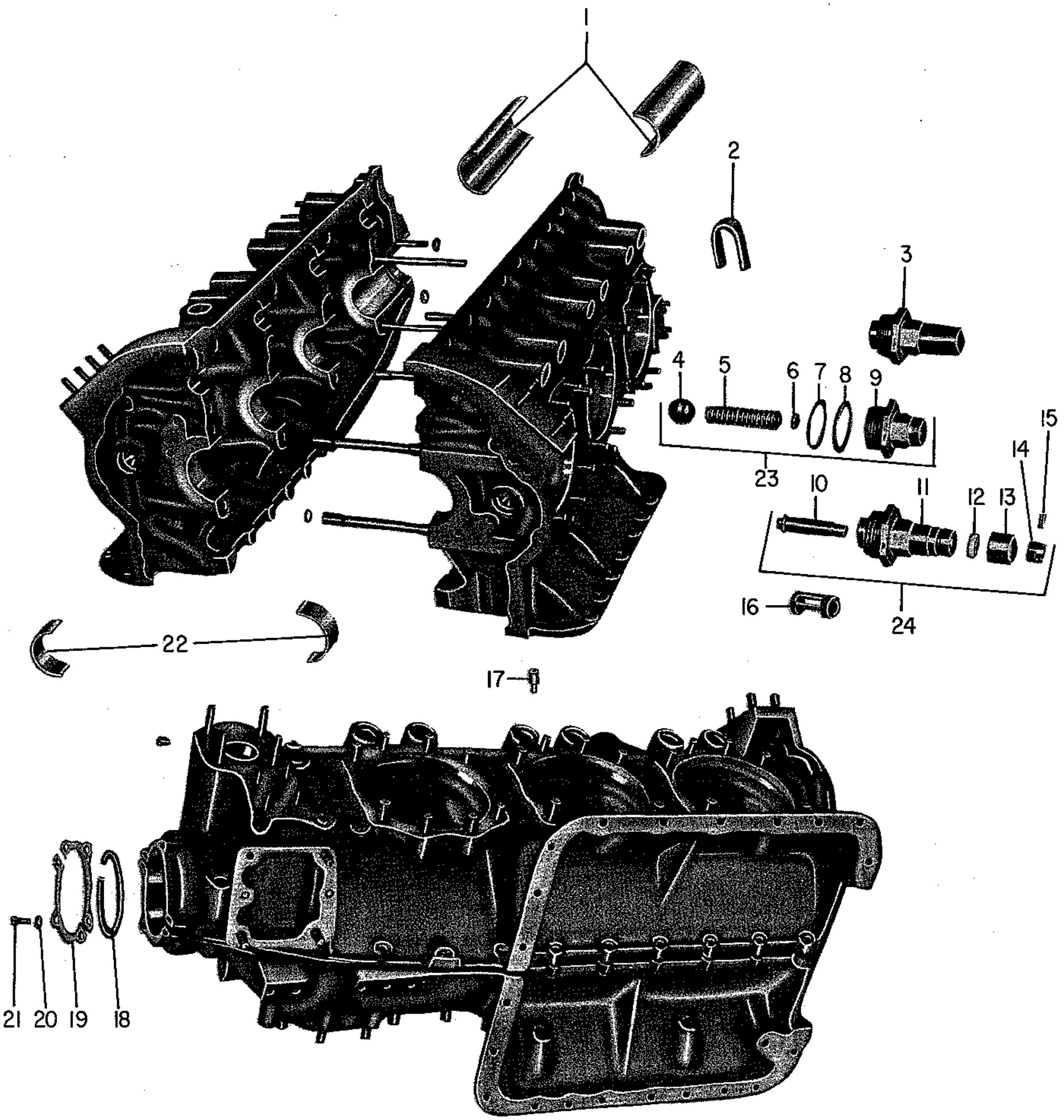


1. Front Main Bearing Insert
2. Lifting Strap
3. Oil Relief Valve Plug (Field Conversion)
4. Ball
5. Spring
6. Washer
7. Spacer
8. Gasket
9. Oil Relief Valve Plug
10. Oil Relief Valve Screw
11. Oil Relief Valve Plug
12. Oil Relief Valve Insert
13. Oil Relief Valve Cap
14. 3/8-24 NF-3 Nut
15. Spring Pin
16. Oil Relief Valve Sleeve
17. Piston Cooling Nozzle
18. Crankshaft Oil Seal
19. Retaining Plate
20. Washer
21. Screw
22. Main Bearing Insert
23. Oil Relief Valve Assy. (Non-adjustable)
24. Oil Relief Valve Assy. (Adjustable)

Figure 7-1. Typical Six Cylinder Crankcase

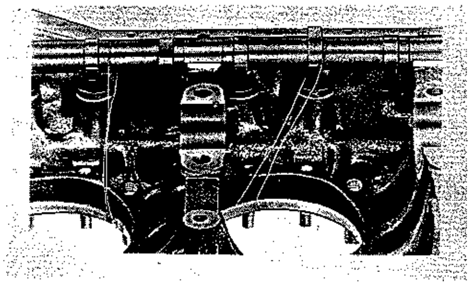


Figure 7-2. Camshaft Wired to Crankcase Half

7-16. Remove the crankshaft oil seal (18, figure 7-1) from the crankshaft. Do not remove the propeller flange bushings from the flange of the crankshaft unless they are damaged and/or loose.

7-17. Counterweights - See figure 7-5. Counterweights (8) are disassembled from the crankcase merely by removing the retaining rings (11), after which the washers (10), rollers (9) and counterweights (8) may be detached from the crankshaft lug.

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 selectively fitted to the washer seats in the counterweights during manufacture. It is advisable, therefore, to mark all counterweight parts during disassembly to insure proper identification. These markings must be impermanent. No scoring, scratching, etching or other permanent marking of any kind is permissible on these parts.

7-18. Sludge Tubes (4 cylinder engines - where applicable). Remove the four crankshaft sludge tubes (30, figure 7-5) with the sludge tube removal drift (P/N 64548) by placing drift end of the tool in the tube and driving out the tube with the bar portion of the tool. Do not clean the tubes but lay them aside to ascertain the presence or absence of metal particles in the sludge deposits. Do not re-use sludge tubes.

7-19. Sludge Tubes (6 and 8 cylinder engines - where applicable). When removing either six or eight cylinder engine sludge tubes use slide hammer puller (P/N 64782) and an adapter. Adapter P/N 64547 for six cylinder engines and adapter P/N 64784 for eight cylinder engines. Remove the jaws from the slide hammer puller and assemble the puller adapter on the slide hammer puller. Remove collar from the adapter, insert the adapter through the sludge tube, and reassemble the collar. Pull the tube out of the crankshaft with a series of quick hard strokes of the slide hammer. Do not clean tubes but lay them aside for examination to ascertain the presence or absence of metal particles in the sludge deposits. Do not re-use sludge tubes.

CAUTION

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. Sludge tubes are not employed in later model crankshafts. However, this is not to imply that sludge tubes can be removed and not replaced in those crankshafts originally using sludge tubes.

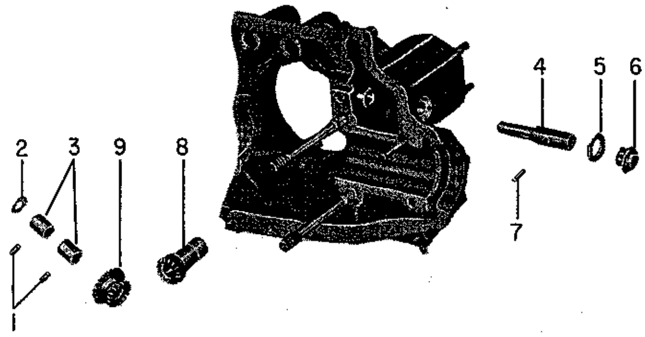
CLEANING

7-20. All crankcase, crankshaft and reciprocating parts are cleaned in accordance with the general instructions outlined in Section 3. 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 clean solvent and compressed air.

CAUTION

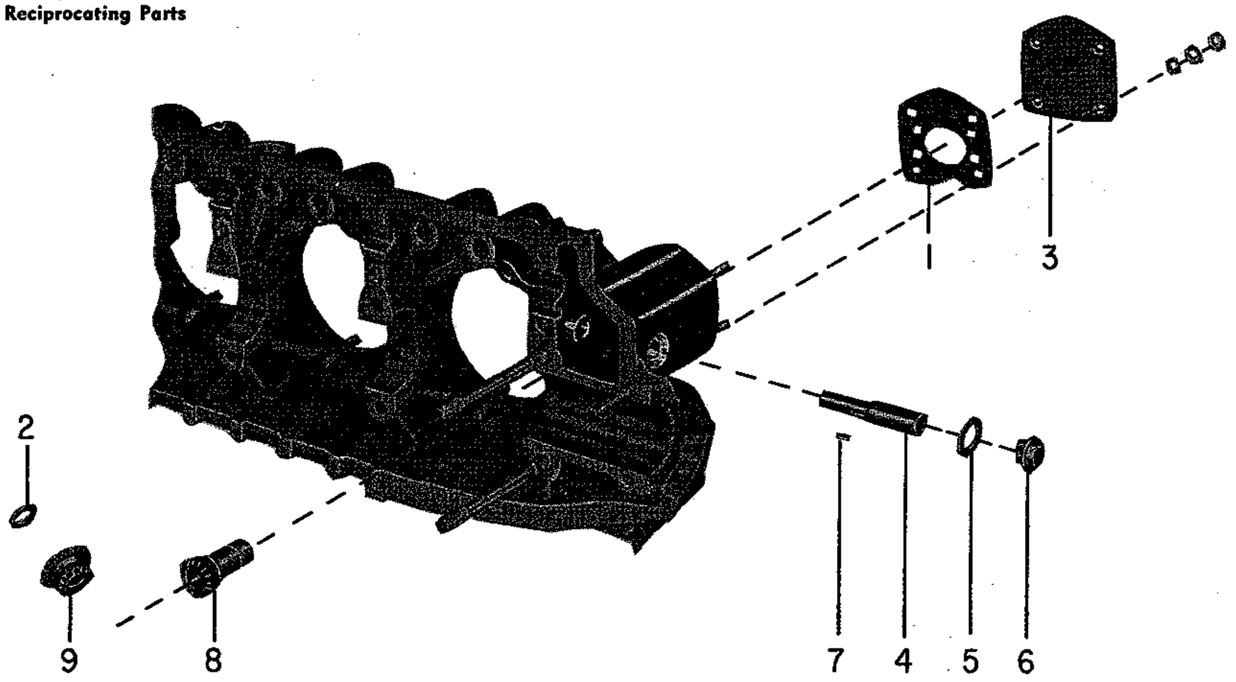
Do not attempt under any circumstances to clean the crankshaft without first removing the crankshaft sludge tubes (where applicable). The solvent will loosen but not remove accumulated sludge. This loose sludge is certain either to form a stoppage in the nearest oil passage, or to wash through and cause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

7-21. Piston Cooling Oil Jets. (Where applicable) Immerse the piston cooling nozzle in petroleum solvent. Hold the ball check valve off its seat in the nozzle by inserting a light copper wire or other relatively soft material through the threaded end of the nozzle and wash thoroughly so that any dirt particles that may be under the ball seat will be washed out.



1. Dowel
2. Thrust Washer
3. Idler Gear Bushings
4. Idler Gear Shaft
5. Gasket
6. Hex Head Plug
7. Spring Pin
8. Prop. Governor Driven Gear
9. Prop. Governor Idler Gear

Figure 7-3. Propeller Governor Drive
(4 cylinder engines with housing on crankcase)



1. Gasket
2. Thrust Washer
3. Cover
4. Idler Gear Shaft
5. Gasket
6. Hex Head Plug
7. Woodruff Key
8. Prop. Governor Driven Gear
9. Prop. Governor Idler Gear

Figure 7-4. Propeller Governor Drive (6 and 8 Cylinder engines)

INSPECTION

7-22. Inspect all crankcase, crankshaft and reciprocating parts in accordance with the general instructions contained in Section 3. Specific instructions follow.

7-23. Bearings (Precision Type). All precision type bearing inserts used for main crankshaft bearings and connecting rod bearings should be replaced with new bearing inserts at overhaul.

7-24. Crankcase (Visual Inspection). Check carefully for burrs, nicks and cracks around the bearing support webs. Check bearing bores and inspect tang slots for any roughness that might cause improper seating of bearing inserts. Check all drilled holes.

7-25. Fretting on the contacting surfaces of the bearing saddle supports in the crankcase occurs on some engines. This condition is caused by slight motion between the contacting surfaces and results in erosion of the metal surface. The affected areas have tiny pit holes and a frosted appearance, as contrasted to adjacent shiny unaffected surfaces. See figure 7-7. This condition can be misleading because of its trivial appearance; nevertheless it can be the cause of severe engine damage.

7-26. Fretting, by itself in this area, does not appreciably damage the structure of the metal, but the metal removed by the fretting action does change the size of the bearing saddles sufficiently to cause loose thru-studs and undersize main bearing bores. If not detected during overhaul, excessively tight crankshaft bearing fits will result with eventual engine failure.

7-27. Crankcase (Dimensional Inspection). The following paragraphs on crankshaft and camshaft dimensions will also describe dimensional requirements of the crankcase.

7-28. Crankshaft (Visual Inspection). Carefully inspect all surfaces of the shaft for cracks, checking the bearing surfaces with particular care for scoring, galling, corrosion, pitting or other damage.

7-29. Crankshaft (Dimensional Inspection). Place the crankshaft in Vee blocks supported at the locations called out in Table of Limits (Reference 556) and using a surface plate and dial indicator measure the run-out at center main bearings. If this total indicator reading exceeds the dimensions given in Reference 556 the shaft must not be re-used. The crankshaft flange run-out may be checked at this time and if the total indicator reading exceeds the run-out given in Table of Limits (Reference 607) the shaft must be rejected.

CAUTION

Any attempt to straighten a bent crankshaft will result in rupture of the nitrided surface of the bearing journals, a condition that will cause eventual failure of the crankshaft.

7-30. Using new inserts at all main bearing locations, assemble crankcase halves together, temporarily torque all thru-bolts to 300 inch pounds and measure the ID of the bearings. Measure the OD of the crankshaft main bearing journals and compare the resulting clearances with the Table of Limits (Reference 501). Assemble the connecting rods temporarily (using new bearing inserts) and check the crankpin journal clearances in the same manner, see Table of Limits, Reference 502. If clearances do not fall within prescribed limits, the shaft must be brought undersize. See Repair and Replacement section for instructions for regrinding.

7-31. 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. Any indication of distress, surface irregularity or feathering at the edge of the cam lobe is cause for rejection of the camshaft.

7-32. Camshaft (Dimensional Inspection). Support the camshaft in Vee blocks at its front and rear bearing journals and check the run-out at the center bearing location. See reference 539, Table of Limits. Slight bending operations are permissible on the camshaft providing careful magnetic inspection follows such procedures. Measure the diameter of the camshaft bearing journals and check them against the bearings formed by the crankcase. Reference 537, Table of Limits.

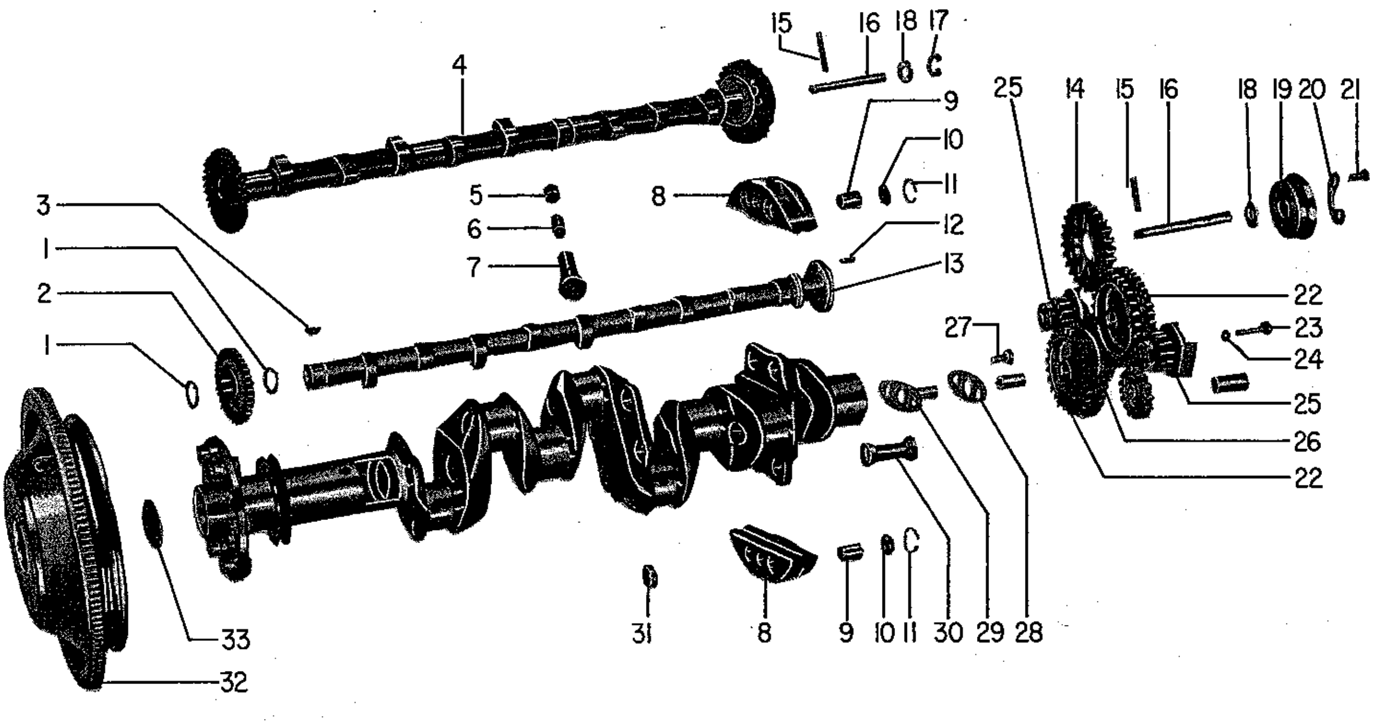
7-33. Crankcase - Main Bearing Clearance. The following inspection on the engines listed below must be accomplished unless thru-studs are marked as shown in figure 7-11.

O-320-B Series	Engines prior to 3815-39
O-340 Series	Engines prior to 405-30
O-360-A, -C Series	Engines prior to 3042-36
O-540 Series	Engines prior to 2790-40

7-34. Place the bearing plug (P/N 64906) so that the drilled clearance holes fit over the main bearing dowels of the center main bearing support to be checked and reassemble crankcase halves.

