Operation and Service Manual

MODEL DP-T3

TURBINE ENGINE MAIN FUEL CONTROL

MODEL AL-AC1

POWER TURBINE GOVERNOR

DOUBLE CHECK VALVE

- Operation
- Installation
- Adjustment
- Service

Bendix Energy Controls Division

Printed in U.S.A.

OPERATION AND SERVICE MANUAL

MODEL DP-T3

TURBINE ENGINE MAIN FUEL CONTROL

MODEL AL-AC1

POWER TURBINE GOVERNOR

DOUBLE CHECK VALVE

THE BENDIX CORPORATION
ENERGY CONTROLS DIVISION
717 N. BENDIX DRIVE
SOUTH BEND, INDIANA 46620

FORM 15-687

15 DECEMBER 1978

TABLE OF CONTENTS

FOREWORD

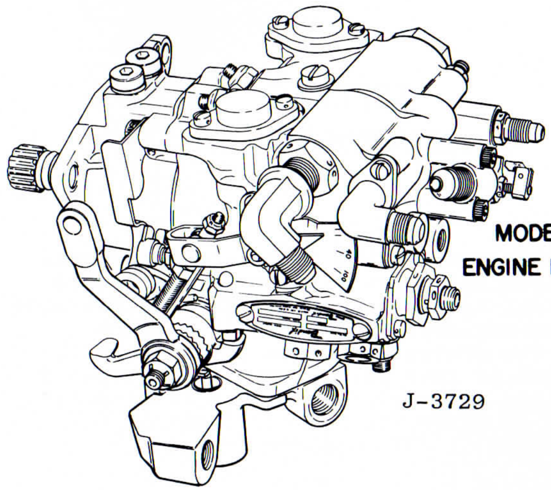
This publication is intended as an operational guide for use by personnel responsible for the installation, adjustment, operation, and maintenance of the described equipment.

Specific reference to engine operation is made only as it will aid in understanding control operation. Always refer to the engine manufacturer's specifications, instructions and operating procedures.

SECTION I
INTRODUCTION

1-1. This publication contains operational instructions and a description of the Bendix Fuel Control System as used on the Allison 250-C28 series engines. The assemblies which comprise the system are shown in figure 1-1. The purpose of this publication is to explain the function and operation of the individual units and to correlate this information with the operation of the complete system.

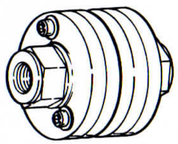
1-2. The individual units comprising this system are manufactured and calibrated with extreme care. In order to derive maximum performance and trouble-free service from this equipment, the components must be installed and adjusted in accordance with the engine manufacturer's instructions.



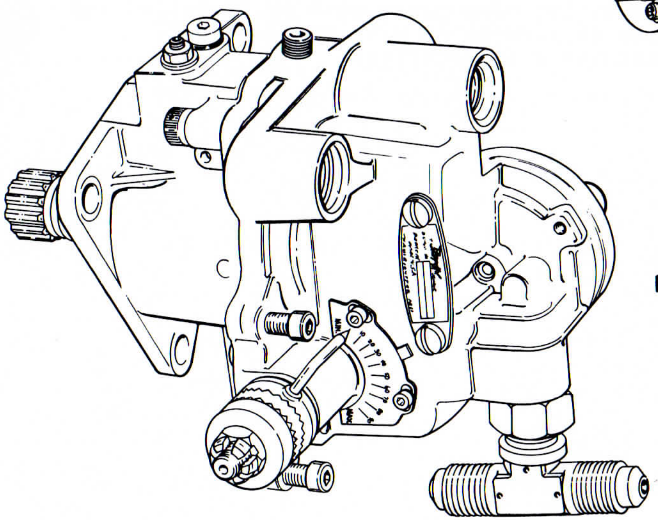
MODEL DP-T3 TURBINE ENGINE MAIN FUEL CONTROL

J-3729

DOUBLE CHECK VALVE ASSEMBLY



LA-5088



MODEL AL-ACI POWER TURBINE GOVERNOR

J-3727

Fuel Control System Components
Figure 1-1

SECTION II

DESCRIPTION AND PRINCIPLES OF OPERATION

2-1. GENERAL.

