LYCOMING

OPERATOR'S MANUAL

MODEL O-320-A SERIES AIRCRAFT ENGINES

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MODEL O-320-A SERIES AIRCRAFT ENGINES

Approved by ____________________

Chief of Engineering and Manufacturing Branch
Federal Aviation Agency

FEBRUARY 1, 1961

LYCOMING

DIVISION Avco CORPORATION

WILLIAMSPORT, PA., U. S. A.

Part No. 60297-2

EIGHTH EDITION

PRICE $1.50

Printed in U.S.A.

WARRANTY

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

This warranty does not cover any labor charges for replacement of parts, adjustments, repair or any other work done on **LYCOMING** engines.

This warranty shall not apply to any engine which shall have been repaired or altered outside of our factory in any way so as in our judgment to affect its operation, or which has been subject to misuse, negligence or accident, or which shall have been operated at a speed exceeding the manufacturer's rated speed.

This warranty shall not apply to any engine which shall have been operated with any other than fuel, oil and other lubricants conforming to specifications of **LYCOMING DIVISION**—AVCO Corporation.

LYCOMING DIVISION—AVCO Corporation, reserves the right at any time to revise, modify or change the construction of **LYCOMING** engines without incurring any obligation to incorporate such alterations to engines previously sold.

LYCOMING DIVISION—AVCO Corporation, makes no warranty with respect to ignition, apparatus, carburetors, generators, starters, voltage regulators or other trade accessories, inasmuch as they are usually warranted specially by their respective manufacturers, and all such items are sold "as is".

SPECIAL WARRANTY

FOR

*Premium Packaged Engines and Service Parts

LYCOMING DIVISION—AVCO Corporation warrants each new premium packaged **LYCOMING** engine and/or service part to be free from defects in material and workmanship when properly installed and used under normal conditions for 100 hours of operation or 90 days subsequent to removal of the engine or part from the original premium packaging, whichever event takes place sooner, provided that (1) such packaging has remained sealed and undamaged at all times, (2) the engine and/or part has been stored at all times in a weather protected dry area under normal humidity conditions, (3) the humidity indicators installed within the vapor barrier have not shown an unsafe condition at any time, and (4) such storage of each engine and/or part in such premium packaging has not extended beyond six months from the date of shipment from **LYCOMING'S** plant in Williamsport, Pennsylvania.

This warranty is limited to replacing or repairing at its shops any part or parts which have been returned to **LYCOMING DIVISION**—AVCO Corporation, with transportation charges prepaid and which, in its opinion, are defective, and **LYCOMING** shall have no responsibility for any consequential damages. This warranty is expressly in lieu of all other warranties and representations, expressed or implied, and all other obligations or liabilities on the part of **LYCOMING DIVISION**—AVCO Corporation

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LYCOMING
Division—AVCO Corporation
Williamsport, Pa.

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

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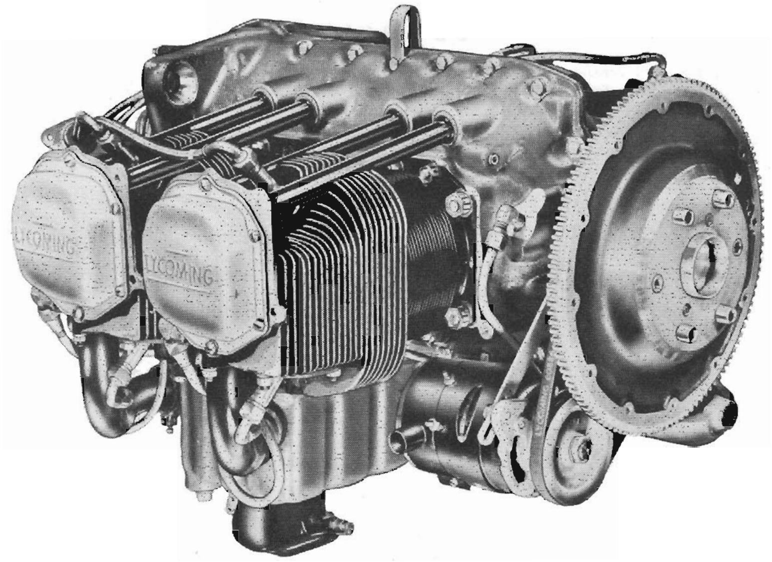
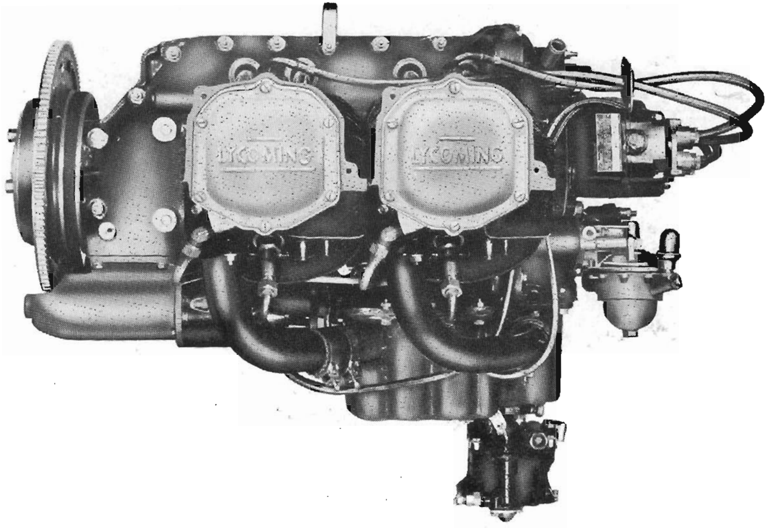
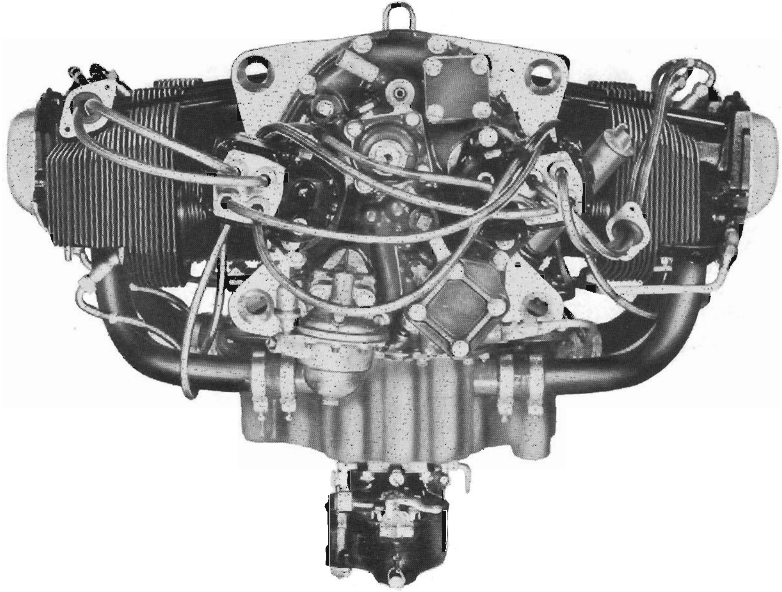


3/4 FRONT VIEW



SIDE VIEW



REAR VIEW

SPECIFICATIONS

LYCOMING O-320-E2A AIRCRAFT ENGINE

(The O-320-E2A model is similar in all respects to the O-320-A Series engines EXCEPT for its alternate rating and Type I Dynafocal engine mounts.)

FAA Type Certificate	274
Rated Horsepower and Speed, RPM	150 @ 2700
Alternate Rating and Speed, RPM	140 @ 2450
Bore, Inches	5.125
Stroke, Inches	3.875
Displacement, Cubic Inches	319.8
Compression Ratio	7.00:1
Head Temperature, Max. °F. (at bayonet location)	500
Barrel Temperature, Max. °F.	300
Fuel, Octane, Minimum	80/87
Oil Sump Capacity — Quarts	8
Oil Sump, Safe Minimum Quantity — Quarts	2
Oil Pressure, Minimum idling, PSI	25
normal operating, PSI	60-90
warm up and start, PSI	100
Crankshaft Rotation, viewed from Rear	Clockwise
Valve Rocker Clearance (Hydraulic Tappets Collapsed)	.028-.080 In.
Spark Occurs, Degrees BTC	25
Firing Order	1-3-2-4

Section I — SPECIFICATIONS

LYCOMING O-320-A SERIES AIRCRAFT ENGINE

TYPE—Four Cylinder, Direct Drive, Horizontally Opposed, Air Cooled

	O-320-A
CAA Type Certificate	274
Rated Horsepower	150
Rated R.P.M.	2700
Cruising R.P.M. Economy	2350
Performance	2450
Bore	5 ⅛ in.
Stroke	3 ⅞ in.
Compression Ratio	7.00:1
Piston Displacement — Cubic Inches	319.8
Head Temparture, Max. ° F. (at Bayonet Location)	500° F.
Barrel Temperature, Max. ° F.	300° F.
Fuel Octane (Min.)	80-87
Oil Sump Capacity — Quarts	8
Oil Sump — Safe Minimum Quantity — Quarts	2
Oil Pressure Minimum Idling — (Lbs. per Sq. In.)	25
Normal Operating — (Lbs. per Sq. In.)	60 to 85
Crankshaft Rotation — Viewed from Propeller End	Counter Clockwise
Valve Rocker Clearance (Hydraulic Tappets Collapsed)	.028-.080 in.

