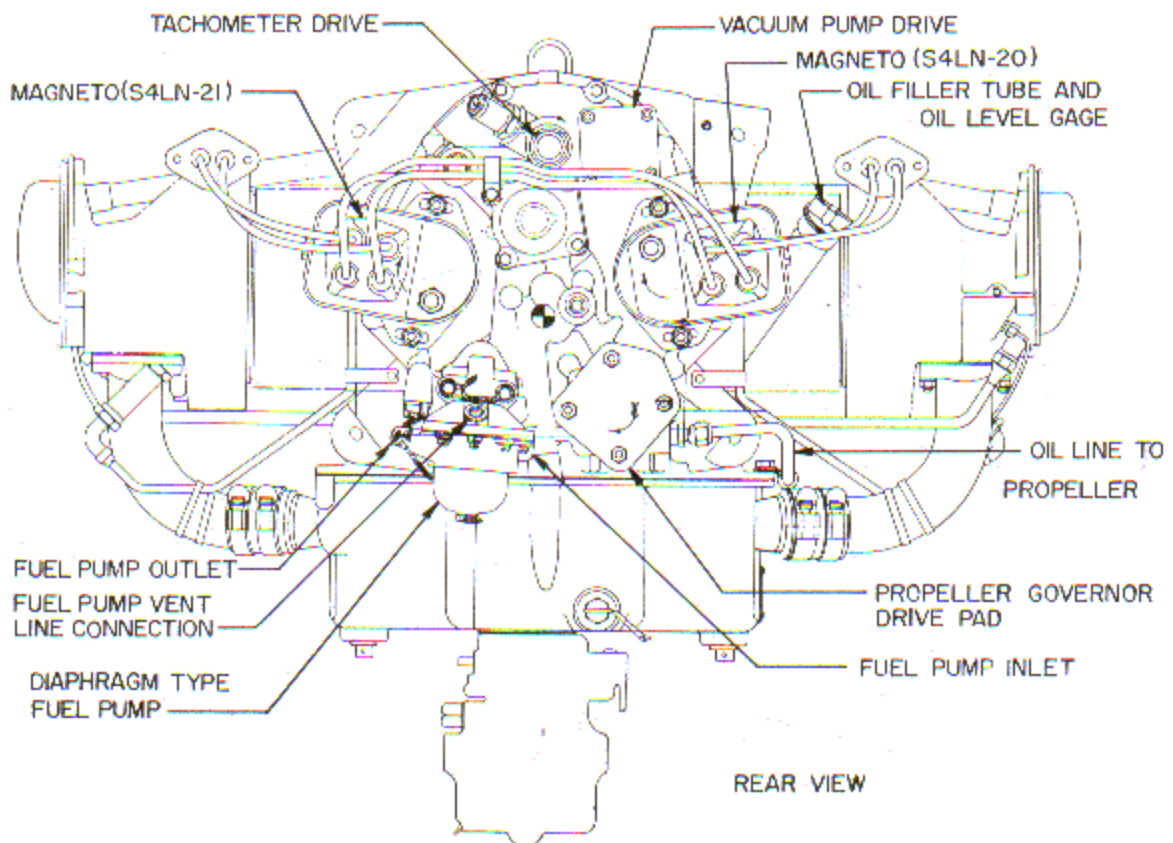
9-27. Engines prepared by the above procedure are not adequately protected for extended periods of storage. If, at the end of 60 days of storage, it is found that the engine must continue in storage, the engine must be represerved according to the above procedure.

#### NOTE

Inspection and represervation will not be the responsibility of the engine manufacturer after engines have been shipped from the engine manufacturer's plant. It shall be the responsibility of the consignee to put engines into service in the order of storage preparation date to reduce the storage period to a minimum.



SIDE VIEW



REAR VIEW

Figure 9-1. Installation Drawing, O-360



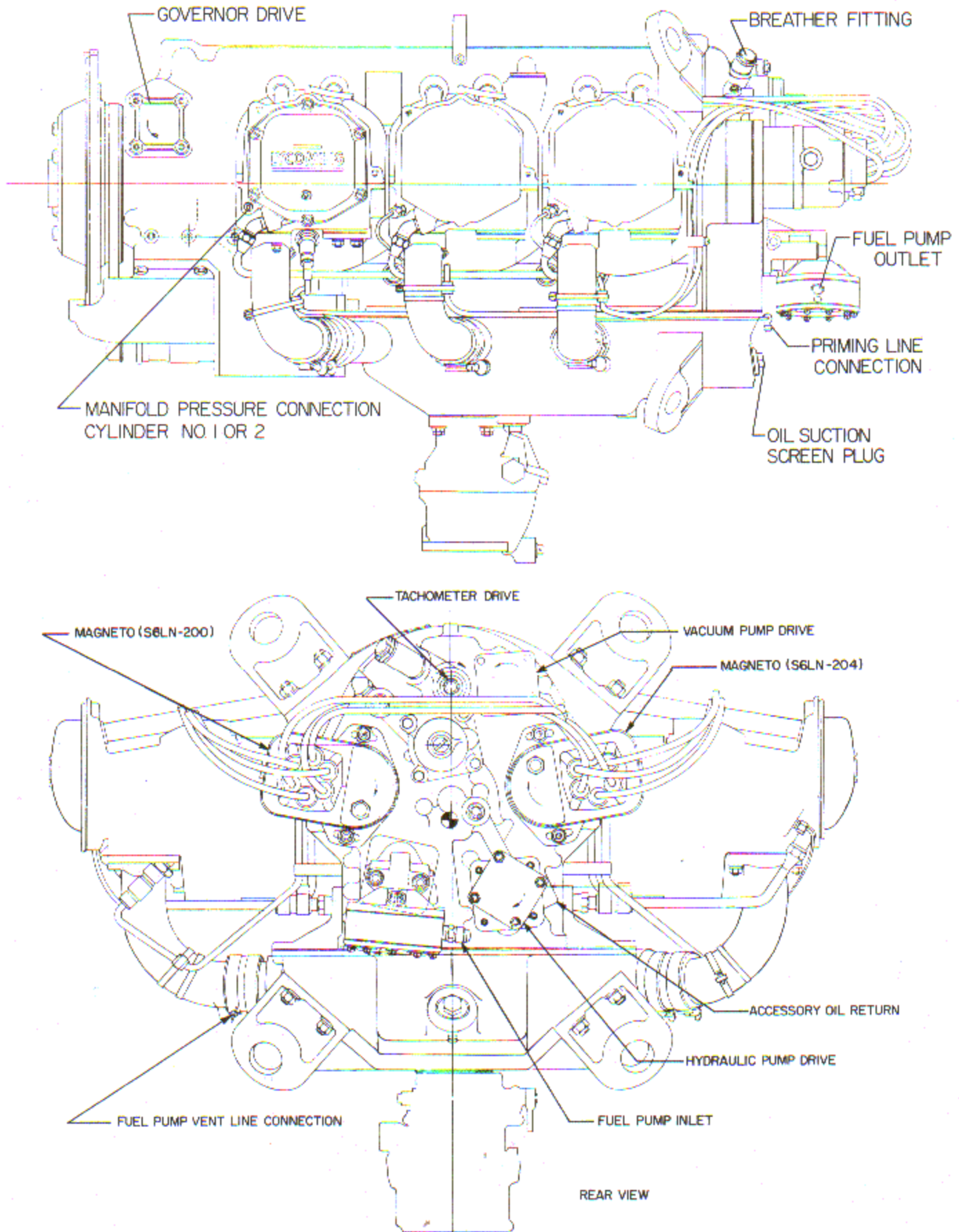


Figure 9-2. Installation Drawing, O-540

## SECTION X

## TABLE OF LIMITS

THE INFORMATION IN THE FOLLOWING TABLE WAS IN EFFECT AT THE TIME THIS MANUAL WAS PRINTED: FOR CURRENT TABLE OF LIMITS INFORMATION, REFER TO SERVICE BULLETIN NO. 268.

10-1. DESCRIPTION AND USE. The following Table of Limits lists all tolerances and dimensions that must be maintained on the various parts of the engine. The figures in the first column, entitled "Reference Number" provide a means of identifying on the Limits Charts (figures 10-1, 10-2 and 10-3) the various fits and clearances listed in the Table. The second column, entitled "Nomenclature," gives a brief description of the part or fit, while the third and fourth columns, entitled "Manufacturing," list the minimum and maximum tolerances allowed during manufacture of the engine. The fifth column, "Maximum Service Allowable," indicates those limits that must not be exceeded in rebuilding the engine. With respect to engine overhaul

the dimensions in the "Manufacturing" column should be considered as ideal limits, while those in the final column indicate measurements which, if not exceeded, permit the part to be continued in service.

10-2. SYMBOLS AND LETTERS. The letter "L" following a limit indicates a loose fit, while the letter "T" indicates a tight fit. The letter "A" in the "Maximum Service Allowable" column, indicates either shrink fits controlled by machining, fits that may be readily adjusted, or fits where wear does not normally occur; in each case, however, the fit must be held to manufacturing tolerances. Additional explanatory notes will be found at the end of the Table.

| Reference Number | Nomenclature  | Manufacturing                        |           | Maximum Service Allowable |
|------------------|---|--------------------------------------|-----------|---------------------------|
|                  |   | Minimum                              | Maximum   |                           |
| 501              | Main Bearing and Crankshaft   | .0015L                               | .0036L    | .0055L                    |
|                  | Main Bearing - Front and Crankshaft (O-360)                         | .0025L                               | .0055L    | .007L                     |
|                  | Main Bearing - Front and Crankshaft (O-540)                         | .0025L                               | .0050L    | .007L                     |
|                  | Diameter of Main Bearing Journal on Crankshaft (O-360)              | 2.375                                | 2.376     | (E)                       |
|                  | Diameter of Front Main Bearing Journal on Crankshaft (O-540)        | 2.3755                               | 2.376     | (E)                       |
| 502              | Connecting Rod Bearings and Crankshaft                              | .0008L                               | .0033L    | .0050L                    |
|                  | Diameter of Connecting Rod Journal on Crankshaft                    | 2.124                                | 2.125     | (E)                       |
| 504              | Crankshaft Timing Gear and Crankshaft                               | .001L                                | .001T     | (A)                       |
| 510              | Connecting Rod and Connecting Rod Bushing                           | Bushings must be burnished in place. |           |                           |
|                  | Finished ID of Connecting Rod Bushing                               | 1.1254                               | 1.1259    |                           |
| 511              | Connecting Rod Bushing and Piston Pin                               | .0008L                               | .0016L    | .003L                     |
| 512              | Piston Pin and Piston   | .0003L                               | .0009L    | .003L                     |
|                  | Diameter of Piston Pin Hole in Piston                               | 1.1249                               | 1.1252    |                           |
|                  | Diameter of Piston Pin  | 1.1243                               | 1.1246    |                           |
| 513              | Piston and Piston Pin Plug (Plain Cylinder)                         | .0009L                               | .0022L    | .004L                     |
|                  | Piston and Piston Pin Plug (Chrome Cylinder)                        | .0002L                               | .0010L    | .002L                     |
|                  | OD of Piston Pin Plug (Plain Cylinders)                             | 1.123                                | 1.124     |                           |
|                  | OD of Piston Pin Plug (Chrome Cylinders)                            | 1.1242                               | 1.1247    |                           |
| 514              | Piston Ring and Piston - Side Clearance - Top Ring - Compression    | .000(B)                              | .004L(B)  | .006L(B)                  |
| 515              | Piston Ring and Piston - Side Clearance - Second Ring - Compression | .000(B)                              | .004L(B)  | .006L(B)                  |
| 516              | Piston Ring and Piston - Side Clearance - Oil Ring                  | .0035L                               | .0055L    | .0075L                    |
| 519              | Piston Skirt and Cylinder   | .006L(D)                             | .0075L(D) | .017L(D)                  |
|                  | Piston Diameter at Bottom   | 5.118(D)                             | 5.119(D)  |                           |
|                  | Piston Diameter at Top  | 5.0826                               | 5.0856    |                           |
| 520              | Cylinder - Maximum Taper - Plain Cylinder                           | .0000                                | .0005     | .004                      |
|                  | Cylinder - Maximum Taper - Chrome Cylinder                          | .000                                 | .0015     | .004                      |

| Reference Number | Nomenclature   | Manufacturing                       |         | Maximum Service Allowable |
|------------------|--|-------------------------------------|---------|---------------------------|
|                  |  | Minimum                             | Maximum |                           |
| 521              | Cylinder - Maximum Out-of-Round - Plain Cylinder                   | .0000                               | .0005   | .004                      |
|                  | Cylinder - Maximum Out-of-Round - Chrome Plated                    | .000                                | .0015   | .004                      |
| 522              | Cylinder Bore Diameter - Plain Cylinder                            | 5.1245                              | 5.1255  | 5.1295                    |
|                  | Cylinder Bore Diameter - Chrome Cylinder                           | 5.1245                              | 5.1265  | 5.1295                    |
| 523              | Exhaust Valve Seat and Cylinder Head                               | .005T                               | .008T   | (A)                       |
|                  | OD Exhaust Seat  | 1.740                               | 1.741   |                           |
|                  | ID Exhaust Seat Hole in Cylinder Head                              | 1.733                               | 1.735   |                           |
| 524              | Intake Valve Seat and Cylinder Head                                | .005T                               | .008T   | (A)                       |
|                  | OD Intake Seat   | 2.082                               | 2.083   |                           |
|                  | ID Intake Seat Hole in Cylinder Head                               | 2.075                               | 2.077   |                           |
| 526              | Exhaust Valve Guide and Cylinder Head                              | .001T                               | .0025T  | (A)                       |
| 527              | Intake Valve Guide and Cylinder Head                               | .001T                               | .0025T  | (A)                       |
|                  | Finished ID of Intake Valve Guides                                 | .4040                               | .4050   |                           |
|                  | Finished ID of Exhaust Valve Guides - Rotator Type                 | .4375                               | .4385   |                           |
|                  | OD Valve Guides  | .5933                               | .5938   |                           |
|                  | ID Valve Guide Holes in Cylinder Head                              | .5913                               | .5923   |                           |
| 528              | Exhaust Valve Stem and Valve Guide                                 | .0035L                              | .0050L  | .006L                     |
|                  | OD of Valve Stem - Exhaust - Rotator Type                          | .4335                               | .4340   |                           |
| 529              | Intake Valve Stem and Valve Guide                                  | .0010L                              | .0025L  | .006L                     |
|                  | OD of Valve Stem - Intake  | .4025                               | .4030   |                           |
| 531              | Valve Rocker Shaft and Valve Rocker Bushings                       | .0010L                              | .0017L  | .004                      |
|                  | OD of Valve Rocker Shaft   | .6243                               | .6245   |                           |
| 532              | Valve Rocker Bushing and Valve Rocker                              | Bushing must be burnished in place. |         |                           |
| 533              | Valve Rocker and Cylinder Head - Side Clearance                    | .003L                               | .009L   | .012L                     |
| 535              | Push Rod and Push Rod Ball End                                     | .0005T                              | .0025T  | (A)                       |
| 536              | Tappet Body and Crankcase  | .0010L                              | .0025L  | .004L                     |
|                  | OD of Tappet Body  | .7172                               | .7177   |                           |
|                  | ID of Tappet Bore in Crankcase                                     | .7187                               | .7197   |                           |
| 537              | Camshaft and Crankcase   | .002L                               | .004L   | .006L                     |
| 538              | Camshaft - End Clearance   | .002L                               | .009L   | .015L                     |
| 539              | Camshaft - Run-out at Center Bearing Journals                      | .000                                | .001    | .006                      |
| 540              | Tachometer Drive Shaft and Accessory Housing                       | .0015L                              | .0035L  | .006L                     |
| 542              | Oil Pump Impeller - Dia. Clearance                                 | .002L                               | .005L   | .008L                     |
| 543              | Oil Pump Impellers - Side Clearance                                | .002L                               | .004L   | .005L                     |
|                  | Width of Oil Pump Impellers  | .748                                | .749    |                           |
| 544              | Oil Pump Driven Impellers and Idler Shaft                          | .0010L                              | .0025L  | .004L                     |
| 545              | Oil Pump Drive Shaft and Oil Pump Cover                            | .0015L                              | .0030L  | .004L                     |
| 553              | Oil Pump Impellers - Backlash                                      | .008                                | .015    | .020                      |
| 556              | Crankshaft Run-Out at Center Main Bearings                         |                                     |         | .005                      |
| 558              | Oil Pump Idler Shaft and Oil Pump Cover or Body                    | .0000                               | .0015T  | (A)                       |
| 559              | Hydraulic Tappet Plunger Assy. and Tappet Body                     | .0010L                              | .0047L  | (A)                       |
| 560              | Hydraulic Tappet Socket and Tappet Body                            | .0020L                              | .005L   | (A)                       |
| 563              | Crankcase Main Bearing Bore Alignment with Front and Rear Bearings |                                     |         | .003                      |
| 564              | Connecting Rod - Side Clearance                                    | .004L                               | .010L   | .016L                     |
| 566              | Connecting Rod Alignment   |                                     |         | .010 in                   |
| 567              | Connecting Rod Twist   |                                     |         | .012 in                   |
|                  |  |                                     |         | 10 inches                 |
| 568              | Crankshaft and Crankcase - Front End Clearance                     | .009L                               | .016L   | .026L                     |
| 578              | Counterweight Bushing and Crankshaft (O-540 Series Only)           | .0013T                              | .0026T  | (A)                       |
| 579              | Counterweight Roller - End Clearance (O-540 Series Only)           | .004                                | .034    | .038                      |
| 580              | Counterweight and Crankshaft - Side Clearance (O-540 Series Only)  | .002                                | .016    | .020                      |

| Reference Number | Nomenclature  | Manufacturing |         | Maximum Service Allowable |
|------------------|---|---------------|---------|---------------------------|
|                  |   | Minimum       | Maximum |                           |
| 590              | Vacuum Pump Gear - End Clearance  | .000          | .067L   | .075L                     |
| 601              | Oil Pump Drive Shaft and Accessory Housing  | .0015L        | .0030L  | .006L                     |
| 602              | Oil Pump Idler Shaft and Accessory Housing  | .0005L        | .0020L  | .003L                     |
| 607              | Crankshaft Propeller Flange Run-Out   |               |         | .005                      |
| 611              | Valve Rocker Shaft and Rocker Shaft Bushing   | .0001L        | .0010L  | .0025L                    |
|                  | Finished ID of Valve Rocker Shaft Bushing<br>in Cylinder Head                           | .6246         | .6253   |                           |
| 612              | Rocker Shaft Bushing and Cylinder Head  | .0022T        | .0035T  | (A)                       |
| 615              | Piston Ring Gap   | .020          | .030    | .045                      |
| 616              | Crankshaft Idler Gear and Camshaft Gear -<br>Backlash                                   | .004          | .015    | .020                      |
| 617              | Crankshaft Idler Gear and Crankshaft Gear -<br>Backlash                                 | .004          | .015    | .020                      |
| 618              | Crankshaft Idler Gear and Magneto Gear -<br>Backlash                                    | .004          | .015    | .020                      |
| 619              | Crankshaft Idler Gear and Crankshaft<br>Idler Gear Shaft                                | .001L         | .003L   | .005L                     |
| 620              | Crankshaft Idler Gear - End Clearance   | .010L         | .045L   | .055L                     |
| 622              | Vacuum Pump Driven Gear and Vacuum<br>Pump Adapter                                      | .0013L        | .0033L  | .005L                     |
| 623              | Vacuum Pump Driven Gear and Camshaft<br>Gear - Backlash                                 | .004          | .015    | .020                      |
| 629              | Fuel Pump Plunger and Accessory Housing   | .0015L        | .003L   | .005L                     |
| 658              | Oil Cooler By-Pass Plunger and Accessory<br>Housing                                     | .0015L        | .0035L  | .005L                     |
| 667              | Governor Drive Gear and Governor Drive Idler<br>Gear - Backlash (O-540)                 | .004          | .015    | .025                      |
| 668              | Governor Drive Idler Shaft (Both Ends) and<br>Crankcase (O-540)                         | .0010L        | .0025L  | .004L                     |
| 669              | Governor Drive Idler Gear (Bevel Gear End)<br>and Governor Driven Gear-Backlash (O-540) | .004          | .008    | .015                      |
| 670              | Governor Driven Gear and Crankcase (O-540)  | .0010L        | .0025L  | .004L                     |
| 674              | Propeller Governor Drive Shaftgear - End<br>Clearance (O-360)                           | .002L         | .024L   | .034L                     |
| 675              | Propeller Governor Drive Shaftgear and Adapter<br>(O-360)                               | .0010L        | .0025L  | .005L                     |
| 676              | Crankshaft Idler Gear and Propeller Governor<br>Drive Shaftgear - Backlash (O-360)      | .004L         | .015L   | .020L                     |
| 677              | Magneto Drive Bearing and Magneto Gear (O-540)  | .0005T        | .0001L  | .0005L                    |
|                  | Magneto Drive Bearing and Crankcase (O-540)   | .0002T        | .0007L  | (A)                       |
| 696              | Dynamic Counterweight Bore and Washer OD<br>(O-540)                                     | .0002L        | .0015L  | (A)                       |
| 765              | AN Fuel Pump Idler Gear and Crankshaft<br>Idler Gear - Backlash                         | .004          | .015    | .020                      |
| 766              | AN Fuel Pump Idler Gear and Fuel Pump Drive<br>Shaft Gear - Backlash                    | .004          | .015    | .020                      |
| 767              | AN Fuel Pump Idler Gear and Fuel Pump Idler<br>Gear Shaft                               | .001L         | .003L   | .005L                     |
| 768              | AN Fuel Pump Idler Gear - End Clearance (O-540)   | .002L         | .018L   | .024L                     |
|                  | AN Fuel Pump Idler Gear - End Clearance (O-360)   | .010L         | .045L   | .055L                     |
| 769              | AN Fuel Pump Drive Shaftgear and Adapter  | .001L         | .0025L  | .004L                     |
| 770              | AN Fuel Pump Drive Shaftgear - End<br>Clearance (O-540)                                 | .009L         | .063L   | .073L                     |
|                  | AN Fuel Pump Drive Shaftgear - End Clearance<br>(O-360)                                 | .000          | .054L   | .064L                     |
| 771              | Hydraulic Pump Driven Gear and Crankshaft<br>Idler Gear-Backlash (O-540)                | .004          | .015    | .020                      |
| 772              | Hydraulic Pump Driven Gear and Adapter (O-540)  | .001L         | .0025L  | .004L                     |
| 773              | Hydraulic Pump Driven Gear - End Clearance<br>(O-540)                                   | .010L         | .066L   | .076L                     |
| 774              | OD of Counterweight Roller - 6th Order (O-540)  | .6945         | .6950   |                           |
|                  | OD of Counterweight Roller - 5th Order (O-540)  | .6650         | .6655   |                           |
| 775              | ID of Counterweight Assembly Bushing (O-540)  | .7485         | .7505   |                           |
|                  | Out of Round of Bushing ID  |               |         | .0005                     |