2-2. The Bendix fuel control system consists of:

a. Model DP-T3 Turbine Engine Main Fuel Control.

b. Model AL-AC1 Power Turbine Governor.

c. Double Check Valve.

2-3. A general understanding of the engine and its operation in a helicopter installation is advantageous when considering the operation of the fuel system. The 250-C28 series engine is a free turbine engine, meaning that there is no mechanical coupling between the two turbine assemblies. The turbines are: first, a gas producer turbine that drives the compressor: and second, a power turbine that drives the helicopter rotor through the appropriate reduction gearing. The hot gas discharged by the gas producer turbine is directed to, and in turn drives, the power turbine. This arrangement provides a "gas coupling" between the turbines and therefore necessitates control of the output or speed of both turbines.

2-4. These helicopters employ a conventional control system whereby collective pitch of the rotor establishes power output or load on the engine. For all practical purposes, rotor speed is held constant. Therefore, engine power turbine speed must be held constant. As collective pitch is changed, the load on the power turbine changes, tending to change its speed. The gas producer turbine must then correct for this tendency by changing its own speed accordingly to supply the power required to maintain a constant power turbine speed.

2-5. The gas turbine fuel control and power turbine governor provide speed governing of the power turbine rotor and overspeed protection for the gas producer rotor system. The fuel control system is pneumatic-mechanical and senses N1 and N2 speeds, compressor discharge air pressure (Pc), and twist grip position to regulate and maintain fuel flow within established limits.

2-6. Fuel flow is a function of Pc as sensed in the gas turbine fuel control. Variations in fuel flow schedules are obtained by modulating the Pc pressure to Px and Py pressures in the gas turbine fuel control through the bleed-down circuit actuated by the governor's sensing N1 RPM and N2 RPM. The design of the fuel control system is based upon controlling the engine power output by controlling N1 RPM. With the twist grip in ground idle, N1 RPM is controlled by the gas turbine fuel control. With the twist grip in full open and N2 RPM at the setting of the power turbine governor, N1 is established by power turbine governor action upon the gas turbine fuel control.

2-7. MODEL DP-T3 TURBINE ENGINE MAIN FUEL CONTROL (See figure 2-1.)

2-8. The Model DP-T3 Turbine Engine Main Fuel Control is the basic component of the engine fuel controlling system. This unit is a pneumatic-mechanical device which schedules the fuel flow delivered to the engine to provide proper engine operation during all starting and load operating conditions.

2-9. The fuel control is mounted on the fuel pump and is driven at a speed proportional to gas producer turbine speed (N1). Additional sensing parameters required by the fuel control to properly schedule fuel flow are:

a. Throttle Angle

b. Fuel Inlet Pressure (P1).

