

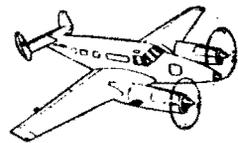
VOLPAR TURBO

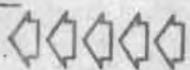


STUDY GUIDE



OPERATIONS TRAINING





DIRECTED STUDY

Training Program

VOLPAR TURBO

BEECH



DIRECTED STUDY PROGRAM

VOLPAR TURBO

BEECH

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GENERAL DESCRIPTION

The Volpar Turbo Beech is a low wing monoplane of semi-monocoque construction. It has a tricycle gear and is powered by two Airsearch TPE 331-47 Turboprop engines, each developing 575 SHP for take-off. Each engine drives a three-blade, constant-speed, reversible, full-feathering, hartzell propeller.

The pilot and copilot have a conventional side-by-side seating arrangement in the cockpit, with excellent visibility. The pilot compartment is separated from the main cabin by a fuselage bulkhead and the steel carry-through structure. The cabin usable length between bulkheads 5 and 9 is 10 feet 5 inches, a width of 52 inches, and the maximum height of the cabin is approximately 66 inches. The cabin normally accommodates 9 persons.

The cabin entrance door is on the left side of the fuselage between bulkheads No. 8 and 9, and opens outward. An emergency release, operated by a handle near the door hinges inside the cabin, will jettison the door when pulled.

The cargo door, which weighs approximately 28 pounds, is a panel extending from bulkhead No. 9 to No. 10, and is removable on the ground. It permits the aircraft to be used for air drops, or for the loading of cargo too large to be passed through the passenger door. It will permit loading of cargo up to 33" x 35" x 75" in size. To remove the cargo door, first open the passenger door, then release the cargo door latches and remove the panel outward.

A cockpit door at bulkhead No. 5 is a leatherette accordian type sliding door, separating the cockpit and cabin. The door can be opened from either the cockpit or the cabin.

The emergency exit window hatch is on the right side of the fuselage between bulkheads No. 8 and 9. An emergency release handle is located just forward of the window, when pulled will release the window hatch. The cabin entrance door, with its release handle, is also considered an emergency exit.

Surface controls consist of either fabric-covered or metal covered ailerons, elevator and rudders, all of which have controllable trim tabs. All surface controls and controllable trim tabs are manually operated from the cockpit. The construction and shape of the flaps are similar to the ailerons. The flaps are raised and lowered electrically, the wing flaps are of metal construction.

The Volpar Turbo Beech has a fully retractable, tricycle type landing gear. The main and nose wheel landing gears are mechanically interconnected to retract and extend simultaneously and are operated by a split field reversible motor with automatic dynamic braking. A safety switch prevents retraction while the airplane weight is on the landing gear. When the landing gear is retracted, it is enclosed by clamshell doors that fit flush with the external skin surface. The landing gear doors are linked to the gear, so they open and close automatically.

The wings consist of outer wing panels, wing tips, and center section wing stubs. The center section wing stubs are built integrally with the fuselage and are not removable. The primary structure of the center section consists of a single, triangular, welded steel tubular spar. This spar carries fittings for the engine mounts, landing gear and outer panel main spar. The rear spar is merely a shear beam and supports the inner flap hinges.

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GENERAL DESCRIPTION

1. The fuselage is _____ construction.

2. The Volpar Turbo Beech is powered by two airesearch _____ turboprop engines, each developing _____ SHP for take-off.

semi-monocoque

3. Each engine drives a three-blade, constant-speed, reversible, full-feathering _____.

TPE 331-47
575

4. The pilot compartment is separate from the main cabin by a fuselage _____ and the steel carry-through structure.

hartzell propeller

5. The cabin usable length between bulkheads 5 and 9 is _____, a width of _____ inches, and the maximum height of the cabin is approximately _____ inches.

bulkhead

6. The cabin can normally accommodate _____ persons.

10'5", 52", 66"

7. The cabin entrance door is on the _____ side of the fuselage between bulkheads No. 8 and 9, and opens _____.

9

8. An emergency release, operated by a _____ near the _____ inside the cabin, will jettison the door when pulled.

left
outward

9. The cargo door, which weights approximately 28 pounds, is a panel extending from bulkhead No. 9 to No. 10, and is removeable on the _____.

handle
door hinges

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10. It permits the aircraft to be used for _____ or for loading of cargo too large to be passed through the _____.

ground

11. It will permit loading of cargo up to _____ in size.

air drops,
passenger door

12. The emergency exit window hatch is on the _____ of the fuselage between bulkheads No. 8 and 9.

33" x 35"

13. An emergency release handle is located just _____ of the window, which when pulled, releases the window hatch.

right side

14. All surface controls and controllable trim tabs are _____ operated from the cockpit.

forward

15. The flaps are raised and lowered _____.

manually

16. The wings consist of _____ sections:
_____, _____, _____.

electrically

three,
center section,
outer panel,
tips.

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PERFORMANCE AND LIMITATIONS

The normal operating procedures including performance and limitations are included in the Company's Volpar Turbo Beech Flight Manual, Performance Tables are included in the manual and should be thoroughly studied and understood, so that they may be easily used for reference.

Airspeed limitations (indicated airspeed).

Maximum Operating Speed (Red Radial):
208 Knots

The maximum operating speed shall not be exceeded.

Normal Operating Range (Green Arc): 80 to 208 Knots.

The normal operating range extends from the stalling speed, fully loaded, with the landing gear and wing flaps retracted, to the maximum operating speed.

Maximum Design Maneuvering Speed: 133 Knots.

This represents the maximum speed at which full deflection of flight controls can be used without exceeding structural limitations of the airplane.

Flap Operating Range:

Power On (White Arc), 76 to 104 Knots
Power Off, 76 to 122 Knots

The operational speed range with flaps down extends from the stall speed, fully loaded, with flaps and landing gear down to the structural limiting speed of the extended position.

Maximum Speed For Landing Gear Extension and for Flight with the Landing Gear Extended: 130 Knots IAS

Powerplant Limitations

The sea level, standard day, take-off rating of the airsearch TPE 331-47 engine is 575 shaft horsepower at 41,730 engine RPM, (2000 prop. shaft RPM) and 1510 pounds feet torque. In a cold (high density) atmosphere the engine must be held within this limit by retarding the power levers. In a hot (low density) atmosphere the power obtainable is reduced as required to stay within the exhaust gas temperature limit.

Takeoff Power, 5 Maximum:

Shaft Horse Power	575
RPM, Propeller	100% (2000)
Exhaust Gas Temperature (EGT)	See OAT gauge
Torque	575 SHP

Observe torque, indicated as SHP, or whichever occurs first.

Maximum Continuous Power:

Shaft Horsepower	500
RPM, Propeller	100% (2000)
Exhaust Gas Temperature (EGT)	See OAT gauge
Torque	500 SHP

Observe torque, indicated as SHP, or EGT limit, whichever occurs first.

Maximum Starting EGT: 815°C for one sec.

Minimum Outside Air Temperature Limit:
-65°F (-55°C)

Engine Overspeed: 2100 propeller shaft RPM (105%) for a transient period not to exceed 10 seconds.

Induction Deicing: The induction deicing valve should not be operated in flight when the outside air temperature is above 40°F (4.4°C).

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Engine Oil:

Mobil Oil Jet 11, only (specification MIL-L-23699).

Rate of RPM Control Lever Movement:

Not faster than full travel in one sec.

Fuel:

Aviation turbine fuels, ASTM designations, Jet A, Jet B, and Jet A-1.

Military fuels, MIL-J-5624 grades, JP-4 and JP-5.

Anti-icing Additive: Phillips PFA-55 MB (MIL-I-27686 Jet fuel anti-icing additive is approved for use in fuels in amounts not to exceed .15% by volume.

Weight Limitations

Maximum Weight	10286 lbs.
Maximum Landing Weight	9772 lbs.
Maximum Zero Fuel Weight	9000 lbs.

Oil	3 Gal.
-----	--------

Fuel:

Main Tanks	100 Gal.
Outboard Aux. Tanks	85 Gal.
Inboard Aux. Tanks	152 Gal.
Rear Aux. Tanks	50 Gal.
Total	<u>387 Gal.</u>

Center of Gravity Range

Center of Gravity: (Aft of Datum)

Aft Limit	121.5 in.
-----------	-----------

Forward Limit at,	
7740 lbs. or less	107 in.
10286 lbs.	114.08 in.

Variation between these points is shown by the following chart.

Maneuvers

This is a Normal Category Airplane. Aerobatic maneuvers, including spins, are unauthorized.

Flight Load Factors

At 10286 lbs. gross weight, the positive limit load factor for this airplane is 3.28 g's.

Approved Operations

Maximum authorized flight altitude of this airplane is 16,500 feet.

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C. POWERPLANTS AND PROPELLERS

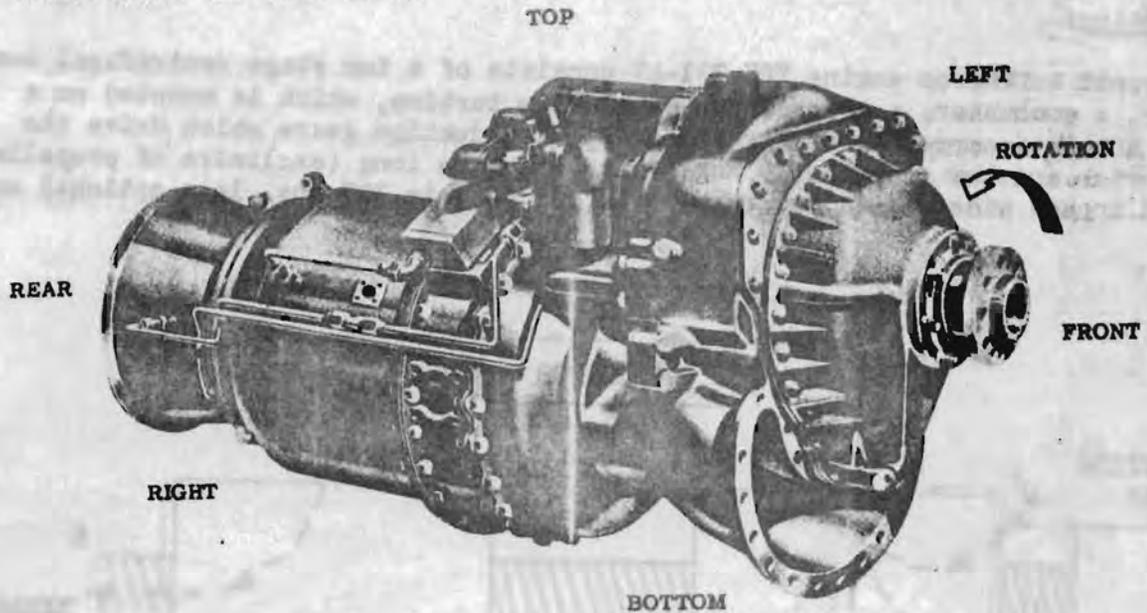


Fig. 1-1

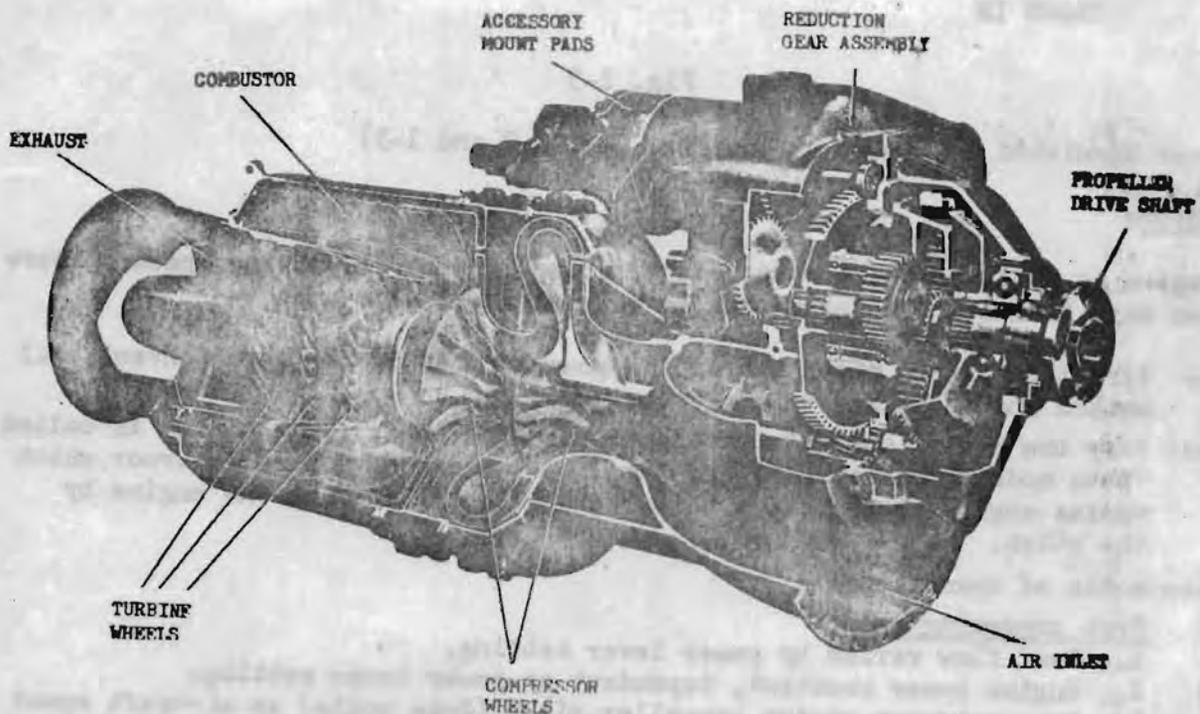


Fig. 1-2

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Description:

The Garrett turboprop engine TPE 331-47 consists of a two stage centrifugal compressor, a combustor, a three stage axial flow turbine, which is mounted on a common turbine-compressor shaft, and a set of reduction gears which drive the accessories and the propeller. Engine is 46 inches long (exclusive of propeller) by 19.5 inches wide and 24.7 inches high. It weights 307 lbs. less optional and

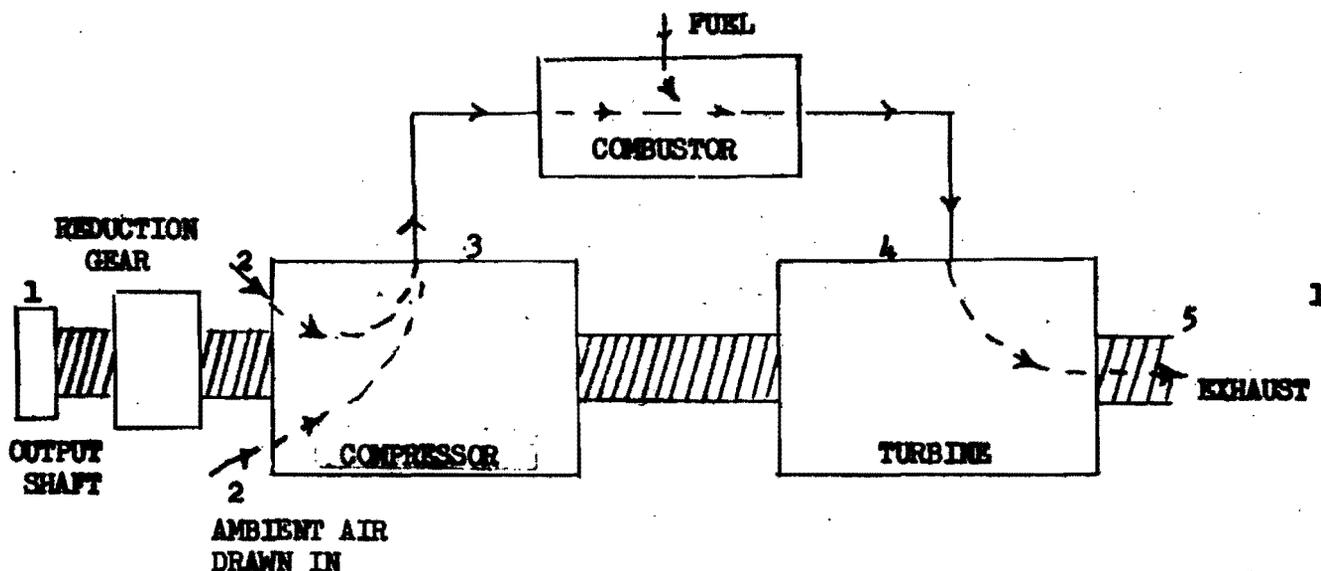


Fig. 1-3

customer furnished equipment. (See Fig. 1-1, 1-2 and 1-3)

Operation:

The engine is designed to operate most efficiently at a particular speed. There are two ways in which the engine can be maintained at this speed:

- First: Vary the load to match the engine power. This is the more conventional method and is called "prop governing".
- Second: Vary the engine power to match a changeable load. This method is called "Beta mode of operation", and involves the use of a fuel governor which varies engine power output to match the load placed on the engine by the pilot.

The two modes of operation are:

Prop governing mode

1. Fuel flow varied by power lever setting.
2. Engine power constant, dependent on power lever setting.
3. Prop governor varies propeller pitch (Beta angle) as aircraft speed varies.
4. Engine speed remains constant between 96% and 100% as set by the condition lever.

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Beta mode

1. Prop governor inoperative.
2. Prop pitch (Beta Angle) varied by power lever setting.
3. Engine speed decreases slightly under load (increase in Alpha angle)
4. Fuel flow adjusts automatically to load.
5. Engine power varies with load.

1. This engine has a variable pitch propeller. The load on the engine can be changed by _____ of the propeller.	
2. Propeller pitch may be changed manually by the _____, or automatically by means of a _____.	changing pitch
3. The Garrett TPE 331 engine uses _____ of these methods to control propeller pitch.	pilot, prop governor
4. Under normal operation when in flight the _____ is used to control propeller pitch.	both
5. Under prop governor control, engine speed remains _____, between 96% and 100% as set by condition lever.	prop governor
6. Under prop governor control, fuel flow is varied by the pilot setting the _____.	constant
7. Beta angle refers to the _____ angle of the propeller.	power lever
8. The angle between the aft surface of the prop blade and the axis of rotation of the propeller, measured at a fixed radius from the hub is known as the _____.	pitch
9. When the propeller pitch is directly varied by the pilot as he sets the power lever, the engine is being operated in _____.	Beta angle
10. In Beta mode the prop governor is _____.	Beta mode
11. Alpha angle refers to the angular difference between the propeller _____ angle and the direction of the relative wind. (The angle at which the air strikes the blade).	inoperative

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12. A change in airspeed would result in a change in the direction of the _____. This would also be a change in the _____.	pitch
13. A change in the airspeed changes the _____ on the engine.	relative wind, Alpha angle
14. In Beta mode of operation a change of alpha angle (engine load) automatically changes _____.	load
15. Therefore in Beta mode we can say that engine power varies with _____.	fuel flow
16. The propeller used with the Garrett TPE 331-47 engine, when installed in the Porter, is the Hartzell <u>controllable</u> , three blade, full feathering and _____ propeller. To put the propeller in reverse, the engine must be in _____.	alpha angle (or engine load)
17. The power lever has a _____ stop (detent) to prevent <u>unintentional</u> _____ of the propeller pitch when operating in Beta mode.	reversible, Beta mode
18. To reverse the propeller the pilot must purposely bypass the _____ which is located at the "max drag" position of the _____.	minimum pitch, reversal
	minimum pitch stop, power lever

The Start Cycle

The aircraft master switch is placed in ON position, which provides 24 volt dc power to the starter relay contacts. The engine switch is placed in the CRANK position. The aircraft ground start switch is closed, which energizes the starter relay. The starter circuit of the starter-generator is energized and the starter generator starts rotating and driving the engine reduction gear system. The starter-on light goes on. The oil pump gears start rotating and begin building up oil pressure to supply oil to the engine bearings, gears, and propeller control system. The fuel system pressure pumps start picking up fuel; the fuel solenoid valve remains in the normally closed position. The reduction gear system starts turning the quill shaft which drives the main drive shaft; the main shaft drives the compressor impellers and turbine wheels. The impellers start compression of inlet air.

When engine speed reaches approximately 10 percent, the flyweight-actuated light-off speed switch (SSI) closes. At 14% the engine switch is placed in the RUN position, the ignition relay energizes; the fuel-on solenoid is energized and

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The Start Cycle (Cont.)

latches in the ON position. Fuel flows to the combustion chamber, mixes with the compressed air and is ignited by the igniter plugs. The combustion gases flow into the turbine section to impart rotational energy to the turbine wheels. Acceleration continues under the combined forces of the starter-generator and combustion.

Fuel flow is scheduled by elements in the fuel control unit which compensate for variations in altitude, inlet temperature, compressor discharge pressure, and speed fluctuations. At lower engine speeds, the fuel control unit delivers lower pressure fuel to the flow divider valve, and a limited quantity of fuel flows through the primary fuel nozzles. As engine speed increases, fuel pressure increases, and the secondary passage in the flow divider valve opens and delivers increased fuel flow through the secondary fuel nozzles as well.

A limit switch in the fuel-on solenoid opens as the solenoid is actuated and latched in the ON position. This switch de-energizes the fuel-on solenoid to prevent damage if mechanical unlatching of the solenoid or electrical actuation of the fuel-off solenoid is required. If light-off does not occur, in approximately 10 seconds after start, shut off engine and determine cause of no start.

When engine speed reaches approximately 45-47% speed, flyweights actuate the normally closed starter cutout speed switch (SS2) which in turn de-energizes the start relay. This opens the circuits to the ignition system, to the fuel-on solenoid, and to the starter-generator starting system, and closes the circuit in the starter-generator generating system. The starter-on light goes off. The starter-generator is now being driven by the engine. The reverse current relay prevents use of generated current until the current reaches a satisfactory output. Voltage output is regulated by the voltage regulator. Combustion in the engine is now self-sustaining and the engine continues to accelerate.

Preflight Inspection

<u>Item</u>	<u>Inspection</u>
Fuel supply	adequate
Electrical supply	24V, 500 amp. (800 amp. momentarily)
Plumbing lines & connections	inspect for leaks, cracks, cuts, rubbing and insecure attachment
Drain & Vents	check for restrictions
Electrical Wiring & Connections	damaged insulation, burns, chaffing and insecure attachment
Mechanical linkages and cables	cracks, bent areas, other damage and insecure attachment.

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Air inlet & turbine exhaust

check for foreign material, obstructions or damage

Inlet sensors

check security of attachment and damage

Oil tank

leakage at fittings proper oil lever

Magnetic oil drain plug

check electrically for metal particles

Oil jet assembly line

leakage at fittings

Prop governor & pitch control

security of attachment, oil leaks at mounting pad & fittings

Fuel solenoid valve,
Flow divider valve,
Fuel nozzle,
Manifold assembly

security of attachment & fuel leakage at fittings

Starter generator

security of attachment, oil leakage, heat damage

Thermocouple assembly

security of attachment, heat damage

Propeller

start position

BEFORE ENGINE START

NOTE: Starting loads & engine temperatures are greatly increased by tail winds. Start into the wind or cross wind.

- a. PARKING BRAKE - Set
- b. SWITCHES - All Off
- c. SEAT BELT NO SMOKING - On
- d. LANDING GEAR CONTROL - Down
- e. FUEL SHUTOFFS - Open (up)
- f. CROSS FEED VALVE - Off
- g. AUXILIARY FUEL TANKS & GAGE - Select, (OUTBOARD AUX., if full).
- h. MAIN FUEL TANK CONTROL - On (up)
- i. PROPELLERS - Check, unfeathered. (if feathered, unfeather per 2.16)
- j. FEATHER LEVERS - Forward
- k. CIRCUIT BREAKER - All in.
- l. POWER LEVERS - Free & set GROUND START
- m. RPM LEVERS - Free & set TAXI
- n. IGNITION-FUEL SWITCH - ON
- o. AIR START-GROUND START SWITCH - GROUND START

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NTS CHECK

(This check should be conducted prior to the first flight of each days operation.)

- a. ELECTRIC POWER - On
- b. PROPELLERS - Clear
- c. NTS SWITCH - NTS
- d. AIR START-GROUND START SWITCH - AIR START
- e. IGNITION-FUEL SWITCH - OFF
- f. STOP-START SWITCH - Hold in START until NTS (BETA) light comes on.
- g. AIR START-GROUND START SWITCH - GROUND START; NTS light should go out as starter begins to rotate propeller.
- h. STOP-START SWITCH - STOP & RELEASE.
- i. NTS SWITCH - BETA
- j. IGNITION-FUEL SWITCH - On

ENGINE START

NOTE: In temperatures below 10°F (4.4°C) an auxiliary power unit will be required for starting.

- a. BATTERY SWITCH - On (or Aux. Power connected & BATTERY SWITCH - OFF)
- b. FIRE & WARNING LIGHTS - Check
- c. FUEL BOOST SWITCHES - AUX. ON; check fuel transfer pressure, positive & TRANSFER LIGHTS ON, then switches OFF, check TRANSFER LIGHTS, OFF.
- d. FUEL BOOST SWITCHES - On MAIN
- e. FUEL PRESSURE - Check, 10-20 PSI
- f. INVERTER SWITCH - On

START R.H. ENGINE FIRST

- g. STOP-START SWITCH - START & release
- h. COMPRESSOR BLEED SWITCH - On
- i. TACHOMETER - Observe until 10-12 % is reached.
- j. FUEL FLOW - Rising
- k. EGT - Rising (at 14-20% RPM)
- l. COMPRESSOR BLEED SWITCH - OFF AT LIGHT OFF

CAUTION: IF IGNITION HAS NOT OCCURED WITHIN 10 SECONDS OR AT 20% RPM, WHICHEVER IS FIRST REACHED, THRU "STOP-START" SWITCH TO "STOP". Allow starter to cool for 5 min. before repeating starting procedure. If second attempt is unsuccessful allow starter to cool until a hand may be held on its surface.

SPECIAL INSTRUCTOR FOR BATTERY START: When starting L.H. engine (R.H. already started), at 20% RPM turn on R.H. Generator.

- m. COMPRESSOR BLEED - On (50 - 85 % RPM)
- n. FUEL ENRICHMENT - On as required, as indicated by a lag in rate of increase of RPM.

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- o. EGT - Observe the rate of increase. If rate does not diminish before 715°C is reached, ABORT START as follows:
 - 1. STOP-START SWITCH - STOP
 - 2. FUEL ENRICHMENT SWITCH COMPRESSOR BLEED SWITCH - Release
- p. RPM - should stabilize at 84-86 %
- q. EGT - Check normal
- r. COMPRESSOR BLEED SWITCH - Release
- s. GENERATOR SWITCH - ON, if battery start, & charge battery until ammeter reads normal load, then OFF until L.H. engine started and reaches 20% RPM.

