TELEDYNE CONTINENTAL MOTORS
Aircraft Products Division
P. O. BOX 90 MOBILE, ALABAMA

CONTINENTAL® AIRCRAFT ENGINE

MODELS TSIO-360-F & FB

Operator's Manual

FORM NO. X-30512

FAA APPROVED
JANUARY 1978

Member of GAMA
General Aviation Manufacturers Association

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Aircraft Products Division

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OPERATOR'S MANUAL FOR MODELS TSIO-360-F & FB AIRCRAFT ENGINES

NOTICE

THE ENGINE(S) DESCRIBED IN THIS MANUAL MUST BE OPERATED IN ACCORDANCE WITH THE INSTRUCTIONS CONTAINED HEREIN. FAILURE TO SO COMPLY WILL BE DEEMED AS MISUSE, THUS RELIEVING THE ENGINE MANUFACTURER OF ANY RESPONSIBILITY.

THIS MANUAL CONTAINS NO WARRANTIES, EITHER EXPRESSED OR IMPLIED. THE INFORMATION AND PROCEDURES CONTAINED HEREIN PROVIDE THE OPERATOR WITH TECHNICAL INFORMATION AND INSTRUCTIONS APPLICABLE TO SAFE OPERATION.

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INTRODUCTION

The operating instructions outlined in this manual have been developed from comprehensive evaluation of the engine performance in relation to its installation in an aircraft. Recommendations, cautions and warnings regarding operation of this engine are not intended to impose undue restrictions on operation of the aircraft, but are inserted to enable the pilot to obtain maximum performance from the engine commensurate with safety and efficiency. Abuse, misuse, or neglect of any piece of equipment can cause eventual failure. In the case of an aircraft engine it should be obvious that a failure may have disastrous consequences. Failure to observe the instructions contained in this manual constitutes unauthorized operation in areas unexplored during development of the engine, or in areas in which experience has proved to be undesirable or detrimental.

Notes, Cautions and Warnings are included throughout this manual. Application is as follows:

NOTE: Special interest information which may facilitate the operation of equipment.

CAUTION: Information issued to emphasize certain instructions or to prevent possible damage to engine or accessories.

WARNING: Information which, if disregarded, may result in severe damage to or destruction of the engine or endangerment to personnel.

Users are advised to keep up with the latest information by means of service bulletins, which are available for study at any approved Teledyne Continental Distributor or Dealer, and are obtainable on an annual subscription basis. Subscription forms are available for the Distributor or from Teledyne Continental Motors, P. O. Box 90, Mobile, Alabama 36601, Attention: Publications Department.

WARNING . . . This engine must be installed in accordance with all requirements and limitations listed in the Detail Specification for Teledyne Continental Aircraft Engines. Any deviations caused by installation, or operation, such as acrobatic maneuvers will be deemed as misuse and Teledyne Continental Motors shall be relieved of any further responsibility.

SECTION I

OPERATING SPECIFICATIONS AND LIMITS

When increasing power, first increase the RPM with the propeller control and then increase manifold pressure with throttle. When decreasing power, throttle back to desired manifold pressure and then change to the desired RPM. Readjust manifold pressure after final RPM setting.

CAUTION . . . Cylinder head and oil temperatures must never be allowed to exceed the limitations specified. Near-maximum temperatures should occur only when operating under adverse conditions, such as high power settings, low airspeed, extreme ambient temperature, etc. If excessive temperatures are noted, and cannot reasonably be explained, or if abnormal cowl flap and/or mixture settings are required to maintain temperatures, then an inspection should be performed to determine the cause. Possible causes of high temperatures may include broken or missing baffles, inoperative cowl flaps, sticking oil temperature control unit, or restricted fuel nozzles (resulting in lean-running cylinders). Faulty instruments or thermocouples may cause erroneously high (or low) temperature indications. Refer to Section VIII of this manual and/or the aircraft overhaul manual for trouble shooting procedures.

WARNING . . . Do not use any propeller that is not certificated and specifically designed for operation on this engine.

DETAILED SPECIFICATIONS

This specification is for the TSIO-360-F,FB and Aircraft Engines which have:

FAA Type Certificate Number E9CE

RATINGS:

Maximum continuous, sea level BHP — RPM . . . . 200 - 2575
  Manifold Pressure, in. Hg. at Sea Level 41
  Manifold Pressure, in. Hg. Critical Altitude (Feet) . . .41 - 12,000

CYLINDER DATA:

Number of Cylinders 6
Displacement (Cubic Inches) 360
Bore and Stroke (Inches) . . . . .4.44 x 3.88
Compression Ratio 7.5:1

PROPELLER DRIVE DATA:

Type . . . . .ARP 502 Modified
Direction of Rotation . . . . .Clockwise
Ratio (To Crankshaft) . . . . .Direct
Vibration Dampers, Number and Order . . . . . One 6th, One 4-1/2

FUEL SYSTEM

Type . . . . .Continuous Flow Fuel Injection
Make . . . . Continental
Fuel - Aviation Gasoline (Grade Min.) . . . . .100 or 100LL

LUBRICATION SYSTEM

Oil Specification MHS-24B
Oil Grade (SAE)
  Above 40°F. Ambient Air (Sea Level) 50
  Below 40°F Ambient Air (Sea Level) . . . . 30 or 10W-30
Sump Capacity, Quarts Maximum 8
  Usable Oil Quarts 25° Nose Up 5
  Usable Oil Quarts 18° Nose Down 5
Filter . . . . Full Flow

ACCESSORIES:

Magnetos . . . . .Bendix 25 Series
Ignition Harness . . . . . . 5MM Shielded (.750-20 Thd. Connection)
Spark Plugs . . 18MM x .750-20 Thd. Connection (FAA Approved)
Turbocharger. . . . . .Ray Jay
Oil Cooler . . . . Harrison
Alternator-12V, 65A . . . . Prestolite
Starter - 12V . . . . Prestolite

BASIC ENGINE WEIGHT NOT INCLUDING LISTED ACCESSORIES . . . . 342.05 lbs.

TOTAL ENGINE DRY WEIGHT WITH ACCESSORIES (SUBJECT TO PRODUCTION VARIATION OF ±2.5%) 393 lbs.

OPERATING LIMITS

OPERATION	MAX. CONTINUOUS HORSEPOWER	MAX. RECM. CLIMB	MAX. RECM. CRUISE	RECM. CRUISE	ECONOMY CRUISE	IDLE	RUN UP
%NRP	100	75	75	65	55	—	—
BHP (SEA LEVEL)	200	150	150	130	110	—	—
RPM	2575	2450	2450	2250	2100	—	1800 - 2000
MANIFOLD PRESSURE	41.0	33	33	32	30	—	—
FUEL FLOW (PPH)	FR	FR	See Fuel Flow Curve Page 29				
CYLINDER HEAD TEMPERATURE (F°)							
MINIMUM	240	240	240	240	240	—	200
NORMAL (Desired)	300-400	300-400	300-400	300-380	300-350	—	200-400
MAXIMUM	460	460	460	460	460	—	460
OIL TEMPERATURE (F°)							
MINIMUM	100	100	100	100	100	—	75
NORMAL (Desired)	160-200	160-180	160-180	160-180	160-180	—	75-180
MAXIMUM	240	240	240	240	240	—	240
OIL PRESSURE (PSI)							
MINIMUM	30	30	30	30	30	10	30
NORMAL	30-80	30-80	30-80	30-80	30-80	—	30-80
MAXIMUM	80	80	80	80	80	—	100**

SECTION II

NORMAL OPERATING PROCEDURE

CAUTION . . . This section pertains to operation under average climatic conditions. The pilot should thoroughly familiarize himself with Section V, Part 1, Abnormal Operating Conditions. Whenever such abnormal conditions are encountered or anticipated, the procedures and techniques for normal operation should be tailored accordingly. For example, if the aircraft is to be temporarily operated in extreme cold or hot weather, consideration should be given to an early oil change and/or a routine inspection servicing.

GENERAL.

The life of your engine is determined by the care it receives. Follow the instructions contained in this manual carefully.

The engine receives a run-in operation before leaving the factory. Therefore, no break-in schedule need be followed. Straight mineral oil (MIL-C-6529 Type II) should be used for the first oil change period (25 hours).

The minimum grade aviation fuel for this engine is 100 or 100LL. In case the grade required is not available, use a higher rating. Never use a lower rated fuel.

> WARNING . . . The use of a lower octane rated fuel can cause pre-ignition and/or detonation which can damage an engine the first time high power is applied. This would most likely occur on takeoff. If the aircraft is inadvertently serviced with the wrong grade of fuel, then the fuel must be completely drained and the tank properly serviced.

PRESTARTING.

Before each flight the engine and propeller should be examined for damage, oil leaks, security and proper servicing.

1. Position the ignition switch to the "OFF" position.

2. Operate all controls and check for binding and full range of travel.

3. Assure that fuel tanks contain proper type and quantity of fuel.

4. Drain a quantity of fuel from all sumps and strainers into a clean container. If water or foreign matter is noted, continue draining until only clean fuel appears.

5. Check oil level in sump.

6. Check cowling for security.

STARTING

1. Fuel Selector - On.

2. Battery Switch - On.

3. Ignition Switch - On.

4. Mixture - Full Rich.

5. Throttle - Full Open.

6. Prime - Pump on momentarily until indicating 6-10 gallons per hour, then off.

NOTE . . . The amount of prime required depends on engine temperature. Familiarity and practice will enable the operator to estimate accurately the amount of prime to use. If the engine is hot, use prime pump only long enough to purge fuel system of accumulated vapor.

7. Throttle - Open approximately 1 inch.

8. Starter - Engage until engine starts, then release.

CAUTION . . . Do not engage the starter when the engine is running as this may damage the starting mechanism.

9. Auxiliary Fuel Pump - Operate as instructed by aircraft manufacturer.

NOTE . . . Operation of auxiliary fuel pumps will facilitate fuel vapor suppression during hot weather operation.

CAUTION. . . If flooding is suspected (as may be evidenced by excess fuel running from the cylinder drain) proceed as follows:

1. Auxiliary Fuel Pump - Off.
2. Throttle - Open.
3. Mixture - Idle Cutoff.
4. Starter - Engage until engine starts, then release.
5. Throttle - Retard to 1200 RPM.
6. Mixture Full Rich.

CAUTION . . . If difficulty in starting is experienced, do not crank for longer than thirty seconds at a time as the starter motor may overheat. If the engine does not start after thirty seconds of cranking, allow a 3 to 5 minute cooling period before continued attempts.

10. Oil Pressure - Check. If no oil pressure is noted within 30 seconds (60 seconds in cold weather), shut down the engine and investigate.

CAUTION . . . Operation of the engine at too high a rotational speed before reaching minimum oil temperatures will cause loss of oil pressure.

GROUND RUNNING; WARM–UP.

Teledyne Continental aircraft engines are aircooled and therefore dependent on the forward speed of the aircraft for cooling. To prevent overheating, it is important that the following rules be observed.

1. Head the aircraft into the wind.

2. Operate the engine on the ground with the propeller in "Full Increase" RPM position.

3. Avoid prolonged idling at low RPM. Fouled spark plugs can result from this practice.

4. Leave mixture in "Full Rich". (See "Ground Operation at High Altitude Airports", Section I, for exceptions.)

5. Warm-up 900-1200 RPM.

PRE–TAKEOFF CHECK

1. Maintain engine speed at approximately 900 to 1000 RPM for at least one minute in warm weather, and as required during cold weather to prevent cavitation in the oil pump and to assure adequate lubrication.