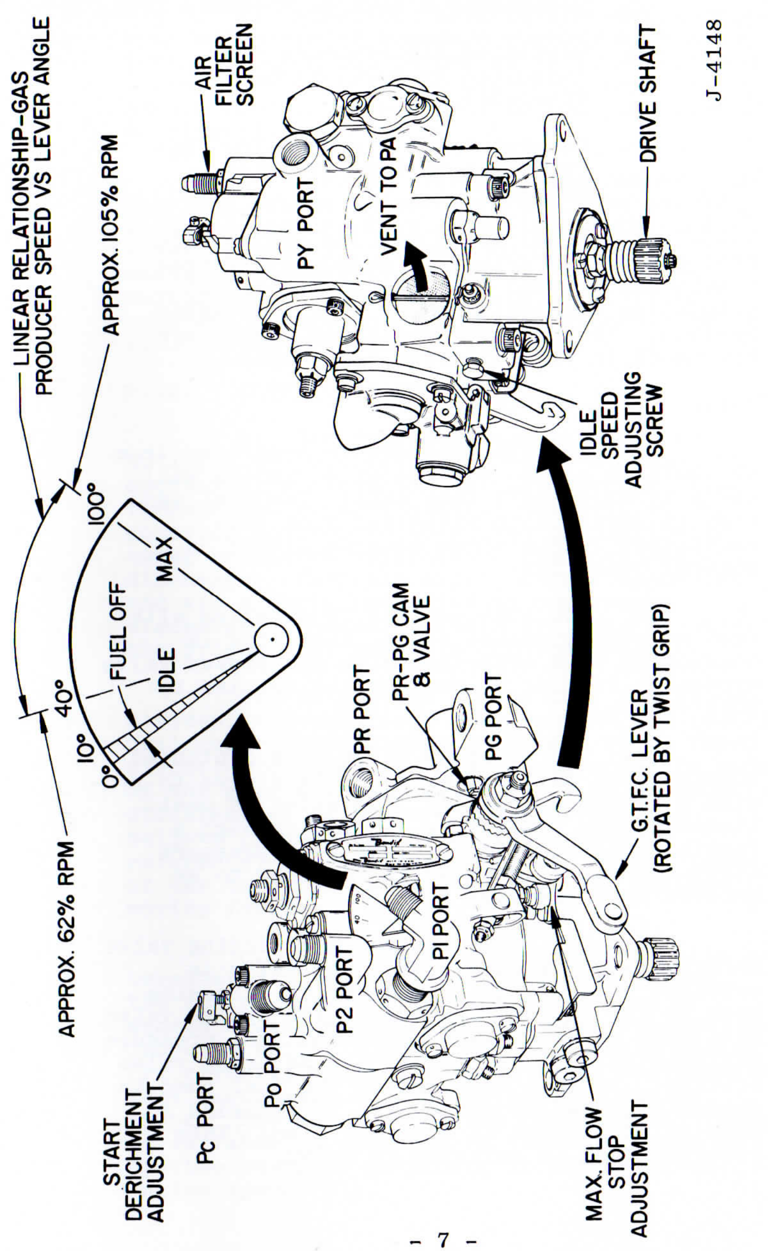


Figure 2-1. Model DP-T3 Turbine Engine Main Fuel Control - Ports and Adjustments

c. Compressor Discharge Pressure (Pc).

d. Regulated Air Pressure (Pr) (supplied by Power Turbine Governor).

e. Govenor Reset Air Pressure (Pg) (supplied by Power Turbine Governor).

2-10. The Model DP-T3 Turbine Engine Main Fuel Control is primarily composed of three functional groups: 1) Fuel Section, 2) Scheduling Section, and 3) Governor Reset Section. The functions of these groups are discussed in the following paragraphs.

2-11. FUEL SECTION.

a. The Fuel Section is separated from the balance of the control by a casting wall and a torsion shaft fuel seal. The fuel section is designed to withstand fuel contamination with minimum adverse effect on control operation.

b. The fuel control is supplied with fuel at pump pressure (P1). Fuel flow is controlled by a metering valve and bypass valve system. Fuel at P1 pressure is applied to both valves.

c. The metering valve is a contoured needle which moves axially in its sleeve to provide a variable orifice. The valve is positioned by the Scheduling Section through a torsion shaft and lever. The fuel pressure after the metering valve is referred to as Metered Fuel Pressure (P2).

d. The bypass valve is a sliding valve working in a ported sleeve. The valve is actuated by a diaphragm and spring. Sensing both P1 and P2 fuel pressures, the bypass valve maintains an essentially constant fuel pressure differential (P1-P2) across the metering valve orifice. P1 fuel supplied by the fuel pump in excess of these requirements, is returned to pump inlet through an external line. This returned fuel is referred to as PO.

e. A relief valve is provided to prevent excessive P1 pressure buildup within the fuel control. The relief valve is positioned in parallel with the bypass valve and permits excess fuel to be returned to the pump through PO circuit.

f. A cutoff valve is incorporated in the fuel outlet of the control. The cutoff valve is mechanically connected to the throttle lever by external linkage to provide a positive means of stopping fuel flow to the engine. During normal operation, this valve is fully open and offers no restriction to the flow of fuel to the nozzles.