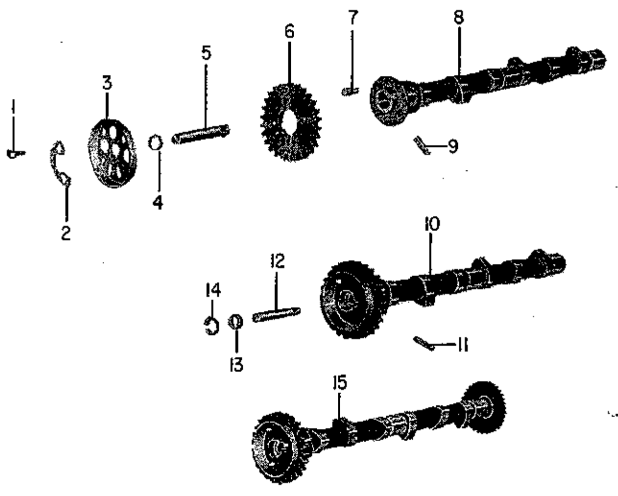
7-35. Using cylinder base hold down plates and nuts, torque all thru-studs in the sequence shown in figures 7-21, 7-22 or 7-23.

7-36. Attempt to insert a 0.004 inch tapered feeler gage between the crankcase mating faces, see figure 7-10. If the gage will not enter between the crankcase parting faces, the crankcase is considered satisfactory to be modified as directed in the repair and replacement section.



1. Retaining Rings	12. Stepped Dowel	23. Screw
2. Camshaft Gov. Drive Gear	13. Camshaft	24. Washer
3. Woodruff Key	14. Camshaft Gear	25. Magneto Drive Gear
4. Camshaft (Integral Gear)	15. Pin	26. Crankshaft Gear
5. Tappet Socket	16. Tachometer Shaft	27. Hex Head Screw
6. Tappet Plunger Assy.	17. Retaining Ring	28. Lockplate
7. Tappet Body	18. Spacer	29. Idler Gear Shaft
8. Counterweight	19. Breather Slinger	30. Sludge Tube (not used on current models)
9. Roller	20. Lockplate	31. Crankshaft Counterweight Bushing
10. Washer	21. Hex Head Screw	32. Ring Gear Support Assy.
11. Retaining Ring	22. Crankshaft Idler Gears	33. Expansion Plug

Figure 7-5. Typical Crankshaft and Related Parts



1. Hex Head Bolt
2. Lockplate
3. Breather Slinger
4. Spacer
5. Tachometer Shaft
6. Camshaft Gear
7. Dowel
8. Camshaft
9. Pin
10. Camshaft Integral Gear
11. Pin
12. Tachometer Shaft
13. Spacer
14. Retaining Ring
15. Camshaft (Prop. Governor Drive on Crankcase)

Figure 7-6. Camshafts - Integral and Separate Gears (4 Cylinder Engines)

7-37. When inspecting O-540 models, the above inspection procedure must be performed on both intermediate bearing saddles.

7-38. Connecting Rods (Dimensional Inspection). 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 bore in small end of bushing with connecting rod bushing plug gage (P/N 64537). If the gage enters the bushing, bushing must be replaced.

7-39. Connecting Rod Parallelism Check. See figure 7-8. Using connecting rod parallelism and squareness gage (P/N 64530), insert tapered sleeves (1 and 2) in bearing holes in connecting rod. Be sure that bearing cap is assembled properly and securely tightened. 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 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.

7-40. Connecting Rod Squareness Check. See figure 7-9. 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 arbor 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.

7-41. Crankshaft Counterweight Bushings. Wear or damage to the crankshaft counterweight bushings, 31, figure 7-5, located in the crankshaft counterweight lugs, is almost impossible to detect by normal inspection procedures. Because of this situation and as damage to the crankshaft counterweight bushings could cause failure of the counterweight and/or the crankshaft, it is mandatory that these bushings be replaced at overhaul. The procedure for removal and replacement of the crankshaft counterweight bushings is contained in the Repair and Replacement section.

7-42. Counterweight Bushings. Wear in the counterweight bushings is usually evident as out-of-round on the inside diameter. Check each bushing with the bore gage, ST-73. The diameter should be between 0.7485 and 0.7505 inch. Out-of-round should not exceed 0.0005 inch. The ST-73 gage is specially made so that it can be set with a micrometer. If the diameter of any bushing is oversize, or excessively out-of-round, all the bushings in the counterweight must be replaced.

7-43. Piston Cooling Oil Jets (Where applicable). Present Avco Lycoming engines are incorporating a piston cooling nozzle designed to open at 37 to 50 psi. Test the nozzle assemblies for correct pressure in the following manner:

a. Use SAE #10 motor oil at a temperature of 65° to 90°F.

b. Direct a flow of oil through the nozzle. The oil stream must pass from the nozzle through a one inch diameter hole located on a center line through the nozzle and 4.5 inches from the face of the nozzle at 50 psi.

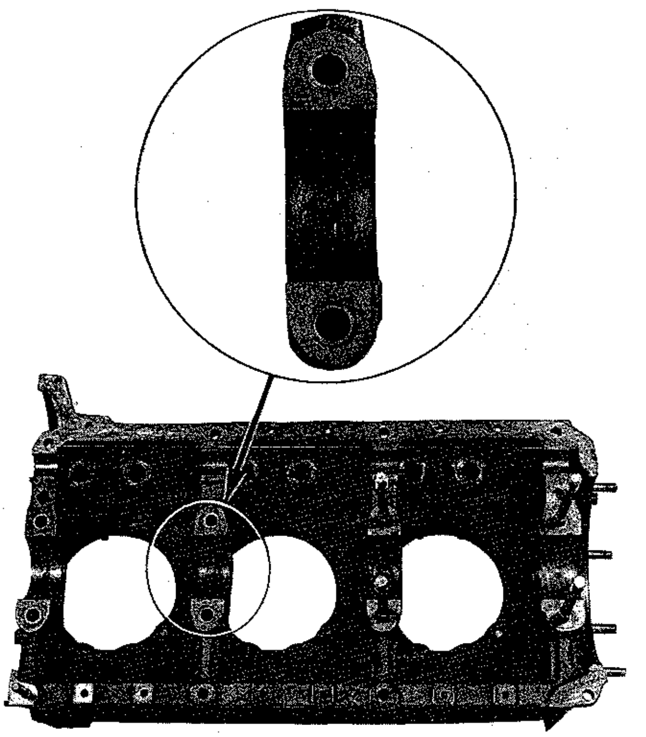


Figure 7-7. Crankcase Interior Showing Moderate Fretting at Stud Locations on Saddle Supports

REPAIR AND REPLACEMENT

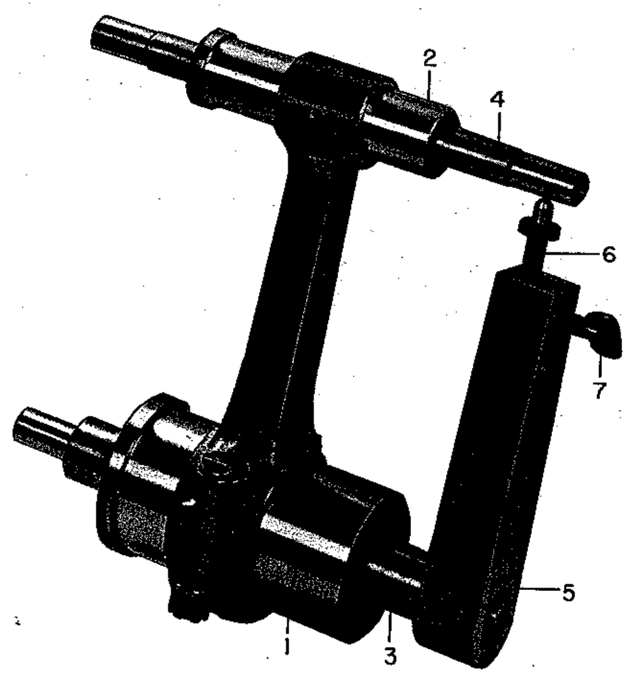
7-44. Repair all crankcase, crankshaft and reciprocating parts in accordance with the general instructions contained in Section III. Specific instructions follow.

7-45. Crankshaft (Bearing Surfaces). During overhaul of the crankshaft, the operator must determine if it has standard or undersize bearing journals, then proceed with its overhaul accordingly. Undersize crankshafts are identified by a code symbol stamped on the front of the flange as a suffix to the part number. In addition to the code symbols the letters RN are stamped as a suffix to the serial number indicating the shaft has been renitrided. The code symbols are, M03MP (main and crankpin journals 0.003 inch undersize) M03M (main bearing journals 0.003 inch undersize) M03P (crankpin bearing journals 0.003 inch undersize). If the maximum service limits are exceeded (Reference 501 or 502, Table of Limits) standard shafts may be polished to 0.003 inch undersize and fitted with 0.003 inch undersize bearing inserts. Renitrided 0.003 inch undersize shafts may be polished to 0.006 inch undersize and fitted with 0.006 inch undersize bearing inserts. Do not allow lathe speed to exceed 150 RPM at any time during polishing operation.

NOTE

Note that if one surface is polished to .003 or .006 undersize all corresponding surfaces must be polished to same size. Polishing to undersize is preferred to grinding because shafts that are polished do not require renitriding whereas any grinding operation requires that the shaft be renitrided. This is necessary because of the nonuniformity of grinding tools. The possibility exists wherein the grinding wheel will cut through the nitrided surfaces on one or more of the journal radii causing areas of stress concentration that can develop into fatigue cracks and ultimately result in a broken crankshaft.

7-46. If it is necessary to make a standard shaft journal surface more than 0.003 inch undersize or a renitrided 0.003 inch undersize more than 0.006 inch undersize, the crankshaft must be ground to undersize and renitrided. Standard shafts may be ground to 0.006 inch or 0.010 inch undersize, renitrided 0.003 inch undersize shafts must be ground to 0.010 inch undersize. Shafts must be fitted with the corresponding undersize bearing inserts. Grinding the crankshaft is a delicate operation requiring adequate grinding facilities and a great degree of skill. A properly dressed wheel (Carborundum (GA54-J5-V10 or equivalent) must be used with generous amounts 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. If any cracks or checks are found, the shaft must be rejected.



1. Tapered Sleeve (Crankpin End)
2. Tapered Sleeve (Piston Pin End)
3. Arbor (Crankpin Sleeve)
4. Arbor (Piston Pin Sleeve)
5. Gage Arm
6. Adjusting Screw
7. Wing Nut

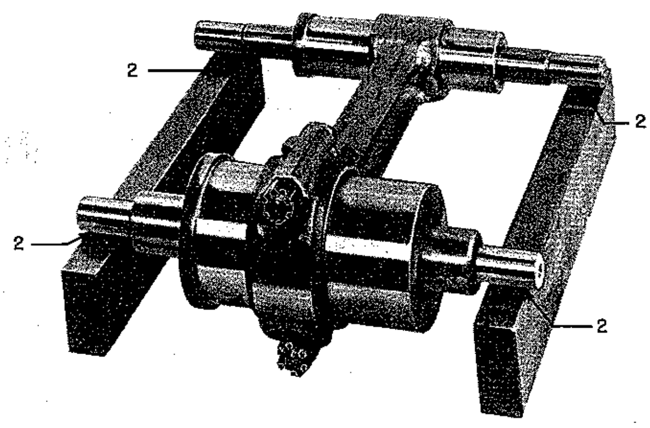
Figure 7-8. Checking Parallelism of Connecting Rods

NOTE

If one crankpin bearing surface is ground undersize all crankpin bearing surfaces must be ground to same undersize. If one main bearing surface is ground undersize all main bearing surfaces must be ground to same undersize. Main bearing surfaces may be ground without affecting crankpin surfaces and similarly crankpin bearing surfaces may be ground without affecting the main bearing surfaces. After any grinding operation the crankshaft must be renitrided. It is recommended that the shaft be returned to Avco Lycoming for renitriding.

7-47. Crankshaft - Straightening Flange. Maximum permissible flange run-out is 0.018 inch TIR. If the flange run-out exceeds 0.018 the crankshaft must be rejected. If the flange run-out is less than 0.018 inch the flange may be straightened as described in the following paragraphs.

Before attempting any straightening operations, the flange bushings must be removed. When the surface distortion of the flange has been reduced as much as possible, the front face of the flange must be trued up by grinding. However, if the minimum width of the flange after grinding (Dimension "A", figure 7-12) is less than the dimensions called out in Table 7-1, the shaft must be rejected.



1. Parallel Blocks 2. Check Points

Figure 7-9. Checking Squareness of Connecting Rods

CAUTION

Extreme care must be exercised during any straightening operation to avoid damage to the nitrided surfaces of the crankshaft. The nitrided surfaces extend from the front face of the slinger to the crankshaft gear mounting surface. These nitrided surfaces are glass hard and will crack if shaft is bent, dropped or handled carelessly.

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

7-48. After inspection, install the flange bushings and then cadmium plate the ground surfaces of the crankshaft flange. The plating, which should be 0.0005 inch maximum thickness, should be permitted to extend along the crankshaft proper only in the area shown in figure 7-12.

TABLE 7-1

Engine Model	Min. Width of Flange
O-235	0.190 inch
O-290-D	0.260 inch
O-290-D2	0.260 inch
O-320	0.260 inch
IO-320	0.260 inch
AIO-320	0.260 inch
O-360	0.370 inch
IO-360	0.370 inch
HO-360	0.370 inch
HIO-360	0.370 inch
AIO-360	0.370 inch
TIO-360	0.370 inch
O-540 (Except O-540-G)	0.370 inch
O-540-G	0.430 inch
IO-540 (Except IO-540-K, -M, -N and -R)	0.370 inch
IO-540-K, -M, -N, -R	0.430 inch
TIO-540-A	0.430 inch
TIO-540-C	0.370 inch
IO-720	0.370 inch

7-49. Reconditioning Worn Crankshaft Oil Seal Surface. If inspection personnel have found that the crankshaft oil seal surface on the shaft itself is damaged to the extent that the oil seal might leak, the following procedures are submitted to recondition this area of the crankshaft.

1. Remove propeller flange bushings from crankshaft flange and note the locations of long and short bushings replacement. Do not scribe on shaft. Use Avco Lycoming Special Tool ST-115 to remove flange bushings.

2. Strip cadmium plate from propeller flange and the area of the oil seal by immersing the shaft in a solution of ammonium nitrate (one pound of ammonium nitrate for each gallon of water).

3. Set up crankshaft in an external grinder and center carefully.

4. Use a No. 54 grit wheel and grind the area between the propeller flange and the oil seal face to remove nicks and scratches. Depth of grind must not exceed 0.005 inch. (0.010 inch u/s diameter).

NOTE

The grinding wheel, on the corner toward the propeller flange must be dressed to 0.50 inch radius while the opposite side, toward oil slinger, must be dressed 0.13 inch radius. Both radii must blend perfectly. Do not permit the side of the wheel to touch the propeller flange or face of oil slinger. See figure 7-13.

5. A No. 54 or 60 grinding wheel will produce a finish of approximately 8 to 10 microns. The surface roughness of the oil seal area should not exceed 10 microns before polishing with crocus cloth.

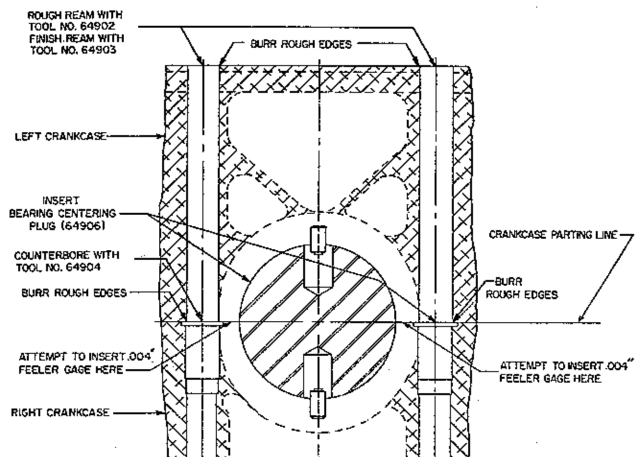


Figure 7-10. Cutaway of Crankcase Showing Steps to Install Body Fit Bolts

6. Polish the oil seal area of the shaft with crocus cloth while the shaft is rotated counter-clockwise when viewed from the flange (front) end of shaft. Do not move the cloth while polishing because the area must be free of spiral marks.

7. Clean the shaft to remove all traces of grinding dust and mask the bushing holes in the flange.

8. Cadmium plate (in accordance with AMS 2400) the flange and oil seal area of the crankshaft as indicated in figure 7-13. Do not plate beyond the 0.13 inch radius.

9. After plating, bake the crankshaft at 275°F. ± 10°F. for 5 hours to eliminate possibility of surface embrittlement.

10. See the applicable Avco Lycoming Parts Catalog for the particular engine model for correct propeller flange bushings and install new plated service bushings in the flange. Chill the bushings by refrigeration and install with Avco Lycoming Service Tool No. ST-115.

11. Support crankshaft in vee-blocks at the end journals and measure run-out at refinished area. Total indicated run-out must not exceed 0.002 inch.

12. Examine crankshaft by magnetic particle method.

7-50. Crankshaft, Counterweight Bushing Replacement (Where applicable). Wear or damage to the crankshaft counterweight bushings located in the crankshaft counterweight lugs, is almost impossible to detect by normal inspection procedures. Because of this situation and as damage to the crankshaft counterweight bushings could cause failure of the counterweight and/or the crankshaft, it is mandatory that these bushings be replaced at overhaul. The procedure for removal and replacement of the crankshaft counterweight bushings follows.

1. 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 7-14.

2. Measure the ID of the roller bushing hole in the crankshaft. If the hole measures 0.9369 - 0.9377 inch, no reaming of the hole is necessary and a standard bushing may be installed. If the roller bushing hole measures more than 0.9377 inch, the next oversize bushing must be installed and the hole reamed accordingly. See Table 7-2.