SPECIFICATIONS — (Continued)

Spark Occurs — Degrees B.T.C. .... 25° B.T.C.
Spark Plug Gap — Shielded .... .015-.018 in.
Spark Plug Gap — Unshielded .... 0.23-.027 in.
Firing Order 1-3-2-4

Accessory Drive	Gear Ratio	*Direction of Rotation
Generator	1.91:1	Clockwise
**Propeller Governor (or) Fuel Pump	.866:1	Clockwise
**Vacuum Pump	1.300:1	Counter Clockwise
Starter	13.556:1	Counter Clockwise
Tachometer	.500:1	Clockwise
**Fuel Pump (Plunger Operated)	.500:1	
Magnetos	1.00:1	Clockwise

* Viewed from rear of engine ** Optional

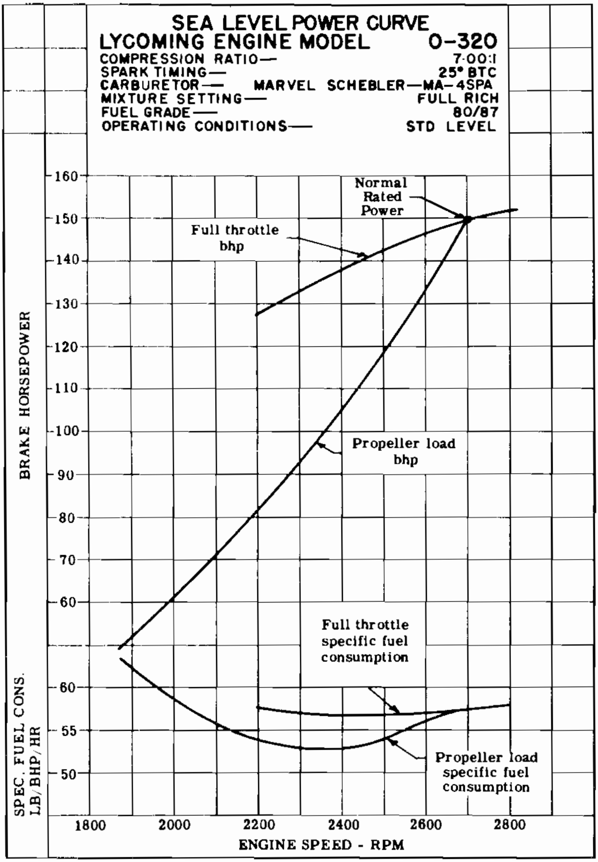
Detail Weight — Standard Engine (dry); includes 12 V. 20 Amp. Generator (10.64 lbs.) and Starter — Average

Engine **LYCOMING** O-320-A Series .... 272 lbs.
Engine Attaching Parts .... 1.35 lbs.
Propeller Attaching Parts .... 2.00 lbs.

SPECIFICATIONS — (Continued)

Optional

Fuel Pump Drive	2.25 lbs.
Fuel Pump Drive (Plunger Type)	.14 lbs.
Vacuum Pump Drive	.85 lbs.
Propellor Governor Drive	2.20 lbs.
Generator (12 V. 35 Amp.)	16.60 lbs.
Generator (12 V. 50 Amp.)	16.60 lbs.
Generator (24 V. 15 Amp.)	16.00 lbs.
Generator (24 V. 25 Amp.)	20.75 lbs.
Generator (24 V. 40 Amp.)	25.00 lbs.
Generator (24 V. 50 Amp.)	25.00 lbs.
Shielded Harness, Packard or equivalent—add	1.65 lbs.
Cooling Baffles	1.20 lbs.



PERFORMANCE CURVE

LYCOMING MODEL O-320-A AIRCRAFT ENGINE

Section II
DESCRIPTION

General—The **LYCOMING** O-320-A Series Aircraft engine is a four cylinder wet sump, horizontally opposed model. The cylinders are not directly opposite from each other but are staggered, thus permitting a separate throw on the crankshaft for each connecting rod.

Cylinders—The cylinders are of conventional air cooled design with the two major parts, head and barrel, screwed and shrunk together. The heads are made from an aluminum alloy casting with a fully machined combustion chamber. The cylinder barrel, which is machined from a chrome nickel molybdenum steel forging with deep integral cooling fins, is graund and honed to a specified finish.

Note—Standard engines are furnished with unplated cylinder barrels and chrome plated piston rings. Engines manufactured with optional chrome plated barrels require unplated piston rings.

WARNING

DO NOT UNDER ANY CIRCUMSTANCES ASSEMBLE CHROME PLATED PISTON RINGS IN A CHROME PLATED CYLINDER BARREL CHROME PLATED CYLINDERS ARE IDENTIFIED BY AN ORANGE BAND AROUND THE BASE OF THE BARREL.

The valve rocker shaft bearing supports and the rocker box housing are cast integrally with the cylinder head. The valves are cooled by means of fins which completely surround the area of the exhaust valve and portions of the intake valve. Bronze valve guides and austentic chrome nickel steel valve seats are shrunk into machined recesses in the head.

Valve Operating Mechanism—The valve operating mechanism is located on the top side of the engine, facilitating proper lubrication and easy accessibility. The camshaft is located parallel to and above the crankshaft and operates in aluminum bearings. The camshaft in turn actuates the valves by means of mushroom type hydraulic tappets, which automatically keep the valve clearance at zero. The valve rockers are supported on a full floating steel pin. The valve springs bear against both upper and lower steel seats and are retained on the valve stems by means of tapered split keys.

Crankshaft—The crankshaft is made from a chrome nickel molybdenum steel forging. All bearing journal surfaces are nitrided, and centrifugal sludge removers are provided in the form of oil tubes at each crankpin journal. These tubes must be removed during overhaul of the engine and replaced.

Note—Crankshafts on O-320-A engines, which are equipped for fixed-pitch operation, are not interchangeable with crankshafts furnished with O-320 engines equipped to operate with constant speed propeller governors.

Crankcase—The crankcase assembly consists of two reinforced aluminum alloy castings divided vertically at the center line of the engine and fastened together by means of through bolts and nuts. The mating surfaces of the crankcase are joined without the use of a gasket, and the main bearing bores are machined for use of precision type main bearing inserts.

Oil Sump—The oil sump incorporates an oil screen filter, carburetor mounting pad, the intake riser, and the intake pipe connections. The fuel air mixture, as it passes through the riser, is vaporized by the heated oil in the sump that surrounds the riser.

Connecting Rods—The connecting rods are made in the form of "H" sections from alloy steel forgings. They have replaceable baring inserts in the crankshaft ends and bronze bushings in the piston ends. The bearing caps on the crankshaft ends of the rods are retained by means of two bolts and nuts through each cap.

Pistons—The pistons are machined from aluminum alloy and their general construction is of the full skirt type. Two compression rings and an oil regulator ring are located above the piston pin. The piston pin is of the full floating type with an aluminum or alminum-bronze plug located at each end to prevent the pin from touching the cylinder wall.

Accessory Housing—The accessory housing is made from an aluminum casting and is fastened to the rear of the crankcase and the top rear of the sump. It forms a housing for the oil pump and the drives for the tachometer, magnetos, and other accessories.

Gears—The gears are of the conventional spur type and are precision machined. They are hardened to insure long life and satisfactory operating qualities.

Cooling System—The air pressure cooling system is actuated by the forward speed of the plane. Baffles are provided to build up a pressure between the cowling and the top of the cylinders, thus forcing the cool air down through the cylinder fins. The air is then exhausted at the rear of the engine cowling.

Lubrication System—The lubrication system is of the pressure wet sump type. The main bearings, connecting rod bearings, camshaft bearings, valve tappets, and push rods are lubricated by positive pressure. Piston pins, gears, cylinder walls, and other parts are lubricated by means of oil collectors and spray. The oil pump, which is located in the accessory housing, draws oil through a tube from an oil suction screen located in the sump. The oil from the pump then enters a drilled passage in the accessory housing, which feeds the oil to a threaded connection on the rear face of the accessory housing, where a flexible line leads the oil to the external oil cooler. Pressure oil from the cooler returns to a second threaded connection on the accessory housing, from which point a drilled passage conducts the oil to the oil pressure screen, which is contained in a cast chamber mounted on the accessory housing. In the event that cold oil or an obstruction should restrict the flow of oil to the cooler, an oil cooler by-pass valve is provided to pass the pressure oil directly from the oil pump to the oil pressure screen chamber.

The oil pressure screen is provided as a means to filter from the oil any solid particles that may have passed through the suction screen in the sump. After being filtered in the pressure screen chamber, the oil is fed through a drilled passage to the oil pressure relief valve, located in the upper right side of the crankcase in front of the accessory housing.

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

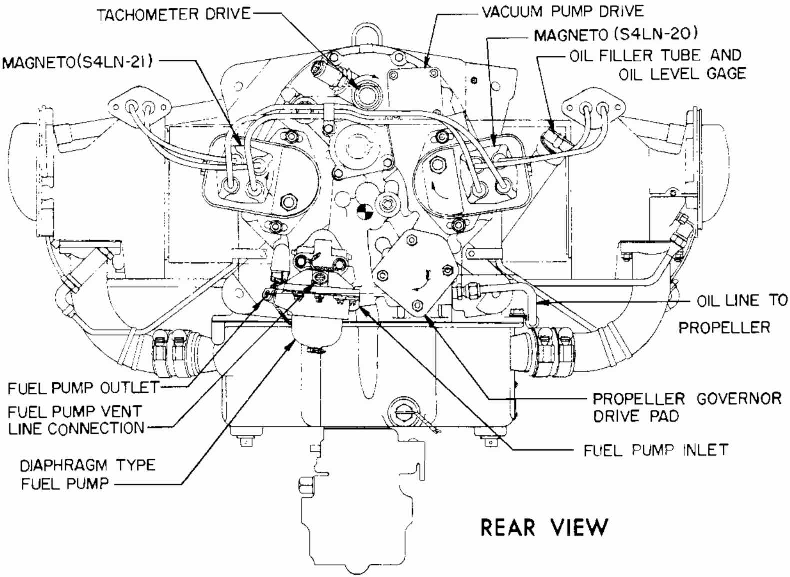
Induction System—The **LYCOMING** O-320-A Series engine is equipped with a Marvel-Schebler model MA-4SPA carburetor. This carburetor is of the single barrel float type, and is equipped with a manual altitude mixture control and an idle cut-off. Particularly good distribution of the fuel air mixture to each cylinder is obtained by the center zone induction system, which is integral with the oil sump and is submerged in oil, insuring a more uniform vaporization of fuel and aiding in cooling the oil in the sump. From the riser the fuel air mixture is distributed to each cylinder by separate steel intake pipes.

Ignition System—Dual ignition is furnished by two magnetos; the left magneto incorporates an impulse coupling. The ignition wiring is so arranged that the left magneto fires the top plugs in the left hand cylinders and the bottom plugs of the right hand cylinders, while the right magneto fires the bottom plugs of the left hand cylinders and the top plugs of the right hand cylinders. (See wiring diagram on page **22**.) This arrangement insures consistent drop-off when switching from both magnetos to either the right or left magneto.

