# OPERATOR'S MANUAL

LYCOMING

## TIGO-541-E1A

AIRCRAFT ENGINES
FOR

**PIPER NAVAJO**
**PA-31-P**

**Part No. SSP-1570** **November, 1988**

**This reprinting contains all previous revisions.**

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**Lycoming**

652 Oliver Street
Williamsport, PA 17701 U.S.A.

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## ATTENTION

## OWNERS, OPERATORS, AND MAINTENANCE PERSONNEL

This operator's 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 Avco Lycoming powered aircraft. Modifications and repair procedures are contained in Avco Lycoming overhaul manuals; maintenance personnel should refer to these for such procedures.

## 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.

## SERVICE BULLETINS, INSTRUCTIONS, AND LETTERS

Although the information contained in this manual is up-to-date at time of publication, users are urged to keep abreast of later information through Avco Lycoming Service Bulletins, Instructions and Service Letters which are available from all Avco Lycoming distributors or from the factory by subscription. Consult the latest edition of Service Letter No. L114 for subscription information.

## SPECIAL NOTE

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

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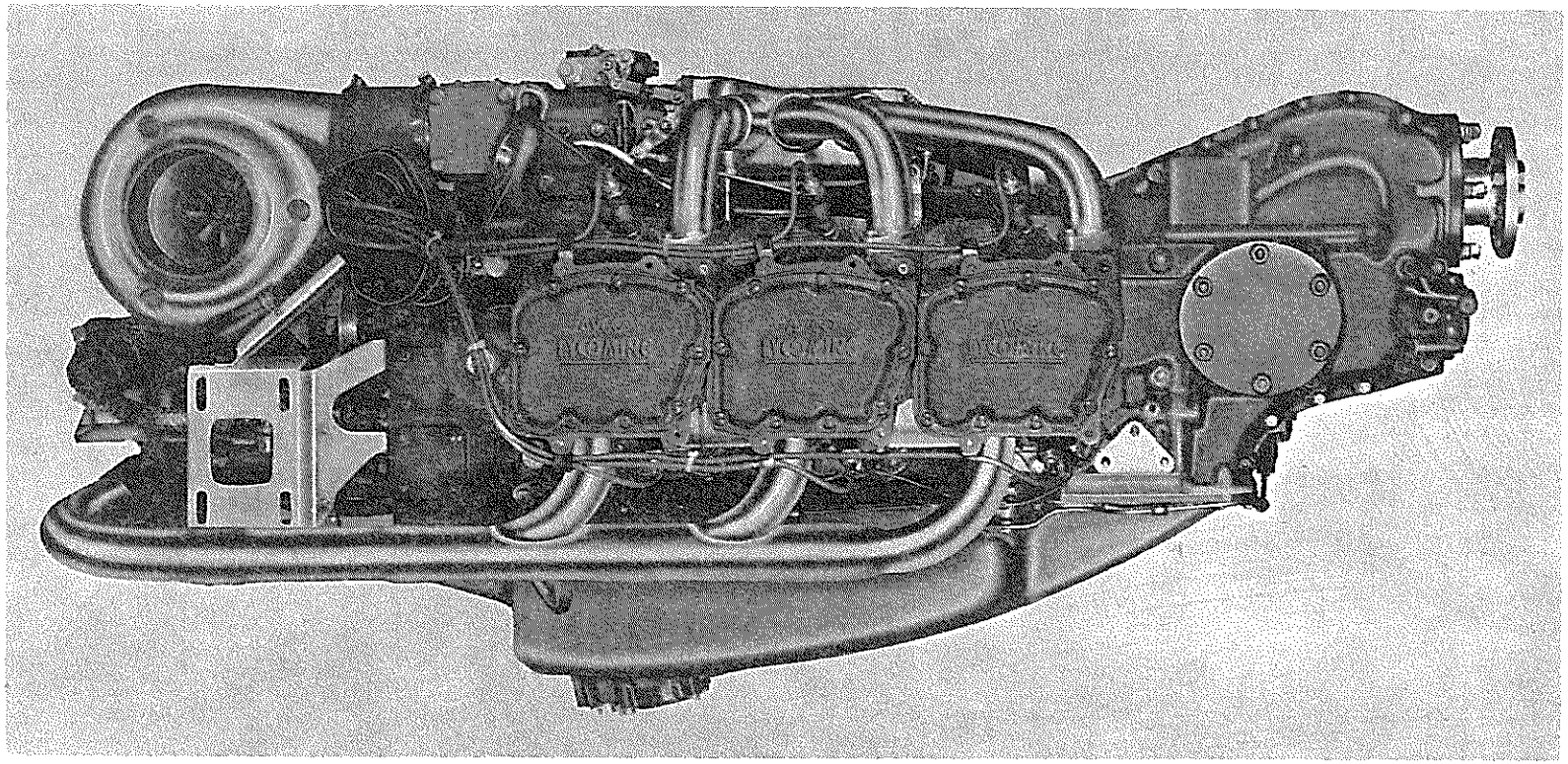
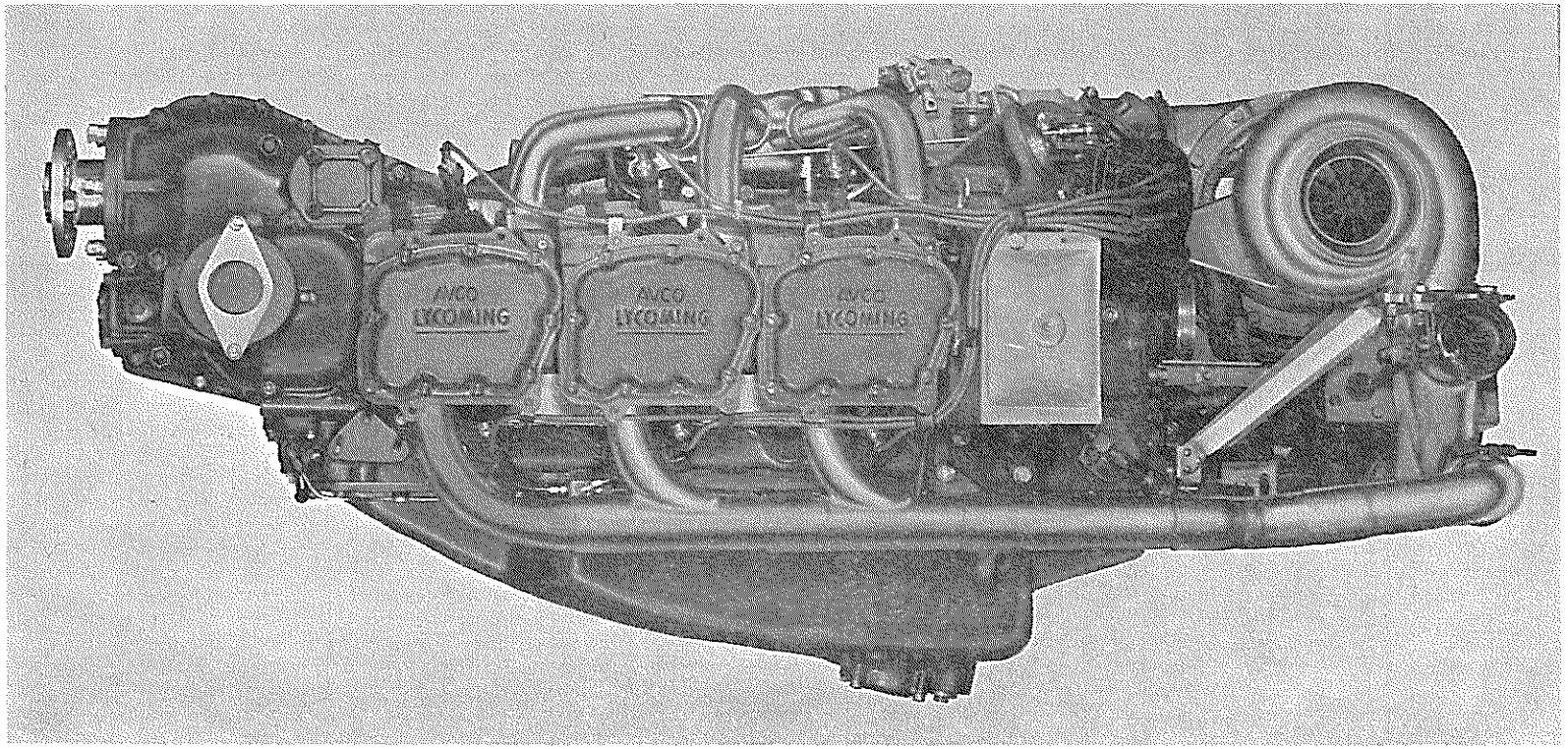


Right Side View - Typical TIGO-541 Series




Left Side View - Typical TIGO-541 Series

## WARNING

SUBJECT ENGINES ARE EQUIPPED WITH A DYNAMIC COUNTERWEIGHT SYSTEM AND MUST BE OPERATED ACCORDINGLY. AVOID HIGH ENGINE SPEED, LOW MANIFOLD PRESSURE OPERATION. USE A SMOOTH, STEADY MOVEMENT OF THE THROTTLE (AVOID RAPID OPENING OR CLOSING). IF THIS WARNING IS NOT HEEDED, THERE MAY BE SEVERE DAMAGE TO THE COUNTERWEIGHTS, ROLLERS AND BUSHINGS.

DESCRIPTION Page

# SECTION 1

## DESCRIPTION

General - The Avco Lycoming TIGO-541 series aircraft engines are six cylinder, reduction gear driven, horizontally opposed, wet sump, fuel injected, turbocharged, air cooled models. Accessories are side mounted and piston cooling oil jets are incorporated in the power section. The integral crankcase forms the housings for the reduction gear, power section and accessory drives.

In referring to the location of the various engine components, the parts are described in their relationship to the engine as installed in the airframe. Thus the power take-off section is considered the front and the sump section the bottom. Reference to the left and right sides are made with the observer facing the rear of the engine. Thus the front cylinder on the left bank is number 1 and the rear cylinder number 5. The front cylinder on the right bank is number 2 and the rear cylinder is number 6. The direction of rotation for accessory drives is determined with the observer facing the accessory mounting pad.

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 for both valve rockers. The cylinder barrels, which are machined from chrome-nickel molybdenum steel forgings, have deep integral cooling fins and the inside of the barrels are ground and honed to a specified finish. New engines are furnished with nitride hardened cylinder barrels.

Valve Operating Mechanism - A conventional type camshaft is located parallel to and below the crankshaft and operates in aluminum bearings. The camshaft actuates the valves by means of hydraulic lifters and push rods, which automatically keep the valve clearance at zero. The valve rockers are supported on full floating steel shafts. The valve springs bear against hardened steel seats.

Crankshaft - The crankshaft is made from a chrome-nickel molybdenum steel forging. All bearing surfaces are nitrided. The crankshaft is fitted with pendulum type dynamic counterweights.

Crankcase - The crankcase or integral housing consists of two reinforced aluminum alloy castings fastened together by means of thru bolts, studs and nuts. The mating surfaces are joined without the use of a gasket, and the main bearing bores are machined for use of precision type main bearing inserts. Bearing supports for the reduction gear drive and accessory drives are assembled in the crankcase. An oil pressure operated fuel drain valve is provided under the reduction gear section of the crankcase. The oil filler cap is located at the left rear of the crankcase.

Oil Sump - The sump fastens to the bottom of the crankcase. Alternate oil drain plug locations are provided on the bottom of the sump. Provision is made for the removal of the oil suction screen. The oil level gage is at the left rear side of the sump.

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. The bearing caps on the crankshaft ends of the rods are retained by means of two bolts and nuts through each cap.

Pistons - The pistons are machined from an aluminum alloy forging. Two compression rings and an oil regulating ring are located above the piston pin. The pistons are equipped with full floating type pins with a plug located on each end of the pin.

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

Cooling System - These engines are designed to be cooled by air pressure actuated by the forward speed of the aircraft. Close fitting baffles build up a pressure and force the air through the cylinder fins. The air is then exhausted to the atmosphere through gills or augmenter tubes usually located at the rear of the cowling.

Lubrication System - These engines are provided with a wet sump pressure oil system.

Induction System - These engines employ a Bendix RSA-type fuel injector which meters fuel in proportion to air flow to a nozzle cluster at a central distribution zone located on top of the engine. Pressure air is supplied to the injector directly from the compressor discharge port of the turbocharger. The center manifold is connected to individual intake pipes which conduct the fuel-air mixture to each cylinder. The intake air pressure is altitude compensated by means of air density controllers in the turbocharger system.

Turbocharger System - A turbocharger is mounted as an integral part of the TIGO-541 series engines. Automatic waste gate control of the turbocharger provides constant air pressure at the fuel injector inlet for a given power setting from sea level to critical altitude. The air pressure varies as a function of power setting. The turbocharger also furnishes air for cabin pressurization.

SPECIFICATIONS

Page

# SECTION 2

# SPECIFICATIONS

## NOTE

The model specifications shown on the following pages of this section are divided according to model designation. When differences among models can be clearly stated, the specifications of more than one model are combined in a single group; otherwise, each model has its specifications listed separately. Also, as additional models are added to this series, new specification pages containing data pertinent to the new models will be added.

## SPECIFICATIONS

### TIGO-541-E SERIES

| | |
|---|---|
| FAA Type Certificate | .E19EA |
| Rated max. continuous HP | .425 |
| Rated speed, RPM | |
| Engine | 3200 |
| Propeller | 2133 |
| Critical altitude, feet | 15000 |
| Bore, inches | 5.125 |
| Stroke, inches | 4.375 |
| Displacement, cubic inches | 541.5 |
| Compression ratio | 7.30:1 |
| Firing order | 1-4-5-2-3-6 |
| Spark occurs °BTC | 20 |
| Valve rocker clearance | |
| (lifters collapsed) | .040-.105 |
| Propeller drive ratio | 2:3 |
| Propeller drive rotation | |
| (viewed from rear) | .Counter-clockwise |
| Crankshaft rotation | |
| (viewed from rear) | Clockwise |
| Fuel Injection System | |
| Fuel Injector, Bendix | RSA-10DB2 |
| Fuel Pump, Lear Siegler | .RG9080J4 |
| Turbocharger, AiResearch | T-18A21 |
| Magnetos, (1) Scintilla (left) | S6LN-1208 |
| (1) Scintilla (right) | S6RN-1209 |
| Dimensions, inches | |
| Height | 22.65 |
| Width | 34.86 |
| Length | 57.57 |

## ACCESSORY DRIVES

| Drives | Drive Ratio | *Direction of Rotation |
|---|---|---|
| Magneto (2) | 1.500:1 | |
| Tachometer | 0.500:1 | Counter-clockwise |
| Propeller Governor | 0.800:1 | Counter-clockwise |
| Hydraulic or Vacuum Pump | 1.000:1 | Counter-clockwise |
| Vacuum or Hydraulic Pump | 1.000:1 | Clockwise |

* - Facing drive pad.

## DETAIL WEIGHTS

| | LBS. |
|---|---|
| 1. ENGINE (STANDARD) - (With Starter and Alternator) | 567.44 |
| Turbocharger, AiResearch Model T-18A21 | 37.50 |
| Mounting bracket, exhaust manifolds, waste gate, automatic boost control, oil lines and baffles | 44.00 |
| Fuel Injector, Bendix RSA-10DB2 | 8.00 |
| Fuel Pump, Lear Siegler RG9080J4 | 1.88 |
| Magneto, S6LN-1208 | 5.85 |
| S6RN-1209 | 5.75 |
| Oil cooler pad cover | 1.50 |
| Oil filter and adapter | 3.00 |
| Compressor drive | 2.00 |
| Spark plugs (12) | 3.00 |
| Ignition harness | 5.40 |
| Intercylinder cooling baffles | |
| Center fin pack baffles | .8 |
| Rear dynafocal mounting brackets | .00 |
| | 0.00 |

| 2. ENGINE INSTALLATION PARTS (STANDARD) | LBS. |
|---|---|
| Starter switch, magnetic | 1.16 |
| Transistor voltage regulator | 1.25 |
| Overvoltage relay | 0.85 |

| 3. ACCESSORIES, DRIVES AND PARTS (OPTIONAL) | LBS. |
|---|---|
| Cylinder Head Thermocouples, Bayonet type | .59 |
| Turbocharger Blanket | 1.00 |

## OPERATING INSTRUCTIONS

# SECTION 3

## OPERATING INSTRUCTIONS

1. General - Close adherance to these instructions will greatly contribute to long life, economy and satisfactory operation of the engine.