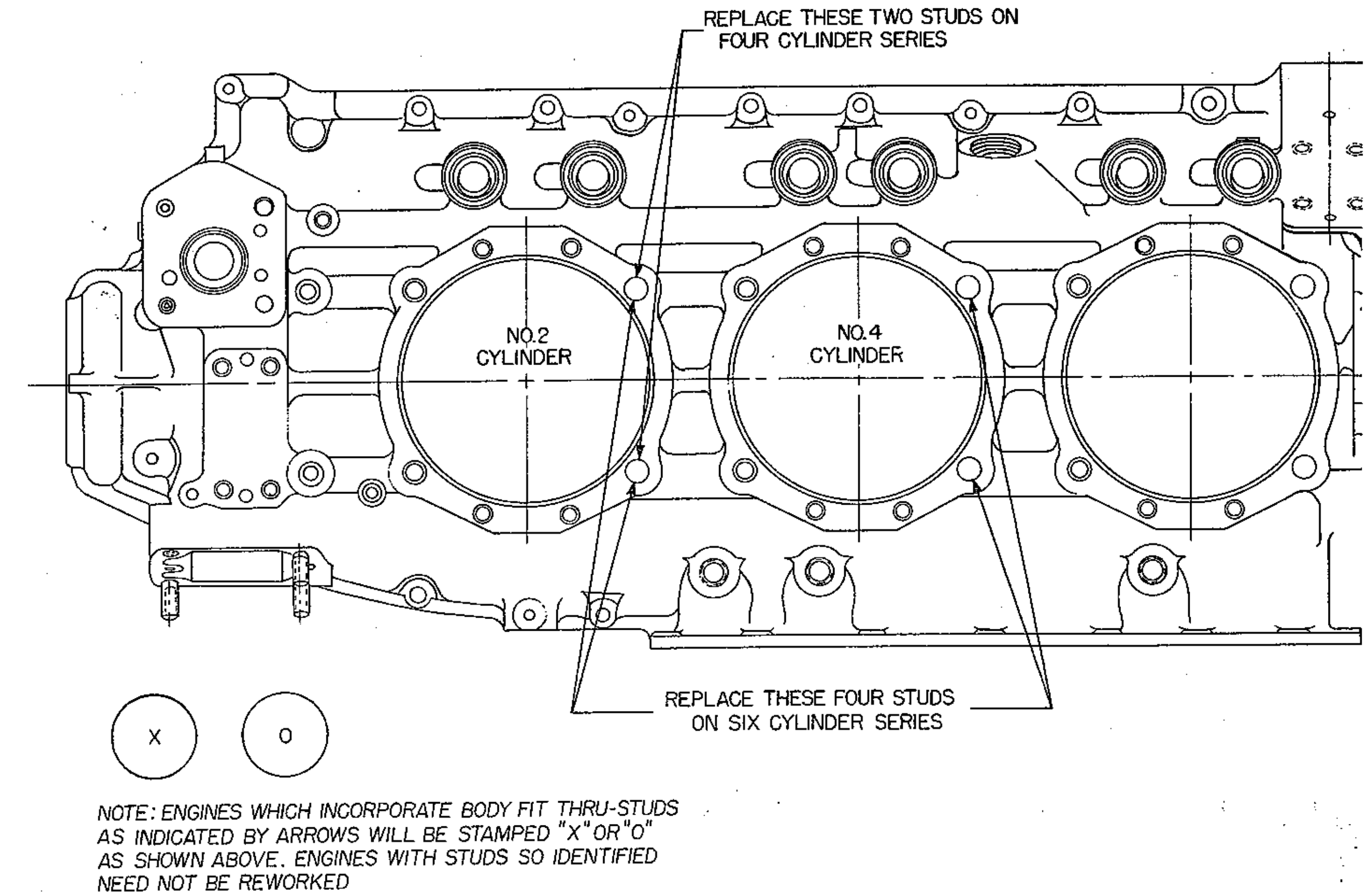


Figure 7-11. Location of Thru-Studs to be Modified

TABLE 7-2

Hole Size	Reamer No.
.9369/.9377	None
.9420/.9425	64874
.9445/.9450	ST-210
.9470/.9475	64875
.9495/.9500	ST-211
.9520/.9525	64876

3. Determine the oversize reamer needed and assemble the reaming fixture over the crankshaft lug. Select the two openings in the fixture to line up with bushing holes and install the plugs provided to line up the holes in the fixture with the holes in the crankshaft lugs. Secure the fixture by tightening the set screw. Assemble the reamer to a suitable brace and proceed to hand ream the hole in the crankshaft lug to proper size.

4. Assemble the puller to the crankshaft in the same manner as described in "Step 1" except that the large puller bushing is used instead of 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, the bushing will be forced into place 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 use of a drift.

5. After the bushing is installed, check its alignment with the main bearings by placing the crankshaft in vee blocks on a surface plate. Install the wedge blocks, Tool No. ST-212, in the bushing and compare parallelism of the wedge blocks with that of the main journals. Bushing must be parallel with .002 per inch. Support the crankshaft in the vee blocks at journals adjacent to the bushing location.

7-51. Counterweight Bushing Replacement - Consult the latest edition of Service Instruction No. 1143 for information relative to rebushing counterweights and subsequent inspection.

7-52. Connecting Rod Bushings. If the bushing in the small end of the connecting rod is worn beyond service limits, it can be removed and replaced by accomplishing the following procedure:

1. Clamp the connecting rod on the connecting rod bushing replacement block (P/N 64597) 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 (P/N 64535) and 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 (P/N 64536) drive a new bushing in place in the rod. Be sure the split in the bushing is located so that it is toward the piston end of rod and 45° off the centerline.

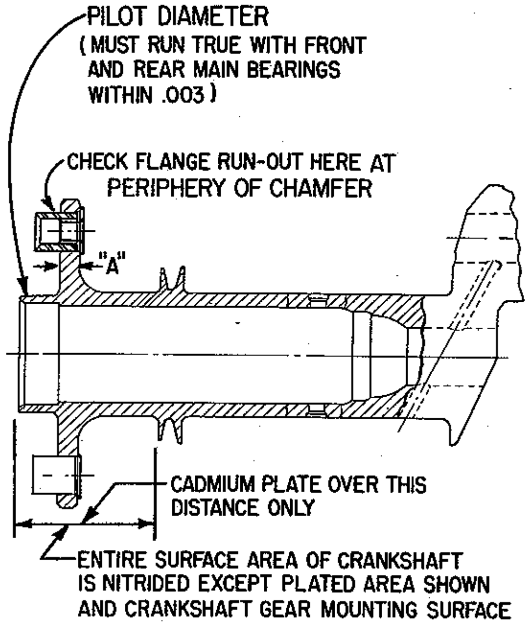


Figure 7-12. Limits for Straightening Bent Flange

2. Use a suitable arbor press and the connecting rod bushing burnisher (P/N 64580) to burnish bushing in place. Pass the burnisher completely through the bushing. Remove the rod from the holding block and finish bore the bushing to diameter shown in Table of Limits, Ref. 510. Check the bushing ID with finish ID gage (P/N 64767). Check alignment of the hole in the bushing with connecting rod parallelism and squareness gage (P/N 64530) as described in paragraphs 7-39 and 7-40. If the assembly does not meet the requirements shown in references 566 and 567, Table of Limits, the entire assembly must be replaced.

7-53. Crankshaft and Gear Assembly. Consult the latest edition of Service Instruction No. 1179 for information relative to inspection and repair of the crankshaft and gear assembly.

7-54. Starter Ring Gear. The latest edition of Service Instruction No. 1141 contains all the information necessary to accomplish the replacement of the starter ring gear.

7-55. Crankcase - Modification of Center Main Bearing Supports to Incorporate Body Fit Thru-Studs. This modification to be performed on the following listed engines only.

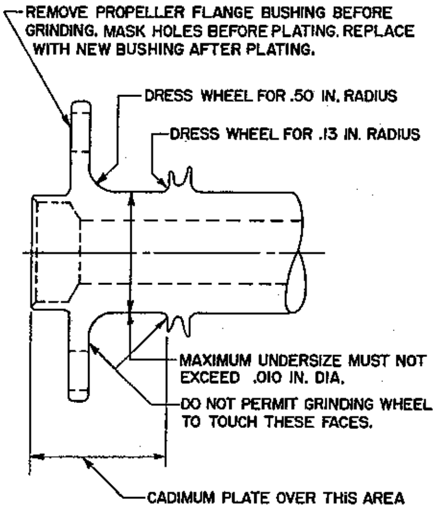


Figure 7-13. Reconditioning Crankshaft Oil Seal Surface

O-320-B Series	Engines prior to 3815-39
O-340 Series	Engines prior to 405-30
O-360-A, -C Series	Engines prior to 3042-36
O-540 Series	Engines prior to 2790-40

1. With the crankcase assembled as directed in paragraphs 7-34 and 7-35, loosen and remove the thru-studs from the locations shown in figure 7-11.

2. Place the crankcase with the odd numbered cylinder side down on eight inch parallel blocks.

3. Set the stop collar (P/N 64905) 5.75 inches above the cutting edge of special piloted reamer (P/N 64902).

4. Assemble the universal (P/N 64908) to a 1/2 inch electric drill motor, the reamer to the universal and proceed to ream 0.547 inch through thru-stud holes from the even cylinder number side. Continue reaming until the reamer reaches the collar. Make sure the drill and reamer has stopped before removal from the stud hole.

CAUTION

A liberal amount of kerosene must be constantly flowing into the hole as the reamer is passing through. This will prevent overheating and scoring.

5. Remove the stop collar from the 0.547 inch diameter reamer and assemble the collar 5.50 inches from the cutting edge of the 0.563 inch diameter finish reamer (P/N 64903).

6. Assemble reamer to universal and proceed to finish ream the holes, once again paying attention to the preceding "caution" note.

7. Disassemble crankcase halves and hand tap the anchor threads 0.007 inch oversize using tap (P/N 64907).

8. Use a 3/4 inch counterbore (P/N 64904) and standard tap handle to resize the oil seal counterbore hole. Exercise caution so as not to go deeper than the present depth. See figure 7-10.

9. Burr to clean up all rough edges caused by the reaming operations. Wash and clean the crankcase thoroughly.

10. Assemble new body fit thru-studs (P/N 72698-P07) in the threaded half of the crankcase. The same size "O" ring seal is used with the 9/16 inch thru-studs as was previously used.

7-56. Oil Relief Valve Sleeve (Non-adjustable oil relief valve). If the sleeve is badly scored or otherwise damaged, remove and replace the sleeve in the following manner.

1. 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.

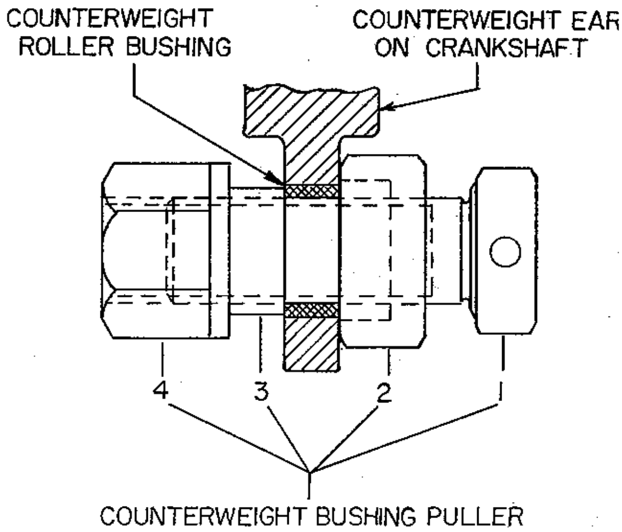


Figure 7-14. Removal of Crankshaft Counterweight Bushing

2. Draw the tap and sleeve straight out of the bore with a sharp quick pull.

3. 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 new sleeve will not seat properly.

4. 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 sleeve driver (ST-215) in the sleeve and drive sleeve into place with light hammer blows on the driver.

5. If the sleeve does not make a 0.001 press fit with the crankcase, but is loose, remove the standard size sleeve and install an 0.003 inch oversize sleeve exactly as described in Step "4" above.

CAUTION

In the event the hole in the crankcase is too small for installation of the 0.003 inch oversize sleeve, place the sleeve in a lathe and lap it sufficiently to fit the hole in the crankcase. Never ream the oil relief valve sleeve hole in the crankcase.

7-57. Oil Pressure Relief Valve (adjustable). The latest edition of Service Instruction No. 1172 contains the information relative to replacing the non-adjustable oil pressure relief valve assembly with the adjustable oil pressure relief valve assembly if required.

7-58. Crankcase - Fretting. Consult the latest edition of Service Instruction No. 1112 for information relative to inspection and repair of crankcases damaged by fretting.

7-59. Crankcase - Fretting. The latest edition of Service Instruction No. 1123 contains all the requirements necessary to modify the crankcase to prevent fretting.

7-60. Crankshaft Idler Gear Shaft Recess. Damaged or worn idler gear shaft recesses in the crankcase can be repaired as described in Service Instruction No. 1197.

REASSEMBLY

7-61. Crankshaft Sludge Tube Assembly (Where applicable). Support the crankshaft in a nearly vertical position and install new sludge tubes. Place a new sludge tube on the applicable drift, P/N 64547 for six and eight cylinder engines and P/N 64548 for four cylinder engines, and drive sludge tube to its correct depth. See figure 7-17 for four cylinder engines and figure 7-18 for six and eight cylinder engines.

NOTE

Sludge tubes are not employed in later model crankshafts. However, this is not to imply that sludge tubes can be removed and not replaced in those crankshafts originally using sludge tubes.

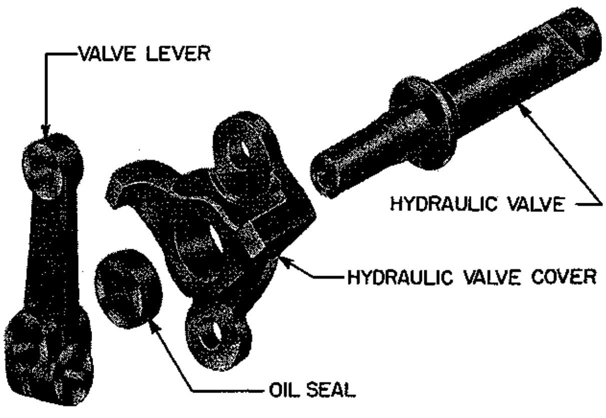


Figure 7-15. Hydraulic Valve Assembly

7-62. Expansion Plug. On engines equipped for fixed pitch propeller use the expansion plug installation drift (P/N 64681) to install a new expansion plug in place in the front of the crankshaft (see figure 7-17) 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.

7-63. Plug. On engines equipped for controllable pitch propeller, a plug is 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 (see figure 7-17). When the plug is properly positioned in the rear of the bore (flange forward) insert the oil plug drift (P/N 64770 for 1-3/4 inch plug, P/N ST-46 for 1-3/8 inch plug) and seat the plug with several sharp hammer blows on the drift.

NOTE

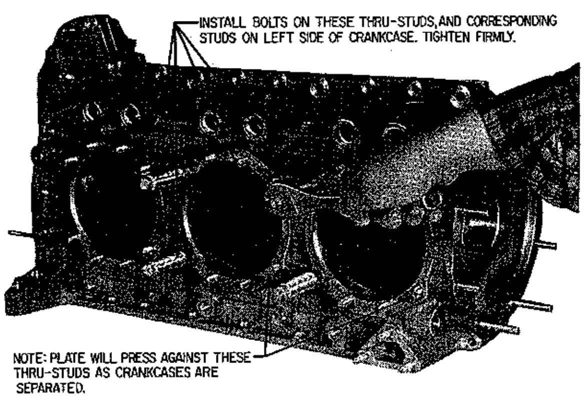
Some crankshafts employ a 1-1/4 inch plug. This size plug cannot be replaced in the field. The crankshaft must be returned to Avco Lycoming for repair.

7-64. Propeller Flange Bushings. If the propeller flange bushings have been removed from the crankshaft, new bushings must be installed. Use the crankshaft flange bushing replacement tool (ST-115) to install new bushings. Consult the applicable Parts Catalog for proper location of the bushings.

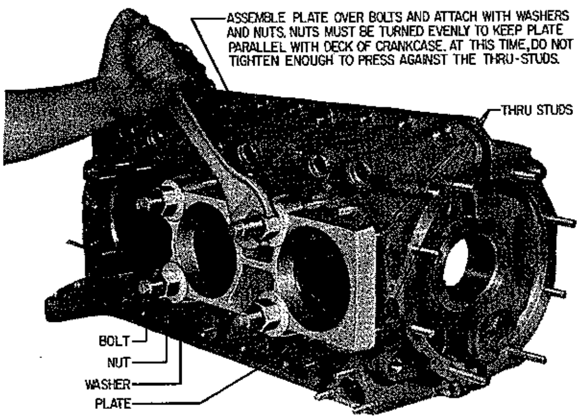
7-65. Crankshaft Gear. See figure 7-5. Position the crankshaft gear (26) over the dowel and be certain the gear is located securely in the counterbored recess in the rear of the crankshaft. Secure the gear to the crankshaft with lockplate and screw (28 and 27).