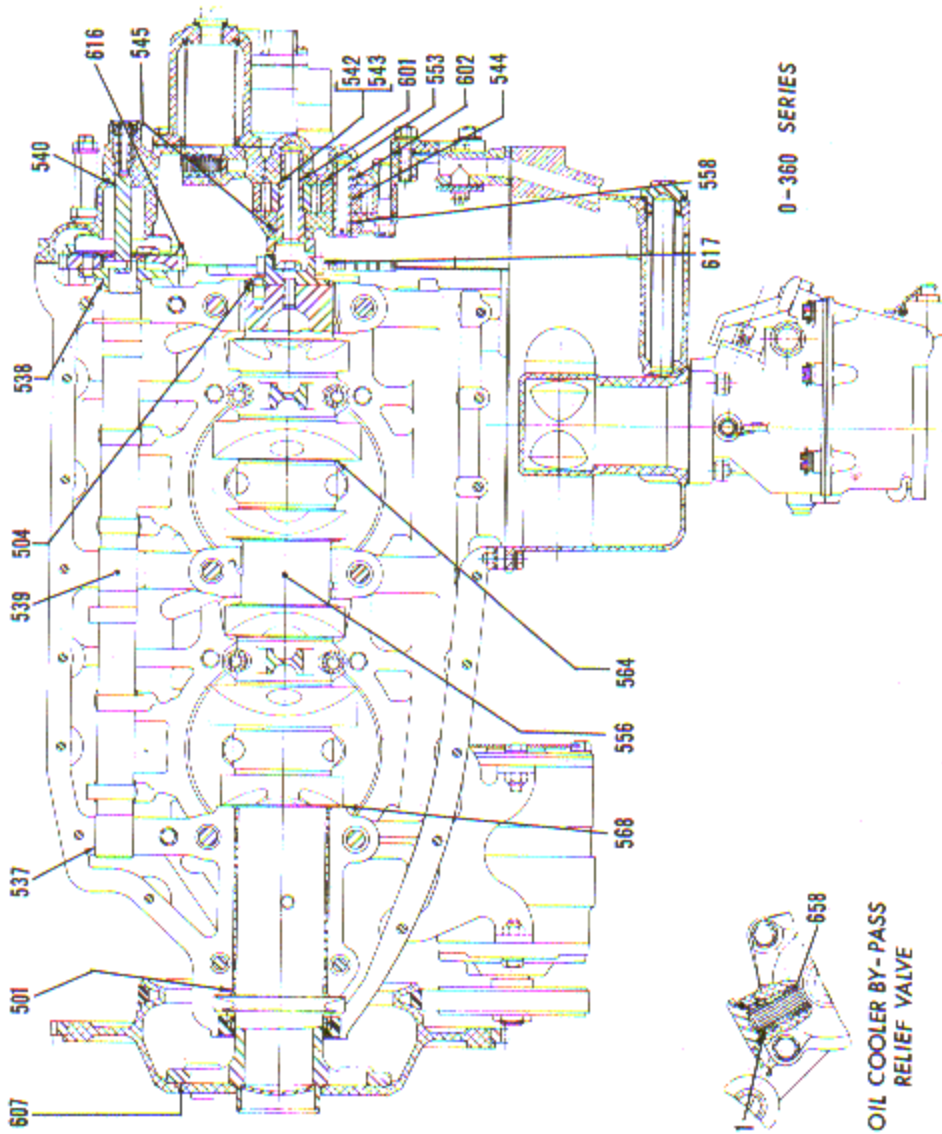
| Reference Number | Nomenclature  | Manufacturing |           | Maximum Service Allowable |
|------------------|---|---------------|-----------|---------------------------|
|                  |   | Minimum       | Maximum   |                           |
| 800              | Outer Valve Spring - Compression Load at 1.30" (Wire Dia. .162)         | 82 lbs.       | 89 lbs.   | 79 lbs. min.              |
| 801              | Auxiliary Valve Spring - Compression Load at 1.17" (Wire Dia. .135)     | 61 lbs.       | 67 lbs.   | 58 lbs. min.              |
| 807              | Oil Relief Valve Spring - Compression Load at 1.30" (Wire Dia. .054)    | 7.25 lbs.     | 7.75 lbs. |                           |
| 811              | Oil Cooler By-Pass Spring - Compression Load at 1.94" (Wire Dia. .0465) | 6.54 lbs.     | 6.92 lbs. | 6.41 lbs. min.            |

### TORQUE LIMITS

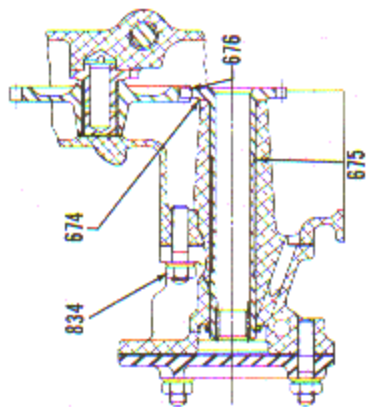
The desired torque for tightening the propeller attaching bolts is 125 in. lbs. and the maximum torque for tracking the propeller is 175 in. lbs. These limits apply to wooden propellers only. Torque limits for metal propeller attaching bolts to be supplied by propeller manufacturer.

|     |  |                     |
|-----|--|---------------------|
| 829 | Connecting Rod Bolt Nuts 3/8" (Apply thread lube to threads before assembly) | 25 to 30 ft. lbs.   |
| 830 | Spark plug, 18MM   | 300 to 360 in. lbs. |
| 831 | 1/2 in. Nuts and Capscrews   | 550 in. lbs.        |
| 832 | 3/8 in. Nuts and Capscrews   | 300 in. lbs.        |
| 833 | 1/4 in. Nuts and Capscrews   | 75 in. lbs.         |
| 834 | 5/16 in. Nuts and Capscrews  | 150 in. lbs.        |
| 836 | 7/16 in. Nuts and Capscrews  | 400 in. lbs.        |
| 839 | #10-32 Screw (attaching ignition cable outlet plate to magneto)              | 12 to 15 in. lbs.   |
| 840 | 3/8 in. Nut (attaching gear to magneto)                                      | 180 to 300 in. lbs. |
| 849 | 3/8 in. Nuts and Capscrews (attaching diaphragm type fuel pump)              | 225 to 250 in. lbs. |

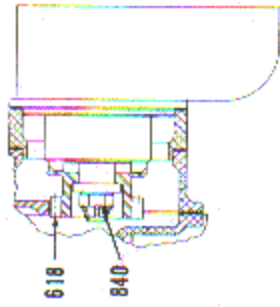
- (A) These fits are either shrink fits controlled by machining, fits that may be readily adjusted or fits where wear does not normally occur. In each case the fit must be held to the manufacturing tolerance.
- (B) Side clearance on wedge type rings must be measured with face of ring flush with piston.
- (D) The dimensions shown are measured at bottom of piston skirt at right angles to piston pin.
- (E) Permissible wear on crankshaft (rod and main bearing journals) to be minus 0.0015 on diameter.



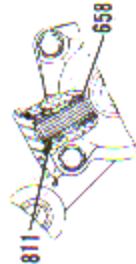
0-360 SERIES



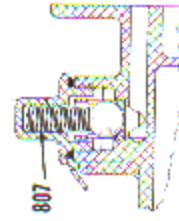
PROPELLER GOVERNOR DRIVE  
0-360 ONLY



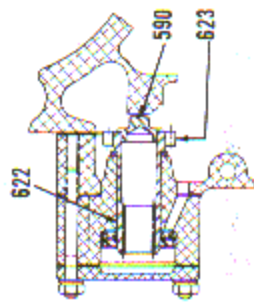
MAGNETO DRIVE 0-360 ONLY



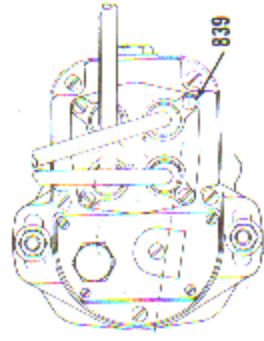
OIL COOLER BY-PASS  
RELIEF VALVE



OIL RELIEF VALVE



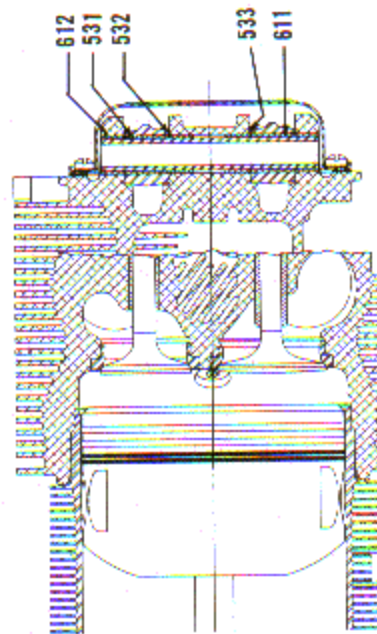
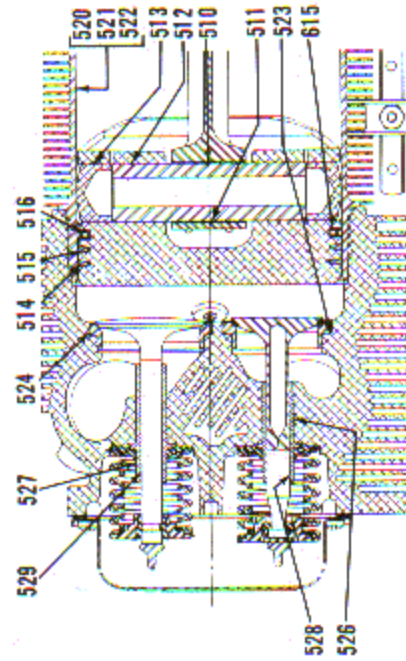
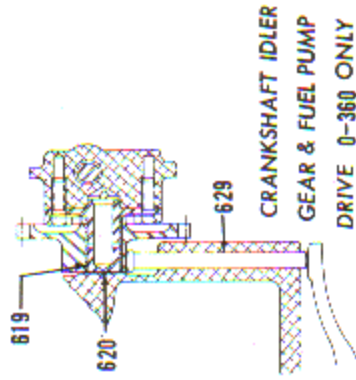
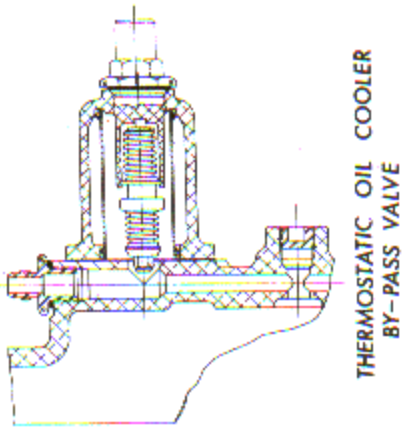
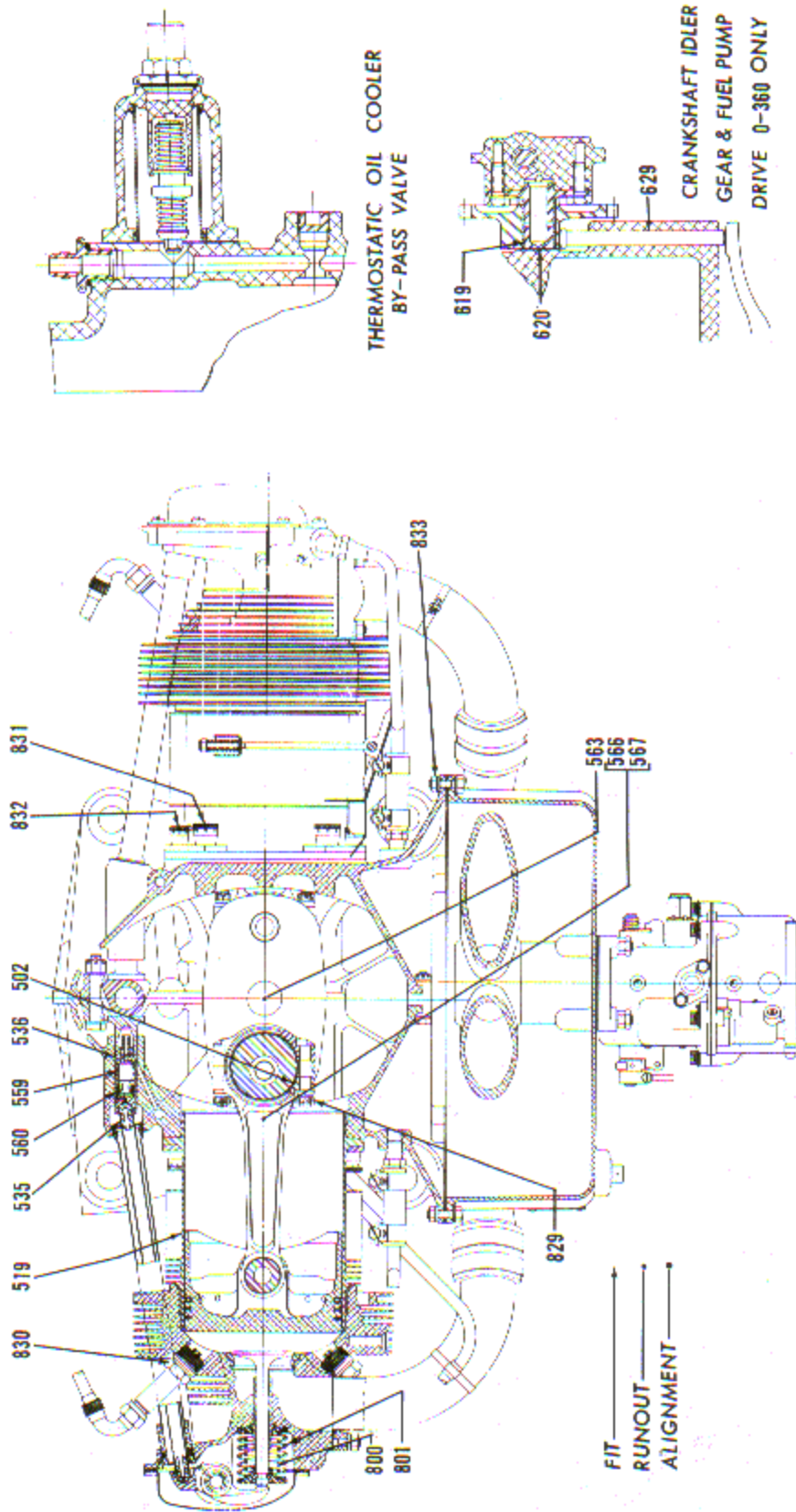
VACUUM PUMP DRIVE

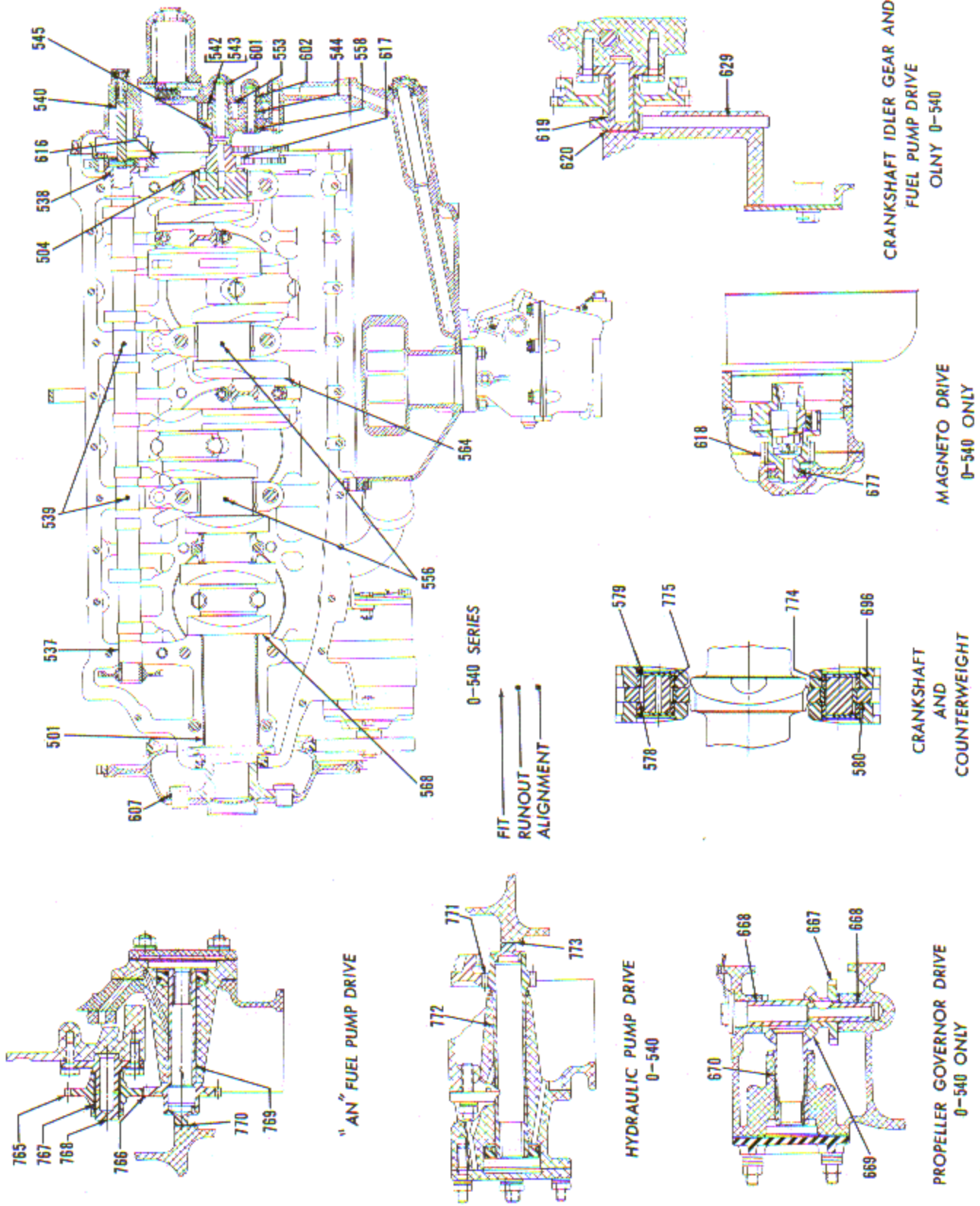


MAGNETO 0-360

FIT ———  
RUNOUT ———  
ALIGNMENT ———

Figure 10-1. Limits Charts







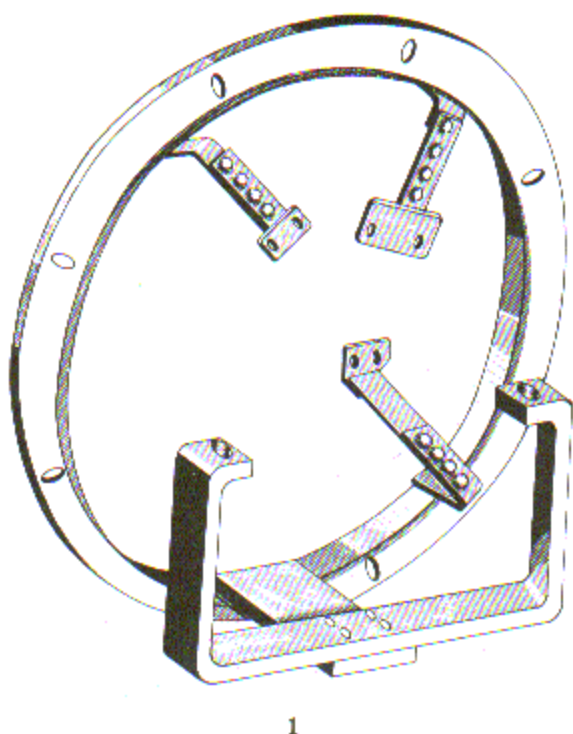
## SECTION XI OVERHAUL TOOLS

11-1. The tools listed and illustrated in this section comprise the special tools which, in conjunction with the standard hand tools and gages to be found in all competent repair shops, are necessary for the overhaul of the engines covered in this manual. The tools are broken down into tables or groups (ignition system, accessory housing, cylinders, etc.) corresponding to

the various sections of the manual. Within each group, the tools are listed numerically according to Lycoming part number. A reference number is assigned to each tool, and the tool is identified wherever mentioned in the manual by reference number and figure (group) number. (Example: 4, figure 11-4.) Note that the figure numbers correspond to the table numbers.

TABLE XI — I  
GENERAL OVERHAUL TOOLS

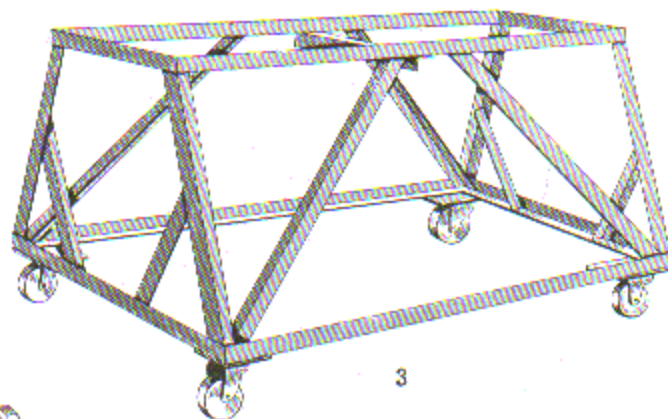
| Reference and Figure Number | Part Number | Nomenclature                             |
|-----------------------------|-------------|--|
| 1, figure 11-1              | 64759       | Ring - Engine mounting                   |
| 2, figure 11-1              | 64760       | Stand - Overhaul                         |
| 3, figure 11-1              | 64762       | Dolly - Overhaul Stand                   |
| 4, figure 11-1              | 64898       | Adapter - Mounting ring, dynafocal mount |



1



2



3



4

Figure 11-1. General Overhaul Tools

TABLE XI — II  
IGNITION SYSTEM OVERHAUL AND TIMING TOOLS

| Reference and Figure Number | Part Number | Nomenclature                                   |
|-----------------------------|-------------|--|
| 1, figure 11-2              | 218-B       | Wrench - Socket, spark plug                    |
| 2, figure 11-2              | 64697       | Pointer - Ignition timing                      |
| 3, figure 11-2              | 64761       | Wrench - Magneto bushing (Breeze harness only) |
| 4, figure 11-2              | 65521       | Handle - Offset                                |



Figure 11-2. Ignition System Overhaul and Timing Tools

TABLE XI — III  
CYLINDER OVERHAUL TOOLS

| Reference and Figure Number       | Part Number | Nomenclature                                       |
|-----------------------------------|-------------|--|
| CYLINDER OVERHAUL TOOLS — GENERAL |             |  |
| 1, figure 11-3                    | 1130-B      | Compressor - Valve Spring                          |
| 2, figure 11-3                    | 64526-2     | Block - Cylinder holding                           |
| 3, figure 11-3                    | 64553       | Basket - Cleaning and inspection, valve parts      |
| 4, figure 11-3                    | 64711       | Handle - Cylinder base nut wrench                  |
| 5, figure 11-3                    | 64712       | Compressor - Piston ring                           |
| 6, figure 11-3                    | 64713       | Expander - Piston ring                             |
| 7, figure 11-3                    | 64717       | Wrench - Hex ID, .500 cylinder base nut            |
| 8, figure 11-3                    | 64718       | Wrench - Hex ID, .375 cylinder base nut            |
| 9, figure 11-3                    | 64843       | Puller - Piston pin                                |
| 10, figure 11-3                   | 64885       | Hook - Installation, intercylinder baffle assembly |
| 11, figure 11-3                   | 64899       | Adapter - Magnaflux (hydraulic tappet bodies)      |
| 12, figure 11-3                   | 65528       | Gage - Valve Clearance                             |