NOTE

YOUR ATTENTION IS DIRECTED TO THE WARRANTIES THAT APPEAR IN THE FRONT OF THIS MANUAL REGARDING ENGINE SPEED, THE USE OF SPECIFIED FUELS AND LUBRICANTS, REPAIRS AND ALTERATIONS. PERHAPS NO OTHER ITEMS OF ENGINE OPERATION AND MAINTENANCE CONTRIBUTE QUITE SO MUCH TO SATISFACTORY PERFORMANCE AND LONG LIFE AS THE CONSTANT USE OF CORRECT GRADES OF FUEL AND OIL, CORRECT ENGINE TIMING AND FLYING THE AIRCRAFT AT ALL TIMES WITHIN THE SPEED AND POWER RANGE SPECIFIED FOR THE ENGINE. DO NOT FORGET THAT VIOLATION OF THE OPERATION AND MAINTENANCE SPECIFICATIONS FOR YOUR ENGINE WILL NOT ONLY VOID YOUR WARRANTY BUT WILL SHORTEN THE LIFE OF YOUR ENGINE AFTER ITS WARRANTY PERIOD HAS PASSED.

Care of a New Engine - New engines have been carefully run-in by Avco Lycoming and therefore, no further break-in is necessary insofar as operation is concerned; however, engines should be operated using only multi-viscosity ashless dispersant oil conforming to specification MIL-L-22851. Oil grades are listed in the Flight Chart, part 10 of this section. Personnel should be thoroughly familiar with the latest edition of Service Instruction No. 1014.

Fuel - The minimum fuel octane rating specified for these engines is listed in the Flight Chart, part 10 of this section. Under no circumstances should fuel of a lower octane rating nor automotive fuel (regardless of octane rating) be used. Personnel should be thoroughly familiar with the latest edition of Service Instruction No. 1070.

Oil Change - These engines are equipped with a full flow oil filter, consequently, lubricating oil may be changed at 100 hour intervals provided the filter element is changed at 50 hour intervals. In no event should the oil be changed without changing the filter. Also, if the aircraft is used under adverse conditions such as under excessive dust conditions, the oil and filter should be changed at more frequent intervals.

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 items are called out in Section 4 under Daily Pre-Flight Inspection.

3. STARTING PROCEDURE (Normal).

a. Perform pre-flight inspection.
b. Prior to initial start after engine change, overhaul, or any prolonged period of inactivity, pre-oil engine as directed in Section 7 before proceeding.
c. Set propeller governor in "Full RPM".
d. Turn fuel valve to "on" position.
e. Open throttle approximately 1/4 travel.
f. Turn boost pump on and move mixture control to "Full Rich" position until a slight but steady flow is indicated.
g. Return mixture control to "idle cut-off" position.
h. Set magneto selector switch on "both".
j. Engage starter.
k. When engine starts, move mixture control slowly and smoothly to "Full Rich".
l. Check oil pressure gage for indicated pressure. If oil pressure is not indicated within thirty seconds, stop the engine and determine cause.

NOTE

If engine fails to achieve a normal start, assume it to be flooded and proceed as follows: With magneto switch on "both", open throttle and place mixture control in idle "cut-off". Crank engine until it starts, then return mixture control slowly and smoothly to "full rich".

4. STARTING PROCEDURE (Hot Engine).

Because of the fact that the fuel percolates and the system must be cleared of vapor, it is recommended that the starting procedure as outlined for normal start, be used for starting a hot engine.

5. STARTING PROCEDURE (Cold Engine).

Starting procedures for normal starting are used except that during extreme cold weather, it may be necessary to preheat the engine and oil before starting.

6. GROUND RUNNING AND WARM-UP. Subject engines are air pressure cooled and depend on the forward movement 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.

a. Head the aircraft into the wind.
b. Leave mixture in "Full Rich".
c. Operate with the propeller in minimum blade angle.
d. Warm up at approximately 800-1000 RPM tachometer speed. Avoid prolonged idling and do not exceed 1466 RPM tachometer speed on the ground except for magneto check as described in 7d.
e. Engine is warm enough for take-off when the throttle can be opened without the engine faltering and oil temperature is in the minimum range (140° F.).

CAUTION

Take-off with turbocharged engines should not be started if indicated lubricating oil pressures, due to cold temperature, is above maximum. Excessive oil pressure can cause overboost and consequent engine damage.

7. GROUND CHECK (Before Take-off).

a. Check both oil pressure and oil temperature.

Note Above Caution

b. Leave mixture in "Full Rich".
c. 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 recom-

mended but the feathering action can be checked by running the engine at 1200 RPM tachometer speed; then momentarily pulling the propeller control into the feathering position. Do not allow the tachometer speed to drop more than 300 RPM.

d. A proper magneto check is important. Additional factors, other than the ignition system, can 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) With the propeller in minimum pitch angle, set the throttle to produce a tachometer speed of 1650 RPM. Mixture control should be in "Full Rich". Oil pressure should be within limits of 55 psi minimum to 90 psi maximum and the engine operating smoothly.

(2) Switch from both magnetos to one and note drop-off, return to both until engine regains speed then switch to the other magneto, note drop-off and return to both. The normal drop-off is 60 RPM tachometer speed. Drop-off should not exceed 80 RPM tachometer speed on either magneto and should not exceed 23 RPM tachometer speed between magnetos. A smooth drop-off past normal is usually a sign of a too lean or a too rich mixture.

NOTE

Do not operate on a single magneto for too long a period, 2 to 3 seconds is usually sufficient to note drop-off and will minimize plug fouling.

8. OPERATION IN FLIGHT.

a. WARNING - Counterweight System - These engines are equipped with a dynamic counterweight system. Use a smooth steady movement (avoid rapid opening and closing) of the throttle. Avoid high engine speed, low manifold pressure operation. If this warning is not heeded, there may be severe damage to the counterweight, rollers and bushings.

b. Power Settings - Consult Table on page 3-18 for various power settings.

c. Fuel Mixture Leaning Procedures - Improper fuel-air mixture during flight is responsible for many engine problems, particularly during take-off and climb. The procedures described in this manual provide proper fuel-air mixture when leaning Avco Lycoming engines; they have proven to be both economical and practical by eliminating excessive fuel consumption and reducing damaged parts replacement. The following should be observed at all times during engine operation.

GENERAL RULES

Never lean the mixture from full rich during take-off; however, it is permissible during climb to lean to 1550° F. EGT provided cylinder head temperature and oil temperature remain within limits. See note 2 on page 18. Also, it is possible, during take-off from high altitude airports or during climb at high altitudes that roughness or reduction of power may occur; in such events the mixture may be leaned enough to obtain smooth engine operation. At such times, always be sure cylinder head and oil temperature limits are not exceeded.

Operate the engine at maximum power mixture for performance cruise powers and at best economy mixture for economy cruise power.

Without exception, observe the red line cylinder head temperature limit during take-off, climb and high performance cruise power operation.

For maximum service life, maintain the cylinder head temperature below 450° F. during high performance cruise operation and below 400° F. for economy cruise powers.

Always enrich mixture before increasing power settings.

During let-down flight operation it may be necessary to lean mixture to obtain smooth operation.

Never exceed 1650° F. turbine inlet temperature (EGT).

(1) Engines may be manually leaned to the proper mixture by monitoring either of the two methods described in the following paragraphs.

(a) Fuel Flowmeter or Flowgage - The airframe manufacturer's handbooks contain appropriate fuel flow tables or the fuel flow indicator may be marked for correct flow for all power settings. The operator need only to lean to the published fuel flow values to obtain correct mixture.

(b) Exhaust Gas Temperature (EGT) - See figure 3-1. For best economy cruise, lean to peak EGT or 1650° F. whichever occurs first.

Note that for operation in the maximum power cruise range, the engine must always be operated on the rich side of peak EGT. As shown in figure 3-1, maximum power performance requires a fuel setting richer than peak and results in a 100° F. to 150° F. reduction in EGT. Leaning to peak EGT even for a short time may cause temperatures in excess of the 1650° F. and damage the turbocharger or may cause abnormal combustion and cylinder overheating resulting in damage to the engine. Therefore, it is important that the following steps are taken to establish a reference point prior to leaning to obtain maximum power mixture, once cruising altitude is reached.

(1a) Establish a peak EGT for best economy operation at the highest economy cruise power without exceeding 1650° F.

(1b) Deduct 125° F. from this temperature and thus establish the temperature reference point for use when operating at maximum power mixture.

(1c) Return mixture control to full rich and adjust the RPM and manifold pressure for desired performance cruise operation.

(1d) Lean out mixture until EGT is the value established in step (1b). This sets the mixture at best power.

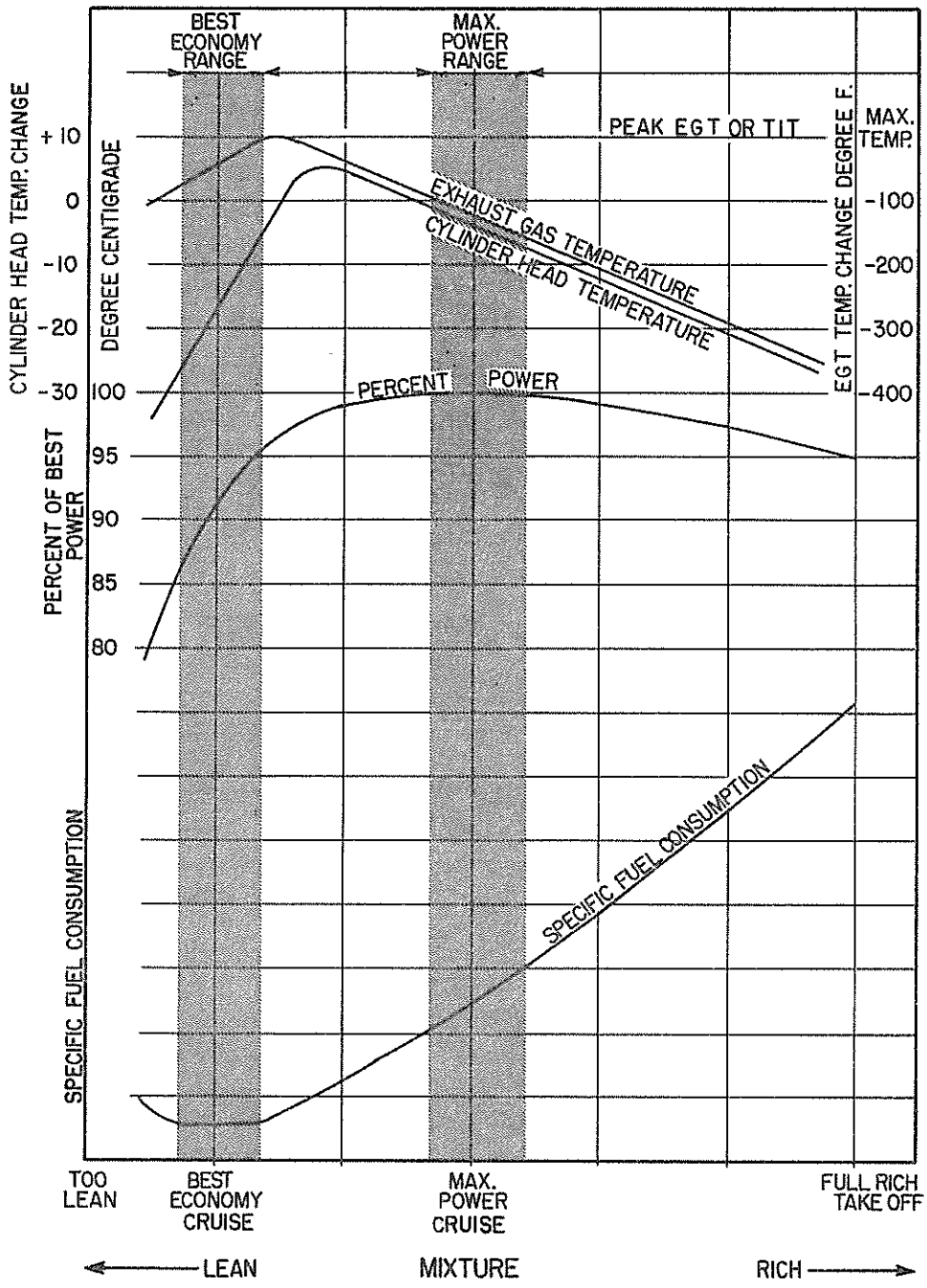



Figure 3-1. Representative Effect of Leaning on Cylinder Head Temperature, TIT (Turbine Inlet Temperature), Engine Power and Specific Fuel Consumption at Constant Engine RPM and Manifold Pressure

NOTE

After establishing any cruise power condition it is important to observe cylinder head temperatures and remember that for long service life the cylinder head temperature should be maintained below 450° F.

9. ENGINE SHUT DOWN.

a. Set propeller at minimum blade angle.

b. Idle until there is a decided decrease in cylinder head temperatures.

c. Move mixture control to "idle cut-off".

d. When engine stops, turn magneto switch off.

10. ENGINE FLIGHT CHART.

FUEL AND OIL

| Model | Aviation Grade Fuel |
|---|---|
| TIGO-541-E Series | 100/130 octane, minimum |

*Recommended Oil Grades

| Average Ambient Air Temperature | Ashless Dispersant Lubricant in Accordance with MIL-L-22851 |
|---|---|
| Above 60° F. | Use grade equivalent to SAE 50 or SAE 60 |
| Below 30° F. | Use grade equivalent to SAE 40 |

* - Consult Service Instruction No. 1014.

| | |
|---|---|
| Oil Sump Capacity | 18 qts. |
| Minimum Safe Quantity in sump | |
| Normal flight conditions | 5 qts. |
| 22° nose up to 24° nose down | 9 qts. |

## OPERATING CONDITIONS

### Fuel Pressure, psi

| | Maximum | Minimum |
|---|---|---|
| Inlet to engine fuel pump | 55 | -2 |
| Inlet to fuel injector | | |
| Normal | 55 | 29 |
| Idling | -- | 12 |
| Injector in idle cut-off to engine fuel pump | 55 | -- |

### Oil Pressure, psi

| | Maximum | Minimum | Idling |
|---|---|---|---|
| Normal operating | 90 | 55 | 10 |
| Start and warm-up | 100 | -- | -- |

### *Oil Inlet Operating Temperature

| Average Ambient Temperature | Desired | Maximum |
|---|---|---|
| Above 30° F. | 180° F. | 245° F. |
| 0° to 70° F. | 170° F. | 225° F. |
| Below 10° F. | 160° F. | 210° F. |

* - Engine oil temperatures should not be below 140° F. during continuous operation.

| Operation | HP | Fuel Cons. Gal./Hr. | Max. Oil Cons. Qt./Hr. | **Max. Cyl. Head Temp. |
|---|---|---|---|---|
| Rated Power | 425 | ---- | 1.90 | 475° F. |
| 75% Rated Power | 319 | 27.2 | 1.42 | 475° F. |
| 60% Rated Power | 255 | 17.9 | 0.85 | 475° F. |

MAXIMUM TURBINE INLET TEMPERATURE 1650° F.

** - At bayonet location - For maximum service life of the engine maintain cylinder head temperatures between 150° F. and 450° F. during continuous operation.

The TIGO-541 series engines employ a reduction gear to drive the propeller shaft at a 2:3 ratio of crankshaft speed. The following table indicates the comparable engine and propeller speeds.