7-66. Counterweight Assembly. When assembling counterweights which have previously been installed on the engine, use the identifying marks, made on the various parts during disassembly, to enable matching each washer with the proper seat on the counterweight from which it was removed. Install washer (10) and retaining ring (11) on one side of the counterweight (8), place the counterweight on its proper ear on the crankshaft, insert the roller (9) and secure the assembly by installing the washer and retaining ring on the second

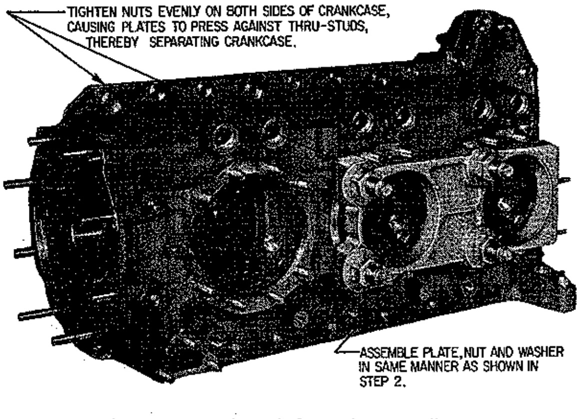
TO SEPARATE DOWELED CRANKCASES



Step 1. Right Side of Crankcase Showing Installation of Bolts on Half-Inch Cylinder Studs

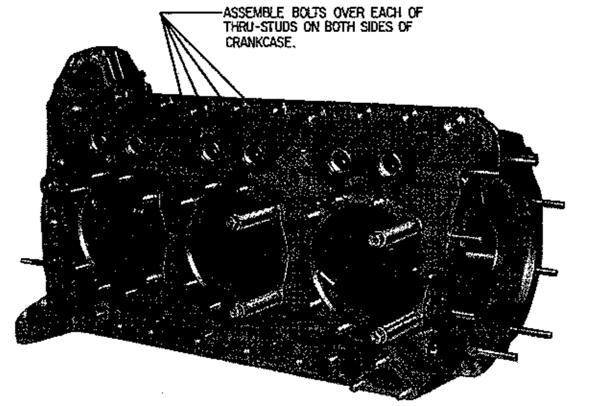


Step 2. Right Side of Crankcase Showing Installation of Plate

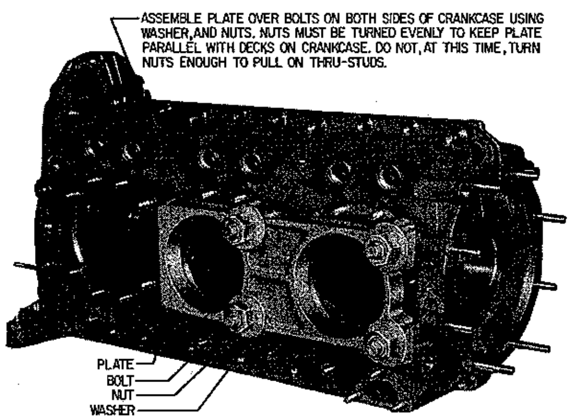


Step 3. Left Side of Crankcase Showing Installation of Plate

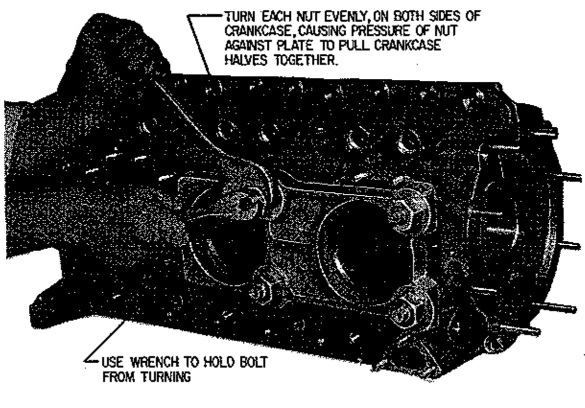
TO ASSEMBLE DOWELED CRANKCASES



Step 1. Right Side of Crankcase Showing Bolts Installed on Thru-Studs

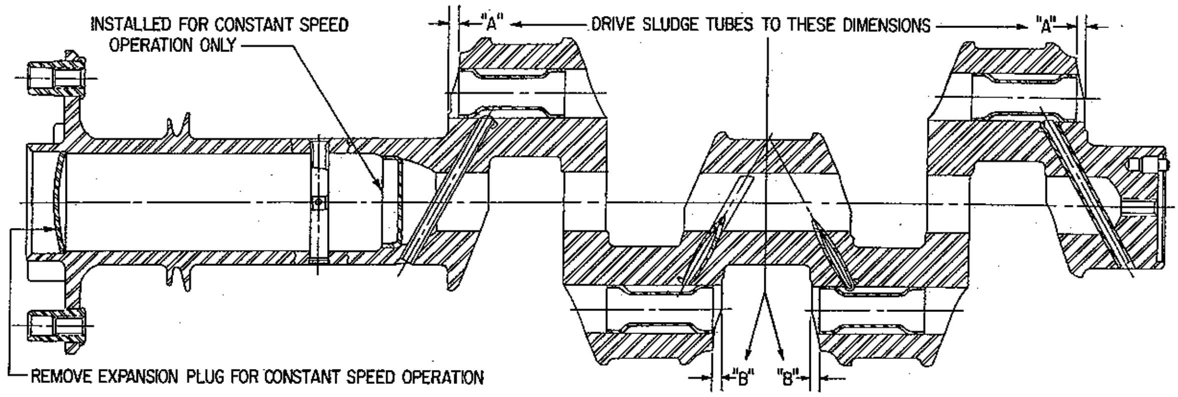


Step 2. Right Side of Crankcase Showing Plate Assembled Over Bolts



Step 3. Right Side of Crankcase Showing Pressure Plate Utilized to Pull Halves of Crankcase Together

Figure 7-16. Separation and Assembly of Doweled Crankcases Using Pressure Plates



MODEL	DIMENSION "A"	DIMENSION "B"
O-235, O-290	0.20 inch	0.20 inch
O-320, O-340	0.20 inch	0.20 inch
O-360	0.25 inch	0.31 inch

Figure 7-17. Dimensions to Drive Sludge Tubes (Four Cylinder Engines)

side of the counterweight. Note that washers are installed with the chamfered side in toward the roller and the circlip with the sharp side toward the outside (see figure 7-19) and gap in position as shown in figure 7-20. Insert one end of the counterweight retaining ring gap gage (P/N 64892) between the ends of the 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. Make sure all rings are properly seated. Consult the latest edition of Service Instruction No. 1012 for proper location of each counterweight on the crankshaft.

7-67. Connecting Rods. Assemble two new connecting rod bolts in each connecting rod cap and install new bearing inserts in the connecting rod and connecting rod cap, making sure the tang of each bearing insert enters locating slot in cap and connecting rod. Assemble each connecting rod assembly and tighten nuts moderately tight. Measure the ID of each bearing and check for clearance against measurements taken previously on the diameter of crankpin journals.

NOTE

> Connecting rods are marked at manufacture with the part number followed by a letter (A through E) designating weight groups. It is recommended that replacement sets of rods be of the same weight classification. Individual rods may be replaced by a service rod bearing the letter "S".

7-68. Place the crankshaft on a suitable support on the bench so that all crankpins are free for installation of connecting rods. Disassemble connecting rods after checking bearing ID, thoroughly coat both 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 rods will be down (toward the sump).

7-69. There are two types of connecting rod bolt and nut assemblies employed. One is tightened to a specified torque and the other to a stretch length. When tightening to a stretch length alternately tighten the nut and check the length using stretch bolt gage (P/N 64945). If the stretch limit is exceeded, the connecting rod bolt must be replaced.

7-70. Camshaft (With Separate Gears). See figure 7-5. On six and eight cylinder engines assemble the Woodruff key (3), install the governor drive gear (2) and secure with retaining rings (1).

7-71. (a) Camshaft (with separate gears) Except O-235 and O-290 - Secure the tachometer shaft (16) to the end of the camshaft with a pin (15). Assemble the camshaft gear (14) over the stepped dowel (12) on the camshaft and insert the spacer (18) into the center recess of the camshaft gear. Assemble the breather slinger (19) and secure assembly to the camshaft gear with lockplate (20) and hex head screw (21).

(b) (O-235, O-290) - The tachometer shaft is installed in the accessory housing. Assemble the tachometer drive pin (15) in the camshaft. Assemble the camshaft gear (14) over the stepped dowel (12) and secure to the camshaft with lockplate (20) and hex head screw.

7-72. (a) Camshaft (with integral gears) Except O-235 and O-290 - Assemble tachometer shaft centering spacer and install pin and tachometer shaft, secure with retaining ring.

(b) (O-235, O-290) - Install pin and tachometer shaft in camshaft gear and secure with retaining ring.

7-73. Crankcase. Place both crankcase halves on a suitable support with the interior of each half 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 place in the left crankcase half making sure the bearing is properly seated on the two dowels.

NOTE

The front main bearing, unlike the center and rear bearings, splits on the horizontal centerline of the engine.

Use a pencil to 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.

NOTE

O-235-C, O-290-D, O-290-D2 series and O-320-E2D do not employ the front main bearing described. They employ the same main bearings in all locations. Also if the O-235-C, O-290-D or O-290-D2 use a hydro control valve they employ a different front main bearing. Consult Parts Catalog.

7-74. Propeller Governor Drive (Located on left crankcase half). See figures 7-3 and 7-4. This drive assembly must be installed before the crankcase halves are assembled. This is accomplished in the following manner.

1. Place the governor driven gear (8) in the drive housing at the front left of the crankcase.

2. Insert the idler gear shaft (4) through the opening in the housing. Note that a Woodruff key is used in the shaft employed on six and eight cylinder engines whereas the shaft used on applicable four cylinder engines is pinned to the housing.

3. Place the idler gear and thrust washer on the shaft. Thrust washers are of selective fit to give proper backlash between the gears.

4. Assemble gasket (5) and hex head plug.

7-75. Assemble an idler gear shaft (29, figure 7-5) to the rear of each crankcase half in the following manner.

1. Insert the pilot of the shaft into the hole provided 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.

2. Place a lockplate (28) over the flange.

3. Secure with the applicable fastenings (27). Consult Parts Catalog.

7-76. Place the left crankcase half on a suitable support on the bench with the cylinder pads down. This support should be so constructed as to give approximately six inches clearance between the crankcase and bench.

7-77. Lay the right crankcase half on the bench with the cylinder pads down.

7-78. A counterbored recess is provided for an oil seal ring at each bolt and stud location. Install a new oil seal ring at the base of each stud.

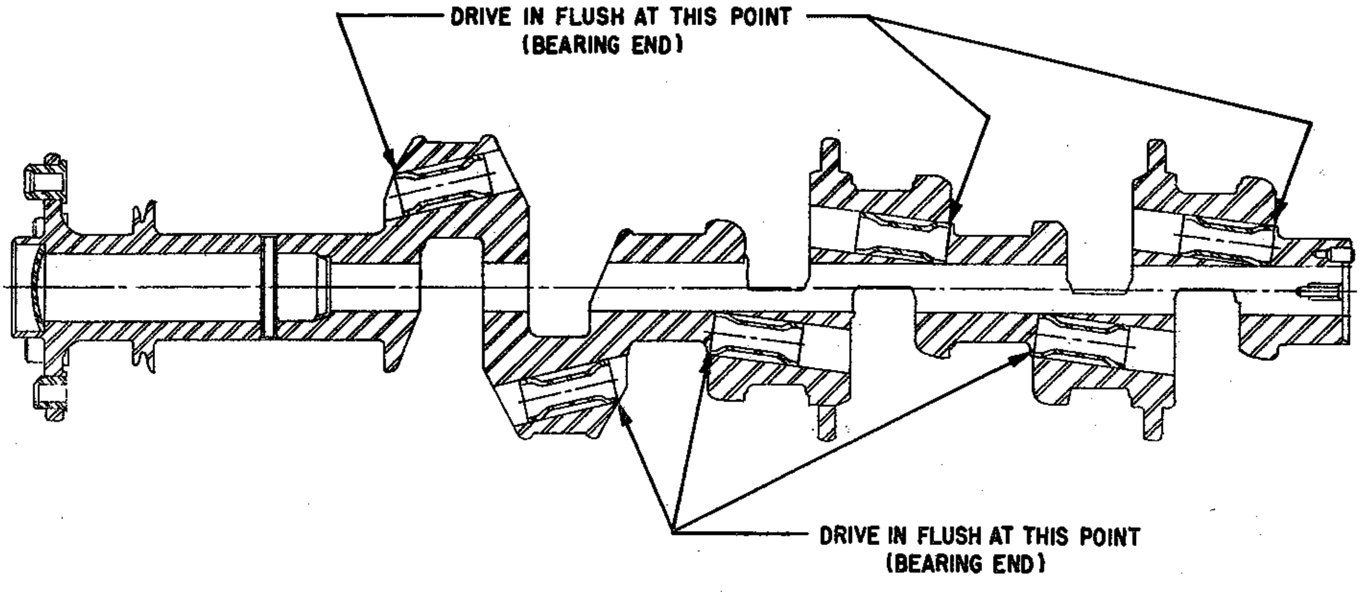


Figure 7-18. Dimensions to Drive Sludge Tubes (Six and Eight Cylinder Engines)

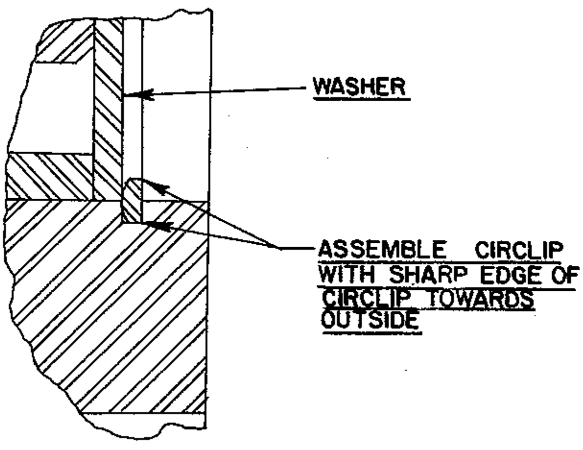


Figure 7-19. Assembly of Washer and Circlip in Counterweight

NOTE

Oil seal rings are not used at center saddles that are doweled nor at center saddles on O-320 and O-360 wide cylinder flange models using thru-studs that are not attached by screw-threads.

7-79. Remove the hydraulic tappet bodies from the cleaning basket, lubricate as directed in paragraph 3-37, and place in proper hole in the crankcase.

NOTE

If a new or reconditioned camshaft is to be used, new tappet bodies must be used.

7-80. Pre-lubricate the camshaft lobes and bearings as directed in Paragraph 3-37. Lay the camshaft in position in the right crankcase half. Loop a soft wire around an adjacent cylinder pad stud in such a manner as to hold the camshaft in place when the crankcase is turned over. See figure 7-2.

7-81. Pre-lubricate the main bearing journals of the crankshaft and the rear and center main bearing inserts in the left crankcase half. Remove the front main bearing halves from the left crankcase half and coat each bearing half liberally 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 the odd numbered connecting rods and lower the crankshaft into the left crankcase half permitting the even numbered rods to protrude through their respective cylinder mounting pads. Using the reference marks made previously, adjust the front main bearing so that the halves are seated squarely on the locating dowels.

7-82. See figure 7-24. If either the crankcase or crankshaft has been replaced, the crankshaft end clearance must be checked. When crankshaft is located in the left crankcase half, 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. (Point "A"). If clearance exists between crankcase and crankshaft thrust surface (Point A) regrind the front face of the crankshaft slinger (Point "B") to remove the clearance. Grind only that amount, from the face of the slinger, necessary to remove clearance. Push the crankshaft as far as possible to the rear of crankcase. Check the clearance between the thrust surface of crankshaft and crankcase.

7-83. Pre-lubricate the main bearing inserts of the right crankcase half.

7-84. Apply a film of non-hardening gasket compound to the outside mating surfaces of each crankcase half. The compound must not be applied to any of the interior mating surfaces such as the bearing support webs. Next imbed a length of "oo" silk thread in the gasket compound along outside edge of left crankcase half. Run the length of thread so that it is on both sides of bolt hole without touching each other. An alternate method of sealing is discussed in Service Instruction No. 1125.

7-85. Lower the right half of the crankcase 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.

NOTE

Crankcases that are doweled at the thru-studs can only be brought together as described above to a point where the dowels are encountered. At that point assemble the pressure plate as described in figure 7-16 and complete the assembly.

7-86. Install all crankcase fastenings. Consult the applicable Parts Catalog for correct attaching parts.

7-87. In order to insure uniform loading on the main bearings, it is necessary to tighten the studs and bolts in the following sequence.

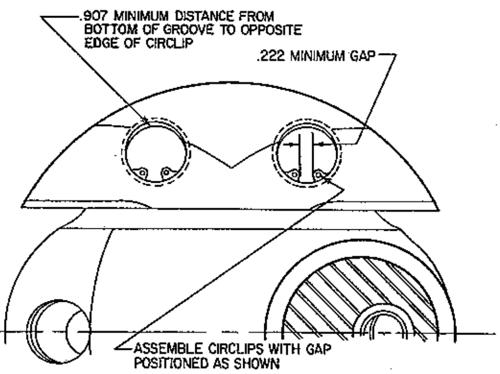


Figure 7-20. Location of Gap When Installing Retaining Rings

7-88. Install torque hold down plates (ST-222 or equivalent) at cylinder pads.

7-89. Install nuts on free ends of 1/2 inch thru-studs and using the sequence specified in figure 7-21, 7-22 or 7-23, whichever is applicable, tighten to 300 inch pounds.

NOTE

O-320 and O-360 wide cylinder flange models using 1/2 inch body fit thru-studs with both free ends must be tightened from both sides simultaneously. Make sure this type of thru-stud is assembled with equal lengths extending from both sides of the crankcase.

7-90. Using same sequence specified in paragraph 7-89, tighten nuts on the thru-studs to 600 inch pounds.

NOTE

O-235 series engines employ 3/8 inch thru-bolts and are only tightened to 300 inch pounds.

7-91. Torque 3/8 inch nuts at front main bearing (4, figure 7-21; 5, figure 7-22 or 6, figure 7-23) to 300 inch pounds.

7-92. Using sequence specified (5 thru 9, figure 7-21; 6 thru 12, figure 7-22 or 7 thru 15, figure 7-23) tighten 1/4 inch nuts at crankcase parting face to 75 inch pounds.

7-93. Torque 3/8 inch nut (10, figure 7-21; 13, figure 7-22 or 16, figure 7-23) at camshaft bearing to 300 inch pounds.

7-94. Using any sequence tighten the remaining 1/4 inch nuts at crankcase parting face to 75 inch pounds.

7-95. Assemble the crankshaft oil seal 18, figure 7-1 in the following manner. Assemble the seal with the

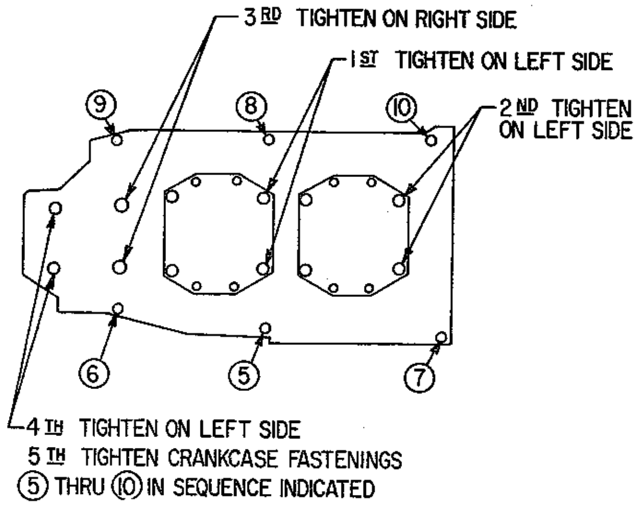


Figure 7-21. Crankcase Tightening Sequence (Four Cylinder Engines)

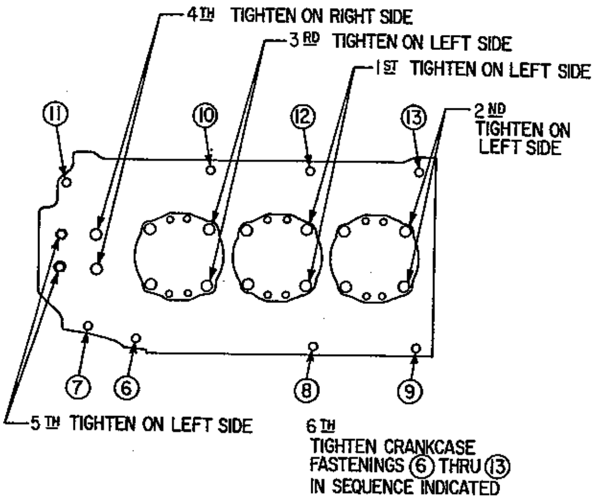


Figure 7-22. Crankcase Tightening Sequence (Six Cylinder Engines)

split located at the 1:00 o'clock position on right hand (standard) rotation and 11 o'clock position on left hand (reverse) rotation engines viewed facing propeller end of engine.