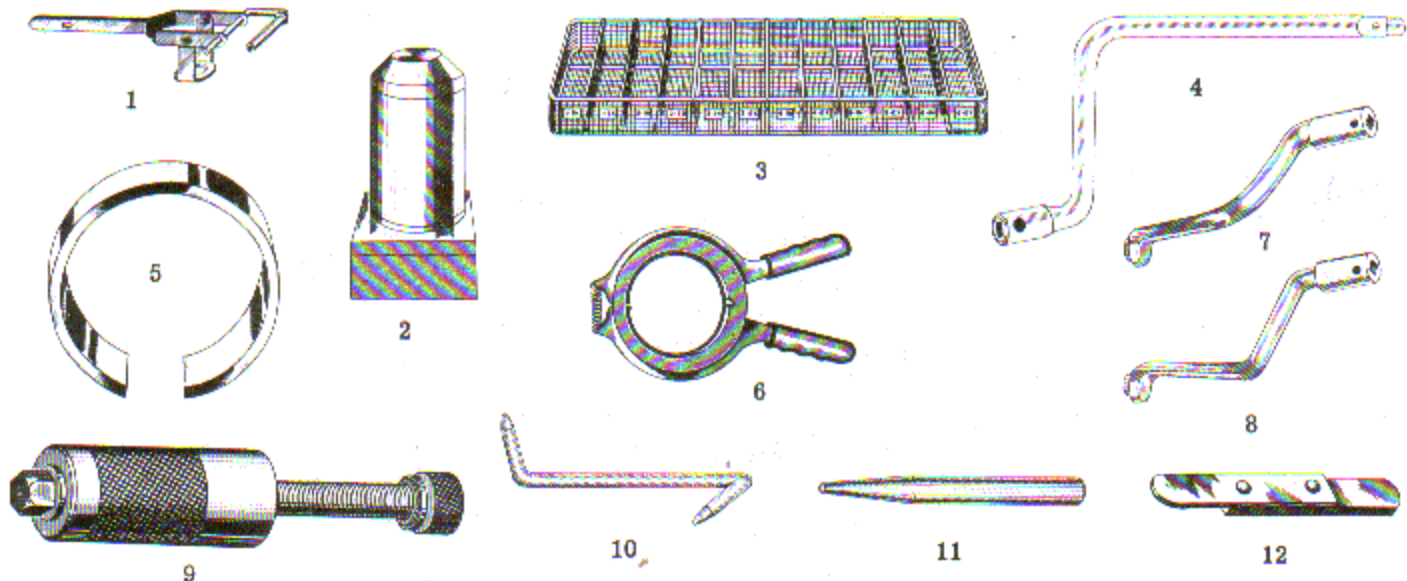


Figure 11-3. Cylinder Overhaul Tools—General

TABLE XI — III (Cont.)  
CYLINDER OVERHAUL TOOLS

| Reference and Figure Number | Part Number | Nomenclature |
|-----------------------------|-------------|--------------|
|-----------------------------|-------------|--------------|

HELI-COIL INSERT TOOLS

|                 |       |   |
|-----------------|-------|---|
| 13, figure 11-3 | 64593 | Expanding and staking tool - Heli-Coil spark plug bushing |
| 14, figure 11-3 | 64594 | Inserting tool - Heli-Coil spark plug bushing             |
| 15, figure 11-3 | 64595 | Extracting tool - Heli-Coil spark plug bushing            |
| 16, figure 11-3 | 64596 | Tap - Heli-Coil spark plug bushing                        |

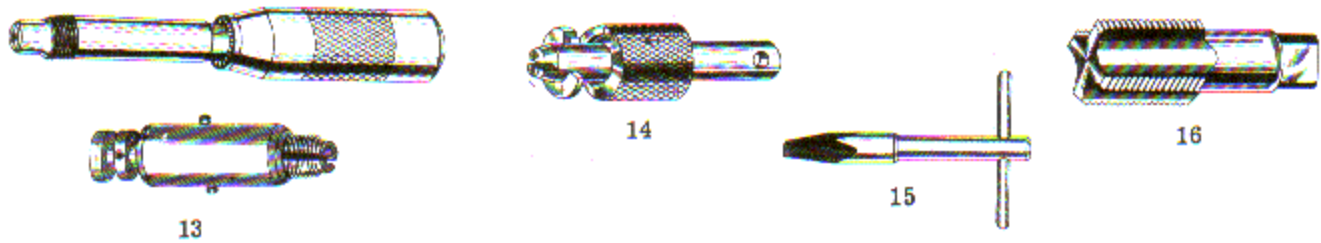


Figure 11-3. (Cont.) Cylinder Overhaul Tools - Heli-Coil

TABLE XI — III (Cont.)  
CYLINDER OVERHAUL TOOLS

| Reference and Figure Number | Part Number | Nomenclature |
|-----------------------------|-------------|--------------|
|-----------------------------|-------------|--------------|

VALVE GUIDE REPLACEMENT TOOLS

|                 |         |  |
|-----------------|---------|--|
| 17, figure 11-3 | 64505   | Drift - Installation, valve guide (Intake)                   |
| 18, figure 11-3 | 64507   | Gage - Plug, .005 oversize valve guide hole in cylinder head |
| 19, figure 11-3 | 64509   | Gage - Plug, .010 oversize valve guide hole in cylinder head |
| 20, figure 11-3 | 64511   | Gage - Plug, .020 oversize valve guide hole in cylinder head |
| 21, figure 11-3 | 64514   | Gage - Plug, valve guide ID (Intake)                         |
| 22, figure 11-3 | 64571   | Gage - Plug, standard valve guide hole in cylinder head      |
| 23, figure 11-3 | 64583   | Gage - Flat plug rejection, valve guide ID (Intake)          |
| 24, figure 11-3 | 64645   | Puller - Valve guide   |
| 25, figure 11-3 | 64678-2 | Reamer - Valve guide hole in cylinder head, .005 oversize    |
| 26, figure 11-3 | 64678-3 | Reamer - Valve guide hole in cylinder head, .010 oversize    |
| 27, figure 11-3 | 64678-4 | Reamer - Valve guide hole in cylinder head, .020 oversize    |
| 28, figure 11-3 | 64684   | Reamer - Valve guide ID (Intake)                             |
| 29, figure 11-3 | 64714   | Fixture - Valve guide replacement                            |
| 30, figure 11-3 | 64724   | Gage - Flat plug rejection, valve guide ID (Exhaust)         |
| 31, figure 11-3 | 64725   | Gage - Plug, valve guide ID, (Exhaust)                       |
| 32, figure 11-3 | 64726   | Reamer - Valve guide ID (Exhaust)                            |
| 33, figure 11-3 | 64796   | Drift - Installation, valve guide (Exhaust)                  |

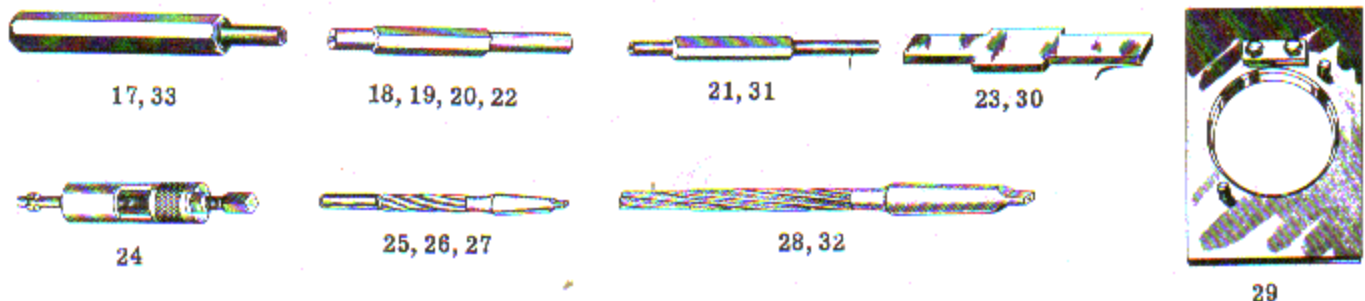


Figure 11-3. (Cont.) Cylinder Overhaul Tools - Valve Guide Replacement Tools

TABLE XI — III (Cont.)  
CYLINDER OVERHAUL TOOLS

| Reference and Figure Number         | Part Number | Nomenclature  |
|-------------------------------------|-------------|---|
| <b>VALVE SEAT REPLACEMENT TOOLS</b> |             |   |
| 34, figure 11-3                     | 64516-1     | Pilot - Valve seat removal (Intake)                 |
| 35, figure 11-3                     | 64516-2     | Pilot - Valve seat removal (Exhaust)                |
| 36, figure 11-3                     | 64517       | Holder - Counterbore, valve seat removal            |
| 37, figure 11-3                     | 64520       | Fixture - Valve seat removal                        |
| 38, figure 11-3                     | 64521       | Drift - Replacement, valve seat (Exhaust)           |
| 39, figure 11-3                     | 64692       | Cutter - Valve seat removal (Intake)                |
| 40, figure 11-3                     | 64694       | Cutter - Valve seat removal (Exhaust)               |
| 41, figure 11-3                     | 64695       | Drift - Replacement, valve seat (Intake)            |
| 42, figure 11-3                     | 64786       | Handle - Cutter, valve seat recess                  |
| 43, figure 11-3                     | 64788-1     | Pilot - Valve seat recess cutter (Intake)           |
| 44, figure 11-3                     | 64788-2     | Pilot - Valve seat recess cutter (Exhaust)          |
| 45, figure 11-3                     | 64794-1     | Cutter - Valve seat recess, intake (.010 oversize)  |
| 46, figure 11-3                     | 64794-2     | Cutter - Valve seat recess, intake (.020 oversize)  |
| 47, figure 11-3                     | 64794-3     | Cutter - Valve seat recess, intake (.030 oversize)  |
| 48, figure 11-3                     | 64795-1     | Cutter - Valve seat recess, exhaust (.010 oversize) |
| 49, figure 11-3                     | 64795-2     | Cutter - Valve seat recess, exhaust (.020 oversize) |
| 50, figure 11-3                     | 64795-3     | Cutter - Valve seat recess, exhaust (.030 oversize) |

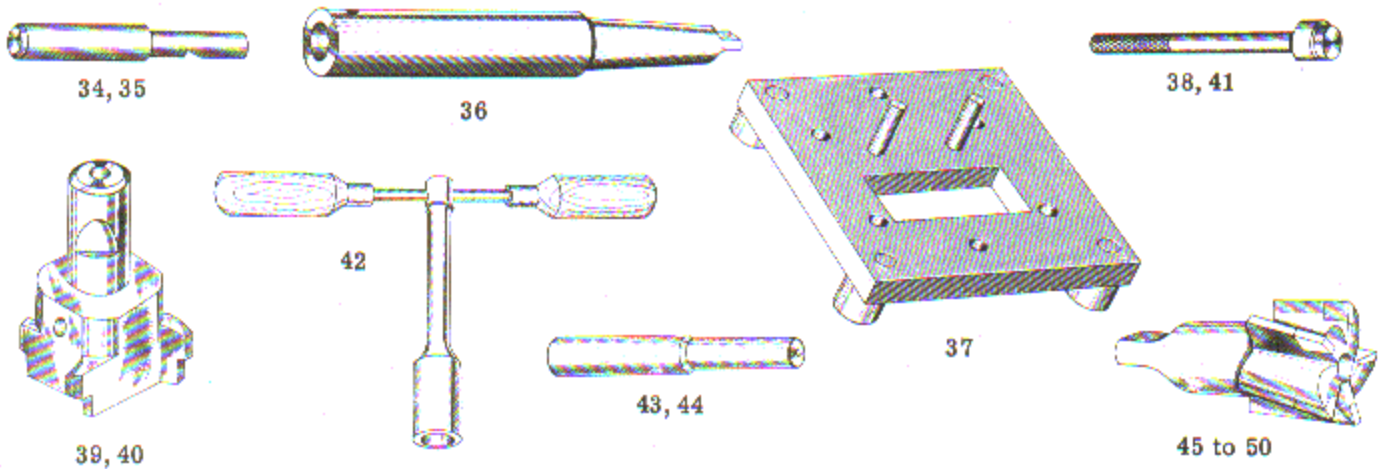


Figure 11-3. (Cont.) Cylinder Overhaul Tools - Valve Seat Replacement Tools

TABLE XI — III (Cont.)  
CYLINDER OVERHAUL TOOLS

| Reference Figure Number                             | Part Number | Nomenclature   |
|---|-------------|--|
| <b>VALVE ROCKER SHAFT BUSHING REPLACEMENT TOOLS</b> |             |  |
| 51, figure 11-3                                     | 64540       | Fixture - Holding, valve rocker  |
| 52, figure 11-3                                     | 64541       | Burnisher - Valve rocker bushing                                       |
| 53, figure 11-3                                     | 64613       | Gage - Service rejection, valve rocker shaft bores                     |
| 54, figure 11-3                                     | 64810       | Gage - Plug, rocker shaft bushing hole in cylinder head                |
| 55, figure 11-3                                     | 64811       | Gage - Plug, 0.005 oversize rocker shaft bushing hole in cylinder head |
| 56, figure 11-3                                     | 64814       | Drift - Removal, rocker shaft bushing                                  |
| 57, figure 11-3                                     | 64823       | Gage - Plug, rocker shaft bushing ID                                   |
| 58, figure 11-3                                     | 64824       | Drift - Installation, outer rocker shaft bushing                       |
| 59, figure 11-3                                     | 64825       | Drift - Installation, inner rocker shaft bushing                       |

TABLE XI — III (Cont.)  
CYLINDER OVERHAUL TOOLS

| Reference and Figure Number                          | Part Number | Nomenclature  |
|--|-------------|---|
| VALVE ROCKER SHAFT BUSHING REPLACEMENT TOOLS (Cont.) |             |   |
| 60, figure 11-3                                      | 64826       | Reamer - Finish, inner and outer rocker shaft bushing ID              |
| 61, figure 11-3                                      | 64838       | Reamer - Rocker shaft bushing hole in cylinder hole (0.005 over-size) |
| 62, figure 11-3                                      | 64839       | Reamer - Rocker shaft bushing hole in cylinder head (0.010 over-size) |

Figure 11-3. (Cont.) Cylinder Overhaul Tools - Valve Rocker Shaft Bushing Replacement Tools

TABLE XI — IV  
CRANKCASE, CRANKSHAFT, AND RECIPROCATING PARTS TOOLS

| Reference and Figure Number | Part Number | Nomenclature  |
|-----------------------------|-------------|---|
| 1, figure 11-4              | 64530       | Gage - Parallelism and squareness of connecting rods                        |
| 2, figure 11-4              | 64535       | Drift - Removal, connecting rod bushing                                     |
| 3, figure 11-4              | 64536       | Drift - Replacement, connecting rod bushing                                 |
| 4, figure 11-4              | 64537       | Gage - Flat plug rejection, connecting rod bushing                          |
| 5, figure 11-4              | 64545       | Block - Vee, crankshaft run-out   |
| 6, figure 11-4              | 64548       | Drift - Removal and replacement, crankpin journal sludge tubes (O-360 only) |
| 7, figure 11-4              | 64580       | Burnisher - Connecting rod bushing  |
| 8, figure 11-4              | 64597       | Block - Replacement, connecting rod bushing                                 |
| 9, figure 11-4              | 64648       | Driver - Crankpin oil tube (O-540 only)                                     |
| 10, figure 11-4             | 64690       | Driver - Oil relief valve sleeve  |
| 11, figure 11-4             | 64767       | Gage - Finish ID, connecting rod bushing                                    |
| 12, figure 11-4             | 64770       | Drift - Installation, oil plug  |
| 13, figure 11-4             | 64782       | Puller - Slide hammer   |
| 14, figure 11-4             | 64864       | Spreader - Roll pin, connecting rod bolt                                    |
| 15, figure 11-4             | 64866       | Adapter - Puller, crankshaft sludge tube (O-540 only)                       |
| 16, figure 11-4             | 64869       | Puller - Removal and replacement, crankshaft flange bushing                 |
| 17, figure 11-4             | 64872       | Puller - Removal and replacement, counterweight bushing in crankshaft       |
| 18, figure 11-4             | 64873       | Fixture - Reaming counterweight bushing in crankshaft                       |
| 19, figure 11-4             | 64874       | Reamer - Counterweight bushing hole in crankshaft (0.005 oversize)          |
| 20, figure 11-4             | 64875       | Reamer - Counterweight bushing hole in crankshaft (0.010 oversize)          |
| 21, figure 11-4             | 64876       | Reamer - Counterweight bushing hole in crankshaft (0.020 oversize)          |
| 22, figure 11-4             | 64892       | Gage - Gap, counterweight retaining ring                                    |
| 23, figure 11-4             | 64896       | Drift - Installation, expansion plug  |

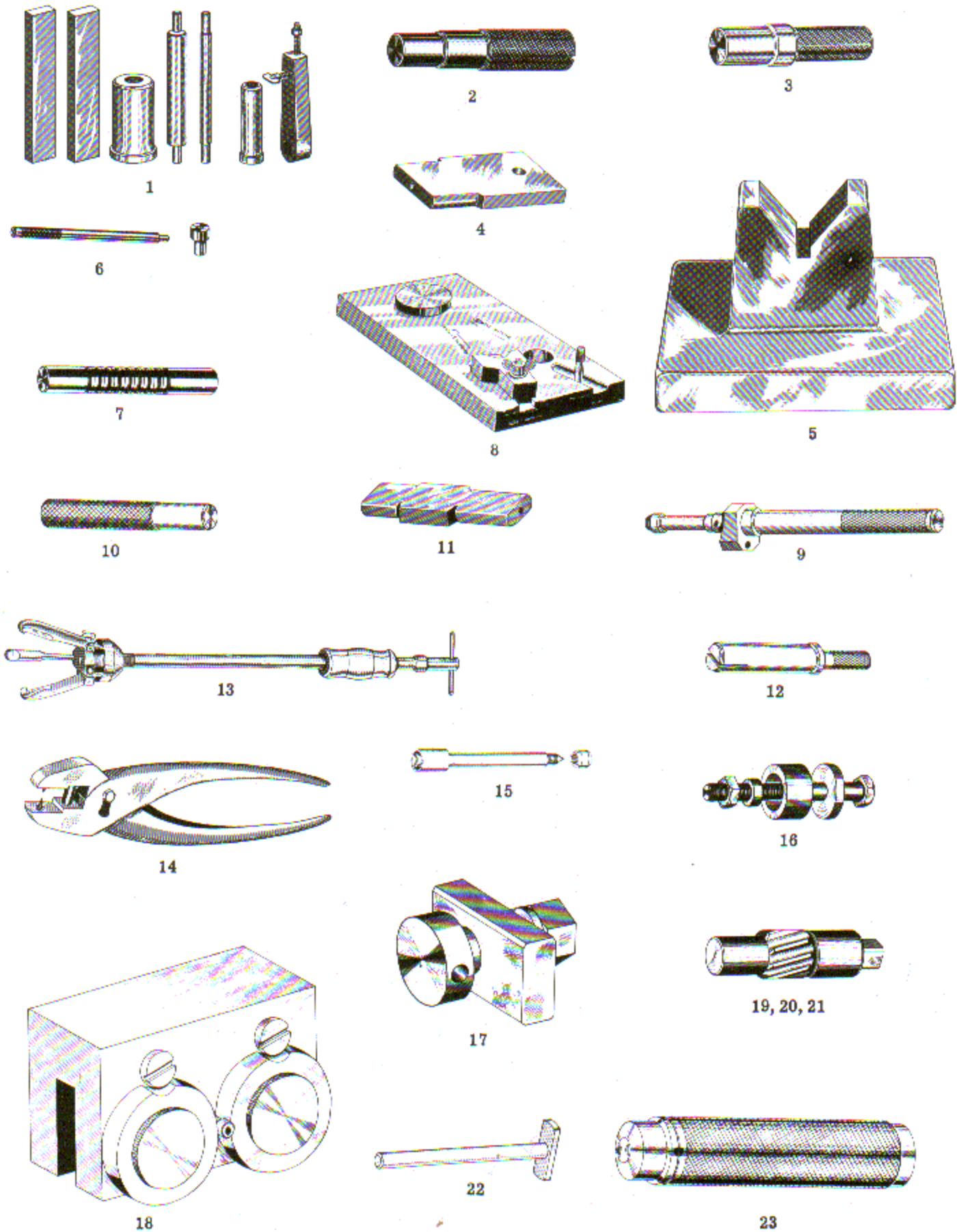


Figure 11-4. Crankcase, Crankshaft, and Reciprocating Parts Tools

TABLE XI—V  
RUN-IN TEST TOOLS

| Reference and Figure Number | Part Number | Nomenclature                  |
|-----------------------------|-------------|-------------------------------|
| 1, figure 11-5              | 64612       | Shroud - Cooling (O-360 only) |
| 2, figure 11-5              | 64803       | Club - Test                   |
| 3, figure 11-5              | 64867       | Shroud - Cooling (O-540 only) |

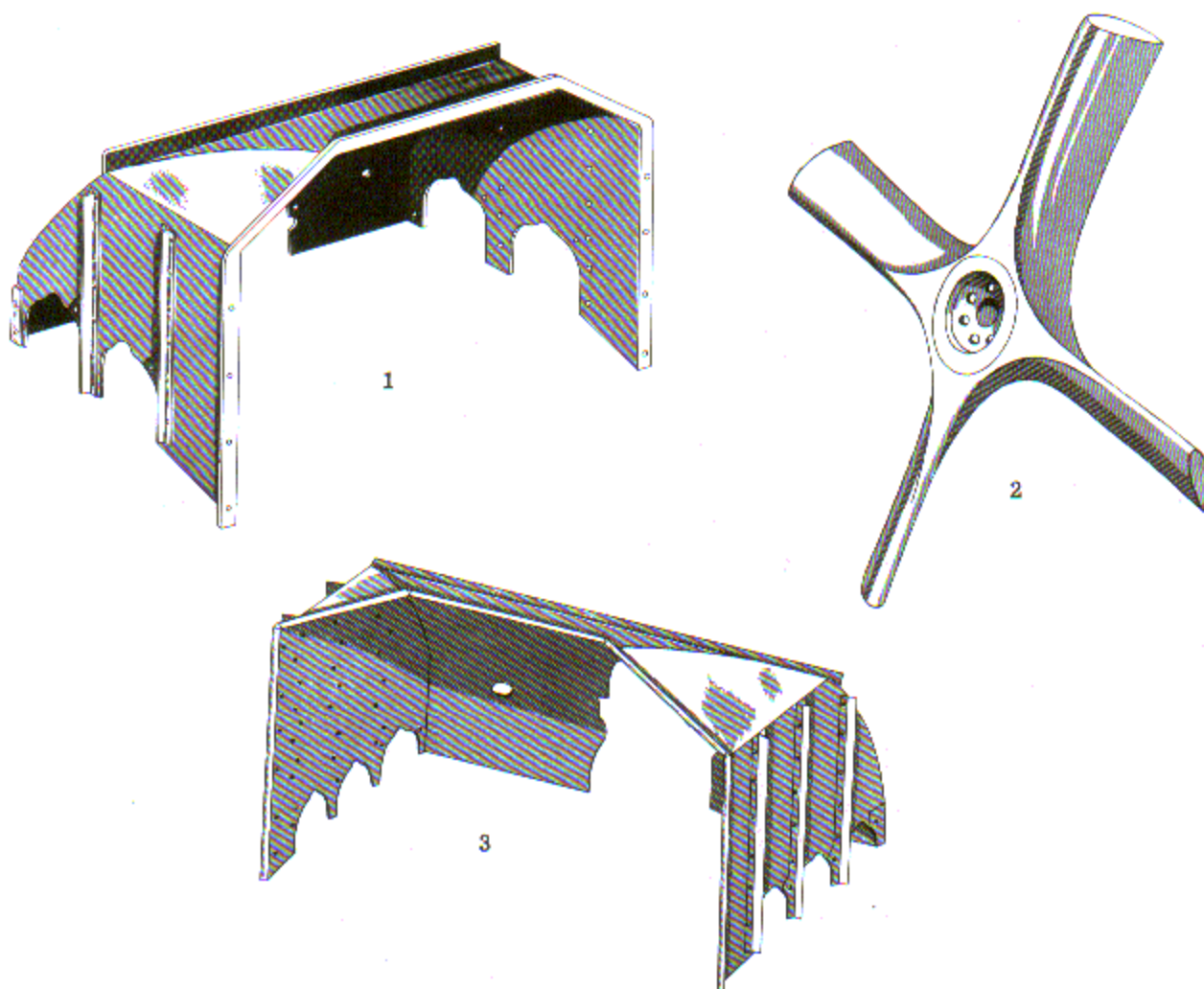


Figure 11-5. Run-in Test Tools

# LYCOMING

## OVERHAUL SUPPLEMENT

Model Affected: IO-720-A1A

### SECTION I

#### INTRODUCTION

1-1. The purpose of this overhaul supplement is to enable personnel to overhaul the IO-720-A1A model Lycoming aircraft engine. This supplement must be used in conjunction with Lycoming O-360, O-540 Overhaul Manual.

