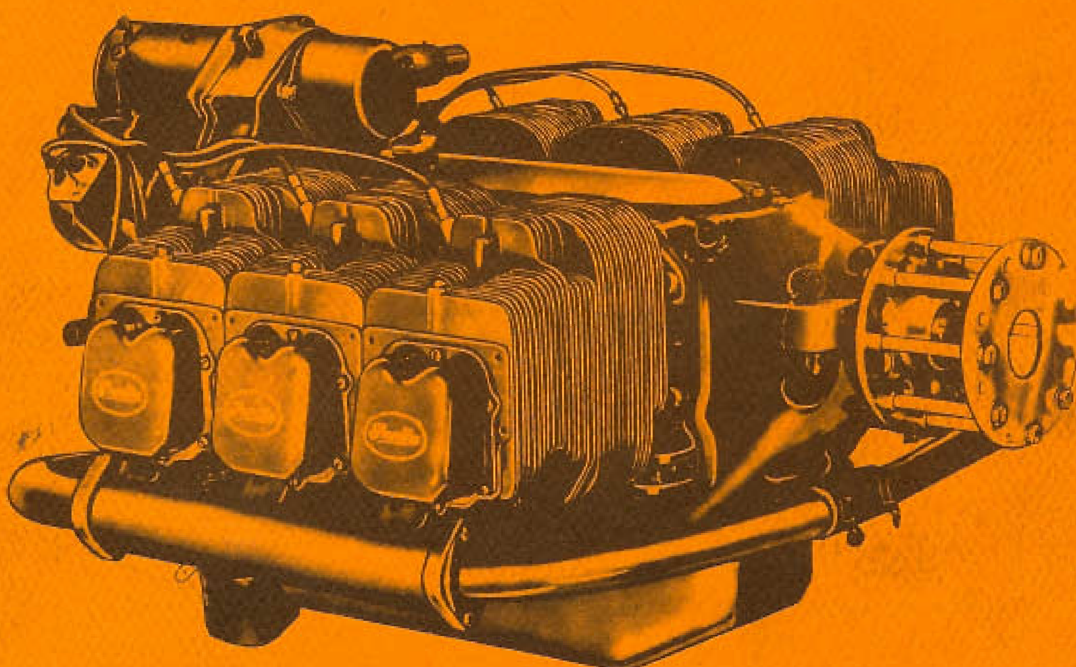
SERVICE MANUAL

FRANKLIN
AIRCRAFT ENGINE

Models 6A4-150-B3, B31, & 6A4-165-B3



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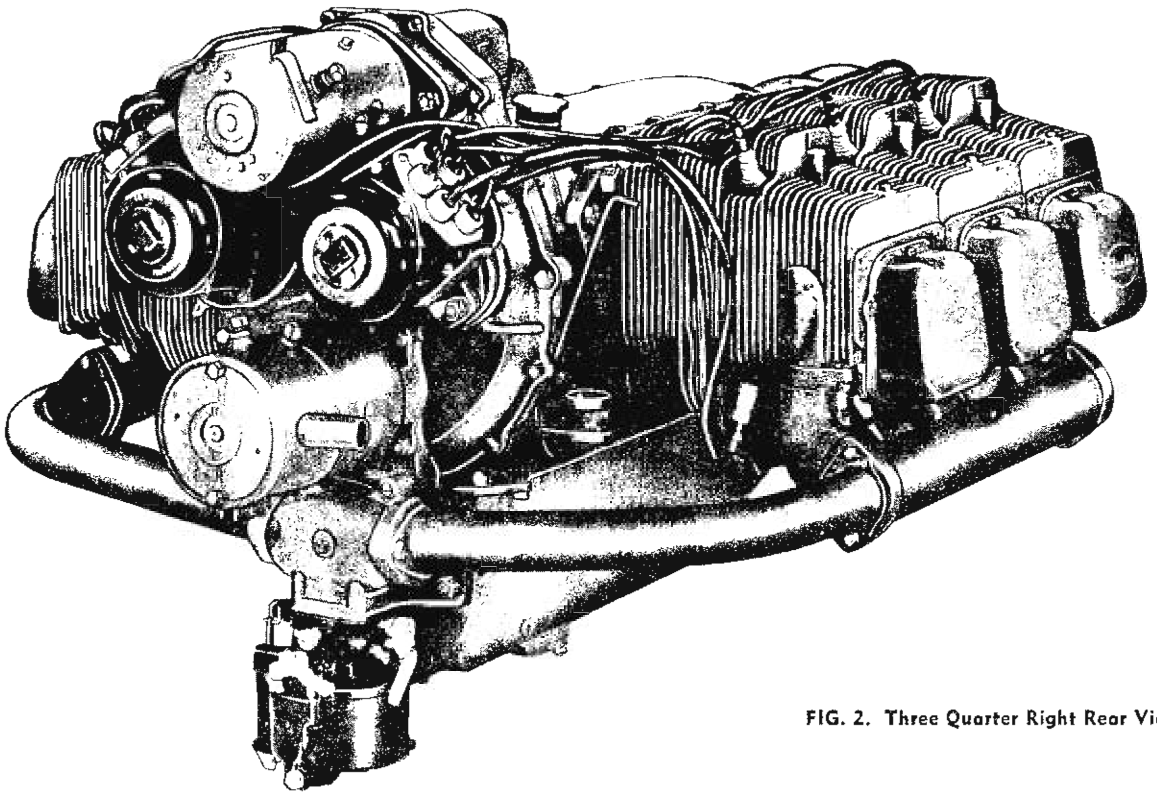


FIG. 2. Three Quarter Right Rear View

V – ENGINE SPECIFICATIONS

Model	6A4-150-B3 & B31		6A4-165-B3	
Number of Cylinders	6		6	
Bore	4.5"		4.5"	
Stroke	3.5"		3.5"	
Piston Displacement	335 cu. in.		335 cu. in.	
Compression Ratio	7:1		7:1	
Rated Speed in RPM	2600		2800	
Rated Brake Horsepower	150 HP at 2600 RPM		165 HP at 2800 RPM	
Idle Speed in RPM	500 to 600		500 to 600	
Crankshaft Rotation	Clockwise		Clockwise	
Propeller Shaft Rotation	Clockwise		Clockwise	
Propeller to Crankshaft Ratio	1:1		1:1	
Maximum Cylinder Temperature	520°F Maximum Spark Plug		520°F Maximum Spark Plug	
Maximum Oil Temperature	230°F		230°	
Oil Pressure	30 to 50 PSI Maximum		30 to 50 PSI Maximum	
Oil Pressure at Idle	10 to 20 PSI Minimum		10 to 20 PSI Minimum	
Oil Capacity	8 Quarts		8.8 Quarts	
Oil Specifications	Free Air Temperature	Viscosity	Free Air Temperature	Viscosity
Heavy Duty	Above 40°F	SAE 40	Above 40°F	SAE 40
Heavy Duty	Below 40°F	SAE 20	Below 40°F	SAE 20
Maximum Operating Time between Oil Changes	25 Hours. More often if conditions warrant.		25 Hours. More often if conditions warrant.	
Valve Clearance with Lifters Bled Down and Engine Cold	.040"		.040"	
Firing Order	Cylinders 1-4-5-2-3-6		Cylinders 1-4-5-2-3-6	
Spark Timing	28 Degrees BTC		32 Degrees BTC	
Spark Plugs	Champion J-10		Champion J-10	
Spark Plug Gap	.014" to .018"		.014" to .018"	
Fuel Minimum Octane	80 Nonleaded Aviation		80 Nonleaded Aviation	
Fuel Pump Pressure (Bellanca Only)	7½ PSI Maximum		7½ PSI Maximum	
Starter	12 Volt		12 Volt	
Generator	15 Amp. to 25 Amp.		25 Amp.	
Magneto Breaker Point Gap	.019" to .021"		Not Specified	
Maximum Drop Single Magneto	200 RPM		200 RPM	

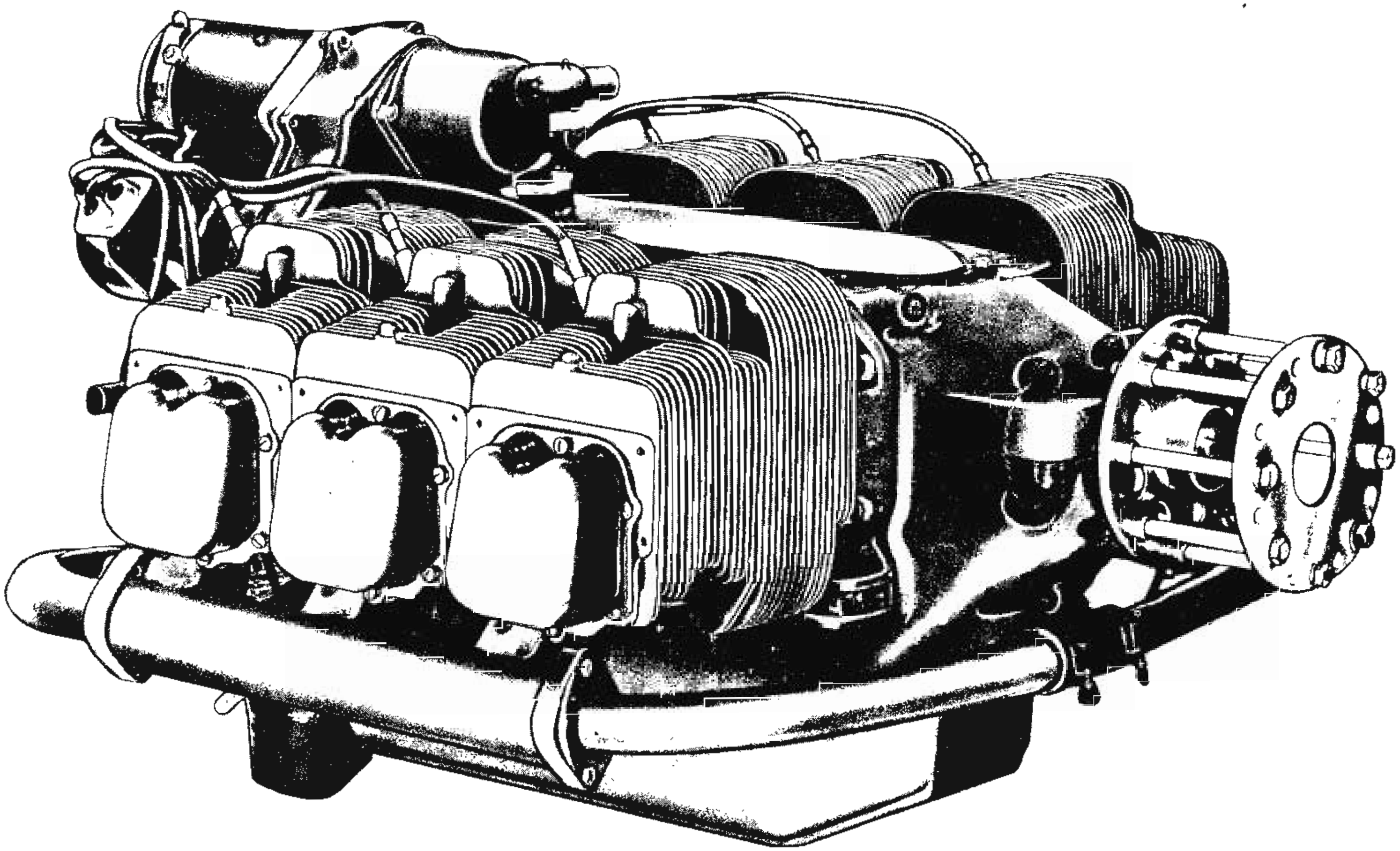


FIG. 1. Three Quarter Right Front View

VI—TABLE OF LIMITS AND TOLERANCES

Description of Limits	Mfg. Min.	Mfg. Max.	Max. After Wear
Crankcase & Thrust Washer Dowel	.0008T	.0017T	.004L
Thrust Washer & Crankcase Dowel	.001T	.005T	.010L
Crankcase Half & Dowel	.0005T	.001L	.001L
Crankshaft Bushing & Crankshaft	.002L	.004L	.006L
Crankshaft End Clearance	.008	.020	.026
Connecting Rod Bushing & Crankshaft	.0015L	.0034L	.0055L
Connecting Rod & Bolt (Diam.)	.0005L	.002L	.002L
Connecting Rod Side Clearance	.008	.014	.018L
Crankcase & Mounting Bracket Dowel	.0005T	.001L	.002L
Mounting Bracket & Crankcase Dowel	.0005T	.001L	.002L
Camshaft Bushing & Camshaft	.0015L	.0025L	.004L
Camshaft End Clearance	.006	.010	.014L
Crankshaft Gear & Crankshaft	.001T	.002T	.001T
Camshaft Gear & Camshaft	.0005T	.002T	.0005T
Crankshaft & Camshaft Gears (Backlash)	.004	.012	.016
Crankshaft & Magneto Drive Gear Hub	.002T	.0038T	.002T
Crankshaft Run Out		.002	.004
Main & Crank Journal Fillet Radii	.125	.140	
Crankshaft & Dowel (Flange)	.0015T	.003T	.001T
Piston & Piston Pin (Hand Push Fit with Piston at Room Temperature)	.0000		.0005L
Connecting Rod & Piston Pin	.0007L	.0012L	.002L
Piston Pin & Plug	.0005L	.0025L	.004L
Cylinder Liner Extension Below Cylinder Flange	.500	.515	
Cylinder Barrel & Piston Pin (End Clear.)	.015	.033	.050
Cylinder Barrel & Piston (Skirt)	.002L	.0035L	.007L
Cylinder Barrel & Piston (Topland & lands between grooves)	.028L	.030L	.036L
Piston Ring Gap (All Rings)	.013	.023	.040
Piston & Top Piston Ring (Side Clearance)	.0055L	.007L	.009L
Piston & 2nd Piston Ring (Side Clearance)	.0035L	.005L	.007L
Piston & 3rd Piston Ring (Side Clearance)	.002L	.0035L	.0055L
Bushing & Valve Rocker Pin	.002L	.0035L	.007L

Valve Rocker Support (Stamped) & Valve Rocker Pin	.001T	.0015L	.0025L
Valve Rocker Support (Al. Block) & Valve Rocker Pin	.001T	.0005L	.0015L
Valve Rocker End Clearance	.003	.008	.008L
Valve Guide & Cylinder Head (Early Engines)	.003T	.004T	.002T
Valve Guide & Cylinder Head (Late Engines)	.002T	.003T	.002T
Valve Guide & Intake Valve	.0025L	.0043L	.006L
Valve Guide & Exhaust Valve	.0025L	.0043L	.006L
Cylinder Head & Intake Valve Seat Insert	.004T	.006T	.003T
Cylinder Head & Exhaust Valve Seat Insert	.0041T	.0061T	.003T
Valve Lifter & Crankcase	.001L	.002L	.004L
Oil Pump Gear & Shaft	.0005T	.002T	.0005T
Oil Pump Drive Shaft & Pump Body	.001L	.0025L	.004L
Oil Pump Drive Gears & Shaft	.0000	.0015T	.000
Oil Pump Stationary Shaft & Pump Body	.0005T	.0015T	.000
Oil Pump Driven Gear & Shaft	.0005L	.002L	.004L
Oil Pump Gears & Pump Body	.002L	.007L	.010L
Oil Pump Gears (Backlash)	.004	.008	.015
Oil Pump Drive & Driven (Backlash)	.004	.008	.012
Mag. Drive Gear Hub & Gear	.002T	.0035T	.002
Mag. Drive Gear Hub & Tach. Drive Gear	.0005T	.002T	.0005T
Mag. Drive & Driven Gears (Backlash)	.006	.010	.016
Mag. & Mag. Adapter	.0005L	.0045L	
Mag. Driven Gear & Magneto, Driven Gear Hub	.0005L	.0025L	.004L
Starter Gear Hub & Crankshaft	.004T	.0052T	.003T
Tach. Drive & Driven Gears (Backlash)	.001	.003	.010L
Tach. Drive Connector & Tach. Driven Gear	.0012T	.002T	.001T
Tach. Connector Sleeve & Tach. Drive Connector	.0005T	.0013T	.0005T
Tach. Connector Sleeve & Tach. Drive Housing	.0015L	.0035L	.008L
Generator Gear & Hub	.0006L	.0026L	.004L
Generator Drive & Driven Gears (Backlash)	.006	.010	.016
Crankcase & Dowel (Timing Case)	.0001T	.0013T	.001L
Timing Gear Case & Crankcase Dowel	.0001T	.0013T	.001L
Timing Gear Case & Mag. Adapter	.0005L	.0045L	.008L
Timing Gear Case & Starter	.0005L	.0045L	.008L
Timing Gear Case & Generator	.0005L	.0045L	.008L

VII – RECOMMENDED TIGHTENING TORQUE VALUES

NAME	SIZE OF THREADS	TORQUE VALUE FOR TIGHTENING (INCH-LBS.) MINIMUM-MAXIMUM
	Standard Studs, Screws & Nuts	
Stud	1/4-20	25-60
Stud	5/16-18	50-90
Stud	3/8-16	75-170
Stud	7/16-14	95-195
Screw	1/4-20	60-75
Screw	5/16-18	105-120
Screw	3/8-16	120-145
Nut	1/4-28	60-75
Nut	5/16-24	110-130
Nut	3/8-24	300-360
	Special Applications	
Oil Pump Attaching Screw	1/4-20	55-60
Crankcase Cover Screw	5/16-18	
Oil Pan Holding Screw	5/16-18	60-75
Cylinder Hold-Down Nut	3/8-24	240-300
Cylinder Hold-Down Nut	7/16-20	300-330
Crankcase Tie Bold Nut	5/16-24	
Camshaft Bearing Stud Nut	5/16-24	145-180
Mounting Bracket Stud Nut	5/16-24	
Distributing Zone to Manifold Bolt	5/16-24	
Starter Mounting Nut	3/8-24	145-180
Spark Plugs	14 MM	180-240
Magneto Nut	7/16-20	240-300

VIII – OVERHAUL PERIODS AND PERIODIC INSPECTIONS

TOP OVERHAUL

The time at which a top overhaul will be necessary will vary considerably with the type of operation and the care taken of the engine generally. Proper inspections performed at the specified periods (See inspection check list) will reveal the necessity of a top overhaul. If a top overhaul is not required at 300 hours, the rubber magneto and generator drive shock absorber cushions should be inspected at this time. Any worn cushions should be replaced.

MAJOR OVERHAUL

No definite period is set for a major overhaul. Most engines will require an overhaul after 600 to 700 hours of operation. The periodic inspections and general operating characteristics will indicate the necessity of a major overhaul if one is needed sooner.

PERIODIC INSPECTIONS CHECK LIST

COVERING MODEL 6A4-150-B31, 6A4-150-B3 and 6A4-165-B3 ENGINES

	Pre-flight and Daily	25 Hour	50 Hour	100 Hour
Propeller Blades (Visual)	x			
Ignition Wires & Terminals (Visual)	x			
Accessible Nuts, Cap Screws & Fasteners (Visual)	x			
Fuel and Oil Level	x	x	x	x
Engine Controls (Free Movement & Full Range)	x	x	x	x
Oil Leaks	x	x	x	x
Fuel Leaks	x	x	x	x
Propeller Bolts (Check for Tightness & Safetying)		x	x	x
Ignition Wires & Terminals (Check for Tightness, Chafing & Soldered Connections—Clean)		x	x	x
Accessible Nuts, Cap Screws & Fasteners (Check for Tightness & Safetying)		x	x	x
Engine Controls (Check Free Movement, Full Range & Linkage System, Lubricate)		x	x	x
Oil Change (More Often if Operating Conditions Warrant)		x	x	x
Propeller Track		x	x	x
Exhaust System (Check for Leaks & Tightness)		x	x	x
Drain Plugs & Filler Caps (Check for Tightness, Safetying & Gasket Condition)		x	x	x
Cooling Air Baffles (Check for Obstructions & Leaks)		x	x	x
Filters, Strainers & Sumps (Inspect & Clean)		x	x	x
Compression Check (Check all cylinders by pulling through Propeller)		x	x	x
Manifold Equalizer Pipe Hose Connection (Check condition of Hose and Tightness of Clamps)		x	x	x
Magneto Breaker Points & Distributor (Check condition of rotor & Distributor & Point Condition & Gap)				x
Magneto Timing & Synchronization				x
Spark Plugs (Clean & Regap)				x
Cylinder Fins (Check for Breaks—Clean)				x
Carburetor (Clean & Drain)				x
Fuel Lines (Check for Chafing—Blow Out)				x
Engine Mounts (Check for Tightness & Wear)				x
Generator (Check Connections, Charging Rate)				x
Starter (Check Connections & Operation of Bendix Drive)				x
Valve Clearance (Check & Adjust) Every 200 Hours Minimum				
Magneto & Generator Shock Absorber Drives (Replace worn absorbers) Every 300 Hours Minimum				

IX – ENGINE LUBRICATION

The primary purpose of engine lubrication is to prevent metal-to-metal contact between moving parts. The friction accompanying such metal-to-metal contact would result in a loss of power, rapid wear, and a temperature rise that might cause parts to fail. The action of the oil is to coat each metal surface with a film. Between the two films, other layers of the oil slide along over each other, thus replacing the high friction of metal-to-metal contact by the low internal friction of the oil.

In the process of circulating through the engine, oil absorbs heat from the various parts. Most of this heat is dissipated when the oil flows through the oil cooler.

It is very important that an oil of the proper viscosity be used, since using too heavy an oil will impair circulation and insufficient lubrication will result.

Operating conditions will control the period between oil changes; however, the maximum time should not exceed 25 hours.

The S.A.E. letters on an oil container do not determine the quality of the lubricant. The refiner's reputation is your best guide to the quality of the product.

Proper lubrication of your engine should be given your most careful attention since improper lubrication is evidenced only after the damage to the engine has occurred and is often very costly. Using the proper grade of a good lubricant is cheaper than repair bills. We strongly recommend that our specification and service instructions be strictly followed.

ENGINE OIL SPECIFICATIONS FOR MODEL 6A4-150-B3 AND B31 AND 6A4-165-B3 ENGINES

SAE 40 when free air temperature is 40°F or above.

SAE 20 when free air temperature is below 40°F.

X – CRANKCASE

The crankcase is built in two halves of high-strength aluminum alloy. (See Fig. 3.) Each crankcase half contains three cylinder mounting pads and two engine mount bracket pads. The left case half also includes pads for the oil pump and oil by-pass plate. The crankcase when assembled as a unit has a top machined face to take a cover and a bottom machined face on which the oil pan is mounted. On the model 6A4-150-B3 and B31 engines, an oil seal is obtained between the halves at the nose section by two .135"-.145" diameter synthetic rubber packing strips. These packing strips fit into grooves machined into the mating face of the right crankcase half. These strips are longer than the grooves so that they must be trimmed to length after the crankcase is assembled with the crankshaft and camshaft. Extreme care should be taken to trim the ends of the packing strips absolutely flush with the face of the crankcase. This is particularly important in the nose oil seal recess, as an oil leak will occur if the packing protrudes at this location. The model 6A4-165-B3 engine does not have the rubber packing strips between the case halves, and the packing strip grooves are omitted. An oil seal is obtained on this model by silk threads placed on the right crankcase half in the same position as the grooves were located in the other models. Fig. 46 shows the location of these grooves. The threads are also trimmed flush with the crankcase faces after assembly. It is important that the small rubber packing rings at the through studs be in place before the case is reassembled. On the model 6A4-165-B3 engine, it is necessary to put a small fiber washer under the oil cross-over passage seal ring to prevent it from falling into the passage. It is advisable to hold the oil seal packing strips and rings in place with a light coat of cup grease during assembly.