NOTE

Crankshaft oil seal may have either a flat surface OD and held in place by retaining plates (19, figure 7-1) or a raised lip on the OD to enter a machined groove in the crankcase. These seals are not interchangeable.

7-96. Coat the OD of the seal and the split of the seal with No. 20 Pliobond or Silastic 140 sealant. Assemble the seal uniformly in the crankcase with the lip matching at the split. Be sure no pliobond gets on the I. D. of the seal or on the crankshaft. See Service Instruction No. 1303 for method of installing solid ring oil seal.

NOTE

Crankshaft oil seal may have either a flat surface OD and held in place by retaining plates (19, figure 7-1) or a raised lip on the OD to enter a machined groove in the crankcase. These seals are not interchangeable.

7-97. Hydro Control Valve (O-235, O-290 series, where applicable). See figure 7-15. The oil seal in the valve cover should be replaced. This seal, which is a drive fit with the cover, should be driven into the bore with a suitable tool until it forms a flush surface with the face of the boss on the valve cover. Install valve body, valve cover and valve lever.

7-98. Generator or Alternator Drive Belt (where applicable) and Ring Gear Support Assembly. Place the drive belt in the pulley of the ring gear support and assemble the ring gear support over the propeller flange bushings. Be sure the bushing hole in the ring gear support bearing the identification "O" is assem-

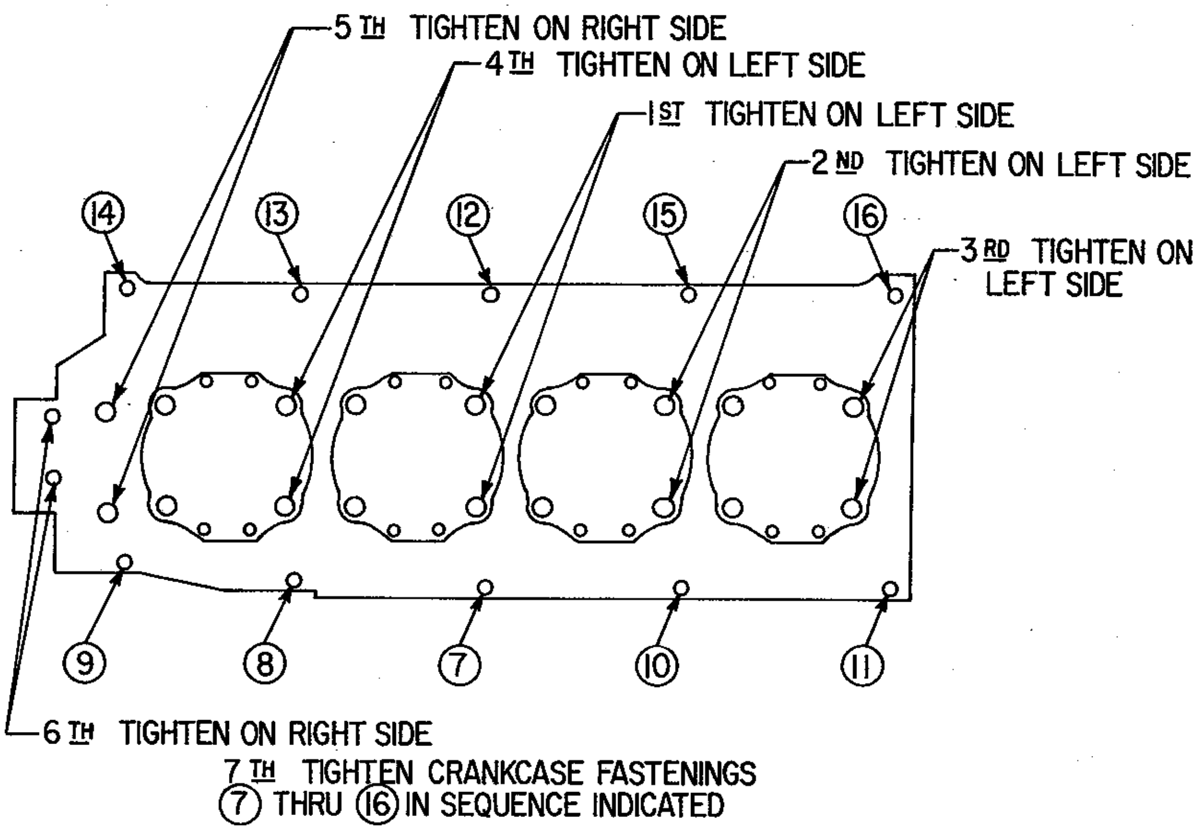


Figure 7-23. Crankshaft Tightening Sequence (Eight Cylinder Engines)

bled over the flange bushing also identified with "O" etched on crankshaft flange next to bushing. The starter ring gear must be located correctly to assure proper alignment of the timing marks on the ring gear.

7-99. Crankshaft Idler Gears (4 cylinder engines). Place the crankshaft idler gear on the idler gear shaft located to the left between the camshaft gear and the crankshaft gear. The crankshaft idler gear is marked in two places with a small etched circle. One of these marks is located at the space between gear teeth and the second is located on a gear tooth. The camshaft gear is marked with two etched circles on adjacent teeth, while the crankshaft is marked with an etched circle on one of the gear teeth. The marked tooth on the idler gear must mesh with the space between the 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 2-7.

7-100. The crankshaft idler gear must be assembled in its proper relationship with both the camshaft gear and the crankshaft gear because no other combination of these three gears will permit correct valve timing. Assemble the second crankshaft idler gear on the idler gear shaft on the right side. The position of the timing mark on this gear is immaterial. Check the backlash between gears.

7-101. Crankshaft Idler Gears (6 cylinder engines). 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, and the crankshaft gear 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 must mesh with the marked teeth of the idler gear. (See figure 2-8).

7-102. 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 2-8).

7-103. Note that the magneto gears shown in figure 2-8 are marked with a circle on one tooth. This tooth must mesh between the two circles etched on adjacent teeth of the larger diameter gear of the crankshaft idler gears.

7-104. Crankshaft Idler Gears (8 cylinder engines). Place the left crankshaft idler gear on the idler shaft located to the left and between the camshaft gear and crankshaft gear. 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 larger diameter gear is marked at one place with the etched circles on two adjacent teeth and at another place a single tooth

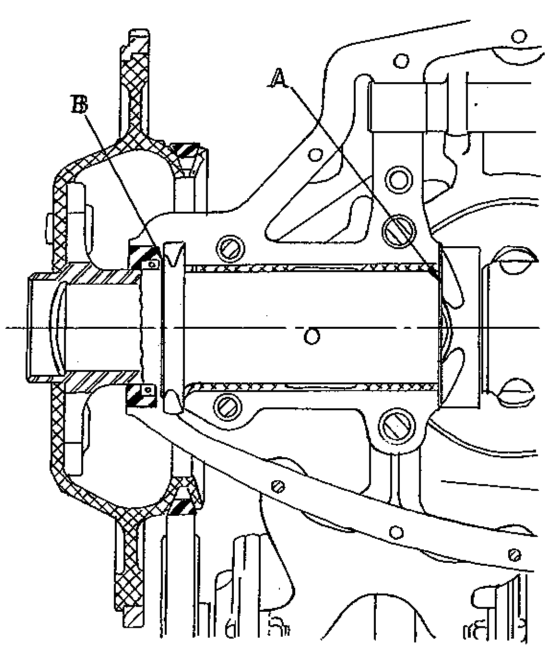


Figure 7-24. Checking Crankshaft End Clearance

is marked. The smaller diameter gear is marked at one location with the etched circles on two adjacent teeth. The camshaft is marked with small etched circles on two adjacent teeth and the crankshaft gear is marked at one location with one circle. The single marked tooth of the idler gear must mesh with the two marked teeth on the camshaft gear while the marked tooth of the crankshaft gear must mesh with the two marked teeth on the idler gear. See figure 2-9.

7-105. Install the right crankshaft idler gear in place on the idler shaft, meshing the etched circle on the crankshaft gear between the two marked teeth on the larger gear surface of the idler gear.

7-106. Note that the magneto gears shown in figure 2-9 are marked with an etched circle on two adjacent teeth. The single tooth etched with a circle on the smaller diameter idler gear surface must mesh between the two marked teeth on the magneto gear.

SECTION 8.

OIL SUMP AND FUEL INDUCTION

8-1. General. To accomodate the number of engine models, covered in this manual, a number of oil sump configurations are employed. Basically all oil sumps are similar and overhaul procedures will apply to all models unless specifically called out to the contrary.

8-2. Various carburetors and fuel injectors are employed on the engine models covered in this manual. No attempt will be made to describe their overhaul. Overhaul information for these trade accessories may be obtained from their respective manufacturers.

8-3. Two methods of assembling intake pipes are employed. One method employs a plain end intake pipe and connections in the oil sump. The second method employs a flanged end which is assembled directly into the oil sump or induction housing.

DISASSEMBLY

8-4. Intake Pipes. Loosen and remove the capscrews that attach the intake pipe flange to the cylinder intake port. Depending on installation, either loosen hose clamps and slide intake pipe off connection or pull intake pipe from the sump or induction housing. Discard the "O" rings. Mark the intake pipes as they are removed from the engine so they may be reassembled in the same location from which they were removed. Engines employing tunes induction will have intake pipes matched in length and diameter.

8-5. Carburetor or Fuel Injector. Remove the carburetor or fuel injector from either the air inlet housing or from the mounting pad on the sump. Remove the air inlet housing on installations employing same. Carburetor or fuel injector mounting pads may be incorporated on either the bottom, front or rear of the oil sump.

8-6. Oil Suction Screen. See figure 8-1 thru 8-4. The oil suction screen housing may be found at any number of locations on the sump. Unscrew the hex head plug and remove gasket and oil suction screen.

8-7. Induction Housing (IO-540, TIO-540). See figure 8-3. Remove the air inlet housing from the sump and induction housing. Remove the induction housing from the bottom of the sump. Remove the studs (14) and clamps (15) that secure the intake pipe extensions and remove the extensions (16).

8-8. Induction Housing (IO-720-A, -C). See figure 8-4. Remove the induction housing (8) from the bottom of the sump.

8-9. Induction Housing (IO-720-B). Remove the air inlet housing from the induction housing. Remove the induction housing cover and the induction housing. Remove the studs and clamps that secure the intake pipe extensions and remove the extensions.

8-10. Oil Sumps - Remove the fastenings from the periphery of the sump and remove the sump.

CLEANING

8-11. Oil Sump - Clean the sump according to the general instructions contained in Section 3. Clean the oil passages with solvent and a suitable brush and blow out with compressed air. Do not clean the oil suction screens until they have been inspected for metal particles.

8-12. Carburetors - Clean the carburetors in accordance with the manufacturer's instructions.

8-13. Fuel Injectors (Bendix). Remove and clean the fuel inlet screen on strainer. Clean the strainer in unleaded gasoline or Varsol cleaning fluid.

8-14. Fuel Injector (Simmonds). Clean all exposed surfaces of the fuel pump and throttle body assemblies with a dry lint free cloth.

8-15. Injector Nozzles - (Simmonds). To clean nozzle orifices use a stream of dry compressed air. Do not use a probe of any kind to clean nozzle orifices.

8-16. Injector Nozzles - (Bendix). Remove the nozzle and submerge it 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 either the shield or screen are removed from the nozzle, both must be thoroughly cleaned prior to reassembly and the shield must have a tight fit on body when installed.

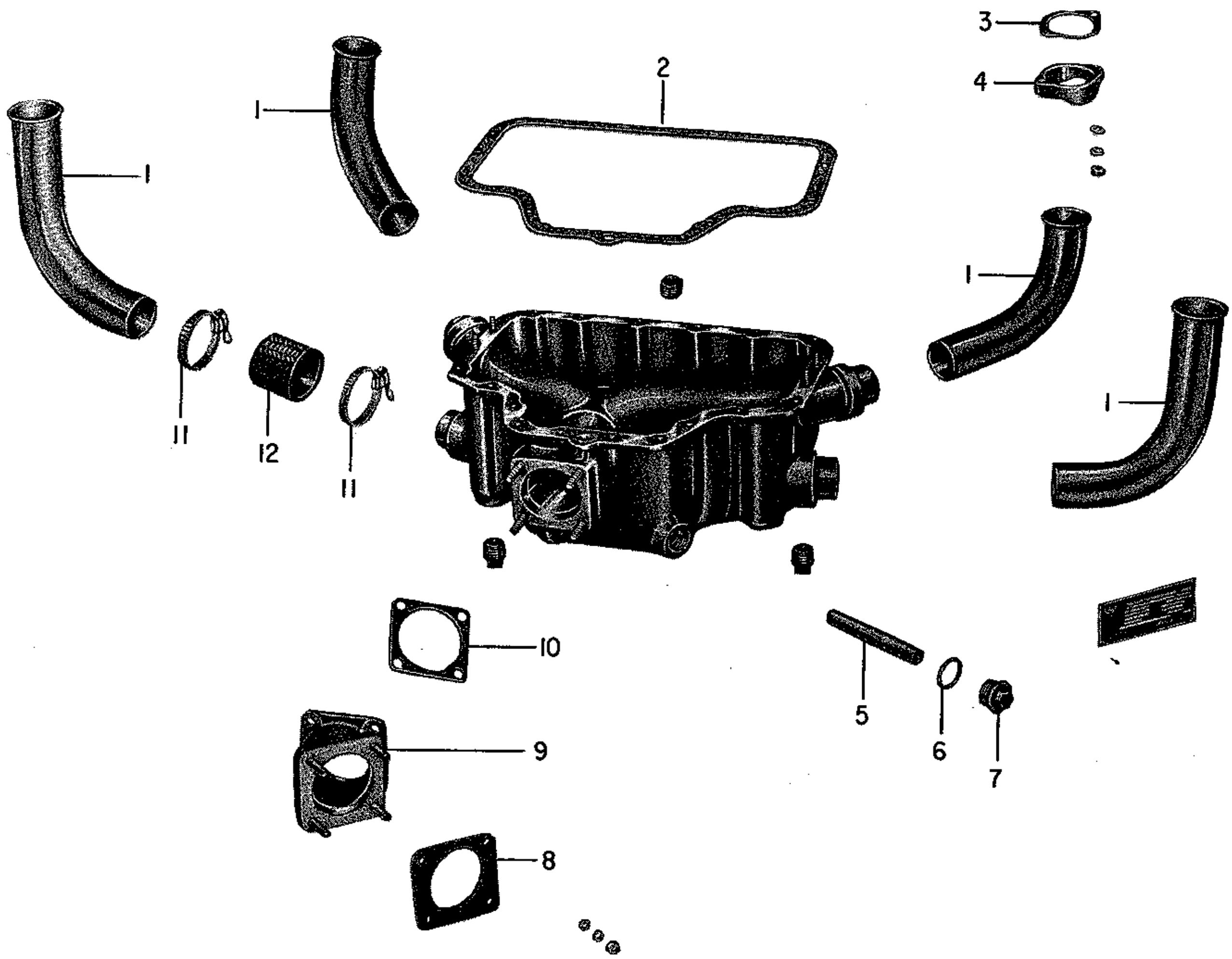
NOTE

At no time is it permissible to use a sharp tool such as a wire to clean out an air bleed nozzle.

INSPECTION

8-17. Inspect the sump according to the general instructions contained in Section 3.

8-18. Oil Suction Screen. Before cleaning the screen, inspect for evidence of metal particles, which could serve as an aid to locate deterioration in some section of the engine. Inspect screen for distortion or openings of the mesh.



1. Intake Pipe
2. Gasket
3. Flange Gasket
4. Flange
5. Oil Suction Screen
6. Gasket
7. Plug
8. Gasket
9. Throttle Body Elbow
10. Gasket
11. Hose Clamps
12. Hose

Figure 8-1. Oil Sump and Related Parts Group

8-19. Carburetors. Inspection of carburetors must determine parts serviceablility and repair and replacement requirements. Check applicable manufacturer's publications for limits to be used when conducting inspection.

8-20. Bendix Fuel Injectors. The fuel metering section should be inspected along with its corresponding fuel lines and fittings for damage or fuel leakage. Check all fuel lines for deformation, restrictions and fuel leakage. Check throttle and mixture control rods for deformation.

8-21. Simmonds #530 Fuel Injectors - The following inspection procedures are applicable to Simmonds # 530 fuel injectors.

8-22. Pump Assembly - Inspect mounting surfaces and fastenings for security. Check for leakage, cracks or other damage to pump housing. Check pump fittings and lines connected to pump for cracks or other damage. Check mixture control lever for damage and wear. Inspect linkage connected to mixture control lever for damage and/or wear.

8-23. Throttle Body - Check all of the following parts for damage and/or wear. (a) Throttle lever and linkage. (b) Throttle body. (c) Accelerator pump linkage, levers and lines (d) Fuel manifold assembly, (e) All other fittings and lines.

8-24. Nozzle Assembly. Check nozzle lines for wear, damage or leakage. Inspect installed nozzles for security of mounting. Make sure fuel lines are connected securely to the nozzles. Check for clogged nozzles. Remove nozzles, if clogged, and conduct a priming operation to make certain fuel flows from the nozzle.

NOTE

Nozzles for this system are a matched set and are stamped "A", "B" or "C". Fuel flows for these nozzles are:

a. "A" - 280 to 284 cc per minute at 9.8 psi supply pressure.

b. "B" - 276 to 280 cc per minute at 9.8 psi supply pressure.

c. "C" - 272 to 276 cc per minute at 9.8 psi supply pressure.

Only matched nozzles must be used in each engine. If nozzles are mixed erratic engine operation and uneven fuel distribution will be experienced. Example: "A" nozzles may be required in one engine, and "B" or "C" nozzles in the other engine. Any combination may be used to match the needles, however, do not mix the nozzles in the same engine. The purpose of the three different rate nozzles is to provide adjustment of the fuel flows between engines to align fuel flow gage needles.