2-12. SCHEDULING SECTION.

a. Scheduling is accomplished by moving a bellows (governor bellows) which is mechanically connected to the metering valve through the torsion shaft. Movement of the governor bellows is performed pneumatically using pressures originating from compressor discharge. Throttle angle, engine speed (N1), and air density (supplied by compressor discharge pressure) signals are used to provide the proper fuel schedule for the engine.

b. Pc applied to the fuel control is divided, through fixed bleeds, into two individual controlling circuits (Px and Py). These circuit pressures are applied to opposite sides of the governor bellows. The Px-Py pressure differential is compared to an evacuated bellows (providing an absolute pressure reference) and the predetermined spring force of the torsion shaft to provide the bellows moving force.

c. The Px and Py pressure circuits are terminated at variable-orifice restrictors. The restrictor orifices are controlled by sensed engine speed (through speed weights) and opposing spring force. The enrichment spring (Px circuit) applies a fixed force and permits fuel enrichment at a predetermined engine speed. The governor spring (Py circuit) force is variable in response to throttle angle to provide on-speed governing at any selected engine speed (N1).

2-13. GOVERNOR RESET SECTION.

a. The governor reset section permits the Power Turbine Governor to override the speed governing elements of the fuel control to alter the fuel schedule in response to changing load conditions applied to the power turbine.

b. A Pr-Pg valve is incorporated which prevents N1 engine speed undershoot during gas producer decelerations when the N1 throttle is moved to the ground idle position. This is accomplished by opening the throttle actuated Pr-Pg valve which equalizes Pr and Pg pressures eliminating the reset action supplied from the power turbine governor.

2-14. MODEL AL-AC1 POWER TURBINE GOVERNOR. (See figure 2-2.)

2-15. The Bendix Model AL-AC1 Power Turbine Governor supplements the Model DP-T3 Turbine Engine Main Fuel Control to provide a complete engine fuel controlling system. The function of the Model AL-AC1 Power Turbine Governor is to maintain the speed of the power turbine (N2) by resetting the Model DP-T3 Turbine Engine Main Fuel Control. This "resetting" establishes the gas producer speed (N1) required to supply N2.

a. The power turbine governor is mounted on the accessory gear case and is driven at a speed proportional to power turbine speed (N2). Additional sensing parameters required by the Model AL-AC1 Power Turbine Governor to accomplish its governing function are:

(1) Throttle Angle.

(2) Compressor Discharge Pressure.

b. The Model AL-AC1 Power Turbine Governor is primarily composed of three functional groups:

(1) Regulator Section.

(2) Governing Section.