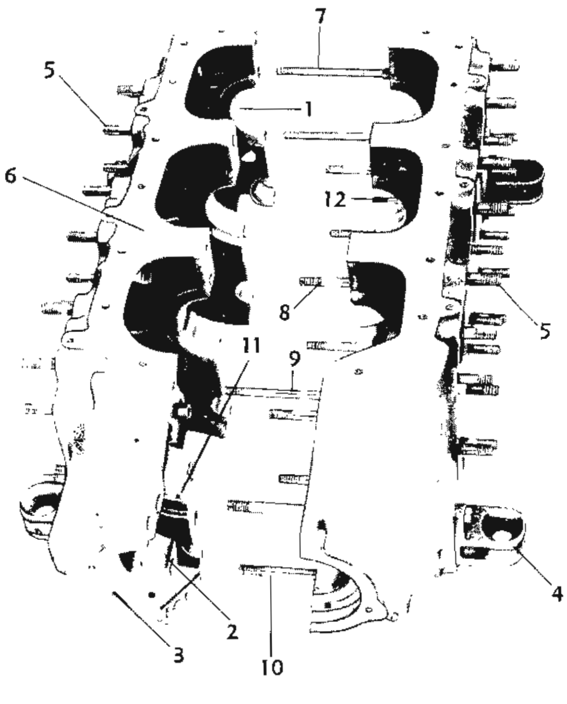


FIG. 3. Crankcase

1. Main Bearing Journal
2. Propeller Shaft Bearing Journal
3. Nose Seal Adapting Recess
4. Engine Mounting Bracket
5. Cylinder Hold-Down Stud
6. Top Crankcase Cover Mounting Pad
7. Rear Through Tie Stud
8. Crankcase Assembly Stud
9. Top Front Through Tie Stud
10. Front Through Tie Stud
11. Thrust Washer Mounting Pad
12. Camshaft Through Tie Stud

The crankcase on the model 6A4-165-B3 engine has drilled oil passages and a mount pad to take a propeller control valve. This pad is on the left front of the crankcase just above the engine mount bracket.

The two halves are joined internally by a series of six special heat-treated 3/8" studs located at the main bearing journals and four heat-treated 5/16" studs located at the camshaft bearing journals. Castle nuts safetied with cotter pins and flat washers are used on all internal studs. Two 3/8" studs at the front bearing journal and two 3/8" studs at the rear bearing journal, as well as one 5/16" stud at the front top protrude through the right crankcase half. These five studs are secured externally using flat washers and elastic stop nuts. Three 5/16"-24 x 7-3/16" hex head bolts are installed along the top of the case, as well as three 5/16"-24 x 1-3/8" hex head bolts installed at the front end of the engine straight through both crankcase halves. Plain 5/16" washers are used under bolt heads and under the specified elastic stop nuts.

When assembling the crankcase halves, observe that the aligning dowels fit in their respective holes and draw up the crankcase assembly nuts evenly. When assembled with mating halves, the crankshaft main bearing hole is bored to 2,406" to 2.407" and the camshaft bearing hole is bored to 1.1245" to 1.1250".

Each of the six cylinder pads are studded at the proper locations as follows: Four studs, 7/16-14 NC stud end, 7/16-20-NF-3 nut end, driven to a height above pad of 1-1/8". Four studs 3/8-16 NC stud end, 3/8-24-NF-3 nut end, driven to a height above pad of 1-1/16".

One pad is located at each of the four lower outside corners of the crankcase to accommodate the engine mounting brackets. Four dowels are located in the case to align the brackets, one dowel for each bracket. On the early engines, the brackets are secured to the case by means of two studs. 5/16-18 x 7/8" hex head cap screws are used on the later engines. Some engine models use flat washers and drilled head hex cap screws safetied with lacing wire. On some engines the lower right-hand bracket is of special design with a pad for fuel pump attachment.

When the crankcase is disassembled at engine overhaul, it is important that all plugs be removed and the oil galleries and oil passages be thoroughly flushed out before reinstalling the plugs.

XI—CRANKSHAFT

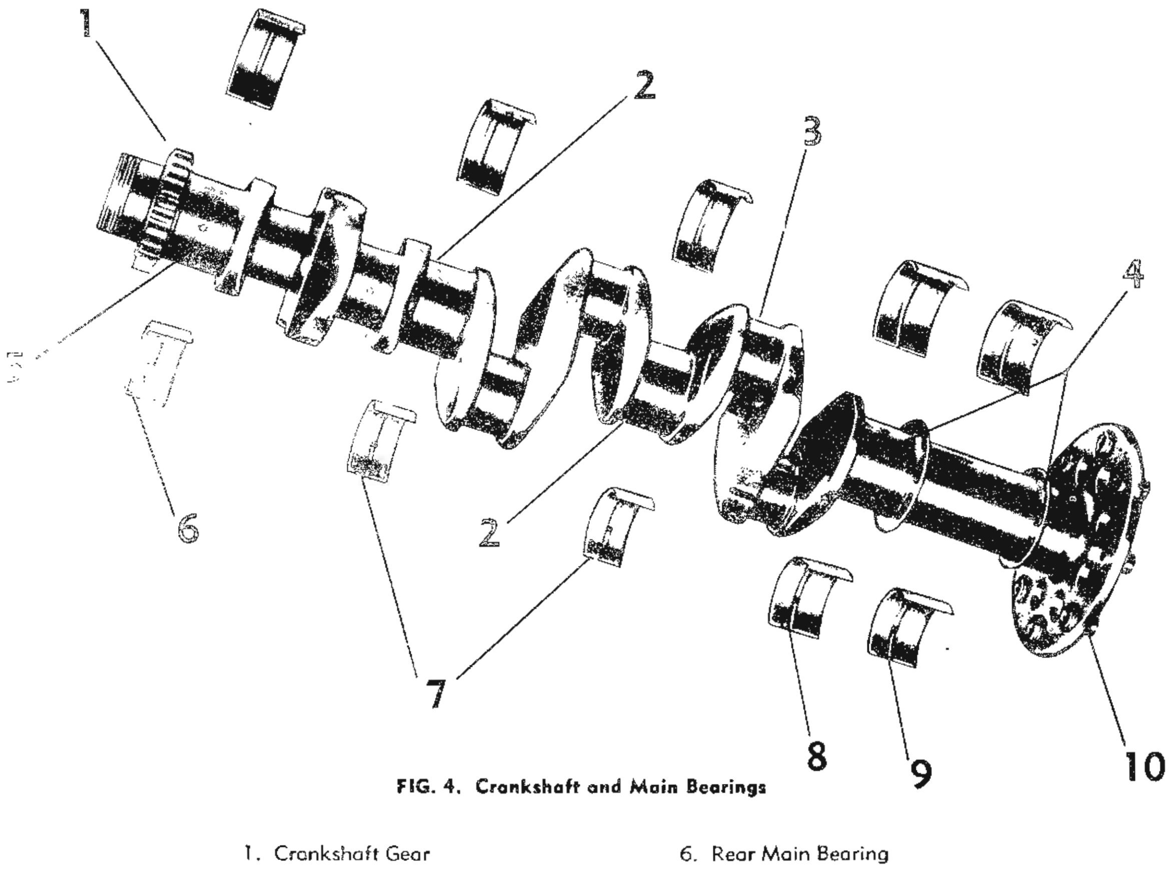


FIG. 4. Crankshaft and Main Bearings

1. Crankshaft Gear
2. Center Main Journal
3. Connecting Rod Journal
4. Front Main and Propeller Shaft Journals
5. Rear Main Journal
6. Rear Main Bearing
7. Center Main Bearing
8. Front Main Bearing
9. Propeller Shaft Bearing
10. Propeller Bolt Flange Bushing

The crankshaft is a one piece, six throw, alloy steel forging, heat treated and designed to withstand high stress. It is drilled for lightness and to supply lubrication to all the bearings. (See Fig. 4.)

The fillets ground on the crankshaft have a .125" to .140" radius on the main bearing journals and connecting rod bearing journals. These fillets reduce the tendency toward localization of stress and for this reason it is important that fillet specifications be observed if the crankshaft is reground. Also, after regrinding the journals, the fillets should be shot peened according to Aircooled Motors specification #11981.

CRANKSHAFT BEARINGS

The crankshaft is supported in the crankcase by five split steel-backed, main bearings of .0770" to .0775" wall thickness after plating. (See Figure 4.) The bearing shells have a crush fit to secure them in the crankcase bore and insure rigid support for the crankshaft. The five bearings are referred to by number with the #1 bearing at the rear of the engine. It is essential that the bearing shell halves containing the oil holes be assembled so that they match the oil passages in the left crankcase half.

Figure No. 4 shows the #4 main bearing with a single oil groove. This bearing on the model 6A4-165-B3 engine has an additional oil transfer groove to provide a passage for propeller control oil. This bearing having the oil transfer groove will be supplied for service replacement for the #4 and #5 bearings on all model engines referred to in this manual.

The crankshaft end-play, when the crankshaft is fitted in the crankcase, is .008" to .020" and is controlled by two split bronze thrust washers located and doweled to the front and rear sides of the crankcase web of the front center main bearing support in both crankcase halves. The end play should be checked with both crankcase halves separately as well as after assembly to make sure that the .008" minimum clearance is obtainable. Thrust washers must be replaced in pairs as slight variations in thickness exist between different pairs.

The crankshaft main bearing journal diameter is ground to 2.249" to 2.250" and the connecting rod bearing journal is ground to 1.9365" to 1.9375". When assembled in the crankcase, the clearance between the crankshaft journals and main bearings is .002" to .004".

Eight bushings with inside diameter threaded 3/8"-24 NF-3 are pressed into the flange at the front of the crankshaft for attaching the propeller. The .6265" to .6270" major outside diameter of the bushing is a .0015" to .003" press fit in the .624" to .625" reamed holes in the crankshaft flange. The model 6A4-150-B31 has a 5" diameter bolt circle flange. The model 6A4-150-B3 and 6A4-165-B3 engines have a standard SAE-3 5.25" bolt circle flange. Two Woodruff key seats 3/16 by 1-1/8" are cut in the rear main bearing journal extension for attaching the crankshaft gear, starter gear and accessory drive gear.

The crankshaft runout, taken with the shaft supported on its main bearing journals, should not exceed .002" total indicator reading.

The crankshaft of the 6A4-165-B3 engine is drilled at the front main journal to provide a passage for propeller actuating oil from the crankcase to the hollow propeller shaft. The aluminum plug closing the end of the propeller shaft should not be removed except possibly at a major overhaul when it is desired to thoroughly clean the shaft. This plug is assembled with a press fit in the shaft and is safetied with a set screw. If the plug is ever removed, it should be replaced by a new part, as the old one is usually damaged by removal. The 1/8" pipe plug, which is installed in the center of the aluminum plug, should also never be removed except when a hydraulically actuated propeller is installed on the engine. The hollow propeller shaft carries engine oil which will escape if either plug is not in place during engine operation.

The crankshaft flange has the following markings on the rim of its outside diameter: "No. 1 U.D.C., 24 and 28 degrees." The No. 1 U.D.C. mark, when in line with the center line of the crankcase at the top of the engine, refers to top dead center of No. 1 cylinder. The 28 degree mark is used for ignition timing on the model 6A4-150 B3 and B31 engines and, when aligned with the crankcase center line, represents 28 degrees before top dead center on No. 1 cylinder when on the compression stroke. The 32 degree mark is used for ignition timing the 6A4-165-B3 and, when aligned with the crankcase center line, represents 32 degrees before top dead center on No. 1 cylinder when on the compression stroke.

Before installation at the factory, every crankshaft is 100% magnetically inspected and tested for dynamic and static balance.

CRANKSHAFT OIL SEAL

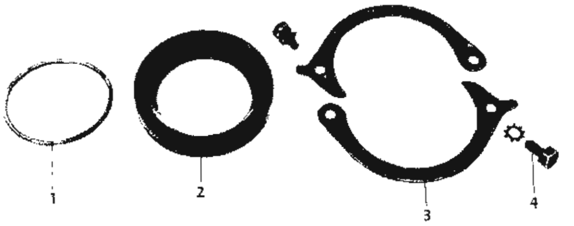


FIG. 5. Crankshaft Oil Seal

1. Crankshaft Oil Seal Spring
2. Crankshaft Oil Seal Packing
3. Oil Seal Retainer Washer
4. Retainer Washer Attachment Screw

A spring loaded oil seal is installed in the 3.248" to 3.250" recess in the front end of the crankcase, formed by the assembly of the two crankcase halves. (See Fig. 5.) The free length of the spring itself in the open position should measure 7-1/8" to 7-1/4". Be sure to specify the correct part number when ordering the seal. (See Fig. 5-1.) The spring side of the seal is towards the rear of the engine and a light coating of sealing compound is applied to the outside surface of the seal before pressing the seal into place. The split in the seal should be located approximately 45 degrees from the crankcase parting line to insure that no oil seepage will occur where the seal ends come together. The seal should be tapped into position evenly to prevent distortion and insure proper seating in the crankcase bore. A split retainer plate is used to hold the seal in position. This plate is attached to the front end of the crankcase by means of two 1/4"-20 x 1/2" hex head cap screws and two 1/4" shakeproof washers.

XII – CAMSHAFT

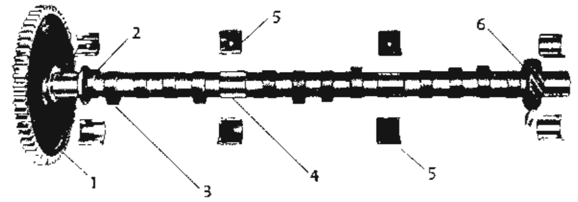


FIG. 6. Camshaft and Bearings

1. Camshaft Gear
2. Fuel Pump Cam
3. Valve Actuating Cam
4. Camshaft Bearing Journal
5. Camshaft Bearing
6. Oil Pump Drive Gear

The camshaft incorporates six intake and six exhaust lobes and has four bearing journals. (See Fig. 6.) The bearing journals are ground .9985" to .999", and the journal clearance with the bearing is .0015" to .0025". The permissible camshaft end play when assembled in the crankcase is .006" to .010". The end play should be checked with each crankcase half separately, as well as after assembly, to make sure that the .006" minimum clearance is obtainable. The permissible camshaft runout is .002" total indicator reading. This reading is taken at the center of the shaft, while being supported on the bearing journals.

The total thickness of the split camshaft bearing shells is .0620" to .06225" when new. Care should be taken when reassembling the bearings in the crankcase. It is essential that the bearing half containing the oil hole be assembled in the left half of the crankcase so that these oil holes will mate with the oil passages in the case.

A camshaft from the 6A4-150-B3 model should never be interchanged with the camshaft from the 6A4-165-B3 model. The cam lobe dimensions are different on the two models. Interchanging camshafts would cause improper function of the valves and damage to the valve operating parts.

Both cast iron and forged steel camshafts have been used on the model 6A4-150-B3 engine. The timing gear is located by a shoulder on the steel shaft. There is no locating shoulder on the cast iron camshaft, however, and the gear is pressed on to a distance of 1.034" to 1.036" from the flange face. As the I.D. of the two timing gears is different, it is necessary to consult the Parts Book to determine the proper gear to order for either shaft.

XIII – TIMING GEAR CASES

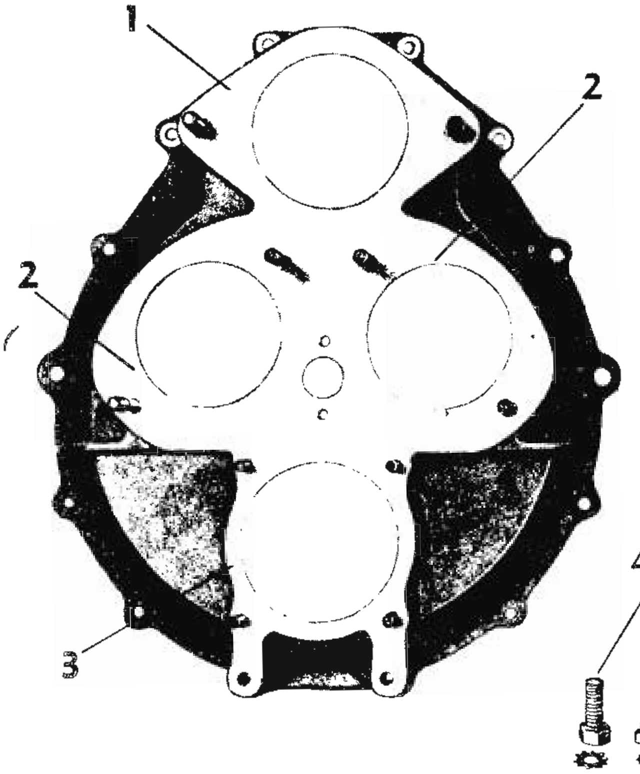
The case enclosing the accessory gear train consists of two aluminum-alloy castings, the front timing or front accessory case and the rear accessory or rear timing gear case. (See Fig. 7.)

The front case which houses the crankshaft and camshaft gears is attached to the rear crankcase surface by eight 5/16"-18 x 7/8" and two 5/16"-18 x 2-1/4" hex head cap screws. The eight short screws use plain 5/16" flat washers and are secured by lacing wire. The two long screws use shakeproof washers. The alignment of this front housing with the crankcase is maintained by two 1/4" x 3/4" dowels embedded in the rear crankcase mating surface.

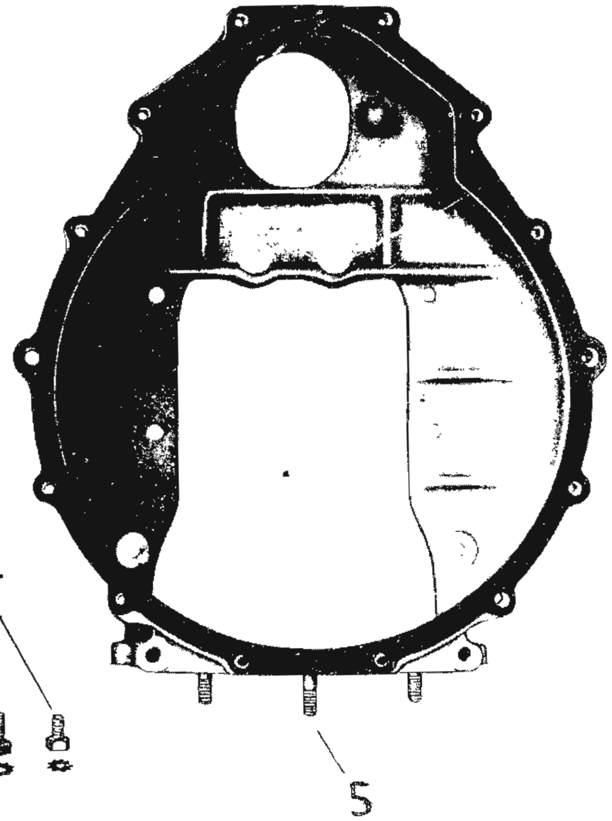
The rear case which houses the accessory gear train is fastened to the front case by ten 1/4"-20 x 5/8" and two 3/8"-16 x 1" hex head cap screws. Shakeproof washers are used throughout on these screws. Later model 6AL-150-B3 and all model 6A4-165-B3 engines incorporate two 1/4" dowel bolts in place of the two large cap screws.

On the older style rear timing gear case, a tennon that matches a pilot diameter in the front timing gear case is used to maintain alignment instead of the dowel bolts used on the later engines. Therefore, the old and new type timing gear cases are not interchangeable. It is important to consult the Parts Book to determine the proper mating timing gear case when ordering replacement parts. The crankcase on all models will take either the old or the new type timing gear cases.

Composition gaskets are used between the crankcase and the front timing case, as well as between the two timing gear cases.



REAR TIMING GEAR HOUSING



FRONT TIMING GEAR HOUSING

FIG. 7. Timing Gear Housings

1. Starter Mounting Pad
2. Magneto Mounting Pad
3. Generator Mounting Pad
4. Rear Housing to Front Housing Cap Screws
5. Oil Pan Support Studs

XIV—CONNECTING RODS

The connecting rods are an alloy steal forging, magnetically inspected before being assembled on the crankshaft. (See Fig. 8.) They are a matched weight assembly and are stamped on the bolt bosses in relation to their cylinder position on the crankshaft.

When reassembling the rods on the crankshaft, it is important that they be returned to their original position. The rods are located in numerical order with #1 rod on the crank throw which is nearest the gear end of the crankshaft and #6 rod is on the throw which is nearest the flange end of the shaft.

The lower bushing is of the steel-backed split type and the halves are interchangeable. When assembling the lower cap to the rod, cylinder position numbers on the bosses should be on the same side of the rod. The #2, #4 and #6 rods have the finished relief surface on the top cap towards the front of the engine while the reliefs on #1, #3 and #5 rods face the rear of the engine. It is important at assembly to see that the tongue on the back of the bushing fits the slot provided in the connecting rod to prevent binding or movement of the bushing halves when installed. The wall thickness of the bushing is .06105" to .06150". The bushings are a crush fit when assembled in the

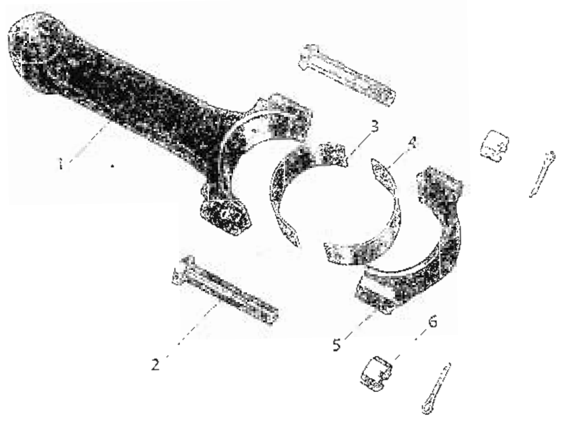


FIG. 8. Connecting Rod Assembly

1. Connecting Rod and Upper Cap
2. Connecting Rod Bolt
3. Upper Cap Connecting Rod Bearing
4. Lower Cap Connecting Rod Bearing
5. Connecting Rod Lower Cap
6. Nut—Connecting Rod Bolt

connecting rods. When assembled to the crankshaft, they have a clearance of .0015" to .0034" on the crankshaft throws.

The connecting rod cap is assembled to the rod by two alloy steel, 3/8"-24 NF rolled thread, upset head bolts. The bolts are installed with the head end toward the piston pin bushing. The two 3/8"-24 slotted nuts must be drawn up evenly and safetied by two 3/32" x 3/4" cotter pins. The side clearance between the connecting rods and the crankshaft cheeks is .008" to .014".

Two holes are drilled in the connecting rod at an angle of 36° to the vertical center-line. These holes index with two holes in the bearing bushing. The holes permit oil to spray upward against the cylinder walls and pistons. To lubricate the piston pins and piston pin bushings, three holes are drilled in the upper end of the connecting rod and piston pin bushing.

The piston pin bushing is a press fit in the 1.0375" to 1.0385" hole of the connecting rod. After installation, it is bored to .9847" to .9849". The bushing must be installed with the three drilled holes indexing with the three holes in the connecting rod upper boss. Clearance between the piston pin and bushing is .0007" to .0012". The two bores of the connecting rod must be parallel.

XV – PISTON, PISTON PINS AND RINGS

The permanent mould cast aluminum alloy pistons are of a special design, which controls expansion to a high degree, permitting a close fit between piston and cylinder wall. (See Fig. 9-1.) This feature provides for long cylinder, piston and ring life and eliminates piston slap.

The clearance between the piston and cylinder wall, taken at the bottom of the piston skirt, is .002" to .0035" and taken at the top of the skirt, just below the slot, is .003" to .0045". (See Fig. 10.) This clearance can best be taken by using a long feeler gauge, which will reach the length of the cylinder liner. The piston should be installed, without the rings, in its normal running position within the cylinder and the clearance taken at the top and bottom of the cylinder bore. A .002" feeler gauge should indicate no drag when checking piston clearance.

FIG. 10. Checking Piston Clearance

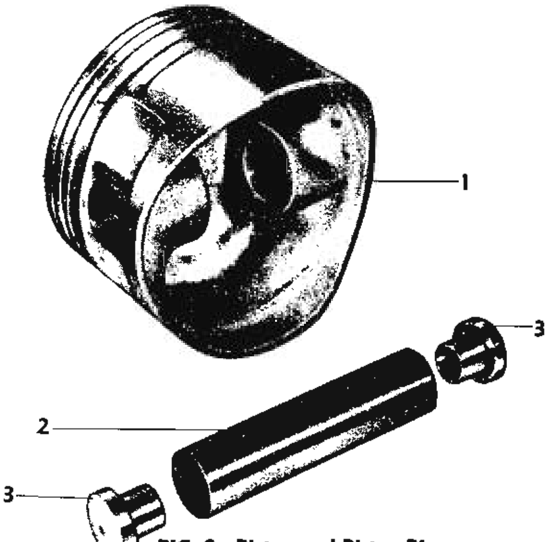


FIG. 9. Piston and Piston Pin

1. Piston
3. Piston Pin Plug
2. Piston Pin

If at any time the piston with rings installed should be inserted by hand in the cylinder bore, do not push the piston into the top of the cylinder as the top groove piston ring will expand above the upper rim of the cylinder liner and lock the piston in the combustion chamber.