REPEAT STEPS "g" thru "s" FOR L.H. ENGINE

PRE-TAXI

- a. AUXILIARY POWER - Disconnect
- b. BATTERY SWITCH - ON (if Aux. Power was used.)
- c. GENERATOR SWITCHES - ON
- d. VOLTAGE - Check
- e. RADIO - ON
- f. AIR CONDITIONER - As Required
- g. REMOTE COMPASS - ON
- h. FLIGHT INSTRUMENTS VACUUM - Check
- i. FUEL BOOST SWITCHES - OFF
- j. AIR START-GROUND START SWITCH - AIR START
- k. OIL TEMPERATURE - Check
- l. OIL PRESSURE - Check
- m. FUEL PRESSURE - Check
- n. OVERSPEED GOVERNOR CHECK:
 - This check should be made whenever air starts are to be intentionally made, there is an indication of malfunction, or when any maintenance or adjustments involving the engine control system have been performed. (Start Locks to remain engaged for this check.)
 - 1. RPM LEVERS - Full forward
 - 2. POWER LEVERS - Advance until further motion causes no increase in fuel flow or RPM; RPM should be 103 to 104 %. CAUTION: DO NOT ALLOW RPM TO EXCEED 105%.
- o. UNLOCK PROPELLER START LOCKS - Move Power Levers back from Ground Start position toward Reverse, a few degrees at a time, until Beta Light goes out. When light comes on again, locks are released. Slowly return Power Levers to Ground Start position. (Release of locks is also indicated by change in propeller sound and increase in fuel flow and EGT.)
- p. AMMETERS - Check, load normal.
- q. RPM LEVERS - Set Taxi.

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TAXI

a. POWER LEVERS - Move forward from GROUND START towards FLIGHT IDLE as required.

NOTE: If greater power is required to taxi, move RPM Levers to Flight Idle or beyond, as required. If REVERSE is required, move RPM Levers to FLIGHT position.

BEFORE TAKEOFF

- a. PARKING BRAKE - Set
- b. TRIM - Set
- c. FLAPS - Up
- d. BOOST PUMPS - On MAIN
- e. RPM LEVERS - FLIGHT (full forward)
- f. BLEED, ANTI-ICE LIGHT - Out
- g. PROPELLER GOVERNOR CHECK - Advance Power Levers toward TAKEOFF position until RPM does not increase with advancing Power Levers. RPM should be 99.5 to 101%.
- h. HIGH SIDE OF UNDERSPEED FUEL GOVERNOR CHECK - Retard Power Levers to the FLIGHT Idle Stop, RPM should be 97-98 %.
- i. ENGINE INSTRUMENTS - Check
- j. FLIGHT INSTRUMENTS - Check
- k. FLIGHT CONTROLS - Full and correct movement.
- l. BEACON LIGHT - On.
- m. RPM LEVERS - If takeoff will not be made immediately, place in TAXI, to reduce fuel consumption.

FUEL SYSTEM (Fig. 2-1) See Page 15

A supply of fuel is stored in a tank and passes through a filter to a boost pump. The boost pump is to discourage vapor formation in the supply line. The fuel flowmeter could be located in the supply line anywhere between the tank and the atomizers as fuel flow must be constant throughout the system. A main shutoff valve isolates the supply tank from the rest of the system.

A second fuel boost pump and the high pressure fuel pump are driven by the engine gear train, maintaining necessary pressure for forcing the fuel through the fuel filter, fuel control's metering valve and the atomizers into the combustor. The fuel control responds to compressor inlet pressure (P_2), temperature (T_2), compressor discharge pressure (P_3), RPM and movement of either the condition lever or power lever. It meters the proper amount of fuel to the combustor.

At about 10% RPM, a speed switch, SS-1, within the reduction gear housing completes the circuit to the fuel solenoid which opens permitting fuel to flow through the primary atomizers to the combustor.

As the engine increases RPM, increased airflow (w_f) through the compressor results in increased P_3 which is sensed by the fuel control (biased by P_2

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and T_2) which opens to allow an increased fuel flow to reach the combustor. When RPM has increased to build enough fuel pump pressure the flow divider opens to permit fuel through the secondary atomizers into the combustor in addition to that already flowing atomizers.

At about 45-47% RPM, speed switch SS-2 opens the ignition circuit through the fuel solenoid. Since the solenoid is a latching type, it remains open without electrical power until it is closed by energizing the "close" coil, or mechanically by actuating the feathering lever.

As the engine nears the RPM for which the ^{RPM} condition lever is set the fuel control's metering valve will begin closing to reduce fuel flow and maintain the engine at the selected speed.

Pushing the power lever forward, mechanically forces the fuel control's metering valve open in spite of the speed governors efforts to keep it closed. Thus the power lever can increase fuel flow to the combustor.

During starting the T_2 bias can be overcome through the start flow system which provides additional fuel.

The fuel enrichment system provides additional fuel to the combustor during use of compressor bleed and during cold weather starts.

These last two systems do not provide carefully programmed quantities of fuel and require special care by the pilot when using.

FUEL CONTROL (Fig. 2-2) See Page 16

The two major units of the Fuel Control are the underspeed governor, which supplies fuel to the engine in increasing quantities as the engine builds its speed of rotation; and the overspeed governor, which cuts down on the supply of fuel to the engine as the engine increases its speed of rotation. These two units develop a balance which keeps the engine rotating at a constant speed.

When the engine is starting, the overspeed governor is full open so that all fuel control is through means of the underspeed governor.

Fig. 2-3 (Page 17) is a graph on which fuel flow is related to engine speed. The lower curve defines the fuel flow which would be required to make the engine run but not accelerate, at any RPM. Any time fuel flow is greater than this "REQUIRED TO RUN" valve, the engine will accelerate. The upper curve is the acceleration curve.

Fig. 2-4 (Page 18) depicts a simplified illustration for holding fuel flow (w_f) within an acceleration limit schedule. As compressor pressure (P_3) rises with RPM, an acceleration limiter cage is forced down allowing the fuel metering valve to open. The greater the pressure (P_3) the greater the fuel flow (w_f).

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A speed governor is incorporated in the fuel control which is arranged to vary fuel flow in inverse proportion to engine speed when engine speed reaches a given setting. This setting is put into the control by use of the condition lever. These vary from 85% at full back position to 97% full forward. A pair of speed-sensing flyweights are used to reduce w_f as engine reaches the set speed. When the speed of the engine increases, the rising compressor pressure moves the acceleration limit stop downward, allowing the fuel metering valve to open, however, the rising speed also causes the gear driven flyweights to produce an increasing force against the lower speeder spring retainer. At some RPM the flyweights will raise the retainer; the metering valve will be lifted off of the acceleration stop and moved toward the closed position. Above this point, as speed increases, fuel flow to the nozzles is reduced. The RPM at which this reduction of fuel flow occurs with an increase in speed depends upon the spring force set by the condition lever position.

When the engine has reached 100% RPM the propeller governor prevents a change in engine speed. When operating in prop governing mode forward movement of the power lever forces the lower speeder spring retainer down against the pressure of the flyweights permitting additional fuel flow (w_f) to the combustor. This is realized as more torque power since the propeller governor prevents engine acceleration.

Once the engine has reached 100% RPM the load on the engine (propeller) keeps the engine from overspeed. Should the load suddenly be removed from the engine (prop control failure) an overspeed governor goes into action at 101%. The overspeed governor operates in much the same manner as the underspeed governor except for the spring tension against the flyweights. As the engine speed exceeds 101% RPM the flyweights pivot out partially closing a fuel flow valve thereby reducing fuel flow to the engine. Thus the engine is prevented from exceeding 103% RPM. If RPM drops below 101% fuel flow increases, maintaining max speed between 101% and 103% when propeller load on engine is unexpectedly reduced.

P₃ Sensor (Fig. 2-4) See page 18

A tap off the engine at station P₃ provides pressure to a bellow-ram (a diaphragm with excess material to permit a long stroke). As P₃ increases the bellow-ram expands, moving a toothed rod. This rod positions a gear which is connected to a three dimension cam. As the cam rotates it actuates a pivoted lever which permits the fuel flow valve to open, increasing w_f to the atomizers. This provides a direct relationship between compressor air flow and fuel flow. A rupture of the P₃ sensor tube will prevent engine acceleration after lightoff.

P₂ Sensor (Fig. 2-5) See page 19 - Air Density

Since the density of the ambient air affects the operation of the engine, it must also modify the fuel flow. An inlet air sensor placed in the inlet duct senses both the pressure and temperature of the air entering the compressor. Variations in P₂ are carried to a bellows within the fuel control assembly.

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A reduction in the value of P_2 will cause the bellows to expand. A rod, connected to the bellows positions the three dimensional cam laterally (see P_3 sensor) thus superimposing P_2 on the P_3 signal being given to the fuel control. A reduction of P_2 at the inlet will result in a reduction in fuel flow with increased P_2 increasing fuel flow.

T_2 Sensor (Fig. 2-5) - Air Temperature

The temperature of the ambient air has an effect on its density and thus on the pressure of the air after it has been processed by the compressor (P_3). This must be compensated for. The T_2 portion of the inlet duct sensor consists of a triple coil of tubing which contains alcohol.

A change in inlet air temperature would expand or contract the alcohol sealed within the sensor, causing a movement of a bellows in the fuel control. Through a linkage, movement of the temperature sensing bellows provides further positioning of the 3D cam, which is already adjusting to compressor discharge pressure (P_3) and inlet pressure (P_2). This results in an additional modification of the fuel flow (w_f) to the combustor. Should damage cause the alcohol to leak from the sensor, fuel flow will not be sufficient to permit light off during the start cycle.

FUEL SHUT-OFF VALVE (Fig. 2-2)

The fuel shut-off valve is located between the fuel control and the atomizers. It is a ball-type valve which can be moved to either the open or closed position by two separate solenoid coils. Following movement of the valve a microswitch breaks the circuit to the coil so no current is consumed by the solenoid assembly. The valve is held in either the open or closed position by a spring latch. In case of power failure the valve can be mechanically closed by pulling the prop feathering handle. Once closed the fuel valve cannot be opened without electric power. When closed the fuel shut-off valve drains the fuel from the line to the atomizers.

FUEL ATOMIZERS (Fig. 2-1)

When the fuel solenoid is opened (above 10% RPM with the engine switch in the RUN position) high pressure fuel flows through the TEN fuel atomizers into the combustor. The fuel atomizers are separated into a primary (small) orifice and a (larger) secondary orifice which surrounds the primary. A pressure operated flow divider distributes all of the fuel flow to the primary orifices of the TEN atomizers while fuel pressure is low (70 - 225 psi), at engine starting speeds prior to light off. When fuel pressure exceeds 225 psi, the flow divider opens to permit fuel flow to the secondary orifices to supplement the fuel already flowing through the primary orifices. If the fuel divider should malfunction and open while fuel pressure is low, the fuel would not develop enough pressure to atomize and the engine would not light off.

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FUEL OIL HEAT EXCHANGER (Fig. 2-2)

Fuel from the high pressure pump is forced through tubes of an oil-fuel heat exchanger where the fuel absorbs some of the heat from the lubricating oil. From the heat exchanger the warmed fuel can flow three ways; through the speed governor, through the fuel enrichment solenoid and through the anti-ice sensor. When fuel entering the system has a low enough temperature to permit entrained water to freeze on the filters, the anti-ice sensor metering valve opens, allowing heated fuel to mix with fuel entering the system from the boost pump, preventing ice formation on the filters. Should ice, or other foreign material clog, the filter, a clogged filter warning light on the pilot's instrument panel comes ON. Once the clogged filter warning light is ON the pilot should land as soon as possible as there is no way of estimating the length of time that the engine will continue to receive sufficient fuel to run. Warm fuel reaching the atomizers, through the fuel control, is more easily atomized and ignited than is cold fuel.