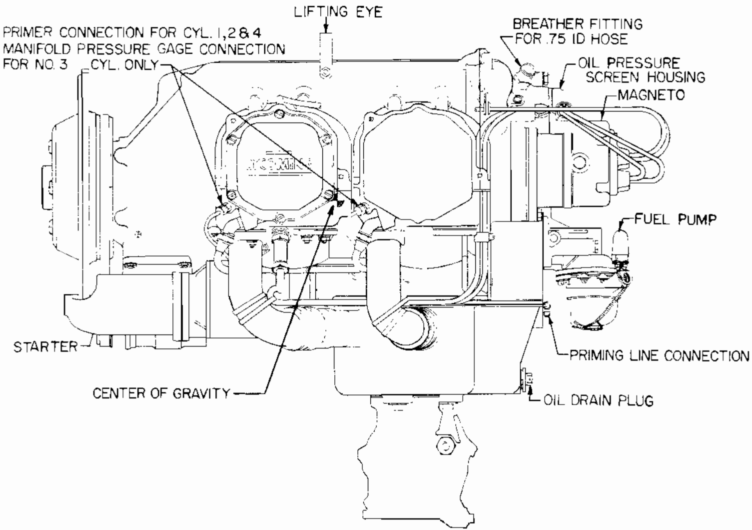
Some O-320-A engines have dual ignition furnished by one Scintilla S6RN-204 and one Scintilla S6RN-200 retard breaker magnetos. The S6RN-200 is a retard breaker magneto which provides a fixed retard and long duration boosted spark for starting. A source of DC power and a starting vibrator are required to complete the installation. Both magnetos incorporate an integral feed thru capacitor and require no external noise filter in the ground lead.

Generator and Starter—The starter is located in the lower left front side of the engine, and its Bendix type drive engages with a ring gear that is integral with the rear propeller flange, while the generator is located on the lower right front side of the engine and is driven by a belt to a pulley which is concentric with and integral to the same ring gear. Where required on twin engine installations, special regulators and paralleling relays can be provided for parallel operation of the generators. Although a 12 volt starter and generator are furnished as standard equipment, a choice of several current ratings in 12 and 24 volt generators is available. (See page **9**.)

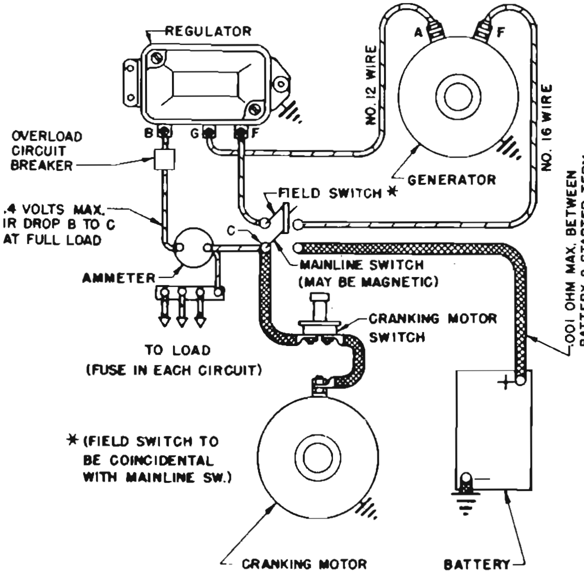
Accessory Drives—The **LYCOMING** Model O-320-A engine is normally furnished with propeller governor drive, vacuum pump drive, an SAE type tachometer drive, and a plunger-operated AC type AH fuel pump. Standard equipment on the Model O-320-A engine includes an SAE tachometer drive and provisions for the installation of the following drives; vacuum pump, propeller governor, and a geared or plunger type fuel pump drive. Various other combinations of drives are available on special order to suit the owner's requirements.


TACHOMETER DRIVE
VACUUM PUMP DRIVE
MAGNETO (S4LN-20)
MAGNETO(S4LN-21)
OIL FILLER TUBE AND
OIL LEVEL GAGE
OIL LINE TO
PROPELLER
FUEL PUMP OUTLET
FUEL PUMP VENT
LINE CONNECTION
DIAPHRAGM TYPE
FUEL PUMP
PROPELLER GOVERNOR
DRIVE PAD
FUEL PUMP INLET

REAR VIEW


LIFTING EYE
PRIMER CONNECTION FOR CYL. 1,2 & 4
MANIFOLD PRESSURE GAGE CONNECTION
FOR NO. 3 CYL. ONLY
BREATHER FITTING
FOR .75 ID HOSE
OIL PRESSURE
SCREEN HOUSING
MAGNETO
FUEL PUMP
STARTER
PRIMING LINE CONNECTION
CENTER OF GRAVITY
OIL DRAIN PLUG

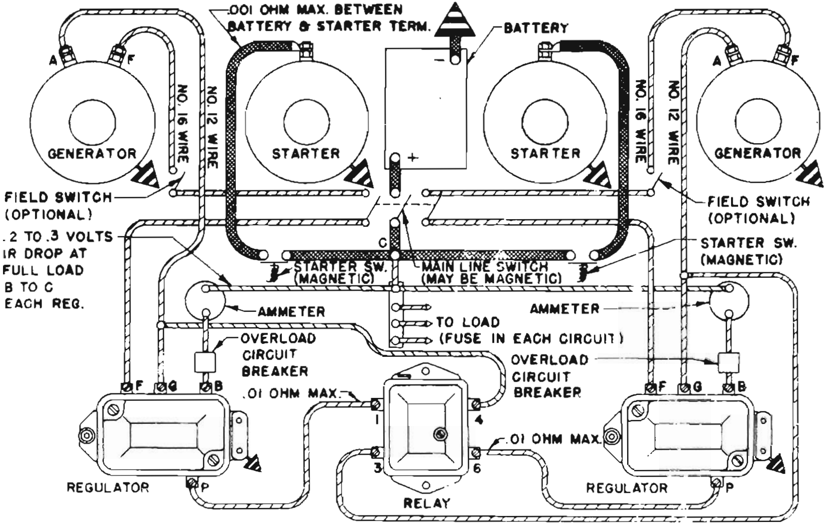
SIDE VIEW



WIRE SIZES SHOWN ARE MINIMUM AND SHOULD
BE USED ONLY WHERE LEAD LENGTHS ARE SHORT.
HEAVIER WIRE SIZES ARE PREFERRED

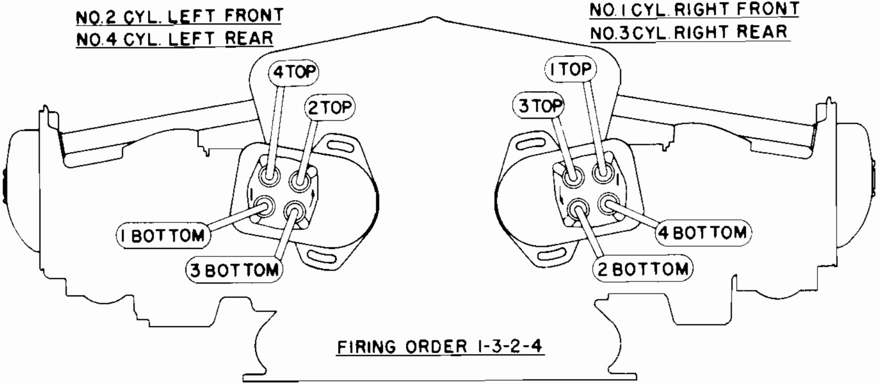
GENERATOR AND STARTER WIRING DIAGRAM

LYCOMING MODEL O-320-A AIRCRAFT ENGINE



WIRE SIZES SHOWN ARE MINIMUM AND SHOULD BE USED ONLY WHERE LENGTHS ARE SHORT. HEAVIER WIRE SIZES ARE PREFERRED.

GENERATOR AND STARTER WIRING DIAGRAM
(Twin Installation)
LYCOMING MODEL O-320-A AIRCRAFT ENGINE



WIRING DIAGRAM

LYCOMING MODEL O-320-A AIRCRAFT ENGINE

Section III

PACKING AND UNPACKING

General—**LYCOMING** type O-320-A aircraft engines are securely packed for shipment, one to the crate in a horizontal position. The carburetor, rubber and steel washers, mounting nuts, propeller hub flange, and propeller mounting bolts are packed in a separate carton within the engine crate.

Packing—In packing it is recommended the engine be first prepared for storage, as described later in this section, to prevent unnecessary damage due to corrosion. Also, take particular care in securing engine to shipping crate.

Unpacking—Open shipping crate. Remove inner carton containing carburetor and loose shipping parts. Attach lifting cable to lifting eye. With a suitable hoist take up the slack cable. Remove the bolts and lift engine clear of shipping crate. With the engine in this position, remove the bottom plugs from each cylinder and rotate cronkshaft a few revolutions to drain the oil from the cylinders. Assemble spark plugs and clean exterior of engine thoroughly.

PREPARATION OF ENGINE FOR STORAGE

General—The following procedure is intended for application to installed engines which are being removed from aircraft, and will provide protection from corrosion for a period of 30 to 60 days.

Preservation Run—Immediately prior to removal of the engine from the aircraft, the engine should be given a preservation run under the following operating conditions:

Fuel—Normal service fuel.

Oil—8 quarts (normal sump capacity) of corrosion-preventive mixture meeting specification Mil-6529C. (Esso "Rust Bane 628" or equivalent.)

Duration of Run—The engine should be operated until the oil temperature as measured at the crankcase outlet has reached a minimum of 103° C. (220° F.). Engine speed should be held to a maximum of 1800 rpm, and all precautions pertaining to ground running (see Section V) should be carefully observed. Cylinder head, ignition harness, and magneto temperatures should not be allowed to exceed the prescribed limits, and every effort should be made to keep the length of the run to a minimum.

Compound Injection—As soon as the oil temperature at the crankcase outlet has reached the limit prescribed above, reduce engine speed to 800-1000 rpm and spray corrosion-preventive mixture into the intake manifold until all cylinders begin to smoke profusely. At this point, place the mixture control in idle cut-off and simultaneously cut the ignition switch to shut down the engine. Continue spraying until the engine stops.

Note—The corrosion-preventive mixture, which should be the same as that used in the crankcase, should be pre-heated to a minimum of 220° F. and applied with a nozzle pressure of 50 psi.