The ring groove widths are as follows: Top groove - .099" to .100", middle groove - .097" to .098", bottom groove - .1885" to .1895".

The diameter of the piston pin holes in the piston is .98415" to .9840". Pistons are plated all over with the exception of the piston pin holes.

The pistons are stamped for location on the bottom of the piston pin boss. The number corresponds to the cylinder location on the engine in which they are installed.

PISTON PIN

The hollow piston pins are of alloy steel, heat-treated and magnetically inspected. (See Fig. 9-2.) They are of the full floating type and are a palm push fit in the piston at room temperature (70°F). They are finished inside to a diameter of .619" to .620" and ground outside to a diameter of .9838" to .9840". The piston pin ends must be square with their axis within .001" total indicator reading to insure proper bearing surface for the end plugs and assembly end clearance. Two aluminum plugs are installed in the ends of the piston pin. The outside diameter of the plugs, where they fit inside the pin, is .6175" to .6185".

The piston pins, when installed, give the piston pin with buttons assembled an end clearance in the cylinder bore of .015" to .033". This clearance is best checked by using a feeler gauge. Install a piston pin in the piston and insert the piston in the cylinder bore far enough to permit checking the piston pin end clearance with a piston pin button against one side of the cylinder bore.

PISTON RINGS: (FIG. 12)

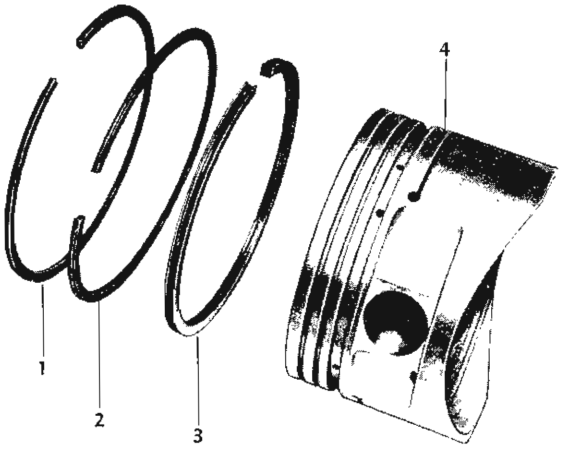


FIG. 12. Piston and Rings

1. Top Compression Ring
2. Middle or Scraper Compression Ring
3. Oil Control Ring
4. Piston

The piston is provided with three ring grooves to accommodate three Perfect Circle piston rings. The lower groove has holes drilled through the piston wall to the inside of the piston for oil return.

The top ring is a compression ring with a width of .0930" to .0935". It has an undercut on the inside diameter of one face, around the circumference of the ring. The ring must be installed with its undercut facing the top of the piston. See Fig. 11 for the diagram showing the proper ring positions.

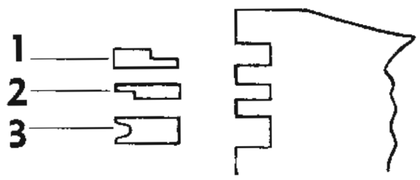


FIG. 11. Piston Ring Installation

1. Top Compression Ring
2. Middle Compression—Scraper Ring
3. Oil Control Ring

The middle ring is a compression scraper ring with a width of .0930" to .0935". Its undercut is on one edge of the outer circumference. This ring must be installed with the undercut facing the bottom of the piston. This is important as reversing the ring at installation will cause it to scrape the oil toward the combustion chamber, resulting in high oil consumption and fouled spark plugs.

The lower groove ring is an oil control ring of the slotted type, with a width of .1860" to .1865". It may be installed in any position in the lower groove.

The piston ring gap for all three rings, when measured in the cylinder, should be .013" to .023". (See Fig. 13 for method of measurement.) The top ring has a side clearance when installed in piston groove of .0055" to .007". The center ring has a side clearance of .0035" to .005", and the bottom ring, .002" to .0035". When the pistons are installed on the engine, the ring gaps are staggered in relation to each other, before installing the cylinders.

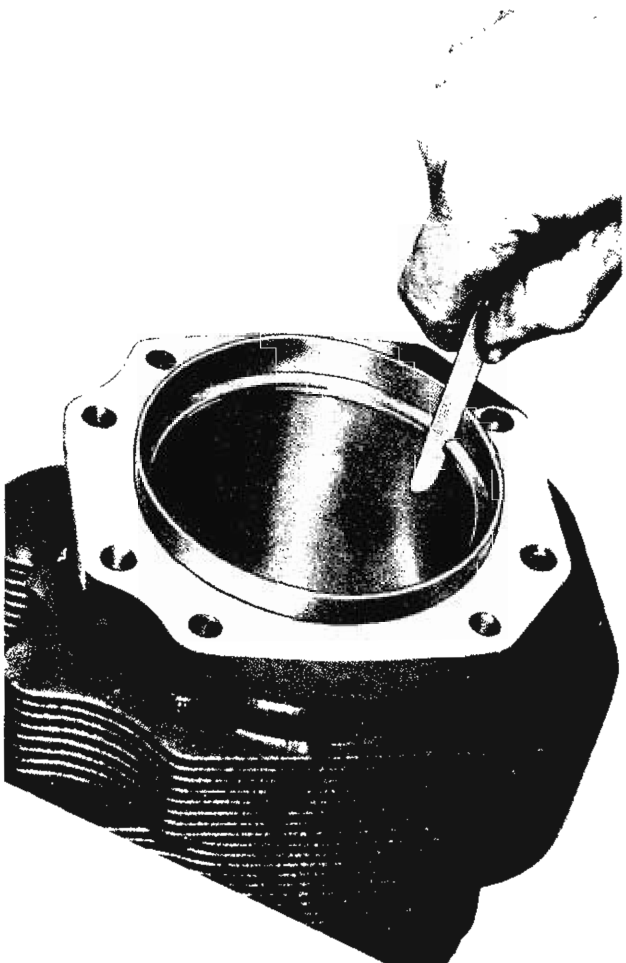


FIG. 13. Ring Gap Clearance

XVI—CYLINDER ASSEMBLY

Franklin cylinders are one-piece aluminum alloy sand castings, incorporating deep, closely spaced fins to insure ample cooling under the various operating conditions of the engine. (See Figs. 14 thru 17.) The piston bore of the cylinder is fitted with a nickel-iron liner which extends the full length of the cylinder barrel section and projects .500 to .515 below the cylinder flange of the cylinder casting. The liner is positioned by a lock pin which is held solidly in place by two lock screws. (See Fig. 14-3, 4.) To prevent oil leaks, the lock pin and lock screws are coated with a liquid jointing compound at assembly. The lock pin or lock screws should never be removed; replacement is necessary only when installing a new liner. On initial assembly, the lock pin is installed before the final grinding and honing of the cylinder barrel operation, and is, therefore, finished to size on the inside of the cylinder bore when the bore diameter is ground to size.

The later model 6A4-150-B3 engines have two lock pins positioned 90 degrees apart to hold the cylinder liner in position. The model 6A4-165-B3 engine has a step machined in the crankcase at the cylinder mount bore. This step acts as a stop for the cylinder liner and only one liner lock pin is used in the cylinder.

The cylinder bore is finish-honed to a diameter of 4.500" to 4.501". The final finish is a fairly coarse honing operation to insure satisfactory seating of the piston rings contacting the liner surface. Tests have proven that with the use of good lubricants, changed regularly, the liners will show little wear over a long period of operation.

Cylinders for the model 6A4-150-B3 and the 6A4-165-B3 are made from the same casting. Cylinders for the 165 hp model have different valve guides from the 150 hp model and an additional shot peening operation has been performed on the cylinder base to provide added strength. It is, therefore, most important that a cylinder originally manufactured for the 150 hp engine MUST NOT be taken from stock and assembled on a 165 hp engine. All cylinders for the model 6A4-165-B3 engine have shot peened bases.

During initial assembly, the aluminum cylinder casting is heated and held for two hours at a temperature between 625° and 650°F to anneal the casting and prepare it for installation of the liner, valve seat inserts and valve guides, all of which are installed while the casting is in the heated condition.

VALVE GUIDES

The intake and exhaust valve guides are a high-quality cast iron and are installed as previously explained, when the cylinder casting is heated. (See Fig. 15-1, 2.) The outside diameter of the valve guides is .5640" to .5645" and the inside diameter of the reamed holes into which they are pressed is .5605" to .5610", giving a shrink fit of .003" to .004". On later engines, the reamed hole is .5615" to .562" giving a shrink fit of .002" to .003". When installed, the distance down from the machined top surface of the cylinder to the top of the guide is .318" to .354". The inside diameter of both guides is .375" to .376" on the early model 6A4-150-B3 and B31 engines. On the later model 6A4-150-B3 engines, the diameter of the exhaust valve stem was increased, which required an increase in the inside diameter of the exhaust guide to .4375" to .4385". On the model 6A4-165-B3 engine, the inside diameter of both

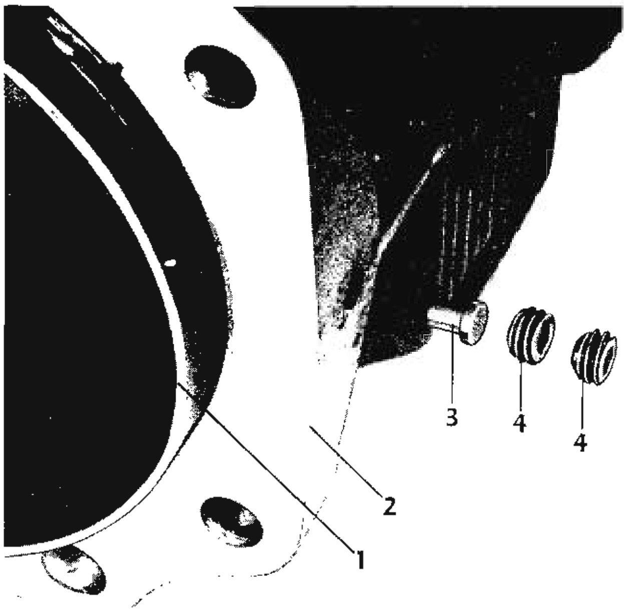
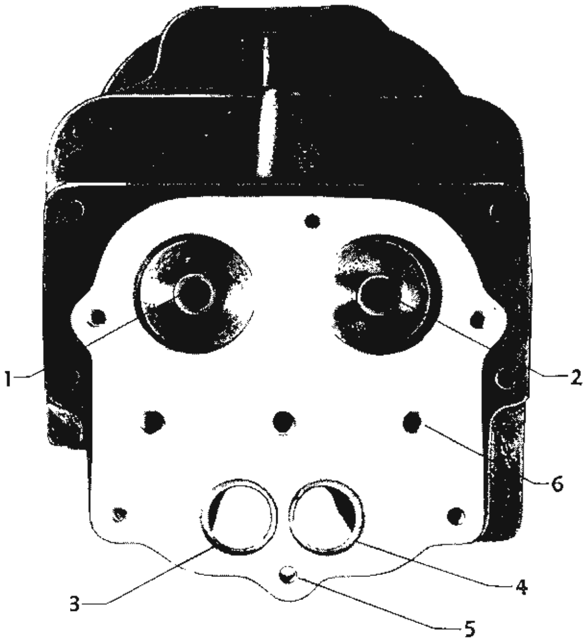


FIG. 14. Cylinder Liner Lock Pin and Set Screws

1. Cylinder Liner
2. Cylinder Hold-Down Flange
3. Liner Lock Pin
4. Lock Pin Screws

FIG. 15. Valve Guides and Top Face of Cylinder

1. Intake Valve Guide
2. Exhaust Valve Guide
3. Intake Lifter Tube Hole
4. Exhaust Lifter Tube Hole
5. Tapped Holes for Valve Cover Screws
6. Tapped Holes for Rocker Support Screws



valve guides is .4063" to .4073". The valve guides should be concentric with the valve seat face within .002 total indicator reading.

To replace the guides, heat the cylinder to a temperature of 625° to 650°F. Support the cylinders on the head end, with supports close to the guide to be pressed out. Press guide out from inside the cylinder head. Measure the internal diameter of the hole in the cylinder—standard inside diameter of reamed guide holes on both the intake and exhaust is .5605" to .5610" and install oversize guides if necessary. Intake and exhaust valve guides can be obtained in three oversizes: .001", .002", and .005". After selecting the proper size guide, and with the cylinder heated to 625° to 650°F., install the new guide by coating it with white lead and pressing it into position until the top of the guide is .318" to .354" below the machined top surface of the cylinder head.

Later engine models have inlet and exhaust valve guides with a shoulder incorporated. The cylinders that take the shouldered guide have an additional counter bore in the bottom of the valve spring well. With this latter type, it is only necessary to press the guide into the cylinder until the shoulder bottoms on the counterbore in the spring well.

VALVE SEAT INSERT (INLET)

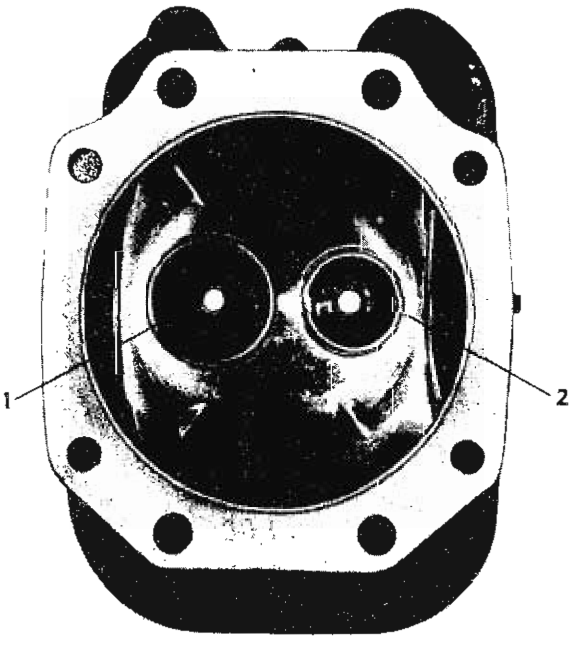


FIG. 16. Valve Seat Inserts
1. Inlet Valve Seat 2. Exhaust Valve Seat

The inlet valve seat insert in the aluminum cylinder head is made of iron alloy to give long service life. (See Fig. 16-1.) It is installed when the cylinder is heated to 625° to 650°F. by being pressed into the 2.1255" to 2.1265" reamed hole in the cylinder head. The outside diameter of the inlet valve seat insert is 2.1295" to 2.1305", giving a shrink fit between the intake valve seat insert and the reamed hole of .003" to .005". When the insert is properly seated and the shrink fit obtained, the seat is further secured by rolling over the aluminum material of the cylinder surrounding the insert. The inlet valve seat is then ground to a 30° angle with a seat face width of 1/16".

Some of the later model 6A4-150-B3 and B31 engines and the early 6A4-165-B3 engines have alloy steel seat inserts with a hard stellite face. On the 6A4-165-B3, the diameter of the reamed hole in the cylinder has been decreased to 2.1245" to 2.1255". This produces a shrink fit on the insert of .004" to .006".

VALVE SEAT INSERT (EXHAUST)

The exhaust valve seat insert is of stainless steel. (See Fig. 16-2.) This material has been found highly resistant to the corrosive action and high temperature of the hot exhaust gases, thus reducing wear and warpage. The exhaust valve seat insert is installed in the same manner as the inlet valve seat insert and the aluminum cylinder head material rolled over it. The seat insert is then ground to a 45° angle with a face width of 3/32". Some of the later model 6A4-150-B3 engines and the early model 6A4-165-B3 engines also have alloy steel seat inserts with the hard stellite face.

The outside diameter of the exhaust valve seat insert is 1.6555" to 1.6565". The inside diameter of its reamed hole in the top of the cylinder head is 1.6514" to 1.6524", giving a shrink fit of .0031" to .0051". On the model 6A4-165-B3, the diameter of the reamed hole in the cylinder head is 1.6504" to 1.6514". The outside diameter of the insert is 1.6555" to 1.6565". This produces a shrink fit on the insert of .0041" to .0061".

The seat inserts may be replaced by cutting them out to a thin shell with a boring tool. The stellite faced inserts should rarely ever need to be replaced. If it does become necessary to remove this type of seat insert, a high-speed steel tool will be required as the stellite face is very difficult to cut through. Care must be used when removing the shell, not to damage the reamed hole in the cylinder head. Heat the cylinder to 625° to 650° for two hours and press in the new inserts. It is important that the inserts bottom flush in the reamed hole and that they are held in position during the time the cylinder is cooling. If it should become necessary to replace the valve seat inserts, the operation must be performed with the proper tools and care must be taken to hold the seat face widths to the specified dimensions, using narrowing stones or cutters.

CYLINDER TAPPED HOLES AND STUDS

The tapped holes in the cylinder for the rocker block and inlet manifold screws are 5/16"-18 NC thread to a depth of 5/8". The two exhaust stack studs, 5/16"-18 NC stud end, 5/16"-24 NF-3 nut end, 5/8" height of studs installed.

Some cylinders have three studs in the top cylinder surface for fastening down rocker assemblies. The studs are 5/16"-18 NC stud end and 5/16"-24 NF-3 nut end. The stud height is 1-33/54".

ROCKER BLOCK SCREWS

In the later engines, three 5/16"-18 x 1-3/4" hex head cap screws are used to fasten rocker assemblies to the cylinder instead of the studs mentioned above.

CYLINDER - OIL SEAL RING: (FIG. 17-6)

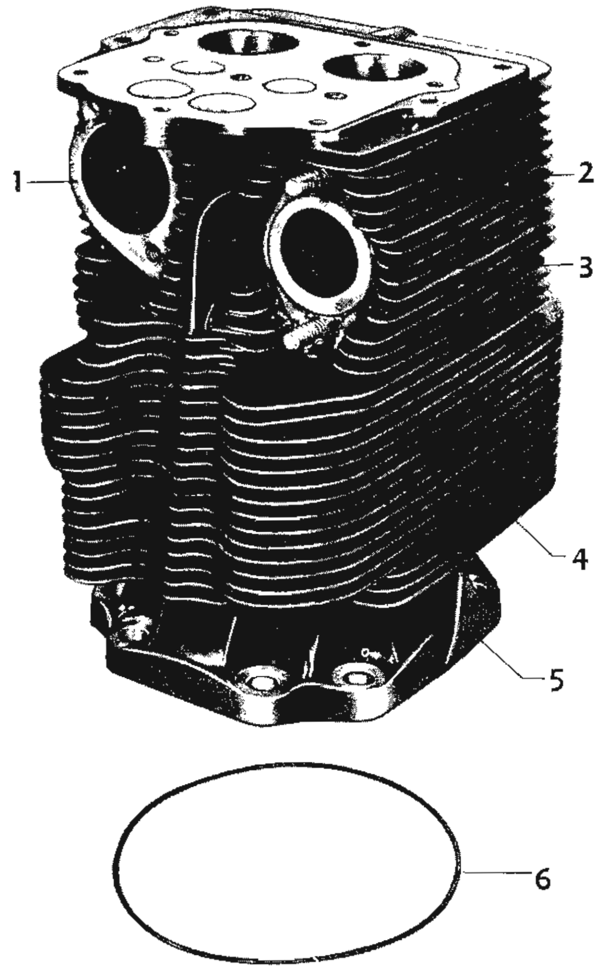


FIG. 17. Cylinder

1. Inlet Valve Port
2. Exhaust Stack Stud
3. Exhaust Valve Port
4. Cylinder Fins
5. Cylinder Hold-Down Flange
6. Cylinder Flange Oil Seal

When installing the cylinder on the crankcase, inspect the cylinder pad surfaces on the crankcase and the bottom of the cylinder flange for nicks and burrs. See that these surfaces are clean. The oil seal ring is installed on the cylinder liner and pushed back so that it is snug against the cylinder flange all around. It is important to check the chamfer on the crankcase at the cylinder bore to determine the proper oil seal ring to use. If the chamfer diameter is 4-13/16", use the seal ring called for in the Parts Book for engines up to No. 11020. If the chamfer diameter is 4-29/32", use the seal ring called for in the Parts Book for engines No. 11021 and up. A new seal ring should be used each time the cylinder is removed and reinstalled and must fit snugly into the chamfer in the crankcase to prevent oil leaks.

CYLINDER HOLD-DOWN NUTS

The cylinder is attached to the crankcase by using four 7/16"-20 and four 3/8"-24 hex nuts with special washers having rounded edges and safetied with palnuts. The nuts should all be pulled down evenly to assure a good seal at the crankcase cylinder pad.

CYLINDER FINS

Inasmuch as the cylinder cooling depends on the maximum flow of air over the cylinder fins, it is imperative that the entire cylinder fin area be kept clean and free from any obstructions. The engine cowling should be checked frequently for leaks and kept securely tightened in its correct position.

HELICOILS

Stainless steel helicoil spark plug inserts are used to accommodate two spark plugs in the head of the cylinder. Their use greatly improves spark plug thread wear and maintenance and, when necessary, they can be easily replaced. (See Fig. 18.)

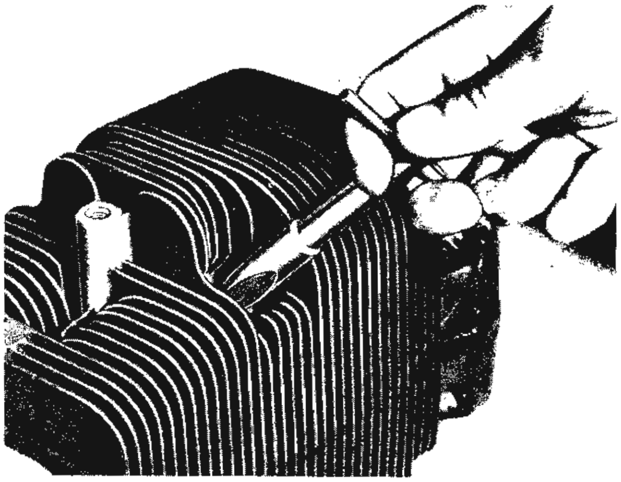
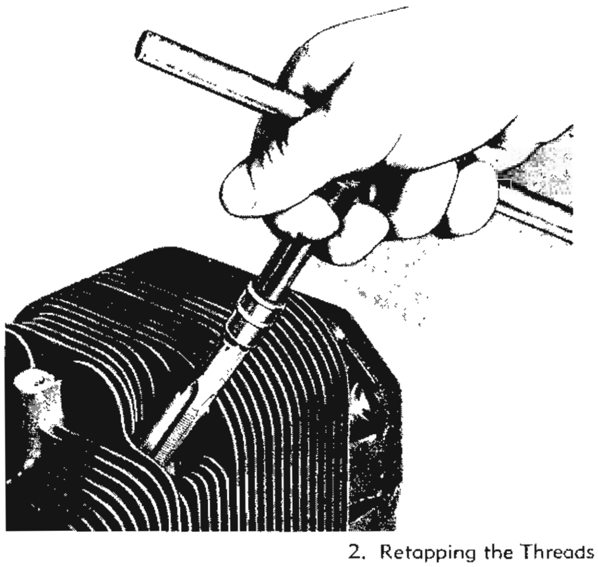


Fig. 18. Helicoil Replacement

1. Removing Helicoil Insert

To remove the helicoil, insert the extracting tool, #13825, in the spark plug hole. (Fig. 18-1.) Tap lightly with a soft hammer. Remove insert by turning it out in an anti-clockwise direction.