ENGINE SPEED - PROPELLER SPEED CONVERSION TABLE

| ENGINE SPEED RPM | PROPELLER SPEED RPM | ENGINE SPEED RPM | PROPELLER SPEED RPM |
|---|---|---|---|
| 500 | 333 | 1875 | 1250 |
| 525 | 350 | 1900 | 1266 |
| 550 | 366 | 1925 | 1283 |
| 575 | 383 | 1950 | 1300 |
| 600 | 400 | 1975 | 1317 |
| 625 | 417 | 2000 | 1333 |
| 650 | 434 | 2025 | 1350 |
| 675 | 450 | 2050 | 1367 |
| 700 | 467 | 2075 | 1384 |
| 725 | 484 | 2100 | 1400 |
| 750 | 500 | 2125 | 1417 |
| 775 | 517 | 2150 | 1433 |
| 800 | 534 | 2175 | 1450 |
| 825 | 550 | 2200 | 1467 |
| 850 | 567 | 2225 | 1484 |
| 875 | 585 | 2250 | 1500 |
| 900 | 600 | 2275 | 1517 |
| 925 | 617 | 2300 | 1533 |
| 950 | 633 | 2325 | 1550 |
| 975 | 650 | 2350 | 1567 |
| 1000 | 667 | 2375 | 1584 |
| 1025 | 684 | 2400 | 1600 |
| 1050 | 700 | 2425 | 1617 |
| 1075 | 717 | 2450 | 1633 |
| 1100 | 733 | 2475 | 1650 |
| 1125 | 750 | 2500 | 1667 |
| 1150 | 767 | 2525 | 1684 |
| 1175 | 784 | 2550 | 1700 |
| 1200 | 800 | 2575 | 1717 |
| 1225 | 817 | 2600 | 1733 |
| 1250 | 834 | 2625 | 1750 |
| 1275 | 851 | 2650 | 1767 |
| 1300 | 868 | 2675 | 1784 |
| 1325 | 885 | 2700 | 1800 |
| 1350 | 900 | 2725 | 1817 |
| 1375 | 917 | 2750 | 1833 |
| 1400 | 934 | 2775 | 1850 |
| 1425 | 951 | 2800 | 1867 |
| 1450 | 968 | 2825 | 1884 |
| 1475 | 985 | 2850 | 1900 |
| 1500 | 1000 | 2875 | 1917 |
| 1525 | 1017 | 2900 | 1933 |
| 1550 | 1033 | 2925 | 1950 |
| 1575 | 1050 | 2950 | 1967 |
| 1600 | 1067 | 2975 | 1984 |
| 1625 | 1085 | 3000 | 2000 |
| 1650 | 1100 | 3025 | 2017 |
| 1675 | 1117 | 3050 | 2034 |
| 1700 | 1133 | 3075 | 2050 |
| 1725 | 1150 | 3100 | 2067 |
| 1750 | 1167 | 3125 | 2084 |
| 1775 | 1184 | 3150 | 2100 |
| 1800 | 1200 | 3175 | 2117 |
| 1825 | 1217 | 3200 | 2133 |
| 1850 | 1233 | | |

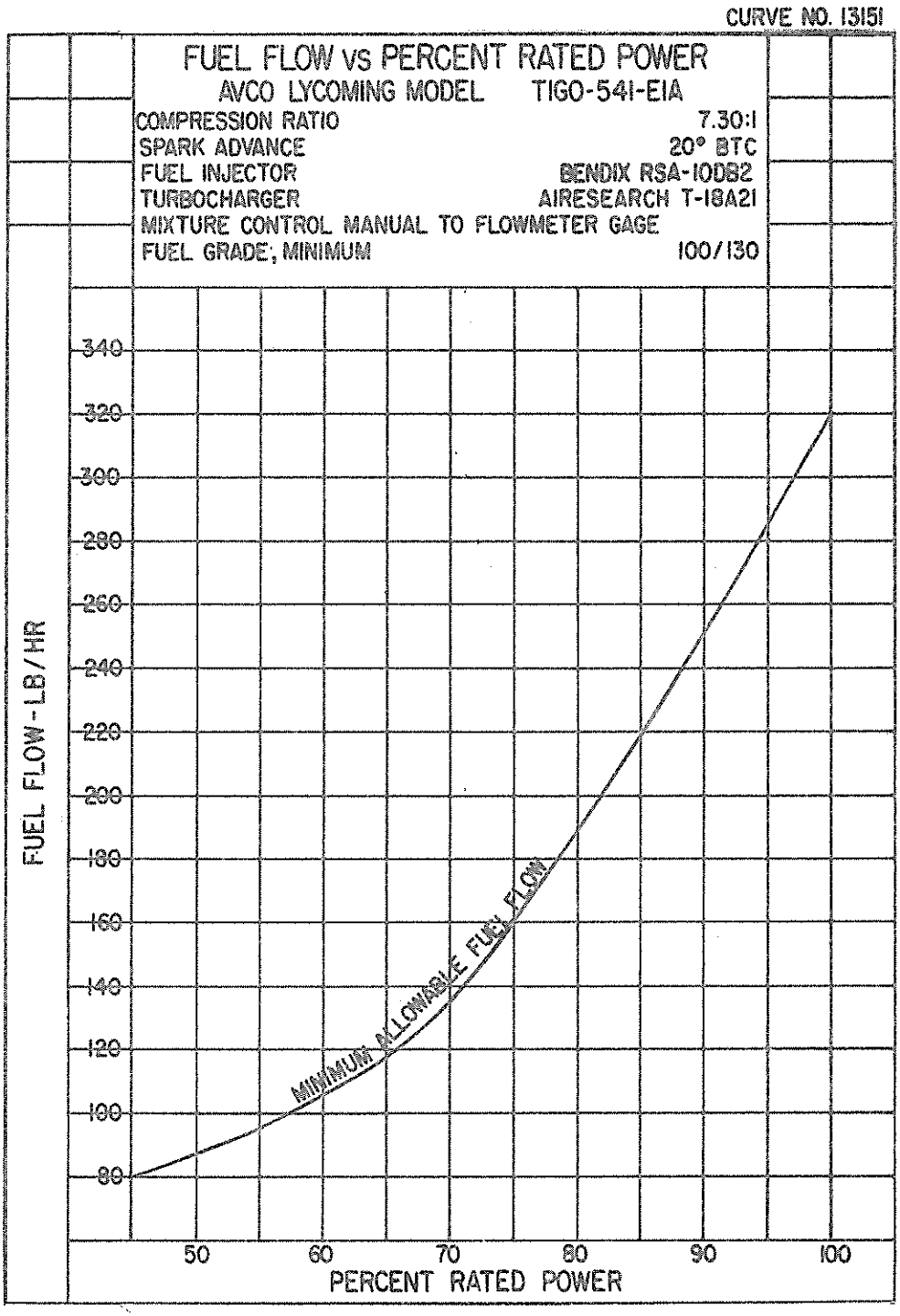



Figure 3-2. Fuel Flow vs Percent Rated Power - TIGO-541-E Series

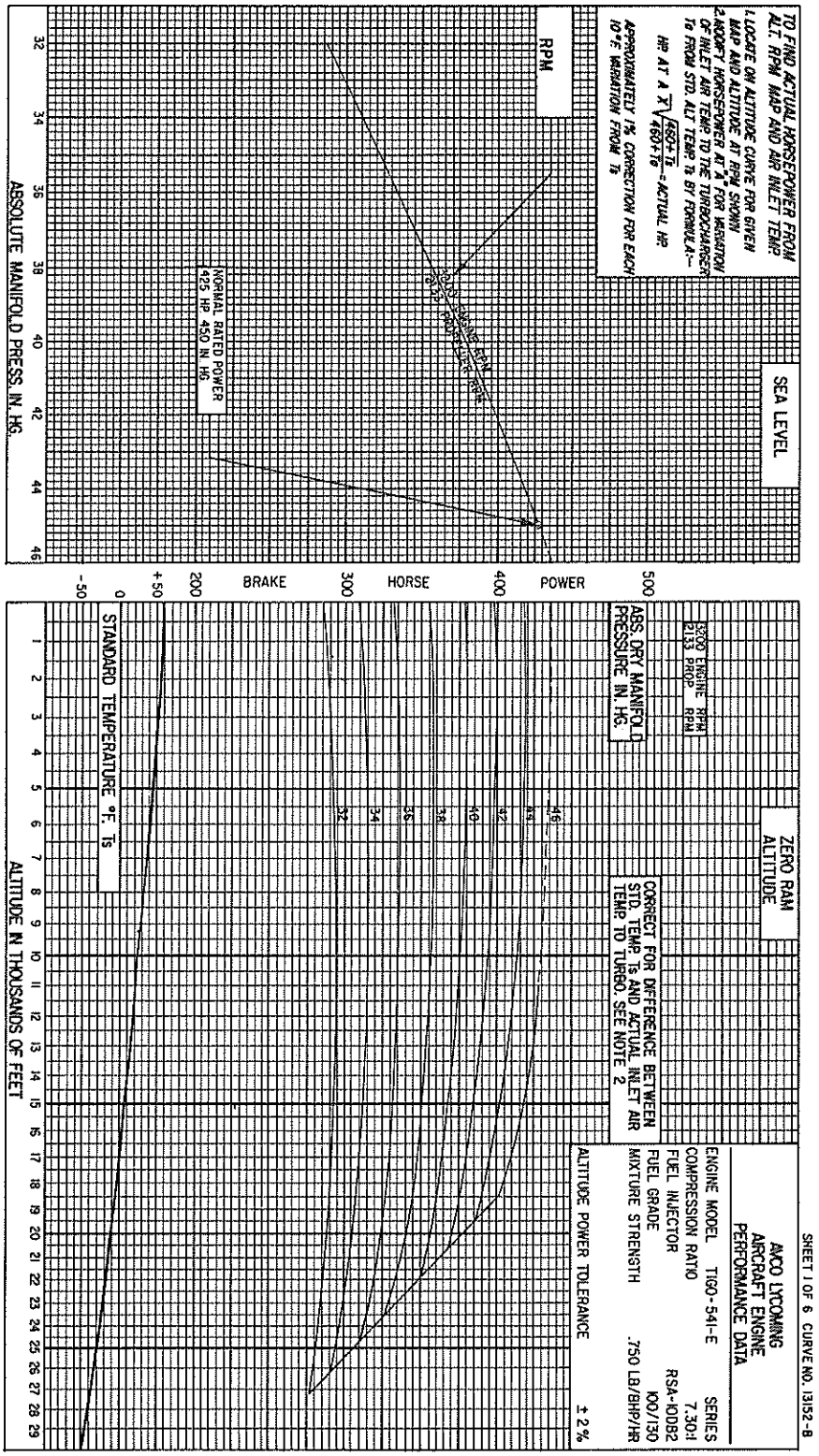



Figure 3-3. Sea Level and Altitude Performance - TIGO-541-E Series - Sheet 1 of 6

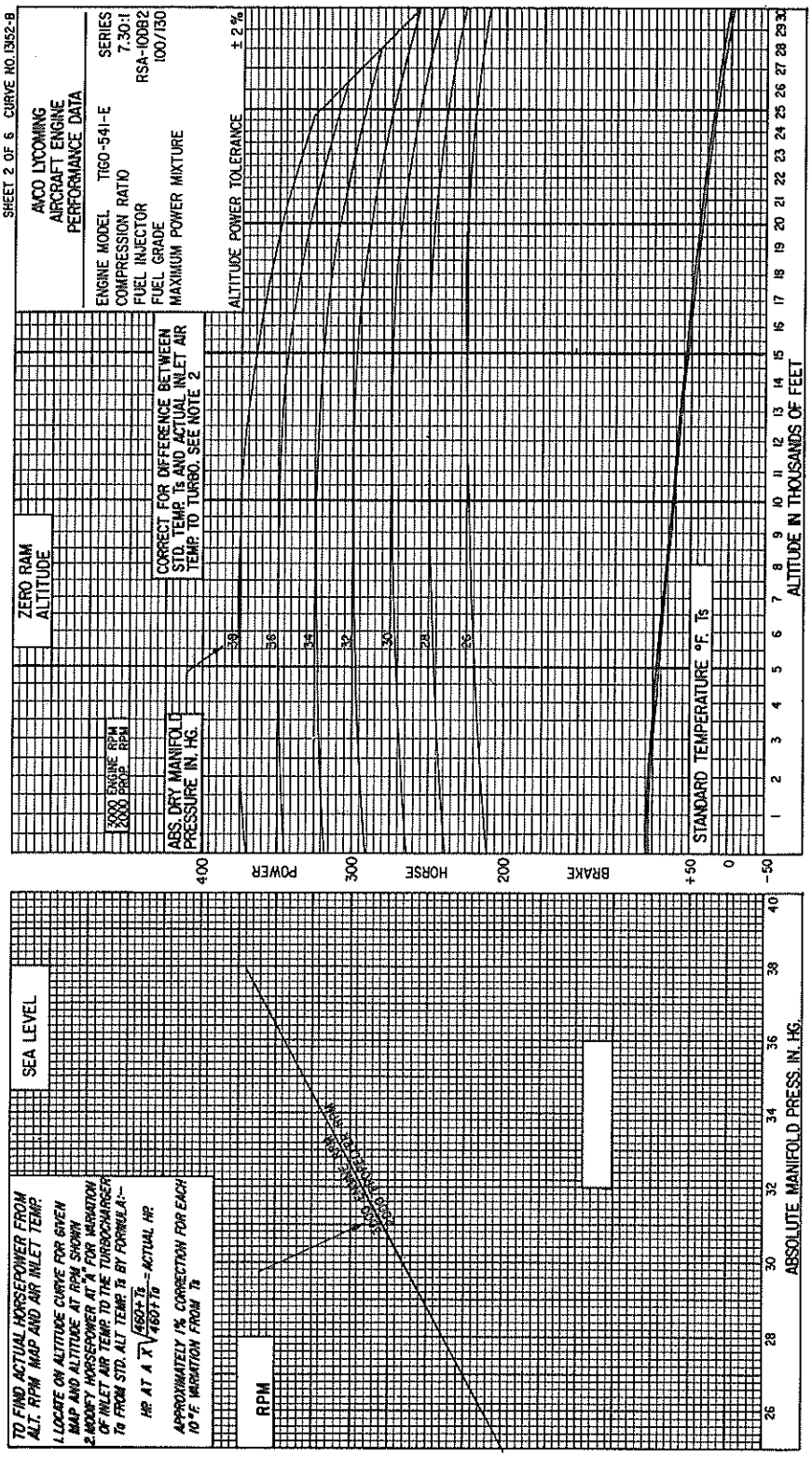



Figure 3-4. Sea Level and Altitude Performance - TIGO-541-E Series - Sheet 2 of 6