1. The Garrett Engine TPE 331 has _____ fuel booster pumps.	
2. One boost pump is _____ driven, the other is _____ driven.	two
3. In addition there is a high _____ fuel pump to force fuel through the system.	electrically, engine
4. To obtain fuel flow there must be _____ in the tanks, the aircraft _____ valve must be open and the _____ must be open.	pressure
5. The fuel solenoid valve is _____ operated. It cannot be opened until the _____ switch is ON, the _____ switch is in RUN, the _____ switch is ON and the SS ₁ switch has automatically closed when the engine reached _____ % RPM.	fuel, fuel shutoff, fuel solenoid valve
6. As the engine gains speed after light off, compressor discharge pressure (P ₃) causes _____ fuel to reach the combustor.	electrically, master, engine, ground start, 10%
7. As engine RPM nears the speed scheduled by the _____ the fuel control automatically reduces fuel flow in order to _____ constant engine RPM.	increased (more)
8. The _____ system and the _____ system make it possible for the pilot to provide extra fuel to the combustor, when needed, during the start cycle.	^{RPM} condition lever, maintain
9. Excessive fuel to the combustor will _____ combustor discharge temperature T ₄ .	start flow, fuel enrichment

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10. On the Garrett engine, T_4 is monitored by means of Exhaust Gas Temperature gage mounted on the _____.	increase
11. Exhaust Gas Temperature (EGT) is measured at engine station _____ on the Garrett engine.	pilot's instrument panel
12. Fuel metering must be carefully monitored by the _____ to be sure that allowable EGT (T_5) temperatures are _____.	T_5
13. The automatic fuel control does not prevent _____.	pilot, not exceeded
14. When maximum T_5 temperatures are approached the _____ must take the necessary action to reduce _____ before _____ occurs.	excessive EGT
15. All fuel entering the system passes through fuel filters. Should the filters become clogged the _____ comes on at the pilot's instrument panel.	pilot, fuel flow, engine damage
16. Should the clogged filter warning light come on, the pilot should _____ as soon as possible.	clogged filter warning light
17. When shutting down the engine, fuel flow is shutoff electrically by closing the _____.	land the aircraft
18. In case of electrical failure, the fuel solenoid valve can be closed manually by _____.	fuel solenoid valve
	pulling the prop feathering handle

01-789

SIMPLIFIED FUEL SYSTEM

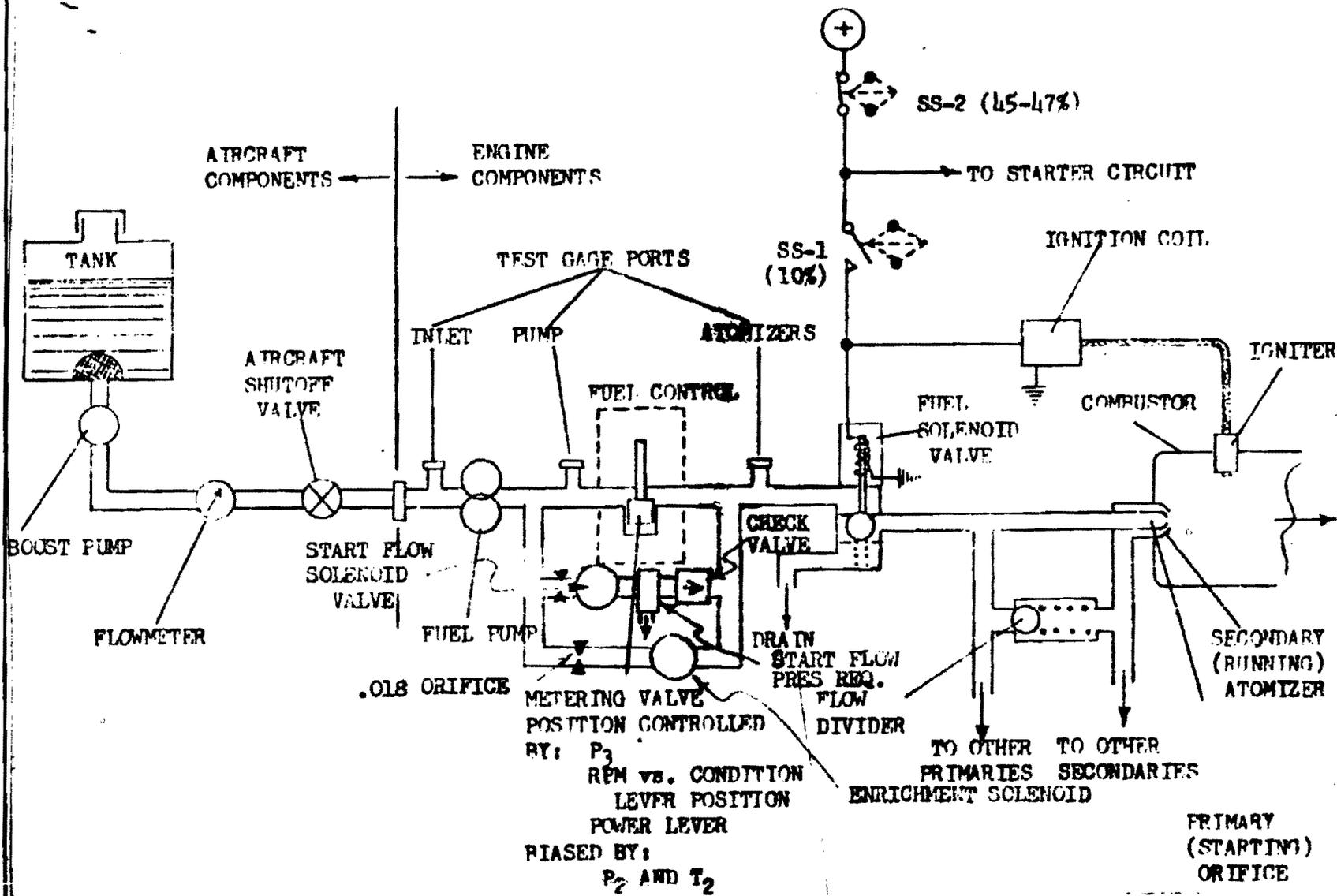


Figure 2-1

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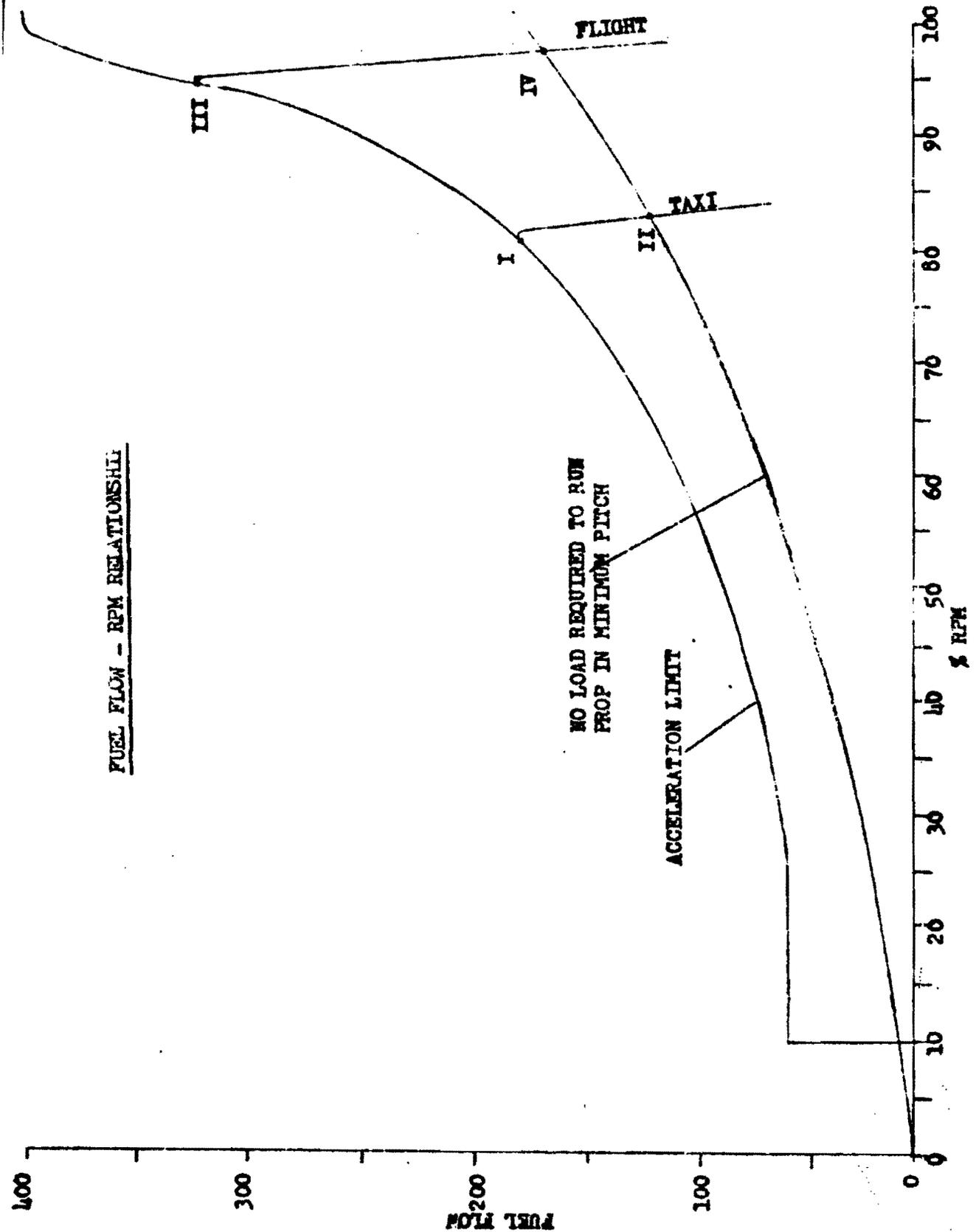
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FUEL FLOW - RPM RELATIONSHIPS

NO LOAD REQUIRED TO RUN
PROP IN MINIMUM PITCH

ACCELERATION LIMIT

FIG. 2-3

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SIMPLIFIED FUEL CONTROL SYSTEM