2. Retapping the Threads

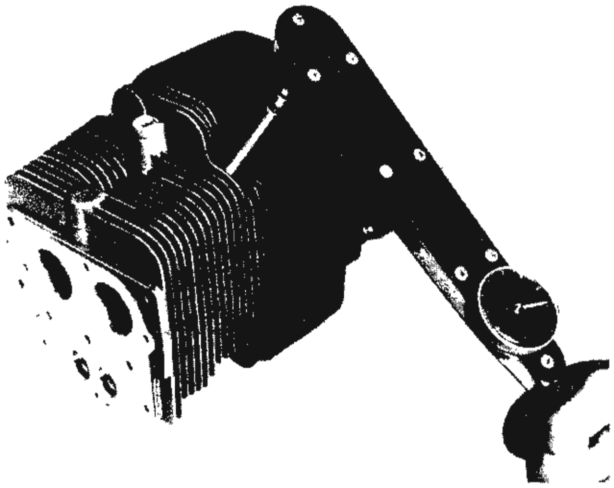
Retap the spark plug hole (Fig. 18-2) to remove any small nicks and to clean the threads, using the bottoming finish tap tool #13822 to a depth of ⅜"

3. Installing the Helicoil Insert

Pull mandrel of the inserting tool, #13826, back into the sleeve and place the helicoil spark plug insert in the recess of the sleeve, tang end of the insert toward the threaded end of the sleeve. Advance the mandrel until its slotted end engages the tang of the insert. Rotate mandrel clockwise while holding the sleeve, until the lead thread of the insert is almost flush, but not above the base of the sleeve. Hold the sleeve of the installing tool firmly against and in line with the spark plug hole. Turn, but do not press down on the mandrel and screw the insert all the way into the spark plug hole (Fig. 18-3) until the end of the top thread of the insert is a half turn inside the top thread of the spark plug hole.

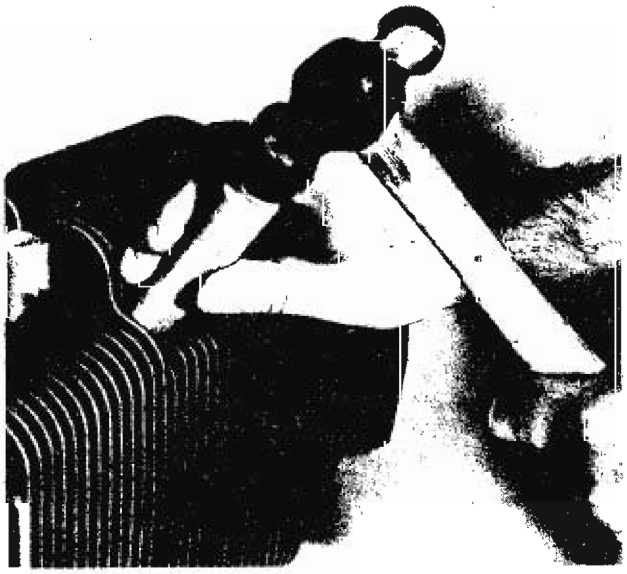
4. Removing the Helicoil Tang

Break off the tang with a pair of long nose pliers (Fig. 18-4). Insert the expanding tool, #18295, and torque to 120 in.-lbs. (Fig. 18-5).



5. Torquing the Expander

With the expanding tool still in position, place the staking tool, #18296, on the face of the spark plug hole. Tap the tool lightly with a soft hammer (Fig. 18-6).



6. Securing the Helicoil in Position

This operation knurls a light chamfer around the spark plug hole and seals the insert in place. Remove the staking tool and expander tool.

XVII – VALVES AND VALVE SPRINGS

VALVES: (FIG. 19)

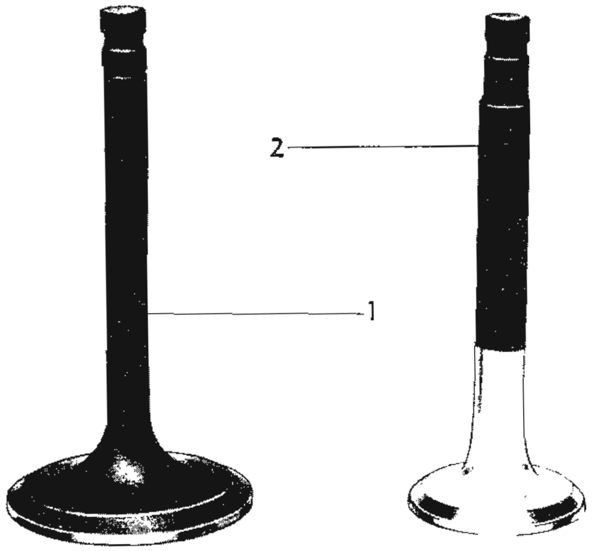


FIG. 19. Valves

1. Intake Valve
2. Exhaust Valve

On model 6A4-150-B3 and B31 engines the alloy steel inlet valve has a stem diameter of .3717" to .3725" and a 30° angle seat. The seat, when ground, must be concentric with the steam within .0015" total indicator reading.

The exhaust valve has a special heat and corrosion-resisting alloy steel head welded to the stem. The valve stem diameter is .4342" to .4350". Some engines have exhaust valves with a steam diameter of .3717" to .3725". It is very important that the proper steam diameter valve be used when replacement is made; otherwise, the clearance between valve stem and guide will be incorrect and serious damage will result. All exhaust valves have a 45° angle seat. The seat, when ground, must be concentric with the stem within .0015" total indicator reading. Both intake and exhaust valves on the model 6A4-165-B3 engine have a stem diameter of .4038" to .4030".

VALVE SPRING: (FIG. 20)

FIG. 20. Valve Spring

1. Spring Tension Adjustment Shims
2. Bottom Washer
3. Valve Spring Damper
4. Valve Spring
5. Top Washer
6. Valve Spring Retainer Lock

The valve spring assembly consists of a single coil spring, cupped bottom washer, shouldered upper washer, a spring damper and a split key or keeper to hold the upper washer in position. The two washers serve to center the spring about the valve stem. The valve spring must be assembled in the cylinder with the spring damper down to avoid damage to the damper and other valve linkage parts.

On the model 6A4-150-B3 and B31 engines, the valve spring force, when compressed to the indicated lengths, is as follows: Spring compressed to 1-5/8" = 46 to 52 lbs. and at 1-1/4" = 108 to 116 lbs. These measurements are made with the spring damper removed. With the valve and valve springs assembled in the cylinder, the valve should support a weight of 50 to 60 lbs. before the valve starts to leave its seat in the cylinder. Adjustment for assembled weight is accomplished by adding or removing shims UNDER the bottom washer. The shims are available in .016" and .031" thickness. Valve travel from the closed to the full open position must be a MINIMUM of .390" to insure proper operation. With the valve in its full open position on the engine, the spring coil should not be solid; otherwise, serious trouble with rocker arms and lifter rods may be experienced. Whenever service operations are performed affecting valve springs or component parts, always check the springs for a minimum travel of .390" and check for clearance between the spring coils when the valve is in the full open position.

On the model 6A4-165-B3 engine, the force exerted by the valve spring when it is compressed to 1.343" without the damper installed should be 138 to 146 lbs. With the valves and spring assembled in the cylinder, the valve should support a weight of 68 to 75 lbs. before the valve leaves its seat. The valve and springs are so designed on the 165 hp engine that NO SHIMS ARE EVER REQUIRED UNDER THE BOTTOM WASHER OF THE VALVE SPRINGS. The actual operating valve travel in the model 6A4-165-B3 engine is .500". The movement obtainable by depressing the valve until the spring is solid is considerably over .500", however.

XVIII – VALVE ACTUATING MECHANISM

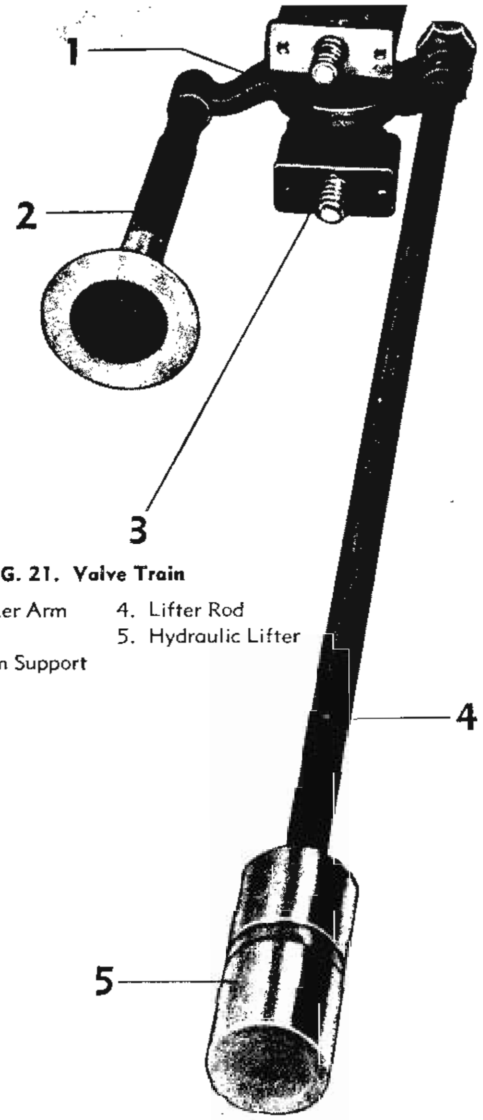


FIG. 21. Valve Train

1. Valve Rocker Arm
2. Valve
3. Rocker Arm Support
4. Lifter Rod
5. Hydraulic Lifter

The valves are actuated from the camshaft through hydraulic valve lifters, lifter rods, and valve rocker assemblies, which contact directly on the valve stems. (See Fig. 21.)

Lubrication to the rockers and valves is accomplished without use of external oil lines since the oil flows through drilled passages in the lifters, lifter rods, adjusting screws, and rockers to insure satisfactory lubrication to these parts and the valves themselves.

Caution must be taken when replacing lifter units, lifter rods, and adjusting screws to make sure that they are of the proper type. Both a forged type and a stamped type of valve rocker are used in the model 6A4-150-B3 and 6A4-165-B3 engines. The adjusting screw in the forged rocker has a 5/16"-24 thread, and the adjusting screw in the stamped rocker has a 3/8"-24 thread. Where a difference exists from one engine to another in parts having the same function, the Parts Book shows the correct part number for specific engine numbers.

HYDRAULIC LIFTERS

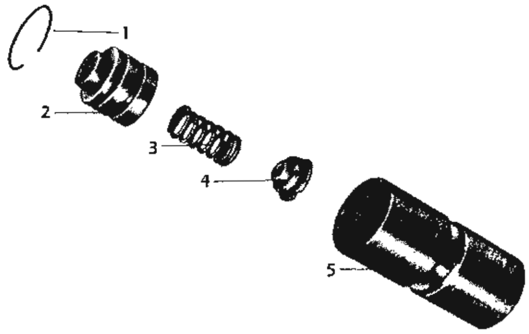


FIG. 22. Johnson Hydraulic Valve Lifter

1. Retainer Ring
2. Piston
3. Return Spring
4. Valve Cage
5. Lifter Body

The hydraulic lifters have proven to be dependable through years of usage. The illustrated views in Figure 22 shows the simplicity of construction, together with the few parts that comprise the assembly of the Johnson Products lifter, and Figure 23 shows the Wilcox-Rich lifter.

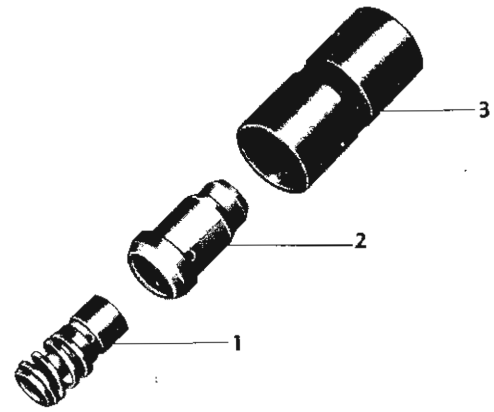


FIG. 23. Wilcox-Rich Hydraulic Valve Lifter

1. Plunger Assembly
2. Cylinder Assembly
3. Lifter Body

Oil under pressure from the engine lubrication system enters the lifter body chamber through two inlets in the annulus around the body. This annulus indexes with a hole drilled in the lifter guide hole in the crankcase. The lifter body chamber is thus filled with oil under pressure. A spring-loaded valve, located under the return spring, lifts off its seat due to the pressure of the oil in the lifter body chamber and allows oil to fill the lifter piston chamber. When the valve is closed, the oil in the piston chamber, being non-compressible, completes a lifting mechanism that operates against the lifter rod as positively as though the entire lifter unit were a single solid piece. As the valve train expands and contracts with changes in engine temperature, the lifter adjusts its own length to compensate for the changes. Accurately determined clearance to within one ten-thousandths of an inch between the piston and the bore of the lifter body permits the escape or leakdown, as it is commonly called, of a small amount of oil from the chamber. This leakage automatically compensates for any expansion in the valve train, allowing positive valve seating. When the valve train contracts, the piston return spring holds the piston outward. This relieves pressure on the oil in the piston chamber and on the valve under the return spring. The valve moves from its seat and permits the intake of oil from the engine lubrication system through the lifter body. Thus, the lifter unit corrects its length each time the valve closes, to maintain zero clearance. Some engine models have a slightly reworked lifter installed. A second annulus has been added to the body to allow more oil to the rocker arm mechanisms. However, this change in no way affects the operating principles of the lifter valve described herein.

Valve lifters furnished by both Wilcox-Rich and Johnson Products are used in model 6A4-150-B3 and B31 engines. These lifters are completely interchangeable and both have a body diameter of .8745" to .8740". The lifter body clearance in the guide is .001" to .002". The Wilcox-Rich lifter is easily distinguished from the Johnson Products lifter by the plunger spring which is visible in the open end of the Wilcox-Rich assembly.

The valve lifter for the model 6A4-165-B3 engine is manufactured by Johnson Products and has a body diameter of .9360-.9355". Care must be taken when replacing lifters in the 165 hp model to see that the smaller diameter lifter for the 150 hp model is not used. The large diameter lifter assembly is easily recognizable by the large chamfer on the lifter rod end of the body.

CAUTION: Hydraulic valve lifters for the older model four and six-cylinder Franklin engines with the external rocker oiling system must not be used in the 6A4-150-B3 and B31 engines. These old style lifters will fit the guide hole in the crankcase, but they are not machined to provide an oil passage to the hollow lifter rods for rocker and valve lubrication.

HYDRAULIC LIFTER (SERVICING)

To disassemble the Johnson type hydraulic lifter, remove the retainer ring from the top of the lifter body. (See Fig. 22-1.) This is done by prying one end out with a small knife blade or similar tool. If the tappet is full of oil and the piston is tight against the ring, first press the piston down slightly by pushing against the upper socket, forcing some of the oil out past the piston. When the retainer ring is removed, the action of the return spring pushes the lifter piston out of the lifter body. In this position, the piston return spring and valve cage may be easily removed. With the lifter parts separated, give them a thorough cleaning. During the cleaning process, do not enlarge the holes or change the dimensions of the piston or the bore of the lifter body by using any tool or material with an abrasive action. Clean each unit separately to avoid mixing parts. This is important as it would change the leak-down rate and affect the proper operation of the unit. After the lifter parts are cleaned and dried, a simple check can be made to test the action of the lifter valve assembly and the leak-down rate, which is controlled by the clearance between the piston and the lifter body.

Install the valve assembly and piston without the return spring, in the lifter body. Place the unit on a bench and tap the piston head sharply with the forefinger. If the unit is in good condition, the piston will rebound sharply, due to the cushion effect of the air in the lifter body chamber. If the piston does not react in this manner, it would indicate improper seating of the valve or excessive clearance between the piston and lifter body. WHEN REASSEMBLING THE UNIT, IT IS VERY IMPORTANT TO REPLACE THE SAME PARTS REMOVED FROM THAT PARTICULAR UNIT AS THEY ARE A MATCHED ASSEMBLY.

When installing the hydraulic lifters, no oil should be used in the chamber. When the lifters are installed dry, the two small holes extending through the piston skirt vent the air very quickly, and oil from the engine lubricating system operates the lifters. The outside of the lifter body should receive a light coat of oil, however, before being installed in the crankcase.

Very infrequent servicing is required and it is advisable not to disturb the lifters unless there is a direct cause traceable to lifter performance. Always replace the lifters in their original locations on the engine.

Some engine models utilize a Wilcox-Rich hydraulic lifter rather than the Johnson Products unit just described. The Wilcox-Rich employs a ball check valve arrangement to control the oil flow. However, the operating principles of the two lifters are practically the same.

The disassembly of the Wilcox-Rich lifter is accomplished by first lifting the hydraulic unit out of the lifter body. It should lift out easily, but if an excessive deposit of sludge or dirt prevents it from doing so, immerse the lifter in clean solvent and wash it until clean. The plunger or piston is locked to the cylinder by the plunger spring which fits into a counterbore in the cylinder. To remove the plunger from the cylinder, first unlock the spring. This is done by simply turning the plunger and spring in the direction that would "wind up" the spring. Pull outward at the same time, and the plunger should then come out easily. If the plunger should be stuck, it will be caused by one of two things: 1. A carbon deposit which has formed at the shoulder of the cylinder above the plunger. 2. The oil chamber is still filled with oil, sealed in by the ball check valve, holding the plunger against the carbon ring. To determine whether or not the plunger is stuck, insert a wooden stick in the oil inlet hole at the bottom of the cylinder. This will unseat the ball check valve and allow the oil to drain out. If the plunger still remains stuck after this procedure, soak the unit in solvent and use taped pliers if necessary. A combination twisting and pulling motion will separate the plunger from the cylinder.

AS IN THE CASE OF THE JOHNSON UNIT, THE PLUNGER AND CYLINDER ARE SELECTIVELY FITTED AT THE FACTORY, AND THE PLUNGER FROM ONE CYLINDER CANNOT BE USED IN OTHER CYLINDERS.

After cleaning and reassembling the unit, the method of checking by creating an air pocket in the cylinder and quickly releasing the plunger to see if it kicks back up is the same as previously described for the Johnson lifter.

LIFTER ROD AND TUBE

The lifter rod is of seamless steel tubing. It has a ball end which contacts the cup in the lifter plunger. A cup on the top of the lifter rod contacts the ball end of the drilled valve rocker adjusting screw. (See Fig. 24-1.) If either tips on the lifter rod show appreciable wear, the lifter rod assembly should be replaced. The holes in the tips and the hollow rod must be free of foreign matter, as oil from the engine must pass through the lifter rod assembly to lubricate the rocker arms and valve assemblies.

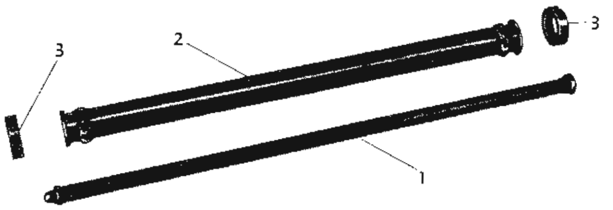


FIG. 24. Lifter Rod, Tube and Oil Seals

1. Lifter Rod Assembly
2. Lifter Rod Tube
3. Lifter Rod Tube Packings

The lifter rod should be straight within .005" total indicator reading.

The lifter rod is encased in a lifter rod tube which contains a coiled spring type circlet fitted in the recess of the bead on the crankcase end of the tube. (See Fig. 24-2.) This circlet centers the lower end of the push rod on the lifter cup and serves as a guide to position the rod during installation and engine operation. Early engines had the Wilcox-Rich valve lifters and were not installed with circlets in the lifter rod tubes. When any of the lifter rod tubes are removed, the crankcase end should be examined at the bead to determine if it contains a circlet. A spring circlet should be installed before the tube is reassembled on the engine. This is particularly important if the Johnson Products hydraulic lifter is being used.

NOTE: It is very important to make sure that the ball end of the lifter rod is positioned in the cup in the valve lifter. Failure to do so will cause improper engine operation and damage to the valve operating parts.

ROCKER PINS AND ROCKERS

The steel rocker pins are mounted through three support blocks on the head of the cylinder. (See Fig. 25.)

If the valve rockers and supports have been removed, it is important to see that a welch plug is installed in the bore of each rocker pin just inboard of the support screw hole. The absence of this plug will eliminate the safety feature of having an oil cross feed between the two rockers in case the oil passage to one rocker gets plugged. The oil hole in the rocker pin should face down toward the cylinder head for the same reason.

The rockers (See Fig. 25-2, 3) may be identified by the part number which is stamped on each piece. Some rockers have only the last number of the part number stamped on the piece, thus, the inlet rocker is stamped with a "7" and the exhaust rocker is stamped with an "8".

The rockers are either metal stampings or forgings, depending on engine serial number.

All of the forged type rockers, both intake and exhaust, have a drilled oil hole that opens out the valve end of the rocker arm. There are some stamped type intake valve rockers that are drilled so that the oil hole opened directly on the valve stem tip. Some of the stamped type exhaust valve rockers were drilled so that oil holes opened both at the end of the rocker arm and also directly on the valve stem tip. All of the intake valve rockers are interchangeable with each other. All types of exhaust rocker are also interchangeable with each other. Any of the rockers mentioned above may be used on all model 6A4-150-B3 and B31 engines.

It is important that only the forged type rocker be used on the model 6A4-165-B3 engine.

Solid aluminum blocks were used as rocker supports in the early engines. A metal stamping is used as support blocks for the rockers in the later engines. (See Fig. 25-5.) These are attached to the cylinder head by means of 5/16"-18 x 1-3/4" hex head cap screws and are secured by a tab-type lockwasher. Some engines having studs in the cylinder head use plain washers, 5/16"-24 plain nut, and 5/16"-24 palnut to secure aluminum block supports to the cylinder. Other engines use aluminum blocks secured by 5/16"-18 1-3/4" cap screws with 5/16" shakeproof washers. The stamped steel and the machined aluminum block rocker supports are interchangeable on the 6A4-150-B3 and B31 engines only. Either type support may be used with either the stud or cap screw hold-down fastenings. The rocker support for the model 6A4-165-B3 engine is of the stamped type. It is not interchangeable with the rocker supports for the other model engines as it supports the rocker pin at a greater height above the top of the cylinder. A 3/8"-24 hex jam nut on a 3/8"-24 NF-3 drilled rocker adjusting screw is used on the stamped rocker. A 5/16"-24 jam nut and adjusting screw are used on the forged rocker.

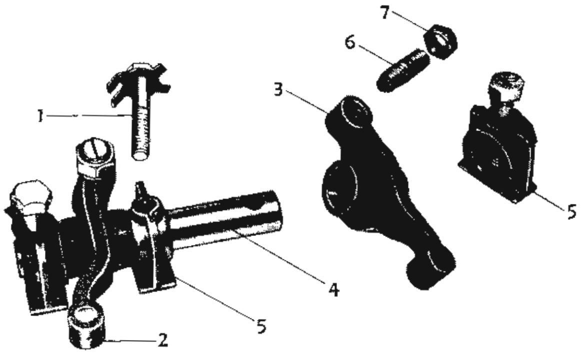


FIG. 25. Valve Rockers and Supports

1. Rocker Assembly Hold-Down Screw and Lock Washer
2. Exhaust Valve Rocker Arm
3. Intake Valve Rocker Arm
4. Rocker Pin
5. Rocker Support
6. Rocker Arm Adjusting Screw
7. Rocker Arm Adjusting Screw Nut

Due to the increased height of the rocker supports on the model 6A4-165-B3 engine, dimpled rocker covers are used. CAUTION: A model 6A4-150-B3 rocker cover should not be used on the 165 hp model as damage to the cover and possibly the rocker will result. The dimpled cover may be used for replacement on all models. Refer to the Parts Book for the correct part number and reference.

The rocker arm bushing inside diameter is .625" to .626". The rocker pin outside diameter is .6225" to .623", giving a bushing on pin clearance of .002" to .0035". The side clearance between the rocker arm and support is .003" to .008" (.006" desired). The rocker pin fit in the aluminum blocks is .001" tight to .0005" loose. The rocker pin fit in the stamped supports is .001" tight to .0015" loose.

XIX – LUBRICATING SYSTEM

Being a wet sump type engine, the oil pan or sump (See Fig. 27) is attached to the bottom of the crankcase and has a maximum service capacity of eight quarts. The total oil capacity of the 6A4-165-B3 engine is 8 3/4 quarts.

The oil is picked up from the reservoir by the oil pump, through the Floto unit, which is designed to receive oil from the cleanest location within the reservoir. This unit incorporates a wire mesh filter to prevent foreign materials from entering the system. Some of the early production 6A4-150-B31 engines were not equipped with the Floto unit. On those units a fine mesh screen is incorporated in the end of the oil inlet pipe assembly.

The gear type oil pump, driven by a gear on the camshaft and mounted inside the engine to the left crankcase section, delivers oil under pressure to the oil by-pass plate. (See Fig. 28.) This plate is located on the outside of the crankcase at the left front of the engine crankcase adjacent to #5 cylinder. Excessive oil pressure in the lubricating system of the engine is controlled by a spring loaded plunger in the oil by-pass plate. The plunger and spring can be removed for inspection by unscrewing the rear hexagon nut on the housing. On some early production engines, the by-pass plunger and spring were incorporated in the oil pump cover mounted at the bottom of the oil pump inside of the oil pan.