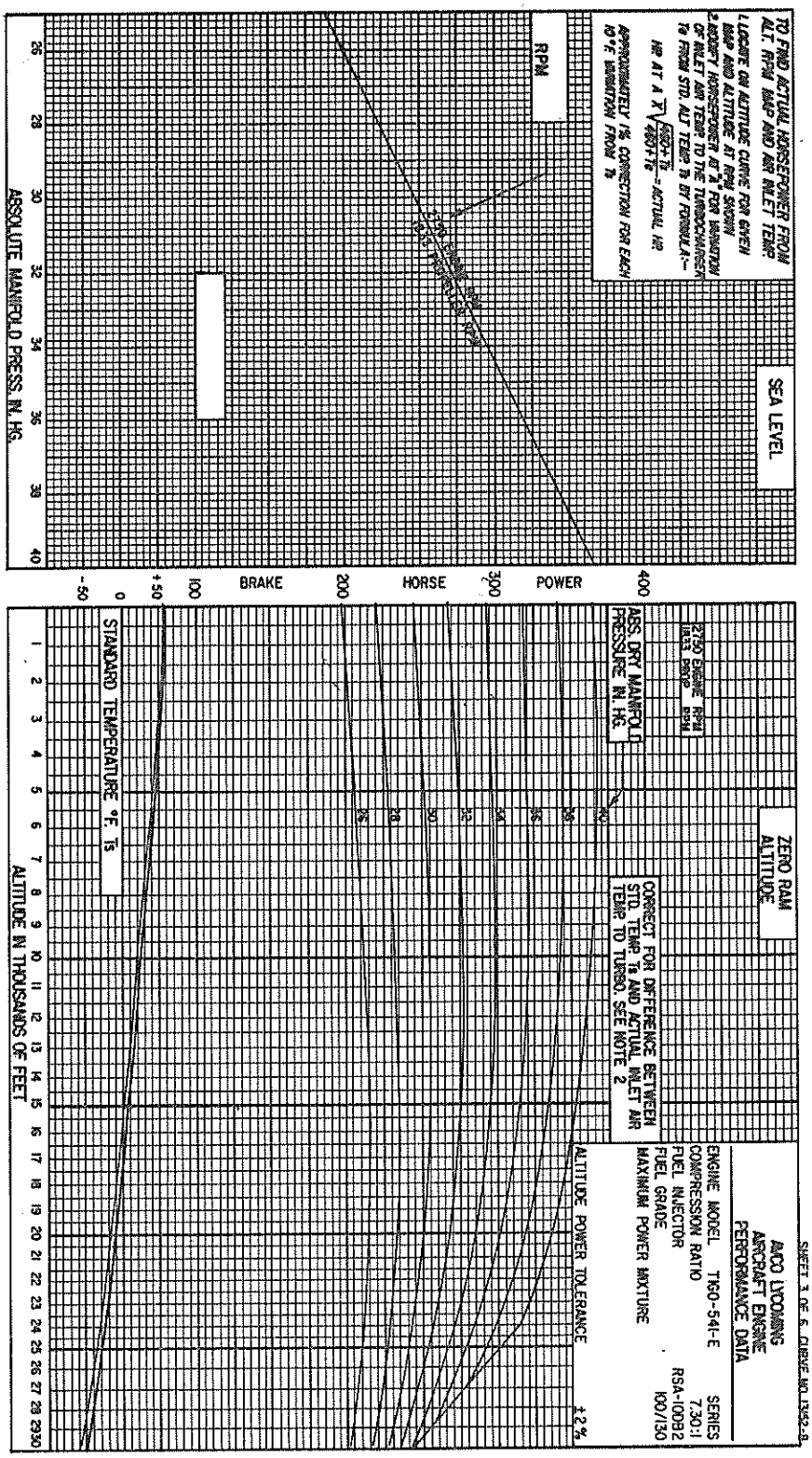



Figure 3-5. Sea Level and Altitude Performance - TIGO-541-E Series - Sheet 3 of 6

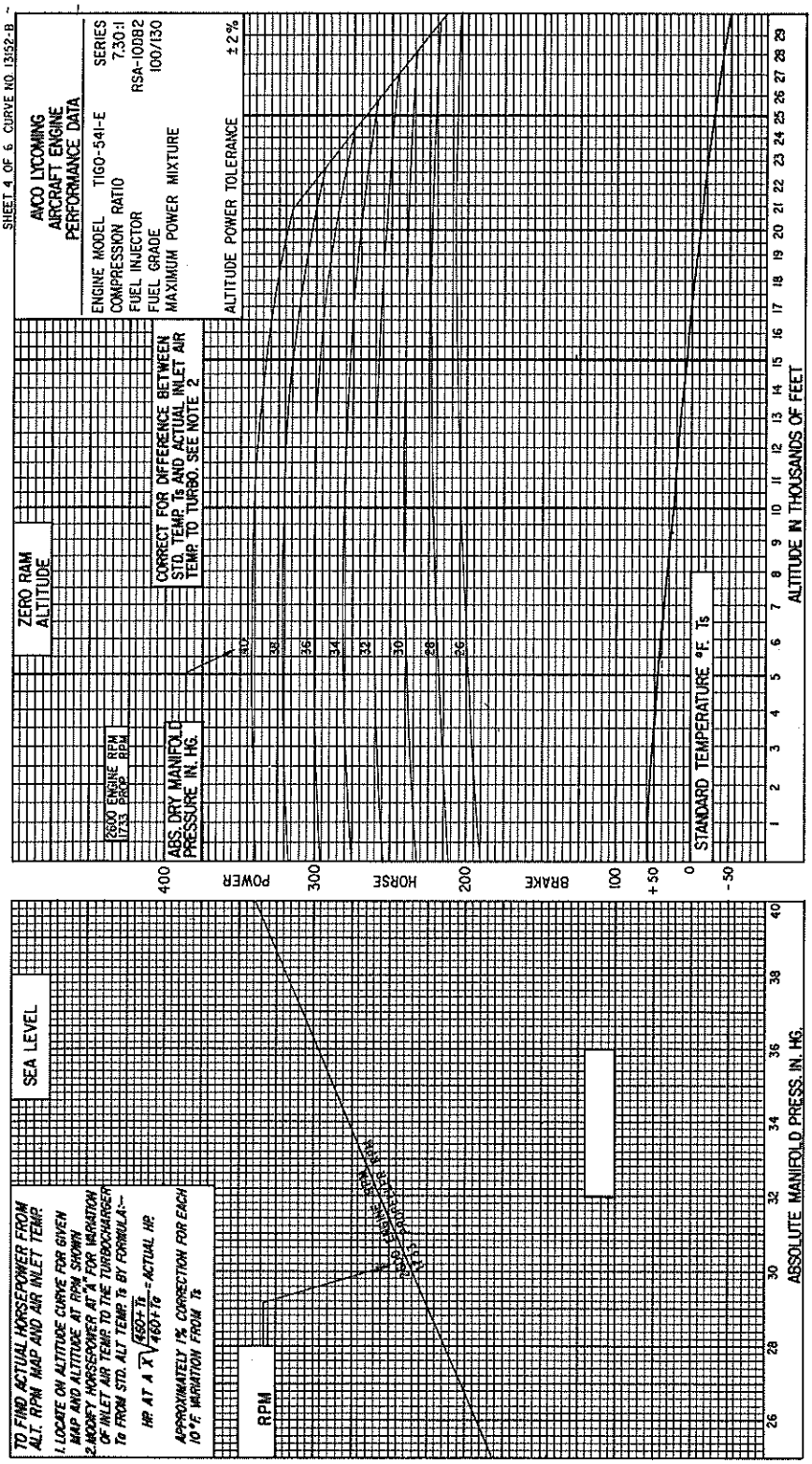



Figure 3-6. Sea Level and Altitude Performance - TIGO-541-E Series - Figure 4 of 6

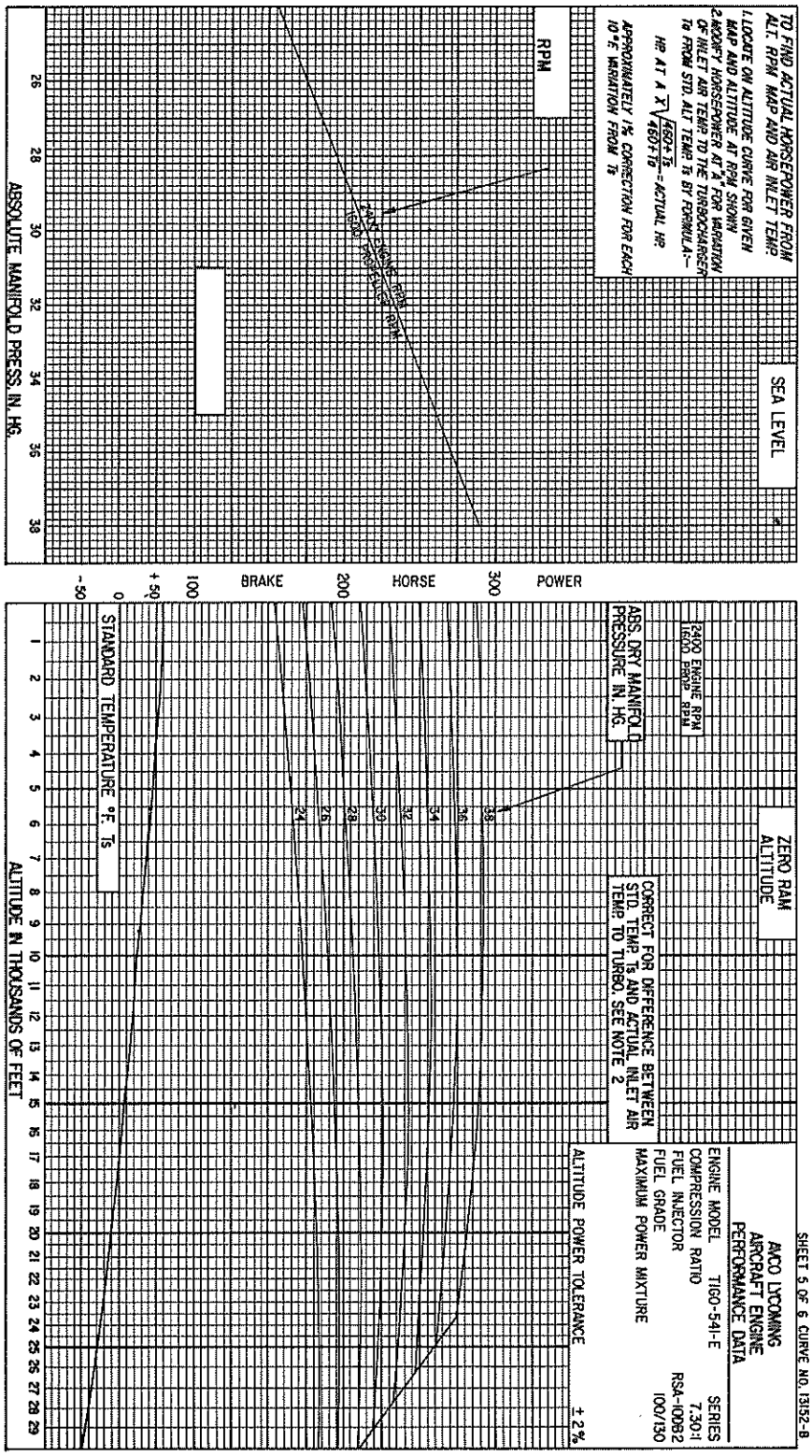



Figure 3-7. Sea Level and Altitude Performance - TIGO-541-E Series - Sheet 5 of 6

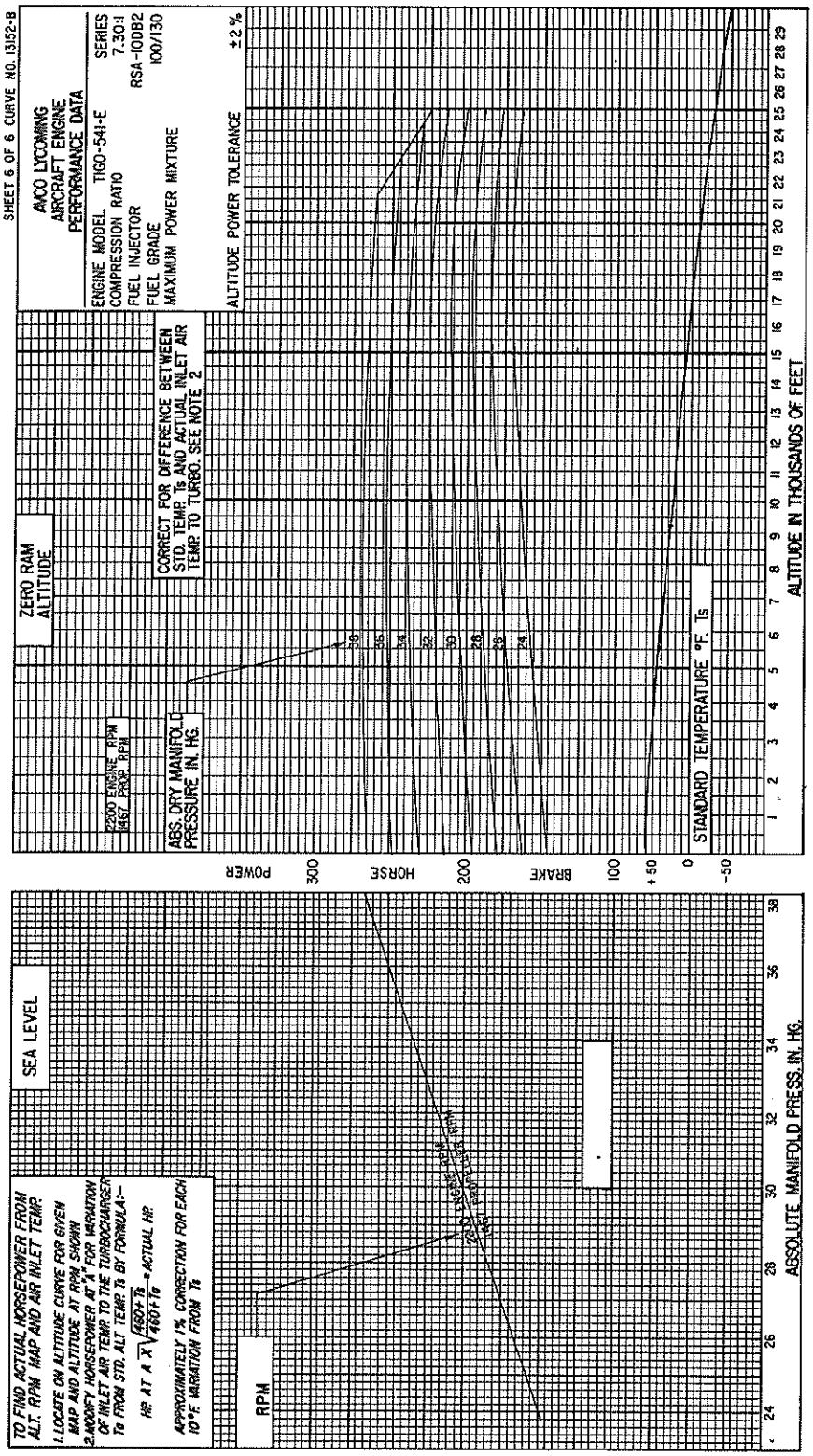



Figure 3-8. Sea Level and Altitude Performance - TIGO-541-E Series - Sheet 6 of 6

PRESSURIZED NAVAJO Power Setting Table - Avco Lycoming Model TIGO-541-E1A, 425 HP Engine

| Press. Alt Feet | Std Alt Temp °F. | High Cruise Prop RPM 2000 58 GPH | High Cruise Prop RPM 1800 54 GPH | Normal Cruise Prop RPM 1800 45 GPH | Normal Cruise Prop RPM 1600 43 GPH | Long Range Cruise Prop RPM 1800 35 GPH | Long Range Cruise Prop RPM 1600 34 GPH | Max Endurance Prop RPM 1800 29 GPH | Max Endurance Prop RPM 1600 28 GPH | Press. Alt Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| SL | 59 | 34.0 | 36.7 | 33.0 | 36.7 | 29.4 | 32.3 | 25.6 | 27.8 | SL |
| 2,000 | 52 | 33.8 | 36.7 | 32.9 | 36.5 | 29.1 | 32.0 | 25.3 | 27.5 | 2,000 |
| 5,000 | 41 | 33.7 | 36.4 | 32.6 | 36.3 | 28.8 | 31.6 | 24.8 | 27.0 | 5,000 |
| 8,000 | 31 | 33.6 | 36.3 | 32.5 | 36.1 | 28.6 | 31.4 | 24.4 | 26.4 | 8,000 |
| 12,000 | 16 | 33.7 | 36.4 | 32.5 | 36.1 | 28.4 | 31.0 | 24.0 | 26.0 | 12,000 |
| 15,000 | +6 | 33.9 | 36.9 | 32.6 | 36.4 | 28.3 | 30.0 | 23.8 | 25.6 | 15,000 |
| 18,000 | -5 | 34.5 | 37.7 | 32.9 | 36.9 | 28.3 | 31.0 | 23.7 | 25.2 | 18,000 |
| 21,000 | -16 | 35.4 | 39.1** | 33.7 | 37.6 | 28.5 | 31.2 | 23.7 | 25.1 | 21,000 |
| 24,000 | -27 | *36.7 | *40.5** | 34.9 | *38.6 | 28.8 | 31.6 | 23.8 | 25.0 | 24,000 |
| 27,000 | -37 | ---- | ---- | *36.4 | ---- | 29.5 | *32.0 | 24.0 | 25.0 | 27,000 |
| 29,000 | -45 | ---- | ---- | ---- | ---- | *29.8 | ---- | *24.2 | *25.0 | 29,000 |

* - If attainable.

