Operation Reference Manual

Lycoming

IO-390 SERIES

Part No. 60297-29

LYCOMING

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IO-390 Operation Reference Manual
Lycoming Part Number: 60297-29

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LYCOMING OPERATION REFERENCE MANUAL

ATTENTION

OWNERS, OPERATORS, AND MAINTENANCE PERSONNEL

This operation reference manual contains a description of the engine, its specifications, and detailed information on how to operate and maintain it. Such maintenance procedures that may be required in conjunction with periodic inspections are also included. This manual is intended for use by owners, pilots, and maintenance personnel responsible for care of Lycoming powered aircraft.

SAFETY WARNING

NEGLECTING TO FOLLOW THE OPERATING INSTRUCTIONS AND TO CARRY OUT PERIODIC MAINTENANCE PROCEDURES CAN RESULT IN POOR ENGINE PERFORMANCE AND POWER LOSS. ALSO, IF POWER AND SPEED LIMITATIONS SPECIFIED IN THIS MANUAL ARE EXCEEDED, FOR ANY REASON; DAMAGE TO THE ENGINE AND PERSONAL INJURY CAN HAPPEN. CONSULT YOUR LOCAL FAA APPROVED MAINTENANCE FACILITY.

SPECIAL NOTE

The illustrations, pictures and drawings shown in this publication are typical of the subject matter they portray; in no instance are they to be interpreted as examples of any specific engine, equipment or part thereof.

IMPORTANT SAFETY NOTICE

Proper service and repair is essential to increase the safe, reliable operation of all aircraft engines. The service procedures recommended by Lycoming are effective methods for performing service operations. Some of these operations require the use of tools specially designed for the task. These special tools must be used when and as recommended.

It is important to note that most Lycoming publications contain various Warnings and Cautions which must be carefully read in order to minimize the risk of personal injury or the use of improper service methods that may damage the engine or render it unsafe.

It is also important to understand that these Warnings and Cautions are not all inclusive. Lycoming could not possibly know, evaluate or advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences that may be involved. Accordingly, anyone who uses a service procedure must first satisfy themselves thoroughly that neither their safety nor aircraft safety will be jeopardized by the service procedure they select.

LYCOMING OPERATION REFERENCE MANUAL

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SECTION 1

DESCRIPTION

The IO-390 series are four cylinder, direct drive, horizontally opposed, air-cooled engines.

In referring to the location of the various engine components, the parts are described as installed in the airframe. Thus, the propeller end is the front and the accessory drive end the rear. The sump section is considered the bottom and the opposite side of the engine where the shroud tubes are located is the top. Reference to the left and right side is made with the observer facing the rear of the engine. The cylinders are numbered from front to rear, odd numbers on the right, even numbers on the left. The direction of rotation of the crankshaft, viewed from the rear, is clockwise for standard rotation engines. Rotation for accessory drives is determined with the observer facing the drive pad.

NOTE

The letter "L" in the model prefix denotes the reverse rotation of the basic model. Example: model IO-390-C has clockwise rotation of the crankshaft. Therefore, LIO-390-C has counterclockwise rotation of the crankshaft.

Cylinders – The cylinders are of conventional air-cooled construction 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. Rocker shaft bearing supports are cast integral with the head along with housings to form the rocker boxes. The cylinder barrels have deep integral cooling fins and the inside of the barrels are ground and honed to a specified finish.

Valve Operating Mechanism – A conventional type camshaft is located above and parallel to the crankshaft. The camshaft actuates hydraulic tappets, which operate the valves through push rods and valve rockers. The valve rockers are supported on full floating steel shafts. The valve springs bear against hardened steel seats and are retained on the valve stems by means of split keys.

Crankcase – The crankcase assembly consists of two reinforced aluminum alloy castings, fastened together by means of studs, bolts and nuts. The mating surfaces of the two castings are joined without the use of a gasket, and the main bearing bores are machined for use of precision type main bearing inserts.

Crankshaft – The crankshaft is made from a chrome nickel molybdenum steel forging. All bearing journal surfaces are nitrided.

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

Pistons – The pistons are machined from an aluminum alloy. The piston pin is of a full floating type with a plug located in each end of the pin. The pistons are machined for three rings and employ half-wedge rings.

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 various accessory drives.

Oil Sump – The sump incorporates an oil drain plug, oil suction screen, mounting pad for fuel metering servo, the intake riser and intake pipe connections.

Cooling System – Inter-cylinder cooling baffles are furnished. End baffles need to be constructed to effectively direct cooling air over the cylinders in a manner equivalent to that obtained by the inter-cylinder baffles.

Fuel Injection System – Various fuel injection systems such as the Airflow Performance Lycoming Fuel Control System and the Precision Airmotive Silverhawk System are available for the Lycoming IO-390 engine. Either system uses a fuel metering servo to meter the fuel in proportion to the air being consumed by the engine. Refer to the manufacturer’s fuel injection system manual for specific details on the operation of the system.

Lubrication System – An impeller type pump contained within the accessory housing actuates the full pressure wet sump lubrication system.

Ignition System – The engine is configured for dual ignition.

Counterweight System – The crankshaft has pendulum type counterweights attached.

SECTION 2
SPECIFICATIONS

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Specifications

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SECTION 2

SPECIFICATIONS

IO-390 Series

Standard rated horsepower..........210*
Rated speed, RPM..........2700*
Bore, inches..........5.319
Stroke, inches..........4.375
Displacement, cubic inches..........389
Compression ratio.......... 8.9:1*
Firing order 1-3-2-4
Spark occurs, degrees BTC..........20*
Valve rocker clearance (hydraulic tappets collapsed) .... .028-.080
Propeller drive ratio 1-1
Propeller drive rotation (viewed from rear)..........Clockwise*

* - These specifications are for the basic IO-390 engine model. These values for customized IO-390 engines may not be the same. Consult the engine nameplate and other documentation.

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SECTION 3
OPERATING INSTRUCTIONS

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SECTION 3

OPERATING INSTRUCTIONS

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

New engines have been carefully run-in by Lycoming and therefore, no further break-in is necessary insofar as operation is concerned; however, new or newly refurbished engines must be operated on straight mineral oil for a minimum of 50 hours or until oil consumption has stabilized. After this period, a change to an approved additive oil may be made.

NOTE

Cruising should be done at 65% to 75% power until a total of 50 hours has accumulated or oil consumption has stabilized. This is to ensure proper seating of the rings and is applicable to new engines, and engines in service following cylinder replacement or top refurbishment of one or more cylinders. See Section 8 for additional information regarding engine break-in.

The minimum fuel octane rating is listed in the flight chart, Part 8 of this section. Under no circumstances should fuel of a lower octane rating or automotive fuel (regardless of octane rating) be used.

2. PRESTARTING ITEMS OF MAINTENANCE. Before starting the aircraft engine for the first flight of the day, there are several items of maintenance inspection that must be performed. These are described in Section 4 under Daily Pre-Flight Inspection. They must be observed before the engine is started.

3. STARTING PROCEDURES.

The following starting procedures are recommended, however, the starting characteristics of various installations will necessitate some variation from these procedures.

(1) Perform pre-flight inspection.

(2) Set alternate air control in “Off” position.

(3) Set propeller governor control in “Full RPM” position (where applicable).

(4) Turn fuel valve “On”.

(5) Turn boost pump “On”.

(6) Open throttle wide open, move mixture control to “Full Rich” until a slight but steady fuel flow is noted (approximately 3 to 5 seconds) then return throttle to “Closed” and return mixture control to “Idle Cut-Off”.

(7) Turn boost pump “Off”.

(8) Open throttle approximately ¼ inch travel or per aircraft manufacturer’s recommendations.

(9) Set magneto selector switch (consult aircraft manufacturer's handbook for correct position).

(10) Engage starter.

(11) When the engine starts move mixture control smoothly to "Full Rich".

(12) Adjust the RPM to 900-1000 RPM (unless otherwise specified in the aircraft manufacturer's manual).

(13) Check oil pressure gauge. If minimum oil pressure is not indicated within thirty seconds, stop engine and determine trouble.

4. COLD WEATHER STARTING. During extreme cold weather, it may be necessary to preheat the engine and oil before starting.

5. GROUND RUNNING AND WARM-UP.

The engines covered in this manual are air-pressure cooled and depend on the forward speed of the aircraft to maintain proper cooling. Particular care is necessary, therefore, when operating these engines on the ground. To prevent overheating, it is recommended that the following precautions be observed.

NOTE

Any ground check that requires full throttle operation must be limited to three minutes, or less if the cylinder head temperature exceeds the maximum as stated in this manual.

a. Fixed Wing.

(1) Head the aircraft into the wind.

(2) Leave mixture in "Full Rich".

(3) Operate only with the propeller in minimum blade angle setting.

(4) Warm-up to approximately 1000-1200 RPM. Avoid prolonged idling and do not exceed 2200 RPM on the ground.

(5) Engine is warm enough for take-off when the throttle can be opened without the engine faltering and the oil pressure is not less than the minimum pressure specified in this operation reference manual.

b. Helicopter.

(1) Warm-up at approximately 2000 RPM with rotor engaged as directed in the aircraft manufacturer's handbook.

6. GROUND CHECK.

a. Warm-up as directed above.

b. Check both oil pressure and oil temperature.

c. Leave mixture control in "Full Rich".

d. *Fixed Wing Aircraft (where applicable).* Move the propeller control through its complete range to check operation and return to full low pitch position. Full feathering check (twin engine) on the ground is not recommended but the feathering action can be checked by running the engine between 1000-1500 RPM or as specified by the airframe manufacturer. Then momentarily pull the propeller control into the feathering position. Do not allow the RPM to drop more than 500 RPM.

e. If your engine has an electronic ignition system, then follow the manufacturers recommended checking procedures. A proper magneto check is also important. A magneto pre-flight test is useful to determine that both magnetos are functioning properly and that no spark plug is misfiring. Additional factors, other than the ignition system, affect magneto drop-off. They are load-power output, propeller pitch, and mixture strength. The important thing is that the engine runs smoothly because magneto drop-off is affected by the variables listed above. Make the magneto check in accordance with the following procedures:

(1) Fixed Wing Aircraft.

(Controllable pitch propeller.) With propeller in minimum pitch angle, set the engine to produce 50-65% power as indicated by manifold pressure gage. At these settings, the ignition system and spark plugs must work harder because of the greater pressure within the cylinders. Under these conditions, ignition problems, if they exist, will occur. Magneto checks at low power settings will only indicate fuel/air distribution quality.

(Fixed pitch propeller.) Aircraft that are equipped with fixed pitch propellers, or not equipped with manifold pressure gauge, may check magneto drop-off with engine operating at approximately 1800 RPM (2000 RPM maximum).

Switch from both magnetos to one and note drop-off; return to both until engine regains speed and switch to the other magneto and note drop-off. Magneto drop-off at 2000 RPM should not exceed 200 RPM on either magneto; but under some conditions; i.e., field elevations and temperature characteristics, a drop in excess of 200 RPM (plus 25 RPM) may be experienced. If engine speed stabilizes and if the engine continues to operate smoothly, the ignition system is operating satisfactorily.

(2) Helicopter.

Raise collective pitch stick to obtain 15 inches manifold pressure at 2000 RPM.

Switch from both magnetos to one and note drop-off; return to both until engine regains speed and switch to the other magneto and note drop-off. Drop-off should not exceed 200 RPM. Drop-off between magnetos should not exceed 50 RPM. A smooth drop-off past normal is usually a sign of a too lean or too rich mixture.

f. Do not operate on a single magneto for too long a period; a few seconds is usually sufficient to check drop-off and to minimize plug fouling.

7. OPERATION IN FLIGHT.

a. See airframe manufacturer's instructions for recommended power settings.

b. Move the controls slowly and smoothly. In particular, avoid rapid opening and closing of the throttle on engines with counterweighted crankshafts. There is a possibility of detuning the counterweights with subsequent engine damage.

c. *Fuel Mixture Leaning Procedure.*

Improper fuel/air mixture during flight is responsible for engine problems, particularly during take-off and climb power settings. The procedures described in this manual provide proper fuel/air mixture when leaning Lycoming engines; they have proven to be both economical and practical by eliminating excessive fuel consumption and reducing damaged parts replacement. It is therefore recommended that operators of all Lycoming aircraft power-plants utilize the instructions in this publication any time the fuel/air mixture is adjusted during flight.

Manual leaning may be monitored by exhaust gas temperature indication, fuel flow indication, and by observation of engine speed and/or airspeed. However, whatever instruments are used in monitoring the mixture, the following general rules must be observed by the operator of Lycoming aircraft engines.

GENERAL RULES

Never exceed the maximum red line cylinder head temperature limit of 465°F (260°C), measured at the bayonet location.

For maximum service life, maintain cylinder head temperatures below 435°F (224°C) during high performance cruise operation and below 400°F (205°C) for economy cruise powers.

On engines with manual mixture control, maintain mixture control in "Full Rich" position for rated take-off, climb, and maximum cruise powers (above approximately 75%). However, during take-off from high elevation airport or during climb, roughness or loss of power may result from over-richness. In such a case adjust mixture control only enough to obtain smooth operation – not for economy. Observe instruments for temperature rise. Rough operation due to over-rich fuel/air mixture is most likely to be encountered in carbureted engines at altitude above 5,000 feet.

Always return the mixture to full rich before increasing power settings.

Operate the engine at maximum power mixture for performance cruise powers and at best economy mixture for economy cruise power; unless otherwise specified in the aircraft manufacturer's manual.

During letdown flight operations it may be necessary to manually enrichen fuel injected engines to obtain smooth operation.

1. *LEANING TO EXHAUST GAS TEMPERATURE GAUGE.*

   a. *Normally aspirated engines with fuel injectors.*

      (1) Maximum Power Cruise (approximately 75% power) – Never lean beyond 150°F on rich side of peak EGT unless aircraft manufacturer's manual shows otherwise. Monitor cylinder head temperatures.

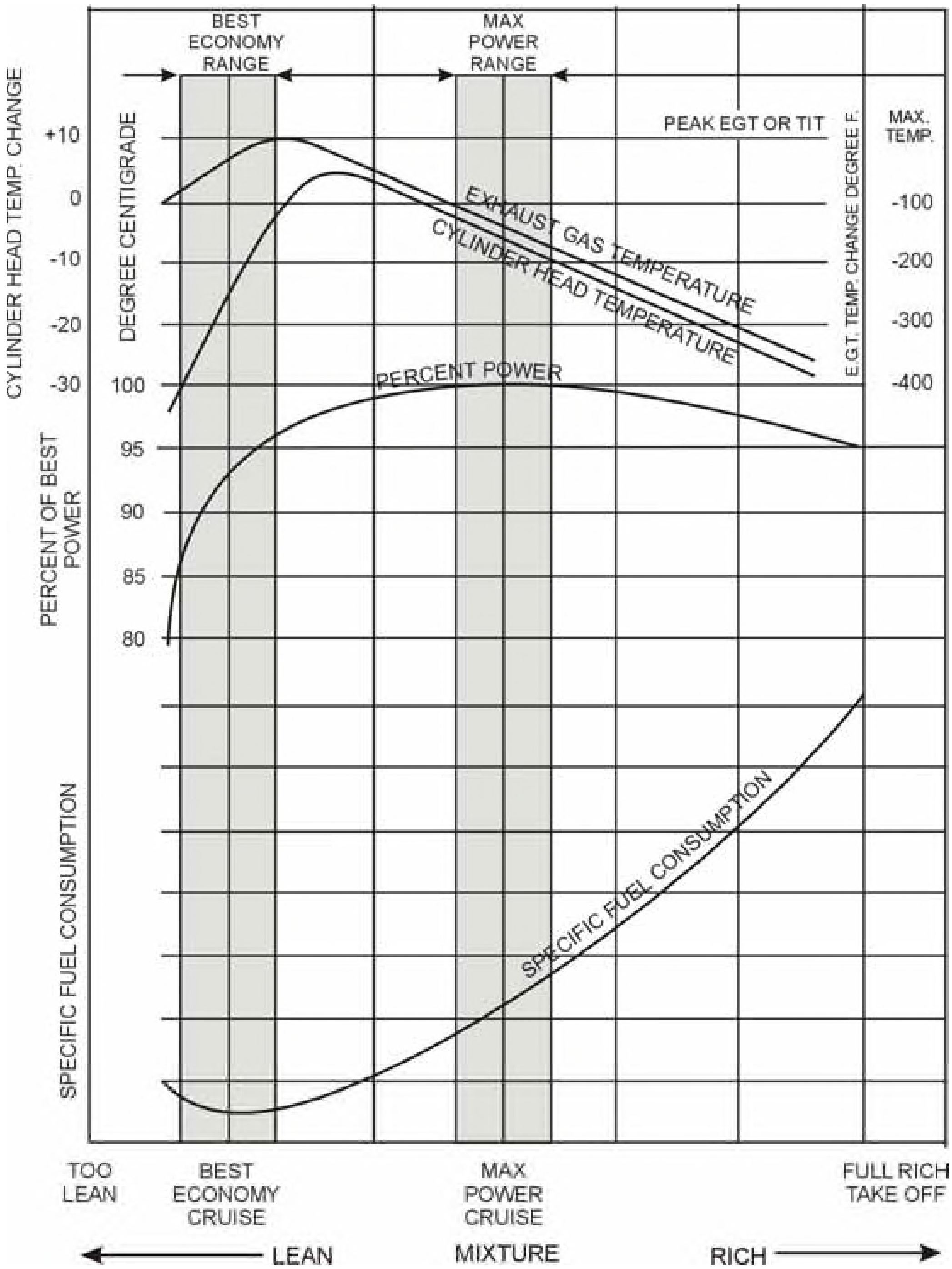

Figure 3-1. Representative Effect of Fuel/Air Ratio on Cylinder Head Temperature, Power and Specific Fuel Consumption at Constant RPM and Manifold Pressure in Cruise Range Operation

(2) *Best Economy Cruise (approximately 75% power and below) –* Operate at peak EGT.

2. LEANING TO FLOWMETER.

Lean to applicable fuel-flow tables or lean to indicator marked for correct fuel flow for each power setting.

3. LEANING WITH MANUAL MIXTURE CONTROL. (Economy cruise, 75% power or less, without flowmeter or EGT gage.)

a. Fuel Injected Engines.

(1) Slowly move mixture control from “Full Rich” position toward lean position.

(2) Continue leaning until slight loss of power is noted (loss of power may or may not be accompanied by roughness).

(3) Enrich until engine runs smoothly and power is regained.

8. ENGINE FLIGHT CHART.

FUEL AND OIL –

Model Series	*Aviation Grade Fuel Minimum Grade
IO-390	100/100LL

NOTE

Aviation grade 100LL fuels in which the lead content is limited to 2 c.c. per gal. are approved for continuous use in the above listed engines.

The importance of using fuel specified for a specific model Lycoming engine has always been stressed in Lycoming service publications. The chart showing the minimum grade fuels that can be safely used in no instance permits use of fuels of lower grade than that which is specified. Also, it is not permissible in any instance to use automotive fuel in aircraft engines, regardless of octane or advertised features because of the corrosive effect of its chlorine content and because of vapor lock that could result due to its high vapor pressure. Any fuel used in Lycoming engines must conform with Specifications ASTM-D910 or MIL-G-5572F.

NOTE

Isopropyl alcohol in amounts not to exceed 1% per volume may be added to the fuel to prevent ice formation in fuel lines and tanks. Although approved for use in Lycoming engines, isopropyl alcohol should not be used in the aircraft fuel systems unless recommended by the aircraft manufacturer.

FUEL PRESSURE, PSI –

Model	Max.	Desired	Min.
IO-390			
Inlet to fuel pump	35	-----	-2
Inlet to fuel injector	45	-----	14

OIL – (All Models) –

Average Ambient Air	Recommended Grade Oil MIL-L-6082B or SAEJ1966 Spec. Mineral Grades	MIL-L-22851 or SAEJ1966 Spec. Ashless Dispersant Grades
All Temperatures	---------	SAE 15W-50 or 20W-50
Above 80°F	SAE 60	SAE 60
Above 60°F	SAE 50	SAE 40 or SAE 50
30° to 90°F	SAE 40	SAE 40
0° to 70°F	SAE 30	SAE30, 40 or 20W-40
0° to 90°F	SAE 20W-50	SAE 20W-50 or 15W-50
Below 10°F	SAE 20	SAE 30 or 20W-30

The latest revision of Lycoming Specification No. 301 approves for use lubricating oils which conform to both MIL-L-6082 or SAEJ1966 straight mineral type and MIL-L-22851 or SAEJ1899 ashless dispersant type lubricants for aircraft engines. Any brand name lubricating oil in accordance with these specifications is acceptable for use; proof of such conformity is the responsibility of the lubricating oil manufacturer.