The oil by-pass plate also contains the oil cooler relief valve, (See Fig. 29), which consists of a steel ball, spring and ball cage. The purpose of this valve is to by-pass the engine lubricating oil directly into the engine lubricating system in the event that the oil cooler or the cooler oil lines should become obstructed. The oil cooler relief valve can be removed for inspection by unscrewing the hexagon nut on the front end of the by-pass plate, just above the oil cooler return line fitting.

On some early model engines equipped with oil by-pass plunger and spring in the oil pump cover, the oil cooler relief valve is incorporated on the oil cooler itself.

Oil under pressure from the pump is carried by an external oil line to the oil cooler. After passing through the cooler, the oil is returned by an external line to the by-pass plate. It is then directed through two drilled passages running the full length of the left crankcase half.

The lower gallery furnishes oil to the left bank of hydraulic lifters. The upper gallery furnishes oil to the main, rod and camshaft bearings. A drilled passage from the first mentioned gallery through one of the camshaft bearing bosses supplies oil to the right bank of hydraulic valve lifters. Oil is directed from the hydraulic valve lifters through the hollow lifter rods to oil the rocker arms, valves and valve springs. The connecting rods are provided with spray holes to keep the cylinder walls and piston pins in a heavy oil spray at all times. Timing and accessory drive gears are continuously bathed in oil.

LUBRICATION SYSTEM - INSPECTION AND SERVICING

Determine the quantity and general condition of the oil in the engine sump by inspecting the oil level as indicated on the graduated oil level gauge or dip stick. This inspection should be made at least daily, or more often if operating conditions warrant. Oil of the same type and viscosity may be added to bring the quantity to or near the full mark. Do not attempt to operate the engine with an insufficient quantity of oil in the sump. Figure 26 shows the oil level gauge for the 6A4-150-B3 engine. The gauge or dip stick for the 6A4-165-B3 is similar to the one shown except the graduations are marked "3", "5", "7" and "full".

FIG. 26. Oil Measuring Stick

The oil filler cap is located on the top of the crankcase cover on the right side, near the rear of the engine. When the filler cap is removed, inspect the gasket for condition. Replace if worn. Do not neglect to reinstall the filler cap.

As previously explained, the maximum service capacity of the oil sump is eight quarts for the 150 HP engine and 8-3/4 quarts for the 165 HP engine. No useful purpose can be served by exceeding this maximum quantity.

The period for changing the oil will vary with operating conditions, however, the maximum time between oil changes should not exceed 25 hours.

Always drain the oil while the engine is warm. To drain the oil, remove the sump drain plug, located at the bottom of the sump pan at the right rear of the engine. Reinstall the sump plug and secure with safety wire to the tab provided.

Refill the sump with a good grade of oil of the recommended viscosity. Use only clean containers and funnels. Inspect the filler cap gasket and reinstall immediately to eliminate the possibility of any small objects being accidentally dropped into the crankcase. Check the level of the fresh oil in the sump by inspecting the dip stick. Screw the dip stick back firmly into place. Remove any excess oil that may have been spilled on the engine.

When starting an engine, always remember to observe the oil pressure gauge. If the oil pressure gauge does not start to indicate within 20 seconds, and tapping the gauge glass with the fingers does not have an immediate effect, STOP THE ENGINE AT ONCE and investigate the cause.

The maximum oil temperature should not exceed 230°F. The oil pressure during normal operation should be between 30 PSI minimum and 50 PSI maximum, with a minimum oil pressure of 10 PSI in the idle range.

When starting a cold engine, do not exceed 1200 RPM engine speed for at least five minutes to permit oil to thin out before going to higher RPM.

OIL PAN

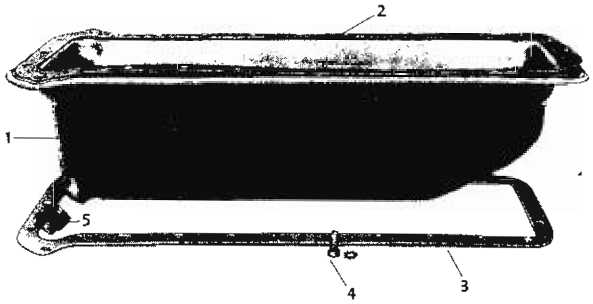


FIG. 27. Oil Pan Assembly

1. Oil Pan
2. Oil Pan Gasket
3. Reinforcement Band
4. Attachment Screw and Shakeproof Washer
5. Oil Drain Plug

The oil pan is attached to the bottom of the crankcase and serves as a reservoir for the engine lubrication oil. (See Fig. 27.) The 3/4"-24 square head oil drain plug has a standard pipe thread and is safetied to a tab by steel lacing wire.

A composition gasket is installed between the oil pan and the bottom crankcase surface. A solid aluminum reinforcing plate under the oil pan flange of stamped pans assures desirable oil sealing qualities at this parting line.

The oil pan is attached to the crankcase by twenty-four 5/16"-18 x 3/4" fillister head screws using 5/16" shakeproof washers. Three plain 5/16"-24 hex nuts with 5/16" shakeproof washers are used to attach the rear end of the oil pan to the timing gear case.

To insure a proper fit and prevent oil leaks, the timing gear case gasket is trimmed flush with the crankcase bottom surface and the trim joints coated lightly with sealing compound.

Some engine models have a magnesium cast oil pan, which is attached to the engine in a similar manner to the stamped pan. However, the cast pan has sufficient flange thickness to eliminate the reinforcement band necessary on the stamped pan.

OIL PUMP

The oil pump is a gear type, positive displacement pump. (See Fig. 28.) The pump drive gear is driven by a gear on the camshaft. The pump body, to which is attached the inlet pipe and Floto unit, is mounted to the bottom front section of the left crankcase half by four 1/4-20 x 2-3/4" hex head cap screws and four 1/4" plain washers. The cap screws are safetied with lacing wire, or in the later engines with tab lock washers.

On the model 6A4-165-B3 engine, only three 1/4"-20 x 2-3/4" cap screws are used with a fourth 1/4"-20 screw which is only 2-1/2" long. When the oil pump is removed from the case, the location of the various screws should be noted. It is essential that the screws be reassembled in the same locations from which they were removed. The threaded hole for the cap screw on the crankcase pad, where the oil pump is attached, and which is nearest the second cam lobe, should be checked carefully after the screws are assembled. The cam lobe in its closest position must clear the end of the screw. The engine should be turned over slowly by hand to check this clearance.

The oil pump cover assembly, which includes the oil inlet pipe and oil inlet float stop, is supported at the Floto end by a bracket, which is attached to the bottom of the crankcase by two 1/4"-20 x 5/8" fillister head screws (and two 1/4" plain washers). A clamp is used to fasten the oil inlet pipe tube to the bracket. (Screws are safetied with lacing wire.)

The backlash between the oil pump gears is .004" to .008". Also, the backlash between the drive gear on the camshaft and the driven gear on the oil pump shaft is .004" to .008".

NOTE: The gear on the oil pump shaft, which is driven by the gear on the camshaft, has been made of cast iron for some engines and of soft steel for other engines. Also the camshaft incorporating the oil pump drive gear is made of cast iron for some engines and of forged steel for other engines. If either of the above parts are replaced, DO NOT assemble a steel oil pump shaft gear to run with a cast iron camshaft gear. Any other combination of gear and camshaft is permissible. The cast iron oil pump shaft gear can run with either type camshaft. This is the only gear that will be supplied for service replacement.

Order by part number as listed in the Parts Book for this model. Gears for earlier models are dimensionally the same and should not be used.

OIL INLET FLOAT (FLOTO)

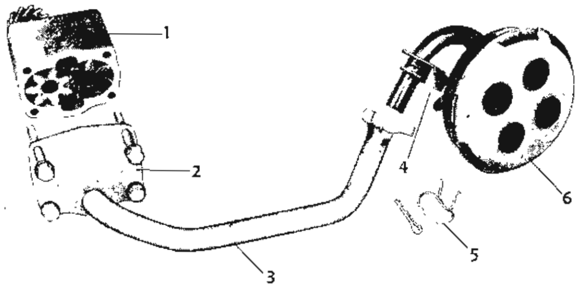


FIG. 28. Oil Pump and Floto

1. Oil Pump Body and Gears
2. Oil Pump Cover and Attachment Screws
3. Oil Inlet Pipe
4. Floto Stops
5. Floto Clip
6. Floto Unit

The Floto unit (Fig. 28-6), is composed of a large diameter oil screen, which is so constructed that it floats in the clean upper portion of the oil in the pan. The screen prevents any foreign matter that might be suspended in the oil from entering the oil inlet pipe.

The Floto unit is attached to the oil inlet pipe by a 1/8" x 1" cotter pin and special wire clip. The clip is omitted in the 6A4-165-B3 engines.

When assembled, the Floto unit should be free to move within the limits of the stops on the inlet pipe. The position of the unit when fully lowered toward the bottom of the pan should be 4" from the bottom face of the crankcase to the centerline of the Floto at the big diameter.

If at any time the Floto unit is removed from the oil inlet pipe or is in any way damaged, it should be carefully checked for condition of inlet pipe and Floto operation before reassembly. The Floto should float if placed in oil or water. If it sinks, it should be replaced.

OIL BY-PASS PLATE

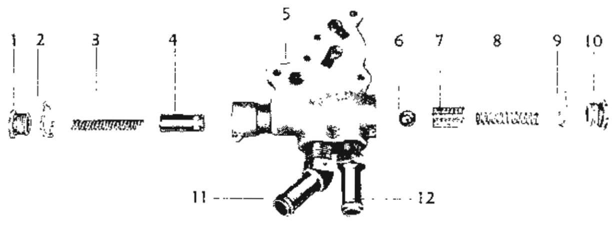


FIG. 29. Oil By-Pass Plate and Relief Valve Assembly

1. Oil Pressure Relief Valve Nut
2. Oil Pressure Relief Valve Gasket
3. Oil Pressure Relief Valve Spring
4. Oil Pressure Relief Valve Plunger
5. Oil By-Pass Plate
6. Oil Cooler Relief Valve Ball
7. Oil Cooler Relief Valve Ball Cage
8. Oil Cooler Relief Valve Spring
9. Oil Cooler Relief Valve Gasket
10. Oil Cooler Relief Valve Nut
11. Oil Out-of-Engine Fitting
12. Oil Into-Engine Fitting

On all but a few of the first engines of this model, the oil by-pass plate contains the oil pump pressure relief valve and the oil cooler relief valve. (See Fig. 29.) It is mounted on the outside of the crankcase at the left front of the engine. The function of the oil pressure relief valve is to by-pass excess oil directly back into the crankcase whenever the pressure in the oil system exceeds the specified limits. When the oil pressure has stabilized, the spring tension will control the valve position to maintain normal pressure within specified limits.

The relief valve plunger and spring on early engines are located in the oil pump cover itself.

Inspection of the oil pressure relief valve plunger (Fig. 29-4) and spring can be made by removing the rear hex nut on the by-pass plate housing. Inspect the plunger and bore for smoothness. Bore diameter is .5615" to .5630". Plunger diameter is .560" to .561". Two types of plungers were used, however, plunger part #14732 is the only one which will be serviced since the two types are interchangeable in all engines of this model.

Free length of spring is 2-11/32" and, when compressed to 1-21/32", the spring should exert a force of 10 to 11 lbs. All of the parts should be cleaned and reassembled with a new copper gasket under the nut.

The operation of the oil cooler relief valve is to by-pass the oil through the by-pass plate should the oil flow through the cooler or cooler oil lines be retarded. (See Fig. 29-6 to 10.) In this manner, the engine would continue to receive lubrication independent of the cooler's operation in the event cooler obstruction occurs. The oil cooler relief valve incorporates a 9/16" steel ball, held against a seat in the by-pass plate by a spring, which has a free length of 1-29/32" and, when compressed to 1-1/16", should exert a force of 2.1 to 2.4 lbs. A perforated brass cage serves as a guide and retainer for the relief valve ball.

Inspection of the oil cooler relief valve assembly can be made by removing the front hex nut on the by-pass plate. Use a new copper gasket when reinstalling the unit.

On a few of the early model engines, the relief is incorporated in the oil cooler line.

If a more detailed inspection is indicated, the entire by-pass plate assembly may be removed from the engine by loosening the cap screws which attach it to the outside of the crankcase. Use a new gasket of the proper type between the by-pass plate and crankcase when reinstalling the housing on the engine.

XX – INLET MANIFOLD

The manifold on the 6A4-150-B3 and B31 engine is composed of seven major units: (See Fig. 30) a cast distributing zone, on which the carburetor is mounted; two aluminum alloy distributing zone pipes, 1-5/8" in diameter, joining the distributing zone to the inlet manifolds; two cast inlet manifolds, one to the even-numbered side and one to the odd-numbered side cylinder ports; two aluminum manifold equalizer pipes, 1-1/4" in diameter, joining the inlet manifolds, one for the odd-cylinder side and one for the even-cylinder side.

The manifold of the model 6A4-165-B3 is composed of units similar to those on the model 6A4-150-B3 engines. The individual parts, however, are not interchangeable between the two models. The distributing zone pipes on the 165 hp model are 1-7/8" in diameter. The manifold equalizer pipes are 1" in diameter. Even though it is physically possible to install the entire induction manifold system for one model on the other model, this should NOT be attempted. Neither engine will function properly with an induction system other than the one properly approved and specified for it.

The distributing zone is fastened to the rear end of the crankcase by one oil pan mounting stud and by two 1/4"-20 x 2-1/2" hex head cap screws through the timing case into tapped holes in the rear crankcase surface. A plain 5/16" shakeproof washer is used on the stud while 1/4" shakeproof washers are used under the cap screw. Some engines use plain washers under the cap screw heads and lacing wire. The distributing zone on the model 6A4-165-B3 engine is mounted in the same manner except that the two 1/4"-20 cap screws are 3" long.

The distributing zone pipes are joined to the zone and manifold by inlet manifold flanges. The flanges are mounted to manifolds at one end and the zone at the opposite end by 5/16"-18 x 5/8" hex head cap screws, using 5/16" shakeproof washers under the screw head. Rubber packings, which are a crush fit in manifolds and zone, are held in position by the flanges. The manifold equalizer pipes are joined to the end of the manifolds, using similar rubber packing and flanges, as well as the same size cap screw and shakeproof washer.

The equalizer pipes are joined together in front of the engine by a fabric-reinforced composition hose, 1-1/4" inside diameter, 2-1/2" long, secured by two adjustable hose clamps. A clamp attached under the head of a front oil pan screw and tightened with a #10-32 screw supports the weight of the front equalizer pipe assembly. The hose connection on the model 6A4-165-B3 is 1" inside diameter by 2-1/2" long.

The cast inlet manifolds are mounted on the cylinder inlet ports by 5/16"-18 Allen head socket screws. The screws are secured in position with lacing wire, and 5/16" plain washers are used under the heads. Later models use 5/16"-18 slotted hex head cap screws with 5/16" shakeproof washers. A composition gasket is used at each cylinder inlet port between the manifold and cylinder matching surfaces.

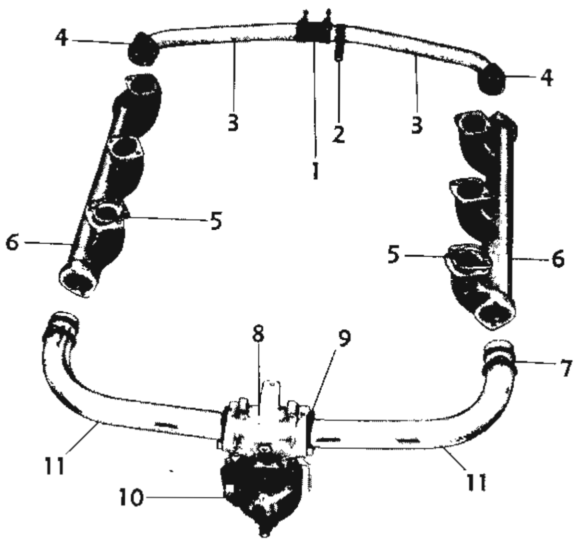


FIG. 30. Inlet Manifold

1. Connecting Hose
2. Supporting Bracket for Front Pipe
3. Front Manifold Equalizer Pipes
4. Flange and Rubber Packing for Front End of Runner
5. Cylinder Intake Port Gasket
6. Cast Runner Inlet Manifold
7. Flange and Rubber Packing for Rear End of Runner
8. Distributing Zone
9. Flange and Rubber Packing for Distributing Zone End of Pipes
10. Carburetor
11. Rear Distributing Zone Pipes

It is of greatest importance that all seals, gaskets, and connections in this manifold induction system be properly installed. The system must be sealed against the entrance of unmetered air as the carburetor will only supply fuel in proportion to the air flow that passes through its venturi system; hence, the entrance of outside air at atmospheric pressure into the lower pressure area of the inside of the induction system will cause the engine to overheat due to a lean fuel mixture.

CAUTION: It is important that the manifolds be properly aligned with the mounting pads on the cylinders. If proper alignment is not obtained, manifold leaks will occur or a manifold casting may be cracked when the mount screws are tightened. To obtain proper alignment, the cylinder hold-down nuts should not be completely tightened when the cylinder is first assembled on the engine. The manifold runners should be temporarily assembled on the cylinders without any gaskets and the mount screws tightened. The cylinder hold-down nuts should then be tightened with the proper torque. The manifold runners should then be removed for later assembly with gaskets.

XXI – ACCESSORY GEAR TRAIN

MAGNETO DRIVE GEAR AND HUB

The magneto drive gear is a steel, 30 tooth, helical gear. (See Fig. 31-2.) The gear itself is machined separately from the hub. The hub is pressed into the gear to form an assembly. A Woodruff key and keyway insure that the proper relation between hub and gear teeth is maintained. This gear and hub are furnished for service replacement only as an assembly. The hub has an extended shank that is pressed into the hollow rear end of the crankshaft. The hub is coated with an anti-sieze compound before being pressed into the shaft. The two Woodruff keys that position the starter gear on the outside of the crankshaft extend through the shaft and also position the magneto drive gear hub on the inside of the shaft. There are two tapped holes in the gear hub that furnish a means of pulling the gear assembly out of the shaft. There is a hole in the center of the hub to take the tachometer drive gear. The magneto drive gear should be checked for squareness with the crankshaft after assembly. The maximum permissible runout is .005" total indicator reading. The permissible backlash of the magneto drive gear with magneto and generator driven gears is .006" to .010".

MAGNETO DRIVEN GEAR

The magneto driven gears are aluminum 20 tooth helical gears. (See Fig. 31-3.) The inner hub of the gear has eight equally spaced recesses machined in it. Also, the outside face of the magneto impulse coupling has eight recesses machined in it. When assembling the gear on the magneto shaft, hold the magneto in a vertical position with the drive shaft pointing straight up. Install the rubber shock absorbers in the recesses of the impulse coupling and then slide the magneto driven gear over the shaft. Line up the gear so that the rubber shock absorbers form a drive between the gear and the impulse coupling. Install the special nut and pull the entire assembly up to the proper torque. Line up the hole through the shaft with a hole in the nut. Before the nut is safetied with a cotter pin, the magneto impulse should be checked for freedom of operation. Hold the magneto in a horizontal position and turn slowly by hand in the normal direction of rotation. The impulse pawl should engage the stop stud. Further turning should cause the impulse to snap. If the impulse does not snap, the magneto gear should be removed and the gear and gear spacer checked. When the gear is assembled against the shoulder on the magneto drive shaft without the rubber shock absorbers in place, the spacer on the shaft should protrude .001" to .007" beyond the face of the gear.

The permissible backlash with the drive gear is .006" to .010".

GENERATOR DRIVEN GEAR

The generator driven gear is an aluminum, 20 tooth helical gear. (See Fig. 31-1.) This gear has eight equally spaced recesses in the hub. When assembling the gear on the generator, it is first necessary to install the special adapter so that

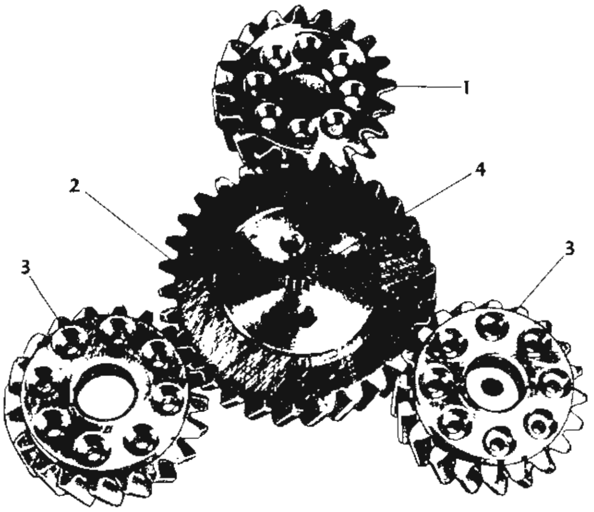


FIG. 31. Accessory Gear Train

1. Generator Driven Gear
2. Accessory Drive Gear
3. Magneto Driven Gear
4. Tachometer Drive Gear

the eight equally spaced recesses in the adapter face away from the generator body. This adapter is keyed to the generator shaft with a #61 Woodruff key. A rubber shock absorber unit with eight projections on either side is used as a drive connection between the gear and the generator shaft. Line up the recesses in the gear with the shock absorber projections and install special flat washer and nut. Pull the entire assembly up tight and safety with a cotter pin. Engines with the 15 ampere generator have the individual rubber shock absorbers and installation will be eased by holding the generator in a vertical position with the shaft upward while assembling. The moulded shock absorber unit and the individual shock absorbers are not interchangeable due to the different overall thicknesses.

CAUTION: Inasmuch as the aluminum helical tooth gears look very much the same, it is most important that proper precautions be taken to avoid a mix-up of the gears. The magneto and generator driven gears are not interchangeable.

The permissible backlash with the drive gear is .006" to .010".

TACHOMETER DRIVE

The tachometer drive gear is a small heat-treated steel, 12 tooth, spur gear. (See Fig. 31-4.) This gear is made with a short .1885" to .1890" diameter shaft that is a press fit in the hole in the magneto drive gear. An assembly composed of a cylindrical housing, a sleeve, a tachometer drive connector, the 24 tooth tachometer driven gear, and a packing complete the tachometer drive. The housing containing this assembly is a press fit into a hole near the center of the rear timing gear case. Two 1/4"-20 x 1/2" cap screws and shakeproof washers secure the housing to the case. The permissible backlash between the tachometer drive and driven gears is .001" to .003".

STARTER GEAR ASSEMBLY

The 103 tooth starter ring gear is shrunk onto a forged steel hub to form a permanent assembly. (See Fig. 50-1, p.) The hole in the gear hub has a diameter of 1.9968" to 1.9975". This produces a .004" to .0052" shrink fit on the 2.0015" to 2.0020" diameter crankshaft end. It is necessary to heat the gear assembly to 200° to 250°F to assemble it on the crankshaft. The end of the crankshaft is coated with an anti-sieze compound before the gear is assembled. The gear is positioned on the shaft by two #16 Woodruff keys and is secured by a spanner nut and tab lockwasher. The spanner nut is brought up as tight as possible. The starter gear should be checked for squareness with the crankshaft after assembly. The maximum permissible runout is .016" total indicator reading.