REPAIR AND REPLACEMENT

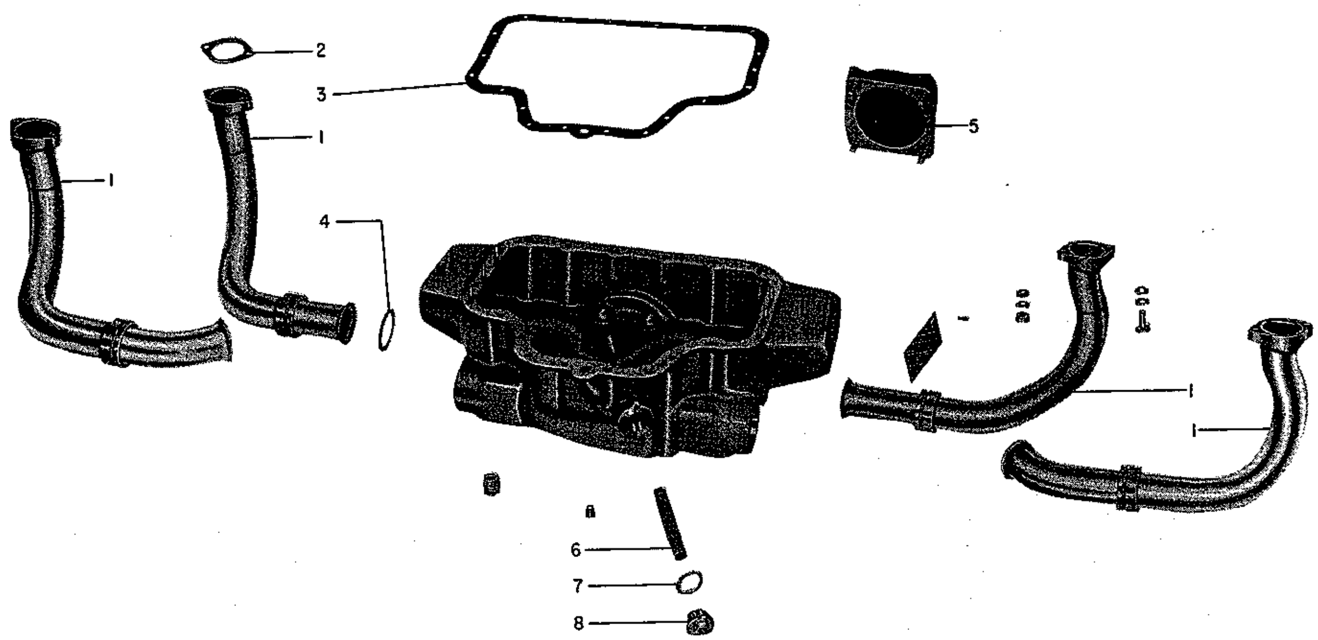
8-25. Intake Pipe Connection Removal. In the event that any of the intake pipe connections are loose or damaged, remove the defective connection by collapsing it with a chisel or punch.

8-26. Intake Pipe Connection - Installation. Place a new connection on the end of the swaging tool (64781) and tighten the screw until the rollers have expanded sufficiently to hold the connection on the tool. Insert the connection into the hole in the sump, making sure that the connection is fully inserted in the hole and seated on the machined shoulder provided. Begin to rotate the tool, stopping every couple of turns to expand the rollers by tightening the screw one or two full turns. When the groove in the connection is fully swaged in the groove in the sump, (this will be evidenced by the increased resistance of the screw) collapse the rollers and withdraw the swaging tool.

8-27. Repair of Intake Pipe Bores. Service Instruction No. 1168A describes in detail the procedures necessary to repair the intake pipe bores in the sump.

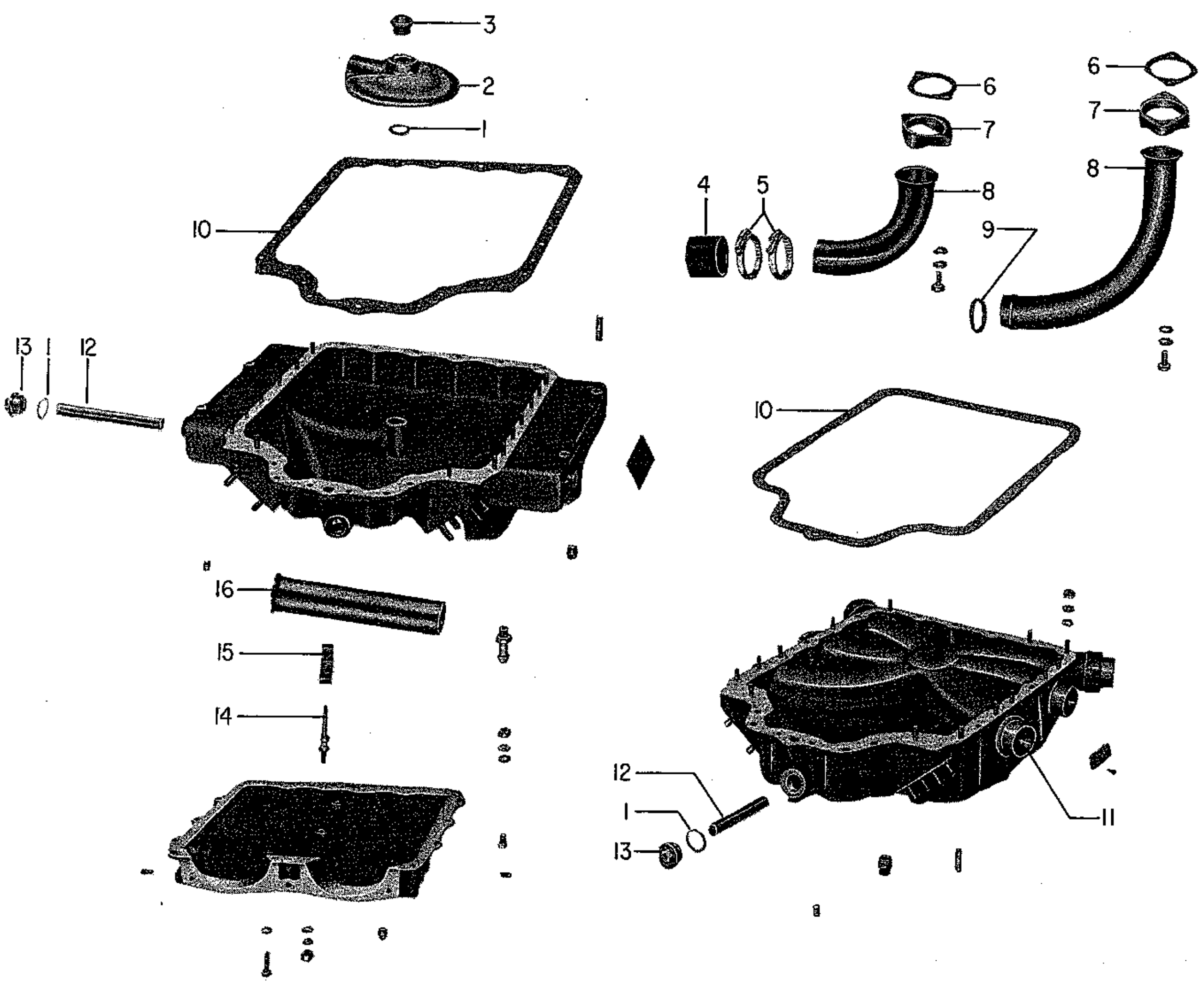
8-28. Carburetors - All repair and replacement procedures must be carried out in conjunction with the manufacturer's publications. Consult Avco Lycoming Service Bulletins nos. 297A, 306, 309 and 323 and be certain the carburetor has been modified to conform with these bulletins.

8-29. Fuel Injectors - All repair and replacement procedures must be carried out in conjunction with



1. Intake Pipe
2. Flange Gasket
3. Gasket
4. "O" Ring Seal
5. Adapter
6. Oil Suction Screen
7. Gasket
8. Plug

Figure 8-2. Oil Sump and Related Parts Group



1. Annular Gaskets
2. Oil Sump Baffle
3. Plug, 7/8 - 14 x .62
4. Hose
5. Hose Clamps
6. Flange Gaskets
7. Intake Pipe Flanges
8. Intake Pipes
9. "O" Ring
10. Gaskets
11. Intake Pipe Connection
12. Oil Suction Screen
13. Plug 1.00 - 20 x .62
14. Intake Pipe Extension Studs
15. Intake Pipe Extension Clamps
16. Intake Pipe Extensions

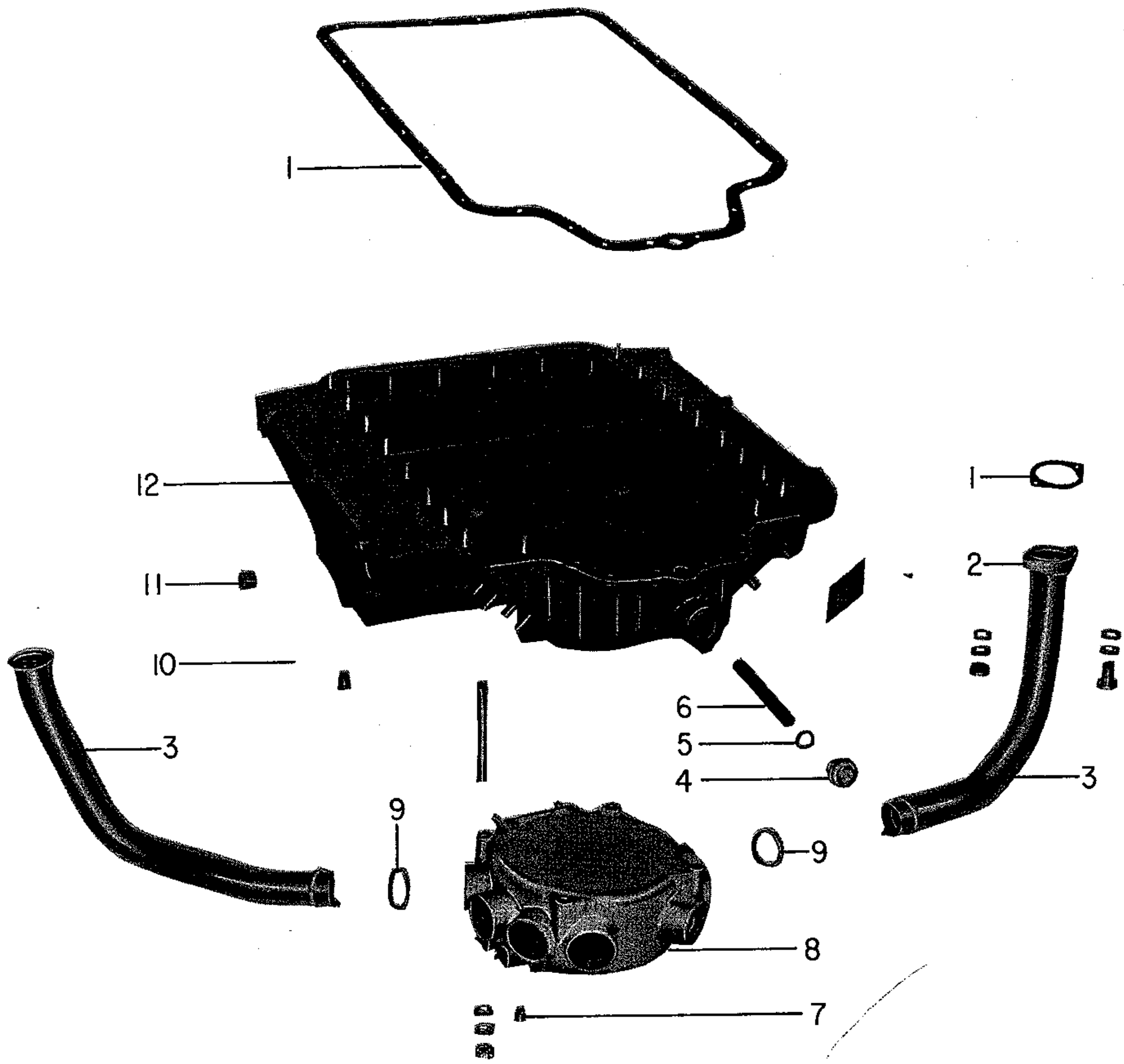
Figure 8-3. Oil Sumps and Induction Housing (O-540)

the manufacturer's publications. Consult Avco Lycoming, Service Bulletins nos. 305B, 320, 321, 322A, 331, 335 and 342 and be certain the fuel injector and nozzle lines have been modified to conform with these bulletins.

REASSEMBLY

8-30. When engine build-up has progressed to the point where the crankcase and the accessory housing have been assembled and the cylinders installed, the sump may be assembled on the engine. Using a new gasket assemble the oil sump to the crankcase and accessory housing. Consult the applicable parts catalog for correct fastenings. Tighten all fastenings to proper torque.

8-31. Induction Housing (IO-540 and TIO-540 Where applicable). See figure 8-3. Assemble the intake pipe extensions (16) in the housing and secure with intake pipe extension clamps (15) and studs (14). Assemble the induction housing to the sump. When the induction housing is fastened to the sump it forms a housing for the air inlet housing. Install the air inlet housing.



1. Gaskets
2. Intake Pipe Flange
3. Intake Pipes
4. 1 Inch Plug
5. Gasket
6. Oil Suction Screen
7. Helicoil
8. Induction Housing
9. Oil Seal
10. 1/2 Inch Plug
11. 3/4 Inch Plug
12. Oil Sump

Figure 8-4. Oil Sump and Induction System (IO-720)

8-32. Induction Housing (IO-720-A, -C). See figure 8-4. Assemble the induction housing (8) to the bottom of the sump.

8-33. Induction Housing (IO-720-B). Assemble the intake pipe extensions in the induction housing and secure with clamps and studs. Assemble the induction housing to the sump and the induction housing cover to the induction housing. Assemble the air inlet housing to the induction housing.

8-34. Carburetor or Fuel Injector - Using a new gasket, install the carburetor or fuel injector on its mounting pad. Note that the serial numbers of the pump assembly and throttle body of the Simmons #530 fuel injector must be the same. These units are not interchangeable.

8-35. Flow Dividers. The flow divider used in the Bendix fuel injection system is mounted in such a fashion that its discharge nozzles are in a horizontal plane. The flow divider is mounted generally to a peripheral crankcase fastening.

8-36. Intake Pipes. See figure 8-3. Slide a flange (7) over each intake pipe (8). Assemble either hose (4) and hose clamps (5) or "O" rings (9) over end of intake pipe and install in sump or induction housing. Place a new gasket (6) over the intake port and secure the flange to the cylinder. Slide hose (4) over connection (11) and tighten clamps.

8-37. Air Bleed Nozzles. Air bleed nozzles are installed in the cylinder head. In upper side of head on down exhaust cylinders and lower side of head on up exhaust cylinders. Install nozzle so that the identification mark (letter or figure on .500 hex) is installed toward the bottom of the engine within approximately one hex flat of the tightening torque limit (60 inch pounds).

8-38. Fuel Lines. Assemble fuel lines from fuel pump to fuel injector and fuel injector to flow divider. Assemble fuel injector nozzle lines. Consult Service Bulletins nos. 335 and 342 for instructions relative to clamping the nozzle lines.

SECTION 9.
TEST PROCEDURE

9-1. At 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 may have been installed and second, to give the operator control over the first critical hours of operation, during which time he can observe the functioning of the engine by means of the test cell instruments. Also, at this time any malfunction can be corrected and oil leaks repaired.

9-2. The test stand should be installed in a test cell that is clean and free of any articles that could be moved by the test club air blast.

9-3. The following instruments should be used, plus any additional instruments that may be deemed necessary by the operator. 0° to 600°F. temperature gage, counter tachometer, fuel flow meter, fuel pressure gage, manifold pressure gage, oil temperature gage, oil pressure gage and an oil flow measuring device.

NOTE

Avco Lycoming recommends that a test cell be used for run-in of engines after overhaul. Consult engine test equipment, SSP1169, for more detail list of cell equipment and schematic of oil supply system and fuel. In the event a test cell is not available, it is permissible to mount the engine in the airframe for the run-in providing the following requirements are observed.