A. *AVERAGE TEMPERATURES* – The ambient ground air temperatures listed in the chart are meant only as a guide. Actually a great deal of personal judgment must be used when selecting the seasonal grade of oil to put into the engines. For example, if an aircraft is to be flown into an area which is much warmer or colder, only personal judgment on the part of the operator can determine what grade oil to use. When oil inlet temperatures approach the maximum allowable during operation, it is a good indication that a higher viscosity oil should be considered.

B. *MINERAL GRADES* – Included in this classification are aviation-grade, mineral lubricating oils. The SAE straight mineral grades, 20, 30, 40, 50 and 60, shown in the chart, are the equivalent to Commercial Grades 55, 65, 80, 100 and 120, and to Military Grades 1040, 1065, 1080, 1100 and 1120 respectively. This classification also includes a multiviscosity aviation grade 20W50 mineral oil.

C. *ASHLESS DISPERSANT GRADES* – This classification contains additives, one of which has a viscosity stabilizing effect, which removes the tendency of the oil to thin out at high oil temperatures and thicken at low oil temperatures. The additives in these oils extend operating temperature range, improve cold engine starting and lubrication of the engine during the critical warm-up period, thus permitting flight through wider ranges of climatic changes without the necessity of changing oil. The ashless dispersant grades are recommended for aircraft engines subjected to wide variations of ambient temperature particularly the turbocharged series engines which requires oil to activate the various turbo controllers. The SAE Grades 30, 40, 50 and 60 shown in the chart are equivalent to grades of 65, 80, 100 and 120 respectively. It must not be presumed however, that these oils will alleviate all of the problems encountered in extremely cold environments (below +10°F). At these temperatures preheating of the engine and oil supply tank will be required regardless of the type of oil used.

D. All engines must be operated on mineral oil during the first 50 hours of operation, or until oil consumption has stabilized. LW-16702 additive may be used. If an ashless dispersant oil is used in a new engine, or a newly refurbished engine, high oil consumption might possibly be experienced. The additives in some of these ashless dispersant oils may retard the break-in of the piston rings and cylinder walls. This condition can be avoided by the use of mineral oil until normal oil consumption is obtained, then change to the ashless dispersant oil. Mineral oil must also be used following the replacement of one or more cylinders or until the oil consumption has stabilized.

CAUTION

AIRCRAFT MANUFACATURERS MAY ADD APPROVED PRESERVATIVE LUBRICATING OIL TO PROTECT NEW ENGINES FROM RUST AND CORROSION AT THE TIME THE AIRCRAFT LEAVES THE FACTORY. THIS PRESERVATIVE OIL MUST BE REMOVED AT END OF THE FIRST 25 HOURS OF OPERATION. WHEN ADDING OIL DURING THE PERIOD PRESERVATIVE OIL IS IN THE ENGINE, USE ONLY AVIATION GRADE STRAIGHT MINERAL OIL OR ASHLESS DISPERSANT OIL, AS REQUIRED, OF THE VISCOSITY REQUIRED.

E. In engines that have been operating on straight mineral oil for several hundred hours, a change to ashless dispersant oil should be made with a degree of caution as the cleaning action of some ashless dispersant oils will tend to loosen sludge deposits and cause plugged oil passages. When an engine has been operating on straight mineral oil, and is known to be in excessively dirty condition, the switch to ashless dispersant oil should be deferred until after the engine is overhauled.

F. When changing from straight mineral oil to ashless dispersant oil, the following precautionary steps should be taken:

1. Do not add ashless dispersant oil to straight mineral oil. Drain the straight mineral oil from the engine and fill with ashless dispersant oil.

2. Do not operate the engine longer than five hours before the first oil change.

3. Check all oil filters and screens for evidence of sludge or plugging. Change oil every ten hours if sludge conditions are evident. Repeat 10 hour checks until clean screen is noted, then change oil at recommended time intervals.

CAUTION

THE TERMS “DETERGENT, ADDITIVE, COMPOUNDED” AND “ASHLESS DISPERSANT” USED HEREIN ARE INTENDED TO REFER TO A CLASS OF AVIATION ENGINE LUBRICATING OILS TO WHICH CERTAIN SUBSTANCES HAVE BEEN ADDED, AT THE REFINERY, TO IMPROVE THEM FOR AIRCRAFT USE. THESE TERMS DO NOT REFER TO SUCH MINERALS COMMONLY KNOWN AS “TOP CYLINDER LUBRICANT”, “DOPES”, “CARBON REMOVER” WHICH ARE SOMETIMES ADDED TO FUEL OR OIL. THESE PRODUCTS MAY CAUSE DAMAGE TO THE ENGINE (PISTONS, RING STICKING, ETC.). UNDER NO CIRCUMSTANCES MAY AUTOMOTIVE OIL BE USED. THE USE OF AUTOMOTIVE LUBRICANTS IN LYCOMING ENGINES IS NOT RECOMMENDED BECAUSE ITS USE COULD CAUSE ENGINE FAILURE.

G. Oil Temperature: The maximum permissible oil temperature is 235°F (118°C). For maximum engine life, the desired oil temperature should be maintained between 165°F (73.8°C) and 200°F (93.3°C) in level-flight cruise conditions.

H.

Oil Pressure, psi (Rear)	Maximum	Minimum	Idling
Normal Operation, All Models	95	55	25
Oil Pressure, psi (Front)	90	50	20
Start, Warm-up, Taxi, and Take-off (All Models)	115		

9. SHUT DOWN PROCEDURE.

a. Fixed Wing.

(1) Set propeller governor control for minimum blade angle when applicable.

(2) Idle until there is a decided drop in cylinder head temperature.

(3) Move mixture control to “Idle Cut-Off”.

(4) When engine stops, turn off switches.

b. Helicopters.

(1) Idle as directed in the airframe manufacturer’s handbook, until there is a decided drop in cylinder head temperature.

(2) Move mixture control to “Idle Cut-Off”.

(3) When engine stops, turn off switches.

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SECTION 4
PERIODIC INSPECTIONS

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SECTION 4

PERIODIC INSPECTIONS

NOTE

Perhaps no other factor is quite so important to safety and durability of the aircraft and its components as faithful and diligent attention to regular checks for minor troubles and prompt repair when they are found.

The operator should bear in mind that the items listed in the following pages do not constitute a complete aircraft inspection, but are meant for the engine only.

Pre-Starting Items of Maintenance – The daily pre-flight inspection is a check of the aircraft prior to the first flight of the day. The inspection is to determine the general condition of the aircraft and engine.

The importance of proper pre-flight inspection cannot be over emphasized. Statistics prove several hundred accidents occur yearly directly responsible to poor pre-flight.

Among the major causes of poor pre-flight inspection are lack of concentration, reluctance to acknowledge the need for a check list, carelessness bred by familiarity and haste.

1. DAILY PRE-FLIGHT.

a. Engine.

(1) Be sure all switches are in the "Off" position.

(2) Be sure magneto ground wires are connected.

(3) Check oil level.

(4) Check that the fuel tanks contain an adequate amount and type of fuel for the flight.

(5) Check the fuel and oil line connections for leakage. Repair any leaks before the aircraft is flown. Also check the fuel and oil lines for security, signs of chafing, kinks, or other physical damage and note for repair at the 50-hour inspection.

(6) Open the fuel drain to remove any accumulation of water and sediment, and continue to drain until the fuel is clear.

(7) Make sure all shields and cowling are in place and secure. If any are missing or damaged, repair or replacement should be made before the aircraft is flown.

(8) Check controls for general condition, travel, and freedom of movement.

(9) Induction system air filter must be inspected and serviced in accordance with the airframe manufacturer's recommendations, or the air filter manufacturer's recommendations.

2. 25-HOUR INSPECTION (ENGINE).

a. At 25 hours after the first replacement/screen cleaning – oil change, filter replacement or pressure screen cleaning and oil sump suction screen check for new, rebuilt or newly overhauled engines and for engines with any newly installed cylinders.

b. 25-Hour interval – oil change, pressure screen cleaning, and oil sump suction screen check for all engines employing a pressure screen system.

3. 50-HOUR INSPECTION (ENGINE). In addition to the items listed for daily pre-flight inspection, the following maintenance checks must be made after every 50 hours of operation.

a. Ignition System.

(1) Whenever operational ground check indicate evidence of spark plug fouling, rotate the spark plugs by moving the bottom plugs to the upper position.

SPARK PLUG ROTATION
Interchange

#1 Top	with	#4 Bottom
#2 Top	with	#3 Bottom
#3 Top	with	#2 Bottom
#4 Top	with	#1 Bottom

(2) Remove the spark plug connector nuts and examine the spark plug cable leads and the ceramic insulation for corrosion and deposits. Corrosion and deposits are evidence of leaking spark plugs or of improper cleaning of the spark plugs walls or connector ends. Clean the cable ends, spark plug walls, and the ceramic insulation with a clean lint-free cloth moistened with methyl-ethyl-ketone (MEK), acetone, or wood alcohol. Dry all parts using compressed air.

(3) Check the ignition harness for security of mounting clamps and be sure the connections are tight at the spark plug and magneto terminals.

b. *Fuel and Induction System –* Remove and clean the fuel inlet strainers. Check the mixture control and throttle linkage for travel, freedom of movement, security of the clamps and lubricate if necessary. Check the air intake ducts for leaks, security, filter damage; evidence of dust or other solid material in the ducts is indicative of inadequate filter care or damaged filter. Check the vent lines for evidence of fuel or oil seepage; if present, the fuel pump may require replacement.

c. *Lubrication System.*

(1) Replace external full flow oil filter element. (Check used element for metal particles.) Drain and replenish the lubricating oil.

(2) *(Engines Not Equipped with External Filter.)* Remove oil pressure screen and clean thoroughly. Note carefully for presence of metal particles that are indicative of internal engine damage. Change oil every 25 hours.

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

d. *Exhaust System –* Visually inspect the exhaust flange to exhaust port connections for a powdery white to light brown or black residue indicating exhaust leakage. Follow the aircraft manufacturer's instructions to correct any leaks. Replace blown gaskets. Retorque loosened gasket flange assemblies. Examine the exhaust manifolds for general condition. Correct deficiencies in accordance with the aircraft or exhaust manufacturer's procedures.

e. *Cooling System –* Check cowling and baffle for damage and security. Any damaged or missing part of the cooling system must be repaired or replaced before the aircraft resumes operation.

f. *Cylinders –* Check rocker box cover for evidence of oil leaks. If found, replace gasket and tighten screws to specified torque (50 in.-lbs.).

Check cylinders for evidence of excessive heat which is indicated by burned paint on the cylinder. This condition is indicative of internal damage to the cylinder and, if found, its cause must be determined and corrected before the aircraft resumes operation.

Heavy discoloration and appearance of seepage at cylinder head and barrel attachment area is usually due to emission of thread lubricant used during assembly of the barrel at the factory, or by slight gas leakage which stops after the cylinder has been in service for awhile. This condition is neither harmful nor detrimental to engine performance and operation. If it can be proven that leakage exceeds these conditions, replace the cylinder.

4. 100-HOUR INSPECTION. In addition to the items listed for daily pre-flight and 50-hour inspection, the following maintenance checks must be made after every one hundred hours of operation.

a. *Electrical System.*

(1) Inspect all wiring connections to the engine and accessories for physical damage and security. Follow the aircraft manufacturer's instructions for replacement of any damaged cables or clamps. Inspect the terminals for security and cleanliness. Clean and tighten as necessary.

(2) Remove spark plugs; test, clean, regap, inspect and rotate. Replace if necessary.

SPARK PLUG ROTATION
Interchange

#1 Top	with	#4 Bottom
#2 Top	with	#3 Bottom
#3 Top	with	#2 Bottom
#4 Top	with	#1 Bottom

b. *Lubrication System* – Drain and replenish the lubricating oil.

c. *Ignition System* – Check the magneto to engine timing. The timing procedure is described in Section 5, 1, b of this manual. If your engine is equipped with an electronic ignition system, follow the manufacturer's recommended inspection procedures.

d. *Engine Accessories* – Engine mounted accessories such as pumps, temperature and pressure sensing units must be checked for secure mounting, tight connections.

e. *Cylinders* – Examine the cylinders for cracked or broken fins.

f. *Engine Mounts* – Check engine mounting bolts and bushings for security and excessive wear. Replace any bushings that are excessively worn.

g. *Fuel Injection Nozzles and Fuel Lines* – Check fuel injector nozzles for looseness, tighten to 60 in.-lbs. torque. Check fuel line for dye stains at connection indicating leakage and security of line. Repair or replacement must be accomplished before the aircraft resumes operation.

5. *400-HOUR INSPECTION.* In addition to the items listed for daily pre-flight, 50-hour and 100-hour inspection, the following maintenance check should be made after every 400 hours of operation.

Valve Inspection – Remove rocker box covers and check for freedom of valve rockers when valves are closed. Look for evidence of abnormal wear or broken parts in the area of the valve tips, valve keeper, springs and spring seats. If any indications are found, the cylinder and all of its components should be removed (including the piston and connecting rod assembly) and inspected for further damage. Replace any parts that do not conform with limits shown in the Table of Limits in Section 8.

SECTION 5
MAINTENANCE PROCEDURES

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SECTION 5

MAINTENANCE PROCEDURES

The procedures described in this section are provided to guide and instruct personnel in performing such maintenance operations that may be required in conjunction with the periodic inspections listed in the preceding section.

1. *IGNITION AND ELECTRICAL SYSTEM.*

a. *Ignition Harness and Wire Replacement* – In the event that an ignition harness or an individual lead is to be replaced, consult the wiring diagram to be sure harness is correctly installed. Mark location of clamps and clips to be certain the replacement is clamped at correct locations.

b. *Timing Magnetos to Engine.*

(1) Remove the bottom spark plug from No. 1 cylinder and place a thumb over the bottom spark plug hole. Rotate the crankshaft in direction of normal rotation until the compression stroke is reached, this is indicated by a positive pressure inside the cylinder tending to push the thumb off the bottom spark plug hole.

(2) Clamp the ignition timing pointer on the advance timing mark on the rear of the starter ring gear. Consult the engine data plate for the correct advance timing mark to use.

(3) Continue rotating the crankshaft until the timing pointer and the parting flange of the crankcase align.

NOTE

In the event that an ignition timing pointer is not available, use the following alternate method.

(a) Rotate the crankshaft in the normal direction of rotation until cylinder number 1 is on the compression stroke.

(b) Continue to rotate the crankshaft until the correct advance timing mark on the front of the starter ring gear is in exact alignment with the small drilled hole located at the two o’clock position on the front face of the starter housing.

(4) Keep the crankshaft in the position until the magnetos are installed.

(5) Install the magneto onto the engine.

CAUTION

DO NOT ROTATE THE MAGNETO OR PROPELLER WITH THE TIMING PIN INSERTED INTO THE DISTRIBUTOR BLOCK. ROTATION OF THE ROTOR SHAFT OF THE PROPELLER IN THIS SITUATION MAY DAMAGE THE INTERNAL COMPONENTS OF THE MAGNETO AND RENDER THE UNIT UN-AIRWORTHY.

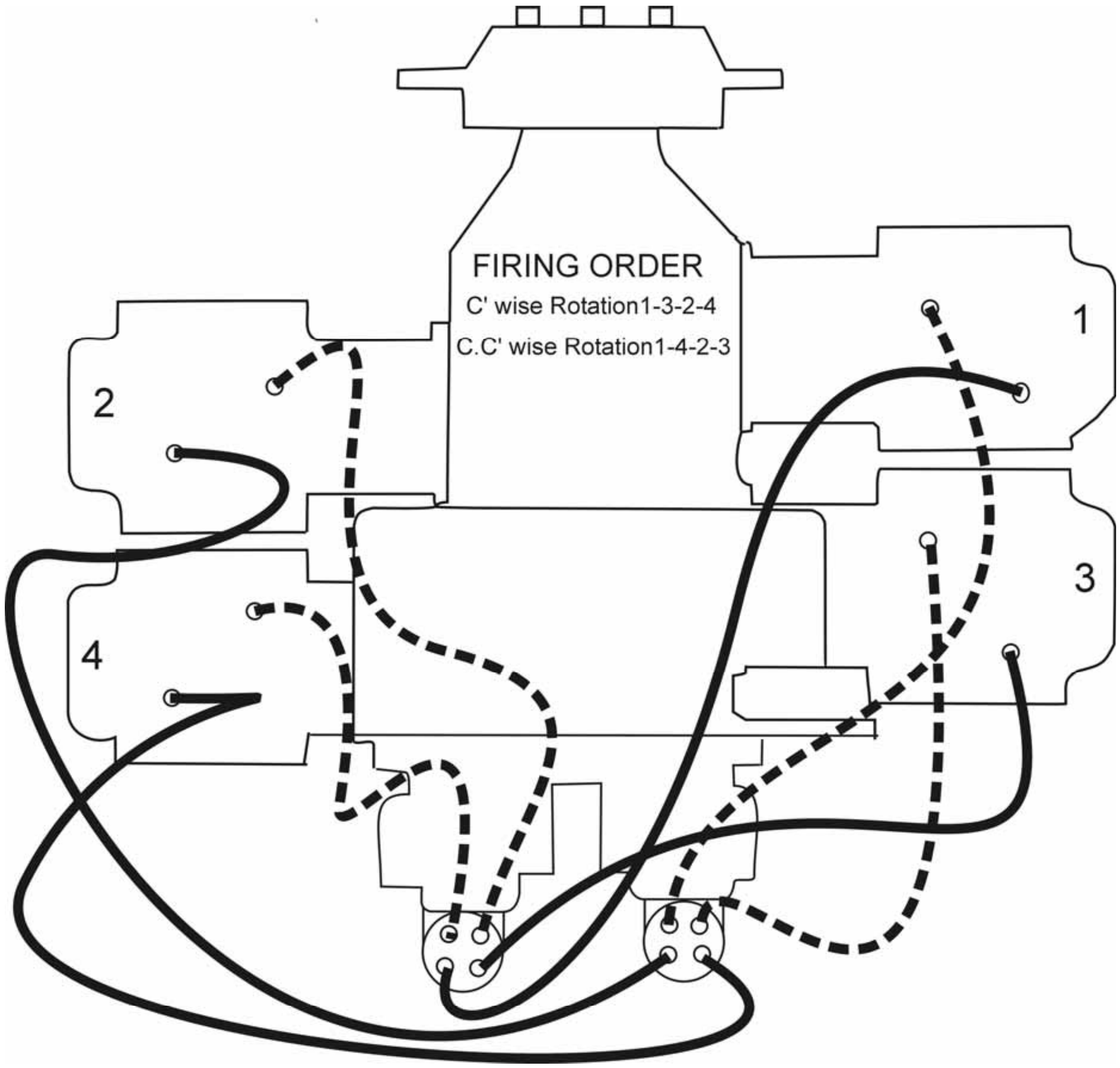

Figure 5-1. Ignition Wiring Diagram

(6) Secure the magneto using the mounting clamps and appropriate hardware. Tighten the hardware sufficiently to hold the magneto loosely in position.

(7) Remove the timing pin from the distributor block.

(8) Attach a timing light to the magneto condenser stud according to the timing light manufacturer's instructions.

(9) Rotate the magneto in the direction of normal rotation until the timing light indicates that the breaker points are open. Refer to the data plate to determine the normal rotation direction. Most timing lights indicate open points with a light or an audible signal.

(10) Slowly rotate the magneto in the direction opposite to that of normal rotation until the timing light goes out or the audible signal stops. Note that some timing lights may operate in the reverse manner as previously described. Refer to the timing light manufacturer's instructions.

(11) Tighten the magneto mounting clamps to secure the magneto to the engine.

(a) Inspect to be sure the correct gasket is being used. The gasket should be circular and no part of the gasket should extend beyond the flange of the magneto housing.

(b) If an attaching nut is removed, install a new internal tooth 5/16 lockwasher.

(c) Alternately tighten the magneto mounting clamp nuts to 8 ft.-lbs. of torque.

(d) Continue to alternately tighten both nuts, using several steps, to 17 ft.-lbs. of torque.

CAUTION

IN NO CASE SHOULD 17 FT.-LBS. BE EXCEEDED. IF THE MOUNTING NUTS ARE TORQUED IN EXCESS OF 17 FT.-LBS., DAMAGE TO THE MAGNETO MOUNTING FLANGE MAY RESULT, RENDERING THE UNIT UN-AIRWORTHY.