** - 27 GPH per engine is minimum allowable at this RPM, MAP, Altitude combination.

1. Rated Power 2133 RPM 45" Hg MAP.
2. Climb Power 2000 RPM 40" Hg MAP. (Permissible to 1500° EGT below 500 feet provided cylinger head temperature (450°) and oil temperature (245°) remains within limits.), and 1550°F. above 5000 feet.
3. To maintain constant power, correct manifold pressure approximately 0.25" Hg for each 10°F. variation in outside air temperature from standard altitude temperature. Add manifold pressure for air temperatures above standard; subtract for temperatures below standard.
4. Power settings less than Long Range Cruise are not recommended above 24,000 feet.

PERIODIC INSPECTIONS

# 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 pertain specifically to the engine and turbocharger only. Consult the airframe manufacturer's handbook for additional instructions concerning the airframe.

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

1. DAILY PRE-FLIGHT (ENGINE).

   a. Be sure all switches are in the off position.

   b. Check oil level.

   c. See that fuel tanks are full.

   d. Open the fuel drain to remove any accumulation of water or sediment.

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

   f. Check controls in cabin for general condition, travel and freedom of operation.

2. 25-HOUR INSPECTION (ENGINE).

   After the first 25 hours operating time, new, remanufactured or newly overhauled engines should undergo a 50-hour inspection including draining and renewing lubricating oil. See the latest edition of Service Instruction No. 1014.

3. 50-HOUR INSPECTION (ENGINE).

   In addition to the items listed under daily pre-flight, the following maintenance checks should be made after every 50 hours of operation.

   a. Ignition System -

      (1) If fouling of spark plugs has been apparent, rotate bottom plugs to upper position.

      (2) Examine spark plug leads of cable and ceramics for corrosion and deposits. This condition is evidence of either leaking spark plugs or improper cleaning of the spark plug walls or connector ends. Where this condition is found, clean the cable ends, spark plug walls and ceramics. Use a dry clean cloth or a cloth moistened with methyl-ethyl-ketone. Spray terminal sleeves with a high temperature mold (MS-122 Flurocarbon Spray, Miller Stephenson Co., Inc., 16 Sugar Hollow Road, Danbury, Conn.) before reassembly. Spark plug elbows and shielding nuts must be secure.

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

b. Fuel and Induction System -

(1) Remove and clean the fuel inlet strainers. Remove and clean the fuel injector strainer. Reinstall strainers.

NOTE

Cleaning the strainers is most essential to insure proper operation of the fuel injection system. Failure to comply could cause irreparable damage.

(2) Check the mixture control and throttle linkage for travel, freedom of movement, security of the clamps and lubricate if necessary.

(3) Check the air intake ducts for leaks, security and filter damage; evidence of dust or other solid material in the ducts is indicative of inadequate filter care or a damaged filter.

(4) Check intake and exhaust systems for leaks, cracks or looseness at connections.

(5) Check fuel lines for condition and security of lines and fittings.

c. Lubrication System -

(1) Check oil lines for leaks, particularly at connections; check for security of anchorage and for wear caused by rubbing or vibration. Check seals and gaskets and replace as required.

(2) Install new element in full flow filter. Before disposing of used sock element, check exterior of element for traces of metal particles that might be evidence of internal engine damage.

(3) Inspect safetying of drain plugs and covers.

d. Exhaust System -

(1) Check attaching flanges at cylinder exhaust ports for leakage.

(2) Check general condition of exhaust manifolds and clamps.

e. Cooling System -

(1) Check cowling and baffling for secure anchorage and evidence of damage. Any damaged or missing part of the cooling system must be repaired or replaced before flying the aircraft.

f. Cylinders -

(1) Check rocker box covers for evidence of oil leaks. If found, replace gasket and tighten screws to 50 inch pounds torque.

(2) Check cylinders for evidence of excessive heat which is indicated by burnt paint. This condition is indicative of internal cylinder damage and the cause should be found and corrected before the aircraft resumes operation.

(3) 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, the cylinder should be replaced.

5. 50-HOUR INSPECTION (TURBOCHARGER). In addition to the items listed under daily pre-flight, the following maintenance check should be made after every 50 hours of operation.

a. All fluid power lines incorporated in the turbocharger system should be checked for leaks, tightness and any damage that may cause a restriction.

b. Check for accumulation of dirt or other interference with the linkage between the bypass valve and the actuator which may impair operation. Clean or correct cause of interference.

c. The vent line from the bypass valve should be checked for evidence of oil leakage. Any constant oil leak is cause for replacement of piston seal.

d. Inspect connections for evidence of oil, air and exhaust gas leakage.

e. Inspect compressor mounting plate bushings, bolts and compressor drive belt.

6. 100-HOUR INSPECTION (ENGINE). In addition to the items listed under daily pre-flight and 50 hour inspections, the following maintenance checks should be made after every 100 hours of operation.

a. Electrical System -

(1) Check all wiring connected to the engine or accessories. Any shielded cables that are damaged should be replaced. Replace clamps on loose wires and check terminals for security and cleanliness.

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

b. Lubrication System -

(1) Drain and renew lubricating oil.

(2) Clean oil suction screen.

(3) Replace full flow filter element.

c. Magnetos -

(1) Check breaker points for pitting and minimum gap.

(2) Check for excessive oil in the breaker compartment; if found, wipe dry with a clean lint free cloth.

(3) Lubricate the felt located at the breaker points in accordance with the magneto manufacturer's instructions.

(4) Check magneto to engine timing.

NOTE

Engines equipped with pressurized ignition systems should be checked using the Bendix Model 11-10090 (Avco Lycoming Special Tool ST-395) airflow tester as described in Service Instruction No. 1308.

d. Engine Accessories -

(1) Engine mounted accessories such as pumps, temperature and pressure sensing units should be checked for secure mounting and tight connections.

(2) Check alternator blast tube for damage and attaching bolt for security. Remove the slip ring bearing cover and inspect the bearing for the proper amount of lubrication. The bearing should be approximately 1/2 full. If there is an insufficient quantity of lubrication replace with one of the following lubricants: Shell Alvania #2, Aeroshell #5, Chevron SRI #2. Consult Service Bulletin No. 386 for more information.

e. Cylinders -

(1) Check cylinders visually for cracked or broken fins. If found, repair or replace cylinder.

f. Engine Mounts -

(1) Check engine mounting bolts and bushings for security and excessive wear. Replace bushings showing excessive wear.

7. 100-HOUR INSPECTION (TURBOCHARGER). In addition to the items listed under daily pre-flight and 50 hour inspection the following maintenance checks should be made after every 100 hours of operation.

a. Inspect all air ducting and connections in turbocharger system for leaks. Check with engine shut down and with engine running.

b. Check manifold connections, at the turbine inlet and at engine exhaust ports, for possible leakage.

c. Check for dust or dirt build-up within the turbocharger. Check for uneven deposits on the impeller. Consult AiResearch Turbocharger Overhaul Manual TP-21 for method to remove all such foreign matter.

8. 400-HOUR INSPECTION (ENGINE). In addition to the items listed under daily pre-flight, 50 hour and 100 hour inspection, the following maintenance check should be made after every 400 hours of operation. See Service Bulletin No. 301.

a. 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 its components (including the piston and connection rod) should be removed and inspected for further damage. Any part not conforming to limits, set forth in the latest edition of Special Service Publication SSP-2070 should be replaced.

b. Remove intake pipes and check security of injector nozzles.

9. NON-SCHEDULED INSPECTIONS. Occasionally, service bulletins or service instructions are issued by Avco Lycoming Division that require inspection procedures that are not listed in this manual. Such publications usually are limited to specific models and become obsolete after corrective steps have been accomplished. All such publications are available from Avco Lycoming distributors, or from the factory by subscription. Consult Service Letter No. L114 for subscription information. Maintenance facilities should have an up-to-date file of these publications available at all times.

MAINTENANCE PROCEDURES

# 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. No attempt is made to include repair and replacement operations that will be found in the applicable Avco Lycoming Overhaul Manual.

1. IGNITION AND ELECTRICAL SYSTEM.

a. Ignition Harness or Wire Replacement - In the event that an ignition harness or an individual lead is to be replaced, consult the wiring diagram (figure 5-1) to be sure harness is correctly installed. Mark location of clamps and clips to be certain that the replacement is clamped at correct locations.

b. Timing Magnetos to Engine - Magnetos are timed to the engine in the following manner:

NOTE

The retard breaker magneto is installed on the left side of the engine.

(1) Remove a spark plug from No. 1 cylinder and place a thumb over the spark plug hole. Rotate the crankshaft in direction of normal rotation until the compression stroke is reached; this will be indicated by a positive pressure, inside the cylinder, tending to push the thumb off the spark plug hole. Remove the timing hole cover, and sighting through the timing hole, continue to rotate crankshaft until the 20° timing mark on the crankshaft gear is in alignment with the parting surface of the crankcase.

(2) At this point, the engine is ready for assembly of the magnetos. Remove the inspection plug from a magneto and turn the drive shaft in direction of normal rotation until the first painted chamfered tooth on the distributor gear is aligned in the center of the inspection window. Being sure that the gear does not move from this position, install gasket and magneto on the engine. Secure with clamps, washers and nuts; tighten only finger tight. Repeat this procedure with the second magneto.

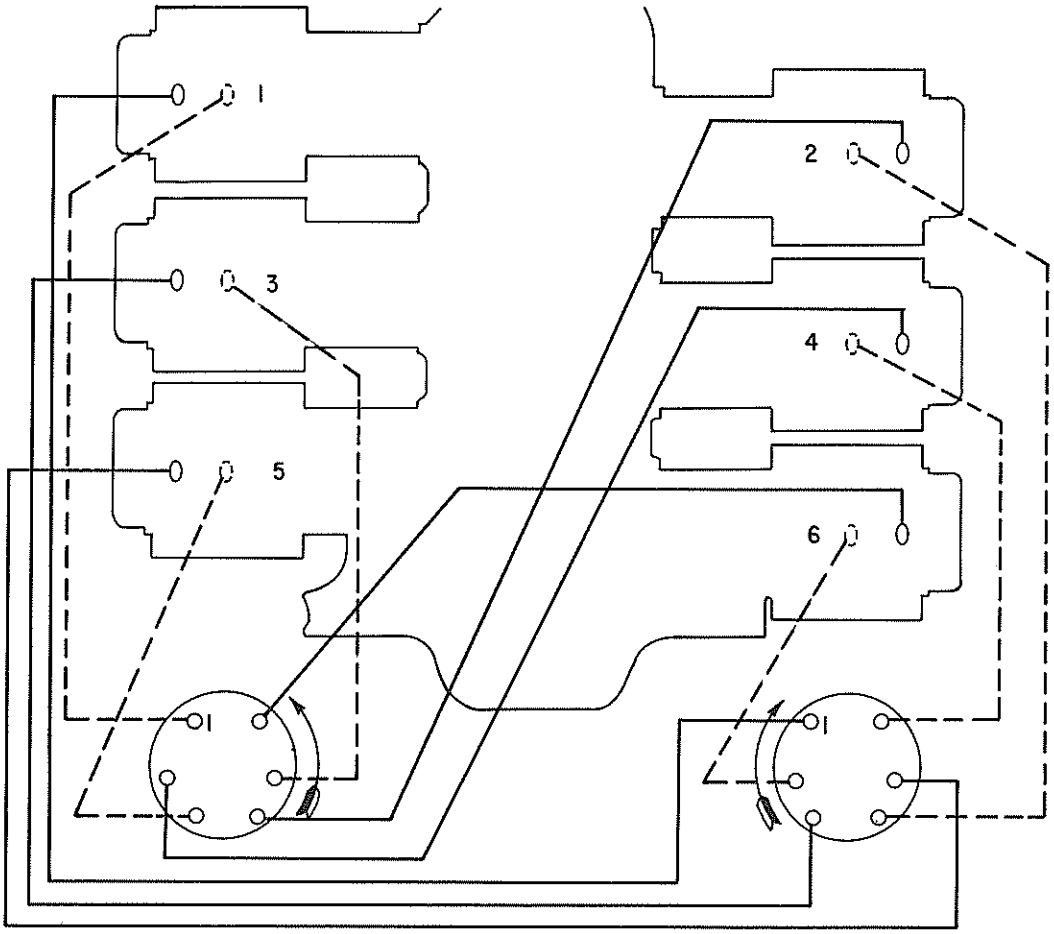



Figure 5-1. Ignition Wiring Diagram

(3) Using a battery powered timing light, attach the positive lead to a suitable terminal connected to the switch terminal of the magneto and the negative lead to any clean, unpainted portion of the engine.

(4) Rotate the magneto in its mounting flange to a point where the light comes on, then slowly turn it in the opposite direction until the light goes out. Bring the magneto back slowly until the light just comes on. Repeat this procedure with the second magneto.

(5) After both magnetos have been timed, check, as described below, to ascertain that both magnetos are set to fire at the same time.

(6) Back off the crankshaft a few degrees; the timing light should go out. Bring the crankshaft slowly back in direction of normal rotation until the timing mark and the crankcase parting surface are in alignment. At this point, both lights should go on simultaneously. Tighten nuts to specified torque. Reinstall inspection plugs and timing hole cover.

NOTE

AC timing lights operate in reverse of the manner described above; the lights go out when the breaker points open.

c. Alternator Output - The alternator should be checked to determine that the specified voltage and current are being obtained.

2. FUEL SYSTEM.

a. Repair of Fuel Leaks - When a new line or fitting is installed in the fuel system, only a fuel-soluble lubricant, such as clean engine oil or Loctite Hydraulic Sealant may be used on tapered threads. No other type thread lubricant or compound may be used.

b. Fuel Injector Inlet Screen Assembly - Remove the assembly and check the screen for distortion or openings in the strainer. Clean the screen assembly in solvent and dry with compressed air. To install screen assembly, place the gasket on the screen assembly and install the assembly in the throttle body and tighten to 65-70 inch pounds torque.

c. Fuel Grades and Limitations - Aviation grade fuel 100/130 minimum octane is the specified fuel for these engines. In the event that the specified fuel is not available at some locations, it is permissible to use a higher octane fuel. Fuel of a lower octane rating is not to be used. Under no circumstances should automotive fuel be used (regardless of octane rating).

NOTE

It is recommended that personnel be familar with Service Instruction No. 1070 regarding specified fuels for Avco Lycoming engines.

d. Air Intake Ducts and Filter - Check air intake ducts for dirt or restrictions. Inspect and service air filters as instructed in the aircraft 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 smooth, 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 engine speed (33 prop speed) 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 the above indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjustment in the 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 engine speed (33 prop speed). Each time the adjustment is changed the engine should be run up to 2000 RPM engine speed (1333 prop speed) to clear 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 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 altitude upon idling adjustment.

3. LUBRICATION SYSTEM

a. Oil Grades and Limitations - Service the engine in accordance with the following recommendations.

| Average Ambient Air | *Recommended Grade Oil Multi Viscosity |
|---|---|
| Above 60° F. | SAE 50 or 60 |
| 30° to 90° F. | SAE 50 |
| 0° to 70° F. | SAE 40 or 20W-30 |
| Below 10° F. | SAE 20W-30 |

* - Ashless dispersant type. Consult the latest revision of Service Instruction No. 1014 and Service Bulletin No. 318.

b. Oil Suction Screen - Whenever the oil is changed, remove and check the oil suction screen for metal particles. Clean and reinstall.

c. Oil Pressure Relief Valve - The adjustable oil relief valve located at the rear right side of the engine below the oil filter enables the operator to maintain the oil pressure within specified limits. If the 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 engine speed (1333 prop speed) 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 and in to increase pressure. The adjusting screw may be turned with either a screw driver or a box wrench.

4. CYLINDERS - Although the complete procedure for disassembly and reassembly is given here; it is recommended that, as a field operation, cylinder maintenance be confined to replacement of the entire assembly. Valve replacement should be undertaken only as an emergency measure.

a. Removal of Cylinder Assembly -

(1) Remove exhaust manifold.

(2) Remove intake pipe, detach ignition harness, rocker box drain tube, fuel drain attachment and baffle.

(3) Disconnect ignition cable at spark plugs and remove spark plugs.

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

(5) Remove rocker shaft covers and push rocker shafts out of cylinder head far enough to remove valve rockers and washers. Remove valve stem cap from exhaust valve stem. Valve rocker shafts can be removed after cylinder is removed from the engine.