1. The proper test club, not a flight propeller, is used.

2. A cooling shroud equivalent to a test cell cooling shroud is installed.

3. The airframe gages may not be used. All necessary calibrated gages shall be installed independent of the airframe.

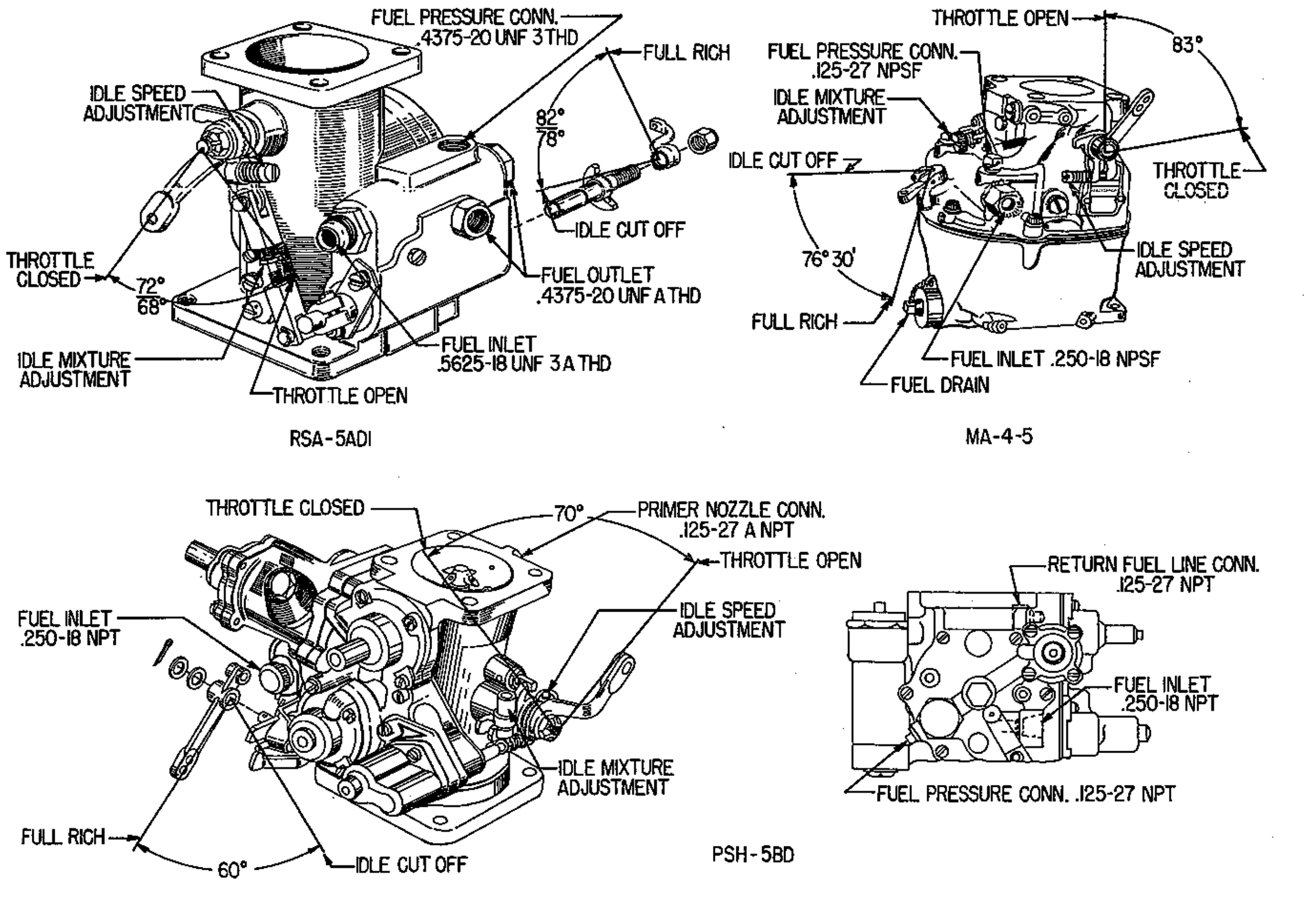


Figure 9-1. Fuel Metering Systems

TABLE 9-1

ENGINE RUN-IN TEST LIMITS

	Fuel Pressure psi - at inlet to carb. or injector	Fuel - Minimum Octane Rating Aviation Grade	Maximum Oil Consumption		Oil Press. Operating - psi		Oil Inlet Temp. °F.	Oil Outlet* Temp. °F.	Max. Cyl. Head Temp. Bayonet Location °F.	Full Throttle Engine Speed RPM
			Lbs./Hr.	Qt./Hr.	Normal	Idle				
O-235-C1, -C1B, -C2A -C2B, -E	2-5	80/87	0.9	.50	75-85	25	165-230	190-210	500	2800
O-235-F, -G, -J	2-5	100/130	0.9	.50	75-85	25	165-230	190-210	500	2800
O-235-C2C, -H2C	2-5	80/87	0.9	.50	75-85	25	165-230	190-210	500	2600
O-290-D, -D2	2-5	80/87	1.0	.56	75-85	25	165-230	190-210	500	2600
O-320-A, -E	2-5	80/87	1.2	.67	75-85	25	165-230	190-210	500	2700
O-320-B, -D	2-5	91/96	1.2	.67	75-85	25	165-230	190-210	500	2700
IO-320-A, -E	18-28	80/87	1.2	.67	75-85	25	165-230	190-210	500	2700
IO-320-B, -D	18-28	91/96	1.2	.67	75-85	25	165-230	190-210	500	2700
LIO-320-B	18-28	91/96	1.2	.67	75-85	25	165-230	190-210	500	2700
IO-320-C	18-28	100/130	1.2	.67	75-85	25	165-230	190-210	500	2700
LIO-320-C	18-28	100/130	1.2	.67	75-85	25	165-230	190-210	500	2700
AIO-320-A, -B, -C	18-28	91/96	1.2	.67	75-85	25	165-230	190-210	500	2700
O-340-A	2-5	91/96	1.3	.72	75-85	25	165-230	190-210	500	2700
O-360-A, -C(except-A1C, -C2B and -C2D	2-5	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
O-360-A1C, -C2B, -C2D	13-18	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
O-360-B, -D	2-5	80/87	1.4	.78	75-85	25	165-230	190-210	500	2700
IO-360-A, -C, -D	14-45	100/130	1.5	.83	75-85	25	165-230	190-210	500	2700
IO-360-B (except -B1A)	18-28	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
IO-360-B1A	-2-+2	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
IO-360-F	18-28	100/130	1.4	.78	75-85	25	165-230	190-210	500	2700
AIO-360	14-45	100/130	1.5	.83	75-85	25	165-230	190-210	500	2700
LIO-360-C	14-45	100/130	1.5	.83	75-85	25	165-230	190-210	500	2700
HO-360-A	2-5	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
HO-360-B	13-15	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
HIO-360-A, -C	14-45	100/130	1.5	.83	75-85	25	165-230	190-210	475	2900
HIO-360-B	14-45	91/96	1.5	.83	75-85	25	165-230	190-210	500	2900
HIO-360-D1A	14-45	100/130	1.5	.83	75-85	25	165-230	190-210	475	3200**
TIO-360-A	23-27	100/130	1.5	.83	70-80	25	165-230	190-210	475	2575
O-540-A, -D	2-5.5	91/96	1.8	1.0	75-85	25	165-230	190-210	500	2575
O-540-B	2-5.5	80/87	1.8	1.0	75-85	25	165-230	190-210	500	2575
O-540-E, -G, -H	2-5.5	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
IO-540-A, -B, -E, -G, -P	18-28	100/130	1.8	1.0	75-85	25	165-230	190-210	475	2575
IO-540-C, -J	18-28	91/96	1.8	1.0	75-85	25	165-230	190-210	500	2575
IO-540-D, -N, -R	18-28	91/96	1.4	.78	75-85	25	165-230	190-210	500	2700
IO-540-K, -L, -M, -S	18-28	100/130	1.8	1.0	75-85	25	165-230	190-210	475	2700
HIO-540-A	18-28	100/130	1.8	1.0	75-85	25	165-230	190-210	475	2575
TIO, LTIO-540-A	37-39	100/130	1.8	1.0	75-85	25	165-230	190-210	475	2575
TIO, LTIO-540-C, -E	37-39	100/130	1.8	1.0	75-75	25	165-230	190-210	500	2575
TIO, LTIO-540-J, -N, -F	37-39	100/130	1.8	1.0	75-85	25	165-230	190-210	475	2575
TIO, LTIO-540-H	37-39	100/130	1.8	1.0	75-85	25	165-230	190-210	500	2575
IO-720-A, -B, -C, -D	24-28	100/130	3.0	1.7	75-85	25	165-230	190-210	475	2650

* - Desired during oil consumption run.

** - Do not exceed 3150 RPM - for test stand at 24-25 inch Hg. manifold pressure. For oil consumption run, operate at 3100 RPM at 24 inch Hg. manifold pressure.

9-4. Test stand oil supply pressure to engines which can be run simulated wet sump shall be held to 1.5 - 2.0 psi throughout the run. Test stand oil supply pressure to engines run simulated dry sump shall be held to 0.5 - 3.0 psi at rated conditions. Personnel should consult Service Bulletin No. 113 when desiring to use dry sump test stand installation for wet sump engines.

9-5. Engines equipped with an integral full flow oil filter, should be run-in with a slave filter and the regular filter installed at the end of the run.

9-6. Turbocharged Engines. A slave filter should be installed between the oil supply hose and the turbocharger oil inlet. This slave filter should have a filtering capability of 100 microns or less and have a pressure relief valve set to 15 - 18 psi differential. This will assure that no metal particles are carried to the turbocharger lubrication system.

9-7. Any engine accessory drive, such as the propeller governor drive, which transmits oil pressure through oil passages in the engine and which is not pressurized by normal operation on the test stand shall be checked for leakage at normal oil pressure by means of a special drive cover with oil transfer holes as required. The oil passages involved shall be inspected for external leaks at the completion of the run.

9-8. It is desirable to have some method of maintaining the oil temperatures within the specified limits during the run-in. See Table 9-1. Engine should be idled until oil temperature is approximately 140°F. before starting the run-in schedule. See Table 9-2.

9-9. Operate during the run-in with (MIL-L-6082, Grade 1100) lubricating oil or if engine is to be stored with a mixture of 35% MIL-C-6529, type 1 and 65% MIL-L-6082.

9-10. Fuel shall conform to specifications. See Table 9-1.

9-11. Engines equipped with a fuel pump shall be tested with a test stand fuel system terminating in a float chamber vented to the atmosphere. The fuel level in this chamber shall be below the entrance to the fuel pump by at least one foot. The fuel pressure to the chamber shall be maintained at 2 to 5 psi.

9-12. Engines not equipped with a fuel pump shall be tested with either a remote or installed representative fuel pump.

9-13. PRESSURE CARBURETORS. New or reconditioned pressure carburetors must undergo a minimum of eight hours soaking before being placed in service. This can be accomplished before or after installation on the engine and is accomplished in the following manner. With the throttle lever wide open and the mixture control lever in "full rich" position, inject fuel into the fuel inlet connection until fuel flows from the fuel outlet. Close the throttle and move the mixture control to "idle cut-off".

9-14. Pre-Oiling 6 and 8 Cylinder Engines. After assembly of engine is complete, engines to be primed with the same lubricating oil as used in the engine by forcing 35 psi oil thru one main gallery until oil flows from the opposite gallery with the front end of the gallery open.

9-15. Attach the instrument connections and connect oil and fuel lines. Connect throttle and mixture control levers to the stand controls. Be sure the cables are free and not binding and that the travel is sufficiently long enough to completely open and close the throttle and to move the mixture control lever from full rich to idle cut-off. Install the applicable cooling shroud, test club and adapter. See Section 11. Be certain the test club will turn up rated RPM ± 50. See Table 9-1.

9-16. It is desirable to keep a log sheet and record the instrument readings during each speed of the run-in schedule. See Table 9-2.

9-17. Before starting be certain that the magneto switch is in the "off" position. Turn the engine over a few revolutions to ascertain that no interference exists within the arc of the test club or within the engine itself. If it does not turn freely, do not try to force it or attempt to start until the cause has been determined and the fault corrected.

9-18. RUN-IN. Start the engine in accordance with the following procedure.

a(1). Float type carburetor or Simmonds Injector - Place mixture control in "full rich" position.

a(2). Pressure Carburetor or Bendix Fuel Injector - Place mixture control in idle cut-off position.

b. Turn fuel valve to "on" position.

c. Set throttle at 1/10 open position.

d(1). Turn magneto switch to "left" and engage starter.

TABLE 9-2

RECOMMENDED RUN-IN SCHEDULE

RPM	LOAD	TIME (MINUTES)	REMARKS
1200	Prop. Load	10	
1500	Prop. Load	10	
1800	Prop. Load	10	Check magneto drop-off.
2000	Prop. Load	10	Do not exceed 125 RPM on either
2200	Prop. Load	10	magneto or 35 RPM between
2400	Prop. Load	10	magnetos.
Normal Rated*	Prop. Load	15	
Normal Rated*	Prop. Load	60	Oil Consumption Run.

* - See Table 9-1.

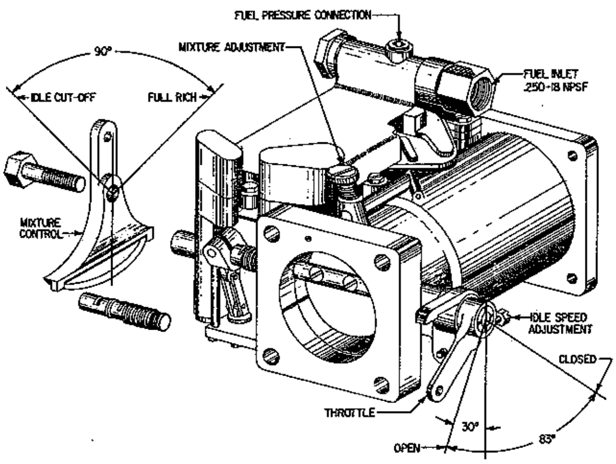


Figure 9-2. Carburetor - HA-6

d(2). Turn combination magneto-starter switch to "start".

e(1). When engine fires, move mixture control smoothly to "Full Rich" on pressure carburetor or Bendix fuel injectors.

e(2). Leave float type carburetors and Simmonds injectors in "full rich".

f(1). Move magneto switch to "both".

f(2). Combination spring loaded switches will return to "both".

CAUTION

If oil pressure is not indicated within ten seconds, stop engine and determine cause.

9-19. Operate engine at approximately 1000 RPM until a minimum oil in temperature of 140° F. is obtained. Check magneto drop-off and general operation of the engine. Check the engine for oil leaks. Any malfunction or oil leak should be remedied before continuing the run.

9-20. Complete the run in accordance with the schedule listed in Table 9-2.

9-21. OIL CONSUMPTION RUN. An oil consumption run should be made at the end of the run-in schedule. Oil consumption can be determined by the use of a scale tank through which the oil lines pass and the scale reading taken at the beginning and end of the oil consumption run. Or it can be determined by draining and weighing the oil supply before and after the oil consumption run. Oil temperature should be held as closely as possible to the limits shown in Table 9-1. Oil consumption should not exceed the maximum as listed in Table 9-1.

9-22. OIL PRESSURE RELIEF VALVE. Subject engines may be equipped with either an adjustable or a non-adjustable relief valve. A brief description, of both types, follows.

9-23. Non-adjustable Oil Pressure Relief Valve - Although the valve is not adjustable, the oil pressure can be controlled by the addition of STD-425 washers under the cap as required (maximum of three) to increase pressure or the use of a spacer (P/N 73629 or 73630) to decrease pressure. A later modification to the relief valve eliminates the need of the spacer and uses STD-425 washers as required (maximum of nine). Particles of metal or other foreign matter between the ball and the seat can cause the oil pressure to drop or fluctuate. Therefore, if a drop or excessive fluctuation is noted it is advisable to disassemble, inspect and clean the valve.

9-24. Adjustable Oil Relief Valve - The adjustable oil pressure relief valve enables the operator to maintain engine oil pressure within the specified limits (see Table 9-1). The oil pressure can be adjusted by turning the adjusting screw in to increase pressure or out to decrease pressure. The adjusting screw can be turned with either a screw driver or a socket wrench.

9-25. IDLE SPEED AND MIXTURE ADJUSTMENT - (Except Simmonds Fuel Injector). See figures 9-1 and 9-2. With engine thoroughly warmed up, check magneto drop-off. If the drop-off is excessive, check for fouled plugs. If drop-off is normal, proceed with idle adjustment. Close the throttle, engine should idle at approximately 600 RPM (turbocharged engines, approximately 1000 RPM). If the RPM increases appreciably after a change in the idle mixture adjustment during the succeeding steps, readjust the idle speed adjustment to restore the desired RPM.

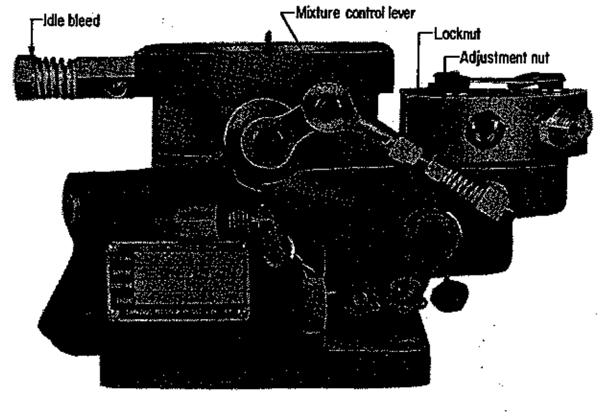
9-26. Move the mixture control lever with a smooth, steady pull into the idle-cut-off position and observe the tachometer for any change during the leaning process. Caution must be exercised to return the mixture control lever to "full rich" before the RPM can drop to a point where the engine cuts out. An increase of more than 50 RPM while "leaning out" indicates an excessively rich mixture. An immediate decrease in RPM (if not preceded by a momentary increase) indicates the mixture is too lean.

9-27. If it is indicated that the mixture is either too lean or too rich, turn the idle mixture adjustment one or two notches in the direction required for correction. Check this setting by repeating the above procedure. Each time the adjustment is changed, the engine should be run up to 2000 RPM to clear the engine before proceeding with the idle speed check. The final adjustment of the idle speed should be made with throttle closed.

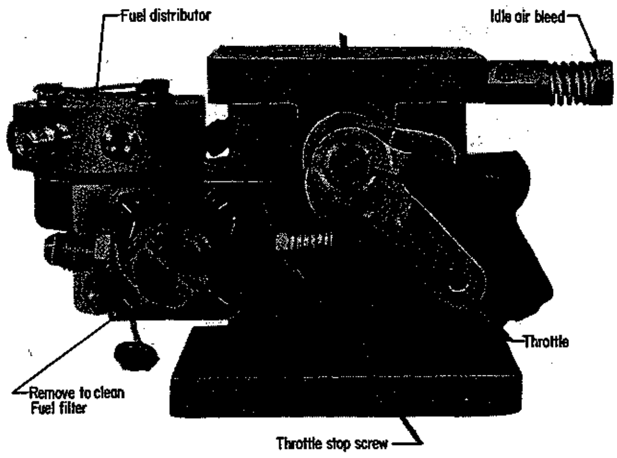
9-28. IDLE SPEED AND MIXTURE ADJUSTMENT - (Simmonds Injector). See figure 9-3. Three adjustments can be made for proper engine idling conditions. All three are made on the throttle body assembly.

1. Throttle Lever Stop Adjustment - This adjustment changes idle speed and mixture simultaneously. If engine idles too slowly turn adjustment screw clockwise until satisfactory idle is obtained.

2. Idle Air Bleed Adjustment. If a satisfactory idle is not obtained by the first adjustment proceed as follows.



Right Side View



Left Side View

Figure 9-3. Simmonds Type 530 Fuel Injector Throttle Body

a. Move the mixture control lever toward the idle cut-off position with a smooth, steady pull and note tachometer. An increase of more than 10 RPM indicates an excessively rich mixture while an immediate decrease (if not preceded by a momentary increase) indicates the mixture is too lean. If mixture is too rich, turn idle air bleed adjustment screw counter-clockwise, if the mixture is too lean turn the idle air bleed adjustment screw clockwise. Make adjustments until a check results in a pick-up of five (never more than 10 RPM). Each time an adjustment is made the engine should be run up to 2000 RPM to clear the engine before the check is made. If idle speed is affected by this change turn throttle lever stop adjustment in the direction required to obtain proper idle speed.

3. Mixture Control Lever Linkage. If proper idle cannot be obtained by the first two steps proceed as follows.

CAUTION

This is a sensitive adjustment, factory pre-set and normally not requiring adjustment. If, however, adjustment is necessary the nut should be moved only 1/6 (one-sixth) of a turn at a time.

a. First unloosen locknut. If mixture is too rich as determined in step 2, turn adjustment nut 1/6 of a turn counter-clockwise. Lock with locknut and check mixture. Repeat 1/6 turn adjustments until a check results in a pick up of five (never more than 10 RPM).

b. If idle mixture is too lean, unloosen locknut and turn adjustment nut clockwise 1/6 of a turn. Lock with locknut and check mixture. Repeat 1/6 turn adjustments until proper idle mixture is obtained.

c. If the preceding adjustments change the idle speed, turn throttle lever stop adjustment in the required direction until proper idle speed is obtained.