Completion of Run—Immediately upon completion of the preservation run, drain the corrosion-preventive mixture from the engine. Remove the oil suction and oil pressure screens, clean, dip in corrosion-preventive compound, and replace.

Note—If corrosion-preventive mixture is prepared in large quantities, the mixture drained from a single engine may be saved and returned to the stock tank, provided the mixture is replenished to the original quantity after the preservation of each engine. The replenishing mixture shall be made up in such a manner as to adjust to the original concentration, taking into account residual lubricant trapped in the engine. Where the stock tank capacity is less than ten gallons, the re-use of the mixture, although replenished, shall be limited to one engine for each two gallons capacity. Where the tank capacity is more than ten gallons, the tank mixture shall be completely replaced at least once every 30 hours operating time.

Preservation of Interior Surfaces—As soon as practicable after the preservation run (and under no circumstances more than four hours afterward), the engine should be removed from the aircraft and the following procedure accomplished, using undiluted corrosion-preventive compound. Mount the engine on a rotary overhaul stand and seal the breather, primer tee, and tachometer drive adapter with oil- and moisture-resistant caps. Then complete any necessary checks, such as ignition timing and valve clearance, that require rotating the crankshaft.

Remove the spark plugs and spray the interior of each cylinder with pre-heated corrosion-preventive compound. Each piston should be at the bottom of its stroke while the cylinder is being sprayed. Then spray each exhaust port and valve with the piston 90° before top center on the exhaust stroke. Upon completion of the above and when absolutely certain that no further need exists for rotating the crankshaft, spray each cylinder again through the spark plug hole, this time without moving the shaft.

Fill the sump with 3 gallons of undiluted corrosion-preventive compound, and then rotate the engine through 360° in increments of 90°, permitting the engine to remain in each of the four positions for five minutes.

Drain the corrosion-preventive compound from the sump; the compound may be re-used indefinitely, replenishing when necessary. Install a crankcase dehydrator plug (Lycoming Part No. 40234 or equivalent in the oil sump drain hole, and cylinder dehydrating plugs (Lycoming Part No. 40238 or equivalent) in the spark plug holes. Install ignition cable protectors (Lycoming Part No. 40239 or equivalent) over the spark plug terminal of each ignition cable and secure by attaching to the end of the dehydrator plug. Flush all accessory drives for which oil seals are provided with corrosion-preventive compound before assembling the drive covers.

Exterior Surfaces and Accessories—All exposed cadmium plated and machined surfaces should be coated with soft film corrosion-preventive compound (E. F. Houghton and Co. Cosmoline 1059 or equivalent). The starter ring gear and propeller mounting surfaces in particular should receive a liberal coating of compound.

Drain all residual gasoline from the carburetor, fill with oil, and flush the interior surfaces by rocking the carburetor. After flushing, drain the carburetor, replace all plugs, lock the throttle in the closed position, and pack the carburetor in a cardboard carton.

Securely anchor a bag of dessicant (Industrial Packaging Products' Silica Gel, NYLCO Products' Dessicite No. 25, or equivalenit) in the intake riser. The bag, which should be as large as is practical, should not be removed from its moisture-proof container until immediately before installation. Seal the riser opening with an oil and moisture resistant cover (Lycoming Part No. 65329 or equivalent).

Make sure that all openings in the engine are properly sealed. Suitable metal covers (Lycoming Part No. 67240 or equivalent) should be used in sealing the exhaust ports moisture-resistant tape will be sufficient for the magneto ground connections and similar openings.

Any other accessories or parts not attached to the engine must be preserved by dipping the part in corrosion-preventive mixture, draining it, wrapping it in paper (Nylco Products Co. NYLWRAP II or equivalent), and packing it in a suitable container to be packed with the engine. This procedure applies to spark plugs and electrical components, with the exception that they are not to be dipped in the corrosion-preventive compound.

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

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

Recommended Procedure for Re-preservation—The engine shall be examined every 30 days. If any evidence of corrosion is present, the affected area shall be cleaned free of corrosion and the engine re-preserved.

Engines prepared by the above procedure are not adequately protected for extended periods of storage. If at the end of 60 days it is found that the engine must remain in storage for an additional period, the engine must be re-preserved according to the foregoing procedure.

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

Section IV
INSTALLATION OF THE ENGINE

Preparation of Engine for Installation—Before installing an engine that has been prepared for storage, remove all dehydrator plugs, silica-gel bags, and corrosion preventive mixture from the engine. Should any of the dehydrator plugs, containing crystals of silica-gel or similar material, be broken during their term of storage or upon their removal from the engine, and if any of the contents should fall into the engine, that portion of the engine must be dis-assembled and thoroughly cleaned before using the engine. Corrosion-preventive mixture can be removed by removing the bottom spark plugs and turning the crankshaft three or four revolutions by hand. The corrosion-preventive mixture will then drain through the spark plug holes. Corrosion-preventive mixture which has accumulated in the sump can be drained by removing the oil sump drain plug. After the oil sump has been drained, the plug should be replaced, safety-wired, and the sump filled with lubricating oil. The crankshaft should again be turned several revolutions to saturate the interior of the engine with clean oil. When installing spark plugs, make sure that they are clean; if not, wash them in clean petroleum solvent. Of course, there will be a small amount of corrosion-preventive compound remaining in the engine but not in sufficient quantity to prove harmful. However, after twenty-five hours of operation, the lubricating oil should be drained while the engine is hot. This will remove any residual corrosion-preventive mixture that may have been present.

CAUTION

Do not rotate the crankshaft of an engine containing corrosion-preventive mixture before removing the spark plugs, because if the cylinders contain any appreciable amount of the mixture, the resulting action, known as hydraulicing, will cause the connecting rods to bend. Also, any contact of the corrosion-preventive mixture with painted surfaces should be avoided.

The oil strainers should be removed and cleaned in gasoline or some other hydrocarbon solvent. The fuel drain screen located in the fuel inlet of the carburetor should also be removed and cleaned in a hydrocarbon solvent. The operator should also note if any valves are sticking. If they are, this condition can be eliminated by coating the valve stems generously with a mixture of gasoline and lubricating oil.

Inspection of Engine Mounting—If the airplane is one from which an engine has been removed, make sure that the engine mount is not bent or damaged by distortion or misalignment, because if it is, abnormal stresses can be produced within the engine.

Engine Accessories—Considerable time and work can be saved if all of the accessories are assembled on the engine; for example, the carburetor and fuel pump along with the lines connecting them.

Attaching Engine to Mount—After the engine has been raised in position to be mounted, two rubber mounting plugs should be inserted in both sides of the mounting bosses of the engine. A steel washer is then placed over the front mounting plug and another over the rear mounting plug if one is not already integral with the mounting framework. The whole assembly is then bolted to the mount by means of ½-inch bolts and castellated nuts. The nuts should be tightened until the rubber mounting plugs are compressed to 1.84 inches when measured with an inside vernier caliper. Cotter pins should be used to secure the castellated nuts.

Attaching Carburetor Controls—The throttle connection is located on the right side of the carburetor and the mixture control on the rear.

Note—After connecting the linkage to both the throttle and mixture control levers, move the controls several times from the cabin to ascertain that they move freely through the full arc of their travel.

Fuel Line Connection—The fuel line may be attached by means of the .250-18 pipe tapped hole in the carburetor. Be certain that it is tight and that no leakage is possible.

Oil Temperature Thermometer Well—An oil temperature thermometer well is provided in the oil pressure screen chamber, which is located on the accessory housing between the magnetos. This well is provided with .625-18 NF-3 tapped hole to attach the thermometer tube fitting.

Oil Pressure Gage Line—The oil pressure gage tube fitting should be attached to the .125-27 pipe hole provided on the right side of the accessory housing above the right magneto.

Breather Connection—Be sure the breather line is correctly installed. An improperly installed breather can cause oil to be sucked out of the engine or excessive pressure in crankcase will cause oil leaks.

Tachometer Cable—The tachometer cable should be attached to the SAE standard drive provided at the rear of the engine on the accessory housing between and above the magnetos.

Propeller Installation—See prapeller manufacturer's instructions.

NOTE

Your attention is directed in particular to the WARRANTIES that appear in the front of this manual regarding engine speed, the use of specified fuels and lubricants, repairs, and alterations. Perhaps no other item of engine operation and maintenance contributes quite so much to satisfactory performance and long life as the constant use of correct grades of fuel and oil, correct engine timing, and flying the airplane at all times within the speed and power range specified for the engine. Do not forget that violation of the operation and maintenance specifications for your engine will not only void your warranty but will shorten the life of your engine after its warranty period has passed.

Section V
OPERATION

General—Close adherence to these instructions will greatly contribute to long life, economy, and satisfactory operation of the engine.

Fuel—This engine is designed to operate on 80/87 octane (Aviation Grade Min.) fuel. Under no circumstances should automotive fuel be used.

Lubricating Oil Recommendations

Oil Sump Capacity .... 8 quarts

Recommended Grode of Oil

Grade (Aviation)	Average Ambient Air Temp. (°F.)	Oil Inlet Temp. (°F.) Desired	Maximum
SAE 50	Above 60	180	245
SAE 40	30 to 90	180	245
SAE 30	0 to 70	170	225
SAE 20	Below 10	160	210

It is recommended that the lubricating oil be changed every 50 flying hours.

Proper Operating Conditions

Minimum Safe Quantity of Lubricating Oil in Sump System ....2 U.S. Qts.

Maximum Oil Temperature .... 245° F.

Minimum Oil Temperature (for continuous operation) .... 140° F.

Minimum Oil Pressure
- Idling .... 25 lbs. per sq. in.
- Cruising .... 60 lbs. per sq. in.

Maximum Oil Pressure .... 85 lbs. per. sq. in.

Fuel Pressure
- Minimum .... ½ lb.
- Desired .... 3 lbs.
- Maximum .... 5 lbs.

Maximum Cylinder Head Temperature
- Take-off and Climb .... 500° F.
- Cruising .... 450° F.

Prestarting Inspection—Following installation after a prolonged period of idleness:

Be sure ignition switch is in the "OFF" position.

Check ground wires on magnetos.

Be sure mixture control is in idle cut-off position.