(12) Turn the engine 5° to 20° opposite direction of rotation, then back in direction of rotation until the light indicates the points are open. Verify timing marks are properly aligned.

(13) Remove the timing light from the magneto condenser stud.

c. *Alternator Output* – The alternator should be checked to determine that the specified voltage and current are being obtained as specified by the airframe manufacturer.

2. *FUEL SYSTEM.*

a. *Repair of Fuel Leaks* – In the event a line or fitting in the fuel system is replaced, only a fuel soluble lubricant such as clean engine oil or Loctite Hydraulic Sealant may be used on tapered threads. Do not use Teflon tape or any other form of thread compound.

b. *Fuel Injector Fuel Inlet Screen Assembly* – Remove the assembly and check the screen for distortion or openings in the strainer. Replace for either of these conditions. Clean screen assembly in solvent and dry with compressed air and reinstall. The fuel inlet screen assembly is tightened to 65-70 in.-lbs. on fuel injector servos.

c. *Fuel Grade and Limitations* – The recommended aviation grade fuel for the subject engines is listed in Section 3, Item 8.

In the event that the specified fuel is not available at some locations, it is permissible to use higher octane fuel. Fuel of a lower octane than specified is not to be used. Under no circumstances should automotive fuel be used (regardless of octane rating).

d. *Air Intake Ducts and Filter* – Check all air intake ducts for dirt or restrictions. Inspect and service air filters as instructed in the airframe manufacturer's handbook.

e. *Idle Speed and Mixture Adjustment.*

(1) Start the engine and warm up in the usual manner until oil and cylinder head temperatures are normal.

(2) Check magnetos. If the "mag-drop" is normal, proceed with idle adjustment.

(3) Set throttle stop screw so that the engine idles at the airframe manufacturer's recommended idling RPM. If the RPM changes appreciably after making idle mixture adjustment during the succeeding steps, readjust the idle speed to the desired RPM.

(4) When the idling speed has been stabilized, move the cockpit mixture control lever with a slow, steady pull toward the "Idle Cut-Off" position and observe the tachometer for any change during the leaning process. Caution must be exercised to return the mixture control to the "Full Rich" position before the RPM can drop to a point where the engine cuts out. An increase of more than 50 RPM while "leaning out" indicates an excessively rich idle mixture. An immediate decrease in RPM (if not preceded by a momentary increase) indicates the idle mixture is too lean.

If step (4) indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjustment in direction required for correction, and check this new position by repeating the above procedure. Make additional adjustments as necessary until a check results in a momentary pick-up of approximately 50 RPM. Each time the adjustment is changed, the engine should be run up to 2000 RPM to clean the engine before proceeding with the RPM check. Make final adjustment of the idle speed adjustment to obtain the desired idling RPM with closed throttle. The above method aims at a setting that will obtain maximum RPM with minimum manifold pressure. In case the setting does not remain stable, check the idle and throttle linkage; any looseness in this linkage would cause erratic idling. In all cases, allowance should be made for the effect of weather conditions and field density altitude upon idling adjustment.

3. *LUBRICATION SYSTEM.*

a. *Oil Grades and Limitations* – Service the engine in accordance with the recommended grade oil as specified in Section 3, Item 8.

b. *Oil Suction and Oil Pressure Screens* –

(1) At 25 hours after the first replacement/screen cleaning – oil change, filter replacement or pressure screen cleaning and oil sump suction screen check for new, rebuilt or newly overhauled engines and for engines with any newly installed cylinder.

(2) 25-Hour interval – oil change, pressure screen cleaning, and oil sump suction screen check for all engines employing a pressure screen system.

(3) 50-Hour interval – oil change and oil filter replacement and suction screen check for all engines using full-flow filtration system.

(4) A total of four (4) months maximum between changes for systems listed under (1), (2) and (3).

c. Oil Pressure Relief Valve –

(1) *Oil Pressure Relief Valve (Adjustable) –* The adjustable oil relief valve enables the operator to maintain engine oil pressure within the specified limits. If pressure under normal operating conditions should consistently exceed the maximum or minimum specified limits, adjust the valve as follows:

With the engine warmed up and running at approximately 2000 RPM, observe the reading on the oil pressure gage. If the pressure is above maximum or below minimum specified limits, stop engine and screw the adjusting screw outward to decrease pressure or inward to increase pressure. The adjusting screw has a screw driver slot plus a pinned .375-24 castellated nut and may be turned with either a screw driver or a box wrench.

4. CYLINDERS. It is recommended that as a field operation, cylinder maintenance be confined to replacement of the entire assembly. For valve replacement, consult the proper overhaul manual.

a. Removal of Cylinder Assembly.

(1) Remove exhaust manifold.

(2) Remove rocker box drain tube, intake pipe, baffle and any clips that might interfere with the removal of the cylinder.

(3) Disconnect ignition cables and remove the bottom spark plug.

(4) Remove rocker box cover and rotate crankshaft until piston is approximately at top center of the compression stroke. This is indicated by a positive pressure inside of cylinder tending to push thumb off of bottom spark plug hole.

NOTE

The hydraulic tappets, push rods, rocker arms and valves must be assembled in the same location from which they were removed.

(5) Slide valve rocker shafts from cylinder head and remove the valve rockers. Valve rocker shafts can be removed when the cylinder is removed from the engine. Remove rotator cap from exhaust valve stem.

(6) Remove push rods by grasping ball end and pulling rod out of shroud tube. Rotate the shroud tube springs to unlock the shroud tubes. Remove the shroud tubes and shroud tube springs.

(7) Remove cylinder base nuts and hold down plates (where employed) then remove cylinder by pulling directly away from crankcase. Be careful not to allow the piston to drop against the crankcase, as the piston leaves the cylinder.

b. *Removal of Piston from Connecting Rod* – Remove the piston pin plugs. Insert piston pin puller through piston pin, assemble puller nut; then proceed to remove piston pin. Do not allow connecting rod to rest on the cylinder bore of the crankcase. Support the connecting rod with heavy rubber band, discarded cylinder base oil ring seal, or any other non-marring method.

c. *Removal of Hydraulic Tappet Sockets and Plunger Assemblies* – It will be necessary to remove and bleed the hydraulic tappet plunger assembly so that dry tappet clearance can be checked when the cylinder assembly is reinstalled. This is accomplished in the following manner:

CAUTION

NEVER USE A MAGNET TO REMOVE HYDRAULIC PLUNGER ASSEMBLIES FROM THE CRANKCASE. THIS CAN CAUSE THE CHECK BALL TO REMAIN OFF ITS SEAT, RENDERING THE UNIT INOPERATIVE.

(1) Remove the hydraulic tappet push rod socket by inserting the forefinger into the concave end of the socket and withdrawing. If the socket cannot be removed in this manner, it may be removed by grasping the edge of the socket with a pair of needle nose pliers. However, care must be exercised to avoid scratching the socket.

(2) To remove the hydraulic tappet plunger assembly, use the special Lycoming service tool. In the event the tool is not available, the hydraulic tappet plunger assembly may be removed by a hook in the end of a short piece of lockwire, inserting the wire so that the hook engages the spring of the plunger assembly. Draw the plunger assembly out of the tappet body by gently pulling the wire.

(3) Be sure there is no oil inside the tappet bodies and that the tappet plunger and cylinder assemblies are thoroughly clean and dry. Wash any lubricating or preservative oil (Varsol, Stoddard oil, or equivalent) from these parts, since tappet assemblies must be absolutely dry to check tappet clearance.

d. *Assembly of Hydraulic Tappet Plunger Assemblies* – To assemble the unit, unseat the ball by inserting a thin clean wire through the oil inlet hole. With the ball off its seat, insert the plunger and twist clockwise so that the spring catches. All oil must be removed before the plunger is inserted.

e. *Assembly of Cylinder and Related Parts* – Rotate the crankshaft so that the connecting rod of the cylinder being assembled is at the top center of compression stroke. This can be checked by placing two fingers on the intake and exhaust tappet bodies. Rock crankshaft back and forth over top center. If the tappet bodies do not move the crankshaft is on the compression stroke.

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

(2) Assemble piston with rings so that the number stamped on the piston pin boss is toward the front of the engine. If installing a new piston, stamp the position number as required. The piston pin should be a handpush 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 hole and on the piston pin.

(3) 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.

(4) Using a piston ring compressor, assemble the cylinder over the piston assuring proper orientation of the cylinder. Push the cylinder all the way on, catching the ring compressor as it is pushed off.

NOTE

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

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

NOTE

At any time a cylinder is replaced, it is necessary to retorque the thru-studs on the cylinder on the opposite side of the engine.

(5) Tighten the ½ inch hold-down nuts to 300 in.-lbs. (25 ft.-lbs.) torque, using the sequence show in Figure 5-2.

(6) Using the same sequence, tighten the ½ inch hold-down nuts to 600 in.-lbs. (50 ft.-lbs.) torque.

(7) Tighten the ⅜ inch hold-down nuts to 300 in.-lbs. (25 ft.-lbs.) torque. Sequence of tightening is optional.

(8) As a final check, hold the torque wrench on each nut for about five seconds. If the nut does not turn, it may be presumed to be tightened to correct torque.

CAUTION

AFTER ALL CYLINDER BASE NUTS HAVE BEEN TIGHTENED, REMOVE ANY NICKS IN THE CYLINDER FINS BY FILING OR BURRING.

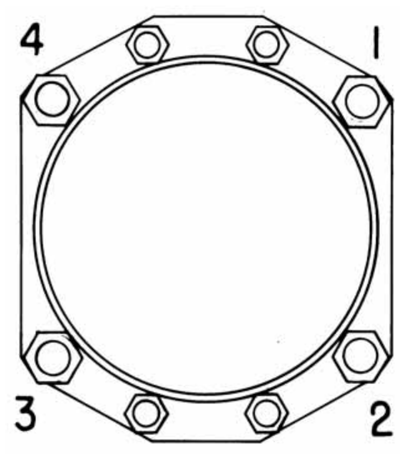

Figure 5-2. Representative Sequence of Tightening Cylinder Base Hold-Down Nuts

(9) Install new shroud tube oil seals on both ends of shroud tube. Install shroud tube and lock in place as required for type of cylinder.

(10) 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 shaft in place to retain rocker. Before installing exhaust valve rocker, place rotator cap over end of valve stems.

(11) Be sure that the piston is at top center of 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, the valve clearance should be between .028 and .080 inch. If clearance does not come within these limits, remove the push rod and insert a longer or shorter push rod, as required, to correct clearance.

NOTE

Inserting a longer push rod will decrease the valve clearance.

(12) Install intercylinder baffles, rocker box covers, intake pipes, rocker box drain tubes and exhaust manifold.

5. ALTERNATOR DRIVE BELT TENSION.

Check the tension of a new belt 25 hours after installation.

There are three methods of checking belt tension:

Torque Method: This method of checking belt tension consists of measuring the torque required to slip the belt at the small pulley and is accomplished as follows:

a. Secure the propeller to prevent rotation of the engine.

b. Apply a torque indicating wrench to the nut that attaches the pulley to the generator or alternator and turn it in a clockwise direction. Observe the torque shown on the wrench at the instant the pulley slips.

c. Check torque indicated in step a. with torque specified in the following chart. Adjust belt tension accordingly.

With of Belt	Condition	Torque Indicated at Generator or Alternator Pulley
3/8 inch	New	11 to 13 ft. lbs.
3/8 inch	Used	7 to 9 ft. lbs.
1/2 inch	New	13 to 15 ft. lbs.
1/2 inch	Used	9 to 11 ft. lbs.
11mm	New	22 to 24 ft. lbs.
11mm	Used	15 to 17 ft. lbs.

NOTE

The higher tension specified for a new belt is to compensate for the initial stretch that takes placed as soon as it is operated. These higher tension values should not be applied to belts which have been used previously.

2. Deflection Method: Belt tension may be checked by measuring the amount of deflection caused by a predetermined amount of tension; this is accomplished in the following manner:

   a. Attach the hook of a small spring-scale to the belt at the approximate mid-point between the ring gear support and the alternator or generator.

   b. Pull on the scale until a reading of 14 pounds is obtained. (10 pounds for used belts.)

   c. Measure the distance the belt has moved with the 10 or 14 pound load applied. The distance (deflectio0n) should be 5/16 inch. If less than 5/16 inch, belt is too tight.

3. Belt Tension Gage: A belt tension gage that measures belt tension by indicating the amount of deflection of the belt under a preset spring load is available as Lycoming tool number ST-131. This tool and its method of use is described below:

   a. Extend the hook to its extreme position by depressing the handle.

   b. Place the hook over the belt. Be sure the nose piece is centered with the belt.

   c. Quickly release the handle and read the indicated tension on the dial. If the handle is released slowly, internal friction will cause an inaccurate indicated on the dial.

   d. Repeat a., b., c. several times to eliminate possibility of an inaccurate reading. Slight variations in readings taken at different locations on the belt are normal.

   e. If a new belt is installed, set the tension about 25% above the operating range to allow for stretch that will occur as soon as the belt has been in operation.

SECTION 6
TROUBLE-SHOOTING – ENGINE

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SECTION 6

TROUBLE-SHOOTING

Experience has proven that the best method of trouble-shooting is to decide on the various causes of a given trouble and then to eliminate causes one by one, beginning with the most probable. The following charts list some of the more common troubles, which may be encountered in maintaining engines; their probable causes and remedies. Consult the airframe manufacturer's manual for additional trouble-shooting causes and corrections.

1. TROUBLE-SHOOTING – ENGINE

TROUBLE	PROBABLE CAUSE	REMEDY
Failure of Engine to Start	Lack of fuel.	Check fuel system for leaks. Fill fuel tank. Clean dirty lines, strainers, or fuel valves.
	Flooded engine (overpriming).	Turn ignition switch "on" and place the mixture control in "Idle Cut-Off". Fully open throttle and crank the engine to start. If the engine does not start in five seconds, discontinue cranking, and do not attempt to start until the starter cools down. When the engine starts, retard the throttle and advance the mixture slowly to "Full Rich".
	Defective spark plugs.	Clean, check gap and test, or replace spark plugs.
	Defective ignition wire.	Check with electric tester, and replace any defective wires.
	Defective battery.	Replace with charged battery.
	Improper operation of magneto breaker.	Clean points. Check internal timing of magnetos in accordance with manufacturer's instructions.
	Lack of sufficient fuel flow.	Disconnect fuel line and check fuel flow.
	Water in fuel injector.	Drain fuel injector and fuel lines. Consult the airframe manufacturer's manual for further instructions on purging water from the fuel system.

TROUBLE	PROBABLE CAUSE	REMEDY
Failure of Engine to Start (Cont.)	Internal failure.	Check oil screens for metal particles. If found, complete overhaul of the engine may be indicated.
Failure of Engine to Idle Properly	Incorrect idle mixture.	Adjust idle mixture.
	Leak in the induction system.	Inspect all connections in the induction system and tighten as necessary to the recommended torque value. Replace any parts that are defective.
	Incorrect idle speed.	Adjust throttle stop to obtain correct idle.
	Uneven cylinder compression.	Check condition of piston rings and valve seats.
	Faulty ignition system.	Check entire ignition system.
	Insufficient fuel servo inlet pressure.	Inspect fuel lines between pump and servo for obstructions. If the fuel pump is of the diaphragm type, replace. If the fuel pump is of the AN type, adjust as required, replace if necessary.
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 nozzles for obstructions. Readjustment of fuel injector by authorized personnel is indicated.
	Mixture too lean indicated by overheating or backfiring.	Check fuel lines for air, dirt or other restrictions. Readjustment of fuel injector by authorized personnel is indicated.
	Leaks in induction system.	Inspect all connections and tighten as necessary to the recommended torque value. Replace defective parts.
	Defective spark plugs.	Clean, check gap and test, or replace spark plugs.

TROUBLE	PROBABLE CAUSE	REMEDY
Low Power and Uneven Running (Cont.)	Improper fuel.	Fill tank with fuel of recommended grade.
	Magneto breaker points not working properly.	Clean points. Check internal timing of magneto in accordance with manufacturer’s instructions.
	Defective ignition wire.	Check wire with electric tester. Replace defective wire.
	Defective spark plug terminal connectors.	Replace defective connectors on spark plug wire.
Failure of Engine to Develop Full Power	Leak in the induction system.	Inspect and tighten as necessary all connections to the recommended torque value, and replace defective parts.
	Throttle level out of adjustment.	Inspect and adjust throttle lever per the airframe manufacturer’s instructions.
	Improper fuel flow.	Check fuel servo strainer, gauge and flow at the fuel inlet.
	Restriction in air scoop.	Examine air scoop and remove restrictions.
	Improper fuel.	Drain and refill tank with recommended grade of fuel. Consult the airframe manufacturer’s manual for further instructions on purging the fuel system.
	Faulty ignition.	Tighten all connections. Check system with tester. Check ignition timing.
Rough Engine	Cracked engine mount.	Replace or repair mount.
	Defective mounting bushings.	Install new mounting bushings.
	Uneven compression.	Check compression.
Low Oil Pressure	Insufficient oil.	Fill to proper level with recommended oil.
	Dirt or contamination in relief valve.	Remove and clean oil pressure relief valve.

TROUBLE	PROBABLE CAUSE	REMEDY
Low Oil Pressure (Cont.)	Leak in suction line or pressure line.	Check gasket between accessory housing and crankcase.
	High oil temperature.	See “High Oil Temperature” in “Trouble” column.
	Defective pressure gauge.	Replace.
	Stoppage in oil pump intake passage.	Clean suction screen.
High Oil Temperature	Insufficient air cooling.	Check the oil cooler, engine cooling baffles and any other duct work for deformation or obstruction in accordance with the airframe manufacturer’s instructions.
	Insufficient oil supply.	Fill to proper level with specified oil.
	Low grade of oil.	Replace with oil conforming to specifications.
	Clogged oil lines or strainers.	Remove and clean oil strainers.
	Excessive blow-by.	Perform a differential compression check.
	Defective temperature gauge.	Replace gauge.
Excessive Oil Consumption	Low grade of oil.	Fill tank with oil conforming to specifications.
	Failing or failed bearings.	Check the oil filter, pressure screen housing and the oil sump for metal particles.
	Worn piston rings.	Remove cylinders and replace piston rings with new ones and deglaze cylinder barrels.
	Incorrect installation of piston rings.	Remove cylinders and replace piston rings with new ones and deglaze cylinder barrels.
	Failure of rings to seat (new nitrided cylinders).	Use mineral base oil Climb to cruise altitude at full power and operate at 75% cruise power setting until oil consumption stabilizes.

SECTION 7
INSTALLATION AND STORAGE

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SECTION 7

INSTALLATION AND STORAGE

PREPARATION OF ENGINE FOR INSTALLATION. Before installing an engine that has been prepared for storage, remove all dehydrator plugs, bags of desiccant and preservative oil from the engine.

CAUTION

DO NOT ROTATE THE CRANKSHAFT OF AN ENGINE CONTAINING PRESERVATIVE OIL BEFORE REMOVING THE SPARK PLUGS. IF THE CYLINDERS CONTAIN ANY APPRECIABLE AMOUNT OF THE MIXTURE, THE RESULTING ACTION, KNOWN AS HYDRAULICING, WILL CAUSE DAMAGE TO THE ENGINE. AVOID CONTACT OF THE PRESERVATIVE OIL WITH PAINTED SURFACES. IF PRESERVATION OIL DOES CONTACT A PAINTED SURFACE, CLEAN IT OFF WITH A SOLVENT AS SOON AS POSSIBLE.

NOTE

Move engines that have been stored in a cold area to an environment of at least 70°F (21°C) for a period of 24 hours before preservative oil is drained from the cylinders. If this is not possible, heat the cylinders with heat lamps before attempting to drain the engine.

1. Remove all bottom spark plugs.
2. Turn the crankshaft three or four revolutions by hand.
3. Tilt the engine to one side until the spark plug holes on that side are oriented vertically.
4. Rotate the crankshaft at least two revolutions and allow the oil to drain out through the spark plug holes.
5. Repeat steps 3 and 4 for the opposite side of the engine.
6. Inspect the spark plugs before reinstalling them. Clean them in accordance with the manufacturer's recommendations.
7. Remove the oil sump plug and allow any preservative oil that has accumulated in the sump to drain.
8. Remove the oil screen and clean it with a hydrocarbon-based solvent such as Varsol or equivalent.
9. Reinstall the oil screen.
10. If a constant speed propeller is to be used, the expansion plug must be removed from the crankshaft. Pierce a 1/8 inch to 3/16 inch hole in the center of the plug to remove it.
11. Replace the oil sump plug and install a safety wire.
12. Fill the sump or external tank with lubricating oil.