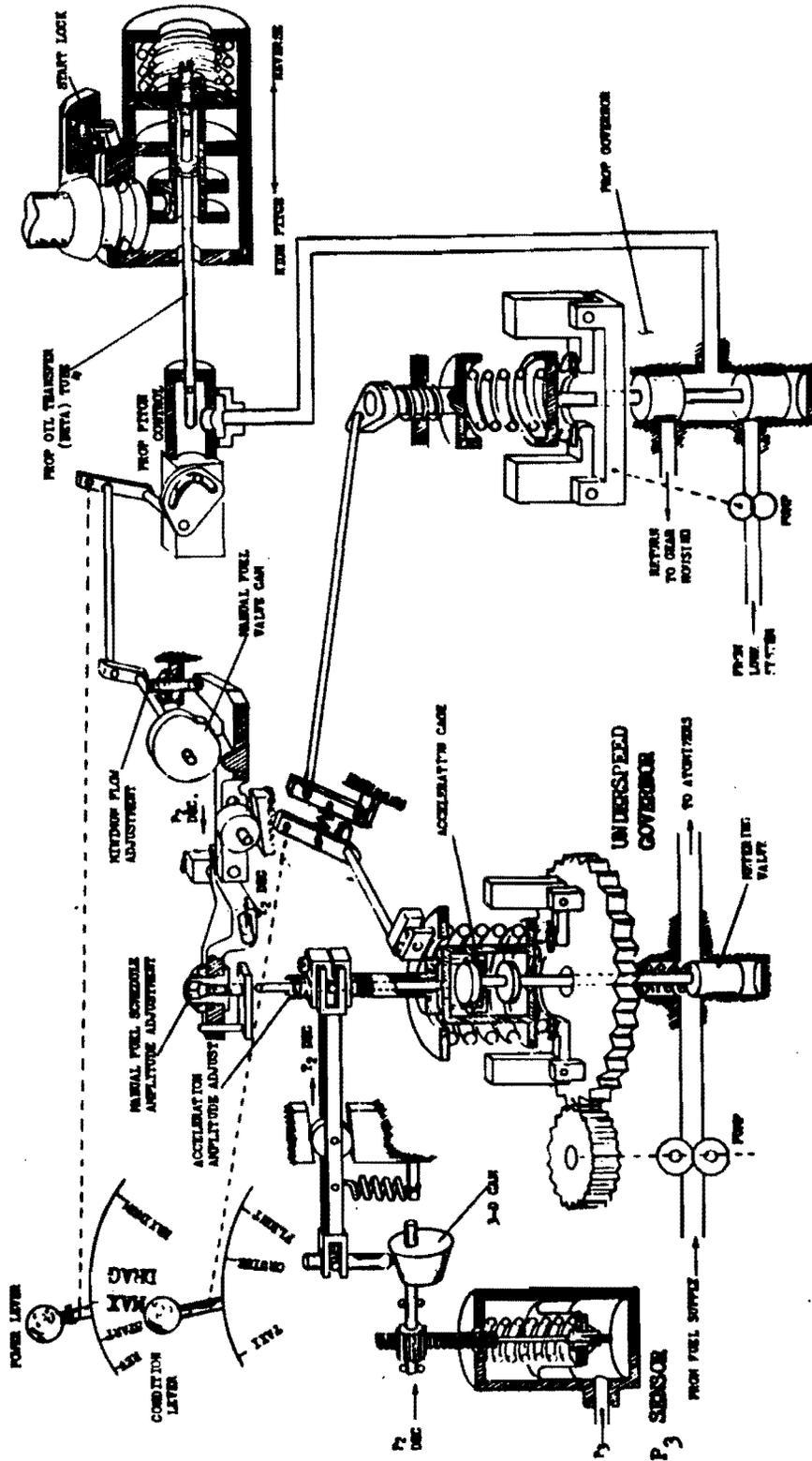


Figure 2-4

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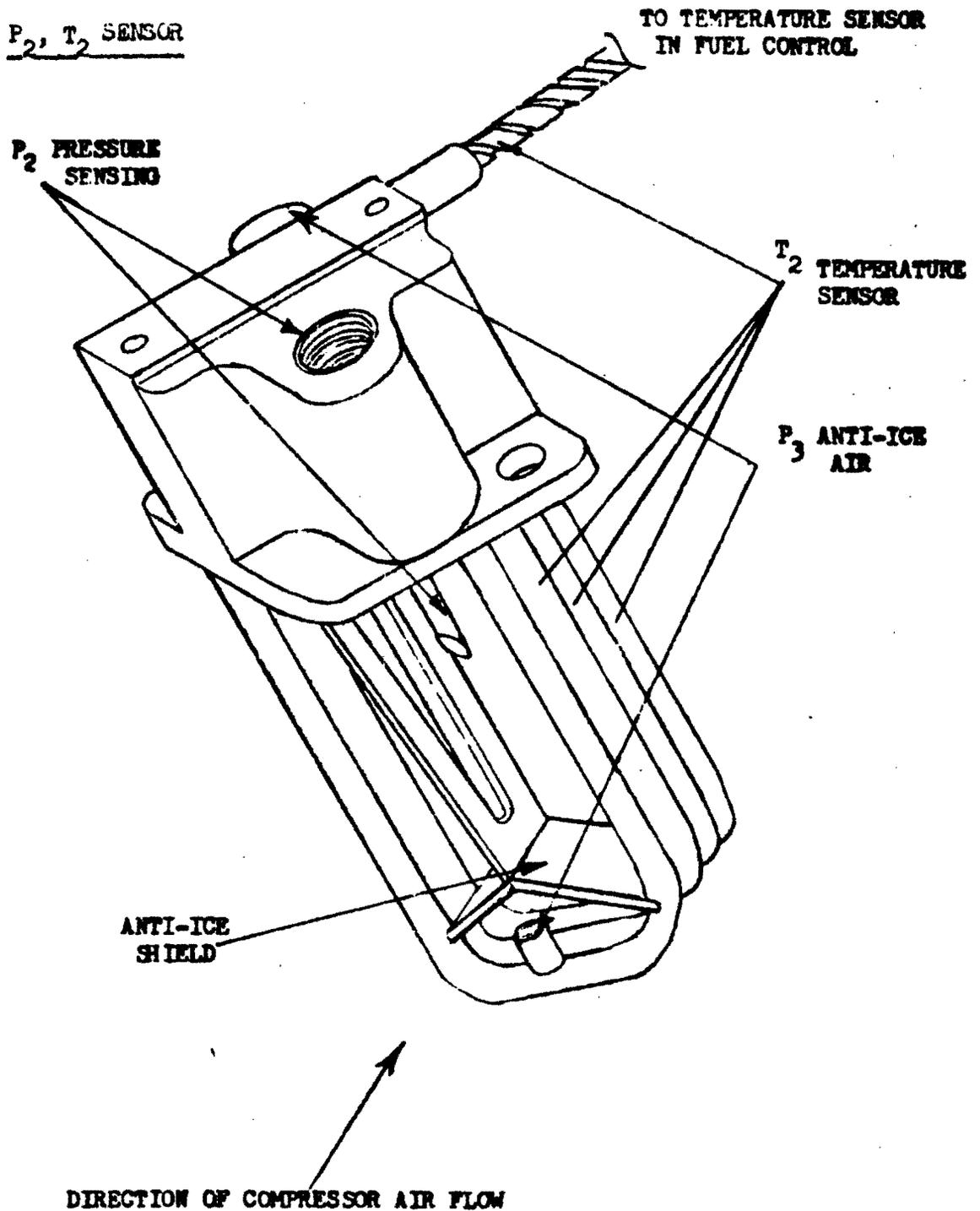


Figure 2-5

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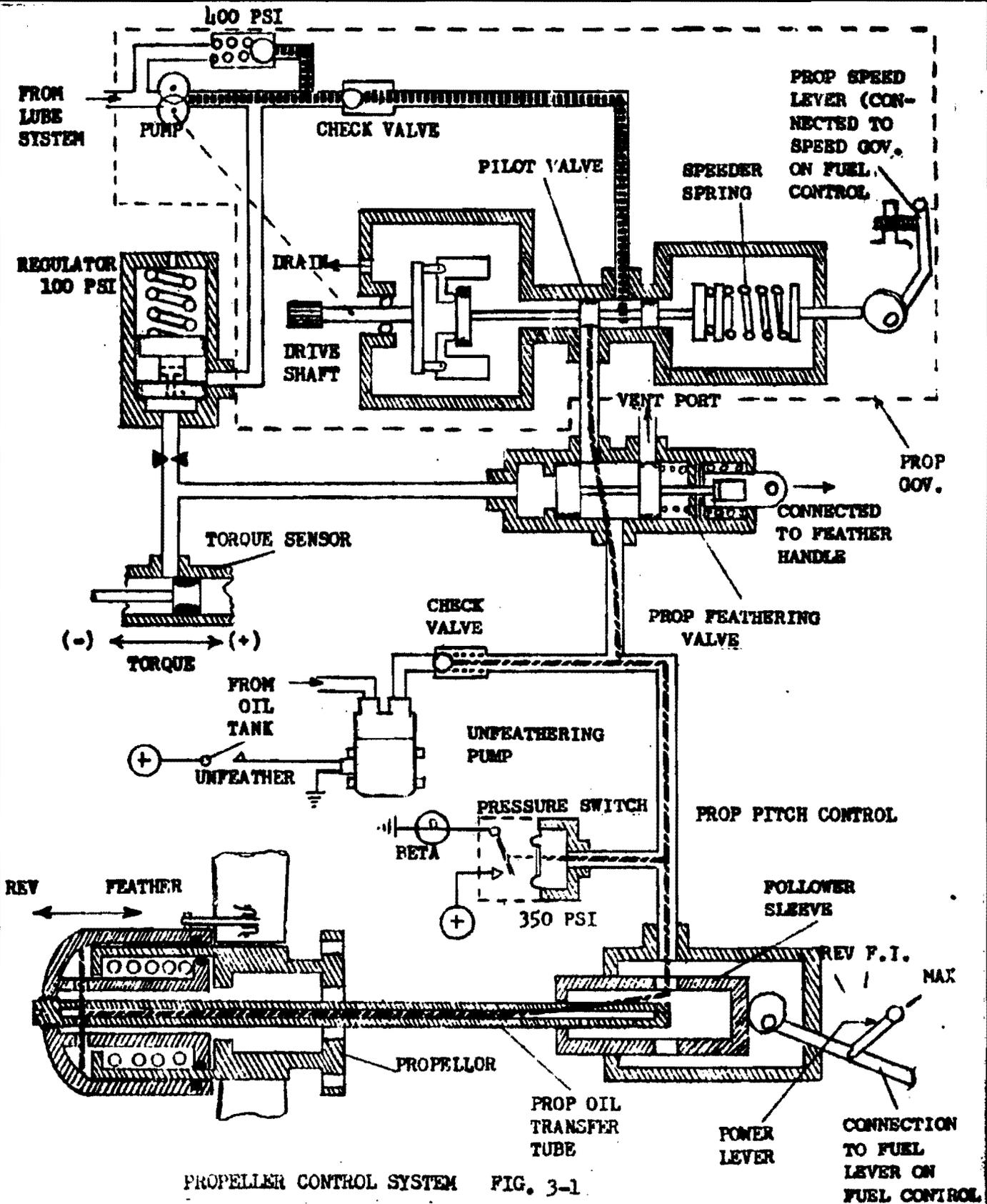
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PROPELLER CONTROL SYSTEM FIG. 3-1

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Propeller Control System (Fig. 3-1) See page 20

The principle components of the propeller controls are the propeller, the prop pitch control, the propeller governor, the prop feathering valve, negative torque sensor, pressure regulator, unfeathering pump and pressure switch. The propeller used on the engine in the Porter installation is the Hartzell, three bladed, variable pitch, reversible propeller. Other propellers of similar design may be used.

Propeller (Fig. 3-2) See page 22

The Hartzell propeller is spring loaded to return to the feathered position. Oil pressure, entering through an oil transfer tube, fills the entire dome of the peller. As oil pressure rises, a piston is forced out, rotating the blades toward low pitch, and eventually to the reverse pitch position. Since the propeller is spring loaded to feather, when oil pressure drops off, the blade will assume the feather position. In order to prevent automatic feathering on engine shut down, the propeller is provided with stop locks which position the blades so as to offer minimum air resistance during the start cycle. Since the engine will not start with the propeller in the feather position, it is important for the pilot to properly position and lock the blades when he shuts down the engine. To accomplish this, when the pilot shuts down the engine he must move his power lever to a reverse position so that the blades will be rotated far enough back of the start position to allow the locks to drop into place as the engine comes to a stop and loses oil pressure.

Propeller Operation (Fig. 3-1)

Oil is supplied to the propeller from the engine lubricating system. This oil is drawn through a gear type pump in the propeller governor and forced through the controls to the propeller piston. Whenever the oil flow is closed off, oil trapped in the propeller dome hydraulically holds the blades in a fixed position. Forcing additional oil into the propeller dome reduces prop pitch. Letting oil drain out of the propeller dome increases prop pitch. If all oil drains out the prop goes to the feather position. The manner in which oil is forced into or let out of the propeller dome comprises the propeller control system.

Propeller pitch is controlled in two different ways. In Beta mode of operation, the pilot directly sets prop pitch with the power lever. In prop governor mode of operation, the prop governor automatically selects the prop pitch required to keep the proper load on the engine so that it will run at a constant speed.

Prop pitch control (Fig. 3-1)

When operating the engine in Beta mode (between 85% and 97% RPM as set by the condition lever), the pilot sets the prop pitch by mechanically moving the

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HARTZELL 3 BLADE, ADJUSTABLE PITCH, REVERSABLE, FULL FEATHERING PROPELLER

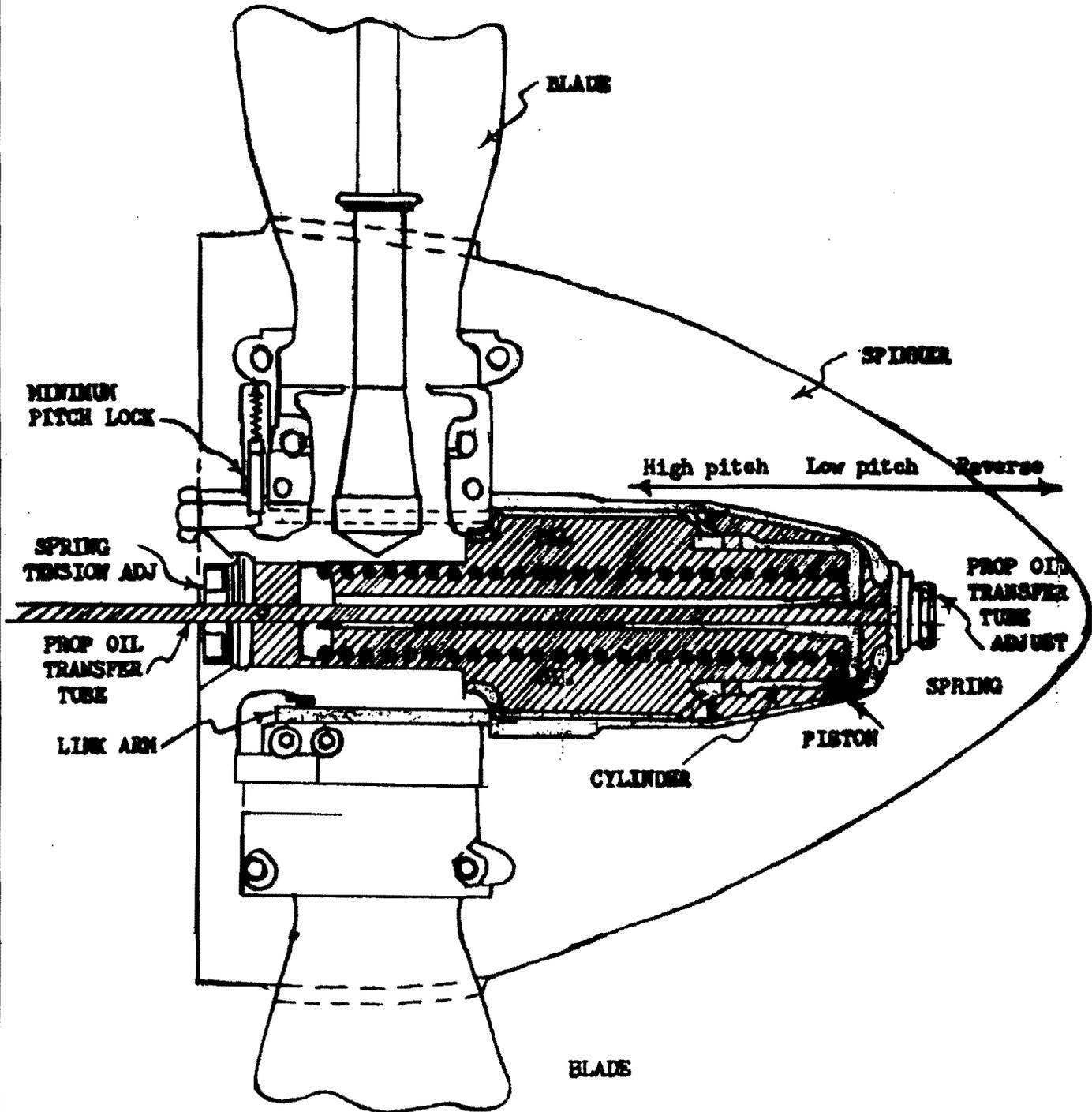


FIG. 3-2

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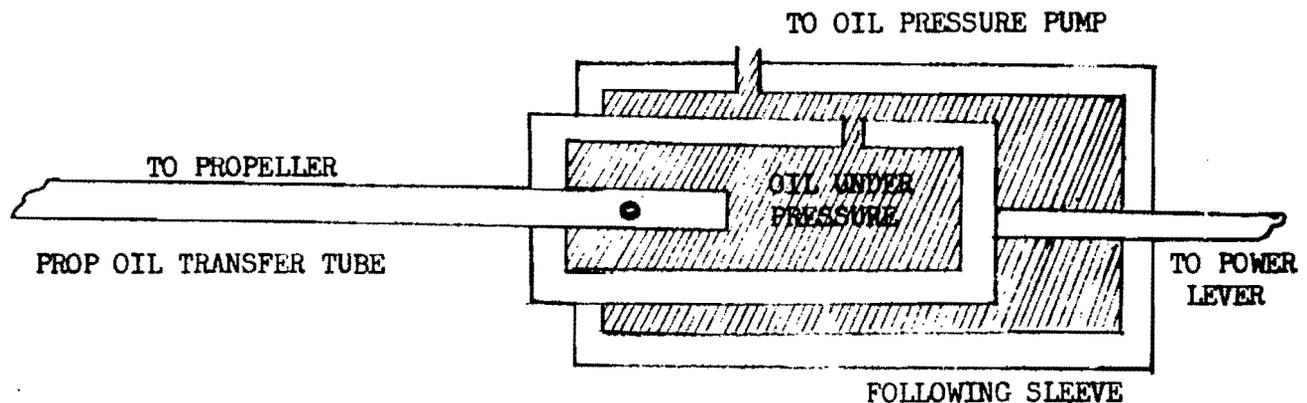
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Prop Pitch Control (Cont.)

prop pitch control with the power lever. Oil pressure at about 400 psi is provided by the propeller system's oil pressure pump. This oil goes through the inoperative prop governor system, activates a pressure switch which gives a panel light indication that the control is in Beta mode, and then to the prop pitch control. The prop pitch control is mounted at the rear of the gear case assembly directly behind the propeller. It consists of a movable follower sleeve into which the rear end of the prop oil transfer tube is fitted. The oil transfer tube has a hole near its end. When the hole in the transfer tube is inside the follower sleeve, high pressure oil can flow freely into the propeller dome causing the piston to move out, reducing the prop pitch. As the piston moves out the prop oil transfer tube moves with it until the hole in the tube is closed by the case of the follower



PROP PITCH CONTROL

Figure 3-3

sleeve. Oil no longer flows, piston movement stops. The propeller blades are hydraulically locked in a fixed position. While in Beta mode, if the pilot pulls back on the power lever, the follower sleeve will slide back on the oil transfer tube, uncovering the hole, permitting oil to escape from the propeller dome. Under spring tension the propeller blades rotate toward higher pitch until the hole in the follower sleeve again is sealed off by the case of the follower sleeve. Thus as the pilot moves the follower sleeve by positioning the power lever, the propeller pitch changes to the desired angle. When in prop governing mode the power lever still positions the follower sleeve to act as a minimum pitch stop in case of prop governor or engine failure.