Inspect mounting and propeller bolts for proper tightness and safety.

Turn propeller over by hand five or six full revolutions, checking airplane and engine clearance.

Check oil level in sump.

See that fuel tanks are full.

Operate all controls and check travel for full range and freedom from binding.

Clean the fuel strainer and drain sufficient fuel to clear out any foreign matter.

Check baffles and cowling for security.

Care of a New Engine—A new engine has been carefully run-in and has passed a rigid final test at the factory, and no further "Break-In" is necessary, but the operator will benefit by treating it carefully during its first few hours in service. Avoid prolonged operation at full throtle or excessive engine speeds.

Starting Procedure—After completion of prestarting inspection.

Head the airplane into the wind.

Lock the wheels by either wheel brakes or chocks.

Set carburetor heat in "cold" position.

Turn fuel valve to "ON" position.

Set mixture control lever in "Full Rich" position.

Set throttle to 1/10 open position.

Prime cold cylinders with one to three full strokes of priming pump depending on engine temperature.

Engage starter and allow engine to turn approximately one full turn before turning ignition switch to the "LEFT MAG" position.

NOTE—Starter manufacturers recommend that cranking periods be limited to ten to twelve seconds with a five minute rest between cranking periods. Longer cranking periods will shorten the life of the starter.

When engine fires evenly, turn ignition switch to "BOTH" and open throttle to an indicated speed of 800 R. P. M. Check oil pressure gage for an indicated pressure. If oil pressure is not indicated within one-half minute, stop engine and determine trouble.

Cold Weather Starting—During extreme cold weather it may be necessary to preheat the engine or the oil before starting. If engine fails to start at the first attempt, another attempt should be made without priming. If this fails it is possible that the engine is overprimed, turn switch to "OFF" position, open throttle slowly, and turn the engine over approximately ten revolutions. Prime with half the original prime and repeat starting procedure. If this fails, refer to Section on Engine Troubles.

Ground Running and Warm-Up—The **LYCOMING** O-320-A is an air pressure cooled engine that depends on the forward speed of the airplane to maintain proper cooling. Therefore, particular care is necessary when operating this engine on the ground. To prevent overheating it is recommended that the following precautions be followed:

head airplane into the wind.

Avoid prolonged idling at low R. P. M. as this practice may result in fauled spark plugs.

Do not exceed 1800 R. P. M. during ground test.

Limit ground running to 4 minutes in cold weather and to 2 minutes at temperatures above 70° F.

Check carburetor heat control.

NOTE—Engine is warm enough for take-off when the throttle can be opened without back-firing or skipping of the engine.

Ground Test

Warm up engine 800 to 1200 R. P. M.

With engine running at 1800 R. P. M. (fixed pitch installation only), switch from both magnetos to only one and check drop-off. Then switch to the other magneto and again note drop-off. Drop-off should not exceed 125 R. P. M. on either magneto. On planes with controllable pitch props the drop-off should not exceed 125 R. P. M. when engine is turning 2000 R. P. M.

Check both oil pressure and oil temperature.

Take off as soon as the test is completed, because excessive ground running will cause overheating.

Use of Carburetor Heat Control—Under certain moist atmospheric conditions it is possible for ice to form in the induction system even in summer weather. This is due to the high air velocity through the carburetor venturi and the absorption of heat from this air by evaporation of the fuel. The temperature in the mixture chamber may drop 20° F. to 70° F. below the temperature of the incoming air. If this air contains a large amount of moisture, the cooling process will cause precipitation in the form of ice. These ice formations generally begin in the vicinity of the butterfly and will often build up to such an extent that a drop in power output results. This loss of power is reflected by a drop in manifold pressure in installations equipped with constant speed propellers and a drop in manifold pressure and R. P. M. in installations equipped with fixed pitch propellers. If not detected, this condition will continue to such an extent that the reduced power will cause complete engine stoppage.

To avoid this condition, all installations are equipped with a system for preheating the incoming air supply to the carburetor. In this way sufficient heat is added to replace the heat loss to vaporization of fuel, and the mixing chambers temperature cannot drop to the freezing point of water. This air preheater is essentially a tube or jacket through which the exhaust pipe from one or more cylinders is passed, and the air flowing over these surfaces is raised to the required temperature before entering the carburetor. Consistently high temperatures are to be avoided because of a loss in power and a decided variation of the mixture. High charge temperatures also favor detonation and preignition, both of which are to be avoided if normal service life is to be expected from the engine. The following outline is the proper method of utilizing the carburetor heat control.

Use of the carburetor air heat on the ground must be held to an absolute minimum. On some installations the air does not pass through the air filter, and dirt and foreign substances can be taken into the engine with the resultant cylinder and piston ring wear. Carburetor air heat should be used on the ground only to make certain it is functioning properly.

Take-offs should be made with carburetor heat in full cold position. The possibility of expansion or throttle icing at wide throttle openings is very remote, so remote in fact, that it can be disregarded.

The carburetor air heat control should be left in the cold position during normal flight operations. On damp, cloudy, foggy or hazy days, regardless of the outside air temperatures, keep a sharp lookout for loss of power. This loss of power will be shown by an unaccountable loss in manifold pressure or R. P. M. or both, depending on whether a constant speed or fixed pitch prop is installed on the aircraft. When this situation arises, apply full carburetor air heat and open the throttle to limiting manifold pressure. This will result in a slight additional drop in manifold pressure which is normal, and this drop will be regained as the ice is melted out of the induction system. When the ice has been melted from the induction system, the carburetor heat control should be returned to the cold position. In those aircraft equipped with a carburetor air temperature gage, partial heat may be used to keep the mixture temperature above the freezing point (32° F.).

Carburetor Mixture Control—(Fixed Pitch Propeller). The carburetor mixture control, in addition to incorporating an idle cut-off when fully closed, can be used to manually lean the fuel-air mixture. The mixture control must be maintained in the "FULL RICH" position for all operations where more than 75% power is being used. If any doubt exists as to the amount of power being used, the mixture should be in the "FULL RICH" position for all operations under 5000 feet.

The following leaning procedure should be used at altitudes above 5000 feet and at the pilot's discretion below 5000 feet when less than 75% power is being used:

1. With the mixture in the "FULL RICH" position,

slowly move the control toward the lean position. It will be noted that as the control is gradually moved, the engine will start to pick up R. P. M. An increase in R. P. M. will be more noticeable above 5000 feet because of the excessively rich mixture.

2. Continue to lean out the mixture control until the engine begins to run rough. At this point the engine will have reached and passed through maximum R. P. M.

3. Richen the mixture by moving the mixture contiol forward just enough to smooth out the engine. At this point the engine is operating at approximately "best economy" at a speed about 3 % below the maximum R. P. M. observed during step 2 above.

4. If it is desired to operate at a higher power output, enrich mixture, increase the throttle to the desired R. P. M. and repeat the leaning procedure as previously described.

Constant Speed Propeller—In those aircraft equipped with a constant speed propeller, the manual leaning procedure is the same as for a fixed pitch prop, except for the fact that the R. P. M. will be held constant by the propeller governing system. Move the mixture control toward the lean position until the engine begins to run rough. At this point richen the mixture until the engine runs smoothly. This procedure should give some decrease in cylinder head temperature from the point at which the leaning procedure started.

CAUTION

1. Never operate an engine above the maximum cylinder head temperature specified in the operator's manual.

2. Never manually lean engines equipped with altitude compensated carburetors.

3. Do not increase power for climbing to higher altitudes above 5000 feet without first increasing engine fuel mixture proprotionately. Readjust engine fuel mixture after attaining new altitude to best economy setting.

Landing—During relatively long glides in making an approach for landing, the throttle should be partially opened at intervals to clear out engine, and the mixture control kept in full rich position to insure maximum acceleration if it should be necessary to open the throttle again. The carburetor heat control should be kept in the "Full Heat" position.

Stopping the Engine—(Note—This engine is equipped with an idle cut off.) After landing, allow the engine to cool by idling for aproximately two minutes at 800 to 900 R. P. M. Then, with the engine still running at this speed, set the carburetor control at "IDLE CUT OFF." After the engine stops firing, set the ignition switch in the "OFF" position. Stopping an engine in the above method will prevent afterfiring.

Cold Weather Suggestions:

Use lighter oil. See page **39.**

In extremely cold weather it may be necessary to preheat the lubricating oil prior to starting.

Avoid excessive running of engine on the ground.

To maintain the desired oil temperature, it may be necessary to block off the oil sump air blast hole or lag sump.

Carburetor Air Cleaner—Inspect the carburetor air cleaner and air intake daily to make sure that the cleaner is functioning properly and that air enters the carburetor only through the cleaner. Service the cleaner daily according to manufacturer's instructions.

NOTE—When operating under extremely dusty conditions, it may be necessary to service the cleaner at more frequent intervals.

ENGINE FLIGHT CHART

Fuel and Oil			O-320-A Series
Fuel Grade 80/87 Octane (Min.)	Oil Grade	Temp. above 60° F.	SAE 50
		Temp, 30 to 90° F.	SAE 40
		Temp. 0 to 70° F.	SAE 30
		Temp. below 10° F.	SAE 20

	Desired	Maximum	Minimum	Idling
Fuel Pressure (Lbs. per Sq. In.)	3	5	.5	....
Oil Pressure (Lbs. per Sq. In.)	75	85	60	25
Oil Temperature				
SAE 50	180° F.	245° F.	....	....
SAE 40	180° F.	245° F.	....	....
SAE 30	170° F.	220° F.	....	....
SAE 20	160° F.	200° F.	....	....

OPERATING CONDITION FOR FIXED PITCH PROPELLER

Operation	R.P.M.	Manifold Pressure	Fuel Cons. Gals. Per Hour	Oil Cons. Qts. Per Hour	* Max. Cyl. Temp. °F.
Normal Rated	2700	28.7	14.0	1.00	**500
Performance Cruise	2450	24.5	10.0	.75	**450
Economy Cruise	2350	22.8	8.6	.65	450

* At bayonet location

** Mixture Control not to be used below 5000 feet.

Section VI

SERVICE INSPECTION AND MAINTENANCE

General—The daily pre-flight inspection is a check of the complete airplane prior to the first flight of the day. This inspection is to determine the general condition of the airplane and engine, but is not designed to detect slight wear and minor maladjustments. Such items should be found during the more thorough 50-hour and 100-hour inspections.