NOTE

If a small amount of preservative oil remains in the engine, it will not be harmful. After twenty-five hours of operation, drain the lubricating oil while the engine is hot. This will remove any residual preservative oil that may have been present.

CAUTION

DISPOSE OF USED ENGINE PRESERVATIVE AND SOLVENTS IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

General – 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 disassembled and thoroughly cleaned before using the engine. The particles will not dissolve and may lodge in an oil passage hole or other similar passage. The oil screens must be removed and cleaned in gasoline or other equivalent hydrocarbon solvent. Remove the fuel drain screen located in the fuel inlet of the fuel injector and clean in a hydrocarbon solvent.

Inspection of Engine Mounting – If the aircraft is one from which an engine has previously been removed, inspect the engine mounts to ensure they are not bent, misaligned, distorted, damaged, corroded or cracked. Distorted, misaligned, bent, damaged, corroded or cracked engine mounts may cause engine or airframe damage, or engine failure.

Attaching Engine to Mounts – See airframe manufacturer's recommendations for method of mounting the engine.

Oil and Fuel Line Connections – Representative oil and fuel line connections to the engine are called out on the accompanying installation drawing.

Propeller Installation – Consult the airframe manufacturer for information relative to propeller installation.

1. PREPARATION OF FUEL INJECTORS FOR INSTALLATION.

Fuel injector servos that have been prepared for storage should undergo the following procedures before being placed in service.

Fuel Injector Servo – Remove and clean the fuel inlet strainer assembly and reinstall. Inject clean fuel into the fuel inlet connection with the fuel outlets uncapped until clean fuel flow from the outlets. Do not exceed 15 psi inlet pressure.

2. CORROSION PREVENTION IN ENGINES INSTALLED IN INACTIVE AIRCRAFT

Corrosion may occur, especially in new or refurbished engines, on cylinder walls of engines that will be inoperative for periods as brief as two days. Therefore, the following preservation procedure is recommended for inactive engines and will be effective in minimizing the corrosion condition for a period up to thirty days.

NOTE

Ground running the engine for brief periods of time is not a substitute for the following procedure; in fact, the practice of ground running will tend to aggravate rather than minimize this corrosion condition

a. Remove both spark plugs from each cylinder.

b. Spray the interior of each cylinder with approximately two (2) ounces of corrosion preventive oil while cranking the engine about five (5) revolutions with the starter. The spray gun nozzle may be placed in either of the spark plug holes.

NOTE

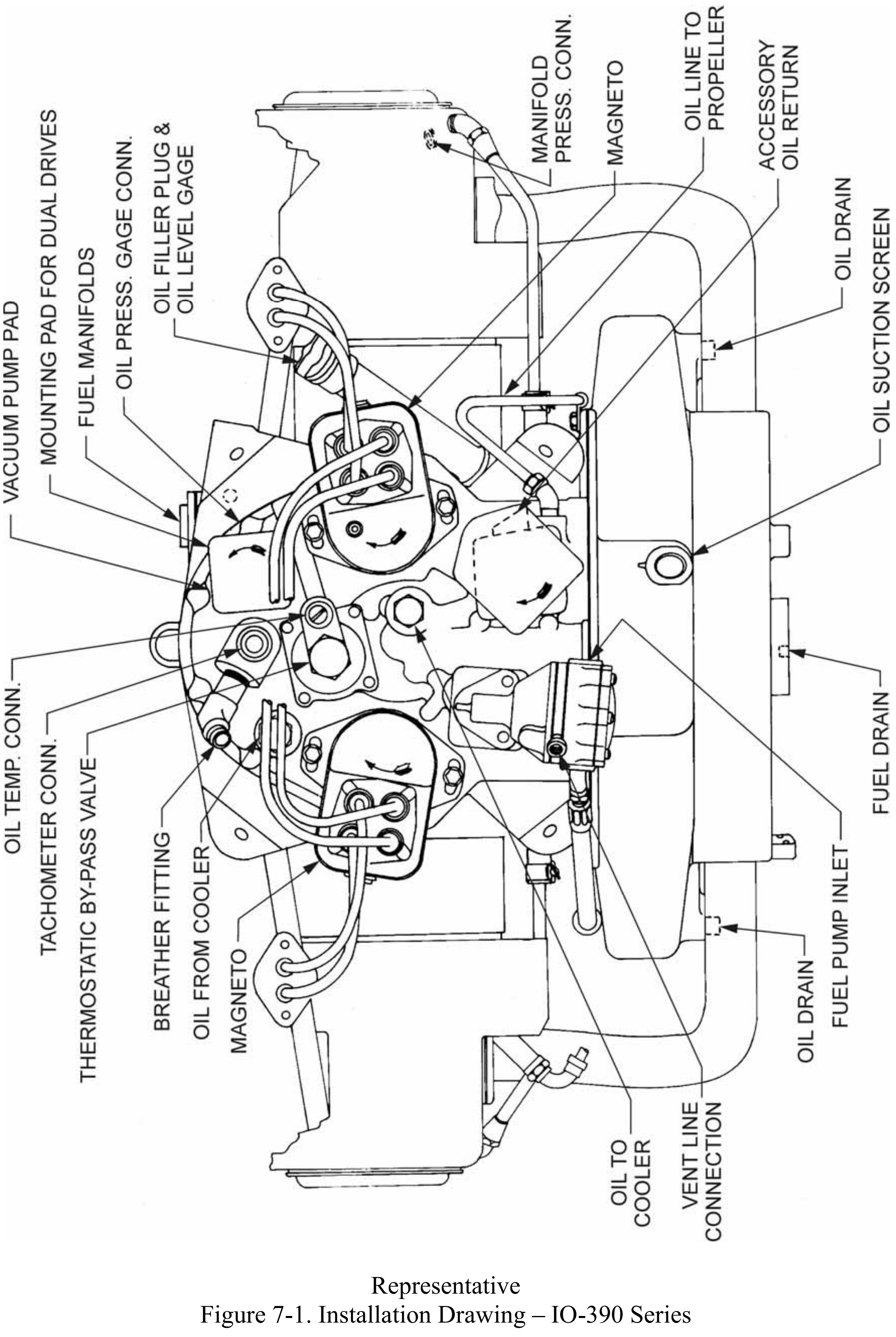
Spraying should be accomplished using an airless spray gun (Spraying Systems Co., "Gunjet" Model 24A-8395 or equivalent). In the event an airless spray gun is not available, personnel should install a moisture trap in the air line of a conventional spray gun and be certain oil is hot at the nozzle before spraying cylinders.

d. With the crankshaft stationary, again spray each cylinder through the spark plug holes with approximately two (2) ounces of corrosion preventive oil. Assemble spark plugs and do not turn crankshaft after cylinders have been sprayed.

The corrosion preventive oil to be used in the foregoing procedure should conform to specification MIL-L-6529, Type 1, heated to 200°F/220°F (93°C/104°C) spray nozzle temperature. It is not necessary to flush preservative oil from the cylinder prior to flying the aircraft. The small quantity of oil coating the cylinders will be expelled from the engine during the first few minutes of operation.

NOTE

Oils of the type mentioned are to be used in Lycoming aircraft engines for corrosion prevention only, and not for lubrication.



Representative
Figure 7-1. Installation Drawing – IO-390 Series

SECTION 8
TABLES

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SECTION 8

TABLES

TABLE OF LIMITS

INTRODUCTION

This Table of Limits is provided as a guide to all service and maintenance personnel engaged in the repair and refurbishment of Lycoming Aircraft Engines. Most of the material contained herein is subject to revision; therefore, any question regarding a specific limit or the incorporation of limits shown should be addressed to the Lycoming factory for clarification.

DEFINITIONS

Ref. (1st column)	The numbers in the first column headed "Ref." are shown as reference numbers to locate the area described in the "Nomenclature" column. This number will be found in a diagram at the end of each section, indicating a typical section where the limit is applicable.
Nomenclature (2nd column)	This is a brief description of the parts or fits specified in the adjacent columns and indicated in the diagram at the end of each section.
Dimensions (3rd and 4th columns)	The dimensions shown in column 3 are the minimum and maximum dimensions for the part as manufactured. The dimensions shown in column 4 indicate the limit that must not be exceeded. Unless it can be restored to serviceable size, any part that exceeds this dimension must not be reinstalled into an engine.
Clearance (5th and 6th columns)	Like the dimensions shown in columns 3 and 4, the clearance represents the fit between two mating surfaces as controlled during manufacture and as a limit for permissible wear. Clearances may sometimes be found to disagree with limits for mating parts; for example, the maximum diameter of a cylinder minus the minimum diameter of a piston exceeds the limit for piston and barrel clearance. In such instances, the specified maximum clearance must not be exceeded.

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

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

(A) These fits are either shrink fits controlled by machining, fits that may readily be adjusted, or fits where wear does not normally occur. In each case, the fit must be held to manufacturing tolerance.

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

(E) Permissible wear of the crankshaft (rod and main bearing journals) to be minus 0.0015 on the diameter.

(L) Loose Fit; wherein a definite clearance is mentioned between the surfaces.

(T) Tight Fit; shrink or interference fit.

Section 1 – Crankcase, Crankshaft, and Camshaft

Ref.	Nomenclature	Dimensions (in.)		Clearance (in.)	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
500	Main Bearings and Crankshaft			0.0015L 0.0045L	0.0060L
	Diameter of Main Bearing Journal on Crankshaft (2-5/8 in. Main)	2.6245 2.6260	(E)		
	Diameter of Main Bearing Journal on Crankshaft (2-3/8 in. Main)	2.3745 2.376	(E)		
	Diameter of Front Main Bearing Journal on Crankshaft (2-5/8 in. Main)	2.6245 2.6255	(E)		
	Diameter of Front Main Bearing Journal on Crankshaft (2-3/8 in. Main)	2.3750 2.3760	(E)		

Ref.	Nomenclature	Dimensions (in.)		Clearance (in.)	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
500	Crankcase Bearing Bore Diameter	2.816 2.817	2.8185		
	Crankcase Bearing Bore Diameter	2.566 2.567	2.5685		
501	Connecting Road Bearing and Crankshaft			0.0008L 0.0038L	0.0050L
	Diameter of Connecting Rod Journal on Crankshaft (2-1/8 in.)	2.1235 2.125	(E)		
	Connecting Rod Bearing Bore Diameter (2-1/8 in.) (Measured at Axis 30° on Each Side)	2.2870 2.2875			
502	Connecting Rod – Side Clearance			0.004L 0.010L	0.016L
503	Connecting Rod – Alignment			0.010 in 10 in.	
504	Connecting Rod – Twist			0.012 in 10 in.	
505	Mounted on No. 1 and 4 Journals Max. Run-Out No. 2 Journal			0.002	0.002
	Mounted on No. 1 and 4 Journals			0.005	0.0075
	Mounted on No. 2 and 4 Journals Max. Run-Out No. 3 Journal			0.003	0.0045
506	Crankshaft and Crankcase Front End Clearance			0.009L 0.018L	0.026L
507	Clearance – Front Face of Crankshaft Oil Slinger to Front Face of Recess in Crankcase (Crankshaft against Thrust Face)			0.002 0.007L	(A)
508	Crankshaft Prop. Flange Run-Out			0.002	0.005
509	Starter Ring Gear and Support			0.014T 0.022T	(A)
511	Tappet Body and Crankcase			0.0010L 0.0033L	0.004L
	OD of Tappet	0.7169 0.7177	0.7166		
511	ID Tappet Bore in Crankcase	0.7187 0.7200	0.7203		

Ref.	Nomenclature	Dimensions (in.)		Clearance (in.)	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
512	Tappet Plunger Assembly and Body			0.0010L 0.0047L	0.0067L
513	Tappet Socket and Body			0.002L 0.005L	0.007L
514	Camshaft and Crankcase			0.002L 0.004L	0.006L
515	Camshaft – End Clearance			0.002L 0.009L	0.015L
516	Camshaft Run-Out at Center Bearing Journal			0.000 0.001	0.006
517	Counterweight Bushing and Crankshaft			0.0013T 0.0026T	(A)
518	Counterweight Roller – End Clearance			0.007L 0.025L	0.038L
519	Counterweight and Crankshaft – Side Clearance			0.003L 0.013L	0.017L
520	Counterweight Bore and Washer OD			0.0002L 0.0030L	(A)
521	ID of Counterweight Bushing	0.7485 0.7505	0.7512		
522	OD of Counterweight Roller – 5.1 Order	0.6572 0.6567			
	OD of Counterweight Roller – 6th Order	0.6895 0.6890			
	OD of Counterweight Roller – 6.3 Order	0.6915 0.6910			
	OD of Counterweight Roller – 8th Order	0.7166 0.7161			