(6) Remove push rods by grasping ball end and pulling out of the shroud tube. Loosen shroud tubes by releasing springs and remove shroud tubes by first releasing them from the seal seats in the cylinder head and then withdrawing from the adapter on the crankcase. Remove shroud tube seals, sleeves and washers from outer ends of tubes and also seals from the adapter. Discard the seals.

NOTE

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

(7) Remove cylinder base hold down nuts; then remove cylinder by pulling directly away from the crankcase. Do not allow the piston to strike the crankcase as the piston leaves the cylinder.

(8) Use the old cylinder base oil seal ring and criss cross over cylinder base studs and around connecting rod to prevent rod from striking crankcase.

NOTE

In the event that a spark plug heli-coil is to be replaced, it must be replaced with a .010 inch oversize heli-coil.

b. Removal of Valves and Valve Springs from Cylinder -

(1) Place cylinder over a block of wood to hold the valves in a closed position.

(2) Using a valve spring compressor, compress the valve springs and remove the split keys from the valve stems.

(3) Remove the valve springs and valve spring seats.

(4) Hold valve stems and remove cylinder from holding block. Remove valves from inside of the cylinder.

c. Removal, Disassembly, Cleaning, Inspection and Reassembly of Hydraulic Lifters -

(1) Remove capscrews that secure shroud tube adapter and remove adapter and gasket.

(2) Lifter can be withdrawn with fingers.

(3) Being careful not to scratch the socket, insert a screwdriver into the lifter and push. This will force the trapped oil out through the vent hole and release the pressure on the circlip.

(4) Remove and discard the circlip.

CAUTION

Be careful! The circlip will release with great force.

(5) Remove the socket, spring and plunger from the lifter and clean the parts and body in solvent. Inspect the lifter body for the following imperfections.

NOTE

Parts of the hydraulic lifter assembly are selectively fitted and are not interchangeable. It is imperative that the mating parts are kept together and not mixed with other assemblies.

(a) Spalling - If the face of the lifter shows small nicks or indentations near the center of the face, it is considered pitted or spalled. The pitting will constitute small irregular holes, not to be confused with Rockwell hardness check marks which are round and even. The area covered by spalling will vary with different lifters, but regardless of the degree, the lifter must be replaced.

(b) Scoring - The lifter face is scored when small scratchlike lines are found on the surface. These marks are usually found near the outer edge of the face and will appear to radiate from the center. Other scoring marks may be present and extend to the center of the lifter face. Any lifter, with this condition in evidence, must be replaced.

(c) Face Wear - The operation of the lifter provides that the lifter rotates during wiping operation of the cam. This will form a groove, or path. This path will extend all the way across the face and deeper penetrations will be noted at the center of the face. If the wear is excessive, it will be noticeable to the touch if the fingernail is rubbed across the lifter face. This condition requires replacement of the lifter body.

(6) Reassemble the spring, plunger and socket into the body and secure with a new circlip.

NOTE

The lifter must be perfectly dry to obtain proper dry tappet clearance.

(7) Coat the face of the lifter assembly with 600W oil or equivalent and install the lifter assembly in its position in the crankcase. Install a new shroud tube adapter gasket and secure the shroud tube adapter with capscrews.

d. Assembly of Valves in Cylinder -

(1) Prelubricate valve stems and interior of valve guides with Molytex Grease O or equivalent and insert each valve stem in its respective guide.

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

NOTE

Place dampened end of spring (close-wound coils marked with dye or lacquer) toward the cylinder.

(3) Using a valve spring compressor, compress the valve springs and place the split keys in the groove around the upper end of the valve stem. Slowly release the pressure on the valve spring compressor and allow the upper spring seat to lock itself in place around the valve keys.

e. Assembly of Cylinder and Related Parts -

(1) Rotate crankshaft so that the piston is at top center position with both tappets on the low side of the cam in a position that corresponds with both valves closed.

NOTE

Assemble the valve rocker shafts in the cylinder head before installing the cylinder on the engine.

(2) Coat piston and inside of the cylinder generously with oil. Using a piston ring compressor, assemble the cylinder over the piston with the intake port on the top and the exhaust port on the bottom. Push the cylinder all the way on, catching the ring compressor as it is pushed off.

NOTE

Before installing cylinder base hold-down nuts, lubricate crankcase through studs 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 30W engine oil and 40% Parker Thread Lube.

(3) Install applicable cylinder base nuts and tighten to specified torque in the manner described in the following paragraphs.

NOTE

The front two 1/2 inch through studs are not secured by screw threads. Therefore, torque must be applied at both ends simultaneously. At any time a cylinder is replaced, it is necessary to retorque the cylinder base nuts on the opposite cylinder.

(4) Tighten the 1/2 inch cylinder base nuts to 300 inch lbs., starting at upper right and proceeding clockwise.

(5) Repeat the tightening sequence and tighten all 1/2 inch nuts to 600 inch lbs. torque.

(6) Tighten the 3/8 inch nuts to 300 inch lbs. torque. Sequence is optional.

(7) As a final check, bring the torque wrench up to 600 inch lbs. on each 1/2 inch nut and hold for five seconds. If the nut does not turn it can be presumed to be tightened to the correct torque value.

CAUTION

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

(8) Assemble new shroud tube oil seals in the shroud tube adapter on the crankcase and an outer end of the shroud tube; then assemble a shroud tube seal sleeve over the outer seals, centering the sleeve on the seal.

(9) Assemble shroud tube springs over inner ends of the shroud tubes so that the detent notches are approximately 90° removed from the detents on the tubes. Use shroud tube washers (maximum of two) to bring minimum overlap between the spring and detent lugs to approximately 1/8 inch and insert the ends through oil seals in the adapter. Insert outer end of tubes in holes in the cylinder head rocker box. See that all seals are inserted squarely and turn spring 90° to engage the notch in the spring with the detent on the shroud tube.

(10) Select the proper push rod, dip the ball ends in preservative oil and insert full length through the shroud tubes.

(11) Assemble cap on end of exhaust valve stem and assemble each rocker in its respective position between the bosses; insert the proper thrust washer between the rocker and inner boss and slide valve rocker shaft in place to retain the rocker and washer.

(12) Assemble rocker shaft gasket and cover.

(13) 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 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 lifter spring. While holding the spring compressed, check clearance with feeler gage; the clearance should be between 0.040 and 0.105 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.

(14) Install rocker box covers, intercylinder baffles, spark plugs, intake pipes, ignition cables, fuel drain lines, exhaust manifold, plus any clips that may have been removed at disassembly.

5. TURBOCHARGER EXHAUST BYPASS VALVE SETTINGS. The butterfly valve in the exhaust bypass valve is set to a predetermined open and closed clearance. The open and closed positions are called out in Figure 5-2.

6. FUEL INJECTOR AND CONTROLLER LINKAGE. Linkage must be set as described below to provide the proper amount of turbocharging and fuel metering to the engine.

a. Remove 2, 4 and 6 cylinder intake pipes and necessary baffling. Cover intake ports to prevent foreign objects from falling into cylinder. Disconnect aircraft throttle cable from cross shaft control lever. Remove injector connecting rod from both the cross shaft control lever and the throttle lever.

b. Position the cross shaft control lever using fixture ST-319 thus: Mount the fixture over no. 4 cylinder hold down 3/8 inch studs and nuts. Secure with two (P/N 383-B) nuts. If unable to secure with nuts because of insufficient thread, hold the fixture by hand. The fixture in position is shown in figure 5-3.

c. Back off idle stop adjusting screw until it just touches the injector stop pin when the throttle butterfly is fully closed. Check clearance with a piece of shim stock of an .0015 inch feeler gage. See figure 5-4.

d. Place gage (ST-318) over injector stop pin with side marked ".040" down and between pin and end of idle stop adjusting screw. Do not turn from full closed setting at this time. See figure 5-5.

e. Align hole in ball end of injector connecting rod, hole in cross shaft control lever and hole in fixture. Insert fixture pin through all three holes. See figure 5-3. With throttle lever held firmly against gage on injector, adjust the connecting rod length (maintaining approximately equal thread engagements on both ends) and attach to throttle lever. Remove fixture (ST-319) and attach injector connecting rod to the cross shaft control lever using hardware shown in figure 5-8. Remove gage (ST-318).

f. Replace gage (ST-318) on injector stop pin with the side marked ".025" up. This is the desired clearance between the pad of the throttle arm and the injector stop pin with the throttle lever in full open position. Move cross shaft control lever forward to put injector throttle lever in full open position and maintain a constant pressure between the throttle arm pad and the gage while completing the following step. See figure 5-6.

g. Remove the controller connecting rod at the controller end. Push the controller arm against the full boost stop pin (forward). With the controller arm in this position and the throttle lever in the position obtained in the preceding step, adjust the controller connecting rod (maintaining approximately equal thread engagement on both ends) to match hole locations in both the controller arm and the connecting rod. Attach the connecting rod to the controller arm and remove the gage from the injector stop pin. See figure 5-7.

h. Check to make certain that all connecting rods are installed with the proper hardware (see figure 5-8): jam nuts and linkage nuts are tight and safety the linkage nuts with cotter pins.

i. Reset the idle stop adjusting screw until the correct idle as recommended by the airframe manufacturer is obtained. If throttle lever on the aircraft console is misaligned, adjustment may be made either at the ball end of the aircraft throttle cable or by moving the bracket which holds the throttle cable to the engine. Attach aircraft throttle cable to top hole of the cross shaft control lever.

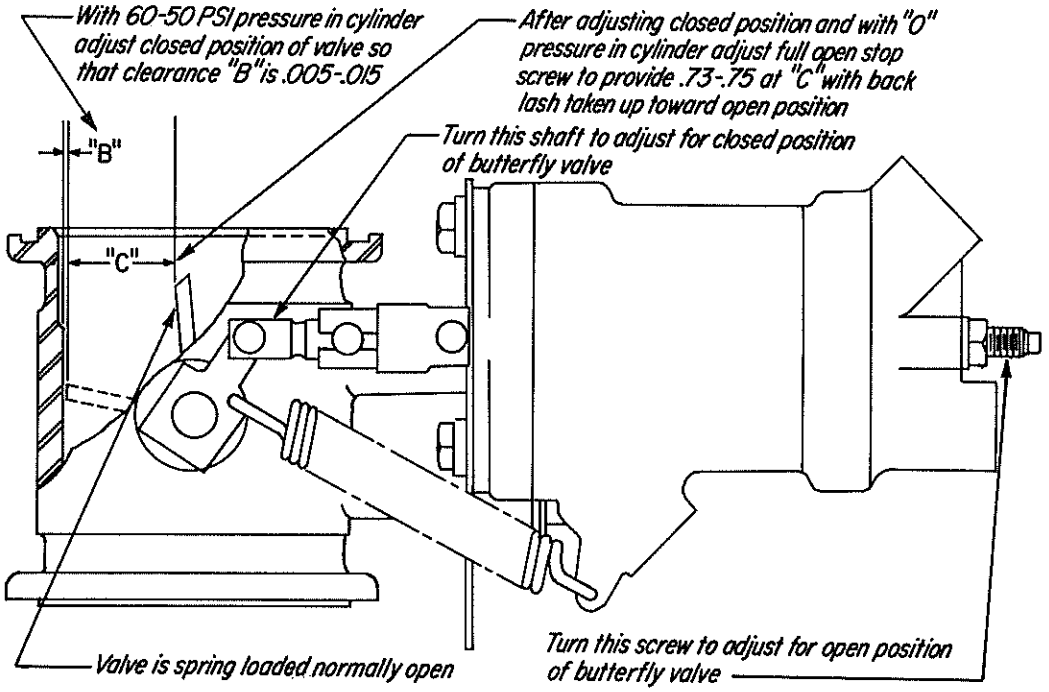



Figure 5-2. Exhaust Bypass Valve - Open and Closed Clearances

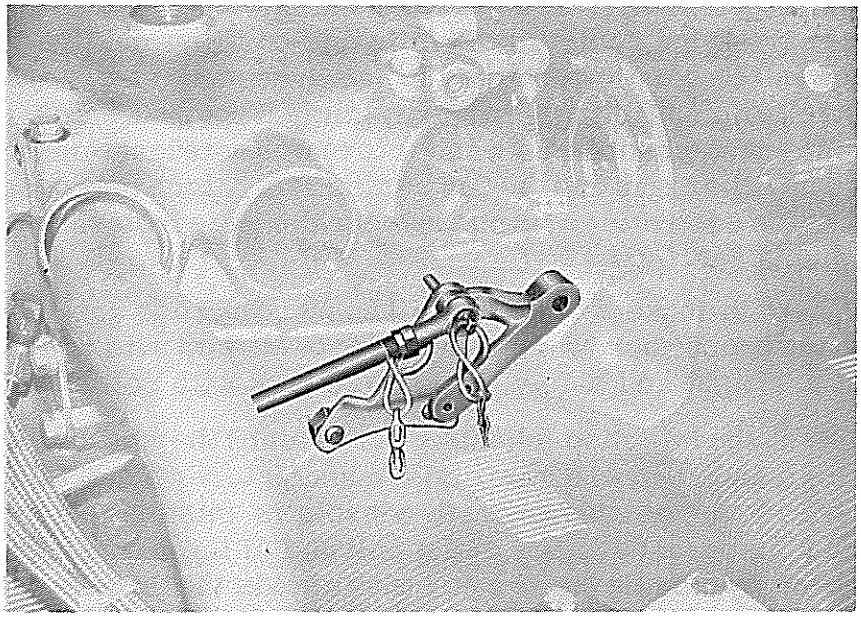


Figure 5-3. Fixture ST-319 Installed and Showing Cross Shaft Control Lever in Closed Throttle Position