The operator should bear in mind that the items listed in the following charts constitute a complete inspection only so far as the engine is concerned; consult the aircraft manufacturer's handbook for complete instructions.

At the conclusion of the first 25 hours of operation the engine should undergo a 50-hour inspection, including the draining and renewing of lubricating oil.

INSPECTION AND MAINTENANCE

Daily Pre-Flight

Check fuel and oil level.

Inspect engine for evidence of oil leakage.

Inspect safetying of all drain plugs and covers.

Inspect carburetor and fuel line connections.

Check engine controls for general condition, travel, and free operation.

CHECK CARBURETOR AIR CLEANER AND SERVICE ACCORDING TO MANUFACTURER'S INSTRUCTIONS.

50-Hour

Check spark plug elbows and shielding nuts for security.

Drain carburetor bowl.

Check priming system for leaks.

Check oil lines for leaks particularly at connections, security of anchorage, wear due to rubbing or vibration, dents, and cracks.

Drain and refill oil sump with new oil.

Remove and clean suction and pressure oil strainers.

Check intake and exhaust systems for leaks and looseness.

Drain and clean fuel strainer.

Note—All the above operations should be performed in addition to those listed under Daily Pre-Flight.

100-Hour

Inspect all electrical wiring for general condition and proper anchorage.

Check baffles for secure anchorage, holes, cracks, bending and close fit around the cylinder.

Check cylinders for cracked or broken fins.

Check air entrances and exits for deformation.

Remove and clean carburetor fuel strainer.

Check magnetos for synchronization.

Check engine mounting bolts and bushings for general condition and proper torque.

Clean and regap spark plugs.

Note—All the above operations should be performed in addition to those listed under Daily Pre-Flight and 50-Hour Inspection.

Carburetor Idling Adjustment—With exception of the idling adjustment, no adjustment of the carburetor is necessary. The mixture is controlled by means of jets and air passages that are not adjustable and are calibrated at the factory.

To adjust the idle mixture and speed: With engine thoroughly warmed up, set throttle stop screw so that engine idles at approximately 550 R. P. M. Turn idle adjusting screw towards "RICH" position until engine "rolls" from richness, then turn screw slowly towards the "LEAN" position (indicated by letter "L") until 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 screw slowly towards a "richer" setting, leaving the final setting at a mixture just lean enough to prevent a rich "roll" or uneven running from richness. This adjustment will in most cases give a slower idle speed than a slightly leaner adjustment, with the same throtle stop screw setting, but will give smoothest idle operation. A change in 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.

Oil Relief Pressure Adjustment—The function of the oil pressure relief valve, which is located between the upper right engine mounting lug and No. 3 cylinder, is to maintain engine oil pressure within specified limits by withdrawing a portion of the oil from the circulating system and returning the oil to the sump should the pressure become excessive. This valve is not adjustable; however, particles of metal or other foreign matter lodged between ball and seat will result in a drop in oil pressure. It is advisable, therefore, to disassemble, inspect, and clean the relief valve at periodic intervals.

The oil pressure relief valve is by no means to be confused with the oil cooler by-pass valve, which is located in the oil pressure screen housing mounting pad. The sole purpose of the by-pass valve is to serve as a safety measure, permitting pressure oil to by-pass the oil cooler entirely in case of an obstruction within the cooler.

Magneto Timing—Remove the top spark plug from the No. 1 cylinder. Place the thumb of one hand over the spark plug hole and rotate the crankshaft in direction of normal rotation until the compression stroke is reached. The compression stroke is indicated by a positive pressure inside the cylinder tending to lift the thumb off the spark plug hole. In this position both valves of No. 1 cylinder are closed.

Rotate the crankshaft opposite to its normal direction of rotation until it is approximately 35° before top center of the compression stroke of No. 1 cylinder.

Align the timing mark on the front face of the ring gear support with the drilled hole in the starter, making sure the final motion of the ring gear is in direction of normal rotation. The ring gear must always be in this position when either magneto is locked in position.

Note—An alternate method is provided to perform the above method if so desired. Locate and fasten ignition timing pointer on the 25° mark located on the rear face of the starter ring gear.

Align the pointer with the parting flange of the crankcase.

With the magneto gear assembled on the right magneto, turn the magneto gear until the chamfered tooth on the distributor gear inside the magnetc aligns with the white pointer as seen through the window in the front of the magneto cover.

Without allowing the gear to turn from this position, assemble the magneto with gasket on the engine. Secure magneto in place with washers and nuts; tighten nuts only finger tight.

Fasten ground wire of electric timing light to any unpainted metallic portion of the engine, and one of the positive wires of the timing light to a suitable terminal connected to the ground terminal connection of the right magneto. Then turn the engine crankshaft several degrees from the 25° BTC in direction opposite to that of normal rotation.

Turn on the switch of the timing light. The light should be lit. Turn the crankshaft very slowly in direction of normal rotation until the timing mark on the front face of the ring gear support aligns with the drilled hole in the starter, at which point the light should dim (or go on on battery operated models). If not, turn the magneto in its mounting flange slots and repeat the procedure until the light dims (or goes on on battery operated models) at 25° before top dead center. Tighten the two mounting nuts and replace magneto inspection plug.

Install magneto impulse coupling adapter with gasket on left magneto mounting pad of the accessory housing.

CAUTION

The impulse coupling magneto can be used only on the left side of the engine, when viewed from the rear, or accessory housing end.

Remove inspection plug and turn magneto drive coupling until the white beveled tooth on the magneto gear aligns with the pointer.

Note—In order to turn the shaft on the impulse coupling magneto, depress the pawl on the impulse coupling with the finger.

Place magneto gasket over mounting studs and secure left magneto in place with washers and nuts; tighten nuts only finger tight.

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

Note—The crankshaft should not be rotated more than 35° in direction opposite normal rotation, as the pawl on the impulse coupling will engage with the stop pin and late timing will be indicated through the impulse coupling mechanism. If this shold happen, rotate engine in normal direction until sharp click is heard, which will indicate that impulse coupling has passed through firing position; then turn crankshaft in direction opposite normal rotation to approximately 35° before top center and proceed with timing check.

After both magnetos have been timed, leave the timing light wire connected and re-check magneto timing as previously described to make sure that both magnetos are set to fire together. If timing is correct, both timing lights will dim (or go on on battery operated models) simultaneously when the mark on the front face of the ring gear support aligns with the drilled hole in the starter. If the breaker points open too early, loosen the mounting nuts and rotate the magneto clockwise. If the breaker points open too late, rotate the magneto counterclockwise. Remove timing light and ignition timing pointer.

The -200 and -204 magnetos are timed as described for other magnetos. Never, however, attempt to time the retard breaker points to the engine. Always use the main breaker points for engine timing.

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

Note—Breaker points on Bendix Scintilla S4LN type magnetos are not to be adjusted to a given clearance. For proper S4LN magneto adjustments, refer to Scintilla's instructions.

Removal of Cylinder Assembly.

Remove exhaust manifold.

Remove rocker box drain tube, intake pipe, baffles, priming lines, and any clips that interfere with the removal of cylinder.

Disconnect ignition cable and remove spark plugs. Remove rocker box cover and rotate crankshaft until piston is approximately at top center of the compression stroke. This approximate position may be located by observing top of the piston through the spark plug hole and also watching the valve action.

Remove valve rockers by sliding valve rocker shaft out of the cylinder head.

Remove push rods by grasping ball end and pulling rod out of shroud tube. Detach shroud tube springs and lockplate and pull shroud tubes out through holes in cylinder head.

Remove cylinder base nuts and washers and remove cylinder by pulling cylinder directly away from crankcase. Be careful not to allow the piston to drop against the crankcase as the piston leaves the cylinder.

Note—The hydraulic tappets, push rods, rocker arms, and volves must be marked so that they can be assembled in the same location from which they were removed.

Removal of Valves and Valve Springs from Cylinder—place the cylinder over a block of wood so as to hold the valves in a closed position. Compress the valve springs using the valve spring compressor. Remove the tapered split keys from the end of the valve stem. The valve springs and valve spring seats may now be removed from the cylinder head. Hold the valve stems so that the valve will not foll out and remove the cylinder from the holding block. The valves may now be removed from the inside of the cylinder.

Removal of Piston from Connecting Rod—Remove the piston pin plugs and remove the piston pin from the piston using a piston pin puller.

Removal of Hydraulic Tappet Sockets and Plunger Assemblies—The hydraulic tappet socket may usually be removed by inserting the forefinger into the concave end of the socket. The socket will usuolly stick to the finger firmly enough to be pulled out of the tappet body. If the socket cannot be removed in this manenr, it may be removed by grasping the edge of the socket with a pair of neeale nose pliers. However, care should be exercised to avoid scratching the socket. To remove the hydraulic tappet plunger assembly, bend a hook in the end of a short piece of lock wire, insert the lock wire around the edge of the plunger assembly and turn the wire so that the hook engages the spring of the plunger assembly. Draw the plunger assembly out of the tappet body by pulling gently on the wire.

Cleaning and Inspection of Hydraulic Tappet Plunger Assembly—Disassemble hydraulic tappet plunger assembly by grasping the tube end of the plunger assembly in one hand and the spring end in the other. Remove the plunger by twisting the spring end of the plunger assembly in a clockwise direction and pulling the plunger out of the tube.

CAUTION

Do not allow parts of two or more plunger assemblies to become mixed, as the parts of the plunger assembly are selectively fitted and are not interchangeable.

Clean the plunger assembly by flushing with petroleum solvent. Work the plunger up and down while the unit is immersed in the solvent, holding the check valve off its seat by means of a copper wire or other relatively soft article inserted through the tube. Do not use a blast of air or pressure spray to clean the plunger assembly as damage to the check valve and check valve seat may result. Thoroughly dry the plunger assembly and check for leaking ball check valve as follows.

Dip the plunger in light machine or engine oil. Hold the lifter cylinder between the thumb and middle finger in a vertical position with one hand; then place the plunger in position so that the plunger just enters the lifter cylinder. Depress the plunger quickly with the index finger; if the plunger bounces back to the original position, the unit may be considered satisfactory. If, however, the plunger does not bounce back to its original position, but remains in a collapsed position, this indicates that the ball check valve is not seating properly. When this condition exists, the plunger assembly is defective and both the cylinder and plunger must be replaced.