2. Advance throttle slowly until tachometer indicates an engine speed of approximately 1200 RPM. Allow additional warm-up time at this speed depending on ambient temperature. This time may be used for taxiing to takeoff position. The minimum allowable oil temperature for run-up is 75°F.

CAUTION . . . Do not operate the engine at run-up speed unless oil temperature is 75°F. minimum. Operation of the engine at too high a speed before reaching minimum oil temperature will cause loss of oil pressure.

3. Perform all ground operations with cowling flaps, if installed, full open, with mixture control in "FULL RICH" position and propeller control set for maximum RPM (except for brief testing of propeller governor).

4. Restrict ground operations to the time necessary for warm-up and testing.

5. Increase engine speed to 1800-2000 RPM only long enough to perform the following checks:

a. Check Magnetos: Move the ignition switch first to "R" position and note engine RPM, then move switch back to "BOTH" position to clear the other set of spark plugs. Then move the switch to "L" position and note RPM. The difference between the two magnetos operated individually should not differ more than 50 RPM. Observe engine for excessive roughness during this check. Maximum allowable drop when operating on one magneto is 150 RPM.

If no drop in RPM is observed when operating on either magneto alone, the switch circuit should be inspected.

> WARNING . . . Absence of RPM drop when checking magnetos may indicate a malfunction in the ignition circuit. Should the propeller be moved by hand (as during preflight) the engine may start and cause injury to personnel. This type of malfunction should be corrected prior to continued operation of the engine.

CAUTION . . . Do not underestimate the importance of a pre-takeoff magneto check. When operating on single ignition, some RPM drop should be noted. Normal indications are 25-75 RPM drop and slight engine roughness as each magneto is switched off. Absence of a magneto drop may be indicative of an open switch circuit or improperly timed magneto. An excessive RPM drop usually indicates a faulty magneto or fouled spark plugs.

Minor spark plug fouling can usually be cleared as follows:

1. Magnetos - Both On.
2. Throttle - 2200 RPM.

3. Mixture - Move toward idle cutoff until RPM peaks and hold for ten seconds. Return mixture to full rich.

4. Magnetos - Recheck.

If the engine is not operating within specified limits, it should be inspected and repaired prior to continued operational service.

Avoid prolonged single magneto operation to preclude fouling of the spark plugs.

b. Check throttle and propeller operation

(1) Move propeller governor control toward low RPM position and observe tachometer. Engine speed should decrease to minimum governing speed (200-300 RPM drop). Return governor control to high speed position. Repeat this procedure two or three times to circulate warm oil into the propeller hub.

(2) Move propeller to "feather" position. Observe for 300 RPM drop below minimum governing RPM, then return control to "full increase" RPM position.

CAUTION . . . Do not operate the engine at a speed in excess of 2000 RPM longer than necessary to test operation and observe engine instruments. Proper engine cooling depends upon forward speed of the aircraft. Discontinue testing if temperature or pressure limits are approached.

6. Instrument Indications.

a. Oil Pressure: The oil pressure relief valve will maintain pressure within the specified limits if the oil temperature is within the specified limits and if the engine is not excessively worn or dirty. Fluctuating or low pressure may be due to dirt in the oil pressure relief valve or congealed oil in the system.

b. Oil Temperatures: The oil cooler and oil temperature control valve will maintain oil temperature within the specified range unless the cooler oil passages or air channels are obstructed. Oil temperature above the prescribed limit may cause a drop in oil pressure, leading to rapid wear of moving parts in the engine.

c. Cylinder Head Temperature: Any temperature in excess of the specified limit may cause cylinder or piston damage. Cooling of cylinders depends on cylinder baffles being properly positioned on the cylinder heads and barrels, and other joints in the pressure compartment being tight so as to force air between the cylinder fins. Proper cooling also depends on operation practices. Fuel and air mixture ratio will affect cylinder temperature. Excessively lean mixture causes overheating even when the cooling system is in good condition. High power and low air speed, may cause overheating by reducing the cooling air flow. The engine depends on ram air flow developed by the forward motion of the aircraft for adequate cooling.

d. Battery Charging: The ammeter should indicate a positive charging rate until the power used for starting has been replaced by the battery charging circuit, unless the electrical load on the alternator is heavy enough to require its full output. The ammeter reading should return to the positive side as soon as the load is reduced. A low charging rate is normal after the initial recharging of the battery. A zero reading or negative reading with no battery load indicates a malfunction in the alternator or regulator system.

CAUTION . . . The turbocharger has no oil temperature indicator. The oil temperature to the turbocharger is the same as indicated by the engine oil temperature gauge. The main shaft of this unit is lubricated by engine oil from the engine oil pressure system. The pressure indicated is measured at the turbocharger inlet. The engine oil must be warm, at least 100°F. before takeoff, to assure proper turbocharger operation. The engine must not be operated at high power until the oil has reached this temperature.

TAKEOFF.

a. Position mixture to "FULL RICH". Where installed, cowl flaps should be positioned as specified by aircraft manufacturer.

b. Position auxiliary fuel pump switch as instructed by aircraft manufacturer.

c. Slowly advance throttle to maximum allowable takeoff manifold pressure, 41.0 inches or red line on manifold pressure gauge.

NOTE . . . If the turbocharger and induction system are properly rigged, manifold pressure will increase to 41.0 inches of Hg. when the throttle is 2/3 open. Do not continue to advance the throttle if it is apparent that overboost will occur. If manifold pressure, RPM and fuel flow are in their respective maximum power ranges, maximum power is being developed even through the throttle is not fully open.

A momentary manifold pressure overshoot to 43 inches Hg. for less than 10 seconds, or stabilized full throttle indications up to 41.5 inches Hg. will not harm the engine.

In cold weather, 41.0" Hg. manifold pressure will be obtained with slightly less throttle angle.

CAUTION . . . When ambient temperature is below standard do not exceed the manifold pressure required to obtain 100% Rated Power. Refer to Section IV, Power Charts.

CAUTION . . . Avoid rapid throttle operation.

CLIMB.

a. Climb at 75% power and above must be done at "FULL RICH" mixture setting, with cowl flaps, if provided, set to

maintain desired temperature. If fuel flow exceeds that specified for power being used, then leaning to specified flow is recommended.

b. During climb (immediately after takeoff) observe manifold pressure and, if necessary, retard throttle to stay below 41.0 inch maximum manifold pressure setting (red line). DO NOT EXCEED THIS LIMIT

WARNING . . . Excessive overboosting will damage the engine and be cause for engine inspection or replacement.

c. Reduce to 75% climb power.

NOTE . . . Although this engine is approved for continuous operation at 100% of Rated Power (41" Hg. Manifold Pressure), it is seldom necessary or desirable to do so for long periods of time. Generally, when the aircraft has been configured for climbout, engine power should be reduced. Recommended power for normal climb is 75%. If power settings of greater than 75% NRP must be used, particular attention should be given to cylinder head, and oil temperature and mixture must be "FULL RICH"..

NOTE . . . Fuel flow during part throttle operation will usually be slightly higher than required. Although this extra richness is not harmful, it may be desirable to adjust the mixture control to achieve the exact fuel flow as specified in the Cruise Control Charts (Section IV). When the mixture is leaned during climb operation, use at least 80 pounds per hour at 75% NRP.

WARNING . . . At power settings above 75% NRP, do not use the E.G.T. gauge to determine "peak" E.G.T. If you attempt to determine the "peak" E.G.T. while the engine is operating at high power, burned valves, detonation, and possible engine failure can occur.

NOTE . . . Exhaust gas temperature in this installation is measured at the turbine inlet. (ie: T.I.T.)

CRUISE.

1. Set manifold pressure and RPM for cruise power selected.

2. After engine temperatures have stabilized at cruise conditon (usually within 5 minutes of operation), adjust mixture to obtain fuel flow according to the cruise control chart.

NOTE . . . During high ambient temperature, a very low fluctuation in fuel pressure may appear in the early flight stages, which is caused by excess vapor. If this occurs, operate the auxiliary fuel pump as recommended by aircraft manufacturer.

3. When an economy mixture setting (step 2, above) is used, and increased power is desired, the mixture control should be positioned to "FULL RICH" before changing the throttle or propeller setting.

NOTE . . . If an exhaust gas temperature gauge is used to monitor fuel flow, fuel mixture should be set no leaner than specifications listed on page 29.

4. If it is necessary to retard the throttle at altitudes above 10,000 feet, leaning of the fuel mixture may be required. Reset mixture to the richer setting before the throttle is returned to the high power position.

NOTE . . . Rapid throttle movements may cause undershooting or overshooting the desired manifold pressure and a subsequent adjustment will be required after the turbocharger temperatures have stabilized for the new power setting. Gradual throttle movement will permit the turbocharger temperatures to keep pace with the change in power.

DESCENT.

Normally, descent from high altitude will be accomplished at cruise power settings and mixture control positioned accordingly.

During descent, monitor cylinder and oil temperatures.

NOTE . . . Avoid long descents at low manifold pressure as the engine can cool excessively and may not accelerate satisfactorily when power is reapplied. If power must be reduced for long periods, adjust propeller to minimum governing RPM and set manifold pressure no lower than necessary to obtain desired performance. If the outside air is extremely cold, it may be desirable to add drag to the aircraft in order to maintain engine power without gaining excess airspeed. Do not permit cylinder temperature to drop below 240°F.

LANDING.

1. In anticipation of a go around and need for high power settings, the mixture control should be set in "FULL RICH" position before landing.

NOTE . . . Advance mixture slowly toward "FULL RICH". If engine roughness occurs, as may happen at very low throttle settings and high RPM, it may be desirable to leave the mixture control approximately 3/4 open until the throttles are advanced above 15 inches of manifold pressure.

2. Operate the auxiliary pump as instructed by aircraft manufacturer.

STOPPING ENGINE.

1. If auxiliary fuel pump has been on for landing, turn to "OFF".

2. Operate the engine at idle for approximately five minutes to allow the turbochargers to cool off and slow down.

NOTE . . . Taxi time after landing may be considered part of five minutes.

The turbochargers will generally spin from 1 to 2 minutes after the engines are shut down. If the engines are shut down too soon, and the turbochargers are still turning at high speed, the shaft bearings could become starved of lubrication. This can cause shaft bearing damage.

3. Place mixture control in "IDLE CUTOFF".

4. Turn magnetos "OFF".

SECTION III

IN–FLIGHT EMERGENCY PROCEDURES

If a malfunction should occur in flight, certain remedial actions may eliminate or reduce the problem. Some malfunctions which might conceivably occur are listed in this section. Recommended corrective action is also included; however, it should be recognized that no single procedure will necessarily be applicable to every situation.

A thorough knowledge of the aircraft and engine systems will be an invaluable asset to the pilot in assessing a given situation and dealing with it accordingly.

> **WARNING . . . Severe roughness may be sufficient to cause propeller separation. Do not continue to operate a rough engine unless there is no other alternative.**

ENGINE ROUGHNESS

Observe engine for visible damage or evidence of smoke or flame. Extreme roughness may be indicative of propeller blade failure. If any of these characteristics are noted, follow aircraft manufacturer's instructions.

1. Engine Instruments - Check. If abnormal indications appear, proceed according to Abnormal Engine Instrument Indications (this section).