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Prop Governor (Fig. 3-1)

When the engine reaches prop governor speed (96% - 100% RPM) the prop pitch control no longer controls the propeller, but acts only as minimum pitch stop in case of prop governor or engine failure.

The prop governor consists of a high pressure oil pump feeding oil through a pilot valve, through the non-functioning prop pitch control to the propeller dome. The pilot valve is contacted by a set of engine driven flyweights which close off the oil to the propeller when the engine reaches the RPM set into the governor. If the engine load is reduced (point plane nose down, increasing airspeed), engine speed increases causing the flyweights to move out, opening the oil line to the propeller, at the pilot valve. The oil flows out of the propeller dome, the spring loading rotating the blades to higher pitch slowing engine RPM and again closing off the oil line at the pilot valve. If the engine load is increased (point plane nose up, reducing airspeed), the engine slows down, allowing the flyweights to be forced in by the speeder spring, permitting the pilot valve to uncover the oil port to the pressure pump. Oil is forced into the propeller dome and the blades rotate to lower pitch, allowing the engine to regain its speed.

The engine RPM in prop governor mode can be set between 96% and 100% RPM by positioning the condition lever. The condition lever puts pressure on the speeder spring, determining the RPM at which the flyweights will move the pilot valve.

In prop governing mode the pilot controls the fuel flow with the power lever. The prop governor automatically controls the prop pitch to maintain constant engine RPM.

Propeller feathering (Fig. 3-1)

The propeller blades are spring loaded to the feather position; the prop may be feathered by dumping oil from the propeller control system. The propeller control oil passes through the prop feathering valve on its way to the propeller. When the feathering handle is pulled by the pilot, it mechanically closes the fuel solenoid valve, shutting off fuel flow, then closes off the oil flow from the propeller governor at the same time letting propeller oil escape through the feathering into the feather position.

In addition to manual control the prop feathering valve will be automatically operated by the negative torque sensor in case of engine failure. If the engine fails, oil pressure will move the prop feathering valve shutting off oil pressure and allowing propeller oil to escape through the vent port. The propeller will automatically feather.

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Propeller feathering (Cont.)

If oil to the propeller is cut off by the prop feathering valve the propeller cannot be unfeathered with the unfeathering pump. The prop feathering valve must be put back in the normal position by pushing the prop feathering handle full in.

Unfeathering Pump (Fig. 3-1)

The propeller can only be unfeathered by supplying oil pressure to the propeller dome. When the engine is not running and the propeller is feathered, oil for unfeathering is supplied by an electrically driven unfeathering pump. This pump is operated by a switch on the pilot instrument panel.

If the unfeathering pump is run while the prop feathering valve is pulled, oil is pumped out the prop feathering valve vent port into the gear housing. No pressure is developed to unfeather the propeller, continued operation of the pump will pump all the oil from the oil reservoir into the gear housing, leaving no oil available for developing pressure to the propeller dome. The engine must be turned several times to pump the oil back into the reservoir before there is oil available to the unfeathering pump. When the prop feathering valve is moved back to the normal position, and there is oil in the reservoir, the prop unfeathering pump will provide oil pressure to unfeather the propeller when the engine is not turning.

Negative Torque Sensor (Fig. 3-1)

Negative torque is applied to the engine when the propeller or the starter turns the engine through the reduction gears. During the start cycle, the propeller is held in flat pitch by propeller start locks. In flight, engine failure would produce a condition where the propeller "windmills" the engine. This is a condition of "negative torque". A negative torque sensor opens an oil valve, permitting oil pressure to move the prop feathering valve to the feather position. Positive torque moves the oil valve back so that the oil pressure to the prop feathering valve drains off into the gear housing, permitting the prop feathering valve to return to its "normal" position. You can see that a windmilling engine would have negative torque, starting the prop to feather position. As the propeller increases pitch it starts to slow the engine, developing positive torque, closing the prop feathering valve and unfeathering the propeller. In the case of engine failure, the prop will be "milked" to the feather position as the engine RPM slows to zero. Without the negative torque system the engine would continue to "windmill".

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1. The propeller control system is built around a propeller which is spring loaded to the _____ position.	
2. A hydraulic system is used to move the propeller to lower pitch by using _____ pressure.	feather
3. Oil to operate the propeller is taken from the _____.	oil
4. Oil pressure to operate the propeller can be taken from _____ sources.	engine lubricating system
5. One is an _____ operated gear type pump located in the prop governor.	two
6. The other is an _____ driven prop unfeathering pump.	engine
7. When starting the engine the propeller must be in _____ pitch.	electrically
8. To keep the propeller in flat pitch when there is no oil pressure, _____ are provided. These are set by the pilot when he is shutting down the engine.	flat
9. The pilot sets the stop locks on engine shut down by pulling the _____ to the reverse position as the engine loses RPM.	stop locks
10. If the propeller has not been properly positioned on engine shut down, the pilot can position the propeller by means of the _____.	power lever
11. First be sure the _____ is in the normal position.	unfeathering pump
12. Then activate the unfeathering pump with the power lever in reverse position, until the _____ are heard to drop into position. The propeller is then in the _____ position.	prop feathering valve

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13. The prop pitch control is used to set prop pitch when the engine is operated in _____.

start locks,
start (flat pitch)

14. The pilot sets the prop pitch control by operating the _____.

Beta mode

15. When the engine RPM reaches the setting of the prop governor, the engine goes into _____ mode of operation.

power lever

16. In prop governor mode, prop pitch is controlled _____ by the prop governor to maintain a _____.

prop governor

17. Although the prop pitch control does not control the propeller pitch in prop governor mode of operation, it does act as a _____ in case of engine failure or _____ failure.

automatically,
constant engine RPM

18. In prop governor mode, engine RPM can be set to between _____. The pilot sets RPM into the prop governor by moving the _____.

minimum pitch stop,
prop governor

19. The ^{RPM}condition lever changes tension on a speeder spring which sets the _____ at which the pilot valve will feed oil pressure into or out of the _____.

96% and 100%,
condition lever
RPM

20. The negative torque system automatically _____ the propeller in case of engine failure.

RPM,
propeller done

feathers

LUBRICATION SYSTEM

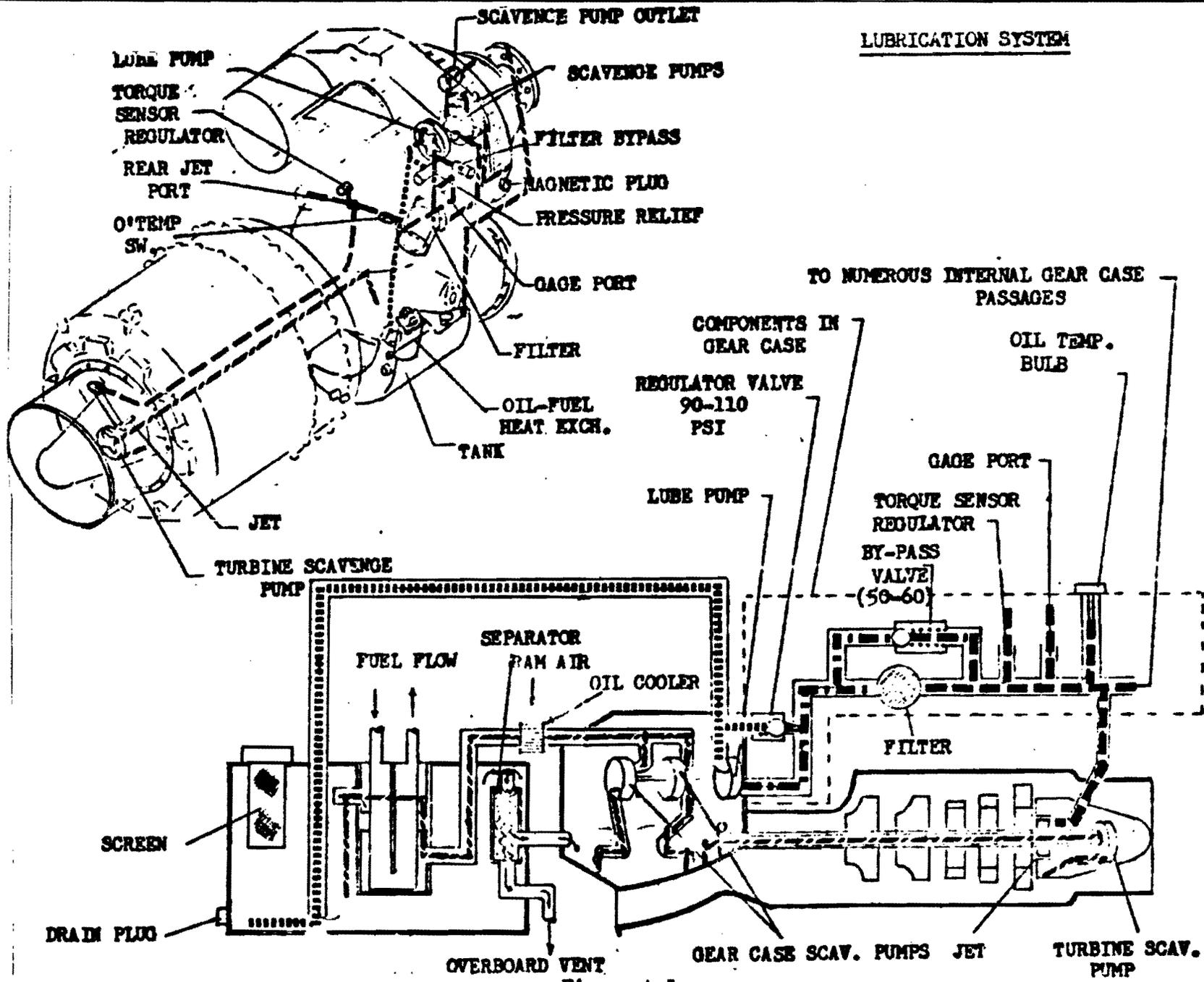


Figure 4-1

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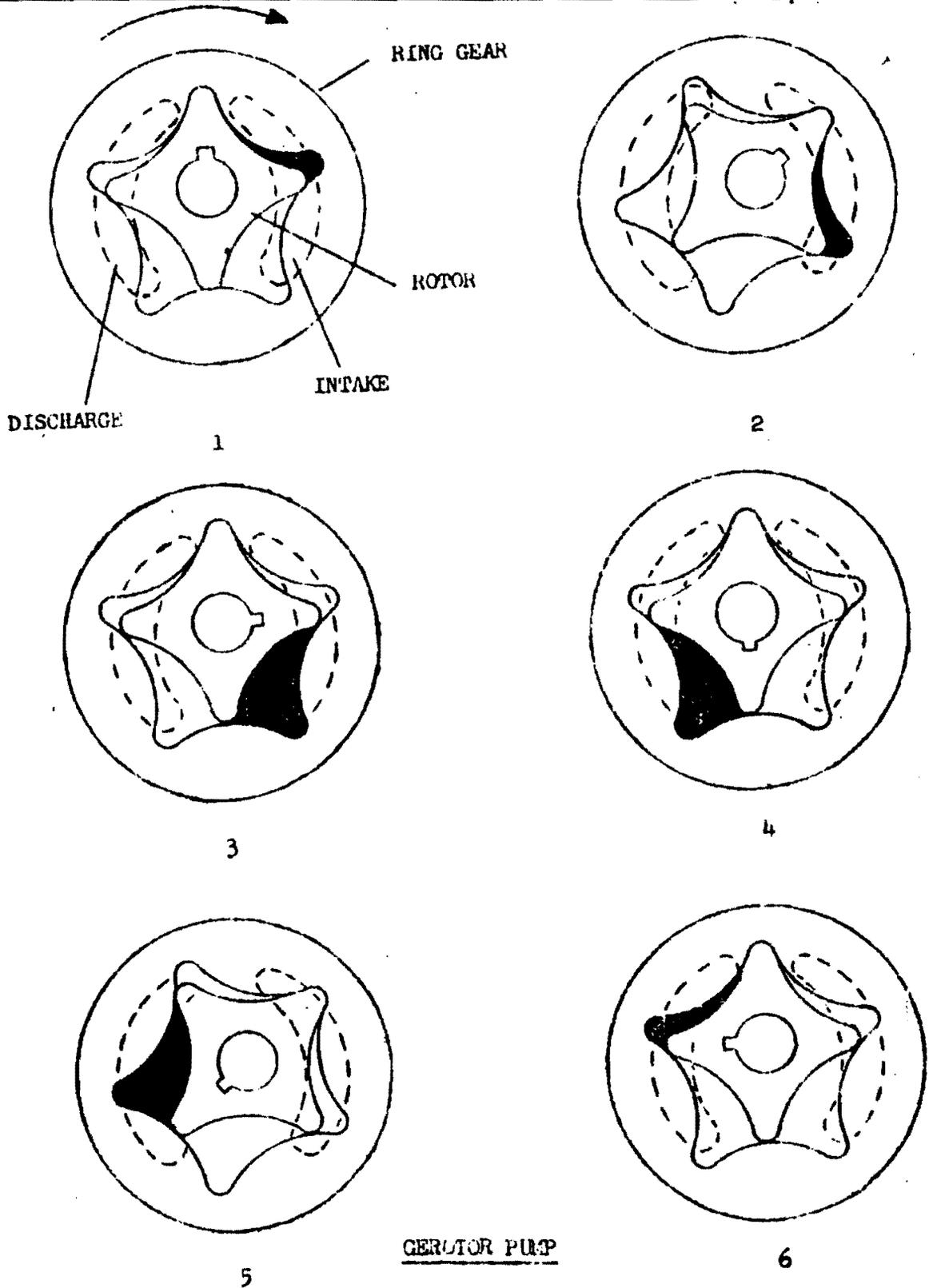
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GEROTOR PUMP