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

To assemble the unit unseat the ball by inserting a thin clean bronze wire through the oil inlet hole. With the ball off its seat, insert the plunger and twist clockwise so that the spring catches.

Assembly of Valves in Cylinder—Insert each valve stem in its respective guide, making certain that the exhaust and intake valves are not reversed.

Note—The exhaust valve head is slightly smaller than the intake valve head.

Place cylinder over a wood block so that the valves are held against the seats and assemble the lower spring seat, auxiliary valve spring and outer valve spring over the valve stem and guide. Place the upper spring seat on top of the springs.

Note—When installing valve springs, place the dampener end of spring (coils marked with colored dye or lacquer) toward cylinder. The dampener end of the spring may also be identified as the end of the spring that has less spacing between the coils.

Using valve spring compressor, compress the valve spring and assemble the two valve keys into the grooves around the upper end of the valve stem. Slowly release the pressure on the valve spring compressor and allow the upper spring seat to lock itself in place around the valve keys.

Assembly of Cylinder and Related Parts—Rotate crankshaft so that the connecting rod of the cylinder being assembled is at the top center position

Place each plunger assembly in its respective tappet body and assemble socket on top of plunger assembly.

Assemble piston with rings so that the cylinder number stamped on the piston pin boss is toward the front end of the engine. The piston pin should be a hand push fit. If difficulty is experienced in inserting the piston pin, it is probably caused by carbon or burrs in the piston pin hole. During assembly always use a generous quantity of oil, both in the piston pin hole and on the piston pin.

Assemble one piston pin plug at each end of the piston pin and place a new rubber oil seal ring around the cylinder skirt. Coat piston and rings and the inside of the cylinder generously with oil.

Using a piston ring compressor, assemble the cylinder over the piston with a new cylinder base oil seal so that the intake and exhaust ports are toward the bottom of the engine. Push the cylinder down over the cylinder mounting studs and install hold down nuts to proper torque.

Insert a new shroud tube oil seal on the crankcase end of each shroud tube and fit a new annular ring in the groove provided in the rocker box end of each shroud tube.

Note—On earlier models (Engine Serial Numbers 101-27 to 216-27 incl., 257-27 to 268-27 incl., and 357-27 to 368-27 incl.), an annular oil seal ring was provided which fitted into a machined recess in the shroud tube hole in the rocker box, and the rocker box end of the shroud tube was formed with straight side walls. On present models the shroud tube hole in the rocker box is machined smooth, and the oil seal ring lies in a groove formed near the end of the shroud tube. Complete cylinder assemblies with either type of machining are interchangeable, but shroud tubes and oil seal rings furnished with individual cylinders of one design are not interchangeable with tubes and rings designed for the other consult the parts catalog when ordering replacements.

Install each shroud tube through the rocker box and seat the end firmly in the crankcase. Place a spacer, two springs, a lockplate, and nut over the stud provided in the rocker box and secure both shroud tubes in place. Bend the tang of the lock in place to prevent the nut and spring from loosening.

Assemble each push rod in its respective shroud tube, and assemble each rocker in its respective position by placing rocker between bosses and sliding valve rocker pin in place to retain rocker.

Be sure that the piston is at top center compression stroke and that both valves are closed. Check clearance between the valve stem tip and the valve rocker. In order to check this clearance, place the thumb of one hand on the valve rocker directly over the end of the push rod and push down so as to compress the hydraulic tappet spring. While holding the spring compressed, check valve clearance, which should be between .028 and .080 inch. If the clearance does not come within these limits, remove the push rod and insert a longer or shorter push rod as required to correct clearance. Push rods are made in four lengths: the shortest rod is marked with three grooves at one end, the next longer is marked with two grooves, the third rod is marked with one groove, and the longest rod is unmarked.

Note—Inserting a longer rod will cause a decrease in the valve clearance.

Generator Drive Belt Tension—Check the tension of a new belt 25 hours after installation. Proper adjustment should allow at mid-point between pulleys, a depression of approximately $\frac{1}{4}$ - $\frac{3}{8}$ of an inch. If the depression in the belt does not fall within the given limits, readjust. Thereafter the belt tension should be checked avery 100 hours.

Section VII

ENGINE TROUBLES AND THEIR REMEDIES

General—Experience has proven that the best method of "trouble-shooting" is to decide on the various possible causes of a given trouble and then to eliminate these causes one by one, beginning with the most probable. The following chart lists some of the more common engine troubles usually found in maintaining aircraft engines.

TROUBLE	CAUSE	REMEDY
Failure of Engine to Start	Lack of Fuel	Check fuel system far leaks. Fill fuel tank. Clean dirty lines, strainers or fuel cocks.
	Underpriming	Prime with 2 or 3 strokes of primer.
	Overpriming	Open throttle and "unload" engine by turning in direction of normal rotation.
	Incorrect throttle setting	
	Defective spark plugs	Clean and adjust or replace spark plugs.
	Defective ignition wire	Check with electric tester, and replace ony defective wires.
	Defective Battery	Replace with charged battery.
	Improper operation of magneto breaker points	Clean Points Check internal timing of magnetos.

TROUBLE	CAUSE	REMEDY
Failure of Engine to Start	Water in carburetor	Drain carburetor and fuel lines.
	Internal failure	Check oil sump strainer for metal particles. If found, complete overhaul of the engine is indicated.
Failure of Engine to Idle Properly	Incorrect carburetor idle adjustment	Adjust throttle stop to obtain correct idle.
	Idle mixture	Adjust mixture—refer to Section VI, page **41** this handbook.
	Leak in the induction system	Tighten all connections in the induction system. Replace any parts that are defective.
	Low cylinder compression	Check condition of piston rings and valve seats.
	"Miss" caused by improper spark	Check entire ignition system.
Low Power and Uneven Running	Mixture too rich; indicated by sluggish engine operation, red exhaust flame at night. Extreme cases indicated by black smoke from exhaust	Check primer shut-off valve for leakage. Readjustment of carburetor by authorized personnel is indicated.
	Mixture too lean; indicated by overheating or back-firing	Readjustment of carburetor by authorized personnel is indicated.

TROUBLE	CAUSE	REMEDY
Low Power and Uneven Running	Leaks in induction system	Tighten all connections. Replace defective parts.
	Defective spark plugs	Clean and replace spark plugs.
	Improper fuel	Fill tank with fuel of recommended grade.
	Magneto breaker points not working properly	Clean points. Check internal timing of magnetos.
	Defective ignition wire	Check wire with electric tester. Replace defective wire.
	Improper ignition timing	Check magnetos for timing and synchronization.
	Defective spark plug terminal connectors	Replace connectors.
	Incorrect valve clearance	Adjust valve clearance to .028-.080.
Failure of Engine to Develop Full Power	Throttle lever out of adjustment	Adjust throttle lever.
	Leak in the induction system	Tighten all connections, and replace defective parts.
	Restriction in carburetor air scoop	Examine air scoop and remove restrictions.
	Improper fuel	Fill tank with fuel of recommended grade.

TROUBLE	CAUSE	REMEDY
Failure of Engine to Develop Full Power	Faulty Ignition	Tighten all connections. Check system with tester. Check ignition timing.
Rough Engine	Cracked engine mount	Replace mount.
	Unbalanced propeller	Remove propeller and have it checked for balance.
	Defective mounting bushings	Install new mounting bushings.
Low Oil Pressure	Insufficient oil	Fill sump to proper level with oil of recommended grade.
	Air lock or dirt in relief valve	Remove and clean oil pressure relief valve.
	Leak in suction line or pressure line	Check gasket between accesory housing and crankcase.
	Dirty oil strainers	Remove and clean oil strainers.
	High oil temperature	See "High Oil Temperature" in "Trouble" column.
	Defecive pressure gage	Replace gage

TROUBLE	CAUSE	REMEDY
Low Oil Pressure	Stoppage in oil pump intake passage	Check line for obstruction. Clean suction strainer.
High Oil Temperature	Insufficient air cooling	Check air inlet and outlet for deformation or obstruction.
	Insufficient oil supply	Fill oil sump to proper level with oil of recommended grade.
	Low grade of oil	Replace with oil conforming to specification.
	Clogged oil lines or strainers	Remove and clean oil strainers.
	Excessive blow-by	Usually caused by worn or stuck rings.
	Failing or failed bearing	Examine sump for metal particles. If found, overhaul of engine is indicated.
	Defective temperature gage	Replace gage.
Excessive Oil Consumption	Low grade of oil	Replace with oil conforming to specification.
	Failing or failed bearing	Check sump for metal particles and, if found, overhaul engine.
	Worn piston rings	Install new rings.

TROUBLE	CAUSE	REMEDY
Excessive Oil Consumption	Incorrect installation of piston rings	Install new rings.
Cold Weather Difficulties	Cold oil	Move aircraft into a heated hangar. Heat oil.
	Inaccurate pressure readings	In extreme cold weather oil pressure readings up to approximately 100 lbs. do not necessarily indicate malfunctioning.
	Overpriming	Rotate crankshaft in counterclockwise direction with throtle "FULL OPEN" and ignition switch "OFF."
	Weak battery	Install fully charged batteryy.

Section VIII

SERVICE TABLE OF LIMITS

Note: The letter "L" following a limit indicates a loose fit, while the letter "T" indicates a tight fit.

Ref. No.	Description	Mfg. Min.	Mfg. Max.	Repl. Max.
512	Piston Pin and Piston—Clearance	.0003L	.0009L	.003L
513	Piston and Piston Pin Plug—Clearance (Plain)	.0009L	.0022L	.004L
	Piston and Piston Pin Plug—Clearance (Chrome)	.0002L	.001L	.002L
514	Piston Ring and Piston—Top Ring—Side Clearance	b .000	b .004L	b .006L
515	Piston Ring and Piston—Second Ring—Side Clearance	b .000	b .004L	b .006L
516	Piston Ring and Piston—Third Ring—Side Clearance	.0035L	.0055L	.0075L
519	Piston Skirt and Cylinder—Clearance	d .005L	d .0065L	d .017L
520	Cylinder—Maximum Taper	.0000	.0005	.004
	Maximum Taper—Chrome Plated	.000	.0015	.004
521	Cylinder—Maximum Out-of-Round	.0000	.0005	.004
	Maximum Out-of-Round—Chrome Plated	.0000	.0015	.004
528	Exhaust Valve Stem and Valve Guide—Clearance	.0035L	.005L	.006L
529	Intake Valve Stem and Valve Guide—Clearance	.0010L	.0025L	.006L
531	Valve Rocker Shaft and Valve Rocker Bushings—Clearance	.001L	.0025L	.006L
533	Valve Rocker and Clinder Head—Side Clearance	.003L	.009L	.012L

(b) Side clearance on wedge type rings must be measured with face of ring flush with piston.