1-2. Some procedures outlined in the O-540 overhaul manual will also apply to the IO-720-A1A model engine. Therefore, except where specific differences are involved, this supplement will follow format of the O-360, O-540 Overhaul Manual. For example, the paragraph numbers in this supplement will correspond to the paragraph numbers in basic O-360, O-540 Overhaul Manual. Specific differences between the IO-720-A1A model engine and the O-540 model engine will be fully described, replacing original paragraph in basic manual. Modification and salvage procedures outlined in basic manual do not necessarily apply to the IO-720-A1A model engine. Figure numbers in this supplement will have no relationship to the basic manual. Section numbers in this supplement will correspond to section numbers in basic manual.

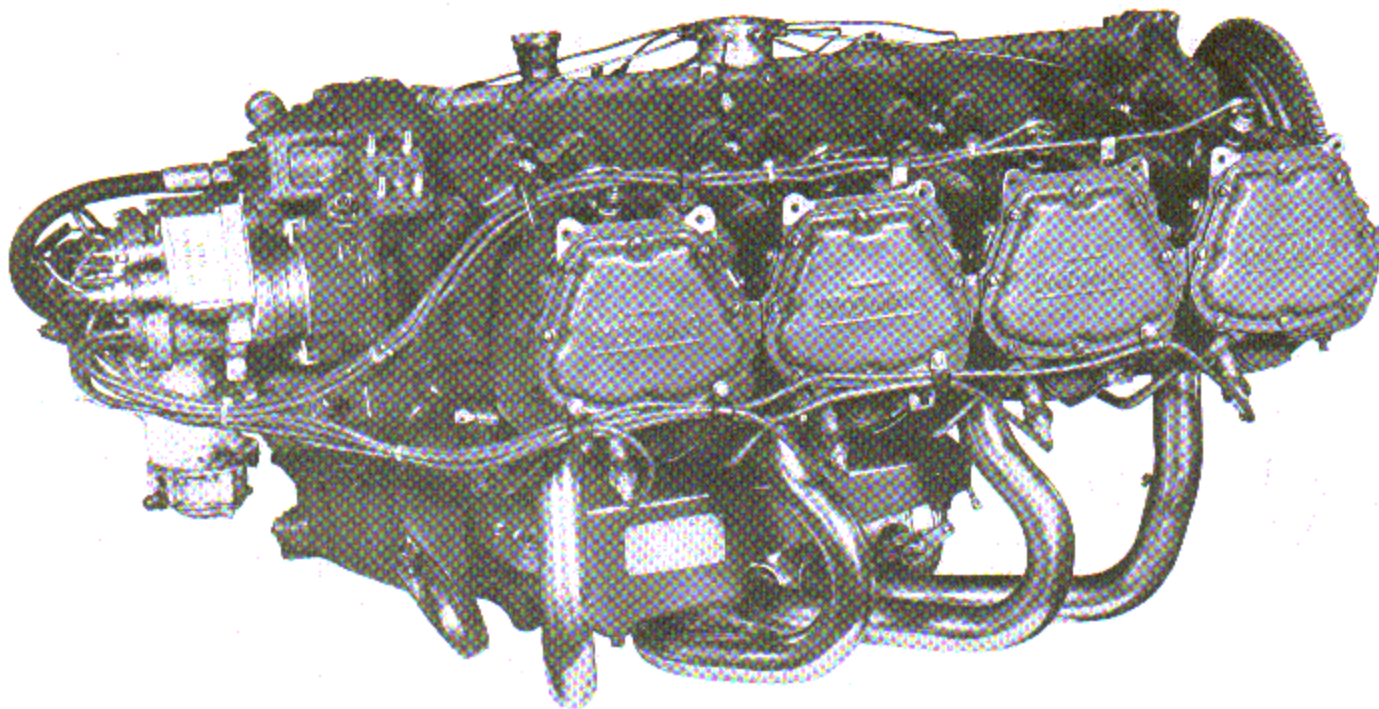


Figure 1. Right Side View - IO-720-A1A Model Engine



# LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

## SECTION II

### DESCRIPTION

#### TYPE OF ENGINE

2-1. The Lycoming model IO-720-A1A aircraft engine is an eight cylinder, direct drive, wet sump, fuel injected, horizontally opposed, air-cooled model with rear mounted accessory drives and accessories. It incorporates a tuned induction system and dynafocal mounts. The total displacement of the eight cylinders is 722.0 cubic inches.

2-2. CYLINDERS - All cylinders for the IO-720-A1A model engine employ nitride hardened steel barrels, and are of the angle valve down exhaust construction. Sodium cooled exhaust valves with a one half inch stem diameter are used in this engine along with bronze valve guides and austenitic chrome nickel steel valve seats. The seats are shrunk into machined recesses in the cylinder head. Rocker bosses are so located as to allow for angle exhaust push rods.

#### NOTE

The nitride hardened steel cylinder barrels are identified by blue paint on cylinder head fins between the shroud tubes. Nitride hardened steel cylinders require the use of chrome plated piston rings.

The cylinders are numbered from front to rear of the engine. Viewed from accessory end of engine, the front cylinder on the left bank is No. 2, the fourth cylinder on the left bank is No. 8. The front cylinder on the right bank is No. 1 and the fourth cylinder on the right bank is No. 7. The engine firing order is 1-5-8-3-2-6-7-4.

2-3 thru 2-5. These paragraphs in basic manual also apply to IO-720-A1A model engines.

2-6. CRANKSHAFT - This paragraph in the basic manual also applies to the IO-720-A1A model engine with the exception that the "NOTE" at end of this paragraph should be disregarded.

2-6-A. CRANKSHAFT COUNTERWEIGHTS - The crankshaft is fitted with one 3.5 order, six 4th order and one 5th order pendulum type counterweights as standard equipment.

2-7. CRANKCASE - This paragraph in basic manual also applies to IO-720-A1A model engines with the following exception. IO-720-A1A engines are equipped with piston cooling oil squirts. These nozzles are self cleaning and inoperative at low idling pressures of 25 psi and spring loaded feature prevents draining the oil galleries when engine is stopped.

#### NOTE

Due to line bore requirements of the crankcase, if either half is damaged, the entire crankcase must be replaced.

2-8. SUMP - Information contained in this paragraph in the basic manual also applies to the IO-720-A1A model engines, except the following.

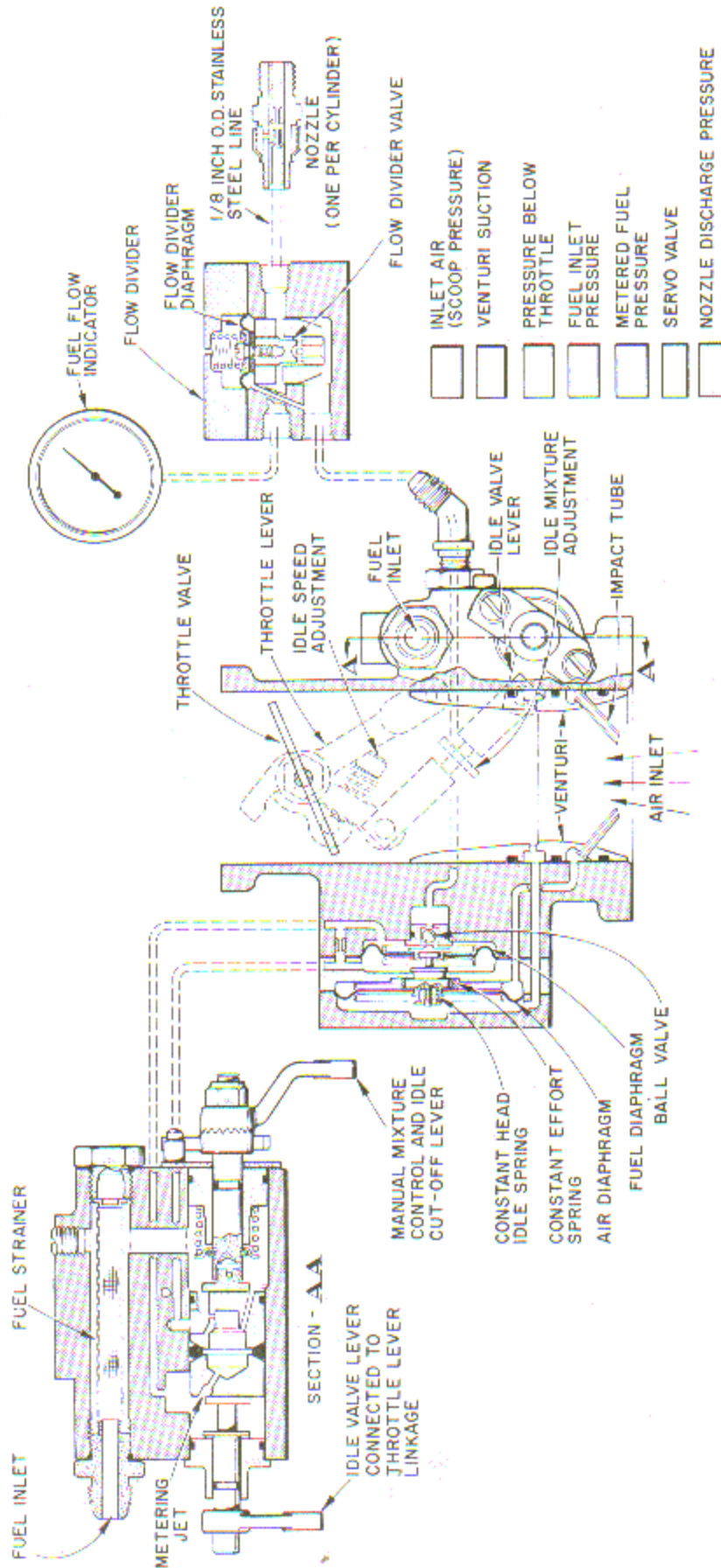
1. An air distribution chamber for the tuned intake system is mounted below the sump.
2. Disregard all information in this paragraph pertaining to carburetors.
3. The oil sump contains an oil suction screen.

2-9. CONNECTING RODS - Connecting rod caps are now secured to the rod with crimp bolts and nuts. See Lycoming Service Instruction No. 1106 for full information.

2-10. PISTONS - IO-720-A1A model engines employ four ring pistons, with all rings located above the piston pin. All other information in this paragraph applies to IO-720-A1A model engines.

2-11 thru 2-16. Information contained in these paragraphs applies to IO-720-A1A model engines.

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT



Fuel Injection Schematic - Bendix RSA-10AD1 System

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

2-17. INDUCTION SYSTEM - IO-720-A1A model engines employ a Bendix RSA-10AD1 fuel injection system. This fuel injection system consists of the following parts:

1. The fuel injector assembly
2. Flow divider assembly
3. Air bleed nozzle assembly

The fuel injector assembly has three sections consisting of the airflow, the regulator and the fuel metering sections. Their relationship is such that it is possible to embody these sections within the throttle body casting.

The minimum fuel pressure requirement for this system is 14 psi. However, the system is relatively insensitive to inlet pressure. In most installations a diaphragm type fuel pump will be employed.

Each new fuel injection system is identified with a specification plate attached to the throttle body. This plate identifies the manufacturer, unit serial number, model designation and parts list and issue number to which the unit was manufactured.

**DESCRIPTION AND PRINCIPLES OF OPERATION** - The following description covers each section separately, and is coordinated with the schematic diagram. Air density is assumed to be maintained at a fixed value.

The RSA type fuel injection system is based on the principle of measuring air flow and using the airflow signal in a stem type regulator to convert the air force into a fuel force. This fuel force (fuel pressure differential), when applied across the fuel metering section (jetting system), makes fuel flow proportional to air flow.

**AIRFLOW SECTION** - The airflow section contains the throttle valve and venturi. The difference between the venturi entrance (impact) and throat pressures is a measurement of the air entering the engine. These pressures are applied to an air diaphragm to create a force across the diaphragm. This force is referred to as "The Air Metering Force". A change in power changes the airflow to the engine which will change the air metering force.

**REGULATOR (STEM TYPE) SECTION** - The regulator contains the aforementioned air diaphragm and a fuel diaphragm. Fuel inlet pressure is applied to one side of the fuel diaphragm. The other side of the fuel diaphragm is exposed to fuel that has passed thru the metering jet (metered fuel pressure). The differential pressure across the fuel diaphragm is referred to as "Fuel Metering Force".

Relatively high fuel metering forces are developed from the air metering forces because of diaphragm areas selected. The air metering force applied to the air diaphragm is transmitted thru the regulator stem and tends to move the ball valve in the opening direction. The fuel metering force across the fuel diaphragm acts to oppose the air metering force and tends to close the ball valve.

Because the air forces are very low in the idle range, a constant head idle spring is provided to maintain an adequate fuel metering force at low RPM. As the air metering force increases, the spring compresses until the spring retainer touches the air diaphragm and acts as a solid member.

The constant effort spring produces a force which provides a smooth transfer from idle to low power cruise operation. Whenever the air metering, fuel metering and spring forces are balanced, the ball valve maintains a fixed position.

**FUEL METERING SECTION** - This section incorporates an inlet fuel strainer, a manual mixture control valve and an idle valve. The idle valve is connected to the throttle valve by means of an external adjustable link. The main metering jet is incorporated in the passage between inlet fuel pressure and metered fuel pressure. In some cases (according to a parts list requirement) an enrichment jet is also located between these pressures. The enrichment jet fuel channel is also uncovered by the idle valve at a pre-determined point to provide additional fuel enrichment in the power range.

The manual mixture control valve produces a full rich condition when the lever is against the rich stop, and a progressively leaner mixture as the lever is moved toward idle-cut-off. Both idle speed (closed throttle position) and idle mixture (relationship between throttle position and idle valve position) may be readily adjusted externally to meet individual engine requirements.

**FLOW DIVIDER** - The flow divider is mounted separately on the engine and is supplied with metered fuel through an external line. On IO-720-A1A model engines, this flow divider is mounted between the fifth and sixth crankcase fastening (standing at rear of engine and looking forward) at the top center of the crankcase. Spring pressure in conjunction with ambient air pressure closes the flow divider valve when fuel pressure from the injector falls below approximately 2 psi.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

As the valve opens the fuel is channeled from the central chamber into individual passages; each passage leads to a nozzle supply line for each cylinder to assure an even distribution of fuel at idle. As power demand is increased above idle requirements, the flow divider valve fully opens and fuel to the engine becomes a function of fuel pressure at the nozzles. Under idle-cut-off conditions, the loss of supply pressure permits the valve to close and immediately stop the flow of fuel to all cylinders resulting in a smooth shut-down.

**AIR BLEED NOZZLE ASSEMBLIES** - A set of eight continuous flow air bleed nozzle assemblies are incorporated in IO-720-A1A model engines. Fuel leaves the flow divider assembly and flows through independent fuel lines to each nozzle.

Ambient air from around the engine is permitted to enter the air bleed in each nozzle through a screen. This air assists in breaking up and atomizing the fuel during idle and part throttle conditions. In addition, ambient air pressure equalizes the pressure at all the nozzles to eliminate the adverse effect of low manifold pressure at idle so that the lines can be maintained full of fuel to provide good distribution and acceleration characteristics.

**2-18. IGNITION SYSTEM** - IO-720-A1A model engines employ a Bendix S8LN-701 retard breaker magneto on the left side of the engine. A conventional, single breaker S8LN-705 magneto is employed in the right side of the engine. The Bendix S-700 series of magnetos are designed for use on eight cylinder engines. The magneto system consists of a dual (retard) contact assembly magneto and a single contact assembly magneto, a starting vibrator, a combination ignition and starter switch, a high tension harness assembly, one transformer assembly mounted to each magneto and two low tension lead assemblies. The starting vibrator is used in conjunction with the retard contact assembly magneto to provide necessary voltage at cranking speeds.

**MAGNETO** - The S-700 series magneto is a self contained unit. Its rotor is of an 8 pole design and turns on two small bearings. The primary coil and lamination assembly consists of 8 coils connected in series and positioned in the housing around the rotor. An 8 lobe cam is secured to the contact assembly end of the rotor shaft. The rotor turns at one half engine speed, thus 8 sparks are produced in 720° of engine crankshaft rotation.

The S-700 dual (retard) contact assembly magneto incorporates a retard contact assembly. The retard contact is actuated by the same cam as the main contact and is so positioned that its points open a predetermined number of degrees after the main points open. A battery operating starting vibrator used with this magneto provides enough voltage for starting, regardless of engine cranking speed. This voltage is in the form of a shower of sparks rather than a single spark as is obtained from a magneto employing an impulse coupling. Suppression of contact point arcing and conducted radio interference is accomplished by a feed thru type capacitor.

**STARTING VIBRATOR** - The starting vibrator for either a 12 or 24 volt system is enclosed in small metal box with a bracket to facilitate mounting. The basic starting vibrator contains a vibrator assembly whose function is to supply interrupted battery current to the magneto primary coil.

**HARNESS AND LEAD ASSEMBLIES** - Harness and lead assemblies are provided as a complete unit with mating connectors for both magnetos and an individual cable assembly for each of the 16 spark plugs. Brackets and clamps for mounting to the engine are provided.

The low tension lead assemblies are used to carry the low tension current, produced by the magneto, to the transformer assembly which in turn produces the high tension current. From the transformer assembly this high tension current is carried back to the magneto thru one outlet in the harness assembly and then is distributed by the magneto distributor finger to each individual spark plug outlet.

**COMBINATION IGNITION AND STARTER SWITCH** - The combination ignition and starter switch used with S-700 series magnetos is designed to control the ignition circuits of both magnetos. The switch has five positions and is actuated by key or lever. Following are switch positions:

1. OFF - Both magnetos inoperative.
2. R - Right magneto operating. Left off.
3. L - Left magneto operating. Right off.
4. BOTH - Both magnetos operating.
5. START - Starter solenoid is energized and vibrator is operating causing vibrator current to flow thru retard contact assembly on left magneto while right magneto is grounded to prevent advanced ignition.

**TRANSFORMERS** - Only two transformers are required with the S-700 series magnetos instead of the six used in S-600 series. Each magneto in S-700 series have the transformer attached to the individual magneto. The basic reason for this series employing only two transformers in place of six, is that current distribution is high tension.

**2-19. ACCESSORY DRIVES** - Drives are provided for the following accessories on IO-720-A1A model engines as standard equipment, Starter, Generator, Tachometer, and Fuel Pump. As optional equipment, drives may be provided for Vacuum Pump, Hydraulic Pump and Propeller Governor.

# LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

## SECTION III

### GENERAL OVERHAUL PROCEDURES

3-1. This paragraph in basic manual also applies to IO-720-A1A model engines.

#### DISASSEMBLY

3-2 and 3-3. These paragraphs in basic manual also apply to the IO-720-A1A model engine. Note following paragraph 3-3 in basic manual applies to IO-720-A1A model engine.

#### CLEANING

3-4 thru 3-10. Information contained in these paragraphs of the basic O-360, O-540 overhaul manual also applies to the IO-720-A1A model engine.

#### INSPECTION

3-11 thru 3-20. Information contained in these paragraphs of the basic O-360, O-540 overhaul manual also applies to IO-720-A1A model engines.

#### REPAIR AND REPLACEMENT

3-21 thru 3-28. Information contained in these paragraphs of the basic O-360, O-540 overhaul manual also applies to the IO-720-A1A model engines. The one exception being as follows: All references to glossy black enamel should read, engine grey enamel.

#### REASSEMBLY

3-29 thru 3-31. Information contained in these paragraphs in the basic O-360, O-540 overhaul manual also applies to IO-720-A1A model engines.

3-32. Add to arbitrary replacement of parts, All crankshaft counterweight bushings. These are the bushings located in the lugs of the crankshaft.

## SECTION IV

### IGNITION SYSTEM

This section replaces in its entirety the "Ignition System" maintenance section of the basic O-360, O-540 overhaul manual.

4-1. For information concerning the maintenance procedures for S-700 series magnetos, consult applicable Bendix Manufacturing Corporation's publications.

4-2. MAGNETO TIMING - Check the unit for proper magneto rotation before placing the unit on an engine. If the magneto is of the correct rotation, turn magneto rotor shaft in direction of rotation until the timing mark on the drive plate is approximately in alignment with an indent on drive end of magneto housing. One of the painted lines on distributor finger and the painted line on the distributor block should also be in alignment when viewed through the opening marked "T" in the housing. When viewed from drive end of the magneto the painted line on the right side of distributor finger, is for clockwise rotation, and the painted line on left side is for counter-clockwise rotation. Magneto is now in number one cylinder advance firing position.

#### NOTE

The lines on distributor finger and distributor block as described above, are for reference only. Absolutely no adjustment of contact point opening from these marks shall be used as an indication of proper internal magneto timing.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

4-3. Turn the engine crankshaft to number one cylinder full advance firing position. Install the magneto on the engine and tighten the mounting clamps sufficiently to hold magneto in position and yet allow it to be rotated.

4-4. Connect a timing light to switch wire (shielded capacitor wire) and to a good ground on the engine.

4-5. If the timing light is out (battery operated model) rotate the magneto housing in direction of its magneto rotation a few degrees until light comes on. Then turn slowly in opposite direction until light just goes out. Secure the magneto in this position.

4-6. Repeat procedure for other magneto using another timing light.

4-7. After both magnetos have been satisfactorily timed, leave the timing light wires connected and re-check timing as previously described to make certain both magnetos are set to fire simultaneously. If the timing is correct, both timing lights will be out. If the breaker points open too soon, rotate magneto in a clockwise direction for right magneto. Turn magneto clockwise for left magneto. If the points open too late turn right magneto counter-clockwise, and left magneto counter-clockwise. When it is certain both magnetos are set to fire together, remove timing lights and replace plugs.

### WARNING

When timing retard breaker magnetos to the engine, only the main breaker points are timed. Never attempt to time retard breaker points to the engine.

### REASSEMBLY

4-8. HARNESS ASSEMBLIES - Before installing harness on magnetos check all mating surfaces for cleanliness. Spray entire face of the grommet with a light coat of Plastic Mold Spray or equivalent. This will prevent the grommet from sticking to the magneto distributor block. Check the two or three exposed leads connected to the distributor block for clearance between distributor block outlets. Install cover and tighten screws around cover alternately so that the cover will seat squarely on the magneto.

4-9. Connect the high tension leads (short center leads) of harness assembly to the large connectors on transformer assemblies. Torque the coupling nuts to 96 to 120 in. lbs. torque. Do not twist leads.