2. Mixture - Adjust as appropriate to power setting being used. Do not arbitrarily go to Full Rich as the roughness may be caused by an already overrich mixture.

3. Magnetos - Check On.

If engine roughness does not disappear after the above, the following steps should be taken to evaluate the ignition system.

1. Throttle - Reduce power until roughness becomes minimal.

2. Magnetos - Turn Off, then On, one at a time. If engine smooths out while running on single ignition, adjust power as necessary and continue. Do not operate the engine in this manner any longer than absolutely necessary. The airplane should be landed as soon as practical and the engine repaired.

If no improvement in engine operation is noted while operating on either magneto alone, return all magneto switches to On.

CAUTION . . . The engine may quit completely when one magneto is switched off, if the other magneto is faulty. If this happens, close throttle to idle and move mixture to idle cutoff before turning magnetos on. This will prevent a severe backfire. When magnetos have been turned back on, advance mixture and throttle to previous settings.

WARNING . . . If roughness is severe or if the cause cannot be determined, engine failure may be imminent. In this case, it is recommended that the aircraft manufacturer's emergency procedure be employed. In any event, further damage may be minimized by operating at a reduced power setting.

TURBOCHARGER FAILURE.

Turbocharger failure will be evidenced by inability of the engine to develop manifold pressure above ambient pressure. The engine will revert to "normally aspirated" and can be operated, but will produce less than its rated horsepower.

Readjust mixture as necessary to obtain fuel flow appropriate to manifold pressure and RPM.

WARNING . . . If turbocharger failure is a result of a loose, disconnected or burned-through exhaust, then a serious fire hazard exists. The first choice should be to follow the aircraft manufacturer's emergency instructions. If turbocharger failure occurs before takeoff, DO NOT fly the aircraft. If failure occurs in flight, and the choice is made to continue operating the engine, proceed as follows:

NOTE . . . At altitudes above 12,000 feet an overrich mixture may result if the turbocharger fails and the engine may quit operating. If this occurs, employ the following procedure:

1. Mixture - Idle Cutoff.

2. Throttle - Full Open.

3. Propeller Control - Normal Cruise RPM.

4. Throttle - Retard to Cruise Position.

5. Mixture - Advance slowly. When the proper mixture ratio is reached, the engine will start. Continue to adjust the mixture control unit until the correct fuel flow for the manifold pressure and RPM is obtained.

NOTE . . . An interruption in fuel flow to the engine can cause engine failure due to turbocharger "run-down". At high altitude, merely restoring fuel flow may not cause the engine to restart, because the mixture will be excessively rich. If the engine does not restart, there will be insufficient mass flow through the exhaust to turn the turbine. This condition may give indications similar to a turbocharger failure. If a power loss is experienced followed by surging of RPM, fuel flow, and manifold pressure, the following steps are recommended:

1. Mixture Control - Idle Cutoff.

2. Fuel Selector - Position so as to permit use of auxiliary fuel pumps (boost pumps).

3. Auxiliary Fuel Pump - On.

4. Throttle - Set to normal cruise position.

5. Propeller - Adjust normal cruise RPM.

6. Mixture - Enrich slowly from idle cutoff. Engine starting will be apparent by a surge of power. As the turbocharger begins to operate, manifold pressure will increase and mixture can be adjusted accordingly.

7. Auxiliary Fuel Pump - Positioned according to aircraft manufacturer's instructions.

8. Mixture - Readjust if necessary.

NOTE . . . If this procedure does not effect a restart, descend below 12,000 feet and repeat. If the engine still will not start, the problem is likely other than fuel starvation or turbocharger failure.

ABNORMAL ENGINE INSTRUMENT INDICATIONS

HIGH CYLINDER HEAD TEMPERATURE.

1. Mixture - Adjust to proper fuel flow for power being used.

2. Cowl Flaps - Open.

3. Airspeed - Increase.

If temperature cannot be maintained within limits, reduce power. And have the engine inspected before further flight.

HIGH OIL TEMPERATURE.

NOTE . . . Prolonged high oil temperature indications will usually be accompanied by a drop in oil pressure. If oil pressure remains normal, then a high temperature indication may be caused by a faulty gauge or thermocouple. If the oil pressure drops as temperature increases, proceed as follows:

1. Cowl Flaps - Open.

2. Airspeed - Increase to normal climb or cruise speed.

3. Power - Reduce if steps 1 and 2 do not lower oil temperature.

CAUTION . . . If these steps do not restore oil temperature to normal, an engine failure or severe damage can result. In this case it is recommended that the aircraft manufacturer's emergency instructions for engine failure be followed.

LOW OIL PRESSURE.

If the oil pressure drops unexplainably from the normal indication of 30 to 80 psi, monitor temperature and pressure closely and have the engine inspected at termination of the flight. If oil pressure drops below 30 psi, an engine failure should be anticipated and the aircraft manufacturer's instructions for such should be followed.

IN–FLIGHT RESTARTING.

CAUTION . . . Actual shutdown of an engine for practice or training purposes should be minimized. Whenever engine failure is to be simulated, it should be done by reducing power. The turbocharger must receive lubricating oil pressure from the engine driven oil pump. A sudden decrease of oil pressure to the turbocharger bearings will cause excessive wear or possible failure.

Whenever a turbocharged engine is shutdown in flight, or when fuel flow is interruped, the turbocharger will "run down" due to lack of mass flow through the exhaust system. If the mixture is placed in "FULL RICH" during restart attempts at high altitude, the fuel flow may be excessive and the engine may fail to start due to overrich mixture. The degree of overrichness will depend primarily on altitude.

The key point in restarting is to increase fuel flow gradually from idle cutoff so the engine will start when a proper mixture is reached. As the mass flow through the exhaust system increases, the turbocharger will spin up and provide increased manifold pressure. The mixture may then be increased and power adjusted as desired.

The following procedure is recommended for in-flight restarting of an inoperative engine:

WITHOUT UNFEATHERING ACCUMULATORS

1. Mixture Control - Rich. (Consider above comments on effect of high altitude on mixture requirements)

2. Fuel Tank Selector - Main tank or as instructed by the aircraft manufacturer.
3. Magnetos - On.
4. Throttle - One-third (1/3) open.
5. Propeller Control - Full decrease RPM position (not feather).
6. Boost Pump - Prime, then off.
7. Starter - Engage until engine starts, or is driven by the propeller.

CAUTION . . . A few minutes exposure to temperatures and airspeed at flight altitudes can have the same effect on an inoperative engine as hours of cold-soak in sub-Arctic conditions. If the engine must be restarted, consideration should be given to descending to warmer air. Closely monitor for excessive oil pressure as the propeller is unfeathered. Allow the engine to warm up at minimum governing RPM and 16-18 inch of manifold pressure.

> **WARNING . . . Operating the engine at too high a rotational speed before reaching minimum oil temperature may cause loss of oil pressure.**

8. Power - Adjust as desired after engine cylinder and oil temperatures are within operating limits.

The following procedure is recommended for in-flight restarting of an inoperative engine:

WITH UNFEATHERING ACCUMULATORS

1. Mixture Control - Idle Cutoff.
2. Fuel Selector - Main tank, or as instructed by aircraft manufacturer.
3. Magnetos - On.

4. Throttle - Adjust to normal cruise position.

NOTE . . . If propeller has not been feathered, adjust to normal cruise RPM.

5. Propeller - Unfeather and adjust for minimum RPM.

6. Boost Pump - On, low boost or as instructed by aircraft manufacturer.

7. Mixture Control - Advance slowly until engine restart is accomplished. Starting will be apparent by slight surge of power and increase of manifold pressure as turbocharger begins to operate.

CAUTION . . . A few minutes exposure to temperatures and airspeed at flight altitudes can have the same effect on an inoperative engine as hours of cold-soak in sub-Arctic conditions. If the engine must be restarted, consideration should be given to descending to warmer air. Closely monitor for excessive oil pressure as the propeller is unfeathered. Allow the engine to warm up at minimum governing RPM and 16-18 inch of manifold pressure.

8. Power - Adjust as desired after engine cylinder and oil temperatures are within operating limits.

SECTION IV

ENGINE PERFORMANCE AND CRUISE CONTROL

The charts in this section are provided as a reference for use in establishing power conditions for takeoff, climb and cruise operation. Refer to aircraft manufacturers flight manual for tabular climb and cruise data.

CRUISE CONTROL BY CHART.

To determine actual horsepower, employ the following procedure:

1. Locate RPM and manifold pressure on altitude chart (Point "A").
2. Locate RPM and manifold pressure on sea level chart (Point "B").
3. Transfer "B" to sea level on altitude chart (Point "C").
4. Draw a line from "C" through "A".
5. Locate Point "D" at pressure altitude and read horsepower.
6. Correct horsepower for inlet air temperature as follows:
   a. Add 1% for each 6°F. below T_S
   b. Subtract 1% for each 6°F. above T_S
   (T_S = Standard Altitude Temperature)

CAUTION . . . When increasing power, enrich mixture, advance RPM and adjust throttle in that order. When reducing power, retard throttle, then adjust RPM and mixture.

NOTE . . . It may be necessary to make minor readjustments to manifold pressure and fuel flow (mixture) after changing RPM.

CRUISE CONTROL BY E.G.T.

If an exhaust gas temperature indicator is used as an aid to leaning, proceed as follows:

a Adjust manifold pressure and RPM for desired cruise setting.

b. Slowly move mixture control toward "lean" while observing E.G.T. gauge. Note position on the instrument where the needle "peaks" or starts to drop as mixture is leaned further.

c. Advance mixture control toward "rich" until EGT is colder than peak as indicated on performance charts.

NOTE . . . Best power mixtures are normally 150°F. rich of "peak" T.I.T.

NOTE. . .The TSIO-360-F,FB exhaust gas temperature is measured at the turbocharger turbine inlet and is commonly referred to as T.I.T.(Turbine Inlet Temperature).

WARNING . . . Continuous operation at T.I.T. in excess of 1650°F. is prohibited for all conditions.

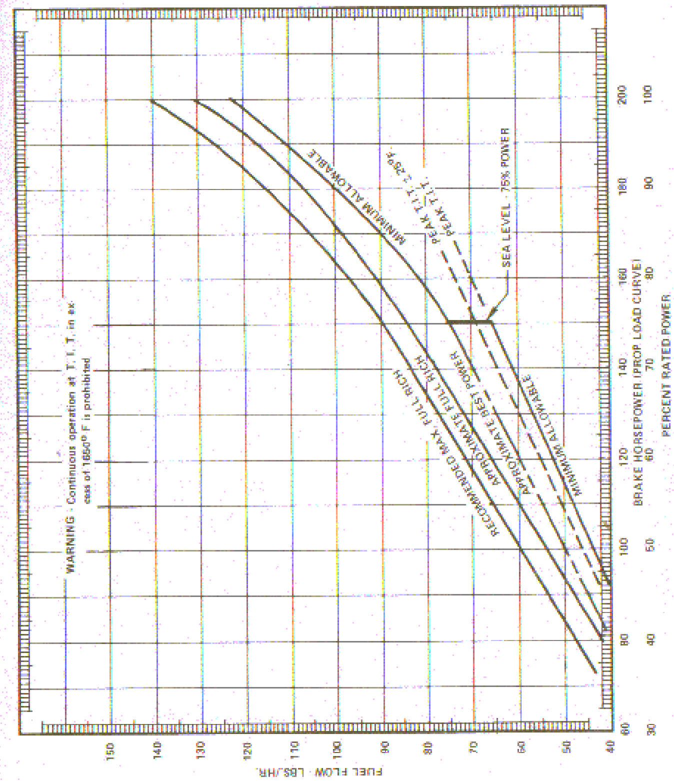


Figure 1. Limits - Fuel Flow Vs. Brake Horsepower.