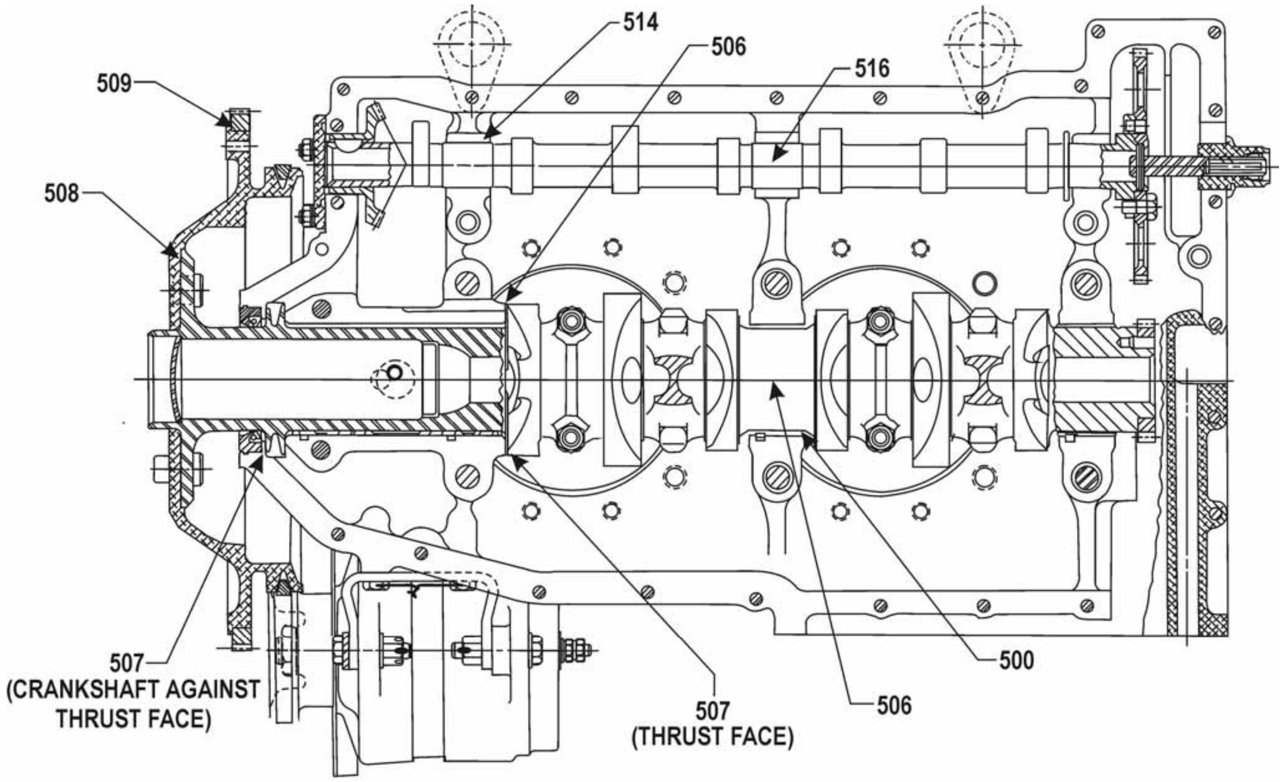


Figure 1

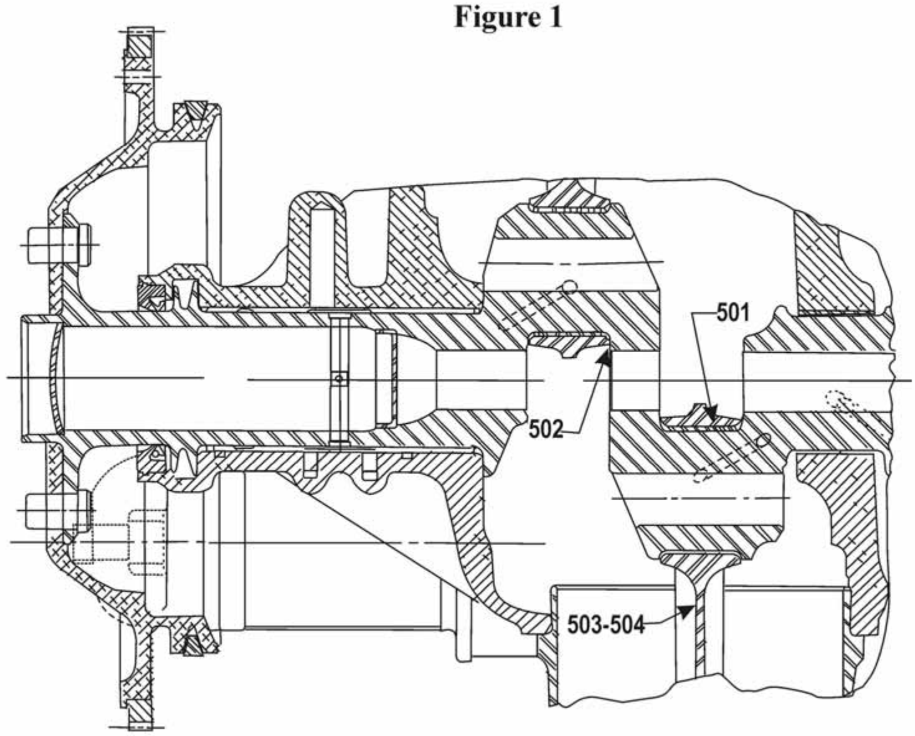


Figure 2

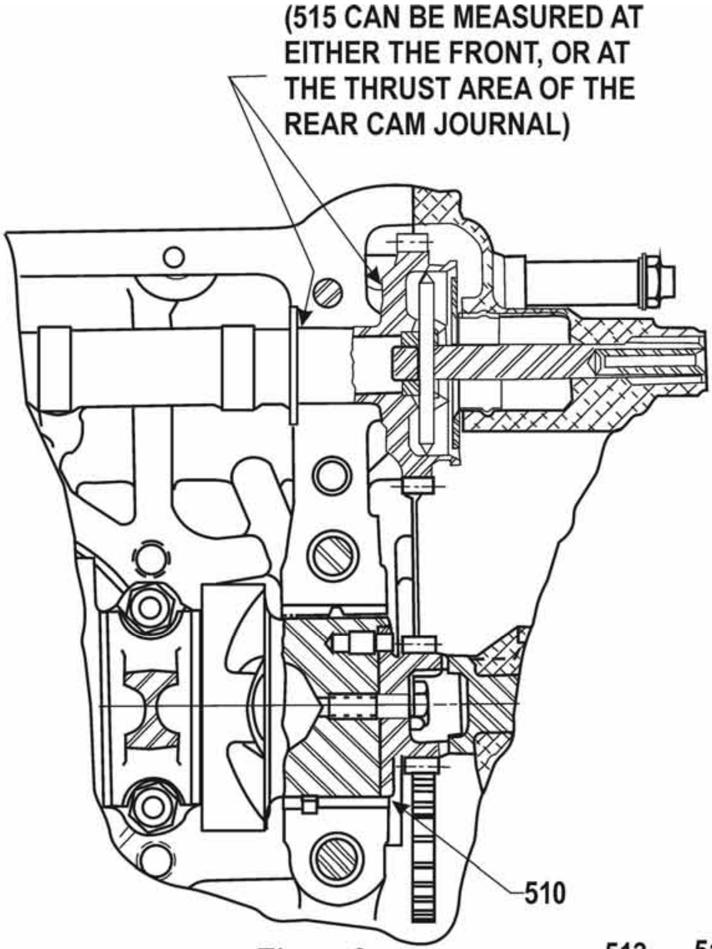


Figure 3

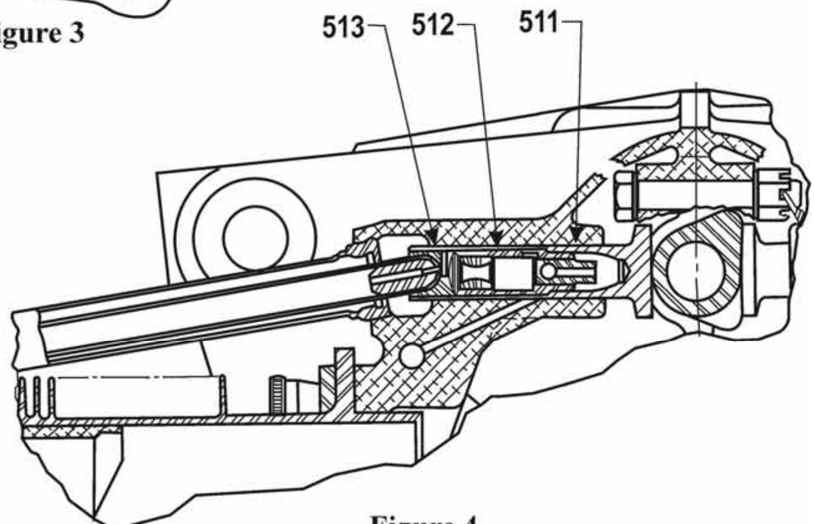


Figure 4

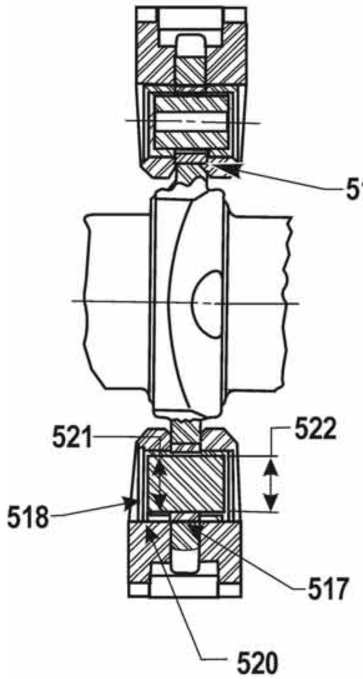


Figure 5

Section 2 – Cylinders

Ref.	Nomenclature	Dimensions: Mfr. Min. & Max.	Dimensions: Service Max	Clearance: Mfr. Min. & Max.	Clearance: Service Max
600	Connecting Rod and Connecting Rod Bushing	Bushing to Be Burnished in Place.			
	Finished ID of Connecting Rod Bushing	1.1254 / 1.1262			
601	Length between Connecting Rod Bearing Centers	6.7485 / 6.7515			
602	Connecting Rod Bushing and Piston Pin			0.0008L / 0.0021L	0.0025L
603	Piston Pin and Piston			0.0003L / 0.0014L	0.0018L
	Diameter of Piston Pin Hole in Piston	1.1249 / 1.1254			
	Diameter of Piston Pin	1.1241 / 1.1246			
604	Piston Pin and Piston Pin Plug			0.0002L / 0.0010L	0.002L
	Diameter of Piston Pin Plug	1.1242 / 1.1247			
606	Piston Ring and Piston – Side Clearance (Top Ring Comp.) Half Wedge			0.0025L / 0.0055L	0.008L(B)
	Piston Ring and Piston – Side Clearance (2nd Ring Comp.) Full or Half Wedge			0.000 / 0.004L	0.006L(B)
	Piston Ring and Piston – Side Clearance (Oil Regulating)			0.002L / 0.004L	0.006L(B)
607	Piston Ring Gap (Compression) Nitrided			0.045 / 0.055	0.067
	Piston Ring Gap (Oil Regulating)			0.020 / 0.035	0.047
The Ring gap is measured within 4 in. from the bottom. Ring gap at top of travel must not be less than 0.0075 in.					

Ref.	Nomenclature	Dimensions		Clearance	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max

Ref.	Piston Number	Minimum Piston Diameter: Top	Minimum Piston Diameter: Bottom	Type of Piston	Cyl. Barrel: Type of Surface	Cyl. Barrel: Max. Diameter	Maximum Clearance Piston Skirt & Cylinder
608	14E22396	5.2756	5.3095	Forged-Cam	N	5.3215	0.018L
609							
610							

Notes for Section 2 — Cylinders

To find the average diameter of a cylinder in an area 4 in. above the bottom of the barrel:

1. Measure diameter at right angles from plane in which valves are located.
2. Measure diameter through the plane in which valves are located.
3. Add both diameters.
4. Divide this sum by 2 to get the average diameter of the cylinder.

To find the average out-of-round, measure the diameter of the cylinder in an area 4 in. above the bottom of the barrel:

1. Measure the diameter at right angles from the plane in which the valves are located.
2. Measure the diameter through the plane in which the valves are located.
3. The difference between the diameters must not exceed 0.0045 in.

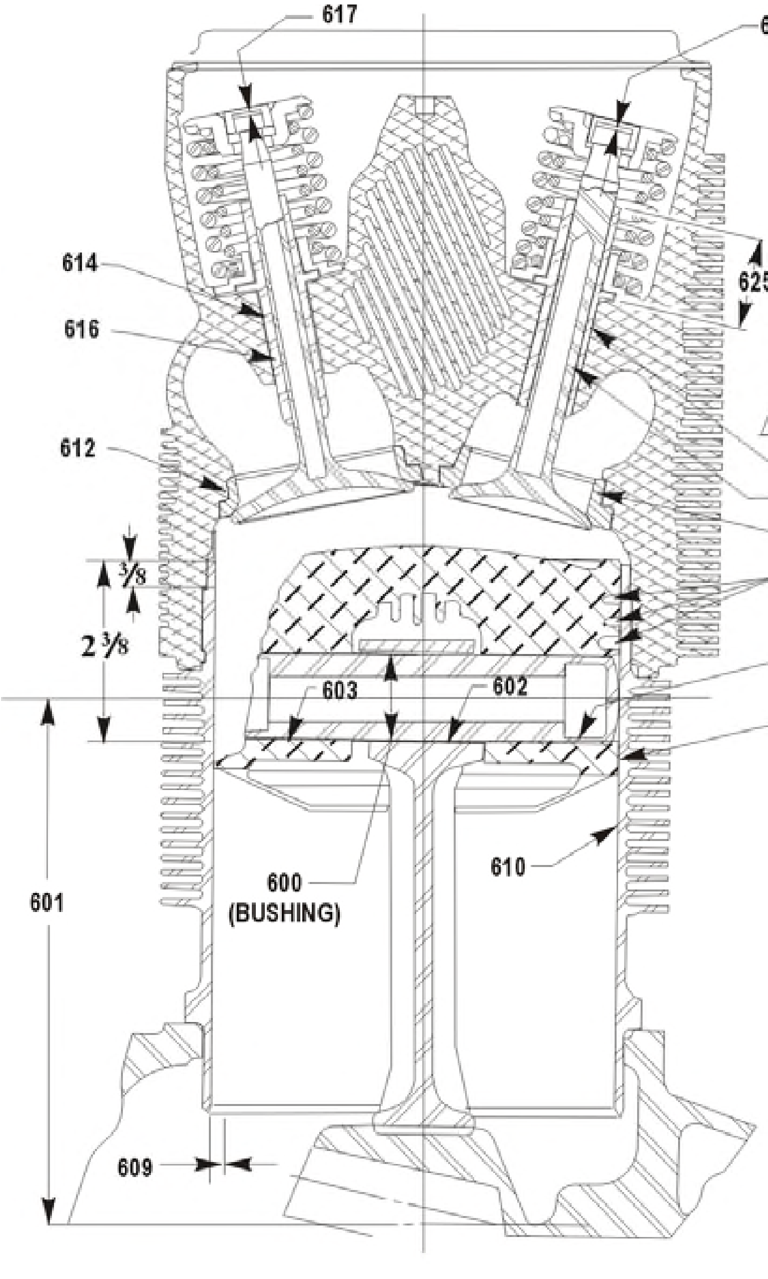
Maximum taper and out-of-round permitted for a cylinder in service is 0.0045 in.

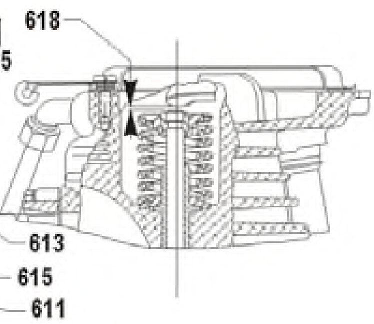
Piston diameter at the top is measured at the top ring land (between the top and second compression ring grooves) at a right angle to the piston pin hole. Piston diameter at the bottom is measured at the bottom of the piston skirt at right angles to the piston pin.

Ref.	Nomenclature	Dimensions: Mfr. Min. & Max.	Dimensions: Service Max	Clearance: Mfr. Min. & Max.	Clearance: Service Max
611	Exhaust Valve Seat and Cylinder Head			0.0075T 0.011T	(A)
	OD Exhaust Seat	1.9355 1.937			

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
	ID Exhaust Seat Hole in Cylinder Head	1.733 1.735			
	Exhaust Seat Hole in Cylinder Head	1.926 1.928			
612	Intake Valve Seat and Cylinder Head			0.0065T 0.010T	(A)
	OD Intake Seat	2.2885 2.290			
	ID Intake Seat Hole in Cylinder Head	2.280 2.282			
613	Exhaust Valve Guide and Cylinder Head			0.001T 0.0025T	(A)
	OD Exhaust Valve Guide	0.6633 0.6638			
	ID Exhaust Valve Guide Hole in Cylinder Head	0.6613 0.6623			
614	Intake Valve Guide and Cylinder Head			0.0010T 0.0025T	
	OD Intake Valve Guide	0.5933 0.5938			
	ID Intake Valve Guide Hole in Cylinder Head	0.5913 0.5923			
615	Exhaust Valve Stem and Valve Guide (Angle Valve Heads)			0.0037L 0.0050L	(A)
	OD Exhaust Valve Stem (Angle Valve Heads)	0.4955 0.4965	0.4937		
	Finished ID Exhaust Valve Guide (Angle Valve Heads)	0.4995 0.5005			
616	Intake Valve Stem and Valve Guide			0.0010L 0.0028L	0.006L
	OD Intake Valve Stem	0.4022 0.4030	0.4010		
	Finished ID Intake Valve Guide	0.4040 0.4050			
617	Intake and Exhaust Valve and Valve Cap Clearance (Rotator Type Small Diameter Head)			0.000L 0.004L	0.005L
618	Dry Tappet Clearance			0.028 0.080	

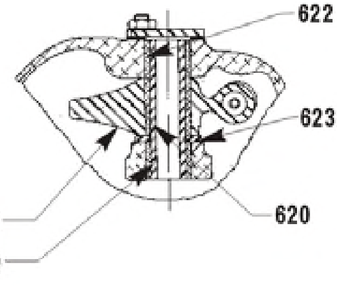
Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
619	Finished ID of Valve Rocker Shaft (Bushing) in Cylinder Head	0.6246 0.6261	0.6270		
620	Valve Rocker Shaft and Valve Rocker Bushing			0.0007L 0.0017L	0.004L
	Finished ID of Rocker Arm Bushing	0.6252 0.6263	0.6270		
	OD Valve Rocker Shaft	0.6241 0.6245	0.6231		
621	Valve Rocker Bushing and Valve Rocker	Bushing must be burnished in place.			
622	Valve Rocker Shaft Bushing Hole in Cylinder Head	0.7380 0.7388			
	Valve Rocker Shaft Bushing and Cylinder Head			0.0022T 0.0038T	(A)
623	Valve Rocker and Cylinder Head – Side Clearance			0.002L 0.020L	0.024L
625	Intake and Exhaust Valve Guide Height	0.914 0.954 Measure the Valve Guide Height from the Valve Spring Seat Counterbore in the Cylinder Head to the Top of the Valve Guide.			





ANGLE VALVE HEAD

Figure 6



ANGLE VALVE HEAD

Figure 7

Section 3 — Gear Train Section–Oil Pump

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
700	Oil Pump Drive Shaft and Oil Pump Body			0.0010L 0.0025L	0.004L
701	Oil Pump Drive Shaft and Accessory Housing			0.015L 0.030L	0.006L
703	Oil Pump Impellers - Diameter Clearance			0.002L 0.006L	0.008L
704	Oil Pump Impeller - Side Clearance			0.002L 0.0045L	0.005L
705	Oil Pump Impeller and Idler Shaft			0.001T 0.003T	(A)
706	Oil Pump Idler Shaft and Oil Pump Body			0.0005L 0.0020L	0.003L
707	Oil Pump Idler Shaft and Oil Accessory Housing			0.0010L 0.0025L	0.0035L

Section 3 – Gear Train Section-Fuel Pump

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max.	Mfg. Min. & Max.	Service Max.
720	Crankshaft Ider Gear and Crankshaft Idler Gear Shaft			.001L .003L	.005L
722	AN Fuel Pump Idle Gear and Shaft			.001L .003L	.005L
724	Crankshaft Idler Gear – End Clearance			.007L .037L	.052L
725	AN Fuel Pump Idler Gear – End Clearance			.002L .018L	.024L
726	AN Fuel Pump Drive Shaft Gear and Adapter			.0010L .0025L	.004L
727	AN Fuel Pump Drive Shaft Gear – End Clearance			0.035L 0.069L	0.079L

Section 3 — Gear Train Section–Governor & Hydraulic Pump

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
729	Front Governor Idler Gear and Shaft			0.0010L 0.0025L	0.004L
731	Front Governor Gear and Crankcase			0.0010L 0.0025L	0.004L
732	Front Governor Gear – End Clearance			0.008L 0.016L	0.021L
735	Hydraulic Pump Gear and Adapter			0.0010L 0.0025L	0.004L
736	Hydraulic Pump Gear – End Clearance			0.010L 0.066L	0.076L

Section 3 — Gear Train Section–Vacuum & Tachometer

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
737	Vacuum Pump Gear and Adapter			0.010L 0.030L	0.0045L
738	Vacuum Pump Gear – End Clearance			0.010L 0.057L	0.075L
739	Tachometer Drive Shaft and Accessory Housing			0.015L 0.0035L	0.006L

Section 3 — Gear Train Section–Magneto, Generator, Starter

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
758	Magneto Gear and Bushing S4LN-21 and S4LN-1227			0.0005L 0.0020L	0.0035L

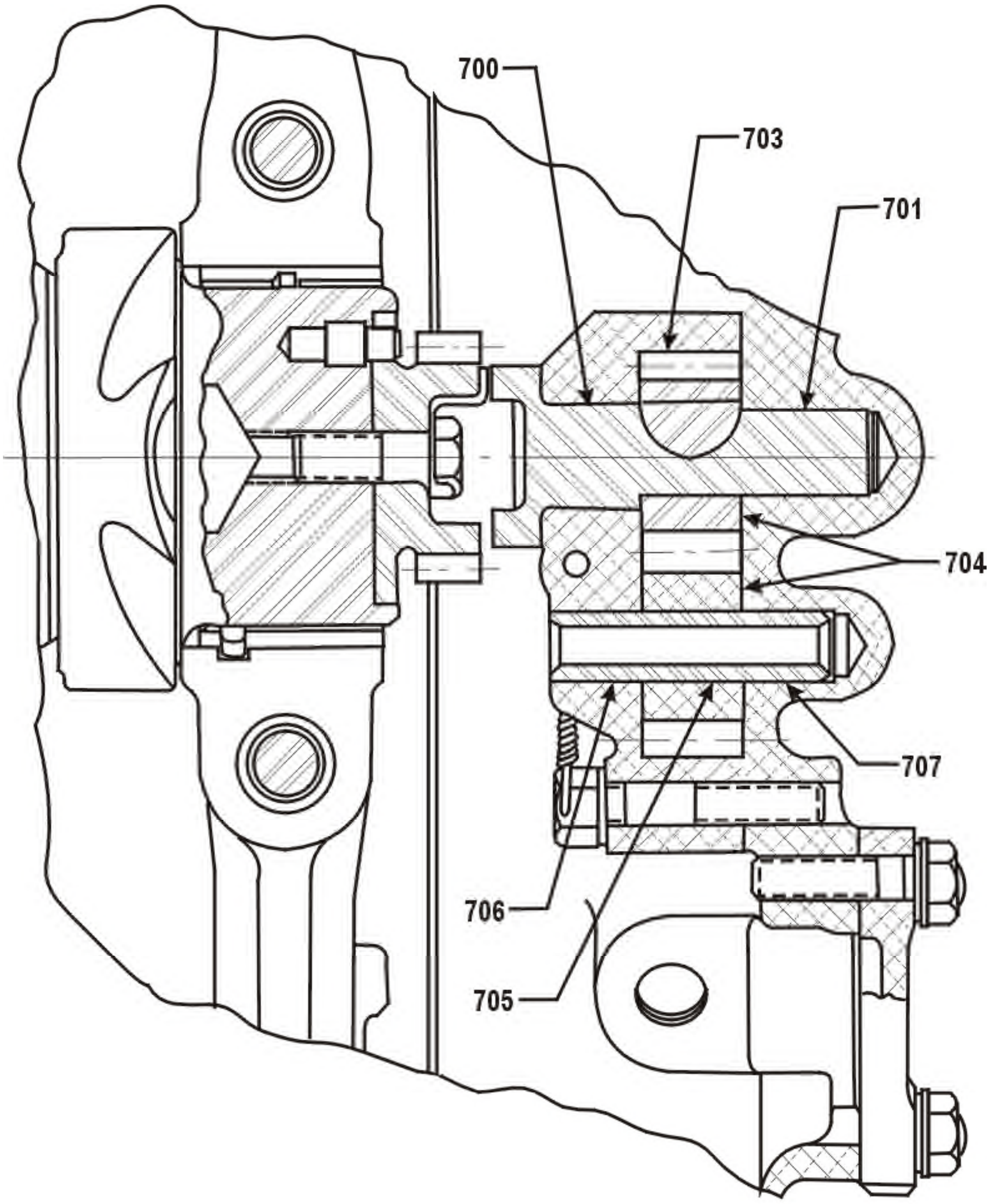
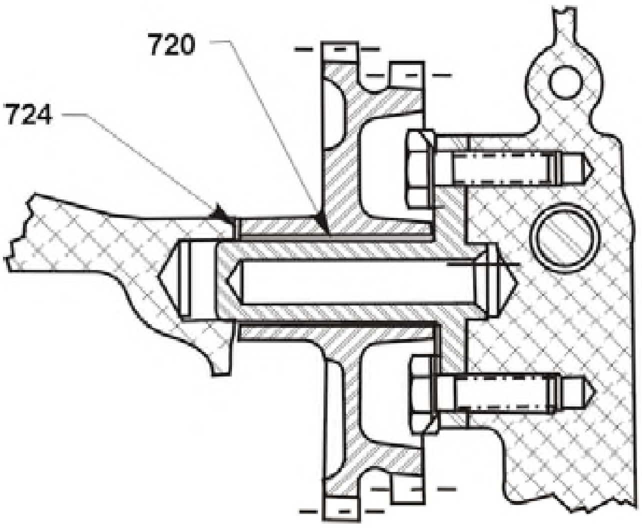
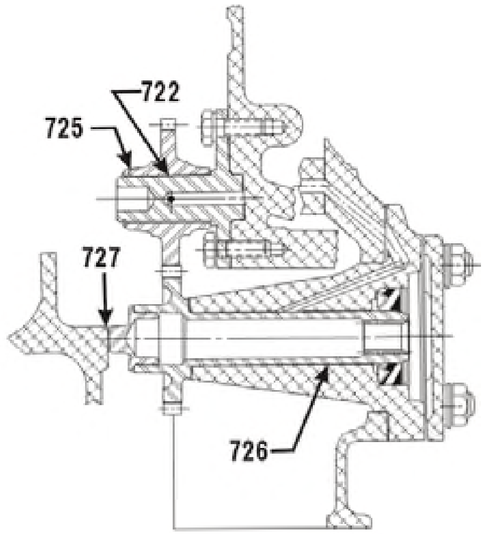