4-10. Connect harness assembly leads to proper engine spark plug. Secure harness assembly to engine using clamps, bands and plates provided on leads. Avoid any location that may cause chafing. If it is necessary to move any of the clamps use care not to damage leads when sliding clamps.

4-11. LEAD ASSEMBLIES - Assemble the small nut of the lead assemblies to harness cover outlets marked "Coil". Torque these nuts to 25 to 30 in. lbs. torque. Connect other end of leads to small terminal on transformer assemblies. Torque these nuts 72 to 96 in. lbs. torque. Care must be taken not to twist leads. Lock wire the two coupling nuts connected to the transformer assemblies together after torquing nuts.

4-12. STARTING VIBRATOR - See applicable airframe manufacturers publications for assembly of starting vibrator. Avoid places of excessive heat, vibration, oil or grease.

### WARNING

Do not use gasoline or any other solvent for cleaning distributor block. Solvent and/or gasoline will remove wax coating and possibly cause electrical leakage.

4-13. ALTERNATOR - Alternator repair and replacement should be carried out in conjunction with applicable manufacturer's publications. However if the alternator pulley is worn and replacement is necessary, check the applicable Lycoming parts catalogs for this pulley.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### SECTION V

#### ACCESSORY HOUSING

5-1. Information in this paragraph in basic O-360, O-540 overhaul manual also applies to IO-720-A1A model engines.

#### DISASSEMBLY

5-2 and 5-3. Disregard these paragraphs in basic O-360, O-540 overhaul manual.

5-4. This paragraph in basic O-360, O-540 overhaul manual also applies to IO-720-A1A model engines.

5-5 thru 5-7. Information contained in these paragraphs of O-360, O-540 basic overhaul manual also applies to IO-720-A1A model engines.

#### CLEANING

5-8 and 5-9. These paragraphs in basic O-360, O-540 overhaul manual also apply to IO-720-A1A model engines.

#### INSPECTION

5-10 and 5-11. These paragraphs in basic O-360, O-540 overhaul manual also apply to IO-720-A1A model engines.

#### REPAIR AND REPLACEMENT

5-12. This paragraph in basic O-360, O-540 overhaul manual also applies to IO-720-A1A model engines.

#### REASSEMBLY

5-13 thru 5-20. These paragraphs also apply to the IO-720-A1A model engines.

5-21. ACCESSORY HOUSING. Since IO-720-A1A model engines employ an "AN" fuel pump drive, assemble as follows:

1. Make certain the fuel pump idler gear shaft is in place on the inside of the accessory housing cover and is secured with two 1/4-20 hex head screws and lock plate.
2. Place fuel pump idler gear on the idler shaft.
3. Install the thrust washer and retaining ring that hold the idler gear in place on the shaft.
4. Make sure that a new oil seal has been inserted in the tachometer drive shaft bore.
5. Rotate the oil pump drive shaft so that the lobes on the shaft align with slots in the crankshaft gear.
6. Apply a liberal coating of preservative oil to the tachometer drive shaft and all other contact surfaces such as gear teeth and hub of left idler gear.
7. Carefully fit the accessory housing in place on the rear of the crankcase, guiding the housing first over the tachometer drive shaft and then on to the locating dowels.
8. Secure the housing in place with ten 1/4-20 x 15/16 hex head bolts and two 1/4-20 x 1-3/4 inch bolts. Assemble all fastenings with plain washers and lock washers.

5-22. This paragraph in basic manual also applies to this IO-720-A1A overhaul supplement.

5-23 thru 5-29. Disregard these paragraphs in the basic O-360, O-540 overhaul manual.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

5-30. Hydraulic pump drives for IO-720-A1A model engines are supplied as an option. If the particular engine has a hydraulic pump drive, the information contained in this paragraph in basic O-360, O-540 overhaul manual will apply. If the engine does not have a hydraulic pump drive the paragraph may be disregarded.

5-31. Information in this paragraph of basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A model engine overhaul supplement.

### SECTION VI

#### CYLINDERS, PISTONS AND VALVE TRAIN

6-1. The IO-720-A1A model aircraft engine employs cylinders equipped with nitride hardened steel barrels. The nitrided barrels may be identified by blue paint on cylinder head fins between the shroud tubes. These cylinders are of angle valve construction.

6-2. Information contained in these paragraphs of basic O-360, O-540 overhaul manual applies to this supplement.

6-3. This paragraph also applies to IO-720-A1A model engines.

#### DISASSEMBLY

6-4. All information regarding primer lines contained in the basic O-360, O-540 overhaul manual should be disregarded. Fuel injection lines and flow divider element should be disassembled from the engine at this time. Fuel injection nozzles should be carefully examined for damage at this time. Damaged nozzles should be removed. However, if the nozzles are not damaged they should not be removed.

6-5. Information in this paragraph of O-360, O-540 overhaul manual also applies to this IO-720-A1A supplement with the following exceptions: There are eight cylinder head oil drain tubes to be removed. Cylinders No. 3, 5, 6, 7, 8 have the same size drain tubes.

6-6. Because the intake pipes for IO-720-A1A model engines do not employ hose connections at the sump, this information in basic manual may be disregarded. However, all other information pertaining to removal, and marking of the intake pipes should be accomplished.

6-7. This paragraph applies to this IO-720-A1A model engine overhaul supplement.

6-8 and 6-9. These paragraphs and the note in basic O-360, O-540 overhaul manual also apply to IO-720-A1A model engines.

6-10. Information contained in this paragraph in the basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement. Use cylinder base nut wrenches, Lyc. T/N's 64942 (1/2 inch) and 64943 (3/8 inch) to remove hold down nuts.

6-11. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement.

6-12. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement. The firing order for IO-720-A1A model engines is 1-5-8-3-2-6-7-4.

6-13. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement. The caution at the end of this paragraph in basic manual is very important.

6-14. This paragraph also applies to IO-720-A1A model engines. Use Lyc. T/N ST-25 valve spring compressor. The note at end of this paragraph in basic manual can be applied to IO-720-A1A model engines.

6-15 and 6-16. These paragraphs in basic O-360, O-540 overhaul manual also apply to IO-720-A1A engines.

6-17 and 6-18. These paragraphs in basic O-360, O-540 overhaul manual also apply to IO-720-A1A engines.

#### CLEANING

6-19 and 6-20. These paragraphs apply to this IO-720-A1A model engine overhaul supplement.



LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

INSPECTION

6-21. This paragraph applies to this IO-720-A1A model engine overhaul supplement.

6-22. Information contained in this paragraph in basic O-360, O-540 overhaul manual will apply to IO-720-A1A model engines with the following exceptions:

Subdivision "c" - The acceptance standards for angle valve cylinders with cracked fins are:

I. Fin adjacent to exhaust port flange

1. Stop drilling 3/16 inch diameter hole is permissible providing end of crack is at least 1/4 inch from base metal.
2. Fin removal to reduce size of vibrating mass, is preferred providing:
  - a. Maximum removal is no more than one half the length of the fin.
  - b. Maximum removal is to within 1/2 inch of base metal.
  - c. No sharp edges or burrs are permitted.
  - d. Minimum fillet at root of removed portion of fin is 1/4 inch radius. Minimum corner radius at tip of fin adjacent to removed portion is 1/2 inch radius.

II. Cracks in other fins are acceptable providing end of crack is at least 1/4 inch from base metal and providing fin stabilizers are used.

Subdivision "h" - It is no longer considered feasible to etch localized areas of the cylinder head when it is suspected that a crack may exist. Use one of the following non-destructive methods:

1. Dye Penetrant
2. Penetrant
3. X-ray
4. Electronic or other non-destructive methods

6-23. This paragraph applies to this IO-720-A1A overhaul supplement.

6-24 thru 6-30. Information contained in these paragraphs of basic O-360, O-540 overhaul manual also applies to this IO-720-A1A model engine overhaul supplement with the following additions:

CYLINDER INSPECTION - A general visual inspection of the cylinder must be made paying particular attention to the top two inches of the cylinder barrel. It is in this area that the top compression ring may cause barrel wear at that point where the piston reverses travel at the top of the stroke. This appears as a "wear step" which may be removed as outlined later in this overhaul supplement.

Dimensional inspection the barrel must be made in the straight portion of the barrel below the starting point of the choke, or at least two inches below the top of the barrel. Dimensional inspection is made with a dial indicator as described in the basic O-360, O-540 overhaul manual. The barrel limits for IO-720-A1A model engines are listed in Table I below. The maximum permissible taper and out-of-round condition of nitrided barrels is 0.004 inch. Both maximum taper and out-of-round checks must be made in accordance with the instructions set forth in basic O-360, O-540 overhaul manual.

TABLE I

|            | Mfg. Min. | Mfg. Max. | Max. Ser. Allow. |
|------------|-----------|-----------|------------------|
| IO-720-A1A | 5.1245    | 5.1260    | 5.1295           |

NOTE

No dimensional inspections are to be made in the top two inches or choke area of the cylinder barrel.

6-31. This paragraph in basic manual also applies to this IO-720-A1A overhaul supplement plus the following caution.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### CAUTION

The factory does not recommend valve face and seat lapping for two reasons:

1. Valve tip failures due to weakening by clamping action of valve lapping equipment.
2. Contamination permitted to enter critical cylinder contact areas which will create an abnormal wear condition.

6-32 thru 6-34. These paragraphs in basic manual also apply to this IO-720-A1A overhaul supplement.

### REPAIR AND REPLACEMENT

6-35. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A model engine overhaul supplement with the following addition:

**CYLINDER PAINTING** - The following procedure should be accomplished when repainting a cylinder:

1. Remove all old paint from the cylinder. A vapor degreaser is best suited for this purpose.
2. Mask off the following parts of the cylinder:
  - a. Rocker box section including rocker box flange
  - b. Both valve ports and flanges
  - c. Thermocouple hole
  - d. Spark plug holes
  - e. Rocker box drain tube hole
  - f. Push rod shroud tube holes
  - g. Valve rocker shaft cover flange
  - h. All other exposed threaded surfaces in which paint may accumulate.
3. Spray a very light coat of zinc chromate primer (.0005 inch maximum thickness) on the cylinder flange. If the correct amount of paint has been applied, the color of the paint will be green with a yellowish tint and the metal will show through. If the paint is too thick, the paint will be a zinc chromate yellow.

### NOTE

It is imperative that the paint thickness on the flange be held to 0.0005 inch maximum. To measure the thickness of the paint layer, one of two methods must be used. A Tinsley thickness gage which incorporates a magnetic needle and is scaled in tenths of thousandths is the most satisfactory method. If this type equipment is not available, use a micrometer to measure the thickness of the flange before and after painting. If the paint is too thick, it must be removed and repainted.

4. Mask off the flange area and proceed to paint the cylinder with an engine grey phthalate resin type paint, properly thinned with Toluol or equivalent. Avoid paint "pockets" or "runs".
5. Use a cloth dipped in paint thinner or equivalent to clean paint from all surfaces where paint may have accidentally accumulated.
6. The best finish will result if the cylinder is air dried for fifteen minutes and then baked in an oven until completely dry.

6-36 thru 6-41. These paragraphs in basic manual also apply to this IO-720-A1A supplement.

6-42 thru 6-46. The information in these paragraphs in basic manual is supplemented by one half inch stem diameter exhaust valve guide tools.

- ST-117 - Gage, Flat Plug Rejection, exhaust valve guide ID
- 64927 - Gage, Plug - Valve guide ID exhaust
- 64928 - Gage, Plug - .005"o/s valve guide hole in cylinder head exhaust
- 64929 - Gage, Plug - .010"o/s valve guide hole in cylinder head exhaust
- 64930 - Gage, Plug - .020"o/s valve guide hole in cylinder head exhaust
- 64931 - Gage, Plug - .030"o/s valve guide hole in cylinder head exhaust
- 64940 - Gage, Plug - Std. Valve guide hole in cylinder head exhaust

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

6-47. This paragraph in basic manual also applies to this IO-720-A1A overhaul supplement.

6-48 thru 6-51. Information in these paragraphs in basic manual also applies to this IO-720-A1A overhaul supplement with the following exceptions: The intake and exhaust valve seat measurements for IO-720-A1A model engines are:

Seat, Intake Valve - Outer face diameter - 2.344/2.334 inches  
Seat, Exhaust Valve - Outer face diameter 1.826/1.816 inches

Intake Valve Face - Specified width - .093/.074 inches  
Exhaust Valve Face - Specified width - .106/.091 inches

6-52 thru 6-58. These paragraphs in basic O-360, O-540 overhaul manual are replaced in their entirety by the following information.

A new and simplified method for removing valve seats has been approved by the factory. This new method eliminates counterboring.

### NOTE

It is also recommended that the new valve seat reconditioning tools be used to insure a tighter valve seat fit with reduced seat leakage.

**VALVE SEAT REMOVAL** - The procedure for removing valve seats without counterboring requires no special tools except for one that may be fabricated. To make this tool, select a piece of 1/2 inch bar stock, fifteen inches long for a handle, and thread two inches of one end. Cut a round piece from a one and one half inch (1-1/2) thick cellulose sponge. Be sure the outside diameter of the sponge is somewhat larger than the minor diameter of the valve seat, about 2-1/2 inches. Cut a hole in the center of the sponge large enough to fit over bar stock. Retain the sponge on rod with one half inch nuts and flat washers. It is used for valve seat removal in the following manner:

### NOTE

While the cylinder is still cold, remove the valve guides by employing valve guide puller, Lyc. T/N ST-49. Do not heat the cylinder to remove guides.

1. Heat the cylinder to 600° to 650° F. in oven.

### CAUTION

At no time is it permissible to use a torch to heat seat area or any other local portion of the cylinder assembly.

2. Secure cylinder to a suitable holding fixture. Preferably Lyc. T/N 64696 for angle valve engines.
3. Soak sponge end of tool in cold water.
4. Insert sponge end of tool in valve seat and hold it squarely in position.
5. The valve seat will shrink and adhere to sponge surface, permitting removal from seat recess.
6. Proceed with valve seat replacement.

**VALVE SEAT REPLACEMENT PROCEDURE** - Following is correct procedure for replacing valve seats in IO-720-A1A model engines. See Lycoming Service Instruction No. 1092 for tool views.

1. Secure cylinder in valve seat replacement fixture, Lyc. T/N 64696 for angle valve engines.
2. Position fixture on drill press table.
3. Choose proper cutter (.010, .020, .030 inch oversize), and proper pilot (STD., .005, .010, .020, .030 inch oversize for valve guide hole in cylinder head). Assemble the pilot through valve seat cutter and secure by tightening nut at the top of the cutter.

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

| Engine     | Seat Intake Valve  | Cutter No. | Counterbore Sizes | Cutter Pilot | Old Cutter No. |
|------------|--------------------|------------|-------------------|--------------|----------------|
| IO-720-A1A | 72212              | ST-51      | 2.281/2.596       | ST-66        | 64922-1-2-3    |
| Engine     | Seat Exhaust Valve | Cutter No. | Counterbore Size  | Cutter Pilot | Old Cutter No. |
| IO-720-A1A | 71894              | ST-54      | 1.927/2.230       | ST-67        | 64883-1-2-3    |

4. Attach the assembled pilot and cutter to the special length, tapered shank, driver Lyc. T/N ST-62.
5. Attach special length, tapered shank, driver and the assembled cutter and pilot to the drill press spindle.

NOTE

If the cutting of the valve seat recess is to be a hand operation, assemble hand drive adapter Lyc. T/N ST-63 to that assembly as described in step "4". ST-63 incorporates a square 1/2 inch socket drive for hand cutting purposes, and a through slot to permit use of a "T" handle.

6. Position cutter assembly carefully into cylinder head and proceed to cut seat recess in cylinder head.

CAUTION

Be very careful to remove no more metal from the bottom of the recess than is absolutely necessary to clean up the surface.

7. Heat cylinder to 600° to 650° F., place a new valve seat on replacement drift, Lyc. T/N's ST-64 or ST-65 (IO-720-A1A model engines employ both - ST-64 for intake valve seat and ST-65 for exhaust valve seat).
  8. Drive valve seat to a firm seat by short sharp blows of a hammer on seat replacement drift handle.
  9. When new seats have been installed, follow grinding procedures listed in basic overhaul manual.
- 6-59. This paragraph also applies to this IO-720-A1A overhaul supplement.
- 6-60 thru 6-69. Information contained in these paragraphs in the basic manual also applies to this supplement.
- 6-70. Information in the following paragraph replaces in its entirety the information contained in paragraphs 6-70 thru 6-77 in the basic O-360, O-540 overhaul manual.

**REMOVAL OF CYLINDER BARREL GLAZE** - If a nitrided steel barrel acquires a varnish or glaze on cylinder wall surface, it can be removed by means of a self centering hone (Snap-On CF-60C, or CF-60CS or equivalent). Only skilled personnel should be permitted to perform this operation, as an adequate cross-hatching pattern must be maintained and a roughness of 15 to 25 micro inches adhered to. The proper stone for glaze removal is a three inch long stone conforming to Micromatic Hone's C-180-K4-VEC-YT or equivalent. The operator must employ a smooth up and down motion of the hone, which should be operating at 70 to 75 RPM. An adequate pattern of cross hatching should be achieved within 6 to 8 passes of the hone. Following is complete procedure for removing glaze and follow up cleaning methods for nitrided cylinders.

WARNING

When nitrided cylinder barrels are honed to remove varnish or glaze, they must be thoroughly cleaned after the honing is completed. Abrasive in the cylinder or head, if not removed, will create an abnormal wear condition and possible ring failure.

1. Fasten cylinder securely to a suitable holding fixture.
2. Remove any hard carbon deposits within cylinder barrels and wipe out barrel with CLEAN cloth.
3. Dip a clean cloth, string mop or equivalent in clean SAE 10 weight engine lubricating oil. Swab all cylinder wall surfaces thoroughly with oil.

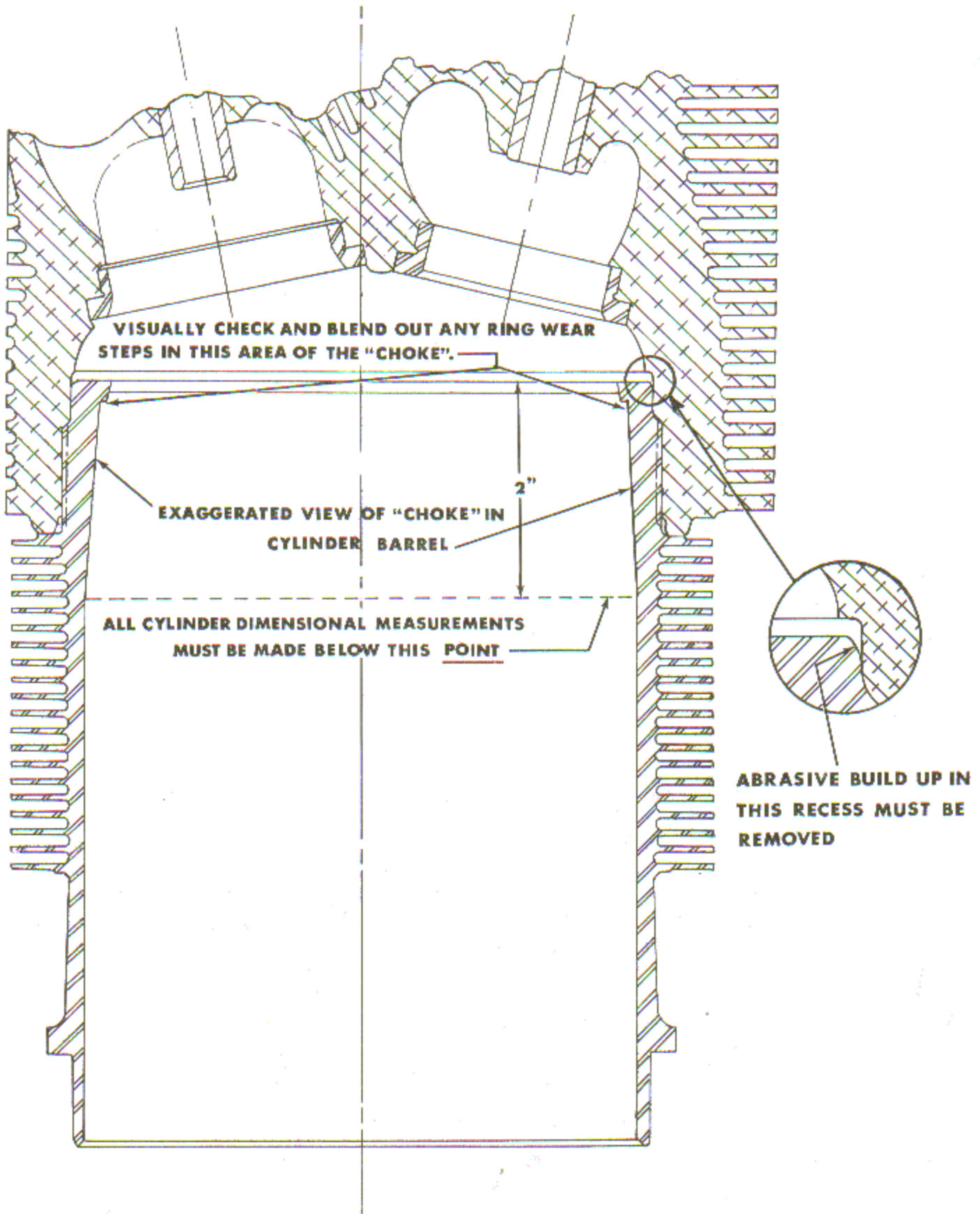


Figure 2. Dimensional Inspection - Nitrided Barrels

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

4. Surface hone each cylinder using a minimum of 6 to 8 passes over the glazed surface. Employ hone and stone types as previously described. Use a smooth up and down motion of the hone to achieve a good cross hatch pattern on cylinder wall. Hone should be operating at 70 to 75 RPM.
5. Clean hone and stones thoroughly before inserting them in another cylinder.
6. Repeat steps 3, 4 and 5 until all cylinders have been deglazed.
7. When deglazing procedure has been accomplished, wipe as much as possible of the abrasive build up from cylinder walls and recesses. Pay particular attention to the recess formed by top of cylinder barrel and bottom of cylinder head. See figure 2. Proceed to clean cylinder as follows:
  - a. Flush cylinder thoroughly with a hydro-carbon solvent (Varsol or equivalent). Use solvent under air pressure.
  - b. The use of a soft bristle brush is recommended, in conjunction with flushing, to remove abrasive build-up in difficult to reach areas. Do not use a wire brush.
  - c. At the conclusion of the first flushing operation, wipe out cylinder with a clean, white cloth, dipped in SAE 10 engine lube. Examine the cloth carefully, under a light, for evidence of abrasive remaining in cylinder. If abrasive is found on the cloth, repeat steps "a" and "b".

### CAUTION

One operation as described above may not be sufficient. It may take as many as three or four complete flushing and wiping operations to satisfactorily clean abrasive from cylinder.

- d. Particular attention must be paid, as previously mentioned, to that area (recess) formed by the top of the cylinder barrel and bottom of cylinder head. Figure 2. Fabricate a hooked tool from soft wire or other suitable material, and run the tool around in the recess to loosen build-up of abrasive. This operation must be performed each time the cylinder is flushed. No abrasive must remain in this area.
- e. The operator can only be certain that all residual abrasive has been removed, when a perfectly clean white cloth, dipped in SAE 10 engine lube, remains perfectly clean when cylinder is wiped.
- f. When the above procedure shows that cylinder contains no remaining abrasive, and no further rework is required, oil the cylinder thoroughly with SAE 50 engine lube or rust preventive oil.