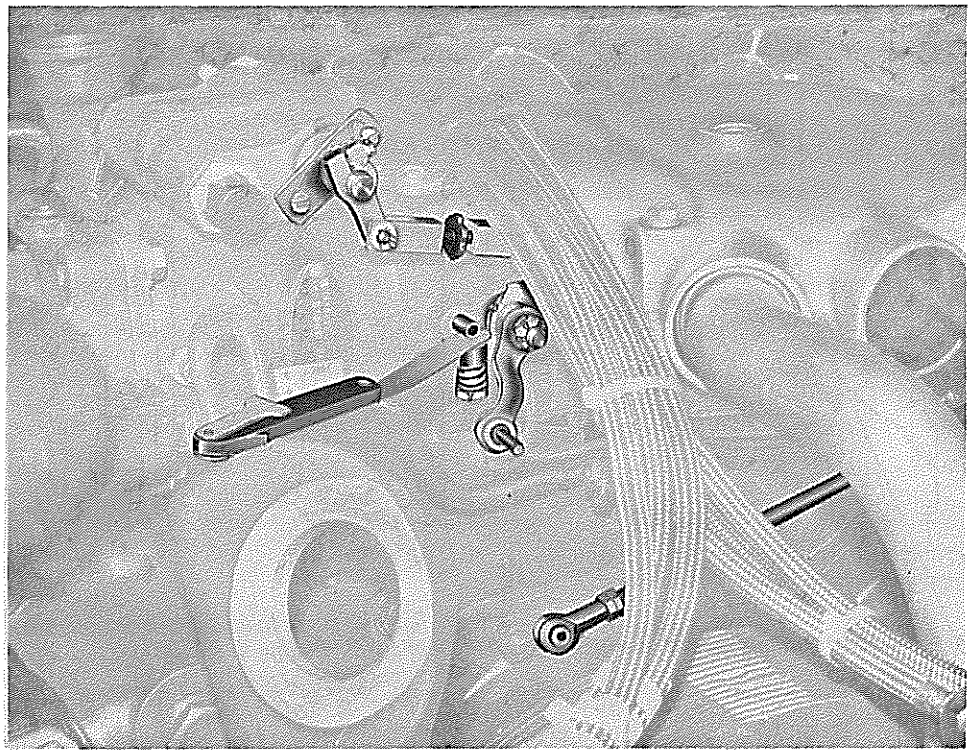


Figure 5-4. Setting Idle Adjusting Screw at Injector Stop Pin

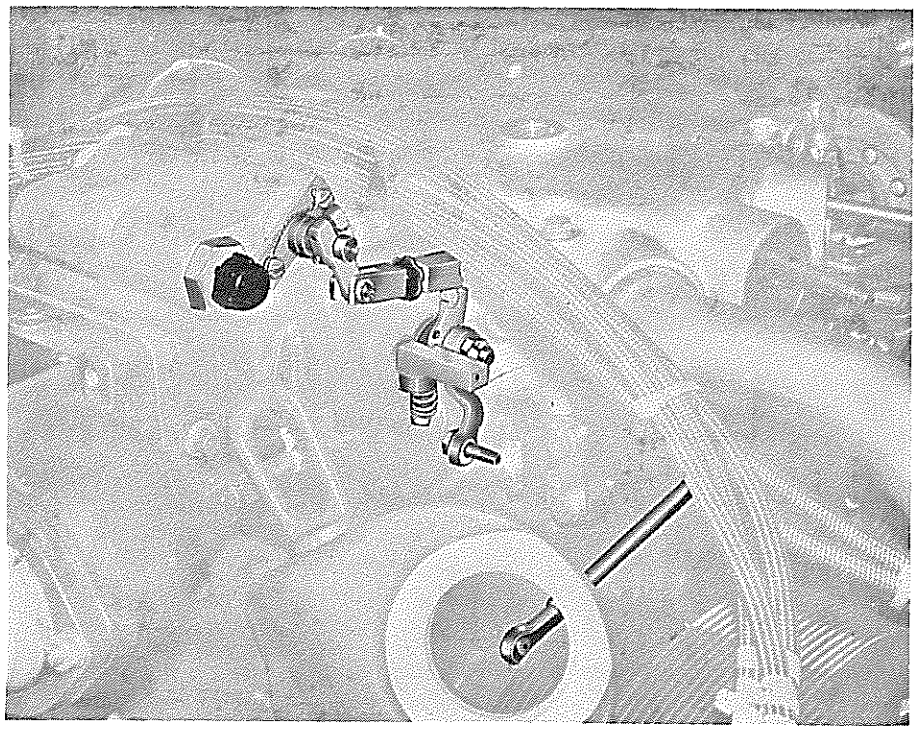


Figure 5-5. Obtaining Clearance of Throttle Lever in Closed Position

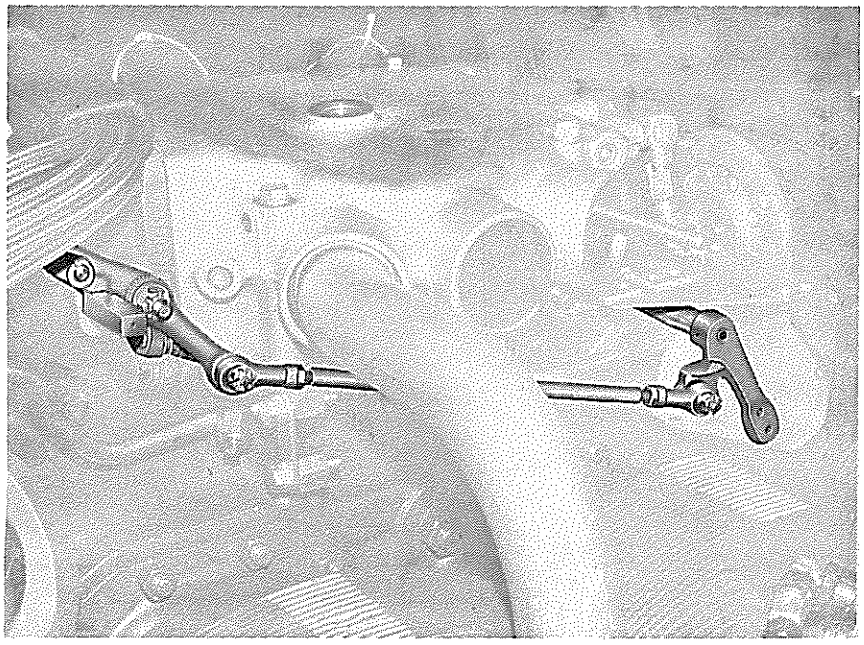


Figure 5-6. Obtaining Clearance of Throttle Lever in Full Open Position

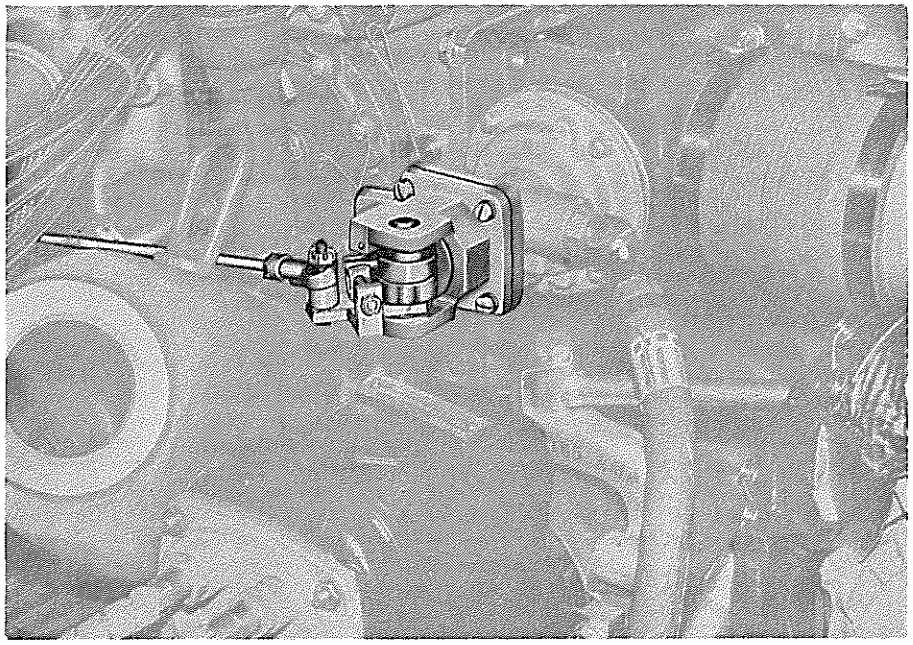


Figure 5-7. View S' 'ing Controller Connecting Rod Secured to C Arm in Full Boost Position

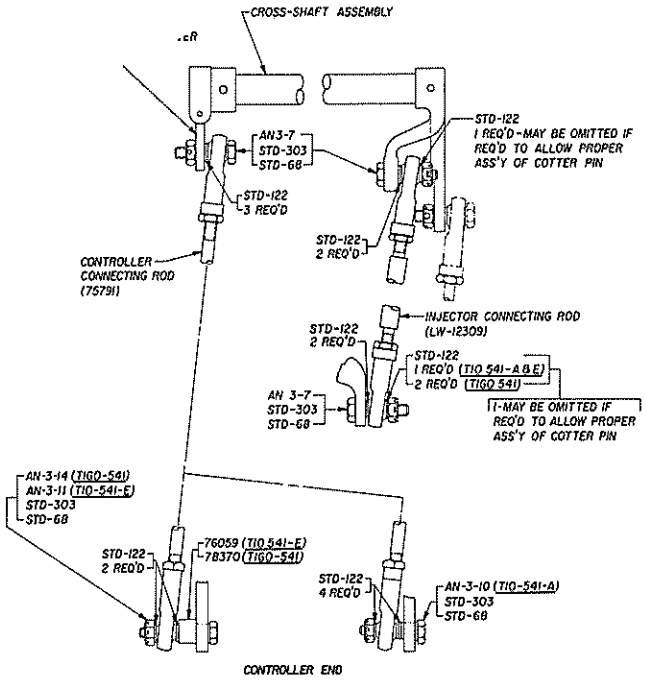



Figure 5-8. Fuel Injector and Controlled Rods Attaching Parts

TROUBLESHOOTING

# SECTION 6

## TROUBLESHOOTING

Experience has proven that the best method of troubleshooting is to decide on the various possible 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 aircraft engines and turbochargers; their probable causes and remedies.

### 1. ENGINE TROUBLESHOOTING.

| TROUBLE | 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. |
| | Overpriming | Unload engine by standard clearing procedure. |
| | Incorrect throttle setting | Open throttle to 1/4 of its range. |
| | Defective spark plugs | Clean and adjust or replace spark plugs. |
| | Defective ignition wire | Check with tester and replace any defective wires. |
| | Improper operation of magneto | Clean points. Check timing. |
| | Internal failure | Check oil screens for metal particles. If found, complete overhaul of engine is indicated. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Failure of Engine to Idle Properly | Incorrect idle mixture | Adjust mixture control. |
| | Incorrect idle speed | Adjust idle speed. |
| | Leak in induction system | Tighten all connections and replace any defective parts. |
| | Uneven cylinder compression | Check condition of piston ring and valve seats. |
| | Faulty ignition system | Check ignition system. |
| Low Power and Uneven Running | Mixture too rich; indicated by sluggish engine, red exhaust flame. Extreme cases indicated by black smoke at exhaust. | Readjustment of fuel injector is indicated. |
| | Mixture too lean; indicated by overheating and backfiring | Check fuel lines for restrictions. Readjust mixture. |
| | Leak in induction system | Tighten all connections, replace any defective parts. |
| | Defective spark plugs | Clean and gap or replace spark plugs. |
| | Improper fuel | Fill tank with recommended grade of fuel. |
| | Magneto breaker points not working properly | Clean points, check timing. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Low Power and Uneven Running (Cont.) | Defective ignition wire | Check wires with tester, replace any defective wires. |
| | Defective spark plug terminal connectors | Check and replace connectors if necessary. |
| Failure of Engine to Develop Full Power | Leak in the induction system | Tighten all connections, replace any defective parts. |
| | Throttle lever out of adjustment | Check travel of throttle linkage. |
| | Improper fuel flow | Check strainers and flow at fuel injector. |
| | Restriction in air scoop | Examine air scoop and remove any obstructions. |
| | Improper fuel | Drain and refill tank with fuel of recommended grade. |
| | Faulty ignition | Check ignition system. |
| Rough Engine | Cracked engine mount | Replace or repair mount. |
| | Defective mounting bushing | Replace bushing. |
| | Uneven compression | Check condition of piston rings and valve seats. |
| Low Oil Pressure | Insufficient oil | Fill sump with oil. |
| | Air lock or dirt in relief valve | Remove and clean oil pressure relief valve. |
| | Dirty oil strainers | Remove and clean oil strainers. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Low Oil Pressure (Cont.) | High oil temperatures | See "High Oil Temperatures" in "Trouble" column. |
| | Defective pressure gage | Replace gage. |
| High Oil Temperature | Insufficient oil supply | Fill sump with oil of recommended grade. |
| | Low grade of oil | Drain and fill sump with oil conforming to specifications. |
| | Clogged oil lines or strainers | Clean oil lines and strainers. |
| | Excessive blow-by | Usually caused by worn or stuck rings. |
| | Failed or failing bearings | Examine oil strainers for metal particles. If found, overhaul of engine is indicated. |
| | Defective temperature gage | Replace gage. |
| | Defective thermostat valve | Replace valve. |
| Excessive Oil Consumption | Low grade of oil | Fill sump with oil conforming to specifications. |
| | Failing or failed bearings | Examine oil strainers for metal particles. If found, overhaul of engine is indicated. |
| | Worn piston rings | Install new rings. |
| | Incorrect installation of piston rings | Install new rings. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Excessive Oil Consumption (Cont.) | Failure of rings to seat (new nitrided barrels) | Check quantity of oil in system, climb to cruise altitude at full power and operate at 75% cruise power setting for approximately one hour. Land aircraft and check oil consumption. Repeat flights until oil consumption stabilizes. Alternate procedure: Remove cylinder, hone lightly and replace piston rings. |

2. TURBOCHARGER SYSTEM TROUBLESHOOTING.

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Excessive Noise or Vibration | Improper bearing lubrication | Supply required oil pressure. Clean or replace oil line. If trouble continues, overhaul turbocharger. |
| | Leak in engine intake or exhaust manifold | Tighten loose connections, or replace manifold gaskets as necessary. |
| Engine will not deliver rated power | Clogged manifold system | Clean all ducting. |
| | Foreign material lodged in compressor impeller or turbine | Disassemble and clean. |
| | Excessive dirt build-up in compressor | Thoroughly clean compressor assembly. Service air cleaner and check for leakage. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Engine will not deliver rated power (Cont.) | Leak in engine intake or exhaust manifold | Tighten loose connections, or replace manifold gaskets as necessary. |
| | Rotating assembly bearing seizure | Overhaul turbocharger. |
| | Restriction in return lines from exhaust bypass valve to variable pressure controller | Remove and clean lines. |
| | Variable pressure controller out of adjustment | Adjust controller. |
| | Oil pressure too low | Tighten fittings, replace lines or hoses. Increase oil pressure. |
| | Oil inlet to exhaust bypass valve clogged | Remove oil line at inlet and clean orifice. |
| | Variable pressure controller malfunction | Adjust controller. Install new controller if needed. |
| | Exhaust bypass valve not closing because of low oil pressure or butterfly shaft binding | Check for oil pressure difficulty. Examine shaft for evidence of binding. |
| | Impeller binding, frozen, or fouling housing | Check bearings for evidence for failure. Overhaul turbocharger. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Engine will not deliver rated power (Cont.) | Piston seal in exhaust bypass valve actuator leaking | Clean cylinder and replace piston seal. |
| Critical Altitude Lower than Specified | Controller not getting enough oil pressure to close bypass valve | Check pump outlet pressure, oil filters and lines for leaks or obstructions. |
| | Chips under metering valve in controller holding it open | Replace controller. |
| | Metering jet in exhaust bypass valve actuator plugged | Remove exhaust bypass valve actuator and clean jet. |
| | Exhaust bypass valve actuator piston seal leaking excessively | Clean cylinder and replace piston seal. |
| | Waste gate valve sticking | Clean and free action. |
| Engine Surges or Smokes | Air in oil lines of exhaust bypass valve actuator | Bleed system. |
| | Controller metering valve stem seal leaking oil into manifold | Replace controller. |
| | Exhaust bypass valve actuator to bypass valve linkage binding. | Correct cause of binding. |

| TROUBLE | CAUSE | REMEDY |
|---|---|---|
| Engine Surges or Smokes (Cont.) | Leaking Seals | Replace Turbocharger. |
| | NOTE<br>Smoke would be normal if engine has idled for a prolonged period. | |
| High Deck Pressure (Compressor Discharge Pressure) | Controller metering valve not opening | Replace controller. |
| | Exhaust bypass valve sticking closed. | Shut-off valve in return line operative. |
| | Controller return line restricted | Clean or replace line. |
| | Oil pressure too high | Reduce oil pressure. |
| | Exhaust bypass valve actuator piston locked in closed position | Disassemble actuator, check condition of piston and packing. |
| | Variable pressure controller malfunction | Replace controller. |

INSTALLATION AND PRESERVATION Page

# SECTION 7

## INSTALLATION AND PRESERVATION

PREPARATION OF ENGINE FOR INSTALLATION. Before installing an engine that has been prepared for storage, remove all dehydrator plugs, bags of dessicant and preservative oil from the engine. Preservation oil can be removed by removing the bottom spark plugs and turning the crankshaft three or four revolutions by hand. The preservative oil will then drain through the spark plug holes. Draining will be facilitated if the engine is tilted from side to side during the above operation. Preservative oil which has accumulated in the sump can be drained by removing the oil sump plug. Engines that have been stored in a cold place should be removed 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.

After the oil sump has been drained, the plug should be replaced and safety-wired. Fill the sump with lubricating oil. The crankshaft should again be turned several revolutions to saturate the interior of the engine with the clean oil. When installing spark plugs, make sure that they are clean, if not, wash them in clean petroleum solvent. Of course, there will be a small amount of preservative oil remaining in the engine, but this can cause no harm. However, after twenty-five hours of operation, the lubricating oil should be drained while the engine is hot. This will remove any residual preservative oil that may have been present.

CAUTION

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

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 oil strainers should be removed and cleaned in gasoline or some other hydrocarbon solvent.

Engine Accessories - Considerable time and effort can be saved if the accessories are installed on the engine before the engine is mounted in the airframe. The locations of the various accessory mounting pads are shown on the accompanying installation drawings.