Figure 8



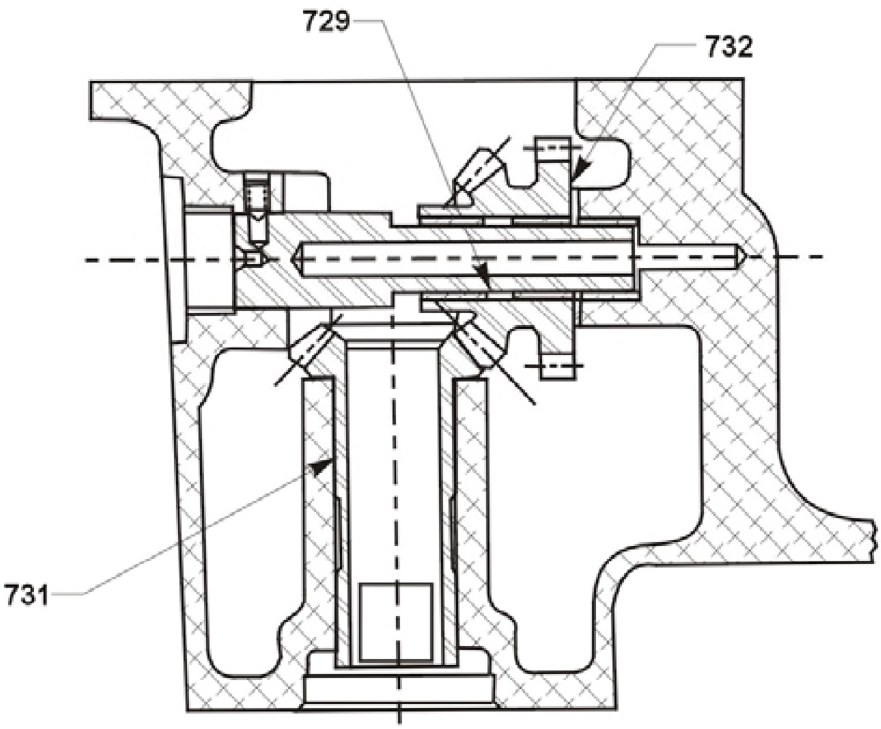
CRANKSHAFT GEAR IDLER

Figure 9



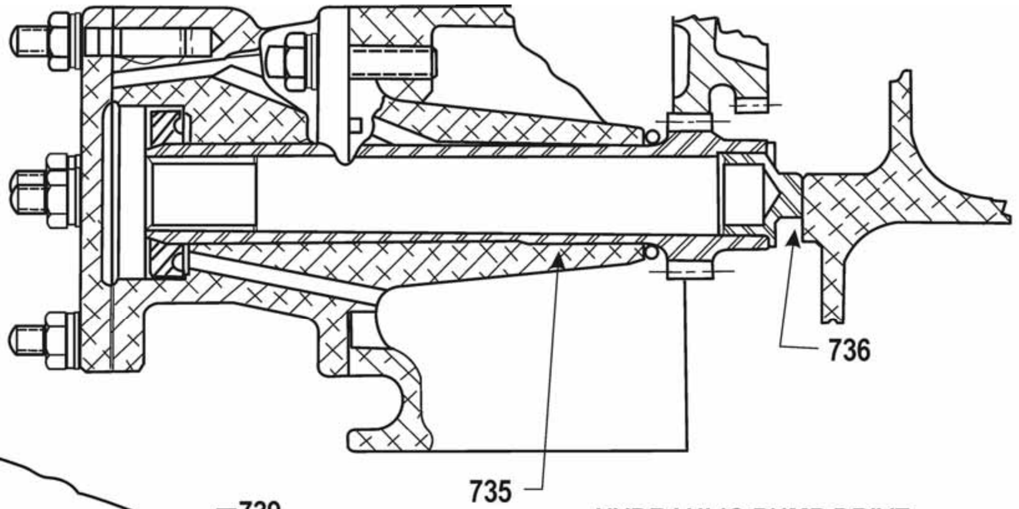
AN FUEL PUMP

Figure 10



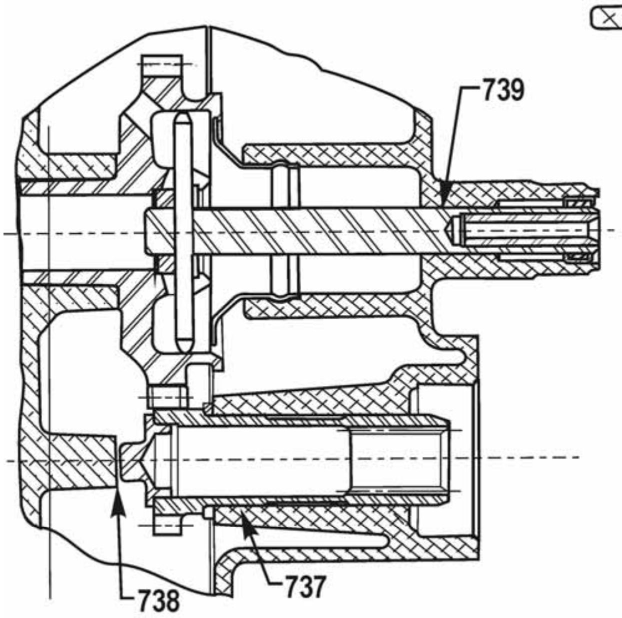
PROP GOVERNOR DRIVE

Figure 11



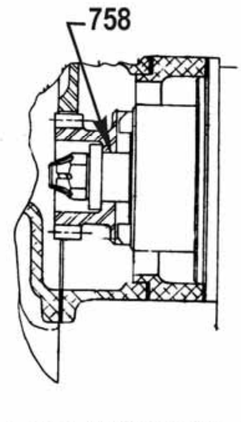
HYDRAULIC PUMP DRIVE

Figure 12



VACUUM PUMP and TACHOMETER DRIVE

Figure 13



4 CYL. (S4LN-21 & S4LN-1227)

Section 4 — Backlash

Ref.	Nomenclature	Dimensions		Clearances	
		Mfr. Min. & Max.	Service Max	Mfr. Min. & Max.	Service Max
800	Crankshaft and Vacuum Pump – Backlash			0.004 / 0.015	0.020
803	Camshaft and Crankshaft Idler – Backlash			0.004 / 0.015	0.020
804	Crankshaft and Crankshaft Idler – Backlash			0.004 / 0.015	0.020
805	Magneto Drive and Crankshaft Idler – Backlash			0.004 / 0.015	0.020
808	Oil Pump Impellers – Backlash			0.008 / 0.015	0.020
817	AN Fuel Pump Idler and Crankshaft Idler – Backlash			0.004 / 0.015	0.020
818	AN Fuel Pump Idler and Fuel Pump – Backlash			0.004 / 0.015	0.020
820	Hydraulic Pump and Crankshaft Idler – Backlash			0.004 / 0.015	0.020
822	Propeller Governor Idler and Camshaft – Backlash (Front Governor)			0.004 / 0.015	0.020
823	Propeller Governor Drive and Idler – Backlash (Bevel Gears) (Front Governor)			0.004 / 0.008	0.015

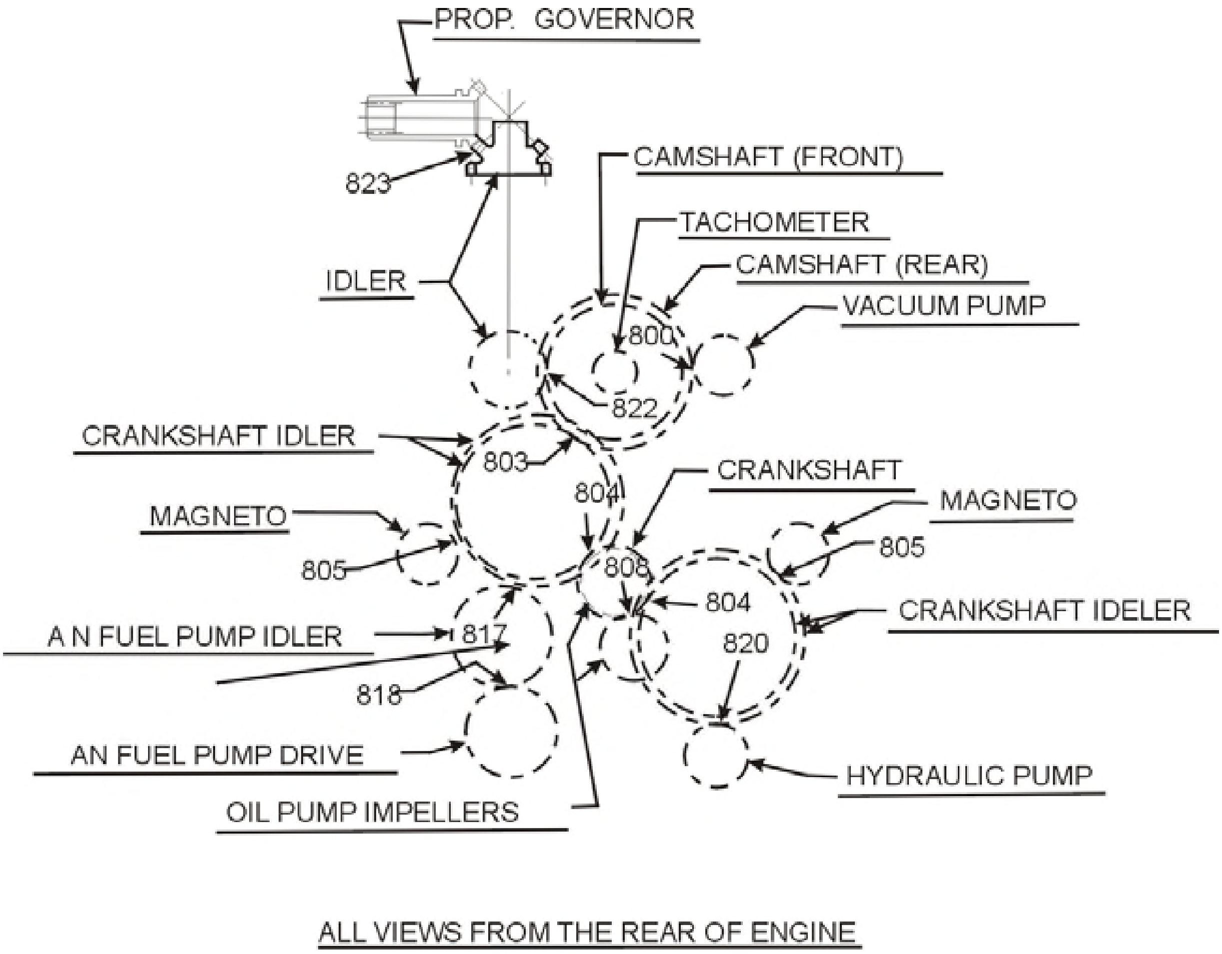

PROP. GOVERNOR
823
CAMSHAFT (FRONT)
TACHOMETER
CAMSHAFT (REAR)
IDLER
VACUUM PUMP
800
822
CRANKSHAFT IDLER
803
804
CRANKSHAFT
MAGNETO
MAGNETO
805
805
808
804
CRANKSHAFT IDELER
A N FUEL PUMP IDLER
817
820
818
AN FUEL PUMP DRIVE
HYDRAULIC PUMP
OIL PUMP IMPELLERS
ALL VIEWS FROM THE REAR OF ENGINE

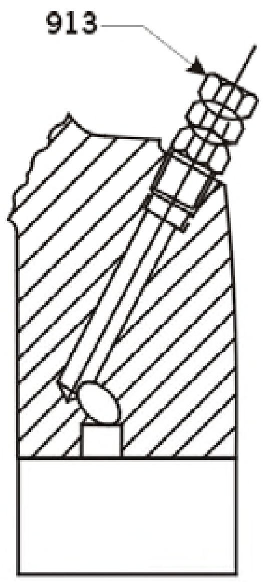
Figure 15

Section 5 — Special Torque Requirements

Ref.	Thread Size	Nomenclature	Torque Limits
900	3/8-24	Connecting Rod Bolts – Tighten to Length	2.255 – 2.256 in.
903		Magneto Nut (To attach drive member to magneto) – Slick	120 – 300 in. lb
904	10-32	Magneto Plate Screws (To attach harness to magneto)	18-28 in. lb
905	¼-20	Rocker Box Screws	50 in. lb
906	5/16-18	Exhaust Port Studs (Driving Torque)	40 in. lb min.
907	18mm	Spark Plugs	420 in. lb
909	5/8-32	Alternator Pulley Nut	450 in. lb
910	¼-28	Alternator Output Terminal Nut	85 in. lb
911	10-32	Alternator Auxiliary Terminal Nut	30 in. lb
913	1/8-27 NPT	Piston Cooling Nozzle in Crankcase	100 in. lb
914	1/8-27 NPT	Injector Nozzle in Cylinder Head	60 in. lb
915	13/16-16	Oil Filter (Throw Away Type)	240 in. lb
917	1.00-14	Thermostatic Bypass Valve	300 in. lb
918	1¼-12	Oil Pressure Relief Valve	300 in. lb
919	¼ Hex Head and Below	Hose Clamps (Worm Type)	20 in. lb
	5/16 Hex Head and Above	Hose Clamps (Worm Type)	45 in. lb
920		Cylinder Head Drain Back Hose Clamps	10 in. lb
928	3/8-16	Cylinder Hold Down Studs (Crankcase Driving Torque)	100 in. lb min.
	½-13	Cylinder Hold Down Studs (Crankcase Driving Torque)	250 in. lb min.
929	3/8-24	Cylinder Hold Down Nuts	300 in. lb
	½-20	Cylinder Hold Down Nuts	600 in. lb
930	.3125-32 NEF-3B	Fuel Injection Line Union Nut	25-50 in. lb

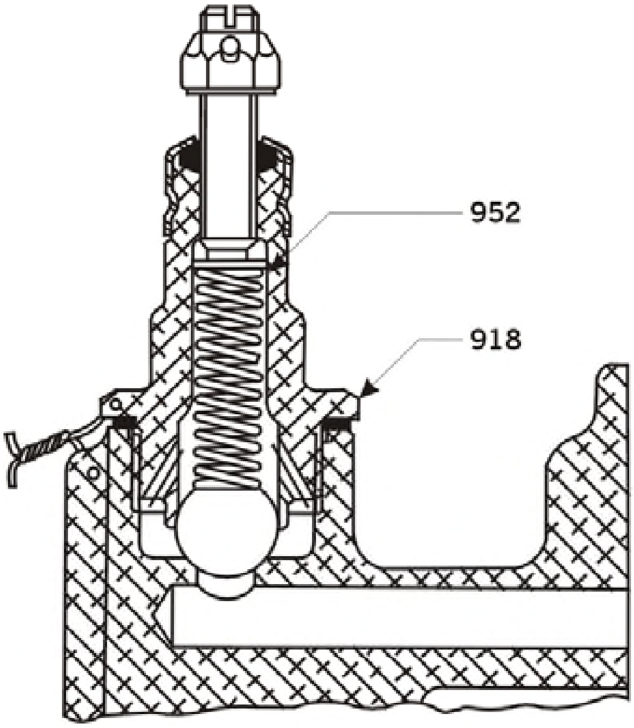
Section 6 — Springs

						Comp. Load		
Ref.	**Chart**	**Nomenclature**	**Lycoming Part No.**	**Wire Dia. (in.)**	**Length at Comp. Length (in.)**	**Mfr. Min. (lb)**	**Mfr. Max. (lb)**	**Serv. Max. (lb min)**
950		Outer Valve Springs (Angle)	LW-11796	0.182	1.43	116	124	113
951		Auxiliary Valve Spring (Angle)	LW-11797	0.142	1.33	75	83	72
952		Oil Pressure Relief Valve Spring						
		Identification						
	Lycom. Part No.	**Dye**	**Free Length**					
	61084	None	2.18	0.054	1.30	8.5	9.5	8.3
	68668	Purple	2.04	0.054	1.30	7.1	7.8	6.9
	77467	Yellow	1.90	0.054	1.30	6.4	7.1	6.2
	LW-11713	White	2.12	0.059	1.44	10.79	11.92	10.5
	LW-18085	White & Purple Dots	1.93	0.067	1.44			