**REWORK OF CYLINDER BARREL WEAR STEP AT TOP OR BOTTOM OF RING TRAVEL** - To blend out ring wear "steps" or ridges in nitride hardened steel cylinders also requires excellent judgment on the part of maintenance personnel. It is recommended that only the most skilled personnel be entrusted to remove ring wear "steps". The following procedure must be accomplished for removal of ring wear steps.

### CAUTION

Since wear steps generally occur in localized areas at the top and bottom of ring travel, a step with a depth of 0.005 inch on the entire diameter may be removed. No more than 0.0025 inch per side may be removed. If a nitrided steel barrel contains a wear step exceeding the above limits, the cylinder must be rebarreled or reconditioned by chrome plating.

1. Secure cylinder in suitable holding fixture.
2. Employ a self centering hone as described in procedure on barrel deglazing.
3. Use same stones as described in barrel deglazing.
4. Operate hone at 70 to 75 RPM.
5. Using a smooth, steady up and down motion of the hone, blend out all ridges or "steps" until all sharp corners have been removed.
6. After wear steps have been honed so that no sharp corners remain, the cylinder must be cleaned exactly as described in deglazing paragraph.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### CAUTION

It is important that both cylinder and head must be cleaned until a perfectly clean white cloth dipped in SAE 10 engine lube, remains unsoiled when it is rubbed over cylinder wall surfaces. DO NOT USE GASOLINE OR KEROSENE to clean cylinders after deglazing. Solvents of this type will not remove abrasive grit from cylinder walls. After cleaning, oil cylinder walls with SAE 50 or heavy rust preventive oil.

**RECONDITIONING OF NITRIDE HARDENED STEEL CYLINDERS WORN BEYOND SERVICE LIMITS** - When a nitrided barrel has worn beyond service limits, it can be reconditioned by having one of Lycoming's approved chrome plating facilities recondition the cylinder, or they can be returned to the factory for re-barreling.

For all owners and/or operators who wish to return present cylinders to service, the following information is submitted:

1. Follow the applicable instructions in the basic O-360, O-540 overhaul manual for reconditioning cylinders by chrome plating. No cylinder which is to be reconditioned by chrome plating can be ground more than 0.015 inch over standard bore diameter. No more than 0.0075 inch may be removed from each side.
2. Grind IO-720-A1A model engine cylinders to 5.140 inches or less.
3. The cylinders must then be returned to standard bore diameter by porous channel type chrome plating process. This must be accomplished by the factory or at any one of the factory approved facilities listed in Lycoming Service Instruction No. 1054.
4. Pistons used in nitrided cylinders which pass inspection may be used in chromed cylinders.

### CAUTION

Do not forget to replace the chrome plated piston rings used in nitride hardened steel barrels with plain piston rings when going to chromed cylinders. Under no circumstances should chrome piston rings be employed in a chrome cylinder. When nitrided cylinders have been reconditioned by chrome plating, the color identification on cylinder head fins between the shroud tubes must be changed from blue to orange.

### REASSEMBLY

6-78 thru 6-84. Information contained in these paragraphs in the basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A model engine overhaul supplement with the following exception: IO-720-A1A model engines employ a four ring piston, all rings located above the piston pin.

### NOTE

Valve stems of both intake and exhaust valves, plus the tips of both valves should be pre-lubricated with Texaco "Molytex O" lubricant or the equivalent. Valve guide ID should receive pre-lubrication as above.

6-85 thru 6-89. Information in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A model engine overhaul supplement with the following exceptions.

1. "Note" following paragraph 6-88. IO-720-A1A model engines employ aluminum piston pin plugs. However, if the cylinder barrel has been reconditioned by chrome plating, use aluminum bronze piston pin plugs.
2. Paragraph 6-89. IO-720-A1A model engines employ a four ring piston. IO-720-A1A model engines are eight cylinder engines.

6-90. This paragraph also applies to this IO-720-A1A overhaul supplement.

6-91. **TIGHTENING CYLINDER BASE NUTS TO PROPER TORQUE.** Use suitable cylinder base nut wrenches (Lycoming T/N 64942, 64943) and a suitable torque handle. Torque wrenches employing a hydraulic principle are not recommended. Torque wrenches employing the flexible beam design with a pivoted or floating handle and a sensory signaling device are preferred.

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Torque wrenches employing a dial indicator are also acceptable. The capacity of the wrench must be 20% greater than the torque required to tighten the nut. The sequence for tightening the nuts must be followed exactly as outlined in this supplement. This procedure will give uniform stress on the thru-studs, equalized bearing crush and even pressures on the crankcase halves at the main bearing locations. Two separate passes are required to tighten the nuts, plus a third pass to check torque. In addition all the requirements set forth in Lycoming Service Bulletin No. 272A must be adhered to.

NOTE

Before installing cylinder hold-down nuts, lubricate crankcase through stud threads with any one of the following four lubricants or combination of lubricants:

1. 90% SAE 50W engine oil and 10% STP
2. Parker Thread Lube
3. SAE 30 engine oil
4. 60% SAE 30W engine oil and 40% Parker Thread Lube

When a cylinder is to be assembled to the engine, accomplish the following procedure:

1. As each cylinder is installed, tighten the 3/8 inch cylinder base nuts to 200 in. lbs. torque, using sequence shown in figure 3.

2. After the cylinders have been installed, tighten the 1/2 inch hold down nuts to 300 in. lbs. torque. The sequence of tightening the nuts is shown in figure 3. The sequence of tightening the cylinders is as follows:

- |         |   |   |
|---------|---|---|
| First   | - | Tighten 1/2 inch nuts on No. 4 cylinder |
| Second  | - | Tighten 1/2 inch nuts on No. 5 cylinder |
| Third   | - | Tighten 1/2 inch nuts on No. 6 cylinder |
| Fourth  | - | Tighten 1/2 inch nuts on No. 3 cylinder |
| Fifth   | - | Tighten 1/2 inch nuts on No. 2 cylinder |
| Sixth   | - | Tighten 1/2 inch nuts on No. 7 cylinder |
| Seventh | - | Tighten 1/2 inch nuts on No. 8 cylinder |
| Eighth  | - | Tighten 1/2 inch nuts on No. 1 cylinder |

3. Check clearance between cylinder base hold-down plates and the cylinder barrel with an 0.010 inch feeler gage. If 0.010 inch clearance is not obtained, loosen the nuts, shift hold-down plates away from the cylinder barrel and repeat steps "1" and "2".

4. Repeat the tightening sequence as previously described, tightening all 3/8 inch nuts to 300 in. lbs. torque and all 1/2 inch nuts to 600 in. lbs. torque. Be certain all nuts are tightened in exact sequence stated.

5. Recheck clearance between hold-down plates and cylinder barrel. If 0.010 inch clearance is not obtained, loosen nuts and repeat steps 1, 2, 3 and 4.

6. During the final tightening procedure, bearing crush or crankcase shift may have occurred, relieving the load on certain of the 1/2 inch stud nuts. Therefore as a final check, repeat step "4" to determine if all 1/2 inch cylinder base nuts are tightened to 600 in. lbs. torque. This may be done by holding the wrench on each nut for about five seconds at 600 in. lbs. If the nut does not turn, it may be presumed to be tightened to the proper torque.

6-92. Apply lock wire as shown in figure 4.

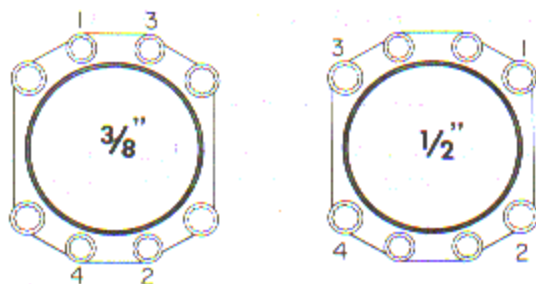


Figure 3. Proper Sequence of Tightening Cylinder Base Nuts



Figure 4. Proper Method of Lock Wiring Cylinder Base Nuts



## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### CAUTION

After all cylinder base nuts have been tightened, remove any nicks in the cylinder fins by filing or burring.

6-93 thru 6-100. Information contained in these paragraphs in basic manual also applies to this IO-720-A1A overhaul supplement with the following exceptions:

1. Paragraph 6-98. IO-720-A1A valve clearance is 0.068 to 0.080 inch.
2. Paragraph 6-98. Later push rod assemblies have Lyc. P/N's etched on rod.
3. Paragraph 6-99. Engine firing order for IO-720-A1A model engines is 1-5-8-3-2-6-7-4.
4. Paragraph 6-100. Torque value for rocker box cover screws is 35 inch pounds torque.

6-101 thru 6-104. The information contained in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement with the following exception:

Paragraph 6-104. Information regarding priming system should be disregarded. Fuel injection lines should be secured to flow divider and nozzles with applicable clamps, clips, etc. as described in Section VIII of this overhaul supplement.

### SECTION VII

#### CRANKCASE, CRANKSHAFT AND RECIPROCATING PARTS

7-1 thru 7-6. Information in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement with the following exception:

Paragraph 7-3. These IO-720-A1A model engines may employ an alternator. The alternator bracket is removed in this case.

Paragraph 7-4. Factory manufactured engines will have a cover assembled over propeller governor drive. The propeller governor is optional equipment on these engines.

#### DISASSEMBLY

7-7 thru 7-8. These paragraphs also apply to this IO-720-A1A model engine overhaul supplement.

7-9. The propeller governor drive is optional on IO-720-A1A model engines.

7-10 thru 7-15. Information contained in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement.

7-16. This paragraph also applies to this IO-720-A1A overhaul supplement except that some front crankshaft oil seals will not have the garter spring.

7-17. This paragraph also applies to this IO-720-A1A overhaul supplement except that flange bushing removal tool must be specified, on order, as Lyc. T/N ST-115 to remove flange bushings from IO-720-A1A model engine crankshafts.

7-18. This paragraph also applies to this IO-720-A1A model engine overhaul supplement.

7-19 thru 7-20. Information in these paragraphs also applies to this IO-720-A1A engine overhaul supplement except that IO-720-A1A engines employ eight sludge tubes in the crankshaft. Use Lyc. T/N ST-116 to replace sludge tubes.

#### CLEANING

7-21. This paragraph and the "Caution" at end of paragraph also apply to this supplement.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### INSPECTION

7-22 thru 7-26. These paragraphs in basic manual also apply to this IO-720-A1A engine overhaul supplement

7-27. Information in this paragraph in basic O-360, O-540 overhaul manual applies to this IO-720-A1A model engine supplement, with the following exceptions:

1. With the crankshaft mounted on numbers 2 and 6 main journals, maximum run-out for No. 1 journal is 0.002 inch.
2. With the crankshaft mounted on numbers 2 and 4 main journals, maximum run-out for No. 3 journal is 0.003 inch.
3. With the crankshaft mounted on numbers 3 and 5 main journals, maximum run-out for No. 4 journal is 0.003 inch.
4. With the crankshaft mounted on numbers 4 and 6 main journals, maximum run-out for No. 5 journal is 0.003 inch.
5. With the crankshaft mounted on numbers 2 and 6 main journals, maximum run-out for numbers 3, 4 and 5 main journals is 0.005 inch.

All other dimensions in paragraph 7-27 in basic O-360, O-650 overhaul manual are also applicable to IO-720-A1A model engine crankshafts.

7-28. This paragraph in basic manual also applies to this IO-720-A1A model engine supplement.

7-29. Disregard this paragraph in basic manual. All counterweight roller bushings in crankshaft lugs **MUST** be replaced at overhaul.

7-30 thru 7-34. Information contained in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement.

### REPAIR AND REPLACEMENT

7-35 thru 7-41. The information contained in these paragraphs of basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement.

### CAUTION

Crankshafts that are reground, must be renitrided. It is recommended that the crankshaft be returned to the factory for renitriding. Also, no attempt should be made to remove oil transfer tubes or the propeller oil tube from the crankshaft. If, for any reason, these tubes must be replaced, the crankshaft should be returned to Lycoming for their removal and replacement.

7-42 thru 7-45. Information contained in these paragraphs in the basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement. However, see figure 5 for applicable flange straightening dimensions.

7-46 thru 7-50. These paragraphs in basic O-360, O-540 overhaul manual also apply to this IO-720-A1A overhaul supplement. However, it is now necessary to replace ALL crankshaft counterweight bushings at overhaul. These bushings are located in the crankshaft lugs.

7-51 thru 7-60. These paragraphs in basic overhaul manual also apply to this IO-720-A1A overhaul supplement.

### REASSEMBLY

7-61 thru 7-65. Information in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement with the following exceptions:

Paragraph 7-62. Use Lycoming T/N ST-116 for sludge tube replacement for IO-720-A1A model engines.

Paragraph 7-63. This paragraph will not apply to IO-720-A1A model engines. However, the note at the end of this paragraph does apply to IO-720-A1A engines.

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

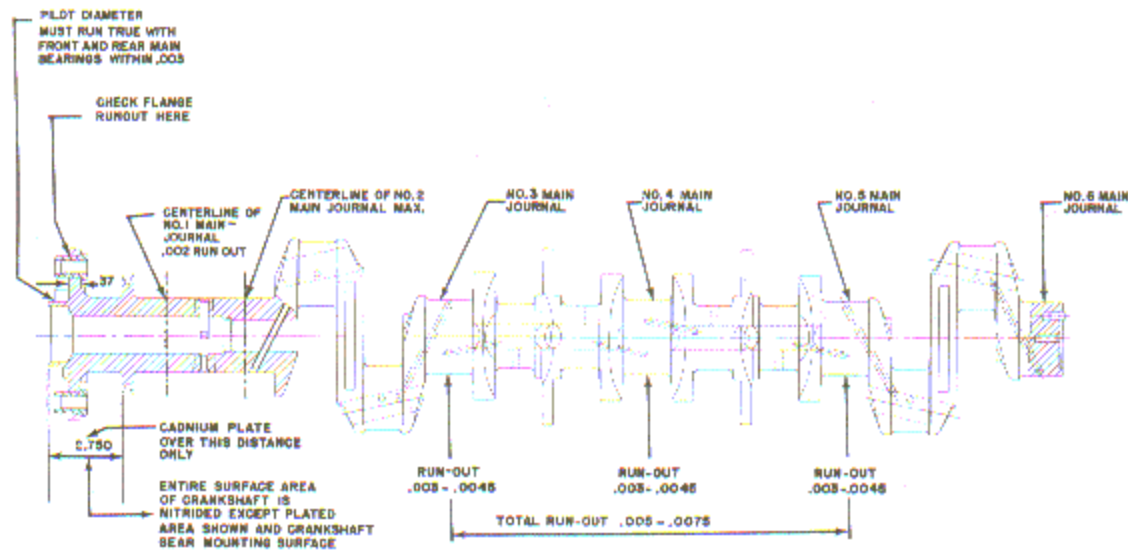


Figure 5. Applicable Flange Straightening Dimensions - IO-720-A1A Crankshaft

Paragraph 7-64. Disregard this paragraph in basic manual.

Paragraph 7-65. Proper tool to replace flange bushings in IO-720-A1A model engine crankshafts in Lycoming T/N ST-115.

7-66 and 7-67. Information in this IO-720-A1A overhaul supplement replaces in their entirety paragraphs 7-66 and 7-67 in basic O-360, O-540 overhaul manual. To replace front crankshaft oil seal at overhaul the following procedures must be accomplished.

1. Inspect crankshaft sealing surfaces for nicks and/or scratches.

CAUTION

Use extreme caution not to scratch the crankshaft sealing surface. Any nicks or scratches in this area will allow seal to leak. To remove any nicks or scratches from the crankshaft journal, the crankshaft must be removed from the engine and polished on a lathe. The crankshaft must be kept turning during this operation as no longitudinal lines are permitted.

2. Clean oil seal recess in crankcase and the crankshaft sealing surfaces of all foreign matter.

NOTE

Should deposits of cement remain in the crankcase seal recess, or on the crankshaft sealing surface, following degreasing, methylethylketone or equivalent applied with a swab will remove these deposits.

3. When the crankshaft oil seal employing a garter spring is used, place the spring around the crankshaft, bringing the two ends together, and insert the pointed end of the spring firmly inside the open end, and turn in a clockwise direction to tighten. Make certain that the pointed end is firmly inside the coils of the open end. The spring should now be a continuous circle around the crankshaft with no kinks or twists. (If the seal being employed does not have a garter spring, this step is not required.)
4. Apply a thin film of Lubriko M-6 grease, or equivalent, on the sealing surface of the seal and around the crankshaft at the sealing surface. This step is applicable to seals with or without garter spring.
5. Apply a fairly liberal film of Lubriko M-6 grease between the split in the seal. This step is applicable to seals with or without garter spring.
6. Slip the seal around the crankshaft ahead of the spring. The sealing lip of the seal should be toward the crankcase recess. If the seal employs a garter spring, work the spring into position in the groove provided in the rear side of the seal.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### NOTE

Assembly will be easier if the seal is slipped on the crankshaft before placing crankshaft in crankcase.

7. Using a cloth dipped in a grease solvent (alcohol, gasoline, etc.), clean any residual grease film from the outside diameter of the seal, and the entire circumference of oil seal recess in the crankcase. It has been found that treatment of this sort will permit the cement to adhere to the seal and crankcase with greater tenacity. This step is of the utmost importance for proper seal installation. Now place Goodyear Pliobond #20 Cement (or equivalent) in the seal recess of BOTH crankcase halves.

8. Place the crankshaft in the left crankcase half with the seal in its recess so the split will be at the one o'clock position. Now install right crankcase half in place. Work the seal for final seating by using both hands, starting opposite the gap and working towards gap. See Lycoming Service Instruction No. 1010B for views of seal installation.

7-68 thru 7-70 Information contained in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement with the following exceptions:

1. Paragraph 7-69. Use Lycoming T/N ST-116 for sludge tube installation.
2. Paragraph 7-70. There are no available oversize counterweight washers on IO-720-A1A model engines.
3. Paragraph 7-70. Counterweight installation is performed the same way as described in basic O-360, O-540 overhaul manual however different order counterweights are employed. Following is installation order for crankshaft counterweights on IO-720-A1A model engines;
  - a. The front two crankshaft lugs have two fourth order counterweights and rollers installed.
  - b. Second set of lugs employ one fourth order and one three and one half order counterweight and roller assemblies.
  - c. Third set of lugs (from front of crankshaft) employ one fourth order and one fifth order counterweight and roller assemblies.
  - d. The fourth set of crankshaft lugs (from front of crankshaft) employ two fourth order counterweight and roller combinations.
4. Disregard "NOTE" at end of paragraph 7-70 in basic manual.

7-71. This paragraph also applies to this IO-720-A1A overhaul supplement.

7-72 thru 7-77. Information contained in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement.

7-78. Information in this supplement supersedes in its entirety paragraph 7-78 of the basic manual. The method of installing connecting rod bolts and nuts for IO-720-A1A model engines is as follows:

1. A new simplified bolt and nut combination that provides a positive means of locking at any degree of nut rotation has been designed for connecting rod application in Lycoming aircraft engines.
2. The new connecting rod bolt shown in Lycoming Service Instruction No. 1106 is characterized by flat areas formed at the threaded end. After the nut has been tightened, these flats serve as a lock when the top integral sleeve of the nut is crimped or pressed against them.
3. The procedure for tightening the new nuts is the same as for conventional nuts except in place of using cotter or roll pins for safety purposes, simply crimp the sleeve section of the nut against the flats on the end of the bolt.
4. Although any heavy pliers may be used to crimp the sleeve of the nut to the flats of the bolt, a good tight crimp is difficult to achieve with a conventional pivot action tool. Also, the wall section of the nut is apt to rupture if the jaws of the tool do not press evenly. A modified 8-1/2 inch "Pliewrench" is quite satisfactory for crimping the nut. This tool is available from Lycoming under Lycoming T/N ST-78
5. Special tools are not required for removal of crimp lock nuts. Usually a force on the wrench sufficient to loosen the nut is enough to open the crimped wall and permit removal. Crimped nuts and connecting rod bolts should not be reused.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

### NOTE

Tightening torque limits and stretch limits have not been changed.

7-79 thru 7-82. Information contained in these paragraphs of the basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement.

7-83 thru 7-87. Information in these paragraphs of basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement with the following exceptions:

Paragraph 7-85. Use Texaco Molytex "O" or equivalent to pre-lubricate the cam face of the hydraulic tappet body.

Paragraph 7-86. Pre-lubricate the cam lobes and bearing surfaces of the camshaft with Texaco Molytex "O" or equivalent.

Paragraph 7-87. Bear in mind that the IO-720-A1A model engine being an eight cylinder engine, there are eight connecting rods employed.

7-88. Information in this paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement. See figure 7-14 in basic manual for end clearance grinding if required.

7-89. This paragraph in basic manual also applies to this overhaul supplement.

7-90 and 7-91. These paragraphs and the "NOTE" at end of paragraph 7-91 in basic O-360, O-540 overhaul manual also will apply to this IO-720-A1A overhaul supplement.

7-91A. After crankshaft, crankshaft seal, etc. have been assembled, and the crankcase halves properly fastened, install one half of the crankshaft oil seal retaining plate, Lyc. P/N 74113, by placing in position and securing three (3) Lyc. P/N STD-1919 hex head screws and three (3) STD-160 lock washers with internal teeth. Then place the remaining half of the crankshaft oil seal retaining plate in position, and secure in the same manner as described for the first half.

7-92 thru 7-96. Information in these paragraphs in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A overhaul supplement with the following exceptions:

1. Paragraph 7-92. Lifting straps for IO-720-A1A model engines are installed on fourth crankcase fastening from the rear of the engine and the fourth crankcase fastening from the front of the engine.

2. Paragraph 7-93. Two mounting brackets are involved if the particular engine employs a generator. If the engine employs an alternator, only one mounting bracket is necessary.

3. Paragraph 7-93. If the particular engine employs an alternator the following parts are assembled on the unused generator pad:

a. Install lock plate, Lycoming P/N 73383, with a 5/16 inch x 1 inch spacing bolt.

b. Secure lock plate with two (2) 5/16 inch -18 x 1 inch long bolts, Lycoming P/N STD-1902.

c. Assemble oil seal ring, Lycoming P/N STD-1002, on each bolt described above, along with Lycoming P/N STD-1727 plain washers.

4. Paragraph 7-94. This paragraph is not applicable when an alternator is employed.

5. Paragraph 7-95. Disregard all information which applies to O-360 engines.

6. Paragraph 7-96. When an alternator is employed on a particular engine, a fan and baffle assembly must also be installed. Parts involved in this assembly are one (1) pulley, alternator Lycoming P/N 74863 and one (1) fan and baffle assembly, Lycoming P/N 74878. Also include in this system a 12 volt voltage regulator Lycoming P/N 74291 and an over voltage relay, 12 volt, Lycoming P/N 74661.

7-97. Pay particular attention the the "NOTE" at the end of this paragraph in basic O-360, O-540 overhaul manual, as the IO-720-A1A model engines do employ dynafocal mounts.

7-98. See figure 6 for the proper sequence of tightening the peripheral crankcase fastenings for IO-720-A1A model engines.