9-29. PRESERVATION AND STORAGE. In the event the engine is to be stored at the completion of the run-in the engine should be preserved in the following manner.

9-30. Upon completion of the run-in, drain the oil. Refill the engine with a 1 to 1 mixture of MIL-L-6529, Type 1, and Bayol "D" or equivalent.

9-31. Remove top spark plugs, and with the crankcase full of oil, slowly turn the propeller through two (2) revolutions. Let engine stand for ten (10) minutes after which the propeller should be turned back and forth through 90° for twelve (12) cycles. Drain the preservative oil.

9-32. Spray the exhaust port and valve of each cylinder with the piston approximately 1/4 turn before top center of the exhaust stroke using MIL-C-6529 oil, Type 1.

9-33. Spray each cylinder with an airless spray gun (Spraying Systems Company "Gunjet" model 24A-8395 or equivalent) through the spark plug holes with MIL-C-6529 oil, Type 1. Spray approximately two (2) ounces of oil into each cylinder.

9-34. For all spraying the spray nozzle temperature shall be maintained between 200°F. and 220°F.

NOTE

In the event an airless spray gun is not available, it is recommended that a moisture trap be installed in the air line of a conventional spray gun and the oil shall be 200°F. to 220°F. at the nozzle.

9-35. Seal the breather openings with oil and moisture resistant caps or dehydrator plug, P/N 40238 or AN4062-11.

9-36. All accessory drives for which oil seals are provided shall be liberally coated with MIL-C-6529 oil, Type 1, before applying the drive covers.

9-37. Engines shall have spark plugs installed in the bottom cylinder location and dehydrator plugs, P/N 40238 installed in the upper cylinder location. The ignition harness shall be attached to the spark plugs in the bottom locations and have ignition cable protectors (AN-4060) on the top locations.

9-38. Exhaust ports and other openings should be closed with suitable covers. The turbine outlet on turbocharged engines should be covered.

9-39. All exposed cadmium plated and machined surfaces should be liberally coated with soft-film, corrosion preventive compound, MIL-C-16173, Grade 2.

9-40. Although the above procedure should prevent corrosion under favorable conditions it is recommended that the engine be periodically inspected for evidence of corrosion. If corrosion should be present, the affected part should be cleaned and the engine represerved. Also, engines preserved by the above procedures are not adequately protected for extended periods of storage. If at the end of 60 days it is found that the engine must remain in storage it must be represerved.

9-41. REPRESERVATION RUN - The represervation run should be accomplished under the same conditions as the run-in after overhaul except that only the following time schedule must be followed.

TABLE 9-3

RECOMMENDED REPRESERVATION SCHEDULE

RPM	LOAD	TIME (MINUTES)
1200	Prop. Load	5
1800	Prop. Load	5
2400	Prop. Load	5
Normal Rated	See Table 9-1	15

9-42. PRESERVATION AND STORAGE - Float Type Carburetors. Carburetor shall be emptied of all residual gasoline and the throttle locked in the closed position.

9-43. Pressure Carburetors and Fuel Injectors - Carburetors and fuel injectors shall be emptied of all residual fuel and flushed with oil, MIL-O-6081, Grade 1010. Injectors will have approximately one (1) ounce poured into inlet under gravity head. The injector will be rocked to cover all interior surfaces. Injectors with fluoro-silicone diaphragms and seals (no cure date) do not require flushing. Carburetors shall have the oil supplied to the inlet port at a pressure of from 5 to 8 psi. Mixture controls shall be at full rich during the flushing operation. Under no circumstances shall the regulator air chambers, air passages, or automatic mixture control be flushed with oil; these must be kept dry at all times. Drain excess oil and install plugs or caps. Lock the throttle in the closed position.

TEXTRON Lycoming

SERVICE TABLE OF LIMITS AND TORQUE VALUE RECOMMENDATIONS

NOTICE

The basic Table of Limits, SSP2070 (including SSP2070-1, SSP2070-2, SSP2070-3 and SSP2070-3A) has been completely revised and reissued herewith as SSP1776. It is now made up of the following four parts, each part contains five sections.

PART I	DIRECT DRIVE ENGINES (Including VO and IVO-360)
PART II	INTEGRAL ACCESSORY DRIVE ENGINES
PART III	GEARED ENGINES
PART IV	VERTICAL ENGINES (Excluding VO and IVO-360)

SECTION I	500 SERIES	CRANKCASE, CRANKSHAFT & CAMSHAFT
SECTION II	600 SERIES	CYLINDERS
SECTION III	700 SERIES	GEAR TRAIN
SECTION IV	800 SERIES	BACKLASH (GEAR TRAIN)
SECTION V	900 SERIES	TORQUE AND SPRINGS

This publication supersedes and replaces the previous publications SSP2070, SSP2070-1, SSP2070-2, SSP2070-3 and SSP2070-3A; it is not to be used in conjunction with them. To make sure that SSP1776 will receive the attention of maintenance personnel, a complete set of pages for the book is sent to all registered owners of Overhaul Manuals. These recipients should remove all previous Table of Limits material from the Overhaul Manual and discard.

Additional copies of this revised Table of Limits, bound in a plastic cover, are available as indicated in the latest edition of Service Letter No. L114.

Reference numbers in the Table of Limits vary from previous Table of Limits therefore, the current as well as the old numbers are listed. The shaded columns contain the old reference numbers.

* - Indicates cut-off date for data retrieved prior to publication.

INTRODUCTION
SERVICE TABLE OF LIMITS

This Table of Limits is provided to serve as a guide to all service and maintenance personnel engaged in the repair and overhaul of Textron Lycoming Aircraft Engines. Much of the material herein contained is subject to revision; therefore, if any doubt exists regarding a specific limit or the incorporation of limits shown, an inquiry should be addressed to the Textron Lycoming factory for clarification.

DEFINITIONS:

Ref. (1st column)	The numbers in the first column headed "Ref." are shown as a reference number to locate the area described in the "Nomenclature" column. This number will be found in a diagram at the end of each section indicating a typical section where the limit is applicable.
Ref. (2nd column)	Indicates the old reference number. There are no diagrams in this manual for these numbers. These numbers are only to be found in previous publications.
Chart (3rd column)	The letter or letter and number in this column are used as symbols to designate engine models to which the specific limits is applicable. A list of the letter or letter and number and the engine to which they refer is shown below.
Nomenclature (4th column)	This is a brief description of the parts or fits specified in the adjacent columns and indicated in the diagram at end of each section.
Dimensions (5th & 6th columns)	The dimensions shown in column 5 are the minimum and maximum dimensions for the part as manufactured. The dimensions shown in column 6 indicate the limit that must not be exceeded. Unless it can be restored to serviceable size, any part that exceeds this dimension must not be rebuilt into an engine.
Clearance (7th & 8th columns)	Like the dimensions shown in the 5th and 6th columns, the clearance represents the fit between the two mating surfaces as controlled during manufacture and as a limit for permissible wear. Clearances may sometimes be found to disagree with limits for mating parts; for example, maximum diameter of cylinder minus minimum diameter of piston exceeds limit for piston and barrel clearance. In such instances, the specified maximum clearance must not be exceeded.

In some instances, where a parts revision has caused a dimensional or tolerance change, the superseded dimenional data has been deleted from the list; provided compliance with the change is not mandatory.

Letters of the alphabet and numbers are used as symbols throughout the Table of Limits to represent specific interpretations and to designate engine models. Letters in parenthesis refer to dimensional characteristics; letters (or combinations of letters and numbers) without parenthesis indicate engine models. They are listed below with their separate definitions.

(A)	These fits are either shrink fits controlled by machining, fits that may readily be adjusted, or fits where wear does not normally occur. In each case, the fit must be held to manufacturing tolerance.
(B)	Side clearance on piston rings must be measured with face of ring flush with piston .
(D)	The dimensions shown are measured at the bottom of the piston skirt at right angles to the piston pin.
(E)	Permissible wear of the crankshaft (rod and main bearing journals) to be minus 0.0015 on the diameter.
(L)	Loose fit; wherein a definite clearance is mentioned between the mating surfaces.
(T)	Tight fit; shrink or interference fit.
(WD)	Wide Deck Crankcase.

Introduction

The illustrations shown are typical of the referenced limit or fit described in the Table and in no instance are these illustrations intended to represent a specific part or engine model unless specified. Also, the terms used to designate cylinder, piston and ring materials such as "nitride, chrome, half-wedge" are more fully explained in the latest edition of Service Instruction No. 1037.

PART I DIRECT DRIVE ENGINES (Including VO and IVO-360)

CHART	MODELS
A	0-235
A1	0-235-F, -G, -K, -L
B	0-290
B1	0-290-D2
D	0-435-A
BD	0-320-H (76 Series)
G	O, IO, LIO, AEIO-320
G1	O, IO-320 With Gov. at Front (0-320-E1F, -E1J, -D1F & IO-320-D1B)
G2	AIO-320
J	0-340
Y	VO, IVO-360
S	O, IO, LIO, HIO, LHIO, TO, TIO, AEIO-360
S1	TO-360
S2	AIO-360
S3	TIO-360
S4	0-360-A With Gov. at Front (0-360-A1H, -A1LD)
S5	IO, LIO-360-A, -C (Angle Valve)
S6	IO, LIO-360-A, -C With Gov. at Front (IO, LIO-360-C1E6 & IO-360-A1D6)
S7	HIO-360-D
S8	HIO-360-B
S9	HIO-360-C, -E
S10	HIO-360-A
T	O, IO, LIO, AEIO, TIO, LTIO-540
T1	0-540-G, -H & IO-540-N, -R (Large Mains - Parallel Valve)
T2	IO-540-A, -B, -E, -G, -P (Angle Valve)
T3	IO-540-K, -M, -S; TIO, LTIO-540-A, -F, -J, -N, -R (Large Mains - Angle Valve)
T4	TIO-540-C, -E, -G, -H
AF	IO-720
BE	O, LO-360-E (76 Series)

NOTE: In "Chart" column, a number appearing after a letter shows exception to the basic model.

SERVICE TABLE OF LIMITS

PART 1 DIRECT DRIVE ENGINES

SECTION I CRANKCASE, CRANKSHAFT, CAMSHAFT

Ref. New	Ref. Old	Chart	Nomenclature	Dimensions Mfr. Min. & Max.	Dimensions Serv. Max.	Clearances Mfr. Min. & Max.	Clearances Serv. Max.
500	501	A	All Main Bearings and Crankshaft			.0025L / .0055L	.0060L
		B-D-G-J-S-T-Y-BD-BE-AF	Main Bearings and Crankshaft (Thin Wall Bearing - .09 Wall Approx.)			.0015L / .0045L	.0060L
		B-G-J-S-T-Y-AF	Main Bearings and Crankshaft (Thick Wall Bearing - .16 Wall Approx.)			.0011L / .0041L	.0050L
		A	Diameter of Main Bearing Journal on Crankshaft	2.3735 / 2.375	(E)		
		B-D-G-J-S-T-Y-BD-BE	Diameter of Main Bearing Journal on Crankshaft (2-3/8 in. Main)	2.3745 / 2.376	(E)		
		T1-T3-AF	Diameter of Main Bearing Journal on Crankshaft (2-5/8 in. Main)	2.6245 / 2.626	(E)		
		S8-S10	Diameter of Front Main Bearing on Journal on Crankshaft (2-3/8 in. Main)	2.3750 / 2.3760	(E)		
		T1-T3-AF	Diameter of Front Main Bearing Journal on Crankshaft (2-5/8 in. Main)	2.6245 / 2.6255	(E)		
500	955	A-B-B1-D-G*-BD-BE	Crankcase Bearing Bore Diameter (All) (Thin Wall Bearing) (2-3/8 in. Main)	2.566 / 2.567	2.5685		
		G**-J-S-T-Y	Crankcase Bearing Bore Diameter (All Except Front) (Thick Wall Bearing) (2-3/8 in. Main)	2.6865 / 2.6875	2.6890		
		T1-T3-AF	Crankcase Bearing Bore Diameter (Front Only) (Thin Wall Bearing) (2-5/8 in. Main)	2.816 / 2.817	2.8185		
		T1-T3-AF	Crankcase Bearing Bore Diameters (All Except Front) (Thick Wall Bearing) (2-5/8 in. Main)	2.9365 / 2.9375	2.9390		
		S1-T-AF	Crankcase Bearing Bore Diameter (All) (Thin Wall Bearing) (2-5/8 in. Main)	2.816 / 2.817	2.8185		
		G**-J-S-T-Y * 0-320-A, -E Narrow Deck. ** 0-320-A, -E Wide Deck.	Crankcase Bearing Bore Diameter (Front Only) (Thin Wall Bearing) (2-3/8 in. Main)	2.566 / 2.567	2.5685		
501	502	ALL	Connecting Rod Bearing and Crankshaft			.0008L / .0038L	.0050L
		A-B-D-G-J-S-T-Y-BD	Diameter of Connecting Rod Journal on Crankshaft (2-1/8 in.)	2.1235 / 2.125	(E)		

SERVICE TABLE OF LIMITS

PART 1 DIRECT DRIVE ENGINES

SECTION I CRANKCASE, CRANKSHAFT, CAMSHAFT

Ref. New	Ref. Old	Chart	Nomenclature	Dimensions Mfr. Min. & Max.	Dimensions Serv. Max.	Clearances Mfr. Min. & Max.	Clearances Serv. Max.
501	502	S-T-AF	Diameter of Connecting Rod Journal on Crankshaft (2-1/4 in.)	2.2485 / 2.250	(E)		
	954	A-B-D-G-J-S-T-Y-BD-BE	Connecting Rod Bearing Bore Diameter (2-1/8 in.) (Measured At Axis 30^{o} on Each Side)	2.2870 / 2.2875			
		S-T-AF	Connecting Rod Bearing Bore Diameter (2-1/4 in.) (Measured At Axis 30^{o} on Each Side)	2.4205 / 2.4210			
502	564	ALL	Connecting Rod - Side Clearance			.004L / .010L	.016L
503	566	ALL	Connecting Rod - Alignment			.010 in 10 Inches	
504	567	ALL	Connecting Rod - Twist			.012 in 10 Inches	
505	556		Crankshaft Run-Out at Center Main Bearing				
		4 CYLINDER	Mounted on No. 1 and 4 Journals Max. Run-Out No. 2 Journal			.002	.002
			Mounted on No. 1 and 4 Journals Max. Run-Out No. 3 Journal			.005	.0075
			Mounted on No. 2 and 4 Journals Max. Run-Out No. 3 Journal			.003	.0045
		6 CYLINDER	Mounted on No. 2 and 5 Journals Max. Run-Out No. 1 Journal			.002	.002
			Mounted on No. 2 and 5 Journals Max. Run-Out No. 3 Journal			.005	.0075
			Mounted on No. 2 and 4 Journals Max. Run-Out No. 3 Journal			.003	.0045
			Mounted on No. 3 and 5 Journals Max. Run-Out No. 4 Journal			.003	.0045
		8 CYLINDER	Mounted on No. 2 and 6 Journals Max. Run-Out No. 1 Journal			.002	.002
			Mounted on No. 2 and 4 Journals Max. Run-Out No. 3 Journal			.003	.0045
			Mounted on No. 3 and 5 Journals Max. Run-Out No. 4 Journal			.003	.0045
			Mounted on No. 4 and 6 Journals Max. Run-Out No. 5 Journal			.003	.0045
			Mounted on No. 2 and 6 Journals Max. Run-Out No. 3,4 and 5 Journals			.005	.0075
506	568	ALL	Crankshaft and Crankcase Front End Clearance			.009L / .016L	.026L
507	938	ALL	Clearance - Front Face of Crankshaft Oil Slinger to Front Face of Recess in Crankcase (Crankshaft Against Thrust Face)			.002 / .007L	(A)

SERVICE TABLE OF LIMITS

PART 1 DIRECT DRIVE ENGINES

SECTION I CRANKCASE, CRANKSHAFT, CAMSHAFT

Ref. New	Ref. Old	Chart	Nomenclature	Dimensions Mfr. Min. & Max.	Dimensions Serv. Max.	Clearances Mfr. Min. & Max.	Clearances Serv. Max.
508	607	ALL	Crankshaft Prop. Flange Run-Out			.002	.005
509	941	ALL	Starter Ring Gear and Support			.014T / .022T	(A)
510	504	A-B-D-G-J-S-T-Y-AF BD-BE	Crankshaft Timing Gear and Crankshaft			.0005T / .0010L	(A)
511	536	A-B-D-G-J-S-T-Y-AF	Tappet Body and Crankcase			.0010L / .0033L	.004L
		BD-BE	Tappet Body and Crankcase			.0010L / .0030L	.004L
		A-B	O.D. of Tappet	.6232 / .6240	.6229		
		B1-D-G-J-S-T-Y-AF	O.D. of Tappet	.7169 / .7177	.7166		
		BD-BE	O.D. of Tappet	.8740 / .8745	.8737		
		A-B	I.D. Tappet Bore in Crankcase	.6250 / .6263	.6266		
		B1-D-G-J-S-T-Y-AF	I.D. Tappet Bore in Crankcase	.7187 / .7200	.7203		
		BD-BE	I.D. Tappet Bore in Crankcase	.8755 / .8773	.8776		
512	559	B1-D-G-J-S-T-Y	Tappet Plunger Assembly and Body - Chilled			.0010L / .0047L	.0067L
		S7-S1-AF	Tappet Plunger Assembly and Body - Hyperbolic			.0010L / .0067L	.0087L
513	560	B1-D-G-J-S-T-Y	Tappet Socket and Body			.002L / .005L	.007L
		S7-S1-AF	Tappet Socket and Body (Hyperbolic)			.002L / .007L	.009L
514	537	ALL	Camshaft and Crankcase			.002L / .004L	.006L
515	538	ALL	Camshaft - End Clearance			.002L / .009L	.015L
516	539	ALL	Camshaft Run-Out at Center Bearing Journal			.000 / .001	.006
517	578	All Models Using Counterweights	Counterweight Bushing and Crankshaft			.0013T / .0026T	(A)
518	579	All Models Using Counterweights	Counterweight Roller - End Clearance			.007L / .025L	.038L
519	580	All Models Using Counterweights	Counterweight and Crankshaft - Side Clearance*			.003L / .013L	.017L
520	696	All Models Using Counterweights	Counterweight Bore and Washer O.D.			.0002L / .0030L	(A)
521	775	All Models Using Counterweights	I.D. of Counterweight Bushing	.7485 / .7505	.7512		
		* Measure below roller next to flat.					