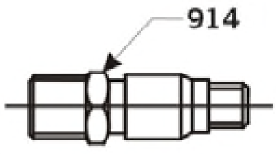
PISTON COOLING NOZZLE

Figure 16



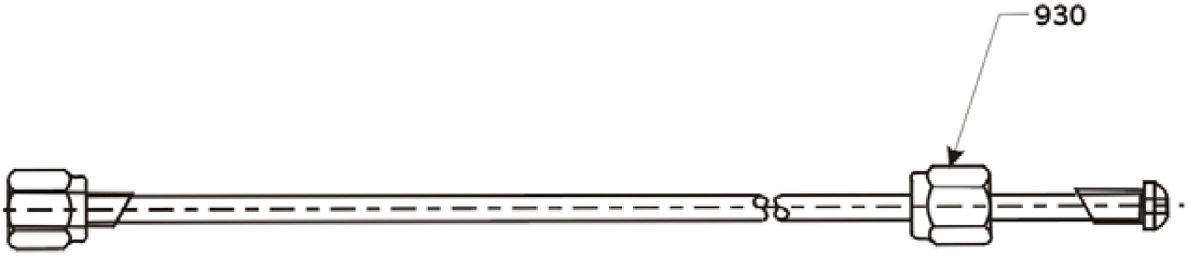
ADJUSTABLE OIL RELIEF VALVE

Figure 17



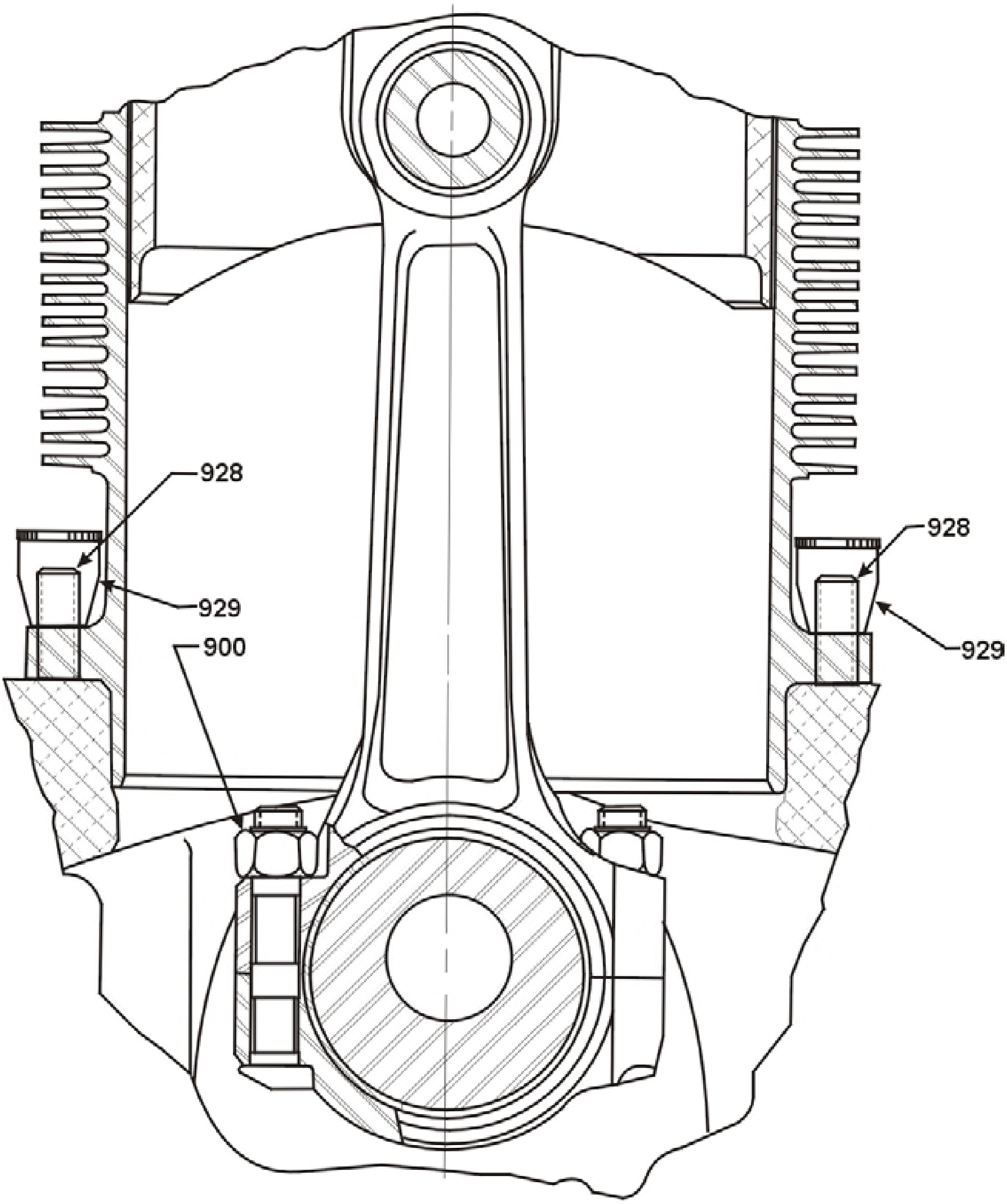
FUEL INJECTION NOZZLE

Figure 18



FUEL INJECTION LINE
UNION NUT

Figure 19



Connecting Rod and Cylinder

Figure 20

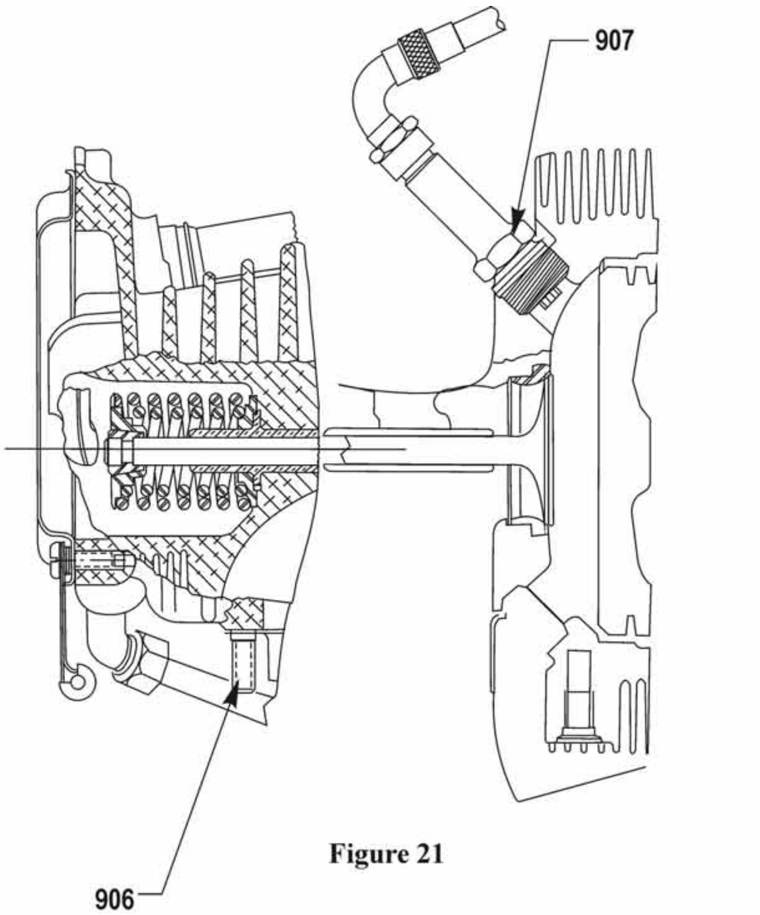


Figure 21

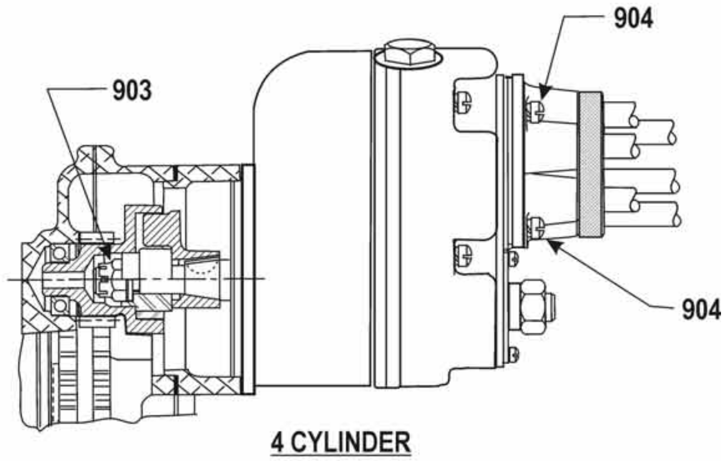


Figure 22

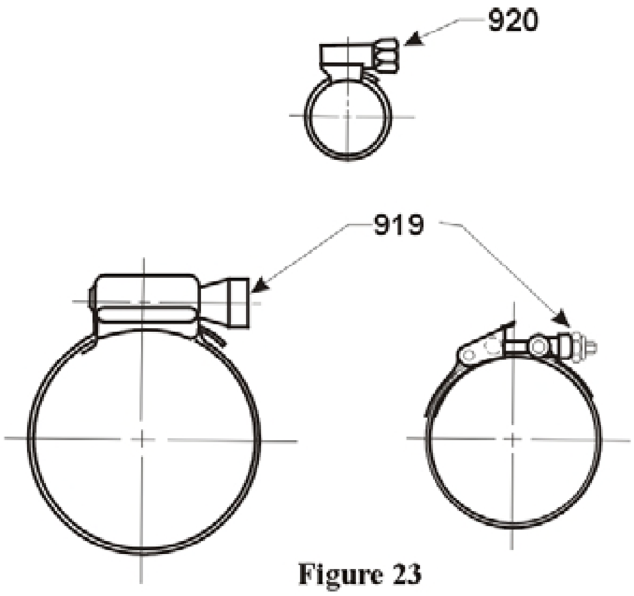


Figure 23

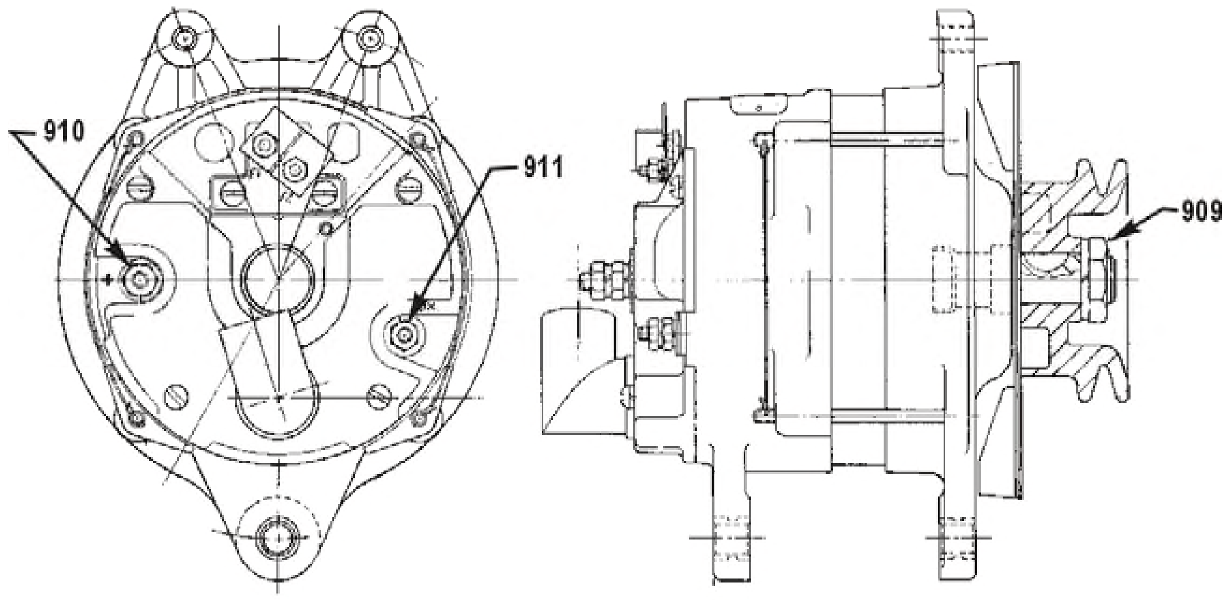
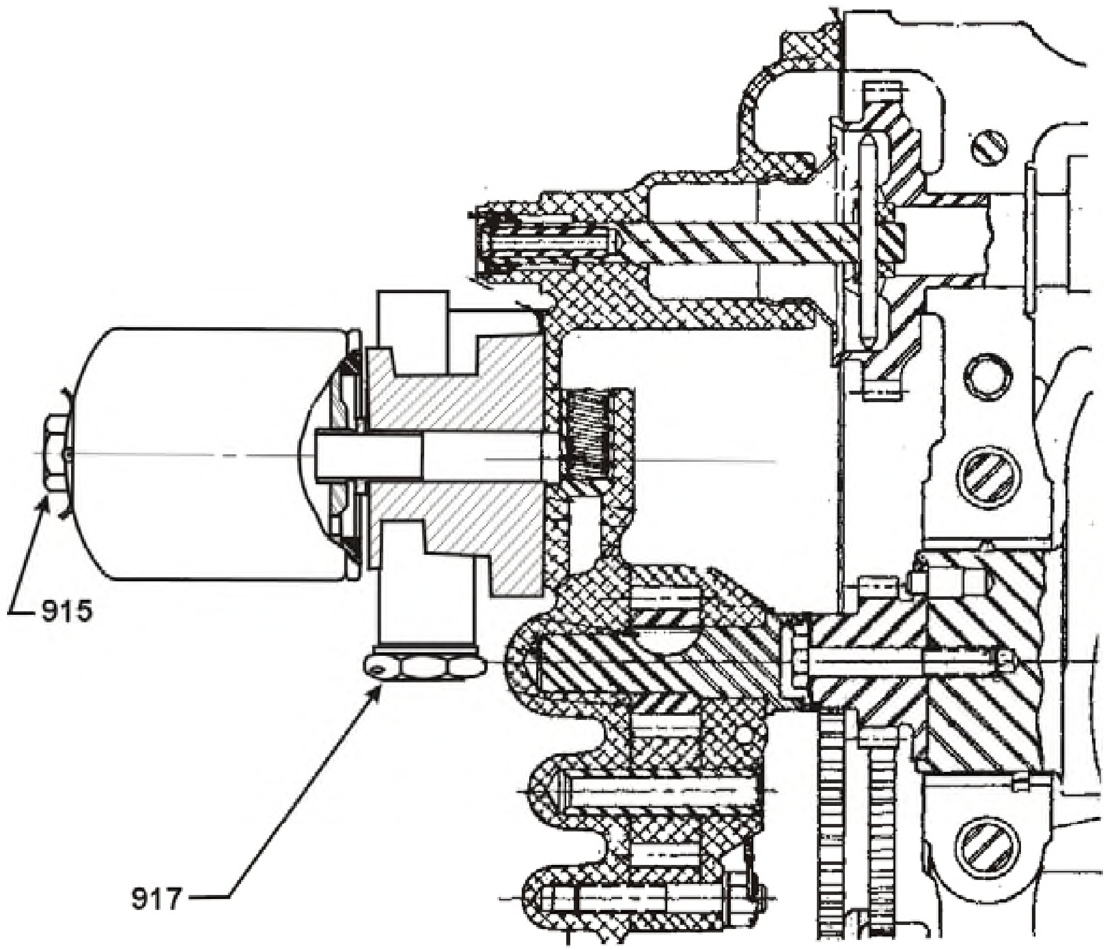


Figure 24



OIL FILTER

Figure 25

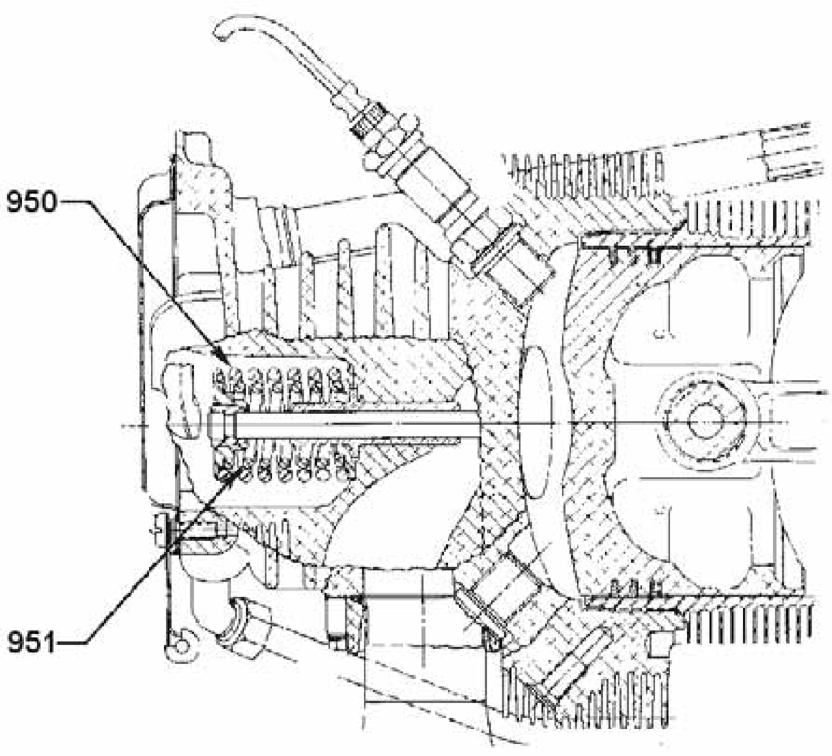


Figure 26

STANDARD TORQUE
UNLESS OTHERWISE LISTED

Torque limits for propeller attaching bolts to be supplied by propeller aircraft manufacturer.

TABLE I

BOLTS, SCREWS AND NUTS

Thread	Torque		Thread	Torque	
	In. Lb.	Ft. Lb.		In. Lb.	Ft. Lb.
10	49	-----	½	900	75
¼	96	-----	9/16	1320	110
5/16	204	17	5/8	1800	150
3/8	360	30	¾	3240	270
7/16	600	50	-----	-----	-----
THIN NUTS (½ DIA. OF BOLT) – ½ LISTED TORQUE					

TABLE II

PIPE PLUGS

Thread	Torque
	In. Lbs.
1/16-27 NPT	40
1/8-27 NPT	40
¼-18 NPT	85
3/8-18 NPT	110
½-14 NPT	160
¾-14 NPT	230
1-11½ NPT	315

TABLE III

Flexible Hose or Tube Fittings

		Torque In. Lbs.	
Tube Size	Thread	Aluminum Alloy	Steel
(-3) 3/16	3/8 – 24	25 – 35	95 – 105
(-4) ¼	7/16 – 20	50 – 65	135 – 150
(-5) 5/16	½ - 20	70 – 90	170 – 200
(-6)	¾ - 16	230 – 260	450 – 500
(-10) 5/8	7/8 – 14	330 – 360	650 - 700

TABLE IV

STUDS MIN. DRIVING TORQUE

Threads	Torque In. Lbs.
¼-20	15
5/16-18	25
3/8-16	50

TIGHTENING PROCEDURES FOR CRANKCASE THRU-STUDS AND BOLTS

The anchored thru-studs are threaded into one of the crankcase halves.

To insure uniform loading on the main bearings, it is necessary to tighten these studs and bolts in a sequence beginning at the approximate center of the engine and progressing evenly to both front and rear of the engine as described in detail in the following procedures.

Two different procedures are shown. The first procedures, shown in PART I, is to be used when the engine has been completely disassembled, or when all the cylinders have been removed; the second procedure, shown in PART II, is used when individual cylinders are replaced on an assembled engine. The procedure shown in PART II is simpler to undertake, because bearing loading is localized.

PART I – TIGHTENING PROCEDURE FOR CRANKCSE THRU-STUDS
(Disassembled engine, or engines on which all cylinders have been removed.)

NOTE

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

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

1. Before the cylinders are assembled on the crankcase, install torque plate P/N ST-222 over the ½ inch thru-studs to simulate the thickness of the cylinder base flange; then install nuts on the free ends of ½ inch thru-studs and tighten each to 300 in.-lbs. (25 ft.-lbs.). Use tightening sequences that following Figure 8-1.

2. Using same sequence as specified in step 1, retorque the ½ inch thru-studs to 600 in.-lbs. torque (50 ft.-lbs.). Where ⅜ inch nuts are used, do not tighten more than 300 in.-lbs. (25 ft.-lbs.).

3. Using sequences shown in Figure 8-1, tighten the ⅜ inch and ¼ inch nuts at the crankcase parting flange. Torque values are:

   ⅜ inch nuts, 300 in.-lbs. (25 ft.-lbs.);
   ¼ inch nuts and capscrews, 96-108 in.-lbs.;
   ¼ inch shear nuts, 55-60 in.-lbs.

NOTE

The tightening sequence procedures following the illustration are numerically keyed to the legends in the illustration. As for those crankcase fastenings not specifically covered, use any sequence and tighten to torque values listed in step 3., PART I.

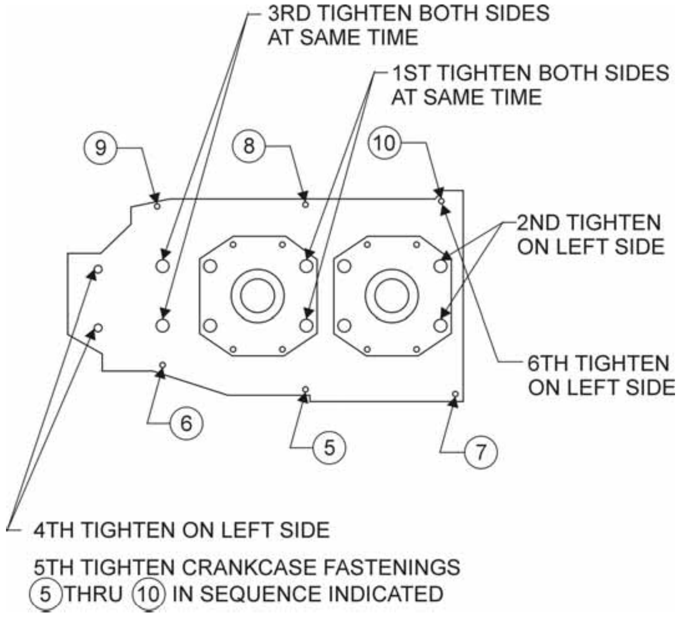


Figure 8-1. Left Side of Crankcase

1st – Tighten both ends of free thru-studs simultaneously at rear of No. 2 cylinder and at front of No. 3 cylinder.
2nd – Tighten thru-studs at rear of No. 4 cylinder.
3rd – Tighten both ends of free thru-studs simultaneously in front of No. 2 cylinder and at front of No. 1 cylinder.
4th – Tighten 3/8 inch nuts at front main bearing (left side) to 300 in.-lbs. (25 ft.-lbs.).
5th – Tighten crankcase fastenings 5 thru 9 in sequence shown.
6th – Tighten 3/8 inch nut 10 at camshaft bearing location (left side) to 300 in.-lbs. (25 ft.-lbs.).

4. Install sump and accessory housing. Remove nuts and torque plate P/N ST-222 from the thru-studs on both rear cylinder mounting pads (cylinders 3 and 4 on four cylinder engines).

5. Install cylinders on the pads from which the nuts were removed in the previous step. Initially tighten cylinder hold-down nuts, to a torque of 300 in.-lbs. (25 ft.-lbs.) in the sequence shown in Figure 8-2.

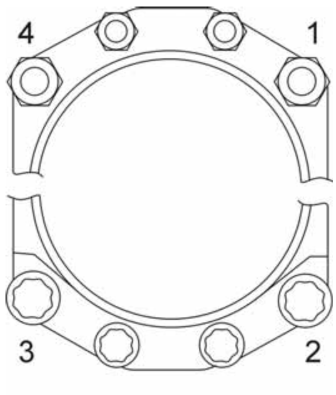


Figure 8-2. Sequence for Tightening Cylinder Basenuts

6. Proceed to install the remaining cylinders on the engine in pairs, proceeding toward the front in the same manner as described in steps 4. and 5.

7. Using ⅜ inch nuts on the remaining cylinder base studs and torque to 300 in.-lbs. (25 ft.-lbs.). The sequence for tightening these nuts is optional.

8. Using the same sequence as described in steps 5. and 6., and shown in Figure 8-2, check all ½-inch nuts for tightness by bringing torque to 600 in.-lbs. (25 ft.-lbs.). Where ⅜-inch nuts are used, do no tighten more than 300 in.-lbs. (25 ft.-lbs.).

9. Check ⅜-inch nuts for tightness on the remaining cylinder base studs by bring torque up to 300 in.-lbs. (25 ft.-lbs.). Sequence is optional.

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

PART II – TIGHTENING PROCEDURE FOR CYLINDER REPLACEMENT
(Assembled engines.)

NOTE

The tightening procedure for cylinder replacement on all wide cylinder flange engines is the same as the following procedure, except that both ends of free thru-studs must be tightened simultaneously. At any time one or more cylinders are replaced, it is necessary to retorque the thru-studs on the cylinder on the opposite side of the engine; the procedure is as follows:

1. Lubricate the threads of the thru-studs with any of he lubricants listed in the note preceding step 1., PART I.

2. Install the cylinder on its mounting pad. Initially torque the ½-inch thru-studs to 300 in.-lbs. (25 ft.-lbs.) per sequence in Figure 8-2.

3. Retorque the ½-inch thru-studs to 600 in.-lbs.) 50 ft.-lbs.) per Figure 8-2.

4. Torque the thru-stud nuts on the opposite cylinder in the same manner as described above.

5. Install ⅜-inch nuts on remaining cylinder base studs and torque to 300 in.-lbs. (25 ft.-lbs.). The tightening sequence for these nuts is optional.