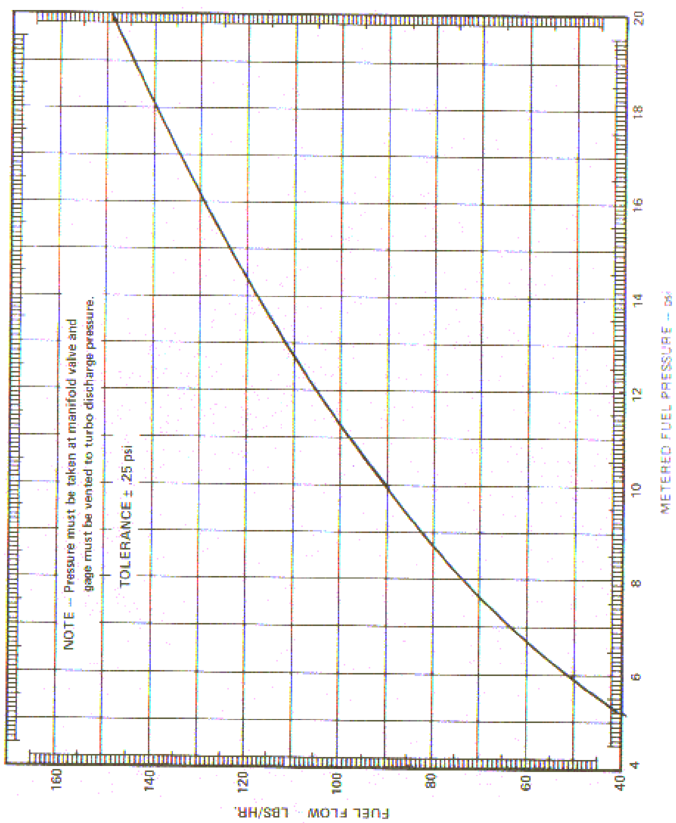


Figure 2. Metered Fuel Assembly Calibration.

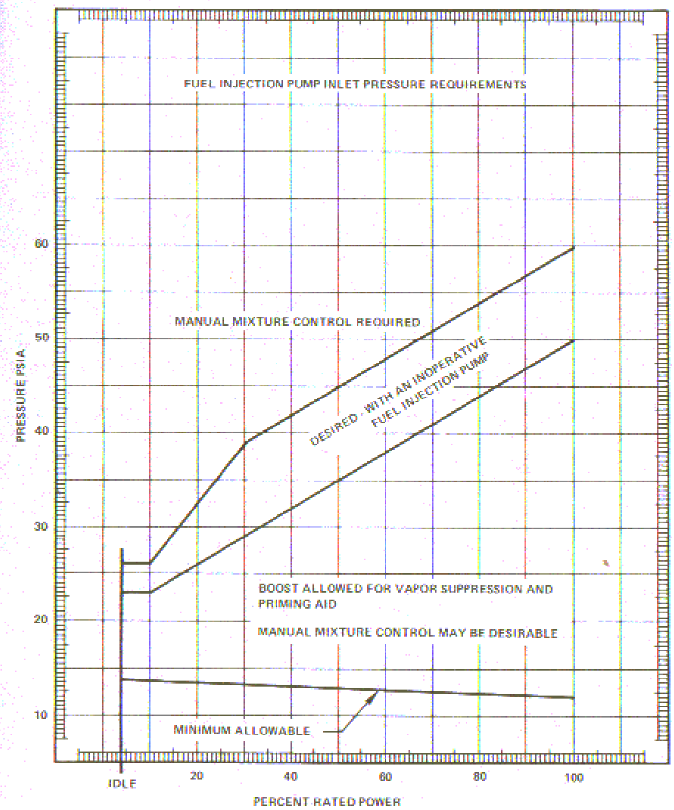


Figure 3. Fuel Injection Fuel Pump Inlet Pressure Vs. Percent of Rated Horsepower With 110°F. Avgas.

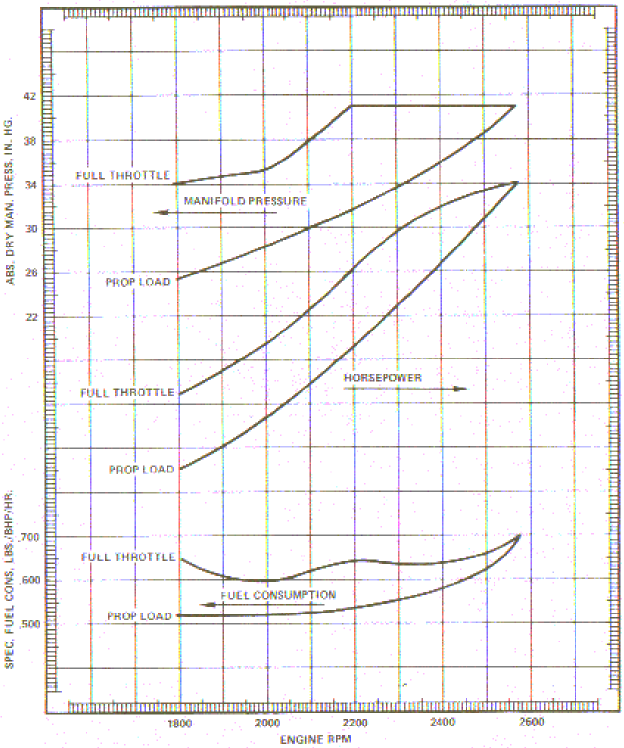


Figure 4. Sea Level Performance Curve.

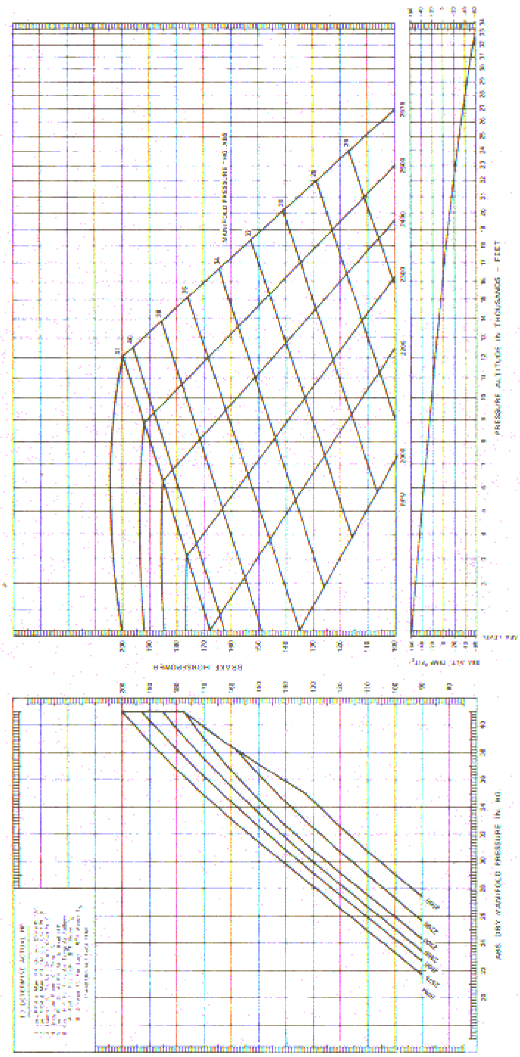


Figure 5. Altitude Performance Curve.

SECTION V

ABNORMAL ENVIRONMENTAL CONDITIONS

Three areas of operation may require special attention. These are (a) extreme cold weather, (b) extreme hot weather and (c) high altitude ground operation. The following may be helpful to the operator in obtaining satisfactory engine performance under adverse conditions.

COLD WEATHER OPERATION (Ambient Temperature Below Freezing).

NOTE . . . Prior to operation and/or storage in cold weather assure engine oil viscosity is SAE 30. In the event of temporary cold weather operation, not justifying an oil change to SAE 30, consideration should be given to hangaring the aircraft between flights.

Engine starting during extreme cold weather is generally more difficult than during temperate conditions. Cold soaking causes the oil to become more viscous and may rob even a fully charged battery of one-half its capacity. These conditions result in slow cranking speed and rapid discharge of the battery. At low temperatures, gasoline does not vaporize readily, further complicating the starting problem.

False starting (failure to continue running after starting) often results in the formation of moisture on the spark plugs due to condensation. This moisture can freeze and will necessitate thawing of the plugs either by removing them or applying heat to the engine.

PREHEATING.

The use of preheat and auxiliary power (battery cart) will facilitate starting during cold weather and is recommended when the engine has been cold soaked at temperatures of 10°F. and below in excess of two hours. Successful starts without these aids can be expected at temperatures below normal, provided the aircraft battery is in good condition and the ignition and fuel systems are properly maintained.

The following procedures are recommended for preheating, starting, warm-up, run-up and takeoff.

1. Select a high volume hot air heater. Small electric heaters which are inserted into the cowling "bug eye" do not appreciably warm the oil and may result in superficial preheating.

WARNING . . . Superficial application of preheat to a cold-soaked engine can have disastrous results.

A minimum of preheat application may warm the engine enough to permit starting but will not de-congeal oil in the sump, lines, cooler, filter, etc. Typically, heat is applied to the upper portion of the engine for a few minutes after which the engine is started and normal operation is commenced. The operator may be given a false sense of security by indications of oil and cylinder temperatures as a result of preheat. Extremely hot air flowing over the cylinders and oil temperature thermocouples may lead one to believe the engine is quite warm; however, oil in the sump and filter are relatively remote and will not warm as rapidly as a cylinder. For example, even when heat is applied directly, oil lines are usually "lagged" with material which does an excellent job of insulating.

Congealed oil in such lines may require considerable preheat. The engine may start and apparently run satisfactorily, but can be damaged from lack of lubrication due to congealed oil in various parts of the system. The amount of damage will vary and may not become evident for many hours. On the other hand, the engine may be severely damaged and could fail shortly following application of high power. Improper or insufficient application of preheat and the resulting oil and cylinder temperature indications may encourage the pilot to expedite his ground operation and

commence a takeoff prematurely. This procedure only compounds an already bad situation.

Proper procedures require thorough application of preheat to all parts of the engine. Hot air should be applied directly to the oil sump and external oil lines as well as the cylinders, air intake and oil cooler. Excessively hot air can damage non-metallic components such as seals, hoses and drive belts, so do not attempt to hasten the preheat process.

Before starting is attempted, turn the engine by hand or starter until it rotates freely. After starting, observe carefully for high or low oil pressure and continue the warm-up until the engine operates smoothly and all controls can be moved freely. Do not close the cowl flaps to facilitate warm-up as hot spots may develop and damage ignition wiring and other components.

2. Hot air should be applied primarily to the oil sump and filter area. The oil drain plug door or panel may provide access to these areas. Continue to apply heat for 15 to 30 minutes and turn the propeller, by hand, through 6 or 8 revolutions at 5 or 10 minute intervals.

3. Periodically feel the top of the engine and, when some warmth is noted, apply heat directly to the upper portion of the engine for approximately five minutes. This will provide sufficient heating of the cylinders and fuel lines to promote better vaporization for starting. If enough heater hoses are available, continue heating the sump area. Otherwise, it will suffice to transfer the source of heat from the sump to the upper part of the engine.