XXII – IGNITION

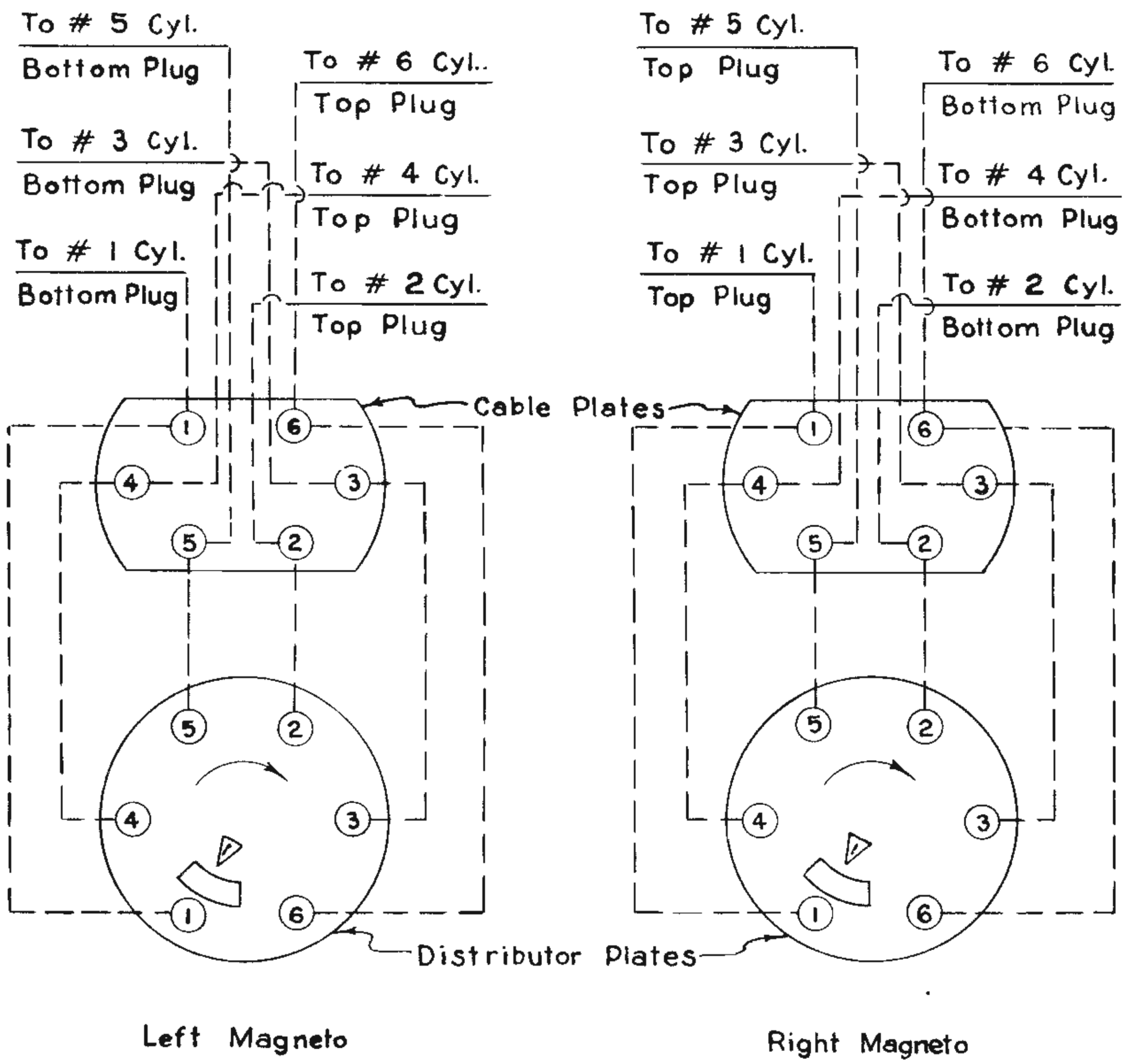


FIG. 32. Wiring Diagram for 6A4-150-B3 and B31 Engines
Engine Firing Order 1-4-5-2-3-6

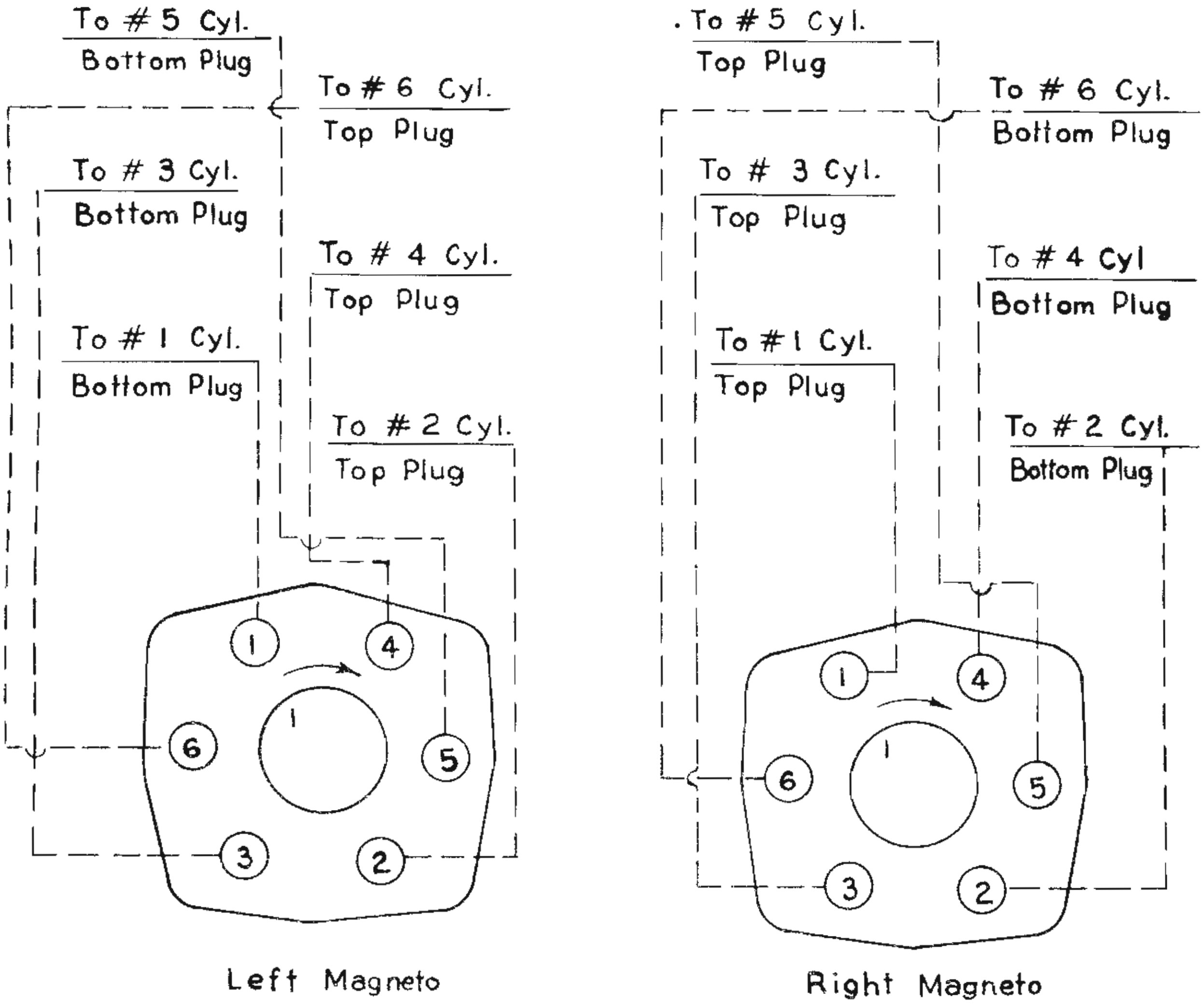


FIG. 33. Wiring Diagram for 6A4-165-B3 Engine
Engine Firing Order 1-4-5-2-3-6

The ignition for the 6A4-150-B3 and B31 engines is supplied by two LA-6 Eisemann magnetos (See Fig. 34), mounted on the rear timing case. The high tension current is carried from the distributor, which is incorporated in the magneto, to the spark plugs, by 7 mm. high tension cable, containing 19 strands of tinned copper wire. The ignition for the model 6A4-165-B3 and a few of the later model 6A4-150-B3 engines is supplied by Bendix-Scintilla S6RN-21 magnetos. The Bendix and the Eisemann magnetos are similar in principle of operation, and the descriptive information below applies to both.

Wiring diagrams for 6A4-150-B3 and B31 and the 6A4-165-B3 engines are shown in Figures 32 and 33 respectively.

MAGNETOS - PRINCIPLES OF OPERATION

The LA-6 and S6RN-21 model aircraft magnetos are of the conventional high tension type. They consist basically of a closed magnetic circuit including a rotating magnet, a coil incorporating a primary and a secondary winding, a breaker, a condenser, and a jump spark high tension distributor.

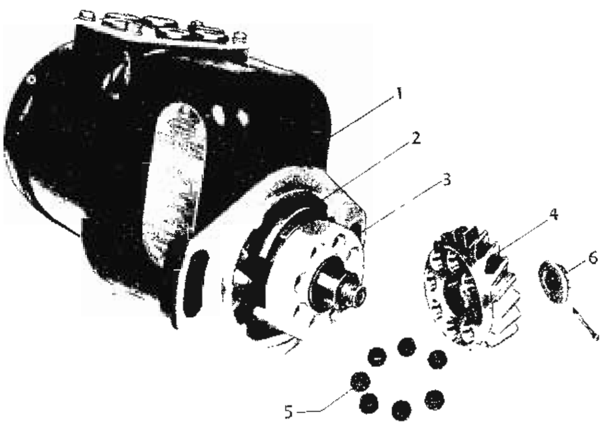


FIG. 34. LA-6 Magneto

1. Magneto
2. Impulse Coupling
3. Drive Adapter
4. Magneto Driven Gear
5. Rubber Drive Shock Absorbers
6. Holding Nut

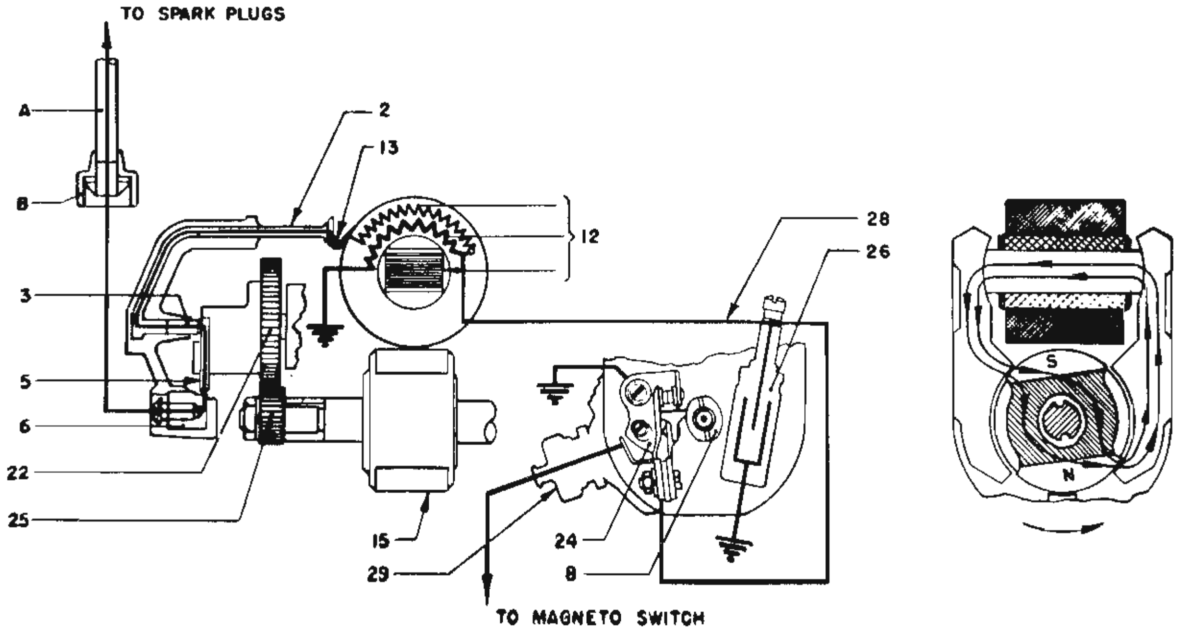


FIG. 35. Schematic Diagram of Electric and Magnetic Circuits

A. High Tension Cable
B. High Tension Terminal
2. Coil Contactor
3. Carbon Brush and Spring
5. Distributor Rotor Electrode
6. Distributor Plate Electrode
8. Breaker Cam
12. Coil—Secondary Winding; Coil—Primary Winding; Coil—Core
13. High Tension Terminal
15. Magnet Rotor
22. Distributor Cam
24. Breaker Assembly
25. Pinion Gear
26. Condenser
28. Breaker Condenser Lead
29. Ground Terminal

The magneto drive shaft carries a two-pole alnico magnet fitted with laminated pole pieces. This magnet assembly rotates in the tunnel of the main housing which includes cast-in laminated pole shoes. These pole shoes are bridged at their upper ends by the laminated coil core to complete the magnetic circuit.

Referring to the schematic diagram of the magnetic circuit (Fig. 35), it is evident that the direction of flux through the coil core is reversed twice for each revolution of the magnet rotor.

This generated current represents energy stored in the magnetic circuit by distorting the magnitude and direction of flux from its normal condition. Interruption of the primary current by opening of the contact breaker releases this stored energy by allowing the flux to change rapidly to its normal state. This rapid change of flux through the primary winding induces the required high voltage surge in the secondary winding.

The design of the cam is such that it opens and closes the breaker in proper relation to the position of the magnet rotor, thereby producing the maximum obtainable value of high voltage surge. The condenser is connected in parallel with the breaker contacts in order to suppress contact arcing when the primary current is interrupted.

The high tension distributor consists of a jump gap type of rotating switch properly geared to the magnet rotor. This serves to distribute the high voltage surges to the proper cylinder at the correct time.

The magneto is "turned off" by connecting the ground terminal to ground through a suitable ignition switch. Grounding this terminal short circuits the breaker, thus making it impossible for the opening of the contact points to interrupt the primary current.

IMPULSE STARTER ON THE LA-6 AND S6RN-21 MAGNETOS

The impulse starter is an automatic device, which operates only during engine starting, and serves a two-fold purpose. It automatically retards the timing of the ignition spark to prevent engine "kicking" when starting, and it intensifies the spark to insure easy starting.

At starting speeds, the impulse starter automatically locks the magnet rotor twice during each revolution. With the rotor blocked, the magneto drive member continues to turn with the engine winding up the impulse starter spring. When the spring is completely wound up, the starter automatically unlocks the rotor and the unwinding of the impulse starter spring rapidly rotates the magnet rotor to its normal position. This rapid rotation of the magnet rotor causes a spark of high intensity to be generated at a time later than normal.

When the engine starts and the magneto comes up to speed, the impulse coupling latches are moved by centrifugal action to their disengaged position. The magneto then continues to operate in the normal manner.

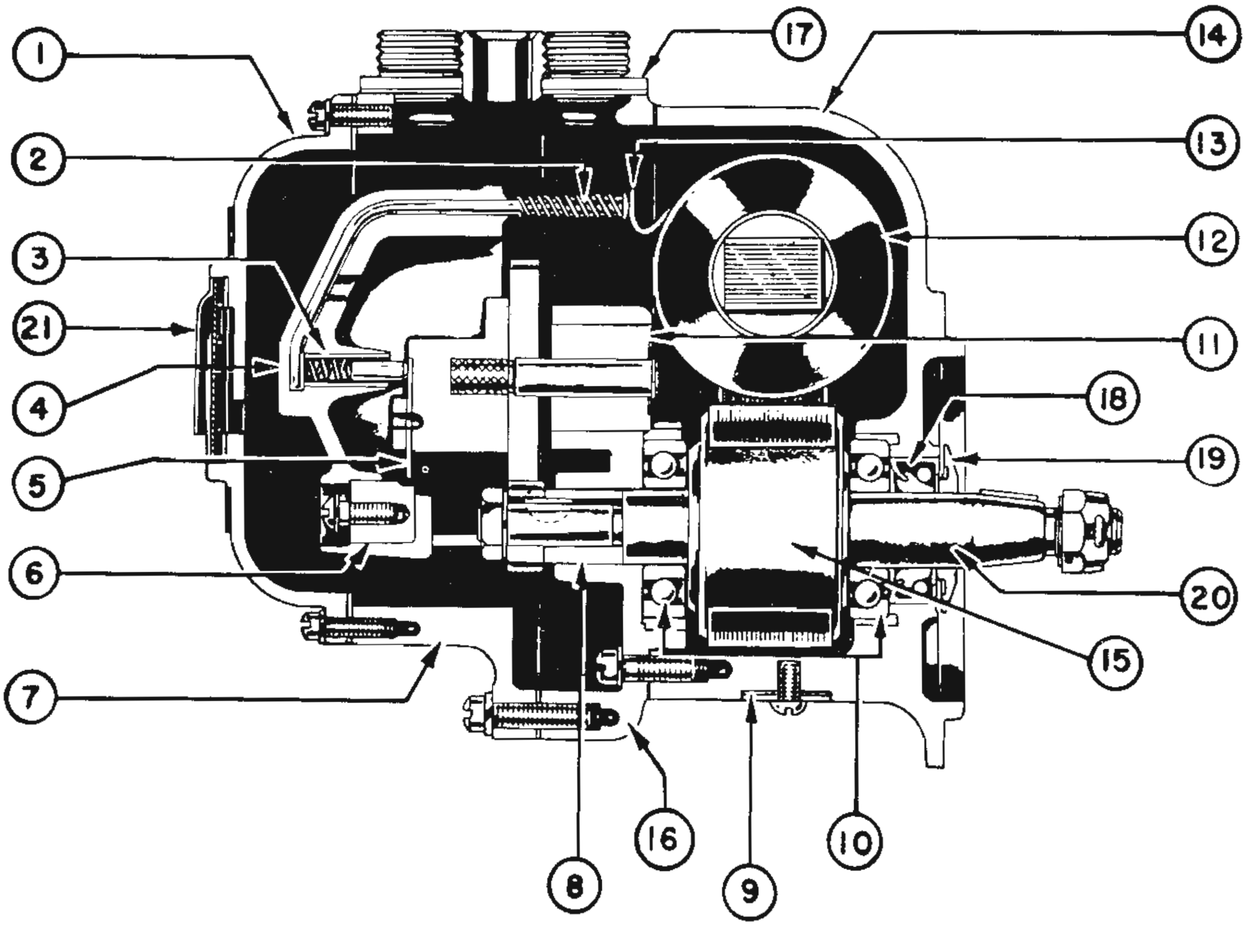


FIG. 36. LA-6 Magneto Longitudinal Section

1. Cover Plate
2. Coil Contactor
3. Carbon Brush and Spring
4. Distributor Spring
5. Distributor Rotor Electrode
6. Distributor Plate Electrode
7. Adapter
8. Breaker Cam
9. Housing Ventilator
10. Ball Bearings
11. Distributor Bearing
12. Coil
13. High Tension Terminal
14. Housing
15. Magnet Rotor
16. End Plate
17. Cable Plate
18. Oil Seal
19. Slinger
20. Rotor Shaft
21. Cover Ventilator

EISEMANN MAGNETOS - MINOR INSPECTION (ON ENGINE)

Remove the two screws which hold the cable plate to the end plate (Fig. 36-16). Also remove the end plate (16). The entire distributor section of the magneto may then be removed to allow inspection of the magneto operating components. Care should be taken in removing the distributor section to pull it straight back from the main housing until dowels, distributor rotor, and coil contactor are in the clear before attempting to swing it to the side.

Wipe out any accumulation of foreign material inside the distributor plate with a cloth moistened in carbon tetrachloride. Be sure that the carbon brush and the coil connector are free. Inspect visually the coil, distributor rotor and gear, coil and breaker leads, and breaker assembly.

If the interior of the magneto appears excessively oily, the magneto should be removed from the engine for thorough cleaning and possible replacement of the oil seal (Fig. 36-18). The distributor rotor and gear should be free, but without excessive backlash or end play.

The breaker contact points should be clean and free from oil. If the contacts appear in good condition, it should not be necessary to check breaker timing. When, however, the contacts show signs of wear, the breaker timing should be readjusted.

To adjust the breaker contacts, turn the engine crankshaft until the cam follower bears on the top of #1 cylinder cam lobe, thus giving maximum contact point separation. Loosen slightly the two screws which secure the breaker assembly in the end plate, and by means of the breaker adjusting eccentric (Fig. 37-27), set the contact for a separation of from .019" to .021". (See Fig. 40.) Retighten the breaker securing screws and recheck contact separation. Care should be exercised that setting gage is free from dirt and oil.

ALWAYS CHECK THE MAGNETO TO ENGINE TIMING WHENEVER ADJUSTMENT OR REPLACEMENT OF THE BREAKER POINTS IS MADE.

Reassemble the distributor section end plate, making sure that the carbon brush is properly located and not broken, and that the dowels enter squarely.

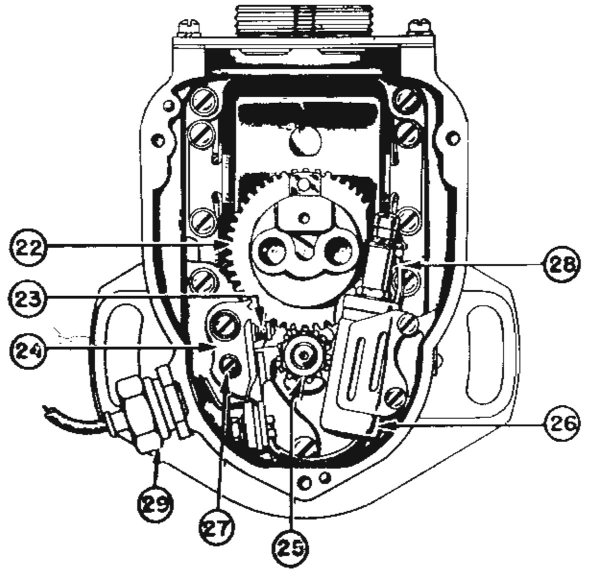


FIG. 37. LA-6 Magneto Transverse Section

22. Distributor Gear
23. Breaker Points
24. Breaker Assembly
25. Pinion Gear
26. Condenser
27. Breaker Adjusting Eccentric
28. Breaker Condenser Lead
29. Ground Terminal

MAGNETO TIMING CHECK

To check the timing of the magnetos when they are installed on the engine, proceed as follows. Turn the crankshaft in the normal direction of rotation, clockwise, as viewed from the rear end of the engine. Observe the action of the inlet valve on #1 cylinder. When the inlet valve has been depressed by the lifter rod and returned to the closed position by the valve spring, the #1 cylinder is on the compression stroke. Continue to turn the crankshaft until the impulse coupling is released. This will occur at approximately top dead center of #1 cylinder and can be identified by an audible click at the magneto. Turn the crankshaft in the reverse direction of normal rotation until the 28° mark on the crankshaft flange has passed the timing pointer by a few degrees or far enough to compensate for backlash in the gears. Do not turn the crankshaft more than this amount as the impulse coupling will become reengaged, giving an incorrect breaker point position.

Remove the magneto distributor cover to observe the action of the breaker points. Using a timing light, .0015" feeler stock or cellophane to determine the breaker point opening, turn the crankshaft in the normal direction of rotation until the 28° mark is reached. (See Fig. 39.) The breaker points on the magneto should be just opening at this position of the crankshaft. If adjustment is necessary to obtain the correct setting, it must be made by moving the magneto in its flange slots. Do not adjust the timing of the magneto points in relation to the crankshaft position by moving the points through the eccentric adjusting screw. It is always good practice to check the breaker points maximum opening as outlined in the section on minor inspection (Page 37) before checking the magneto timing. (See Fig. 40.)

On the model 6A4-150-B3 and B31 engines, a 2° tolerance is allowed on the ignition timing so that 28° to 30° before top dead center is permissible. The left magneto setting is at 28°, but it is often possible to decrease the "magneto drop" by setting the right magneto to 29° or 30°.

BENDIX - SCINTILLA MAGNETO

The sections above on minor inspection and magneto timing also apply in most part to the Bendix-Scintilla magnetos on the model 6A4-165-B3 engine. On the Scintilla magneto, however, it is necessary to remove the breaker cover to observe or adjust the breaker points. The points are adjusted by loosening the set screw in the slotted breaker arm. The high tension cable contact sockets may be inspected for moisture by removing the high tension grommet retainer plate.

CAUTION: Do not, under any circumstances, remove the five screws which hold the two sections of the magneto together, while the magneto is on the engine. To do so would disengage the distributor gears, causing the distributor timing to be "lost" and necessitating complete removal and re-timing of the magneto.

SPARK PLUGS

The approved non-shielded spark plug for all the engine models covered in this manual is the Champion J-10. The approved shielded spark plug is the Champion C-10S. The spark gap setting for both type plugs is .014" to .018". Spark plugs should be screwed into the cylinders with the fingers only until they are snug to avoid crossing the threads. They should be tightened with a torque wrench to a value of 180 to 240 in. lbs.