6. Recheck all thru-studs and ⅜-inch cylinder basenuts on both the installed cylinder and its opposing cylinder by applying maximum torque values given.

NOTE

If thru-studs and other cylinder basenuts are tightened properly, it is not necessary use lockwire or Pal-Nuts for security purposes. However, this is the prerogative of the mechanic.

7. After all cylinder basenuts have been tightened, remove any nicks in cylinder fins by burring or filing.

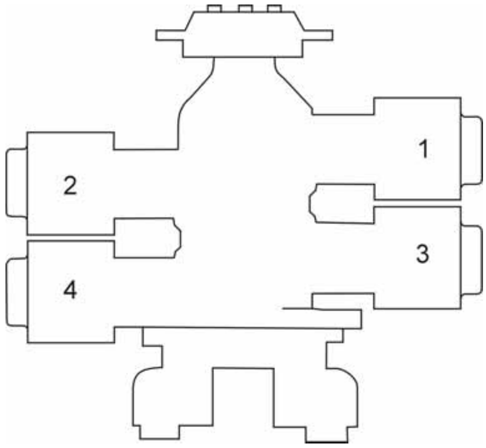


Figure 8-3. Cylinder Numbering System (Viewed from Top)

TOOL DATA:

CYLINDER BASENUT PART NUMBER	TYPE	STUD SIZE	WRENCH PART NUMBER
71134	Allen head	⅜	64943 and ST-84 (⅜-inch Allen head)
71133	Allen head	½	64942 and ST-83 (½-inch Allen head)
Torque Hold Down Plate			ST-222

LYCOMING ENGINE BREAK-IN AND OIL CONSUMPTION LIMITS

NOTE

All engines that have had initial run-in conducted in a test cell should proceed directly to the FLIGHT TEST section that is applicable to your aircraft.

Ideally, a newly overhauled aircraft engine should be tested in a test cell where operating conditions can be closely monitored. If the engine is test cell run, the engine must have inter-cylinder baffles in place, cooling shroud and club propeller to provide engine RPM requirements. Where a test cell is not available, the engine should be tested on a test stand with a club propeller and a cooling shroud. However, it is not always convenient to test an engine in this manner.

If a test cell or a test stand is not available, the engine should be properly tested after it has been installed in the aircraft. If the engine is run in the aircraft, it should still use a club propeller for proper airflow cooling. However, the aircraft propeller may be used. In either case, the inter-cylinder baffles must be in place. The engine to cowling baffles must be new or in good condition to assure proper cooling airflow differential across the engine. The cylinder head temperature gauge, oil temperature gauge, oil pressure gauge, manifold pressure gauge and tachometer must be calibrated to assure accuracy.

The purpose of a test cell or ground run test if done in the aircraft is to assure that the engine meets all specifications, RPM, manifold pressure, fuel flow and oil pressure. The oil cooler system must hold oil temperatures within limits shown in this manual.

NOTE

Extended ground operation can cause excessive cylinder and oil temperatures. Prior to start of a ground run, the oil cooler system should be inspected for metal contamination and be free from air locks. When the engine oil is at operating temperature, oil goes through cooler first then through oil filter. If a previous engine failed, the oil cooler, propeller and governor may be contaminated and should be replaced or cleaned and inspected by an approved repair facility.

The purpose for engine break-in is to seat the piston rings and stabilize the oil consumption. There is no difference or greater difficulty in seating the piston rings of a top refurbished engine versus a complete engine refurbishment.

NOTE

The maximum allowable oil consumption limits for all Lycoming aircraft engines can be determined by using the following formula:

$$.006 \times BHP \times 4 \div 7.4 = Qt./Hr.$$

The following procedure provides a guideline for testing a newly refurbished engine that is mounted in the aircraft. Information on the "ground run after top refurbishment or cylinder change with new rings" and the "flight test after top refurbishment or cylinder change with new rings" procedures are published in this manual.

I. <u>FIXED WING</u>

A. PREPARATION FOR TEST WITH ENGINE INSTALLED IN AIRCRAFT.

1. Pre-oil the engine in accordance with the following:

   a. Fill the tank or sump to the proper level.

   b. Engines with external oil tanks.

      (1) Disconnect the oil inlet connection at the oil pump and drain a sufficient amount of oil to eliminate any possible obstructions or air in the inlet passage. Reinstall oil inlet connections to the oil pump.

   c. For wet sump engines, fill the cooler with oil.

   d. Remove one spark plug from each cylinder of the engine.

   e. Place the mixture control in idle cut-off and the fuel selector or shut off in the "off" position. If the engine is not equipped with idle cut-off, open throttle to full open position and put fuel and ignition switches in "off" position.

   f. Turn the engine with starter (or external power source, if available) until oil is visible at the end of the oil lines disconnected in steps b. and c. Reconnect the oil lines. Turn engine with starter (or external power source, if available) until a minimum pressure of 20 lbs. is indicated on the oil pressure gauge.

NOTE

If oil pressure is not attained after cranking for 10-15 seconds, allow starter to cool.

g. Energize starter for 2 or more 10-15 seconds periods.

CAUTION

DO NOT ENERGIZE STARTER FOR PERIODS OF OVER 10-15 SECONDS. ALLOW TO COOL AFTER EACH ENERGIZING.

Lack of pressure build-up or rapid drop-off of pressure is an indication of the presence of oil in the line and the engine is not being pre-oiled. To remedy this, repeat steps b. and c. and continue until oil pressure is indicated.

h. The line disconnected in step b. may be reconnected after the oil pressure is attained and the oil is flowing from the disconnected lines.

i. Turn the engine with the starter for approximately 10 seconds to check for continued oil pressure.

j. Reinstall spark plugs and proceed with normal starting procedure which should not be later than three hours after pre-oiling.

k. When engine is started it should be run for about three minutes at approximately 1000 RPM for fixed wing applications, and idle RPM on helicopters before increasing power for other ground operations or take-off power.

2. It is particularly important that the cylinder head temperature gauge, oil temperature gauge, oil pressure gauge, and tachometer be calibrated prior to testing.

3. Engine accessories, such as the fuel pump, fuel metering unit, and magnetos, should be overhauled in accordance with accessory manufacturer's recommendations, or replaced with new units before testing engine. This applies to refurbished engines only.

CAUTION

CHECK THAT ALL VENT AND BREATHER LINES ARE PROPERLY INSTALLED AND SECURED AS DESCRIBED IN THE AIRFRAME MAINTENANCE MANUAL.

4. Install all inter-cylinder baffles. Install all airframe baffles and cowling.

5. For optimum cooling during ground testing, a test club should be used. Where this is not possible, the regular flight propeller can be substituted but cylinder head temperature must be monitored closely.

B. GROUND TEST.

1. Face the aircraft into the wind.

2. Start the engine and observe the oil pressure gauge. If adequate pressure is not indicated within 30 seconds, shut the engine down and determine the cause. Operate the engine at 1000 RPM until the oil temperature has stabilized or reached 140°F. After warm-up, the oil pressure should not be less than the minimum pressure specified in this manual.

3. Check magneto drop-off as described in Section 3.

4. Continue operation at 1000/1200 RPM for 15 minutes. Insure that cylinder head temperature, oil temperature and oil pressure are within the limits specified in this manual. Shut the engine down and allow it to cool if necessary to complete this portion of the test. If any malfunction is noted, determine the cause and make the necessary correction before continuing the test.

5. Start the engine again and monitor oil pressure. Increase engine speed to 1500 RPM for a 5-minute period. Cycle propeller pitch and perform feathering check as applicable per airframe manufacturer's recommendation.

6. Run engine to full static airframe recommended power for a period of no more than 10 seconds.

7. After operating the engine at full power; allow it to cool down moderately. Check idle mixture adjustment prior to shutdown.

8. Inspect the engine for oil leaks.

9. Remove the oil suction screen and the oil pressure screen or oil filter to determine any contamination. If no contamination is evident, the aircraft is ready for flight testing.

NOTE

Compile a log of all pertinent data accumulated during both the ground testing and flight testing.

C. FLIGHT TEST.

WARNING

ENGINE TEST CLUBS MUST BE REPLACED WITH APPROVED FLIGHT PROPELLERS BEFORE FLYING AIRCRAFT.

1. Start the engine and perform a normal preflight run-up in accordance with this manual.

2. Take off at airframe recommended take-off power, while monitoring RPM, fuel flow, oil pressure, oil temperature and cylinder head temperatures.

3. As soon as possible, reduce to climb power specified in this manual. Assume a shallow climb angle to a suitable cruise altitude. Adjust mixture per pilot's operating handbook.

4. After establishing cruise altitude, reduce power to approximately 75% and continue flight for 2 hours. For the second hour, alternate power settings between 65% and 75% power.

NOTE

If the engine is normally aspirated (non-turbocharged), it will be necessary to cruise at the lower altitudes to obtain the required cruise power levels. Density altitude in excess of 8,000 feet (5,000 feet is recommended) will not allow the engine to develop sufficient cruise power for a good break-in.

5. Increase engine power to maximum airframe recommendations and maintain for 30 minutes, provided engine and aircraft are performing within specifications.

CAUTION

AVOID RAPID CHANGES IN ENGINE SPEEDS WITH ENGINES THAT HAVE DYNAMIC COUNTERWEIGHT ASSEMBLIES. THESE CONDITIONS CAN DAMAGE THE COUNTERWEIGHTS, ROLLERS OR BUSHINGS, THEREBY CAUSING DETUNING.

6. Descend at low cruise power while closely monitoring the engine instruments. Do not reduce altitude too rapidly or the engine temperature may drop too quickly.

CAUTION

AVOID ANY CLOSED THROTTLE DESCENTS. CLOSED THROTTLE OPERATION DURING DESCENTS WILL CAUSE RING FLUTTER CAUSING DAMAGE TO THE CYLINDERS AND RINGS.

7. After landing and shutdown, check for leaks at fuel and oil fittings and at engine and accessory parting surfaces. Compute fuel and oil consumption and compare the limits given in this manual. If consumption exceeds figures shown in this manual, determine the cause before releasing the aircraft for service.

8. Remove oil suction screen and oil pressure screen or oil filter to check again for contamination.

NOTE

To seat the piston rings in a newly refurbished engine, cruise the aircraft at 65% to 75% power for the first 50 hours, or until oil consumption stabilizes.

II. ROTARY WING (HORIZONTAL INSTALLATIONS ONLY)

Proper break-in of helicopter engines is accomplished by following a sequence of steps ranging from servicing the engine on the ground to progressively increasing its power output during operation. Although this manual contains detailed information pertaining to break-in, it is impossible to cover all aspects of break-in for individual helicopter models. For that reason, consult the pilot’s flight manual or pilot operating handbook (POH) for a particular helicopter model.

Some facts should be kept in mind regarding break-in of piston engines employed in helicopters. They are as follows:

Because helicopters always operate at a fixed or rated engine speed, any reduced engine RPM required during break-in must be undertaken with the helicopter on the ground and with the rotor engaged. During flight, all power reductions must be made by manifold pressure alone.

Manifold Pressure Values. Some helicopters do not have red line on the manifold pressure gage and therefore use all rated power. Some are redlined to airframe limitations and not to engine performance parameters.

The method of rotor engagement, centrifugal clutch or manually operated belt drive must also be considered.

NOTE

Because of the difference in helicopter models, refer to the helicopter pilots operating handbook (POH) for specific method of operation for a particular helicopter concerning rotor engagement and manifold pressure ratings.

A. GROUND TEST.

1. Check that engine is serviced with proper grade and quantity of oil.
2. Review the appropriate starting procedure detailed in the helicopter pilot's operating handbook (POH).
3. Position the helicopter to take advantage of prevailing wind to assist in engine cooling.
4. Insure that throttle and mixture control are at the full off position.

NOTE

In following step, if adequate oil pressure not indicated with 30 seconds, shut the engine down and determine the cause.

5. Refer to helicopter pilot's operating handbook for proper starting procedures. Start engine and run 5 minutes at idle RPM (1200-1450 RPM).
6. Adjust idle mixture and oil pressure as required.
7. Shut engine off.
8. Inspect the engine for oil and fuel leaks.
9. If plug fouling is noted on magneto check, remove, inspect and test spark plugs. Clean oil and lead from plug. Reinstall spark plugs and leads. Torque as required.
10. Restart engine and run for 5 minutes at idle speed (1200-1450 RPM).
11. Engage rotor, if required, and increase RPM to 50%-60% of rated engine speed for 5 minutes with rotor blades at flat pitch (collective full down).
12. Then increase engine RPM to 80% of rated engine speed for 5 minutes, followed by 100% airframe manufacturer's rated engine speed for another 5 minutes, provided that oil pressure is normal and that oil temperature is between 180°F-200°F, with the cylinder head temperatures between 350°F-400°F.

NOTE

For proper break-in, do not exceed 420°F cylinder head temperature.

13. After running engine for the last 5 minute segment, cool down as recommended in helicopter pilot's operating handbook (POH), then shut engine down.

14. Drain oil and clean the suction screen in the sump. Also clean oil pressure screen, or replace pressure oil filter. Make proper oil pressure adjustments at this time.

15. After reinstalling the suction screen and pressure screen (or new oil filter) to proper torque, service engine with correct grade and quantity of oil.

16. Start engine and idle at 1450 RPM.

17. Engage rotor, if required, and increase engine RPM to 2000 RPM. Warm engine to ground run check as described in helicopter pilot's operating handbook (POH).

18. At this time perform magneto check per helicopter pilot's operating handbook (POH).

B. FLIGHT TEST.

Start engine and warm up at 1450 RPM. Engage rotor, if required, increase engine speed to 75% RPM. Warm up the engine and conduct a ground check in accordance with the helicopter pilot's flight manual, including magneto check.

NOTE

It is advisable to have two qualified crew member aboard to perform the various control operations and to monitor the engine instruments. All aircraft and engine operating temperature and pressures are to be monitored. If any exceed the helicopter pilot's flight manuals limitations, the break-in is to be discontinued until corrective maintenance has been performed.

1. Put helicopter into a hover mode for 10 minutes while charting manifold pressure, fuel pressure, oil temperature, oil pressure and cylinder head temperature, etc.

2. If engine instruments prove satisfactory, climb to cruise altitude.

3. Cruise at 70%-75% of engine rated power for 30 minutes at an airspeed that will allow for a constant safe altitude.

4. At termination of 30-minute flight at 70%-75% power, chart manifold pressure and engine temperature. Increase engine RPM and manifold pressure to maximum limits allowed in helicopter pilot's operating handbook (POH). Maintain this power setting for 45 minutes at a constant safe altitude.

5. At the end of 45 minutes, again chart manifold pressure and engines temperatures.

6. Return to base and hover aircraft for 10 minutes or cool down time recommended in helicopter pilot's operating manual. Again chart manifold pressure and engine temperatures.

C. AFTER FLIGHT – ON GROUND.

NOTE

Reference helicopter pilot's operating handbook (POH) for cool down and shut down procedures.

1. Inspect engine for leaks.

2. Compute fuel and oil consumption. If figures exceed limits, determine cause(s) and correct before releasing aircraft.

3. Remove oil suction screen and pressure screen (of oil filter). Inspect for contamination.

4. After reinstalling the suction screen and pressure screen (or new filter) to proper torque, service engine with correct grade and quantity of oil.

After the aircraft has been released, the engine must be operated on straight mineral oil during the first 50 hours of operation or until the oil consumption stabilizes. During this time, maintain engine power above 65% and insure that all aircraft and engine operating temperatures and pressures are monitored and maintained within limits. Refer to *NOTE* under step II.B. FLIGHT TEST.

FULL THROTTLE HP AT ALTITUDE
(Normally Aspirated Engines)

Altitude Ft.	% S.L. H.P.	Altitude Ft.	% S.L. H.P.	Altitude Ft.	% S.L. H.P.
0	100	10,000	70.8	19,500	49.1
500	98.5	11,000	68.3	20,000	48.0
1,000	96.8	12,000	65.8	20,500	47.6
2,000	93.6	13,000	63.4	21,000	46.0
2,500	92.0	14,000	61.0	21,500	45.2
3,000	90.5	15,000	58.7	22,000	44.0
4,000	87.5	16,000	56.5	22,500	43.3
5,000	84.6	17,000	54.3	23,000	42.2
6,000	81.7	17,500	53.1	23,500	41.4
7,000	78.9	18,000	52.1	24,000	40.3
8,000	76.2	18,500	51.4	24,500	39.5
9,000	73.5	19,000	50.0	25,000	38.5

TABLE OF SPEED EQUIVALENTS

Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.
72.0	50	24.0	150	14.4	250
60.0	60	22.5	160	13.8	260
51.4	70	21.2	170	13.3	270
45.0	80	20.0	180	12.8	280
40.0	90	18.9	190	12.4	290
36.0	100	18.0	200	12.0	300
32.7	110	17.1	210	11.6	310
30.0	120	16.4	220	11.2	320
27.7	130	15.6	230	10.9	330
25.7	140	15.0	240	10.6	340

CENTIGRADE – FAHRENHEIT CONVERSION TABLE

Example: To convert 20°C to Fahrenheit, find 20 in the center column headed (F-C); then read 68.0°F in the column (F) to the right. To convert 20°F to Centigrade; find 20 in the center column and read –6.67°C in the (C) column to the left.

C	F-C	F	C	F-C	F
-56.7	-70	-94.0	104.44	220	428.0
-51.1	-60	-76.0	110.00	230	446.0
-45.6	-50	-58.0	115.56	240	464.4
-40.0	-40	-40.0	121.11	250	482.0
-34.0	-30	-22.0	126.67	260	500.0
-28.9	-20	-4.0	132.22	270	518.0
-23.3	-10	14.0	137.78	280	536.0
-17.8	0	32.0	143.33	290	554.0
-12.22	10	50.0	148.89	300	572.0
-6.67	20	68.0	154.44	310	590.0
-1.11	30	86.0	160.00	320	608.0
4.44	40	104.0	165.56	330	626.0
10.00	50	122.0	171.11	340	644.0
15.56	60	140.0	176.67	350	662.0
21.11	70	158.0	182.22	360	680.0
26.67	80	176.0	187.78	370	698.0
32.22	90	194.0	193.33	380	716.0
37.78	100	212.0	198.89	390	734.0
43.33	110	230.0	204.44	400	752.0
48.89	120	248.0	210.00	410	770.0
54.44	130	266.0	215.56	420	788.0
60.00	140	284.0	221.11	430	806.0
65.56	150	302.0	226.67	440	824.0
71.00	160	320.0	232.22	450	842.0
76.67	170	338.0	237.78	460	860.0
82.22	180	356.0	243.33	470	878.0
87.78	190	374.0	248.89	480	896.0
93.33	200	392.0	254.44	490	914.0
98.89	210	410.0	260.00	500	932.0

INCH FRACTIONS 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	1/2	.5	.1964	12.700
1/32	.0312	.0008	.794	17/32	.5312	.2217	13.494
3/64	.0469	.0017	1.191	35/64	.5469	.2349	13.891
1/16	.0625	.0031	1.587	9/16	.5625	.2485	14.288
3/32	.0937	.0069	2.381	19/32	.5937	.2769	15.081
7/64	.1094	.0094	2.778	39/64	.6094	.2916	15.478
1/8	.125	.0123	3.175	5/8	.625	.3068	15.875
5/32	.1562	.0192	3.969	21/32	.6562	.3382	16.669
11/64	.1719	.0232	4.366	43/64	.6719	.3545	17.065
3/16	.1875	.0276	4.762	11/16	.6875	.3712	17.462
7/32	.2187	.0376	5.556	23/32	.7187	.4057	18.256
15/64	.2344	.0431	5.593	47/64	.7344	.4235	18.653
1/4	.25	.0491	6.350	3/4	.75	.4418	19.050
9/32	.2812	.0621	7.144	25/32	.7812	.4794	19.844
19/64	.2969	.0692	7.540	51/64	.7969	.4987	20.241
5/16	.3125	.0767	7.937	13/16	.8125	.5185	20.637
11/32	.3437	.0928	8.731	27/32	.8437	.5591	21.431
23/64	.3594	.1014	9.128	55/64	.8594	.5800	21.828
3/8	.375	.1105	9.525	7/8	.875	.6013	22.225
13/32	.4062	.1296	10.319	29/32	.9062	.6450	23.019
27/64	.4219	.1398	10.716	59/64	.9219	.6675	23.416
7/16	.4375	.1503	11.112	15/16	.9375	.6903	23.812
15/32	.4687	.1725	11.906	31/32	.9687	.7371	24.606
31/64	.4844	.1842	12.303	63/64	.9844	.7610	25.003