4. Start the engine immediately after completion of the preheating process. Since the engine will be warm, use normal starting procedure.

NOTE . . . Since the oil in the oil pressure gauge line may be congealed, as much as 60 seconds may elapse before oil pressure is indicated. If oil pressure is not indicated within one minute, shut the engine down and determine the cause.

5. Operate the engine at 1000 RPM until some oil temperature is indicated. Monitor oil pressure closely during this time and be alert for a sudden increase or decrease. Retard throttles, if necessary, to maintain oil pressure below 100 psi. If oil pressure drops suddenly to less than 30 psi, shut down the engine and inspect lubrication system. If no damage or leaks are noted, preheat the engine for an additional 10 to 15 minutes before restarting.

6. Before takeoff, run up the engine to 1800 RPM. If necessary, approach this RPM in increments to prevent oil pressure from exceeding 100 psi.

At 1800 RPM, adjust the propeller control to Full Decrease RPM until minimum governing RPM is observed, then return the control to Full Increase RPM. Repeat this procedure three or four times to circulate warm oil into the propeller dome. If the aircraft manufacturer recommends checking the propeller feathering system, move the control to the Feather position but do not allow the RPM to drop more than 300 RPM below minimum governing speed.

NOTE . . . Continually monitor oil pressure during run up.

7. Check magnetos in the normal manner.

HOT WEATHER OPERATION (Ambient Temperature in Excess of 90°F.)

CAUTION . . . *When operating in hot weather areas, be alert for higher than normal levels of dust, dirt or sand in the air. Inspect air filters frequently and be prepared to clean or replace them if necessary. Weather conditions can lift damaging levels of dust and sand high above the ground. In the event the aircraft should be flown through such conditions, an oil change is recommended as soon as is practical. Do not intentionally operate the engines in dust and/or sand storms. The use of dust covers on the cowling will afford additional protection for a parked aircraft.*

In-flight operation during hot weather usually presents no problem since ambient temperatures at flight altitudes are seldom high enough to overcome the cooling system used in modern aircraft design. There are, however, three areas of hot weather operation which will require special attention on the part of the operator. These are: (1) Starting a hot engine, (2) Ground operation under high ambient temperature conditions and (3) Takeoff and initial climbout.

1. Starting a Hot Engine. After an engine is shutdown, the temperature of its various components will begin to stabilize; that is, the hotter parts such as cylinders and oil will cool, while other parts will begin to heat up due to lack of air flow, heat conduction, and heat radiation from those parts of the engine which are cooling. At some time period following engine shutdown the entire unit will stabilize near the ambient temperature. This time period will be determined by temperature and wind conditions and may be as much as several hours. This heat soaking is generally at the worst from 30 minutes to one hour following shutdown. During this time, the fuel system will heat up causing the fuel in the pump and lines to "boil" or vaporize. During subsequent starting attempts, the fuel pump, which is a metering device, will initially be pumping some combination of fuel and fuel vapor. At the same time, the injection nozzle lines will be filled with varying amounts of fuel and vapor. Until the entire fuel system becomes filled with liquid fuel, difficult starting and unstable engine operation will be experienced.

Another variable affecting this fuel vapor condition is the state of the fuel itself. Fresh high octane fuel contains a concentration of volatile ingredients. The higher this concentration is, the more readily the fuel will vaporize and the more severe will be the problems associated with vapor in the fuel system. Time, heat or exposure to altitude will "age" aviation gasoline; that is, these volatile ingredients tend to dissipate. This reduces the tendency of fuel to vaporize and, up to a point, will result in reduced starting problems associated with fuel vapor. If the volatile condition reaches a low enough level, starting may become difficult due to poor vaporization at the fuel nozzles, since the fuel must vaporize in order to combine with oxygen in the combustion process.

The operator, by being cognizant of these conditions, can take certain steps to cope with problems associated with hot weather/hot engine starting. The primary objective should be that of permitting the system to cool. Low power settings during the landing approach will allow some cooling prior to the next start attempt. Ground operation tends to heat up the engine, therefore, minimizing this will be beneficial. Cowl flaps should be opened fully while taxiing. The aircraft should be parked so as to face into the wind to take advantage of the cooling effect. Restarting attempts will be the most difficult during the 30 minutes to one hour. Following that interval, the fuel vapor will be less pronounced and normally will present less of a restart problem.

Normal starting procedure should be used except that the throttle should be opened more while cranking.

2. Ground Operation Under High Ambient Temperature Conditions. Oil and cylinder head temperatures should be monitored closely during taxiing and engine run up. Operate with cowl flaps full open and do not operate the engines at high RPM except for necessary operational checking. If takeoff is not to be made immediately following engine run up, the aircraft should be faced into the wind and the engine idled at 900-1000 RPM. It may be desirable to operate the auxiliary fuel pumps at low pressure to assist in suppressing fuel vapor and provide more stable fuel pressure during taxiing and engine run up.

3. Takeoff and Initial Climbout. Do not operate at maximum power any longer than necessary to establish the climb configuration recommended by the aircraft manufacturer. Temperatures should be closely monitored and sufficient airspeed maintained to provide adequate cooling of the engine.

GROUND OPERATION AT HIGH ALTITUDE AIRPORTS.

Idle fuel mixture will be rich at high density altitudes. Under extreme conditions it may be necessary to manually lean the mixture in order to sustain engine operation at low RPM. When practical, operate the engines at higher idling speed.

SECTION VI

ENGINE DESCRIPTION

The designation TSIO-360-F,FB describes this engine as follows:

TS: Denotes "turbosupercharged".

I: Denotes "fuel injected".

O: Denotes "opposed", and refers to the horizontally-opposed cylinder arrangement.

360: Denotes piston displacement in cubic inches.

F: Denotes "specific engine model and configuration".

FB: Incorporates modified crankshaft

This engine is normal rotation (clockwise) as viewed from rear of engine.

OIL SYSTEM. (See Figure 6)

The oil supply is contained in an 8-quart, wet sump attached to the bottom of the crankcase. A conventional dipstick is provided for determining the oil quantity.

When the crankshaft is turning, oil is drawn through a screen and pick up tube which extends from the sump to a port in the crankcase. It then passes to the inlet of the gear-type, engine-driven oil pump and is forced under pressure through the pump outlet. A pressure relief valve prevents excessive oil pressure by allowing excess oil to be returned to the sump. After exiting the pump, the oil (now under pressure), enters a full-flow filter and is passed on to the oil cooler. If the filter element becomes blocked, a bypass relief valve will open to permit unfiltered oil to flow to the engine. As the oil enters the oil cooler, it will flow in one of two directions: (a) When the oil is cold, an oil temperature

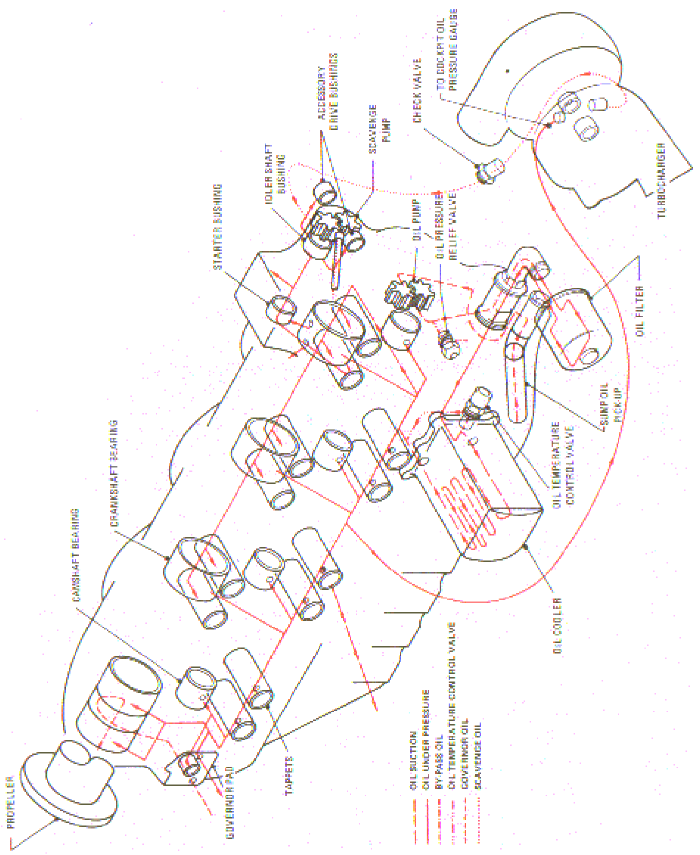


Figure 6. Lubrication Diagram

control unit will open and most of the oil will bypass the cooler. Some oil always flows through the cooler to help prevent congealing in cold weather. (b) As the oil warms, the oil temperature control unit actuates to close off the cooler bypass forcing the oil to flow through the cooler core. In operation, the oil temperature control unit modulates to maintain oil temperature in the normal range of approximately 170°F.

After leaving the cooler, the oil enters the crankcase where the various channels and passageways direct it to the bearing surfaces and other areas requiring lubrication and cooling. The propeller governor boosts engine oil pressure for operation of the propeller. It controls oil pressure going to the propeller hub to maintain or change propeller blade angles. This oil flows through the propeller shaft to reach the hub.

Other areas within the engine receiving oil include the valve lifters, inner piston domes and lower cylinder walls. A tap supplies oil pressure for lubrication of the turbocharger bearings. This oil is carried to the turbocharger through an external line. After lubricating the turbocharger bearings, it is drawn into a scavenge pump and returned to the oil sump. Oil within the engine drains, by gravity, back into the sump.

FUEL SYSTEM

The fuel injection system is of the multi-nozzle, continuous-flow type which controls fuel flow to match engine requirements (Figure 7). Any change in air throttle position, engine speed, deck pressure, or a combination of these causes changes in fuel pressure in the correct relation to the engine requirements. A manual mixture control, and a pressure gauge indicating metered fuel flow are provided for precise leaning at any combination of altitude and power setting. As fuel flow is directly proportioned to metered fuel pressure, settings can be predetermined and fuel consumption can be accurately predicted and controlled.

The continuous-flow system permits the use of a typical rotary vane pump with integral relief valve. With this system there is no

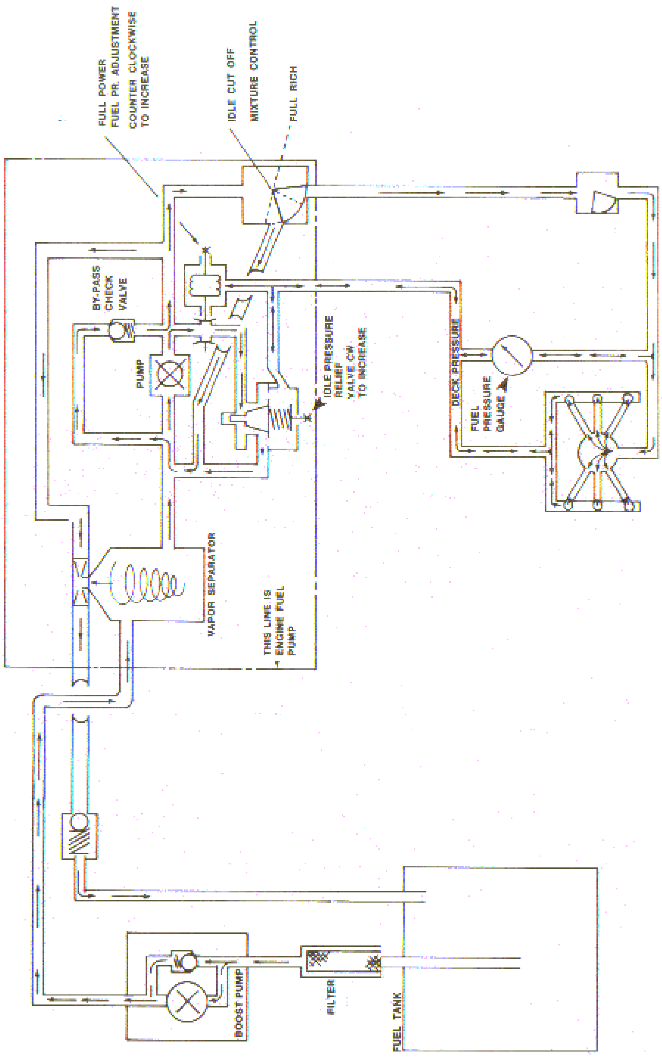


Figure 7. Fuel System Schematic

need for an intricate mechanism for timing injection to the engine.