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

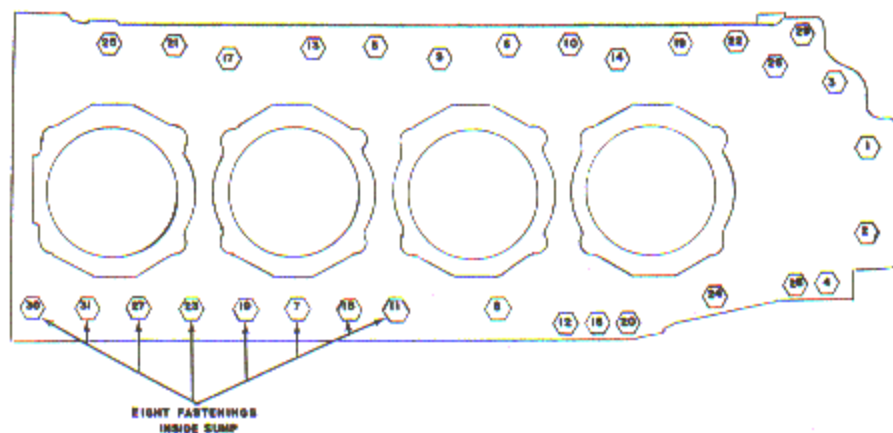


Figure 6. Proper Peripheral Crankcase Fastening, Tightening Recommendations

7-99 and 7-100. Information contained in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement. The "NOTE" at the end of paragraph 7-100 is also applicable to IO-720-A1A model engines.

7-101 to 7-103. Disregard these paragraphs in basic O-360, O-540 overhaul manual.

7-104 thru 7-107. These paragraphs in basic O-360, O-540 overhaul manual will apply to this IO-720-A1A model engine overhaul supplement. Check that backlash between camshaft gear and crankshaft idler gear should not be less than 0.004 inch nor more than 0.020 inch. The same is true for the backlash between the crankshaft idler gear and crankshaft gear, and the crankshaft idler gear and magneto gear.

7-108. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A engine overhaul supplement.

7-109. Disregard this paragraph in basic manual.

7-110. The oil level gage tube on IO-720-A1A model engines is assembled on the right hand side of crankcase (standing at rear of engine looking forward) between cylinders numbers 5 and 7.

7-111 thru 7-113. Information pertaining to generator listed in these paragraphs in basic O-360, O-540 overhaul manual will also apply to IO-720-A1A model engines. However, see paragraphs 7-92 thru 7-96 of this overhaul supplement for installation of alternator and accessories.

7-114. This paragraph in basic O-360, O-540 overhaul manual also applies to this supplement.

7-115. Disregard this paragraph in basic O-360, O-540 overhaul manual.

SECTION VIII

OIL SUMP AND INDUCTION SYSTEM

This section of this IO-720-A1A overhaul supplement will replace in its entirety Section VIII of the basic O-360, O-540 overhaul manual. Paragraphs in this supplement for Section VIII, will therefore be in numerical order and will be preceded by paragraph titles. Section VIII of this overhaul supplement will be divided into two parts: Part I will describe overhaul procedures to the sump. Part II will describe overhaul procedures to the induction system.

PART I

DISASSEMBLY

8-1. INTAKE PIPE REMOVAL. When the intake pipes are removed from engine, it would be well to mark the pipes so that they may be reassembled in the exact place of removal. These pipes are matched in length and diameter for engine tuned induction, and therefore should be replaced at location of removal.

8-2. SUMP DISASSEMBLY. Remove the sump from the engine following the removal of the cylinders as described in Section VI of this overhaul supplement. Remove the fuel injector throttle body. Then remove the 1/4 inch bolts and nuts from the periphery of the sump. Remove sump and discard the gasket.

8-3. No further disassembly of the sump is required beyond the removal of any loose or damaged studs or intake pipe connections.

CLEANING

8-4. Clean the sump in accordance with Section III of the basic O-360, O-540 overhaul manual.

INSPECTION

8-5. Inspect the sump in accordance with Section III of basic O-360, O-540 overhaul manual.

REPAIR AND REPLACEMENT

8-6. Repair and/or replace any damaged parts of the sump assembly in accordance with instructions listed in Section III of the basic O-360, O-540 overhaul manual. In the event any of the intake pipe connections are loose or damaged, remove the defective connection by collapsing it with a suitable tool and install a new connection.

REASSEMBLY

8-7. Check the basic O-360, O-540 overhaul manual for full description of sump reassembly. Disregard any information pertaining to a carburetor in basic manual.

PART II

INDUCTION SYSTEM

CLEANING

8-8. AIR FLOW SECTION. The fuel injector assembly should be inspected and the fuel inlet screen or strainer should be removed and cleaned. Clean the strainer in unleaded gasoline, or Varsol cleaning fluid. Damaged strainer "O" rings should be replaced at this time. Install fuel strainer, and secure with lock wire.

INSPECTION

8-9. FUEL METERING SECTION. The fuel injector should be checked, in conjunction with all injector fuel lines for evidences of fuel leakage.

8-10. Check tightness and lock wiring of all nuts and screws which fasten injector to the engine. Check all fuel lines for tightness and evidence of leakage. A slight fuel stain adjacent to the air bleed nozzles is not cause for concern. Check the throttle and mixture control rods and levers for tightness and lock wiring.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

8-11. FIELD ADJUSTMENTS. The idle speed and mixture adjustment is accomplished as follows:

1. Check magnetos for "mag drop". If "mag drop" is normal, proceed with idle adjustment. Close throttle to idle (approximately 650 RPM). If the RPM changes appreciably after making idle mixture adjustment during the succeeding steps, readjust the idle speed to desired RPM.
2. When the idling speed has been stabilized, move cockpit mixture control lever with a smooth, steady pull, into the idle-cut-off position and observe the tachometer for any change during leaning out process. Caution must be exercised to return the mixture control to the full-rich position before the RPM can drop to a point where the engine cuts out. An increase in RPM while leaning out indicates the idle mixture is too rich. An immediate decrease in RPM (if not preceded by a momentary increase) indicates that the idle mixture is too lean.
3. The typical idle setting should fall between a setting that is rich enough to provide satisfactory acceleration under all conditions and lean enough to prevent spark fouling and/or rough operation. A rise of 25 - 50 RPM will usually satisfy both of these conditions.
4. If step "2" indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjusting mechanism one or two notches in the direction required for correction, and check the new position exactly as in step "2". Make any additional adjustments necessary.
5. Each time an adjustment is changed, clear engine by running it up to approximately 2000 RPM before making mixture check.

8-12. IDLE MIXTURE ADJUSTMENT. The idle mixture adjustment for Bendix RSA-10AD1 fuel injection system as installed on IO-720-A1A model engines, is performed as follows:

1. The actual idle mixture adjustment is made by lengthening (more rich) or shortening (more lean) of the linkage between the throttle lever and idle valve lever. The center screw assembly has right hand threads on both ends but one end has a 10-24 thread and the other a 10-32 thread. For easy reference, consider only the coarse thread end. When it is turned out of its block, the linkage is shortened and a leaner mixture provided.
2. A major adjustment is provided when the center screw bottoms out on either of the blocks. If the idle adjustment is nearly satisfactory, measure the distance between the two blocks. Disconnect the spring from the most accessible linkage pin and remove the pin. Turn the block and the adjustment screw until the adjusting wheel is centered and the distance between blocks is the same as previously measured. There is now additional adjustment range and the reference point is retained.
3. Make the final idle speed adjustment to obtain the desired idling RPM with a closed throttle.
4. If the setting does not remain stable, check the idle linkage. Any looseness in this linkage will cause erratic idling. In all cases, allowance should be made for the effect of weather conditions upon idling adjustments. The relationship of the aircraft to the direction of prevailing wind will have an effect on the propeller load and its RPM, hence, it is desirable to make the idle setting with aircraft cross wind.
5. Idle speed and mixture adjustments made according to this method should require very little further attention except for extreme variations in temperature and altitude.

8-13. AIR BLEED NOZZLES. If an air bleed nozzle is suspected of being dirty, remove the nozzle and submerge in cleaning solvent (Stoddard Solvent, methyl ethyl ketone or equivalent). Remove nozzle from solvent, and dry with clean, dry compressed air. Under normal conditions the shield and screen are not removed from the nozzle assembly. However, if they are removed, the shield and screen must be thoroughly cleaned prior to reassembly and the shield must have a tight fit on body when reinstalled.

### CAUTION

At no time is it permissible to use a sharp tool such as wire to clean out an air bleed nozzle.

### REASSEMBLY

8-14. The fuel injector is mounted on the engine intake riser at the front of the sump (standing at rear of engine looking forward toward propeller end).

8-15. The flow divider is mounted in the center, on the top of the crankcase between numbers 5 and 6 peripheral fastenings of the crankcase (viewed standing at rear of engine looking forward to the propeller end).



## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

- 8-16. Air bleed nozzles are installed in 1/2 inch pipe threaded ports at the top of each cylinder. Since they are mounted at the top of the cylinder, it is not necessary to locate the identification mark 180° from air bleed hole.
- 8-17. A flexible hose is used from engine driven fuel pump to the injector fuel inlet. Check applicable manufacturer's publications for size of this line.
- 8-18. In most installations a No. 4 flexible hose is used from the injector outlet to the flow divider. Later model injectors have an alternate fuel outlet 180° from the standard outlet. Either can be used.
- 8-19. A 1/8 inch OD stainless steel tube is routed from a restricted fitting on the flow divider to the fire wall. A number 3 low pressure hose is used from fire wall to gage. Hose volume should be held to a minimum.
- 8-20. Nozzle lines are made from 0.085 - 0.090 inch ID x 1/8 inch OD stainless steel tubing, with fittings to connect to the top of the nozzle and to the flow divider. Lines are clamped at suitable locations to minimize vibration.

### LUBRICATION

- 8-21. There is very little need for lubrication of the injector. However, the clevis pins used in connection with the throttle and manual mixture control levers should be checked for freedom of movement, and lubricated with a drop of engine oil. Place a drop of engine oil on the end of the throttle shaft in such a manner that it can work into the throttle shaft bushings.

## SECTION IX

### TEST PROCEDURE

- 9-1. This paragraph in basic O-360, O-540 overhaul manual applies to this IO-720-A1A overhaul supplement.
- 9-2 thru 9-3. These paragraphs in basic O-360, O-540 overhaul manual also apply to this IO-720-A1A overhaul supplement with the following addition:
- Paragraph 9-3. Cooling shroud for IO-720-A1A model engines should be ordered under Lycoming T/N ST-114.
- 9-4. Lubricating oil for test run-in shall be Lycoming Specification 138 (Sohio, or equivalent) for IO-720-A1A model engines. Should preparation for storage be indicated, at this time, the following preservative oils, or equivalents should be used: Standard Oil's "Rust-Ban 622" or Socony Vacuum's "Avrex 901".
- 9-5. This paragraph in basic O-360, O-540 overhaul manual also applies to this IO-720-A1A supplement.
- 9-6. Disregard this paragraph in basic O-360, O-540 overhaul manual. Bendix RSA-10AD1 fuel injectors require no pre-service maintenance except that all preservative oil must be purged from the system. To accomplish this, turn on fuel boost pump, filling system with fuel. This operation will also purge lines of air. When hissing stops at the air bleed nozzle set mixture control at idle-cut-off. To make sure preservative oil has been purged disconnect fuel nozzle on the throttle body and examine fuel for oil, continue purge until all fuel flowing from nozzle hole is free of oil.
- 9-7. Minimum operating fuel pressure is 12 psi. Maximum operating fuel pressure is 40 psi for IO-720-A1A model engines.
- 9-8 thru 9-12. Information contained in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement with the following exceptions:
- Paragraph 9-11. Oil temperature should be maintained between 160° and 245° F.  
Maximum oil temperature of 245° F., the maximum oil pressure of 90 psi and the maximum cylinder head temperature of 475° F. should not be exceeded. If an alternator is employed, the following temperature at the alternator should not be exceeded: 160° F.
- 9-13. The oil consumption on an overhauled engine with new rings installed, should not exceed 0.012 lbs./bhp/hr. on IO-720-A1A model engines.

## LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

9-14. Information contained in this paragraph and the "NOTE" at the end of the paragraph in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement.

### RUN IN TEST SCHEDULE

#### IO-720-A1A MODEL ENGINES

| RPM or Air<br>Flow-lbs./hr. | Entrance Pressure<br>Inches Hg. | Time<br>Minutes |                            |
|-----------------------------|---------------------------------|-----------------|----------------------------|
| 1. 1200 RPM                 | Ambient                         | 5               |                            |
| 2. 1400 RPM                 | Ambient                         | 5               |                            |
| 3. 600 (Air Flow)           | 28.5                            | 5               | Bleed Nozzle Pressure Line |
| 4. 1000 (Air Flow)          | 28.5                            | 10              | Check Magneto Drop-off     |
| 5. 1400 (Air Flow)          | 28.5                            | 5               |                            |
| 6. 1800 (Air Flow)          | 28.5                            | 5               |                            |
| 7. 2200 (Air Flow)          | 28.5                            | 5               |                            |
| 8. Full Throttle            | 28.5                            | 15              | Rated Speed $\pm$ 50 RPM   |
| 9. Full Throttle            | 28.5                            | 30-60           | Oil Consumption Run        |

#### NOTE

Idle adjustment of injector must be made prior to start of above run-in schedule and, if necessary, again at completion of test.

9-15 thru 9-17. Information contained in these paragraphs in basic manual also applies to this supplement.

9-18 and 9-19. Information in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A model engine overhaul supplement with the following exceptions: Use the following parts in addition to those listed in basic manual.

1. Lycoming P/N 61545 - Cap, Tachometer Drive
2. Lycoming P/N 74156 - Cover, Exhaust port seal
3. Use 2.00 wide moisture proof tape at throttle body inlet.
4. Lycoming P/N 61596 - Cap, Sealing for generator blast tube
5. Lycoming P/N 73711 - Cap, Sealing for Breather fitting
6. Lycoming P/N 62744 - Plug, Thermometer well (for temperature gage connection hole)
7. Lycoming P/N STD 1848 - Plug, To be assembled in oil cooler inlet and outlet bosses

9-20 and 9-21. Information in these paragraphs in basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A overhaul supplement.

9-22 thru 9-24. These paragraphs in basic manual may be disregarded, and the following procedures employed to provide adequate preservation to Bendix RSA-10AD1 fuel injectors:

1. Any unit taken out of service, or units being returned for overhaul must be flushed with Esso Turbo 1010 oil using the following procedure.
  - a. Remove plugs and drain all fuel from the injector. If available apply 10 to 15 psi air pressure to the fuel inlet, until all fuel is discharged from the injector.
  - b. Replace plugs and apply flushing oil filtered through a 10 micron filter at 13 to 15 psi to the injector fuel inlet until oil is discharged from the outlet.
  - c. Replace fuel inlet shipping plug.

#### CAUTION

At no time should the pressures listed in steps "a" and "b" above be exceeded. To do so would promote internal damage to the injector.

- d. After filling with preservative oil the injector should be protected from dust and dirt, and given such protection against moisture as climatic conditions at the point of storage require. In most cases, storing the unit in a dry area will be sufficient.

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e. If the unit is to be stored near or shipped over salt water, observe the following precautions:

(1) Spray exterior of the injector with an approved preservative oil.

(2) Pack in a dust proof container, wrap container with moisture proof, and vapor proof material. Then seal and wrap the packaged unit in a suitable shipping case. Pack a one-half pound bag of silica-gel crystals in the dust proof container with the injector. The bag must not touch the injector.

CAUTION

Extreme caution should be exercised when handling or working around the injector to prevent oil or fuel from entering the air sections of the injector. As explained previously, damage to the air diaphragm will result. Fluid can easily enter the air section of the injector through impact tubes or the annular groove around the venturi. For this reason, a protective plate should be installed on the scoop mounting flange when performing routine maintenance on the engine, such as washing down the engine and air scoop, servicing the air filter (surplus oil on the element) or when injecting preservative into the engine prior to storing or shipping.

9-25 thru 9-27. These paragraphs in the basic O-360, O-540 overhaul manual will also apply to this IO-720-A1A model engine overhaul supplement.

GENERAL SPECIFICATIONS

(IO-720-A1A Model Engine)

|   |                    |
|---|--------------------|
| Type Certificate (FAA)                          | 1E15               |
| Rated Horsepower @ RPM and BSFC                 | 400 @ 2650 and .50 |
| Performance Cruise (75% Rated)                  | .300 @ 2400        |
| Economy Cruise (60% Rated)                      | .240 @ 2200        |
| Fuel Consumption, Cruise, GPH @ 75% Rated Power | 23.3               |
| 65% Rated Power                                 | 17.5               |
| 60% Rated Power                                 | 16.0               |
| Propeller Drive Ratio                           | 1:1                |
| Propeller Shaft Rotation                        | Clockwise          |
| Bore, Inches                                    | 5.125              |
| Stroke, Inches                                  | 4.375              |
| Displacement, Cubic Inches                      | 722.0              |
| Compression Ratio                               | 8.7:1              |
| Weight, lbs. (without installation parts)       | 600                |
| Dimensions: Height, Inches                      | 22.53              |
| Width, Inches                                   | 34.25              |
| Length, Inches                                  | 46.08              |
| Oil, SAE Number, Above 60° F.                   | 50                 |
| 30° to 90° F.                                   | 40                 |
| 0° to 70° F.                                    | 30                 |
| Below 10° F.                                    | 20                 |
| Oil Sump Capacity, Quarts.                      | 17                 |
| Fuel, Aviation Grade, Minimum Octane            | 100/130            |
| Fuel Injector, Bendix                           | RSA-10AD1          |
| Magnetos (1) Scintilla (Left)                   | S8LN-701           |
| (1) Scintilla (Right)                           | S8LN-705           |
| Valve Rocker Clearance                          | .028 - .080        |
| Spark Occurs - Degrees BTC                      | 20°                |
| Spark Plug Gap Shielded Fine Wire               | .015 - .018        |
| Massive Electrode                               | .018 - .022        |
| Firing Order                                    | 1-5-8-3-2-6-7-4    |

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| Accessory           | Type of Drive | Direction of Rotation | Drive Ratio |
|---------------------|---------------|-----------------------|-------------|
| Starter             | SAE (Auto.)   | Counter-Clockwise     | 13.566:1    |
| Generator           | SAE (Auto.)   | Clockwise             | 2.500:1     |
| *Vacuum Pump        | AND 20000     | Counter-Clockwise     | 1.300:1     |
| *Hydraulic Pump     | AND 20000     | Clockwise             | 1.300:1     |
| Tachometer          | SAE           | Clockwise             | .500:1      |
| *Propeller Governor | AND 20010     | Clockwise             | .895:1      |
| Fuel Pump           | AND 20003     | Counter-Clockwise     | 1.000:1     |

\* Optional Equipment

DETAIL WEIGHTS - POUNDS

|   |  |        |
|---|--|--------|
| 1. ENGINE (STANDARD)  |  |        |
| Basic Engine, Lycoming IO-720-A1A . . . . .                           |  | 509.42 |
| Ignition System   |  |        |
| S8LN-701 and S8LN-705 Magnetos, Coil and Harness . . . . .            |  | 17.50  |
| Spark Plugs, Shielded . . . . .                                       |  | 5.07   |
| Fuel Injection System   |  |        |
| Fuel Injector, Bendix RSA-10AD1 . . . . .                             |  | 8.50   |
| Fuel Pump Drive, AN . . . . .   |  | 1.75   |
| Fuel Pump, RG 17980 . . . . .   |  | 1.25   |
| Tachometer Drive . . . . .  |  | 0.08   |
| Starter and Alternator or Generator Drive . . . . .                   |  | 6.53   |
| Starter, 3.00:1, Geared, Delco-Remy with Bendix Unit . . . . .        |  | 35.00  |
| Alternator, Delco-Remy, 12 V., 70 A., with Mounting Bracket . . . . . |  | 12.60  |
| Intercylinder Cooling Baffles . . . . .                               |  | 2.30   |

STANDARD ENGINE DRY WEIGHT . . . . . 600.00

|  |  |      |
|--|--|------|
| 2. ENGINE INSTALLATION PARTS (STANDARD)                            |  |      |
| Continuous Field Relay, 12 V. . . . .                              |  | .31  |
| Starter Switch, Magnetic, Delco-Remy . . . . .                     |  | 1.16 |
| Transistor Voltage Regulator, Alternator, Delco-Remy 12 V. . . . . |  | 1.50 |

WEIGHT OF INSTALLATION PARTS . . . . . 2.97

|  |  |       |
|--|--|-------|
| 3. ACCESSORIES, DRIVES AND PARTS (OPTIONAL)                  |  |       |
| Vacuum Pump Drive . . . . .                                  |  | 1.01  |
| Hydraulic Pump Drive . . . . .                               |  | 1.50  |
| AN Propeller Governor Drive . . . . .                        |  | 1.50  |
| Alternator, Delco-Remy, 24 V., 50 A., with Bracket . . . . . |  | 12.60 |
| Alternator, Delco-Remy, 24 V., 72 A., with Bracket . . . . . |  | 23.00 |
| Transistor Voltage Regulator 24 V. . . . .                   |  | 1.50  |
| Continuous Field Relay 24 V. . . . .                         |  | .31   |
| Generator, Delco-Remy, 12 V., 20 A., with Bracket. . . . .   |  | 11.18 |
| 12 V., 35 A., with Bracket. . . . .                          |  | 16.60 |
| 12 V., 50 A., with Bracket. . . . .                          |  | 16.60 |
| 24 V., 15 A., with Bracket. . . . .                          |  | 16.60 |
| 24 V., 25 A., with Bracket. . . . .                          |  | 20.75 |
| 24 V., 40 A., with Bracket. . . . .                          |  | 25.00 |
| 24 V., 50 A., with Bracket. . . . .                          |  | 25.00 |
| Voltage Regulator, Generator, Delco-Remy . . . . .           |  | 1.68  |
| Starter, Delco-Remy, 24 V. . . . .                           |  | 20.50 |
| Exhaust Flanges . . . . .                                    |  | .99   |
| Cylinder Base Thermocouples . . . . .                        |  | .16   |
| Cylinder Head Thermocouples, Bayonet Type . . . . .          |  | .59   |
| Dynafoal Mounting Brackets . . . . .                         |  | 4.47  |
| Extended Oil Filler, Long, Added Weight. . . . .             |  | .65   |
| Extended Oil Filler, Short, Added Weight. . . . .            |  | .21   |

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

SECTION X

TABLE OF LIMITS

10-1 and 10-2. These paragraphs in basic O-360, O-540 overhaul manual also apply to this IO-720-A1A overhaul supplement.