Fig. 4-1a

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Lubrication System (Fig. 4-1) See page 28

The lubrication system is a dry-sump type. All excess oil being scavenged from the sumps and stored in an externally mounted oil tank. The system holds 7 quarts of oil. Mobil oil jet II is the specified lubricant.

Operation

Oil is drawn from the external tank by the lubrication oil pump. The oil is pumped through an oil filter. A pressure relief valve is set at 90-110 psi. The oil flows through an internally cored passage to the various bearings, jets and gears within the gear housing. An external line carries oil to the aft bearing in the turbine sump. After lubricating, the oil collects in the aft turbine sump and the accessory gear case. A gerotor type scavenge pump, located within the aft turbine sump area, forces oil through the hollow compressor shaft into the gear case. Two gerotor type scavenge pumps take the oil from the gear case through the fuel-oil heat exchanger and an air oil separator back into the oil tank. Since the volume removed from the gear case by the scavenge pump exceeds the liquid input from the lube oil pump, air is also removed from the gear housing keeping it under negative pressure in relation to ambient air. This negative pressure assists the seals in preventing oil leaks. The engine uses a maximum of 0.02 gal of oil per hour. The oil pressure and oil temperature are shown on instrument panel gages. A slow drop in pressure, down to 50-60 psi, would indicate time to change a clogged oil filter. Overfilling of the oil system will result in oil being jettisoned from the overboard vent. A magnetic drain plug attracts ferrous particles which may be present in the lower gear sump area. Metal particles at the drain plug light a chip detector light on the pilot's instrument panel.

1. The lubrication system is a _____ type.

2. The sumps are kept clear of excess oil by _____ pumps.

dry sump

3. Oil capacity is _____ quarts or _____ gallons.

scavenger

4. Oil specification is _____.

7, 1.75

5. Normal oil consumption is _____ per hour.

Mobil oil jet II

6. Normal oil pressure is _____ psi.

0.02 gal.

7. If aircraft log shows slowly falling oil pressure over several hours of flight, look for _____.

90-110

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8. If oil pressure is above or below the normal operating range _____ maintenance is indicated.

clogged oil filter

9. The fuel oil heat exchanger has two functions. One is to _____ the oil circulating through the engine. The other is to _____ the fuel before it reaches the atomizers.

preventive

10. Normal operating oil temperature is _____.

cool, heat

11. On the ground with ^{RPM} ~~condition~~ lever back and power lever at max drag, minimum oil pressure of _____ psi. is less than that expected in flight.

-40° to 127°C
-40° to 268°F

70

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TORQUE SENSING SYSTEM

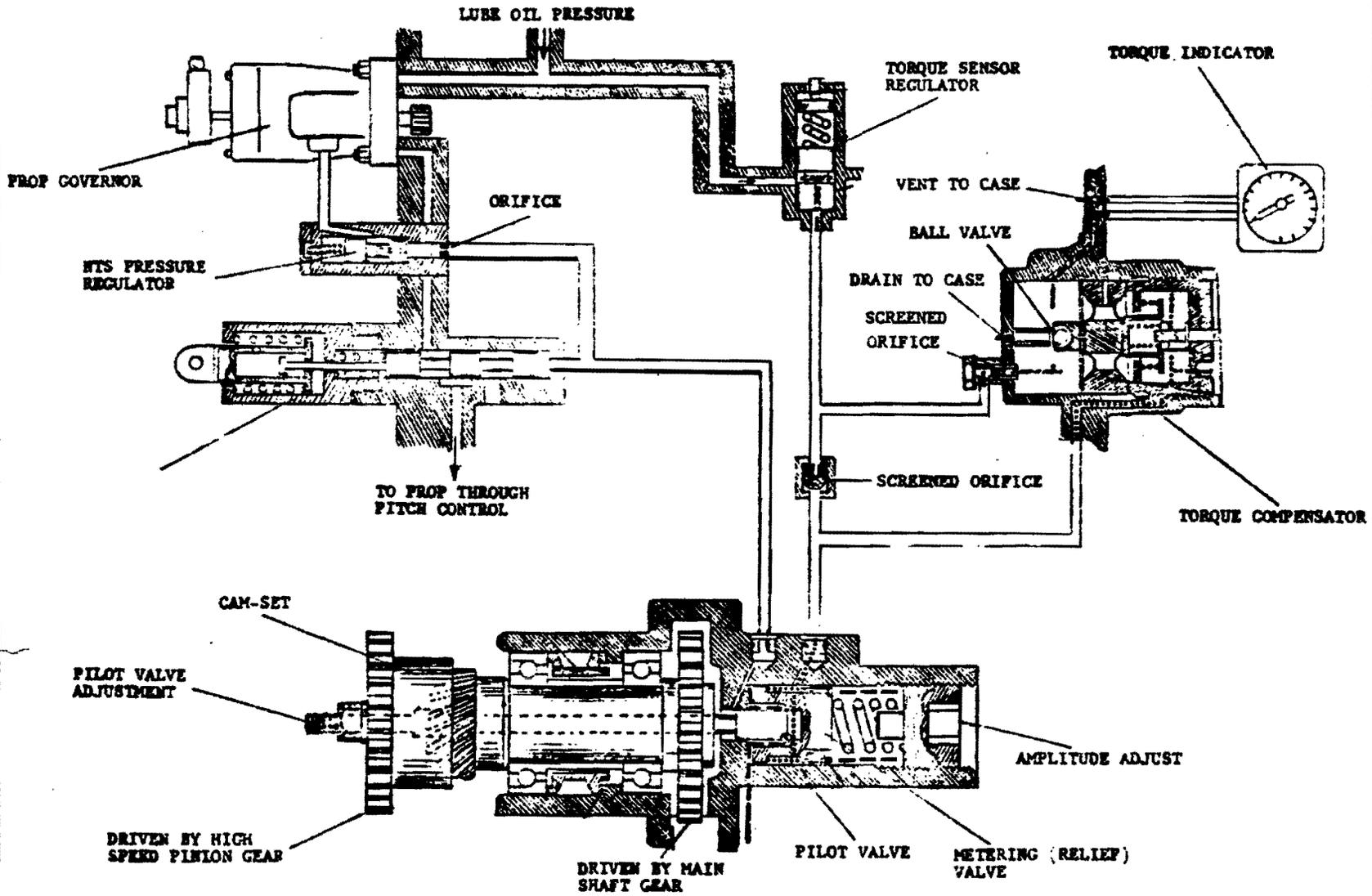


Fig. 5-1

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Torque Sensing System (Fig. 5-1) See page 32

The compressor and turbine are mounted on a common shaft. A torsion shaft transmits the torque to the propeller through the reduction gear train. Being connected together, both shafts always rotate at the same speed; however, as propeller load increases, the torsion shaft exhibits a twist with respect to the compressor shaft. The amount of this twist is measured by a torque sensor which converts the amount of twist in the torsion shaft to varying oil pressure. The oil pressure is taken to a torque pressure indicator on the pilot's instrument panel. Although the instrument actually measures changes in oil pressure, it is calibrated to read foot pounds of torque. As the engine can generate more torque than the gear train can transmit, it is important that torque limits not be exceeded. ~~Minimum torque for takeoff, and not to exceed 5 minutes duration, is 1510 ft.lbs. Normal cruise should not exceed 1367 ft.lbs. Maximum instantaneous, never exceed, torque is 1706 ft.lbs.~~

- | | |
|--|---|
| 1. The torque sensing system is to give the pilot an indication of the _____ of the engine. | |
| 2. The engine is capable of producing _____ than the gear train can transmit. | power output |
| 3. The power being transmitted to the gear train is shown on a _____ on the pilot's instrument panel. | more power |
| 4. The torque pressure indicator is calibrated in _____. | Torque Pressure Indicator |
| 5. At normal cruise the torque pressure should not exceed _____ ft.lbs.
<i>SHP</i> | feet pounds of torque
<i>SHAFT HORSEPOWER</i> |
| 6. On takeoff, maximum torque should not exceed _____ ft.lbs. and for not more than _____ minutes duration.
<i>SHP</i> | 1367
<i>500</i> |
| 7. The absolute maximum, instantaneous, never exceed torque pressure is _____ ft.lbs. | 1510, 5
<i>575</i> |
| 8. If these limits are exceeded, _____ as soon as possible. Call for _____. | shut down the engine, maintenance |

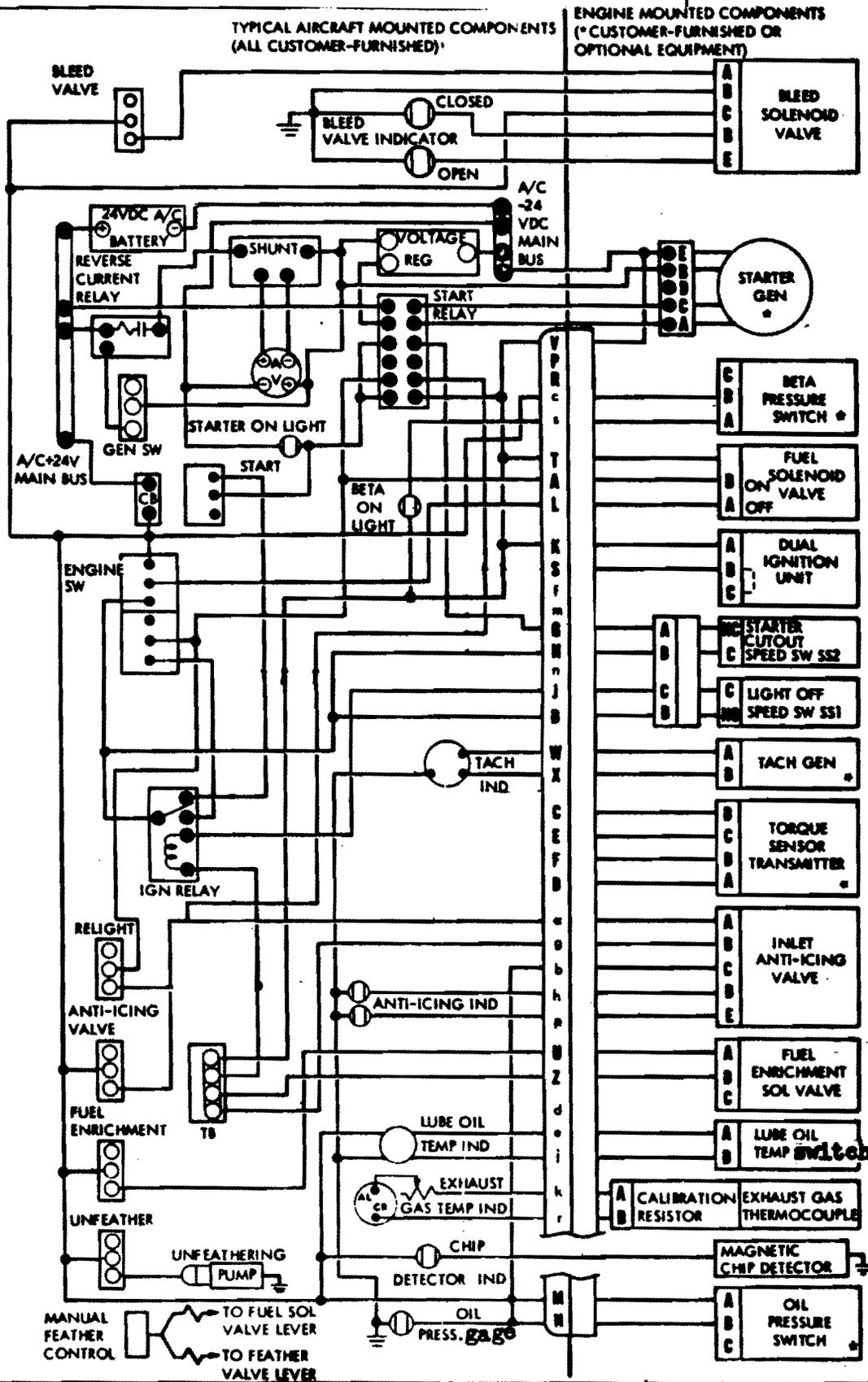
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ELECTRICAL SYSTEM