The fuel injector pump is equipped with a vapor separator where the vapor is separated by a swirling and augmentor system from the solid fuel and returned to the tank. The fuel injector pump forces solid fuel into the metering unit assembly.

The fuel metering unit/air throttle controls the amount of intake air admitted into the intake manifold and meters the proportionate amount of fuel to the fuel manifold valve. The assembly has two control units; one for air in the air throttle assembly, and one for the fuel control unit.

The manifold valve receives fuel from the metering unit. When fuel pressure reaches approximately 3.5 psi, a check valve opens and admits fuel to six ports in the manifold valve (one port for each fuel nozzle line). The manifold valve also serves to provide a clean cutoff of fuel to the cylinder when the engine is shut down.

The injector nozzle lines connect the manifold valve to the six fuel injector nozzles.

The injector nozzles (one per cylinder) are "air bleed" type fuel nozzles which spray fuel directly into the intake port of the cylinder. When the engine is running, flow through the nozzle is continuous and will enter the cylinder combustion chamber when the intake valve opens.

Since the size of the fuel nozzles is fixed, the amount of fuel flowing through them is determined by the pressure applied. For this reason, fuel flow may be accurately determined by measuring the pressure at the manifold valve.

All of the items described above are interdependent on each other to meter the correct amount of fuel according to the power being developed by the engine.

INDUCTION SYSTEM. (See Figure 8)

The induction system components include the aircraft filter/alternate air door, turbocharger compressor, throttle, manifold tube and cylinder intake ports. Air flows through these components in the order they are listed.

The filter normally accepts all incoming air from the aircraft intake scoop. Should the filter become blocked for any reason, the alternate air door will open to preclude engine stoppage.

The turbocharger compressor is a high volume air pump connected to the opposite end of the turbocharger turbine (see Turbocharger System). It increases the volume and pressure of air admitted to the cylinder for combustion. At high compressor discharge pressures, considerable heating of the induction air occurs, due to compression.

The intake manifold system is a six-tube, air distribution system mounted atop the engine. It serves to carry induction air to the individual cylinder intake ports.

The cylinder intake ports are cast into the cylinder head assembly. Air from the manifold tube is carried into the intake ports, mixed with fuel from the injector nozzles, and enters the cylinder as a combustible mixture when the intake valve opens.

Overboost protection is provided by a pressure relief valve located between the compressor and the throttle. The relief valve will open to prevent excessive manifold pressure.

TURBOCHARGER.

The complete turbocharger system consists of a turbine and compressor assembly, wastegate assembly, necessary hose, and ducting required for a functional installation (Figure 9).

The wastegate assembly is ground adjustable. When open, the valve allows exhaust gas to bypass the turbine and flow directly

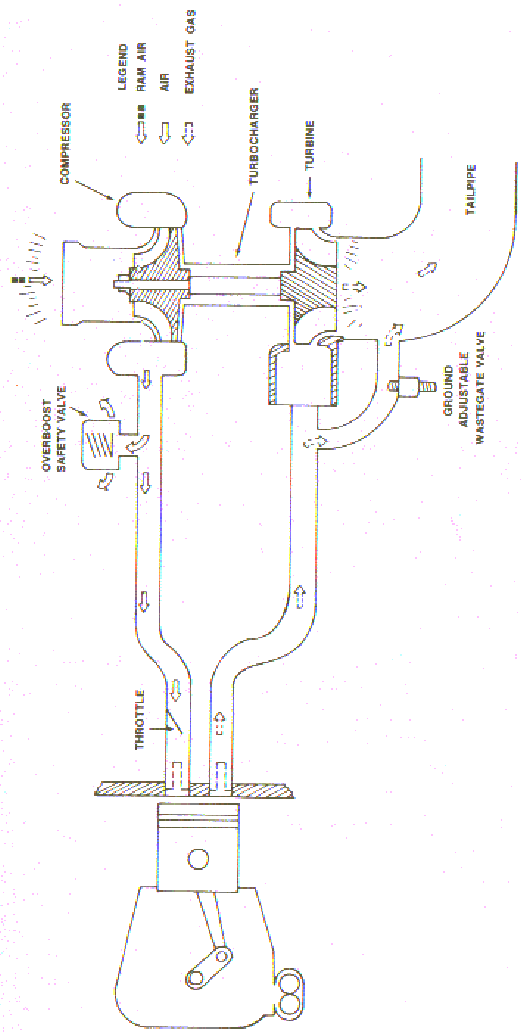


Figure 8. Induction System Schematic.

overboard. In the closed position, the wastegate valve diverts the exhaust gases into the turbine.

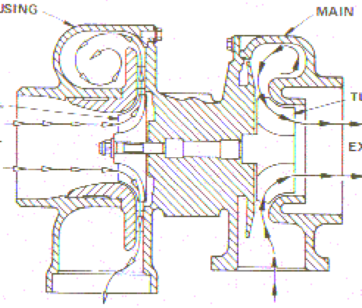


Figure 9. Turbocharger Schematic.

CYLINDERS.

Before assembly, the aluminum cylinder heads are heated and screwed on to the steel alloy barrels. The valve guides and seats are pressed into the hot cylinder head. When the entire unit has cooled, a permanent cylinder assembly results. Replaceable helical coil inserts are installed in the spark plug ports.

VALVES.

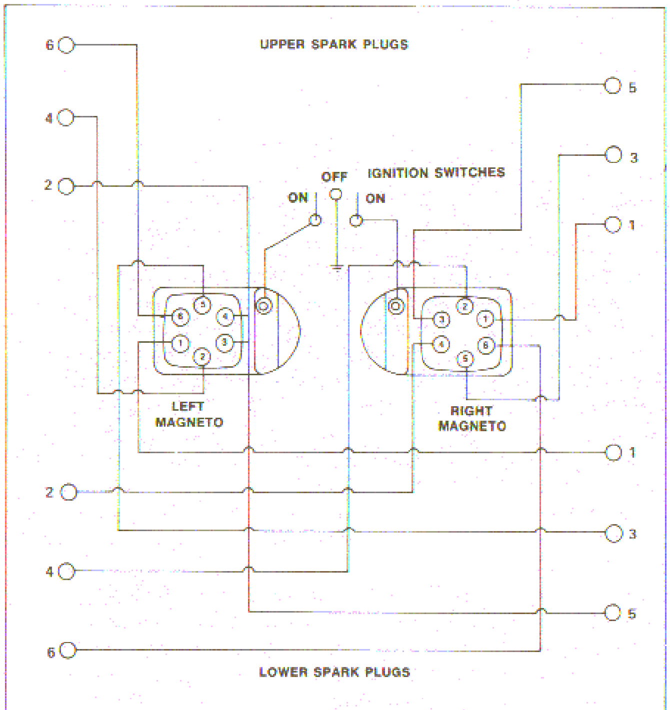
Exhaust valves are faced with a special heat and corrosion-resistant material and the valve stems are chromed for wear resistance. Oil fed to the hydraulic valve lifters, under pressure from the main galleries, lubricates the lifter guide surfaces and fills the reservoirs inside the lifters. Oil from the lifters which reaches the pushrod ends flows through the pushrods to the rocker arms. Each rocker directs a portion of its oil through a nozzle towards the respective

valve stem. Oil is returned to the crankcase through the pushrod housings, which are sealed to the cylinder head and crankcase by rubber seals. Drain holes in the lifter guides direct returning oil to the sump.

IGNITION SYSTEM.

(a) Torque from the engine crankshaft is transmitted through the camshaft gear to the magneto drive gears, which in turn drives the magneto drive coupling. The magneto incorporates an impulse coupling. As the rubber bushings in the drive gear turns the coupling drive lugs, counterweighted latch pawls, inside the coupling cover, engage pins on the magneto case and hold back the latch plate until forced inward by the coupling cover. When the latch plate is released, the coupling spring spins the magneto shaft through its neutral position and the breaker opens to produce a high voltage surge in the secondary coil. The spring action permits the latch plate, magnet and breaker to be delayed through a lag angle of 30 degrees of drive gear rotation during the engine cranking period. Two lobes on the breaker cam produce two sparks per revolution of the drive shaft. After engine is started, counterweights hold the latch pawls away from the stop pins and the magneto shaft is driven at full advance.

(b) Engine firing order is 1-6-3-2-5-4 (TSIO-360-F,FB), (Figure 10). Observe the position of the No.1 cable terminal in the magneto case. As viewed from the distributor end, the TSIO-360-F,FB magneto rotor turns counterclockwise, passing in succession the terminals of spark plug cables in engine firing order. Cables are connected to the magnetos so that the right magneto fires the upper plugs on the right side and lower plugs on the left. The left magneto fires the upper plugs on the left and the lower plugs on the right. The magneto cases, spark plugs, cables and connections are shielded to prevent radio interference.



ENGINE FIRING ORDER	1	6	3	2	5	4
MAGNETO FIRING ORDER	1	2	3	4	5	6

Figure 10. Engine Firing Order.

SECTION VII

SERVICING AND INSPECTION

SERVICING.

Maximum efficiency and engine service life can be expected when a sound inspection program is followed. Poor maintenance results in faulty engine performance and reduced service life. Efficient engine operation demands careful attention to cleanliness of air, fuel, oil and maintaining operating oil temperatures within the required limits.

Good common sense is still the rule, but certain basic maintenance and operational requirements, that we find widely disregarded, do determine, to a large degree, the service life of the modern aircraft engine.

Fuel — Aviation Grade 100 or 100 LL

WARNING . . . The use of a lower octane rated fuel can result in destruction of an engine the first time high power is applied. This would most likely occur on takeoff. If the aircraft is inadvertantly serviced with the wrong grade of fuel, then the fuel must be completely drained and the tank properly serviced.

Oil: (First 25 hours operation) — Mineral (Non-Detergent) oil (MIL-C-6529 Type II)

Normal Service — SAE 50 (Above 40°F)
SAE 30 (Below 40°F)

Oil Sump Capacity: — 8 U.S. Quarts

Oil Change Interval: — 100 hours

Filter Change Interval: 50 hours

NOTE . . . The use of multi-viscosity oil is approved.

CAUTION . . . Use only oils conforming to Teledyne Continental Motors Specification MHS-24B after break-in period.