Inspection of Engine Mounting - If the aircraft is one from which an engine has been removed, make sure that the engine mount is not bent or damaged by distortion or misalignment as this can produce abnormal stresses within the engine.

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

Oil and Fuel Line Connections - The oil and fuel line connections are called out on the accompanying installation drawings.

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

Pre-oiling - After engine change, overhaul or any prolonged period of inactivity the engine should be pre-oiled prior to starting. This is accomplished in the following manner.

1. Fill the sump to the proper level with ashless dispersant oil conforming to specification MIL-L-22851.

2. Disconnect inlet line to turbo-charger and the two front lines to exhaust valve guide oilers.

3. Remove one spark plug from each cylinder.

4. Place the mixture control in idle-cut-off, open throttle to full open, place fuel and ignition switches in off position.

5. Turn engine with starter for thirty (30) seconds, if oil pressure is not indicated at this time, stop and allow starter to cool for one (1) minute.

6. Turn engine again with starter for approximately forty-five (45) seconds when oil pressure should read 35-45 psi on oil gage and oil is flowing from disconnected lines.

7. Connect the three oil lines previously disconnected and again turn the engine with the starter for another forty-five (45) seconds. Oil pressure should read 35-50 psi on oil gage.

8. Re-install spark plugs and proceed with normal start which should not be later than three to eight hours from the completion of the pre-oiling.

9. When engine is started it should be run for about three (3) minutes at 1000 RPM.

## PREPARATION OF FUEL INJECTORS FOR INSTALLATION

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

Fuel Injector (Bendix) - 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 flows from the outlets. Do not exceed 15 psi inlet pressure.

## CORROSION PREVENTION IN ENGINES INSTALLED IN INACTIVE AIRCRAFT

Corrosion can occur, especially in new or overhauled 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. As soon as possible after the engine is stopped, move the aircraft into the hangar, or other shelter where the preservation process is to be performed.

b. Remove sufficient cowling to gain access to the spark plugs and remove both spark plugs from each cylinder.

c. Spray the interior of each cylinder with approximately (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 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-C-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 Avco Lycoming aircraft engines for corrosion prevention only, and not for lubrication. See the latest edition of Avco Lycoming Service Instruction No. 1014 and Service Bulletin No. 318 for recommended lubricating oil.

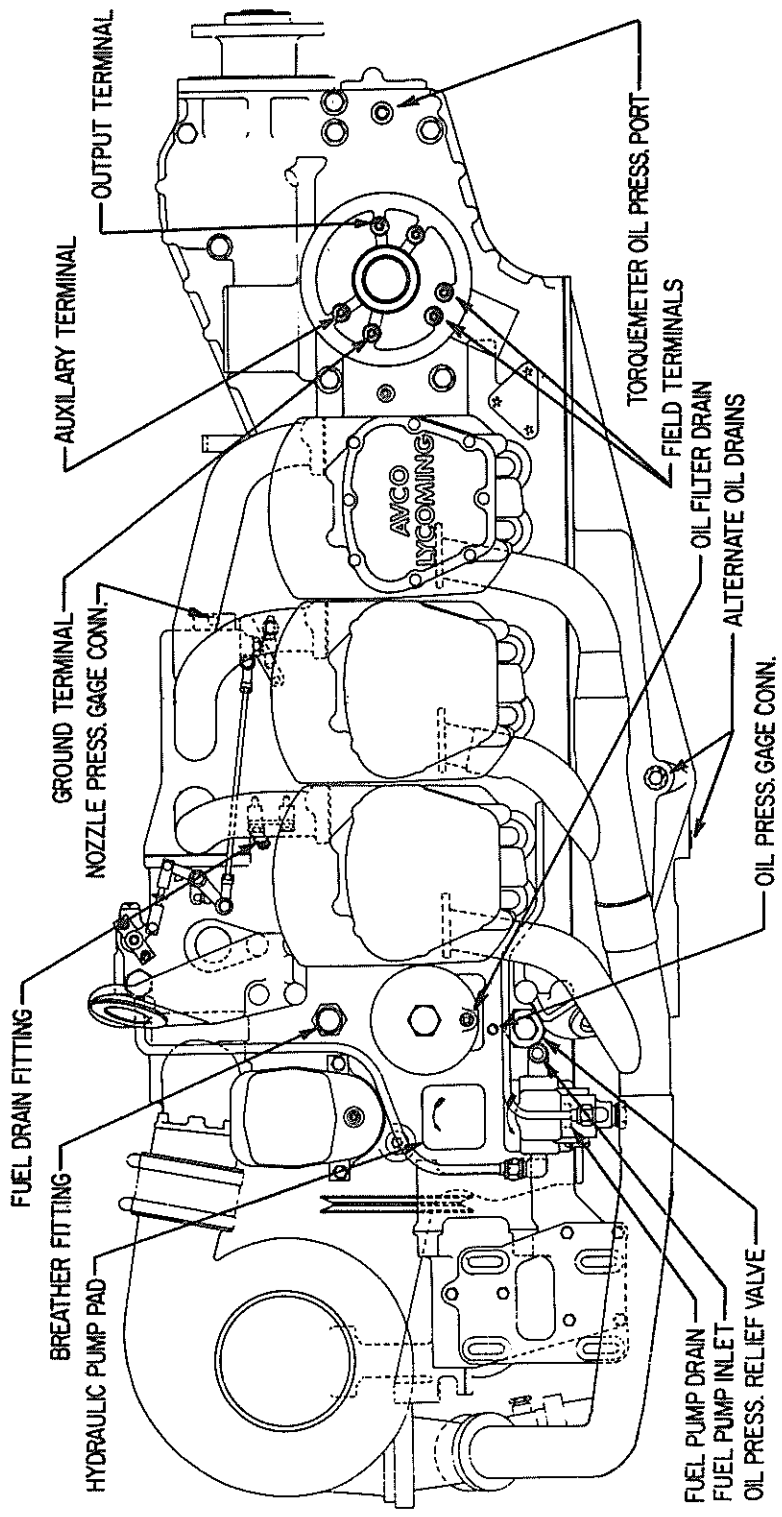



Figure 7-1. Installation Drawing - Right Side View - Typical TIGO-541 Series

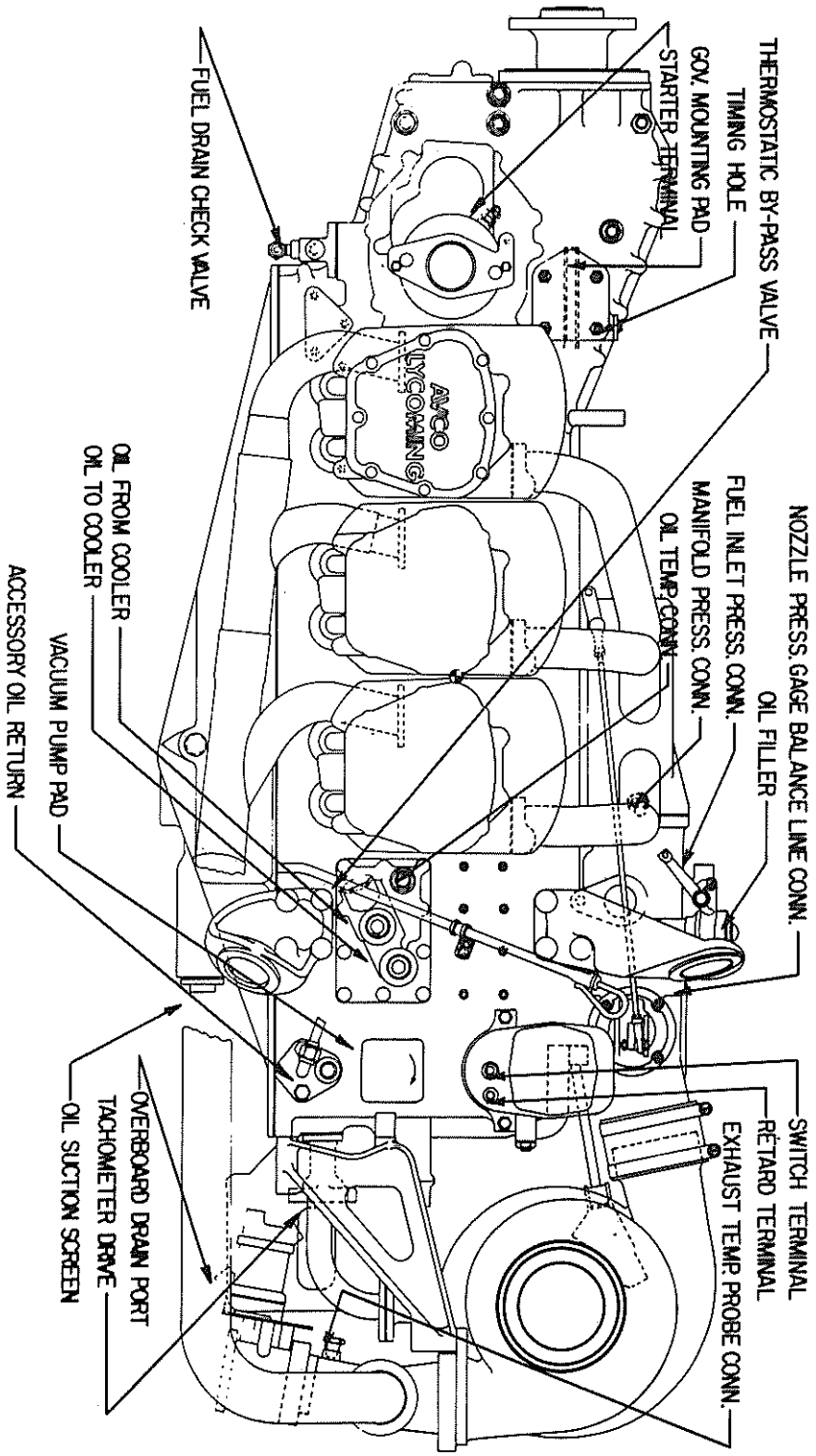



Figure 7-2. Installation Drawing - Left Side View - Typical TIGO-541 Series

TABLES

Page

# SECTION 8

## TABLES

FOR TIGHTENING TORQUE RECOMMENDATIONS AND INFORMATION CONCERNING TOLERANCES AND DIMENSIONS THAT MUST BE MAINTAINED IN AVCO LYCOMING AIRCRAFT ENGINES, CONSULT SPECIAL SERVICE PUBLICATION NO. SSP 2070.

CONSULT LATEST EDITION OF SERVICE INSTRUCTION NO. 1029 AND NO. 1150 FOR INFORMATION PERTINENT TO CORRECTLY INSTALLING CYLINDER ASSEMBLY.

FIXED WING ONLY

## GROUND RUN AFTER TOP OVERHAUL OR CYLINDER CHANGE WITH NEW RINGS

(DO NOT USE AFTER MAJOR OVERHAUL)

1. Avoid dusty location and loose stones.
2. Head aircraft into wind.
3. All cowling should be in place, cowl flaps open.
4. Accomplish ground run in full flat pitch.
5. Never exceed 200° F. oil temperature.
6. If cylinder head temperatures reach 400° F., shut down and allow engine to cool before continuing.

Type Aircraft _____

Registration No. _____

Aircraft No. _____

Owner _____

Engine Model _____ S/N _____

Date _____

Run-Up By _____

GROUND RUN

| | | | Temperature | | | | Pressure | | | | Temperature | | | Fuel Flow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | RPM | MAP | L.oil | R.oil | L.cyl | R.cyl | L.oil | R.oil | L.fuel | R.fuel | L.carb | R.carb | Amb.Air | Left | Right |
| 10 min | 1000 | | | | | | | | | | | | | | |
| 20 min | 1200 | | | | | | | | | | | | | | |
| 20 min | 1300 | | | | | | | | | | | | | | |
| 15 min | 1500 | | | | | | | | | | | | | | |
| 10 min | 1600 | | | | | | | | | | | | | | |
| 10 min | 1700 | | | | | | | | | | | | | | |
| 5 min | 1800 | | | | | | | | | | | | | | |

Mag. Check

Power Check

Idle Check

Adjustment Required

After Completion of Ground Run

1. Visually inspect engine(s)
2. Check oil level(s)

## FLIGHT TEST AFTER TOP OVERHAUL OR CYLINDER CHANGE WITH NEW RINGS

1. Test fly aircraft one hour.
2. Use standard power for climb, and at least 75% power for cruise.
3. Make climb shallow and at good airspeed for cooling.
4. Record engine instrument readings during climb and cruise.

Tested by _____

### FLIGHT TEST RECORD

| | | | Temperature | | | | Pressure | | | | Temperature | | | Fuel Flow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | RPM | MAP | L.oil | R.oil | L.cyl | R.cyl | L.oil | R.oil | L.fuel | R.fuel | L.carb | R.carb | Amb.Air | Left | Right |
| (Climb) | | | | | | | | | | | | | | | |
| Cruise | | | | | | | | | | | | | | | |

Adjustments Required After Flight

After Test Flight

1. Make careful visual inspection of engine(s).
2. Check oil level(s).
3. If oil consumption is excessive, (see operator's manual for limits), remove spark plugs and check cylinder barrels for scoring.

## TABLE OF SPEED EQUIVALENTS

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

## CENTIGRADE-FAHRENHEIT CONVERSION TABLE

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

| C | F C | F | C | F C | F |
|---|---|---|---|---|---|
| -62.2 | -80 | -112.0 | 71.00 | 160 | 320.0 |
| -56.7 | -70 | -94.0 | 76.67 | 170 | 338.0 |
| -51.1 | -60 | -76.0 | 82.22 | 180 | 356.0 |
| -45.6 | -50 | -58.0 | 87.78 | 190 | 374.0 |
| -40.0 | -40 | -40.0 | 93.33 | 200 | 392.0 |
| -34.0 | -30 | -22.0 | 98.89 | 210 | 410.0 |
| -31.7 | -25 | -13.0 | 104.44 | 220 | 428.0 |
| -38.9 | -20 | -4.0 | 110.00 | 230 | 446.0 |
| -36.1 | -15 | 5.0 | 115.56 | 240 | 464.0 |
| -23.3 | -10 | 14.0 | 121.11 | 250 | 482.0 |
| -20.6 | -5 | 23.0 | 126.67 | 260 | 500.0 |
| -17.8 | 0 | 32.0 | 132.22 | 270 | 518.0 |
| -15.0 | 5 | 41.0 | 137.78 | 280 | 536.0 |
| -12.22 | 10 | 50.0 | 143.33 | 290 | 554.0 |
| -9.44 | 15 | 59.0 | 148.89 | 300 | 572.0 |
| -6.67 | 20 | 68.0 | 154.44 | 310 | 590.0 |
| -3.89 | 25 | 77.0 | 160.00 | 320 | 608.0 |
| -1.11 | 30 | 86.0 | 165.56 | 330 | 626.0 |
| 1.67 | 35 | 95.0 | 171.11 | 340 | 644.0 |
| 4.44 | 40 | 104.0 | 176.67 | 350 | 662.0 |
| 7.22 | 45 | 113.0 | 182.22 | 360 | 680.0 |
| 10.00 | 50 | 122.0 | 187.78 | 370 | 698.0 |
| 12.78 | 55 | 131.0 | 193.33 | 380 | 716.0 |
| 15.56 | 60 | 140.0 | 198.89 | 390 | 734.0 |
| 18.33 | 65 | 149.0 | 204.44 | 400 | 752.0 |
| 21.11 | 70 | 158.0 | 210.00 | 410 | 770.0 |
| 23.89 | 75 | 167.0 | 215.56 | 420 | 788.0 |
| 26.67 | 80 | 176.0 | 221.11 | 430 | 806.0 |
| 32.22 | 90 | 194.0 | 226.67 | 440 | 824.0 |
| 27.78 | 100 | 212.0 | 232.22 | 450 | 842.0 |
| 43.33 | 110 | 230.0 | 257.78 | 460 | 860.0 |
| 38.89 | 120 | 248.0 | 243.33 | 470 | 878.0 |
| 54.44 | 130 | 266.0 | 248.89 | 480 | 896.0 |
| 60.00 | 140 | 284.0 | 254.44 | 490 | 914.0 |
| 65.56 | 150 | 302.0 | 260.00 | 500 | 932.0 |