FIG. 6-1

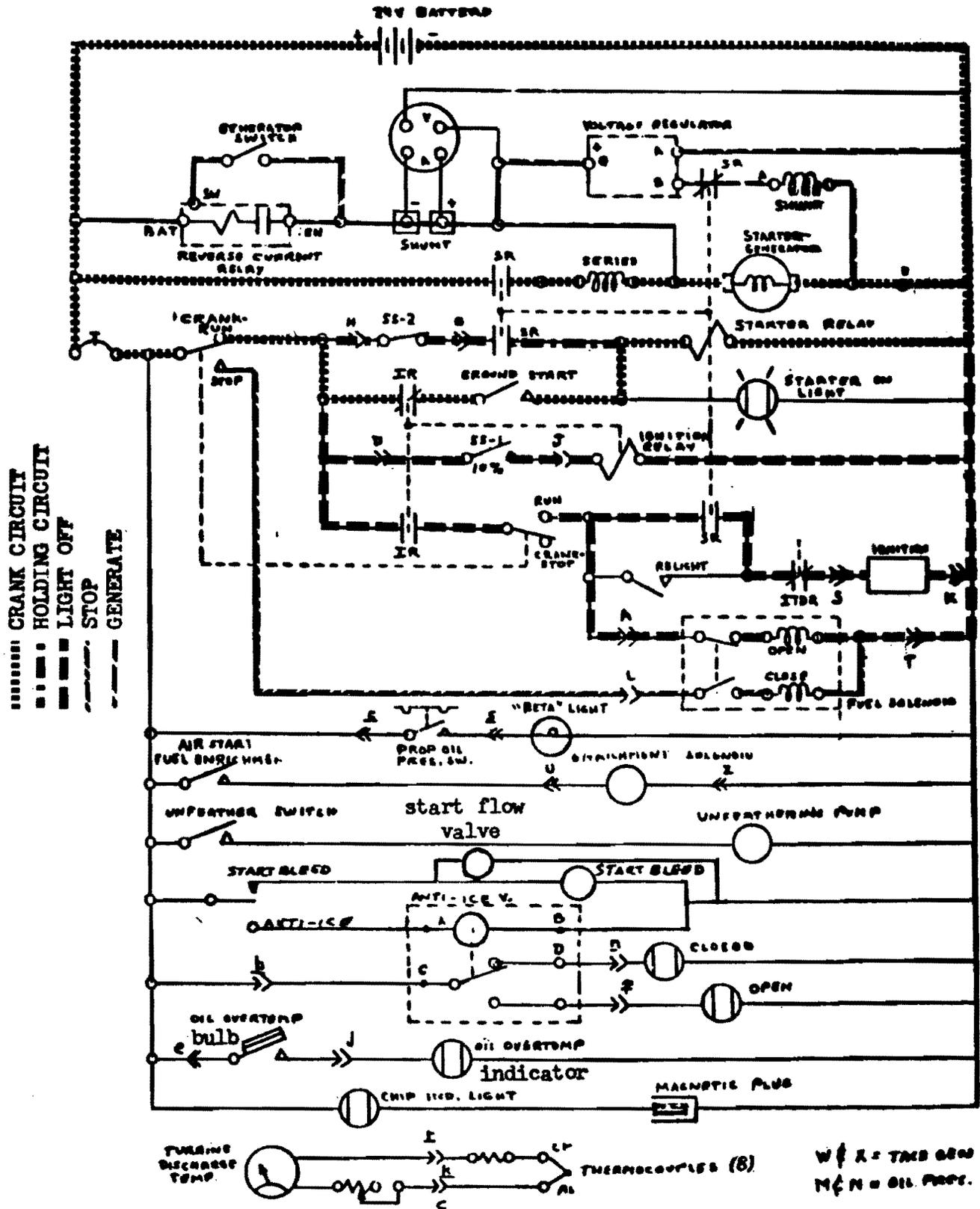
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ELECTRICAL SYSTEM

FIG. 6-2

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Electrical System (Fig. 6-1 and Fig. 6-2) See page 34 & 35

Only a few components of the electrical system are part of the engine. The main system is part of the aircraft electrical system and may vary in different installations. The operation of a typical system is given here.

D.C. Electrical power comes from a 24 volt battery through a Master switch then a circuit breaker to the engine circuits. A starter generator serves to crank the engine at start and then becomes a generator during operation. A volt amp meter on the pilot's instrument panel monitors available voltage, current flow and generator output. A voltage regulator prevents over voltage from going into the electrical system.

Electrically operated engine instruments are:

Tachometer	Oil temperature gage
Torque pressure indicator	Oil pressure gage
Exhaust gas temperature indicator	Fuel pressure gage
	Fuel flow gage

To initiate an engine start the engine switch is placed in the crank position, the ground start switch is momentarily depressed. Current flows through the starter relay. The starter-generator begins to crank the engine. The starter ON light illuminates as long as the starter relay remains energized. At 10% RPM the SS-1 switch closes completing the electrical circuit through the fuel solenoid and ignition relay to the engine switch. When the engine switch is moved to the RUN position, fuel flow and ignition are energized. At 43-47% RPM the SS-2 switch opens the circuit to the starter relay, the start light goes out, the generator is connected to the voltage regulator, the ignition circuit is turned off and the voltmeter and ammeter begin to read generator output. Generator output increases as engine comes up to speed.

The engine may be shut down by moving the engine switch to stop. This energizes the fuel solenoid valve to the closed position and the engine coasts to a stop.

There are several electrically operated accessories which are not concerned with engine acceleration. When held in the ON position the fuel enrichment switch activates the fuel enrichment solenoid providing additional fuel flow. The unfeathering pump switch will energize the unfeathering pump. The ignition override switch provides energy to the igniters for air starts where the starter is not used. These three switches are spring loaded to the down or off position. The anti-ice switch will energize the anti-ice solenoid while held in the ON position. At the same time the anti-ice warning light comes on. The anti-ice switch when held in the compressor bleed position will energize the compressor bleed solenoid and the startflow solenoid.

The engine may be cranked without light off by placing the engine switch in the crank position. Pushing the spring loaded ground start switch to ON will

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Electrical System (Cont.)

energize the starter motor. The engine will continue to be turned by the starter motor until the engine switch is placed in the STOP position. Be sure to avoid exceeding the duty cycle of the starter-generator.

There are ^{THREE} ~~five~~ light indicators on the pilot's instrument panel. The Beta light is on when the engine is being operated in Beta Mode. The chip detector warns of metal particles in the gear housing. ~~The clogged-filter light warns of the need to change the fuel filter.~~ The anti-ice light glows when the anti-ice solenoid is open. ~~The start light glows while the starter is cranking the engine.~~

1. The electrical system is a _____ volt, _____ system.	
2. The starter-generator acts as a starter during the _____ period, and as a generator during the _____ period.	24, D.C.
3. The starter _____ becomes a generator as the engine nears _____ RPM.	engine crank, engine run
4. The pilot knows when the starter function stops and the generator function begins by reference to the pilot's instrument panel. The _____ goes out. The _____ shows a current build up. The _____ shows 24-27 volts.	automatically, 50%
5. In case of electrical failure the engine will _____.	start light, ammeter, voltmeter
6. In case of electrical failure the engine may be shut down by closing the _____ solenoid valve mechanically. This can be done by pulling the _____ part way out.	continue to run
7. Once shut down, the engine _____ during an electrical power failure.	fuel, prop feathering handle
8. In case of electrical power failure the engine instruments on the pilot's instrument panel, with the exception of the _____ indicator, will be _____.	cannot be restarted
	EGT, inoperative

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Ignition System

The ignition system consists of two igniters located in the combustor. Ignition is energized by the SS-1 switch when the engine reaches 10% RPM and the engine switch is in the RUN position. Fuel and ignition initially reach the combustor at the same time. Ignition produces a sharp sound which can be heard from the cockpit. Following light off, the ignition circuit is cut off by the SS-2 switch when engine RPM reaches 45-47%.

Turbine Discharge Temperature

Eight chromel-alumel thermocouples are located in the tailpipe. These thermocouples entirely separate and independent of the aircraft electrical system, generate an electrical current which is proportional to EGT (T_5). This electrical current operates the exhaust gas temperature indicator on the pilot's instrument panel. It is important for the pilot to check the thermocouples for heat damage during preflight, walk around, inspection.

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Trouble Shooting List

The following pages give information for analysing and remedying engine malfunctions. They should be studied carefully.

SYMPTOM	CHECKS AND FURTHER SYMPTOMS	PROBABLE CAUSE	REMEDY
No response when start switch is actuated	Nothing electrical operates on instrument panel	Dead Battery Aircraft switches, circuit breakers etc. not properly positioned.	The remedy is obvious. Read the instructions for operating the aircraft before starting engine, and follow them.
	Electrical components on panel operate; starter relay is heard to actuate when start switch is actuated; engine can be turned freely by hand.	Starter-generator failed	Replace
	As above, but engine cannot be turned freely by the prop	Engine internally failed	Obvious
	Electrical components on the panel operate, but starter relay cannot be heard to actuate when start switch is actuated. Ohmometer check of pins A to B on speed switch connector on front of gear housing shows no continuity.	SS-2 stuck in actuated position	With ohmometer still connected between A and B, turn SS-2 position adjust screw (furthest from connector) CCW (out) no more than one turn. If continuity is established turn CCW 2½ turns beyond point where continuity was obtained, and lockwire. If no continuity in one turn, switch is failed, and must be replaced before running engine.
	As above, but the ohmometer indicates continuity from A to B	Aircraft wiring or switches failed or not properly set.	Refer to aircraft operation or maintenance instructions
Starter cranks engine only until start switch is released	Voltmeter on panel shows less than 12 volts when start initiated.	Voltage too low to hold in actuated position	Recharge battery. Use ground power when available. Don't release start switch too quickly after initiating start.

SYMPTOM	CHECKS AND FURTHER SYMPTOMS	PROBABLE CAUSE	REMEDY
Starter cranks engine only until start switch is released (Continued)	Voltage on panel meter shows normal during start. Check for continuity from pin A to B on connector on front of gear housing shows none.	Speed switch SS-2 stuck in actuated position	With ohmeter connected between A and B, turn SS-2 screw (furthest from connector) out (CCW) until continuity shows, but not more than one turn. After continuity shows, turn screw $2\frac{1}{2}$ turns more and lockwire. If no continuity in first turn, switch is failed and must be replaced.
	As in check above, but A to B circuit shows continuity.	Aircraft wiring failed	Refer to maintenance manual pertaining to aircraft.
Starter cranks engine but combustion does not occur	RPM less than 10%, battery voltage low; engine coasts to stop normally	Low battery or high electrical load on system	Recharge battery. Use ground power. Remove bus loads before starting.
	RPM less than 10%, battery voltage normal. Unit coasts quickly and noisily to stop.	Internal engine failure	Obvious
	RPM over 10%; no ignition sound nor fuel fumes from exhaust. No continuity from pin C to D on connector pins on front of gear housing when rpm over 10%. If aircraft so equipped, actuating SS-1 bypass switch produces combustion.	Speed switch SS-1 failed to actuate	With ohmeter still on C to D pins turn SS-1 (closest to connector) no more than 2 turns in (CW). If no continuity, SS-1 failed. If continuity is found, turn screw out (CCW) until continuity is again lost and turn screw $\frac{1}{4}$ turn more CCW and lockwire.
	As above, but C to D pins show continuity when engine rpm over 10%	Aircraft wiring or electrical component failed	Refer to aircraft maintenance manual
	RPM over 10%. Fuel fumes from turbine exhaust, but no sound of ignition. Voltmeter check of ignition coil connector pins C to A shows at least 16 Volts when engine speed over 10%	Ignition coil ignitor or high tension leads failed	Replace coil, igniters and leads, in that order, until faulty component is located.

SYMPTOM	CHECKS AND FURTHER SYMPTOMS	PROBABLE CAUSE	REMEDY
No Light off (Cont'd)	As above but voltmeter check of pins C to A shows low or no voltage.	Aircraft wiring or component defective	Refer to aircraft maintenance manual
	RPM over 10% and ignition "snap" heard, but no evidence of fuel at turbine exhaust. No flowmeter reading, but fuel inlet pressure positive. Gage at pump test port shows over 100 psi, and voltage check of fuel solenoid plug shows over 16 volts when rpm over 10%.	Fuel solenoid valve failed, or its manual override lever in MAN OFF position.	Reset linkage to lever or replace solenoid.
	As above, but no voltage present at solenoid plug.	Aircraft wiring or electrical component failed.	Refer to aircraft maintenance manual.
	RPM over 10%, ignition snap heard, but no fuel flow or fumes from exhaust. Fuel inlet pressure positive, but gage at pump test port reads only boost pressure until 10%, then drops to near zero.	High pressure pump or drive shaft in fuel control failed.	Replace pump or shaft, or complete fuel control.
	RPM over 10% but fuel inlet pressure is zero or below.	Fuel supply obstruction.	Refer to aircraft maintenance manual. (Shutoff valve, tank quantity, filters, etc.)
	RPM over 10%, fuel flow near 60#/hr. ignition snap heard, pump test port pressure over 160 psig.	Flow divider stuck open.	Clean or replace divider valve and screen, or replace divider assembly.