(d) The dimensions shown is measured at bottom of piston skirt at right angles to piston pin. The dimensions in line with piston pin is .010 smaller.

SERVICE TABLE OF LIMITS

Ref. No.	Description	Mfg. Min.	Mfg. Max.	Repl. Max.
607	Crankshaft Run-out at Propeller Flange			.005
611	Valve Rocker Shaft and Rocker Shaft Bushing—Clearance	.0001L	.0010L	.0025L
615	Piston Ring Gap—(All Rings)	.020	.030	.045
800	Outer Valve Spring—Compression Load at 1.30" (Wire Diameter .162)	82 lbs.	89 Lbs.	79 Lbs. Min.
801	Auxiliary Valve Spring—Compression Load at 1.17" (Wire Diameter .135)	61 Lbs.	67 Lbs.	58 Lbs. Min.
807	Oil Relief Valve Spring—Compression Load at 1.30" (Wire Diameter .054)	7.25 Lbs.	7.75 Lbs.	
811	Oil Cooler By-Pass Spring—Compression Load at 1.94" (Wire Diameter .0465)	6.54 Lbs.	6.92 Lbs.	6.41 Lbs. Min.

TORQUE LIMITS

Tightening Torque Table		Recommended Torque
830	Spark Plugs	300 to 360 In. Lbs.
831	1/2" Nuts and Capscrews	550 In. Lbs. Torque
832	3/8" Nuts and Capscrews	75 In. Lbs. Torque
833	1/4" Nuts and Capscrews	150 In. Lbs. Torque
834	5/16" Nuts and Capscrews	300 In. Lbs. Torque
839	No. 10-32 Screw (Attach Ignition Cable Outlet Plate to Magneto)	12 to 15 In. Lbs. Torque
849	3/8" Nuts and Capscrews for Diaphragm Fuel Pump	225 to 250 In. Lbs. Torque

The torque limits applicable to propeller attaching bolts must be obtained from the propeller manufacturer.

FULL THROTTLE HP AT ALTITUDE

Altitude Ft.	% S.L. HP.	Altitude Ft.	% S.L. HP.	Altitude Ft.	% S.L. HP.
0	100	8,500	74.8	17,000	54.3
500	98.5	9,000	73.5	17,500	53.1
1,000	96.8	9,500	72.5	18,000	52.1
1,500	95.3	10,000	70.8	18,500	51.4
2,000	93.6	10,500	69.5	19,000	50.0
2,500	92.0	11,000	68.3	19,500	49.1
3,000	90.5	11,500	67.2	20,000	48.0
3,500	89.3	12,000	65.8	20,500	47.6
4,000	87.5	12,500	64.7	21,000	46.0
4,500	85.9	13,000	63.4	21,500	45.2
5,000	84.6	13,500	62.3	22,000	44.0
5,500	83.2	14,000	61.0	22,500	43.3
6,000	81.7	14,500	59.8	23,000	42.2
6,500	80.2	15,000	58.7	23,500	41.4
7,000	78.9	15,500	57.6	24,000	40.3
7,500	77.5	16,000	56.5	24,500	39.5
8,000	76.2	16,500	55.4	25,000	38.5

TABLE OF SPEED EQUIVALENTS

Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.
72.0	50	31.3	115	20.0	180	13.8	260
65.5	55	30.0	120	19.4	185	13.3	270
60.0	60	28.8	125	18.9	190	12.8	280
55.4	65	27.7	130	18.4	195	12.4	290
51.4	70	26.6	135	18.0	200	12.0	300
48.0	75	25.7	140	17.6	205	11.6	310
45.0	80	24.8	145	17.1	210	11.2	320
42.3	85	24.0	150	16.7	215	10.9	330
40.0	90	23.2	155	16.4	220	10.6	340
37.9	95	22.5	160	16.0	225	10.3	350
36.0	100	21.8	165	15.6	230	9.6	375
34.3	105	21.2	170	15.0	240	9.0	400
32.7	110	20.6	175	14.4	250		

CENTIGRADE-FAHRENHEIT CONVERSION TABLE

Example: To convert 15° C. to Fahrenheit, find 15 in the center column headed (F-C); then read 59.0° F. in the column (F) to the right. To convert 15° F. to Centigrade; find 15 in the center column and read —9.44° C. in the (C) column to the left.

C	←F↓C→	F	C	←F↓C→	F
—62.2	—80	—112.0	4.44	40	104.0
—56.7	—70	—94.0	7.22	45	113.0
—51.1	—60	—76.0	10.00	50	122.0
—45.6	—50	—58.0	12.78	55	131.0
—40.0	—40	—40.0	15.56	60	140.0
—34.0	—30	—22.0	18.33	65	149.0
—31.7	—25	—13.0	21.11	70	158.0
—28.9	—20	—4.0	23.89	75	167.0
—26.1	—15	5.0	26.67	80	176.0
—23.3	—10	14.0	29.44	85	185.0
—20.6	—5	23.0	32.22	90	194.0
—17.8	0	32.0	35.00	95	203.0
—15.0	5	41.0	37.78	100	212.0
—12.22	10	50.0	40.56	105	221.0
—9.44	15	59.0	43.33	110	230.0
—6.67	20	68.0	46.11	115	239.0
—3.89	25	77.0	48.89	120	248.0
—1.11	30	86.0	51.67	125	257.0
1.67	35	95.0	54.44	130	266.0

CENTIGRADE-FAHRENHEIT CONVERSION TABLE—(Continued)

C	← F ↓ C →	F	C	← F ↓ C →	F
57.22	135	275.0	176.67	350	662.0
60.00	140	284.0	182.22	360	680.0
65.56	150	302.0	187.78	370	698.0
71.11	160	320.0	193.33	380	716.0
76.67	170	338.0	198.89	390	734.0
82.22	180	356.0	204.44	400	752.0
87.78	190	374.0	210.00	410	770.0
93.33	200	392.0	215.56	420	788.0
98.89	210	410.0	221.11	430	806.0
104.44	220	428.0	226.67	440	824.0
110.00	230	446.0	232.22	450	842.0
115.56	240	464.0	257.78	460	860.0
121.11	250	482.0	243.33	470	878.0
126.67	260	500.0	248.89	480	896.0
132.22	270	518.0	254.44	490	914.0
137.78	280	536.0	260.00	500	932.0
143.33	290	554.0	265.56	510	950.0
148.89	300	572.0	271.11	520	968.0
154.44	310	590.0	276.67	530	986.0
160.00	320	608.0	282.22	540	1004.0
165.56	330	626.0	287.78	550	1022.0
171.11	340	644.0			

INCH FRACTION CONVERSIONS

Decimals, Area of Circles, and Millimeters

Inch Fraction	Decimal Equiv.	Area Sq. In.	MM. Equiv.	Inch Fraction	Decimal Equiv.	Area Sq. In.	MM. Equiv.
1/64	.0156	.0002	.397	9/32	.2812	.0621	7.144
1/32	.0312	.0008	.794	19/64	.2969	.0692	7.540
3/64	.0469	.0017	1.191	5/16	.3125	.0767	7.937
1/16	.0625	.0031	1.587	21/64	.3281	.0845	8.334
5/64	.0781	.0048	1.984	11/32	.3437	.0928	8.731
3/32	.0937	.0069	2.381	23/64	.3594	.1014	9.128
7/64	.1094	.0094	2.778	3/8	.375	.1105	9.525
1/8	.125	.0123	3.175	25/64	.3906	.1198	9.922
9/64	.1406	.0154	3.572	13/32	.4062	.1296	10.319
5/32	.1562	.0192	3.969	27/64	.4219	.1398	10.716
11/64	.1719	.0232	4.366	7/16	.4375	.1503	11.112
3/16	.1875	.0276	4.762	29/64	.4531	.1612	11.509
13/64	.2031	.0324	5.159	15/32	.4687	.1726	11.906
7/32	.2187	.0376	5.556	31/64	.4844	.1842	12.303
15/64	.2344	.0431	5.953	1/2	.5	.1964	12.700
1/4	.25	.0491	6.350	33/64	.5156	.2088	13.097
17/64	.2656	.0553	6.747	17/32	.5312	.2217	13.494

INCH FRACTION CONVERSIONS

Decimals, Area of Circles, and Millimeters

Inch Fraction	Decimal Equiv.	Area Sq. In.	MM. Equiv.	Inch Fraction	Decimal Equiv.	Area Sq. In.	MM. Equiv.
35/64	.5469	.2349	13.891	25/32	.7812	.4794	19.844
9/16	.5625	.2485	14.288	51/64	.7969	.4987	20.241
37/64	.5781	.2625	14.684	13/16	.8125	.5185	20.637
19/32	.5937	.2769	15.081	53/64	.8281	.5386	21.034
39/64	.6094	.2916	15.478	27/32	.8437	.5591	21.431
5/8	.625	.3068	15.875	55/64	.8594	.5800	21.828
41/64	.6406	.3223	16.272	7/8	.875	.6013	22.225
21/32	.6562	.3382	16.669	57/64	.8906	.6229	22.622
43/64	.6719	.3545	17.065	29/32	.9062	.6450	23.019
11/16	.6875	.3712	17.462	59/64	.9219	.6675	23.416
45/64	.7031	.3883	17.859	15/16	.9375	.6903	23.812
23/32	.7187	.4057	18.256	61/64	.9531	.7134	24.209
47/64	.7344	.4235	18.653	31/32	.9687	.7371	24.606
3/4	.75	.4418	19.050	63/64	.9844	.7610	25.003
49/64	.7656	.4604	19.447	1	1.	.7854	25.400

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