The marketers of the aviation lubricating oil listed below have supplied data to Teledyne Continental Motors indicating their products conform to all the requirements of TCM Specification MHS-24B, Lubricating Oil, Ashless Dispersant.

In listing the product names, TCM makes no claim of verification of marketer's statements or claims. Listing is made in the order in which the data was received by TCM, and is provided only for the convenience of the users.

APPROVED PRODUCTS.

Supplier	Brand Name
Phillips Petroleum Co.	Phillips 66 Aviation Oil, Type A
Shell Oil Company	Aeroshell Oil W
Continental Oil	Conoco Aero S
Texaco, Inc.	Texaco Aircraft Engine Oil - Premium AD
Mobil Oil Company	Mobil Aero Oil
Castro Limited (Australia)	Castrolaero AD Oil
Pennzoil Company	Pennzoil Aircraft Engine Oil
Sinclair Oil Company	Sinclair Avoil
Humble Oil & Refining Company	Esso Aviaion Oil Enco Aviation Oil
Delta Petroleum Company	Delta Avoil Oil
Union Oil Company of California	Union Aircraft Engine Oil HD
Gulf Oil Company	Gulfpride Aviation AD

INSPECTIONS.

The following procedures and schedules are recommended for engines which are subjected to normal operation. If the aircraft is exposed to severe conditions, such as training, extreme weather, or infrequent operation, inspections should be more comprehensive and the hourly intervals decreased.

DAILY INSPECTION (PREFLIGHT).

Before each flight the engine and propeller should be examined for damage, oil leaks, proper servicing and security. Ordinarily the cowling need not be opened for a daily inspection.

50 AND 100 HOUR INSPECTIONS.

Detailed information regarding adjustments, repair and replacement of components may be found in the appropriate Service Manual. The following items should be checked during normal inspections:

50 HOUR INSPECTION

1.	Engine Conditions:	Magneto RPM drop:	Check
		Full Power RPM:	Check
		Full Power Manifold Pressure:	Check
		Full Power Fuel Flow:	Check
		Idle RPM:	Check

Record any values not conforming to engine specifications in order that necessary repair or adjustment can be made.

2.	Oil Filter:	Replace filter.
3.	Air Filter:	Inspect and clean or replace as necessary.
4.	Wastegate Assembly:	Check for condition and safetying.

5.	High Tension Leads:	Inspect for chafing and deterioration.
6.	Magnetos:	Check and adjust only if discrepancies were noted in Step 1.
7.	General:	Check hoses, lines, wiring, fittings, baffles, etc. for general condition.
8.	Adjustments & Repairs:	Perform service as required on any items found defective.
9.	Engine Condition:	Run up and check as necessary for any items serviced in Step 8. Check engine for oil leaks before returning to service.

100 HOUR INSPECTION.

Perform all items listed under 50 Hour inspection, and add the following:

1.	Oil	Drain while engine is warm. Refill sump.
2.	Valves/Cylinders:	Check compression (refer to Service Bulletin M73-19).
3.	Spark Plugs:	Inspect, clean, regap (if necessary) and reinstall. Rotate plugs from upper to lower position and visa versa to improve plug life.
4.	Cylinder, Fins, Baffles:	Inspect.
5.	Control Connections:	Inspect and Lubricate.
6.	Fuel and Oil Hoses and Lines:	Inspect for deterioration, leaks, chafing.

7.	Fuel Nozzles:	Inspect nozzles and vent manifold for leaks or damage.
8.	Turbocharger:	Check freedom of rotation.
9.	Exhaust:	Check all fittings for condition and leaks.
10.	Alternate Air Door:	Check Operation.
11.	Magnetos:	Check. Adjust points and timing if necessary.

NOTE . . . Minor changes in magneto timing can be expected during normal engine service. The time and effort required to check and adjust the magnetos to specifications is slight and the operator will be rewarded with longer contact point and spark plug life, smoother engine operation and less corrective maintenance between routine inspections.

12.	Oil Pressure Relief Valve:	Inspect and clean.
13.	Oil Temperature Control Unit:	Inspect and clean.
14.	Throttle Shaft and Linkage:	Lubricate.
15.	High and Low and Unmetered Fuel Pressure:	Check. Adjust if necessary.
16.	Adjustments and Repairs:	Perform service as required on any items found defective.
17.	Engine Condition:	Perform complete run up. Check engine for fuel or oil leaks before returning to service.

SECTION VIII

WARNING . . . Do not attempt to use this manual as a guide for performing repair or overhaul of the engine. The Engine Overhaul Manual must be consulted for such operations.

TROUBLE SHOOTING

The trouble shooting chart which follows, discusses symptoms which can be diagnosed and interprets the results in terms of probable causes and the appropriate corrective action to be taken.

For additional information on more specific trouble shooting procedures, refer to Maintenance and Overhaul Manual.

All engine maintenance should be performed by a qualified mechanic. Any attempt by unqualified personnel to adjust, repair or replace any parts, may result in damage to the engine.

WARNING . . . Operation of a defective engine without a preliminary examination can cause further damage to a disabled component and possible injury to personnel. By careful inspection and trouble shooting, such damage and injury can be avoided and, in addition, the causes of faulty operation can be determined without excessive disassembly.

This trouble shooting chart is provided as a guide. Review all probable causes given, check other listings of troubles with similar symptoms. Items are presented in sequence of the approximate ease of checking, not necessarily in order of probability.

TROUBLE SHOOTING CHART

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
1. Engine will not start.	a. No fuel gauge pressure- No Fuel to engine.	a. Check fuel control for proper position, boost pump "ON" and operating, feed valves open. Fuel filters open, and tank fuel level.
	b. Have gauge pressure - Engine flooded.	b. Turn off auxiliary pump and ignition switch, set throttle to "FULL OPEN" and fuel control to "IDLE CUTOFF", and crank engine to clear cylinders of excess fuel. Repeat starting procedure.
	c. Have gauge pressure - No fuel to engine.	c. Check for bent or loose fuel lines. Loosen one line at fuel nozzle. If no fuel shows replace fuel manifold valve.
2. Engine starts but fails to keep running.	a. Inadequate fuel to fuel manifold valve.	a. Set fuel control in "FULL RICH" position turn auxiliary pump "ON", check to be sure feed lines and filters are not restricted. Clean or replace defective components.
	b. Defective ignition system.	b. Check accessible ignition cables and connections. Tighten loose connections. Replace defective spark plugs.
3. Engine runs rough at idle.	a. Improper idle mixture adjustment.	a. Readjust idle setting. Turn adjustment screw clockwise to lean mixture and counter clockwise to richen mixture.
	b. Fouled spark plugs.	b. Remove and clean plugs, adjust gaps. Replace defective plugs.
	c. Discharge nozzle air vent manifolding restricted or defective.	c. Check for bent or loose connections. Tighten loose connections. Check for restrictions and replace defective components.
4. Engine has poor acceleration.	a. Idle mixture too lean.	a. Readjust idle setting. Clockwise to lean mixture and counter clockwise to richen mixture.
	b. Incorrect fuel-air mixture.	b. Tighten loose connections, Service air cleaner.
	c. Defective ignition system.	c. Check accessible ignition cables and connections. Replace defective spark plugs.
	d. Malfunctioning turbocharger.	d. Check operation, listen for unusual noise. Check wastegate valve and exhaust system for defects. Tighten loose connections.

5.	Engine runs rough at speeds above idle.	a. Improper fuel-air mixture.	a. Check manifold connections for leaks. Tighten loose connections. Check fuel control for setting and adjustment. Check fuel filters and screens for dirt. Check for proper pump pressure, and readjust as necessary.
		b. Restricted fuel nozzle.	b. Remove and clean all nozzles.
		c. Ignition System and spark plugs defective.	c. Clean and regap spark plugs. Check ignition cables for defects. Replace defective components.
6.	Engine lacks power, reduction in maximum manifold pressure or critical altitude.	a. Incorrectly adjusted throttle control, "sticky" linkage or dirty air cleaner, wastegate adjusted improperly.	a. Check movement of linkage by moving control from idle to full throttle. Make proper adjustments and replace worn components. Service air cleaner.
		b. Defective ignition system.	b. Inspect spark plugs for fouled electrodes, heavy carbon deposits, erosion of electrodes, improperly adjusted electrode gaps and cracked procelains. Test plugs for regular firing under pressure. Replace damaged or misfiring plugs. Spark plug gap to be 0.015 to 0.019 inch.
		c. Improperly adjusted wastegate valve.	c. For adjustment of wastegate, see aircraft manufacturer's instructions.
		d. Loose or damaged exhaust system.	d. Inspect entire exhaust system to turbocharger for cracks and leaking connections. Tighten connections and replace damaged parts.
		e. Loose or damaged manifolding.	e. Inspect entire manifold system for possible leakage at connections. Replace damaged components, tighten all connections and clamps.
		f. Fuel nozzles defective.	f. Inspect fuel nozzle vent manifolding for leaking connections. Tighten and repair as required. Check for restricted nozzles and lines and clean and replace as necessary.

		g.	Malfunctioning turbocharger.	g.	Check for unusual noise in turbocharger. If malfunction is suspected remove exhaust and/or air inlet connections and check rotor assembly for possible rubbing in housing, damaged rotor or defective bearings. Replace turbocharger if damage is noted.
		h.	Exhaust system gas leakage.	h.	Inspect exhaust system for gas leakage, gaskets at cylinder exhaust ports, slip joints, gaskets at turbine inlet flanges, etc., and correct as necessary.
7.	Low Fuel Pressure.	a.	Restricted flow to fuel metering valve.	a.	Check mixture control for full travel. Check for restrictions in fuel filters and lines. Clean filters, replace damaged parts.
		b.	Fuel nozzle vent system defective causing improper pressure regulation.	b.	Check venting system for leaks at connections and other defects. Tighten connections and replace defective parts
		c.	Fuel control lever interference.	c.	Check operation of throttle and mixture control and adjust as required to obtain correct operation.
		d.	Incorrect fuel injector pump adjustment and operation.	d.	Check and adjust using appropriate equipment. Replace defective pumps.
		e.	Defective fuel injector pump relief valve.	e.	Replace pump if cleaning and lapping valve does not correct problem.
		f.	Air leakage in fuel pump pressurization line.	f.	Locate cause of leakage and correct.
8.	High Metered Fuel Pressure Indication.	a.	Restricted flow beyond fuel control assembly.	a.	Check for restricted fuel nozzles or fuel manifold valve. Clean or replace nozzles Replace defective fuel manifold valve
		b.	Defective relief valve operation in fuel injection pump.	b.	Check fuel injection pump control line from throttle body adapter for loose connections and defects. Tighten connections, replace damaged line.
		c.	Restricted recirculation passage in fuel injector pump.	c.	Replace pump.
		d.	Air leakage in fuel gauge vent pressurization line.	d.	Locate cause of leakage and eliminate

9. Fluctuating Fuel Pressure.	a.	Vapor in fuel system. excess fuel temperature.	a.	Normally operating the auxiliary pump will clear systems. Operate auxiliary pump and purge system.
	b.	Fuel gauge line leak or improperly purged line.	b.	Purge gauge line and tighten connections.
10. Low Oil Pressure on Engine Gauge.	a.	Insufficient oil in oil sump, oil dilution, or using improper grade oil for prevailing ambient temperature.	a.	Add oil or change oil to proper Viscosity.
	b.	Defective check valve in turbocharger oil supply line.	b.	Disassemble and clean valve or replace
	c.	High Oil temperature.	c.	Oil cooler dirty exterior or interior. Defective oil temperature control unit in oil cooler. Replace valve or clean oil cooler.
	d.	Leaking, damaged or loose oil line connection. Restricted screens and filter.	d.	Check for restricted lines and loose connections, partially plugged oil filter and screens. Clean parts, tighten connections and replace defective parts.
11. Poor Engine Idle Cutoff.	a.	Engine getting fuel.	a.	Check fuel control for being in full IDLE CUTOFF" position. Check auxiliary pump for being "OFF". Check for leaking fuel manifold valve. Replace defective components.
12. White Smoke Exhaust.	a.	Turbo coking, oil forced through seal turbine housing.	a.	Clean or change turbocharger.