| Ref. No. | Nomenclature   | Mfg. Min.                          | Mfg. Max. | Max. Ser. Allow. |
|----------|--|------------------------------------|-----------|------------------|
| 501      | Main bearing and crankshaft  | .0015L                             | .0036L    | .0055L           |
|          | Main bearing - front and crankshaft                                | .0025L                             | .0050L    | .007L            |
|          | Diameter of main bearing journal on crankshaft                     | 2.625                              | 2.626     | (E)              |
|          | Diameter of front main bearing journal on crankshaft               | 2.6255                             | 2.6260    | (E)              |
| 502      | Connecting rod bearings and crankshaft                             | .0008L                             | .0033L    | .0050L           |
|          | Diameter of connecting rod journal on crankshaft                   | 2.249                              | 2.250     | (E)              |
| 504      | Crankshaft timing gear and crankshaft                              | .001L                              | .001T     | (A)              |
| 510      | Connecting rod and connecting rod bushing                          | Bushing must be burnished in place |           |                  |
|          | Finished ID of connecting rod bushing                              | 1.1254                             | 1.1259    |                  |
| 511      | Connecting rod bushing and piston pin                              | .0008L                             | .0016L    | .003L            |
| 512      | Piston pin and piston  | .0003L                             | .0009L    | .003L            |
|          | Diameter piston pin hole in piston                                 | 1.1249                             | 1.1252    |                  |
|          | Diameter piston pin  | 1.1243                             | 1.1246    |                  |
| 513      | Piston and piston pin plug (nitrided cylinder)                     | .0009L                             | .0022L    | .004L            |
|          | OD piston pin plug (nitrided cylinder)                             | 1.123                              | 1.124     |                  |
| 514      | Piston ring and piston - side clearance (top ring compression)     | .0015L(B)                          | .0055L(B) | .008L(B)         |
| 515      | Piston ring and piston - side clearance (2nd ring compression)     | .000(B)                            | .004L(B)  | .006L(B)         |
|          | Piston ring and piston - side clearance (3rd ring compression)     | .000(B)                            | .004L(B)  | .006L(B)         |
| 516      | Piston ring and piston - side clearance (oil control ring)         | .002L(B)                           | .004L(B)  | .006L(B)         |
| 519      | Piston skirt and cylinder - forged type piston - nitrided cylinder | .0070L                             | .0095L    | .017L            |
|          | Piston diameter at bottom - forged type piston                     | 5.1165(D)                          | 5.1175(D) |                  |
|          | Piston diameter at top - forged type piston                        | 5.0816                             | 5.0846    |                  |
| 520      | Cylinder - maximum taper - nitrided                                |                                    |           | .004             |
| 521      | Cylinder - maximum out-of-round - nitrided                         |                                    |           | .004             |
| 522      | Cylinder bore diameter - nitrided                                  | 5.1245                             | 5.1260    | 5.1295           |
| 523      | Exhaust valve seat and cylinder head                               | .008T                              | .011T     | (A)              |
|          | OD exhaust seat  | 1.936                              | 1.937     |                  |
|          | ID exhaust seat hole in cylinder head                              | 1.926                              | 1.928     |                  |
| 524      | Intake valve seat and cylinder head                                | .007T                              | .010T     | (A)              |
|          | OD intake seat   | 2.289                              | 2.290     |                  |
|          | ID intake seat hole in cylinder head                               | 2.280                              | 2.282     |                  |
| 526      | Exhaust valve guide and cylinder head                              | .001T                              | .0025T    | (A)              |
| 527      | Intake valve guide and cylinder head                               | .001T                              | .0025T    | (A)              |
|          | Finished ID intake valve guides                                    | .4040                              | .4050     |                  |
|          | Finished ID exhaust valve guides - rotator type                    | .4985                              | .4995     |                  |
|          | OD valve guides (intake only)                                      | .5933                              | .5938     |                  |
|          | OD exhaust valve guide   | .6633                              | .6638     |                  |
|          | ID valve guide hole in cylinder head (intake only)                 | .5913                              | .5923     |                  |
|          | ID exhaust valve guide hole in cylinder head                       | .6613                              | .6623     |                  |
| 528      | Exhaust valve stem and valve guide                                 | .0020L                             | .0035L    | (A)              |
|          | OD valve stem - exhaust, rotator type                              | .4960                              | .4965     |                  |
| 529      | Intake valve stem and valve guide                                  | .0010L                             | .0025L    | .006L            |
|          | OD valve stem - intake   | .4025                              | .4030     |                  |
| 531      | Valve rocker shaft and valve rocker bushings                       | .0007L                             | .0017L    | .004L            |
|          | OD valve rocker shaft  | .6243                              | .6245     |                  |
| 532      | Valve rocker bushing and valve rocker                              | Bushing must be burnished in place |           |                  |
| 533      | Valve rocker and cylinder head - side clearance                    | .002L                              | .020L     | .024L            |
| 536      | Tappet body and crankcase  | .0010L                             | .0025L    | .004L            |
|          | OD of tappet body  | .7172                              | .7177     |                  |
|          | ID tappet bore in crankcase  | .7187                              | .7197     |                  |
| 537      | Camshaft and crankcase   | .002L                              | .004L     | .006L            |

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

| Ref. No. | Nomenclature  | Mfg. Min. | Mfg. Max. | Max. Ser. Allow.         |
|----------|---|-----------|-----------|--------------------------|
| 538      | Camshaft end clearance  | .002L     | .009L     | .015L                    |
| 539      | Camshaft run-out at center bearing journals   | .000      | .001      | .006                     |
| 540      | Tachometer drive shaft and accessory housing  | .0015L    | .0035L    | .006L                    |
| 542      | Oil pump impeller - diameter clearance  | .002L     | .006L     | .008L                    |
| 543      | Oil pump impellers - side clearance   | .002L     | .004L     | .005L                    |
|          | Width of oil pump impellers   | .996      | .997      |                          |
| 544      | Oil pump driven impellers and idler shaft   | .0010L    | .0025L    | .004L                    |
| 545      | Oil pump drive shaft and oil pump cover   | .0015L    | .0030L    | .004L                    |
| 553      | Oil pump impellers - backlash   | .008      | .015      | .020                     |
| 556      | With crankshaft mounted on 2 and 6 main journals, maximum run-out for No. 1 journal                 |           | .002      | .002                     |
|          | With crankshaft mounted on 2 and 4 main journals, maximum run-out for No. 3 journal                 |           | .003      | .0045                    |
|          | With crankshaft mounted on 3 and 5 main journals, maximum run-out for No. 4 journal                 |           | .003      | .0045                    |
|          | With crankshaft mounted on 4 and 6 main journals, maximum run-out for No. 5 journal                 |           | .003      | .0045                    |
|          | With crankshaft mounted on 2 and 6 main journals, maximum run-out for Nos. 3, 4 and 5 main journals |           | .005      | .0075                    |
| 558      | Oil pump idler shaft and oil pump cover or body   | .0000     | .015T     | (A)                      |
| 559      | Hydraulic tappet plunger assembly - tappet body (chilled)   | .0010L    | .0047L    | .0067L                   |
| 560      | Hydraulic tappet socket and tappet body (chilled)   | .002L     | .005L     | .007L                    |
| 563      | Crankcase main bearing bore alignment with front and rear bearings                                  |           |           | .003                     |
| 564      | Connecting rod - side clearance   | .004L     | .010L     | .016L                    |
| 566      | Connecting rod alignment  |           |           | .010 in. in<br>10 inches |
| 567      | Connecting rod twist  |           |           | .012 in. in<br>10 inches |
| 568      | Crankshaft and crankcase front end clearance  | .0075L    | .016L     | .026L                    |
| 578      | Counterweight bushing and crankshaft  | .0013T    | .0026T    | (A)                      |
| 579      | Counterweight roller - end clearance  | .004      | .034      | .038                     |
| 580      | Counterweight and crankshaft - side clearance   | .003      | .013      | .017                     |
| 590      | Vacuum pump gear - end clearance  | .000      | .067L     | .075L                    |
| 601      | Oil pump drive shaft and accessory housing  | .0015L    | .0030L    | .006L                    |
| 602      | Oil pump idler shaft and accessory housing  | .0005L    | .0020L    | .003L                    |
| 607      | Crankshaft propeller flange run-out   |           |           | .005                     |
| 611      | Valve rocker shaft and rocker shaft bushing   | .0001L    | .0010L    | .0025L                   |
|          | Finished ID of valve rocker shaft bushing in cylinder head  | .6246     | .6253     |                          |
| 612      | Rocker shaft bushing and cylinder head  | .0022T    | .0035T    | (A)                      |
| 615      | Piston ring gap - oil control ring  | .020      | .030      | .045                     |
|          | Piston ring gap - 1/2 wedge compression ring (chrome)   | .045      | .050      | .065                     |
| 616      | Crankshaft idler gear and camshaft gear - backlash  | .004      | .015      | .020                     |
| 617      | Crankshaft idler gear and crankshaft gear - backlash  | .004      | .015      | .020                     |
| 618      | Crankshaft idler gear and magneto gear - backlash   | .004      | .015      | .020                     |
| 619      | Crankshaft idler gear and crankshaft idler gear shaft   | .001L     | .003L     | .005L                    |
| 620      | Crankshaft idler gear - end clearance   | .010L     | .045L     | .055L                    |
| 622      | Accessory drive gear and vacuum pump adapter  | .0010L    | .0025L    | .004L                    |
| 623      | Accessory drive gear and camshaft gear - backlash   | .004      | .015      | .020                     |
| 667      | Governor drive gear and governor drive idler gear - backlash  | .004      | .015      | .020                     |
| 668      | Governor drive idler shaft (both ends) and crankcase  | .0010L    | .0025L    | .004L                    |
| 669      | Governor drive idler gear (bevel gear end) and governor driven gear - backlash                      | .004      | .008      | .015                     |
| 670      | Governor driven gear and crankcase  | .0010L    | .0025L    | .004L                    |
| 696      | Dynamic counterweight and washer  | .0002L    | .0015L    | (A)                      |
| 765      | AN fuel pump or injector pump gear and crankshaft idler gear - backlash                             | .004      | .015      | .020                     |
| 766      | AN fuel pump idler gear and fuel pump drive - shaft gear - backlash                                 | .004      | .015      | .020                     |
| 767      | AN fuel pump idler gear and fuel pump idler gear shaft  | .001L     | .003L     | .005L                    |
| 768      | AN fuel pump idler gear - end clearance   | .002L     | .018L     | .024L                    |
| 769      | AN fuel pump or injector pump driveshaft gear and adapter   | .001L     | .0025L    | .004L                    |
| 770      | AN fuel pump driveshaft gear - end clearance  | .009L     | .063L     | .073L                    |

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| Ref. No. | Nomenclature   | Mfg. Min. | Mfg. Max. | Max. Ser. Allow. |
|----------|--|-----------|-----------|------------------|
| 771      | Hydraulic pump driven gear and crankshaft idler gear - backlash              | .004      | .015      | .020             |
| 772      | Hydraulic pump driven gear and adapter                                       | .001L     | .0025L    | .004L            |
| 773      | Hydraulic pump driven gear - end clearance                                   | .010L     | .066L     | .076L            |
| 774      | OD of counterweight roller   | .6093     | .6098     |                  |
|          | OD of counterweight roller   | .5647     | .5652     |                  |
|          | OD of counterweight roller   | .6567     | .6572     |                  |
| 775      | ID of counterweight assembly bushing   | .7485     | .7505     |                  |
|          | Out-of-round of bushing ID   |           |           | .0005            |
| 800      | Outer valve spring compression load at 1.46 inches (wire diameter .177)      | 103 lbs.  | 111 lbs.  | 100 lbs. min.    |
| 801      | Auxiliary valve spring compression load at 1.33 inches (wire diameter .142)  | 75 lbs.   | 83 lbs.   | 72 lbs. min.     |
| 807      | Oil relief valve spring compression load at 1.30 inches (wire diameter .054) | 7.25 lbs. | 7.75 lbs. |                  |

TORQUE LIMITS

|     |  |      |        |              |
|-----|--|------|--------|--------------|
| 829 | Connecting rod bolt nuts 3/8 inch (apply thread lube to threads before assembly).                                      |      |        | 30 ft. lbs.  |
| 830 | Spark plugs 18 mm  |      | 360 to | 420 in. lbs. |
| 831 | 1/2 inch nuts and capscrews  |      |        | 550 in. lbs. |
| 832 | 3/8 inch nuts and capscrews  |      |        | 300 in. lbs. |
| 833 | 1/4 inch nuts and capscrews  |      |        | 75 in. lbs.  |
| 834 | 5/16 inch nuts and capscrews   |      |        | 150 in. lbs. |
|     | Crankshaft idler gear attaching screws   |      |        | 200 in. lbs. |
| 839 | #10-32 screw (to attach ignition cable outlet plate to magneto)  |      |        | 15 in. lbs.  |
| 840 | 3/8 inch nuts to attach gear to magneto  |      | 120 to | 180 in. lbs. |
| 858 | Cylinder hold down nuts 3/8 inch   |      |        | 300 in. lbs. |
|     | 1/2 inch   |      |        | 600 in. lbs. |
| 938 | Clearance - front face of crankshaft oil slinger to front face of recess in crankcase (crankshaft against thrust face) | .002 | .007   | (A)          |

CURVE 12889-A

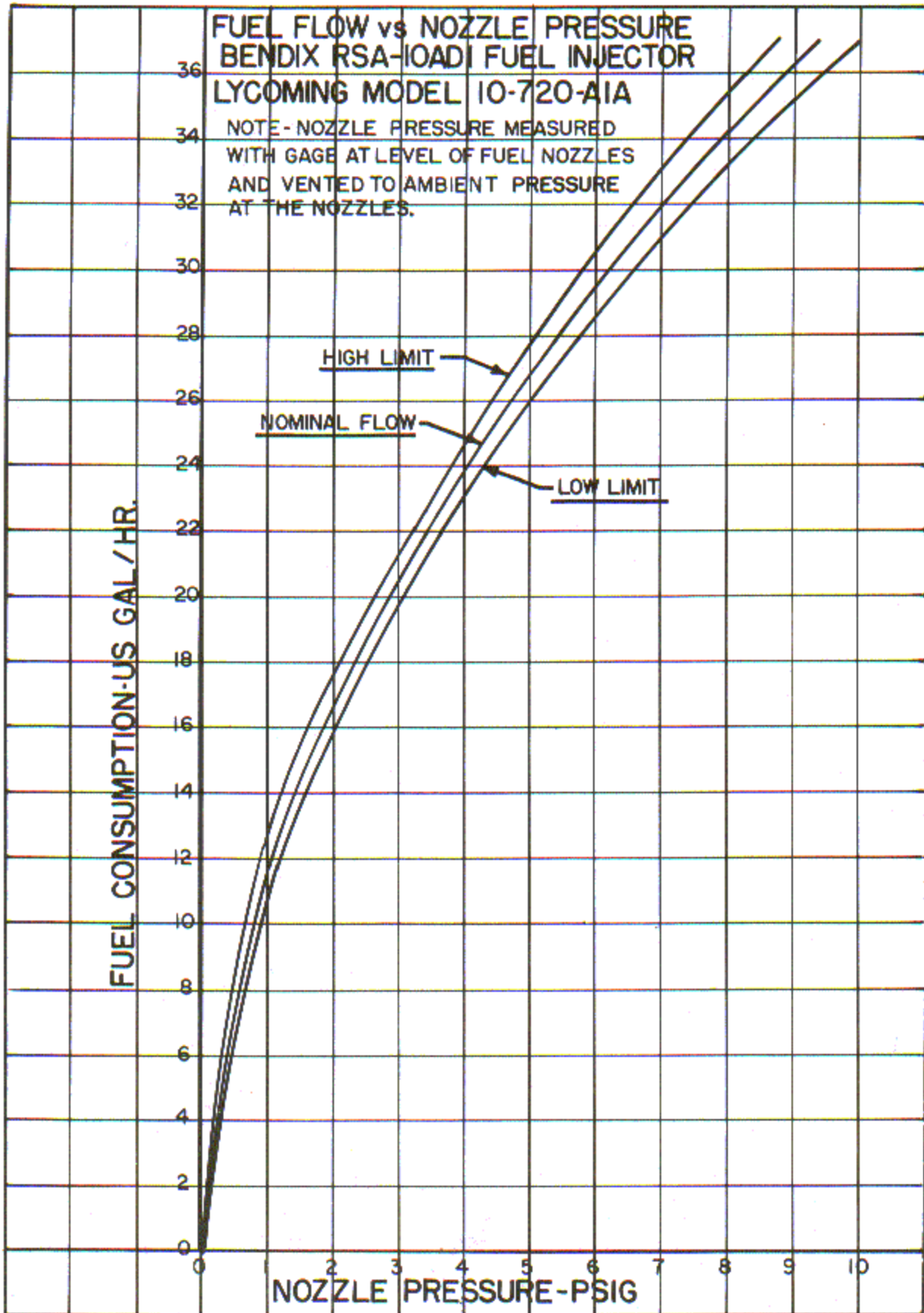


Figure 7. Curve, Fuel Flow vs. Nozzle Pressure - IO-720-A1A



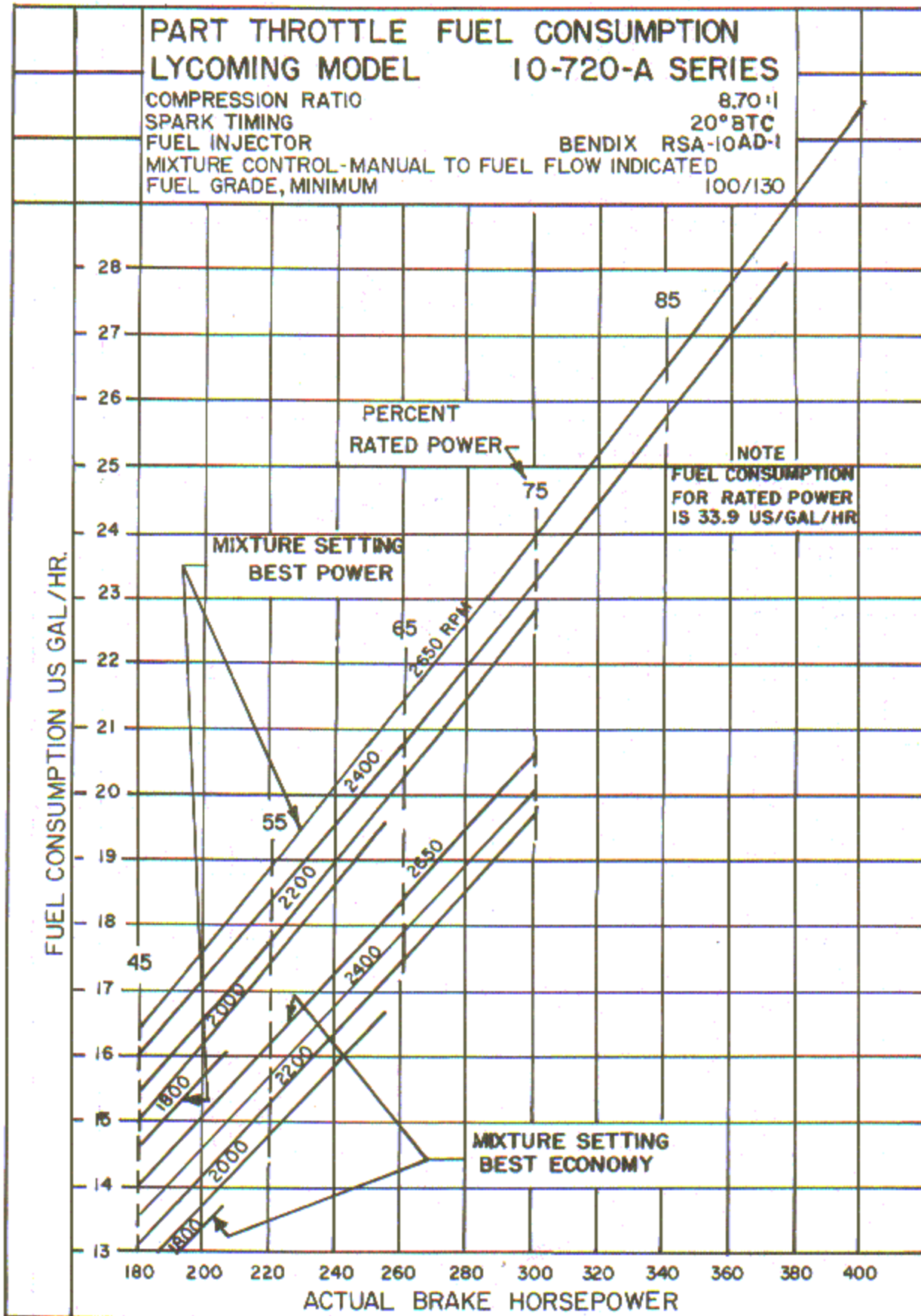


Figure 8. Part Throttle Fuel Consumption Curve - IO-720-A1A

LYCOMING MODEL IO-720-A1A OVERHAUL SUPPLEMENT

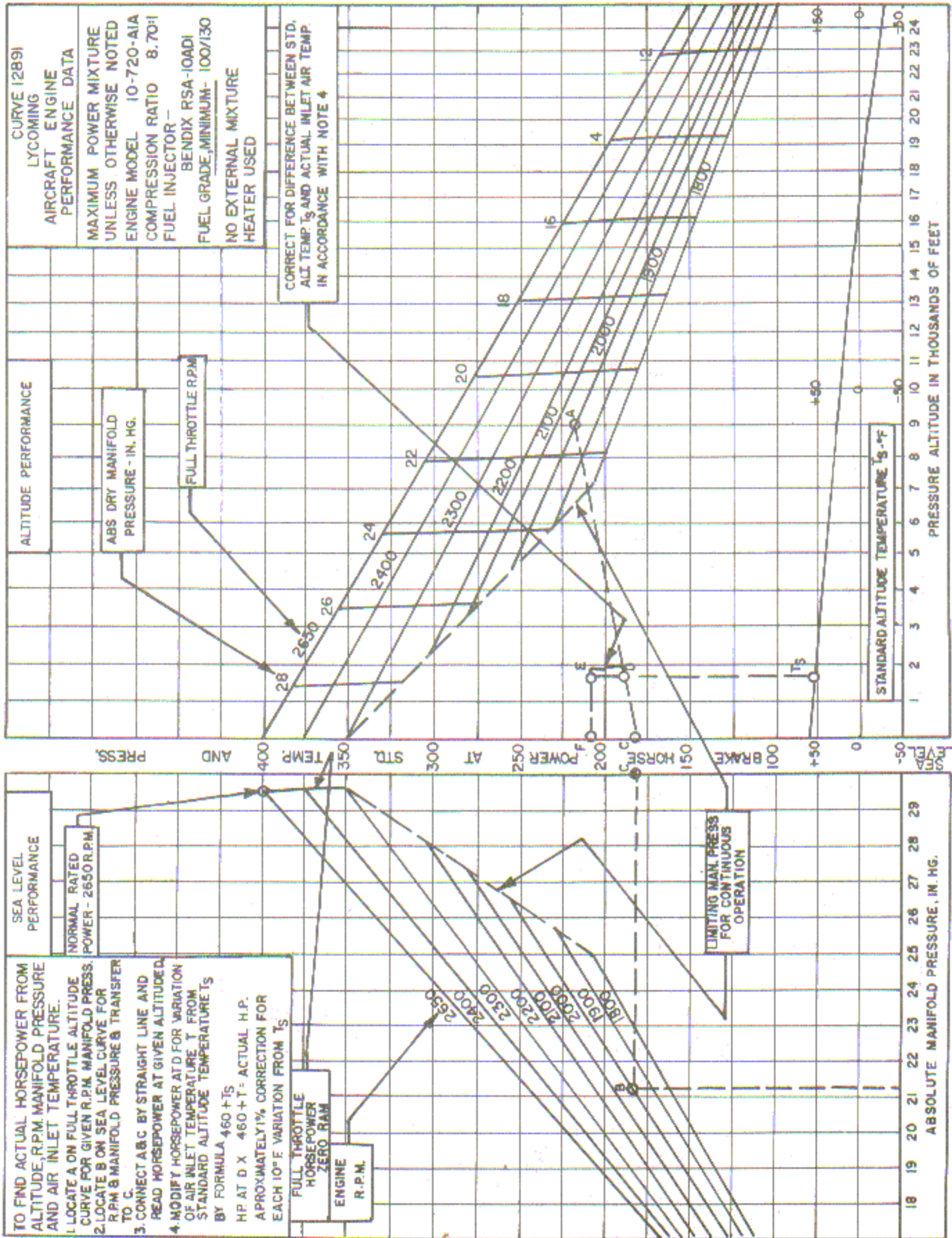


Figure 9. Altitude Performance Chart - IO-720-A1A