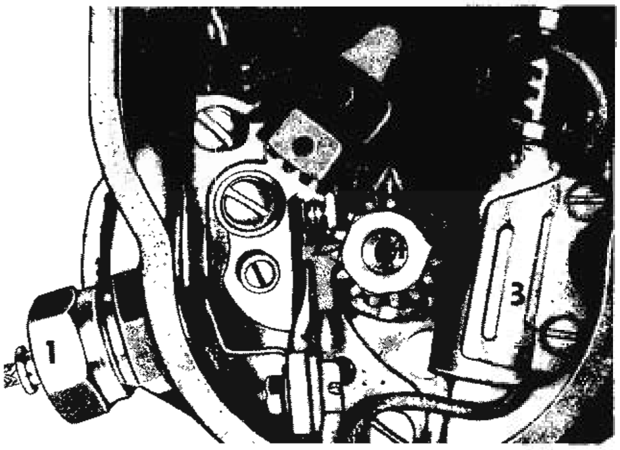


FIG. 38. LA-6 Magneto Timing Marks, Internal Parts

1. Magneto Ground Wire
2. Magneto Breaker Points
3. Magneto Condenser
4. Magneto Gear Timing Marks

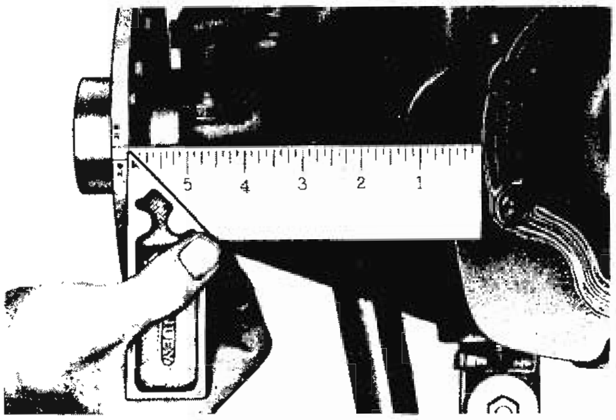


FIG. 39. Setting Timing Marks on Propeller Flange

MAGNETOS - INSTALLATION ON MODEL 6A4-150-B3 AND B31 ENGINES

Remove the valve cover from #1 cylinder, left rear of engine, to observe the valve action. Rotate the crankshaft in the normal direction, clockwise, as viewed from the rear of the engine. Observe the #1 cylinder inlet valve (left-hand valve when facing the cylinder head). When the inlet valve has been depressed and returned to its normal position, the #1 cylinder is on the compression stroke. Continue rotating the crankshaft in the same direction until the 28° magneto timing mark on the outer rim of the crankshaft propeller flange at the front end of the engine is in line with the parting line formed by mating surfaces of the two crankcase halves (See Fig. 39). The engine is now in correct timing position to install magnetos, i.e., 28° before top dead center of #1 cylinder on its compression stroke.

Install the spiral magneto drive gear complete with rubber cushion drive, making sure the eight rubber projections engage properly in the gear hub and in the counterbore on the face of the impulse coupling on the magneto.

Remove the distributor cover on the magneto to expose the distributor electrode and breaker points. With the magneto hand-held in a horizontal position, turn the rotor shaft in the direction of normal rotation and snap the impulse coupling several times to check its operation. Next, turn the rotor in reverse direction to normal rotation, to avoid engaging the impulse unit, until the center-line mark on the rotor gear is indexed with the punch mark on the breaker cam gear. The distributor rotor electrode is now in the 7 o'clock position and is in position to fire #1 cylinder (See Fig. 38). Install a gasket on the magneto pad of the rear timing case and install the magneto adapter plate. Install a second gasket between this adapter and the magneto itself. Now install the magneto with the timing case studs in the middle of the magneto flange slots. Install the special 5/16" plain washers and 5/16"-24 elastic stop nuts, leaving the nuts loose enough so that the magneto may be moved in its slots by a slight tap of a soft mallet. Using a timing light, .0015" feeler stock or thin cellophane to check the point opening, tap the magneto until the points are just separating. With the magneto housing in this position, tighten the stud nuts.

MAGNETOS - INSTALLATION ON THE MODEL 6A4-165-B3 ENGINE

The magneto on this engine is installed in a manner similar to that described in the section above with the following exceptions: The 32° timing mark is lined up with the crankcase centerline as shown in Fig. 39. Remove the plug from the inspection hole provided at the top and rotate the magneto until the chamfered tooth with a white paint mark is near the center of the hole. The breaker cover should be removed so that the points may be observed. The magneto is installed on the engine and checked for proper timing as described above.

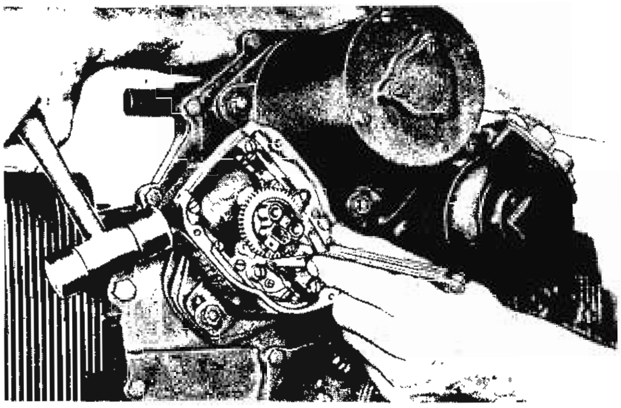


FIG. 40. Setting Magneto Breaker Gap

XXIII – CARBURETION

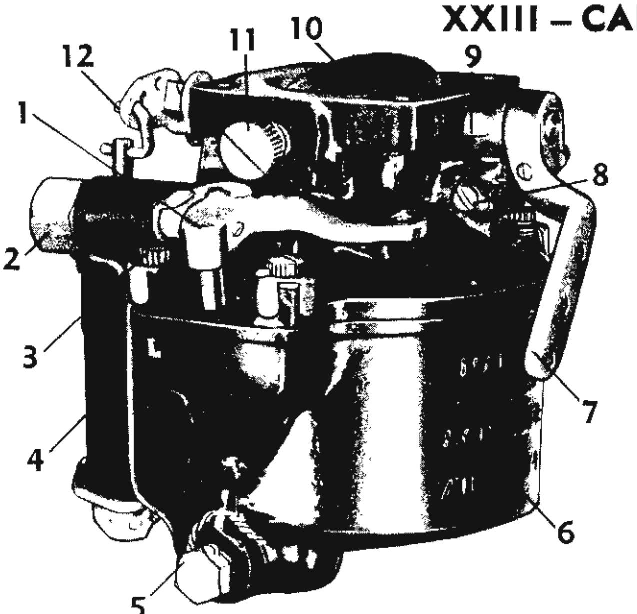


FIG. 41. MA-3SPA Carburetor

1. Mixture Control Linkage and Stop
2. Fuel Inlet
3. Fastening Screw between Upper and Lower Bodies
4. Accelerating Pump Body
5. Float Bowl Drain Plug
6. Float Bowl
7. Throttle Arm
8. Idle Speed Adjustment Screw
9. Throttle Stop
10. Throttle Butterfly Valve
11. Idle Mixture Adjustment Screw
12. Accelerating Pump Linkage

The model MA-3SPA Marvel-Schebler carburetor used on the 6A4-150-B3 and B31 engines is of the float type and incorporates an accelerating pump and a mixture control unit. (See Fig. 41.) The carburetor is made up of two major units—a cast aluminum throttle body and bowl cover, and a cast aluminum fuel bowl and air entrance. The model MA-4-5 carburetor is used on the model 6A4-165-B3 engine. The model MA-3SPA and MA-4-5 carburetors are very similar except for the size of the various parts. The information below applies to both models. Fig. 42 is a diagramatic picture showing all of the operating parts.

ADJUSTMENTS AND PRECAUTIONS

The only adjustment that is ordinarily made on the carburetor while it is on the engine is to obtain proper idle conditions. The engine should be thoroughly warmed up before making the idle adjustment. The idle speed adjusting screw (Fig. 41-8) should be set so that the engine idles at approximately 550 RPM. The idle mixture adjusting screw (Fig. 41-11) should be turned out slowly until the engine "rolls" from richness, then turn the screw in slowly until the engine "lags" or runs "irregularly" from leanness. This step will give an idea of the idle adjustment range and of how the engine operates under these extreme idle mixtures. From the lean setting, turn the needle out slowly to the richest mixture that will not cause the engine to roll or run unevenly. This adjustment will in most cases give a slightly slower idle speed than a leaner mixture adjustment, with the same throttle stop screw setting, but it will give the smoothest idle operation. A change in the idle mixture will change the idle speed and it may be necessary to readjust the idle speed with the throttle stop screw to the desired point. The idle adjusting needle should be from 3/4 to 1 turn from its seat to give a satisfactory idle mixture.

This procedure is the same on both the MA-3SPA and the MA-4-5 carburetors. The idle mixture adjusting screw on the MA-4-5 model is in the same position as shown in Fig. 41-11, but it is arrow shaped to indicate the adjustment position.

CAUTION: Care should be taken not to damage the idle needle seat by turning the idle adjusting needle too tightly against the seat, as damage to this seat will make a satisfactory idle adjustment very difficult to obtain.

FLOAT HEIGHT (FIG. 42-3): The float height is set at the factory, and can be checked by removing the throttle body and bowl cover and float assembly. The carburetor is turned upside down. The proper position of the floats on the MA-3SPA should be 7/32" from the bowl cover gasket to the closest surface of the floats. On the MA-4-5 carburetor this dimension is 13/64". Be sure to check both floats to the proper dimensions, making sure that the floats are parallel to the bowl cover gasket.

When the carburetor is disassembled for cleaning, extreme care should be taken not to enlarge or damage any of the jet holes. Damage or enlargement of the jets will change the metering characteristics of the carburetor and affect engine operation. A new gasket should be used between the two sections of the carburetor when it is reassembled.

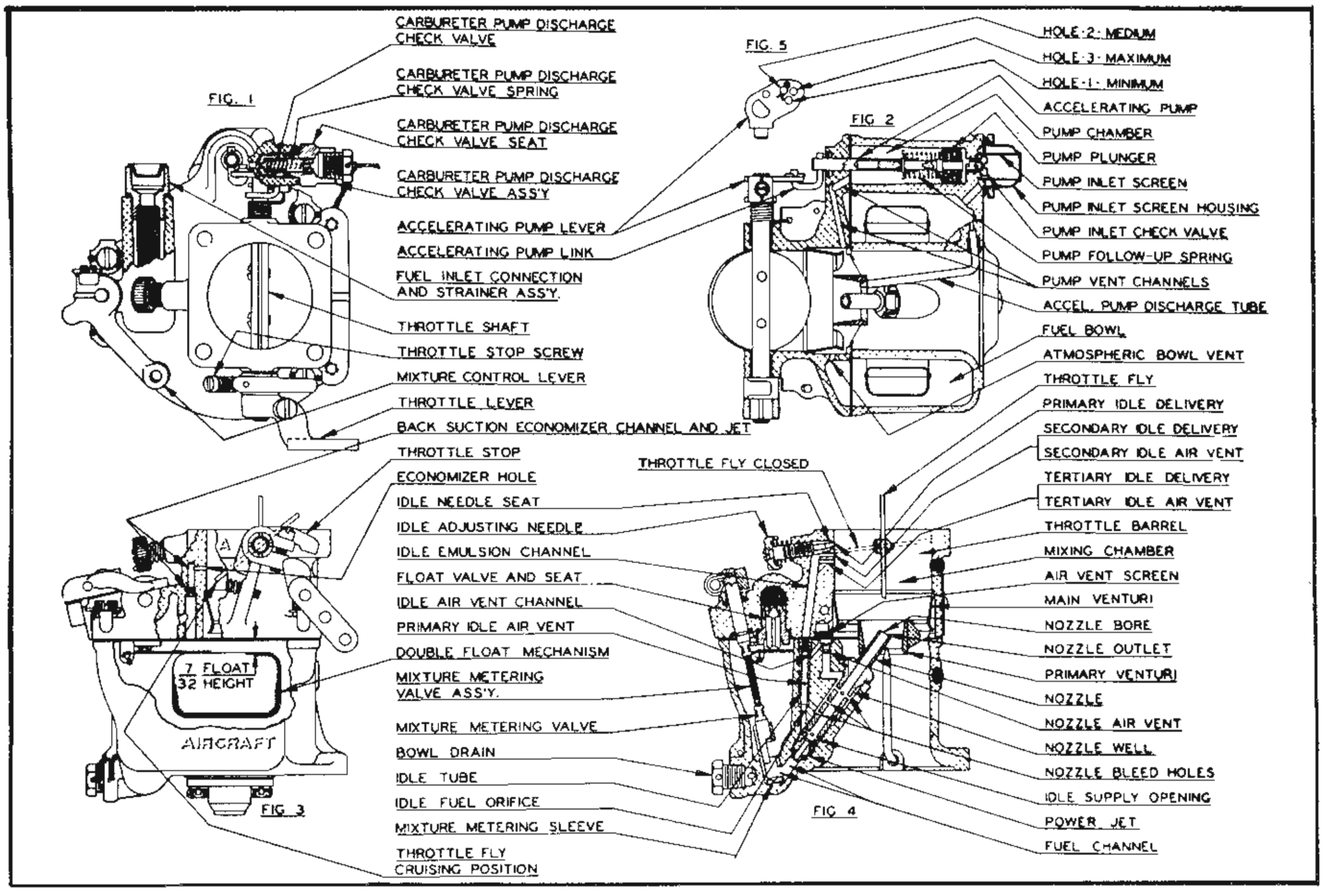


FIG. 42. Schematic Drawing of the MA-3SPA Carburetor

CAUTION: Care must be taken when reassembling the mixture metering valve assembly to see that the metering valve pilots properly into the valve body. (See Fig. 4.) The metering valve is actuated by a flexible shaft and it is possible for the valve to be assembled without sliding properly into the valve body. If this occurs, the carburetor will meter extremely rich.

USE OF MIXTURE CONTROL IN FLIGHT: The mixture control should not be used under 3,000 feet. When adjusting the mixture control for altitudes higher than 3,000 feet, move the control in and out slowly, with the throttle at cruising position until the highest RPM is attained. The carburetor mixture will then be correctly adjusted for that throttle position and load at that particular altitude.

CAUTION: Always have the mixture control in the full rich position when coming in for a landing, so that if full power is required in an emergency near the ground, the engine will operate satisfactorily and will not over-heat because of too lean a mixture.

STARTING—COLD ENGINE: At air temperatures of freezing or above, two or three strokes of the throttle should prime the engine sufficiently for easy starting. When the engine is cranked with the starter and with the throttle cracked slightly open, it should start immediately. At temperatures below freezing down to about 10°F, three strokes of the engine primer in addition to the three strokes of the throttle should be used. After the engine initially starts, occasional operation of the primer may be necessary during the first 30 seconds of operation. At temperatures below 10°F, additional priming may be necessary. The mixture control should be in the full rich position for all starting attempts. If the starter fails to turn the engine on the first or second try, the engine should be turned through a few times by hand with the ignition off and the starter again tried. If the starter still fails to crank the engine, the battery should be checked to see if it is adequately charged.

CAUTION: It is important to lock the primer securely after using to prevent fuel leakage into the induction system and improper engine operation.

STARTING—HOT ENGINE: With the mixture control in the full rich position and the throttle closed, the engine should start immediately when cranked. No priming is necessary when the engine is hot regardless of the outside air temperature.

XXIV – GENERATOR AND VOLTAGE REGULATOR

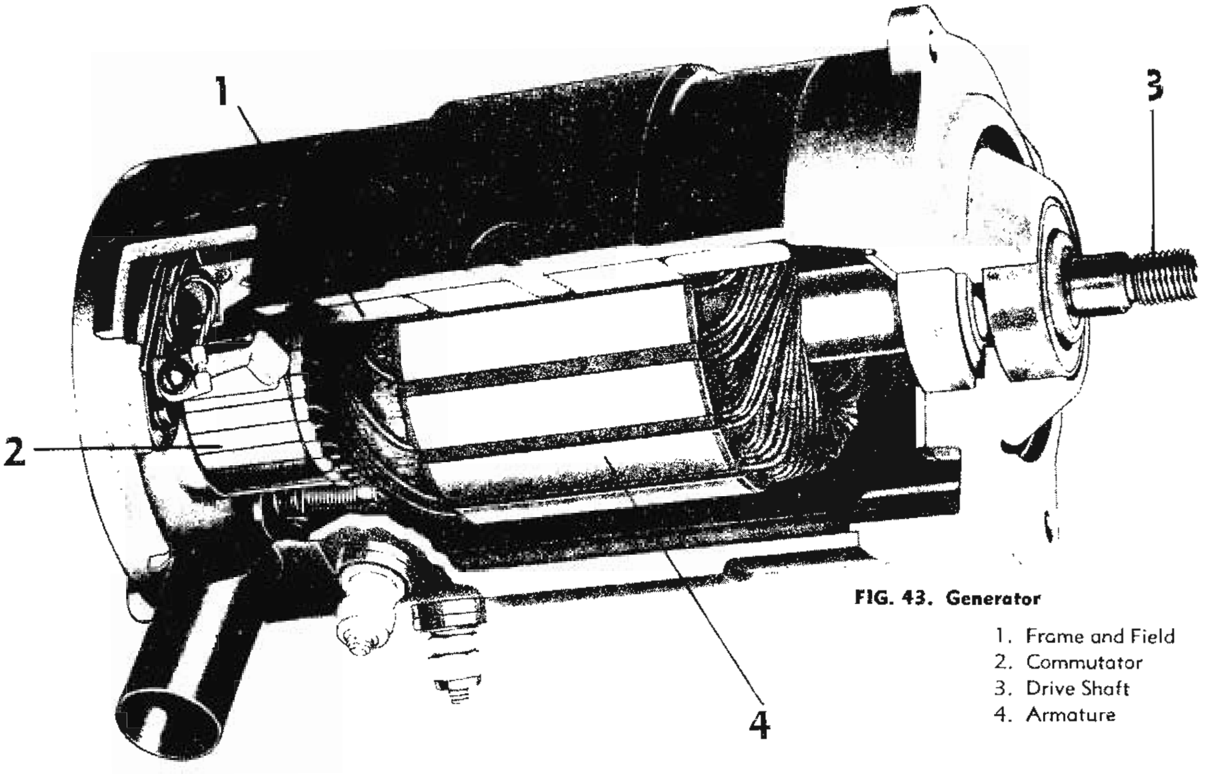


FIG. 43. Generator

1. Frame and Field
2. Commutator
3. Drive Shaft
4. Armature

The generator is a device for changing mechanical energy into electrical energy. It consists of four main subassemblies. These are: The frame and field, the commutator end head, the drive end head and the armature assemblies. (See Fig. 43.) The frame and field consists of the frame which supports the components of the generator, the pole shoes and the field coils. The coils supply the magnetic field which is necessary for generating electricity; the pole shoes and frame supply the path for the magnetic field. The commutator end head supports the brush holders and brushes that are needed to conduct the electricity from the revolving armature. A ball bearing in the commutator end head supports one end of the armature shaft. The drive end head includes a ball bearing which supports the drive end of the armature shaft. The armature consists of a soft iron core, a commutator and the windings, which are wound in slots in the core and are connected to the commutator. The commutator consists of a number of copper segments insulated from each other and from the armature shaft.

The voltage regulator is a device that regulates the generator current and voltage output to the battery and electrical units. It protects the generator from overload and the battery from overcharging. (See Fig. 44.) It also acts as a reverse-current relay to prevent battery current from flowing back through the generator when it is not operating, causing the battery to discharge.

If the generator is not charging properly, all connections and wiring from the generator to the voltage regulator and the battery should be checked. The connections should be dry and tight and the wiring should be free from frayed spots or cuts. If the wiring and general condition of the generator is satisfactory, the trouble may be in the voltage regulator. Ordinarily, the voltage regulator is not serviced but is replaced by a new regulator of the proper type.

A low charging rate and a fully charged battery indicate normal regulator operation. A discharged battery will normally produce a high charging rate.

The electrical accessories may be serviced in an engine shop that has complete electrical repair and testing equipment. Usually the most satisfactory procedure, however, is to take the accessory needing service to a registered service station that handles the make of equipment involved.

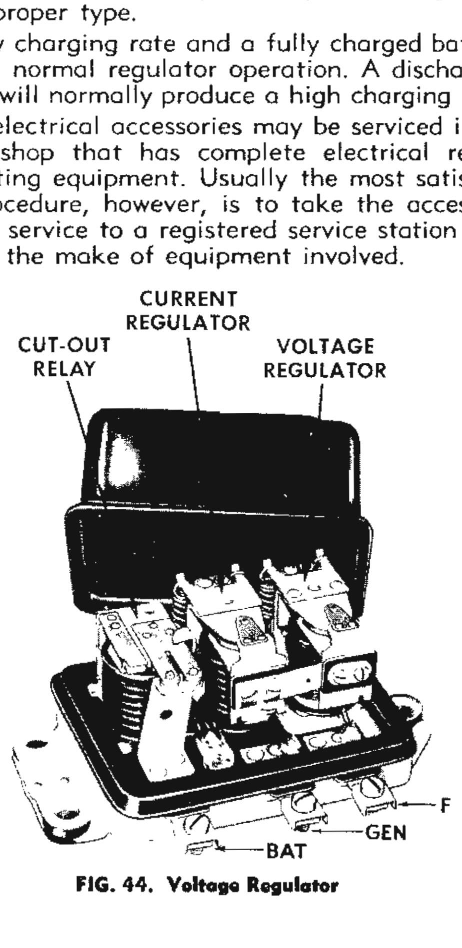


FIG. 44. Voltage Regulator

XXV – STARTING MOTOR

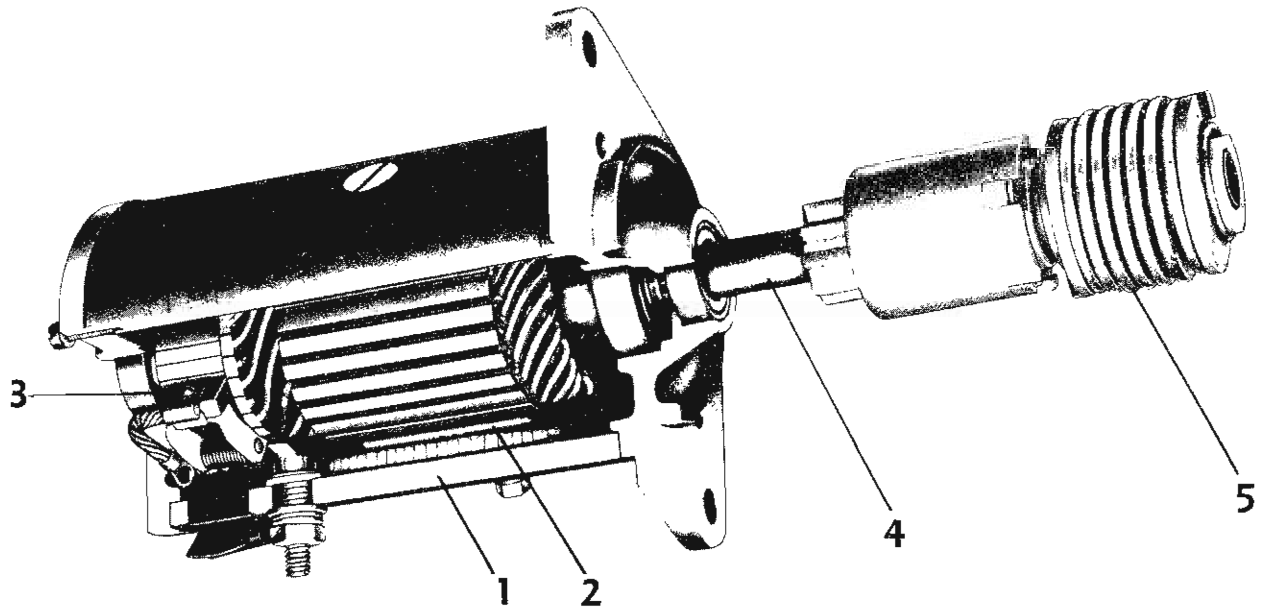


FIG. 45. Starting Motor

1. Frame and Field
2. Armature
3. Commutator
4. Drive Shaft
5. Bendix Drive

The starting motor is designed to crank the engine when the starting switch closes the circuit between the storage battery and the motor. It consists of five main subassemblies which are: The frame and field, the armature, the commutator end head, the pinion housing or drive end head and the Bendix drive. (See Fig. 45.) The frame and field consists of the frame which supports the components of the motor, the pole shoes and the field coils. The coils supply the magnetic field which is necessary for producing torque; the pole shoes and frame supply the path for the magnetic field. The armature consists of a soft iron core, a commutator and the windings which are wound in slots in the core and are connected to the commutator. The commutator consists of a number of copper segments insulated from each other and from the armature shaft.