SECTION IX

STORAGE AND REMOVAL FROM STORAGE

A. FLYABLE STORAGE (7 to 30 DAYS).

1. **Preparation for Storage.** If an aircraft, which has been in operation, is to be stored much longer than a week under normal climatic conditions, and if periodic running to circulate the oil will not be carried out, it is advisable to prepare the engine for storage in the following manner:

a. Operate the engine until the oil temperature reaches the normal range. Drain the oil supply from the sump as completely as possible, and replace the drain plug.

b. Fill the sump to the full mark on the dipstick gauge with MIL-C-6529 Type II oil which will mix with normal oil, which is suitable as a lubricant, and will provide protection against corrosion.

c. Run the engine at least five minutes at a speed between 1200 and 1500 RPM with the oil temperature and cylinder head temperature in the normal operating range.

2. During Flyable Storage.

a. Each seven days during flyable storage, the propeller shall be rotated by hand without running the engine. After rotating the engine six revolutions, stop the propeller 45° to 90° from the position it was in.

b. If at the end of thirty (30) days the aircraft will not be removed from storage, the engine shall be started and run. The preferred method will be to fly the aircraft for thirty (30) minutes. If flying is impractical, a ground run shall be made of thirty (30) minute duration, and up to, but not exceeding normal oil and cylinder temperatures.

3. Preparation for Service.

a. If the engine has a total time of more than twenty-five (25) hours, the MIL-C-6529 oil shall be drained after a ground warm-up. Install the TCM recommended oil before flight. It should be noted that MIL-C-6529 Type II is the TCM recommended oil for the first twenty-five (25) hours of flight.

B. TEMPORARY STORAGE (UP TO 90 DAYS).

1. Preparation for Storage.

a. Remove top and bottom spark plugs and atomize spray preservative oil, (Lubrication Oil-Contact and Volatile, Corrosion-Inhibited, MIL-L-46002, Grade 1) (221° - 250°) through upper spark plug hole of each cylinder with the piston in the down position. Rotate crankshaft as each pair of cylinders is sprayed. Stop crankshaft with no piston at top position.

NOTE . . . Shown below are some approved preservative oils recommended for use in Teledyne Continental engines for temporary storage.

MIL-L-46002, Grade 1 Oils:

Nucle Oil 105	-	Daubert Chemical Co. 4700 S. Central Avenue Chicago, Illinois
Petrotect VA	-	Pennsylvania Refining Co. Butler, Pennsylvania
Ferro-Gard 1009-G	-	Ranco Laboratories, Inc. 3617 Brownsville Road Pittsburgh, Pennsylvania

b. Re-spray each cylinder without rotating crank. To thoroughly cover all surfaces of the cylinder interior, move the nozzle or the spray gun from the top to the bottom of the cylinder.

c. Reinstall spark plugs.

d. Apply preservative to engine interior by spraying the above specified oil (approximately 2 ounces) through the oil filler tube.

e. Seal all engine openings exposed to the atmosphere using suitable plugs, or non-hygroscopic tape, and attach red streamers at each point.

f. Engines, with propellers installed, that are preserved for storage in accordance with this section should have a tag affixed to the propeller in a conspicuous place with the following notation on the tag: "DO NOT TURN PROPELLER - ENGINE PRESERVED".

2. Preparation for Service.

a. Remove seals, tape, paper and streamers from all openings.

b. With bottom plugs removed, hand turn propeller several revolutions to clear excess preservative oil, then reinstall plugs.

c. Conduct normal start up procedure.

d. Give the aircraft a thorough cleaning, visual inspection and test flight.

SECTION X

GLOSSARY

ADMP—Absolute dry manifold pressure. It is used in establishing base-line standards of engine performance. Manifold pressure is the absolute pressure in the intake manifold; it is expressed in inches of mercury ("Hg).

AMBIENT—A term used to denote a condition of the surrounding atmosphere at a particular time. For example: Ambient Temperature or Ambient Pressure.

BHP—Brake Horsepower. The power actually delivered to the engine propeller shaft. It is so called because it was formerly measured by applying a brake to the power shaft of an engine. The required effort to brake the engine could be converted to horsepower—hence: "brake" horsepower.

BSFC—Brake Specific Fuel Consumption. Fuel consumption stated in pounds per hour per brake horsepower. For example, an engine developing 200 horsepower while burning 100 pounds of fuel per hours, has a BSFC of .5.

$$\frac{\text{Fuel consumption in PPH}}{\text{Brake horsepower}} = .5$$

COLD SOAKING—Prolonged exposure of an object to cold temperatures so that its temperature throughout approaches that of ambient.

CRITICAL ALTITUDE—The maximum altitude at which a component can operate at 100% capacity. For example, an engine with a critical altitude of 16,000 feet cannot produce 100% of its rated manifold pressure above 16,000 feet.

DENSITY ALTITUDE—The effective altitude, based on prevailing temperature and pressure, equivalent to some standard pressure altitude.

DYNAMIC CONDITION—A term referring to properties of a body in motion.

EXHAUST BACK PRESSURE—Opposition to the flow of exhaust gas, primarily caused by the size and shape of the exhaust system. Atmospheric pressure also affects back pressure.

E. G. T—Exhaust gas temperature. Measurement of this gas temperature is sometimes used an an aid to fuel flow management.

FOUR CYCLE—Short for "Four Stroke Cycle". It refers to the four strokes of the piston in completing a cycle of engine operation (Intake, Compression, Power and Exhaust).

FUEL INJECTION—A process of metering fuel into an engine by means other than a carburetor.

GALLERY—A passageway in an engine or component. Especially one through which oil is flowed.

"Hg—"Inches of Mercury". A standard for measuring pressure, especially atmospheric pressure or manifold pressure.

HUMIDITY—Moisture in the atmosphere. Relative humidity, expressed in percent, is the amount of moisture (water vapor) in the air compared with the maximum amount of moisture the air could contain at a given temperature.

IMPULSE COUPLING—A device used in some magnetos to retard the ignition timing and provide higher voltage at cranking speeds for starting.

LEAN LIMIT MIXTURE—The leanest mixture permitted for any given power condition. It is not necessarily the leanest mixture at which the engine will run.

MANIFOLD PRESSURE—Pressure as measured in the intake manifold. Usually measured in inches of mercury.

MIXTURE—Mixture Ratio. The proportion of fuel to air used for combustion.

NATURALLY ASPIRATED (ENGINE)—A term used to describe an engine which obtains induction air by drawing it directly from the atmosphere into the cylinder. A non-supercharged engine.

NRP—Normal Rated Power.

OCTANE NUMBER—A rating which describes relative anti-knock (detonation) characteristics of fuel. Fuels with greater detonation resistance than 100 octane are given Performance Ratings.

OIL TEMPERATURE CONTROL UNIT—A thermostatic unit used to divert oil through or around the oil cooler, as necessary, to maintain oil temperature within desired limits.

OVERBOOST VALVE—A safety device used on some turbo-charged engines to relieve excessive manifold pressure in event of a malfunction or improper manipulation of engine power controls.

OVERHEAD VALVES—An engine configuration in which the valves are located in the cylinder head inself.

PERFORMANCE RATING—A rating system used to describe the ability of fuel to withstand heat and pressure of combustion as compared with 100 octane fuel. For example, an engine with high compression and high temperature needs a higher Performance Rated fuel than a low compression engine. A rating of 100/130 denotes performance characteristics of lean (100) and rich (130) mixtures respectively.

PRESSURE ALTITUDE—Altitude, usually expressed in feet, (using absolute pressure (static) as a reference) equivalent to altitude above the standard sea level reference plane (29.92" Hg).

PROPELLER LOAD CURVE—A plot of horsepower, versus RPM depicting the power absorption characteristics of a fixed pitch propeller.

PROPELLER PITCH—The angle between the mean chord of the propeller and the plane of rotation.

RAM—Increased air pressure due to forward speed.

RATED POWER—The maximum horsepower at which an engine is approved for operation.

RETARD BREAKER—A device used in magnetos to delay ignition during cranking. It is used to facilitate starting.

RICH LIMIT—The richest fuel/air ratio permitted for a given power condition. It is not necessarily the richest condition at which the engine will run.

ROCKER ARM—A mechanical device used to transfer motion from the pushrod to the valve.

SCAVENGE PUMP—A pump (especially an oil pump) to prevent accumulation of liquid in some particular area.

SONIC VENTURI—A restriction, especially in cabin pressurization systems, to limit the flow of air through a duct.

STANDARD DAY—By general acceptance, a condition of the atmosphere wherein specific amounts of temperature, pressure, humidity, etc. exist.

STATIC CONDITION—A term referring to properties of a body at rest.

SUMP—The lowest part of a system. The main oil sump on a wet sump engine contains the oil supply.

TBO—Time Between Overhauls. Usually expressed in operating hours.

T.D.C.—Top Dead Center. The position in which the piston has reached the top of its travel. A line drawn between the crankshaft rotational axis, through the connecting rod end axis and the piston pin center would be a straight line. Ignition and valve timing are stated in terms of degrees before or after TDC.

THERMAL EFFICIENCY—Regarding engines, the percent of total heat generated which is converted into useful power.

T.I.T. —Turbine Inlet Temperature. The measurement of E.G.T. at the turbocharger turbine inlet.

TORQUE—Twisting moment, or leverage, stated in pounds - foot (or pounds - inch).

TURBOCHARGER—A device used to supply increased amounts of air to an engine induction system. In operation, a turbine is driven by engine exhaust gas. In turn, the turbine directly drives a compressor which pumps air into the engine intake.

VAPOR LOCK—A condition in which the proper flow of a liquid through a system is disturbed by the formation of vapor. Any liquid will turn to vapor if heated sufficiently. The amount of heat required for vaporization will depend on the pressure exerted on the liquid.

VISCOSITY—The characteristic of a liquid to resist flowing. Regarding oil, high viscosity refers to thicker or "heavier" oil while low viscosity oil is thinner. Relative viscosity is indicated by the specified "weight" of the oil such as 30 "weight" or 50 "weight". Some oils are specified as multiple-viscosity such as 10W30. In such cases, this oil is more stable and resists the tendency to thin when heated or thicken when it becomes cold.

VOLATILITY—The tendency of a liquid to vaporize.

VOLUMETRIC EFFICIENCY—The ability of an engine to fill its cylinders with air compared to their capacity for air under static conditions. A "naturally aspirated" engine will always have a volumetric efficiency of slightly less than 100%, whereas superchargers permit volumetric efficiencies in excess of 100%.

WASTEGATE VALVE–A unit used on turbocharged engines to divert exhaust gas through or around the turbine, as necessary, to control turbine speed.