The commutator end head supports a bearing and four brush holders and brushes. The Bendix drive is an automatic clutch that engages the cranking motor with the engine flywheel when the motor cranks the engine and disengages when the engine starts. It consists of a threaded sleeve fastened to the armature shaft through a drive spring, and a pinion mounted on the threads of the sleeve. When the starting circuit is closed, the armature revolves, turning the sleeve within the pinion, and forces the gear forward, meshing it with the flywheel gear. The sudden shock of meshing is absorbed by the spring. When the engine starts, the pinion is driven faster than the sleeve and is forced back along the threads, automatically unmeshing it from the flywheel.

The starter ordinarily requires very little servicing. Brushes should be replaced when worn to half their original length. The starter should be disassembled and inspected at 300 hours. Any worn Bendix drive parts should be replaced. The armature shaft should be lubricated sparingly with light oil before it is reassembled.

XXVI – ENGINE ASSEMBLY

The following procedure is intended to serve as a guide in assembling the 6A4-150-B3 and B31 and 6A4-165-B3 engines after they have received a complete overhaul. The method outlined is similar to the procedure used when the engines were originally assembled at the factory. It is assumed that the units being installed have been thoroughly inspected, cleaned and reconditioned and that they conform to the tolerance specifications recommended. General assembly only will be covered, therefore, you should be thoroughly familiar with the assembly of the individual components as outlined in the text of this manual.

CRANKSHAFT

Coat the crankshaft rear hub with Anti-Seize. Install the two #16 Woodruff keys in the key slots. Heat the crankshaft gear to 200°F for one-half hour and install it on the crankshaft. Use a soft hammer to bottom the gear on the crankshaft shoulder. Press the bushings for the propeller bolts into the front crankshaft flange. Refer to the Parts List for available oversize bushings.

CAMSHAFT

Coat the rear hub of the camshaft with Anti-Seize. Install the Woodruff key in the key slot. Heat the camshaft gear to 200°F for one-half hour and press the gear on the camshaft.

CRANKCASE

Attach the engine mounting brackets to the two crankcase halves. Install the main bearing shells, camshaft bearing shells, and thrust washers in the crankcase halves. Check the crankshaft in both halves for end play. (See Fig. 46.) This clearance is controlled by the thickness of the thrust washers. Check for clearance between the crankshaft throws and crankcase walls. Check the camshaft in both open halves of the crankcase for end play. Check for clearance between the oil pump gear on the camshaft and the crankcase walls. Specified camshaft end play is .006" to .010". Crankshaft end play is .008" to .020".

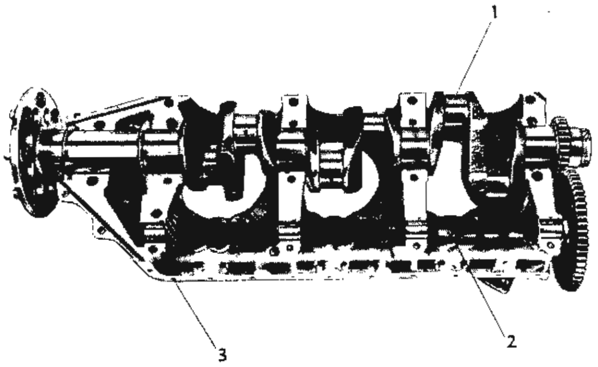


FIG. 46. Camshaft and Crankshaft Installed in Crankcase

1. Crankshaft with Gear
2. Camshaft with Gear
3. Crankcase

FIG. 47. Torquing Connecting Rod Bolt

Install the holding fixture on the crankshaft front flange. Figure 47 shows a production type holding fixture used for engine build up. Place the crankshaft with the propeller flange end down on the holding fixture base. Install a matched set of connecting rods on the crankshaft, placing the machined surface on the rod bolt boss towards its adjacent or nearest main bearing journal on the crankshaft. Oil the crankshaft journals prior to installing rods. The connecting rods are numbered relative to their cylinder position on the crankshaft and the numbers are positioned so that they can be read when viewed through the open top of the crankcase. After the connecting rod bolts have been torqued (See Fig. 47), check the rod side clearance on the crankshaft. Specified clearance is .008" to .014". Install the cotter pins with their heads toward the rear of the crankshaft. Coat the inside surfaces of the four thrust washers with cup grease to hold them in position during assembly of the crankcase.

Oil the crankshaft and camshaft bearings. Install the right crankcase half on the crankshaft. See that all crankcase seals are in place as described in Section X. Install the camshaft by indexing the zero on the crankshaft gear with the zero marking on the camshaft gear. (See Fig. 48.) On engines having a fuel pump, install the fuel pump push rods. Install the left crankcase half. Install the washers and elastic stop nuts on the two rear and two front through tie-studs. Draw the two crankcase sections together, being sure that the crankcase seals have been properly installed. Draw the two sections together tightly by torquing the elastic stop nuts down evenly. Install the castle nuts on the internal studs in the crankcase. Torque the nuts and install cotter pins. Install the three long through-bolts along the topside and three short through-bolts at the front end of the case. Make sure that flat washers are under the bolt heads as well as under the elastic stop nuts. Now, recheck the camshaft and crankshaft end play. Check the backlash of the camshaft and crankshaft gears within the specified limits of .004" to .012". Install the oil by-pass plate and gasket on the lower left hand corner of the case and torque the cap screws securing them with shakeproof washers.

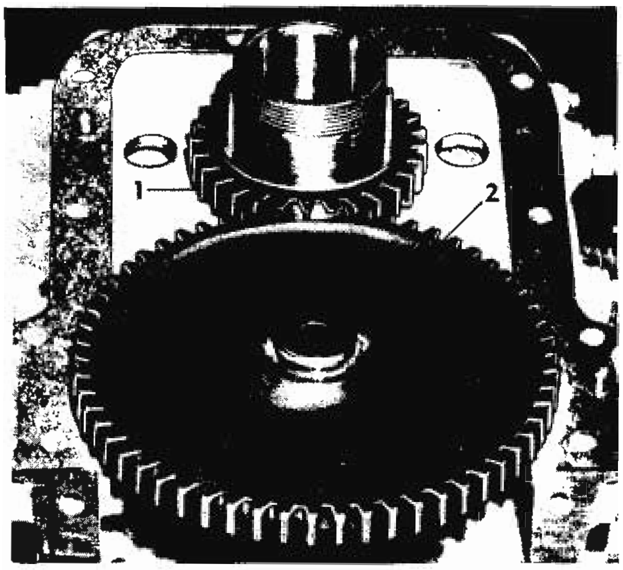


FIG. 48. Timing Gears

1. Crankshaft Gear
2. Camshaft Gear

PISTONS AND CYLINDERS WITH VALVES INSTALLED

Install rings on the piston as follows: First, slide the oil control ring down over the top of the piston and fit it into the bottom groove; Second, insert the scraper ring with the outside groove facing down into the middle piston groove; Third, insert the top compression ring with the inside groove facing up into the top piston groove. Install a set of pistons, balanced within plus or minus 1/8 ounce between any two, beginning with the front pistons and cylinders and working back towards the rear of the engine, the #1 assembly being installed last. Oil the piston pin bushing and install the piston with the piston pin location number on the piston pin boss facing the front of the engine. Install the rear piston pin plug. Oil the piston rings and grooves as well as the piston skirt. Oil the inside of the cylinder bore. Install cylinder oil seal ring on the underside of the cylinder flange. Make sure the ring gaps are staggered and using a ring compressor, slide the cylinder over the piston, using correct cylinder as numbered on the flange. When the cylinder skirt is just over the bottom ring, remove the ring compressor and install the front piston pin plug. Slide the cylinder into position on the crankcase. Do not fully torque the cylinder hold-down nuts at this time. When all the cylinders are installed on the crankcase, temporarily attach the intake manifolds without gaskets to the intake ports on the cylinders for the purpose of aligning the cylinders while torquing the cylinder hold-down nuts. This will assure a flush fit at the manifold to inlet port location, thus eliminating the possibility of induction leaks. Remove the intake manifolds.

VALVE ACTUATING UNITS

Install the hydraulic lifters. Install the rubber packings against the bead on the cylinder head end of the lifter tubes. Slip the tubes through the holes in the top cylinder flange with the inside wire circlets towards the crankcase. Install rubber packings against the bead on the lower end of the tube. Now oil the outside diameters of the lifter tube oil seals. Using a piloted driver, tap the lifter tubes into position so that the outer end of the tubes come flush or below flush with the machined top surface of cylinders. Be sure lower packing goes into hole in crankcase. Install the lifter rods properly centered in the lifters. Install the rocker support blocks with the oil holes in the rocker pins facing down towards the crankcase and rocker arms installed on the pin. Torque the rocker support block nuts or cap screws. Rotate the crankshaft to eliminate torquing the nuts or screws while the lifters are on the peak of their respective cam lobes. Check the side clearance of the rocker arms to specified limits of .003" to .008" (Desired .006"). Set the valve clearance to .040". Insert .040" feeler stock between the valve tip and rocker arm with piston on top center of its compression stroke and the rocker arm fully depressed against the spring tension of the valve lifter. Turn the rocker arm adjustment screw until the feeler is a light drag fit. (See Fig. 49.) Tighten the jam nut to hold the screw in position. Recheck .040" clearance after the nut is tightened.

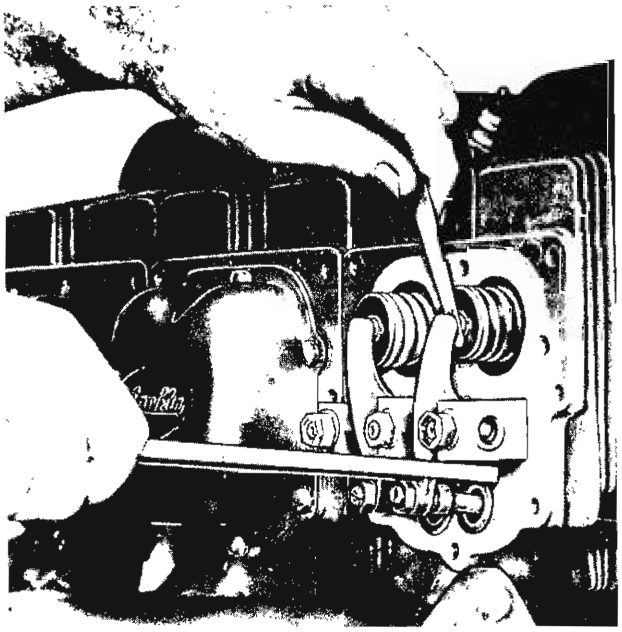


FIG. 49. Checking Valve Clearance

TIMING GEAR CASES AND ACCESSORY DRIVE GEARS

Trim the crankcase oil seal rubber packings flush with the crankcase surfaces. Install the front timing gear case with the specified gasket between the crankcase and the timing gear case surfaces, making sure the two alignment dowels located in the crankcase line up with the holes provided in the timing gear case. Pull the timing gear case down tight against the crankcase by torquing the eight internal 5/16"-18 x 7/8" hex head cap screws down evenly. (See Fig. 50-5.) Use plain 5/16" flat washers and secure with lacing wire. At the same time install and torque the two 5/16"-18 x 2-1/4"

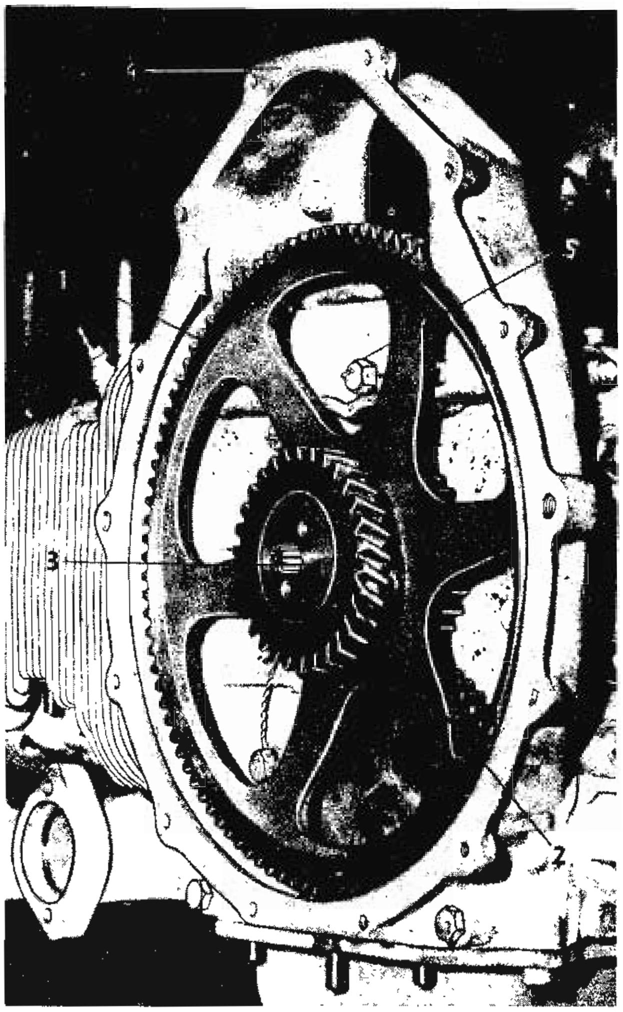


FIG. 50. Starter and Accessory Drive Gear Assembly

1. Starter Gear and Hub
2. Accessory Drive Gear
3. Tachometer Drive Gear
4. Front Timing Gear Housing
5. Front Timing Gear Housing to Crankcase Cap Screws

cap screws with shakeproof washers holding the bottom of the timing case to the crankcase.

The starter gear is then heated to 200° to 250° F and driven onto the rear end of the crankshaft until inside hub of the gear bottoms on the crankshaft gear. (See Fig. 50-1.) The special tab washer and crankshaft nut are then installed to hold the gear in position. A proper spanner wrench should be used to tighten the nut. Rap the wrench handle several times with a hammer to make sure the nut is down tight. Wedge the washer material into the slots in the nut to prevent the nut from loosening. The accessory or magneto drive gear is then installed in the rear end of the crankshaft, making sure that the slotted keyways in the gear hub fit over the keys in the crankshaft. The inside gear face should bottom on the end of the crankshaft and a soft metal driver and hammer may be used for this purpose. On both gear installations, the contact surfaces should be coated with Anti-Seize Compound.

The rear timing gear case is aligned with the front timing gear case by means of a pilot tennon on the rear case fitting into the front case. Make sure the specified gasket is aligned correctly between the contact surfaces of the two cases. The ten 1/4"-20 x 5/8" hex head cap screws holding the two cases together are then torqued down evenly. At the same time, the two 3/8"-16 x 1" hex head cap screws on either side of the case are torqued. Shakeproof washers are used throughout. On some engine models, the pilot tennon is omitted and the two cases are aligned by means of two special hollow dowels on either side of the case. Two special heat-treated 1/4"-28 x 1" through bolts machined to .2495" to .2505" diameter with flat washers and elastic stop nuts are installed through the dowel holes.

OIL PUMP AND FLOTO UNIT

Install the oil pump with the inlet tube and Floto unit attached. (See Fig. 51.) The pump cover with attached inlet tube and the pump body enclosing the pump gears are secured to the oil pump pad on the bottom side of the front left half of the crankcase by four 1/4"-20 x 2-3/4" hex head cap screws and plain 1/4" flat washers. On the model 6A4-165-B3, one of the four 1/4"-20 cap screws is only 2-1/2" long. This screw goes in the boss nearest the cam lobe to provide cam lobe clearance.

A cotter pin and special wire clip hold the Floto unit to the end of the inlet tube. Install the bracket and clamp about the inlet tube to support the outer end of the tube, as well as the weight of the Floto unit. The bracket mounting screws and clamp tightening screw are drawn up tight and secured with lacing wire. Check the Floto unit for free travel. Also check the distance of Floto in its lowest position from the bottom of the crankcase. This measurement must be less than the depth of the oil pan to prevent interference between the bottom of the pan and the Floto unit.

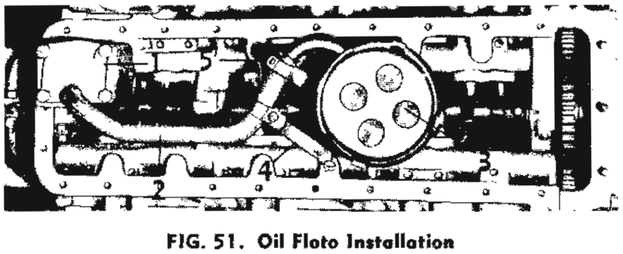


FIG. 51. Oil Floto Installation

1. Oil Pump
2. Oil Inlet Pipe
3. Floto Unit
4. Oil Inlet Pipe Support Bracket
5. Oil Inlet Pipe Clamp to Bracket

OIL PAN

Install the specified gasket between the oil pan and the crankcase. Install the solid aluminum reinforcement band under the oil pan mounting flange. Draw the pan up to the crankcase by evenly torquing the twenty-four 5/16"-18 x 3/4" fillister head screws. The oil cooler brackets at either side of the pan should be installed under the three specified cap screws. The two outside nuts holding the rear of the pan to the timing gear case may then be torqued. Shakeproof washers are used throughout. Some engines will be equipped with cast oil pans and no reinforcement band is needed. Leave the middle stud on the bottom rear of the crankcase free for installation of the distributing zone.

CRANKCASE COVER AND VALVE COVERS

The top crankcase cover is secured to the top crankcase surface by means of sixteen 5/16"-18 x 5/8" hex head cap screws. (See Fig. 52.) The cap screws are torqued and shakeproof washers are used. A specified gasket is used between the two matching surfaces. Before installing the crankcase cover, the raised bead around the inside of the cover mounting flange should be inspected to see that it is undamaged.

Before installing the valve covers, make the following inspection. Examine the top surface of the cylinder for nicks or scratches. Examine the raised bead of the valve cover mounting flanges for dents or warpage. Place the valve cover on the cylinder head without the gasket and check for contact with .003" feeler gauge. Use a specified gasket which is in good condition. Draw the cover down evenly by tightening the screws in a criss-cross fashion, a few turns at a time. This procedure is most important to prevent warpage and/ or bending of the cover.

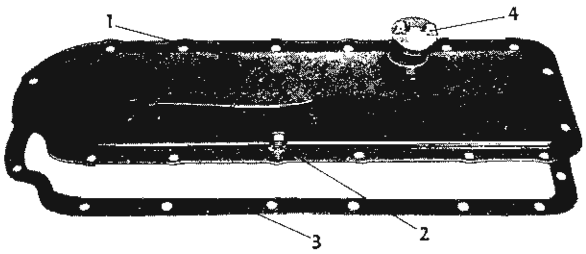


FIG. 52. Crankcase Cover

1. Crankcase Cover
2. Attaching Screw and Shakeproof Washer
3. Crankcase Cover Gasket
4. Oil Filler Cap

INDUCTION SYSTEM

Install the inlet manifolds, observing that all screw plugs are installed and tight and that the manifolds and gaskets fit flush to the inlet ports on the cylinder. Tighten down evenly the six Allen head 5/16"-18 x 1" screws holding each manifold to the cylinders. Use plain 5/16" flat washers and secure the screws with lacing wire. Later engine models use slotted hex head cap screws and shakeproof washers for attaching the manifolds.

Install the front equalizer pipe assembly complete with the connecting hose and supporting bracket holding this assembly to the crankcase.

Attach the distributing zone to the timing gear case by means of two 1/4"-20 x 2-1/2" hex head cap screws, as well as by the center stud at the rear end of the crankcase through the oil pan flange. Torque the cap screws and use shakeproof washers. Now install the rear connecting pipes between the zone and the manifolds.

IMPORTANT — In assembling the induction system, extreme care must be exerted to see that all gaskets and packings are properly installed so as to eliminate induction leaks. Do not reuse worn or mutilated gaskets and/or rubber packings. Use specified parts only.

ACCESSORIES

STARTER: Install the starter on the studs at the top pad of the rear timing case using two 3/8"-24 elastic stop nuts or flat washers, 3/8" plain nuts and palnuts. The cover having the breather tube attachment may then be installed, complete with a gasket, on the front side of the timing case. Torque the two 1/4"-20 x 1/2" hex head cap screws and use shakeproof washers.

FUEL PUMP: Engine models having a fuel pump carry a special right rear mounting bracket, having a pad for the pump. Check to see that the end of the pump actuating push rod extends .292" to .311" beyond the fuel pump pad gasket. Install the pump on this pad and pull the two 5/16" through bolts up tightly. Be sure the gasket between the pump and the pad is of the specified type and is installed properly. Inasmuch as fuel leaks cannot be tolerated, it is best to use a new gasket whenever assembling this unit to the engine. The pump inlet and outlet are marked "in" and "out". Hook the "in" side of the pump to the fuel supply tank and the "out" side of the pump to the carburetor supply line.

IGNITION SYSTEM: Install specified 14 mm. spark plugs using a 13/16" deep socket and torquing to 180 to 240 in. lbs. Be sure that copper gaskets are installed under each plug. Install magnetos as outlined in the magneto installation section of this manual on page 39. Secure magnetos with special flat washers, plain nuts, and palnuts. Connect all ignition wires between magnetos and plugs as shown in Figs. 32 and 33. Carefully inspect all ignition wires for any breaks in the wire insulation.

GENERATOR: Install the generator on the bottom pad of the rear timing case. Use either flat washers, plain 1/4" nuts and palnuts, or elastic stop nuts on four 1/4"-28 studs to attach the generator to the engine.

CARBURETOR: Install the carburetor over four 1/4"-20 studs on the bottom of the distributing zone. Use 1/4"-28 elastic stopnuts to secure the carburetor to the zone. The model 6A4-165-B3 engines use 5/16"-24 studs and elastic stop nuts.

OIL COOLER

The oil cooler is attached to the engine just below the oil pan and is suspended from two brackets which are supported by three oil pan holding cap screws on either side of the engine. Before the actual installation of the Heat Exchanger oil cooler, the small brackets supporting the rubber bumpers which act as shock absorbers against the oil pan are lined up by slipping the 1/4"-28 x 5/8" cap screws through the cooler attachment holes, then through the bumper bracket holes, and finally through the holes in the brackets on the engine. Use 1/4" plain flat washers and elastic stop nuts with the heads of the cap screws being towards the engine oil pan. When assembly is complete, the two rubber bumpers should be crushed slightly against either side of the engine oil pan. Some engine models have Fedders oil coolers, which will incorporate the rubber bumpers directly on the engine oil cooler supporting brackets and the necessity for an individual bracket to hold the rubber bumper is eliminated. The "T" shaped connection having the adapter for the oil temperature bulb is the "oil-out-of-cooler" fitting. This pipe is connected to the "oil-into-engine" or front fitting on the oil by-pass plate. The pipe elbow near the bottom of the cooler is the "oil-into-cooler" fitting and should be connected directly to the "oil-out-of-engine" or rear fitting on the oil by-pass plate. Special formed tubing and composition hoses with hose clamps are used for the oil cooler hook-up.

The engine is now ready for installation on the test block or in the aircraft, depending on the extent of the overhaul made.

Disassembly for overhaul can be conveniently accomplished by performing the above procedure in reverse.

Clearances and torque limits are listed on page ....12........ of this manual.

XXVII – ENGINE TESTING

The procedure outlined is intended to serve as a guide for testing the engine after it has been overhauled.

FACTORY RUN-IN SCHEDULE

Model 6A4-150-B3 & B31		Model 6A4-165-B3	
RPM	Duration	RPM	Duration
1400	30 min.	1400	15 min.
1600	30 min.	1600	15 min.
1800	30 min.	1800	30 min.
2000	30 min.	2000	30 min.
2200	30 min.	2200	30 min.
2400	30 min.	2500	30 min.
2600	30 min.	2600	30 min.
2650-2750	30 min.	2750	30 min.
		2850-2950	30 min.
	4.00 hrs. Total		4.00 hrs. Total

Check acceleration.

Check magneto at full throttle. Maximum drop 200 RPM.

Check mixture control.

Check idle speed.

Shut down with idle cut-off.