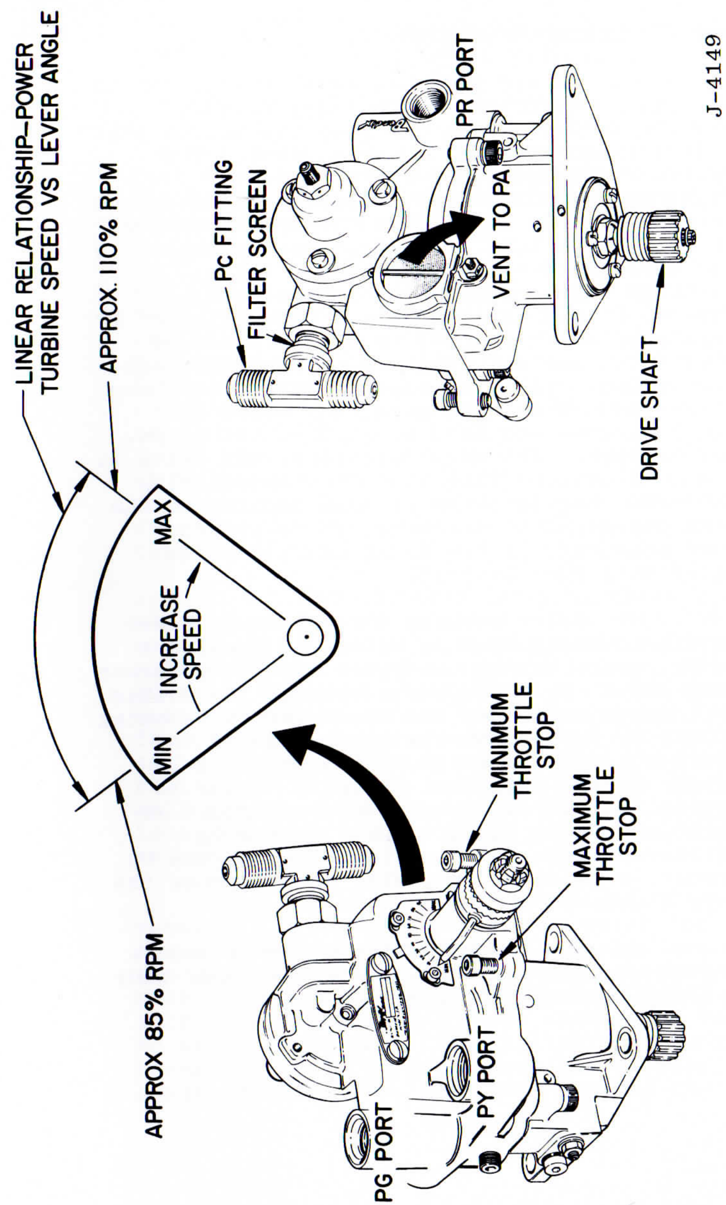


Figure 2-2. Model AL-AC1 Power Turbine Governor - Ports and Adjustments

(3) Overspeed Section.

2-16. REGULATOR SECTION.

a. An air pressure regulator system is built into the cover of the power turbine governor to provide an air pressure source that is at a fixed pressure above ambient. The regulator consists of a spring-loaded, diaphragm-operated valve. Compressor discharge pressure (Pc) is applied to the system through the Pc machine hole. The resultant pressure is then applied to the air regulator valve diaphragm and is opposed by ambient air pressure Pa and spring force. Regulation of Pr (regulated air pressure) is accomplished by bleedoff to ambient pressure through the regulator valve. If Pr attempts to increase above the desired value, the regulator valve is opened farther and more Pr is bled off to Pa. A Pr decrease will cause the regulator valve to move in a closing direction thus restricting bleedoff. Regulator Pr is then applied to the Pr-Pg bleed and to one side of the governor reset diaphragm in the Model DP-T3 Turbine Engine Main Fuel Control.

b. After passing through Pr-Pg bleed the air is designated as Pg and is applied to the Pg restrictor in the power turbine governor drive body. Pg then passes through the double check valve when used and accumulators becoming Pg' and is applied to the other side of the governor reset diaphragm in the Model DP-T3 Turbine Engine Main Fuel Control. Prior to opening the Pg restrictor, the Pg circuit is static and Pg is equal to Pr. As the Pg restrictor opens and air flows through the Pg circuit, a pressure drop will occur across the Pr-Pg bleed.

c. The power turbine governor incorporates a vent port which vents the inner body cavity to atmospheric pressure Pa.

2-17. GOVERNING SECTION.

a. The governing section of the power turbine governor employs a variable orifice restrictor (Pg) to modify the Pg' pressure in the Model DP-T3 Turbine Engine Main Fuel Control when the power turbine speed varies from desired value. This reduces or increases the fuel flow delivered to the engine, by action of the governor reset rod, to maintain the power turbine speed selected.

b. This unit is a compound governor and also incorporates an overspeed restrictor (Py). The cover has a Py port which is connected to the Py port of the Model DP-T3 Turbine Engine Main Fuel Control. An overspeed lever is used which will move away from the restrictor (Py) and provide a bleed off of Py from the DP-T3 control if the power turbine speed (N2) reaches 113 percent. This reduction of Py pressure in the DP-T3 control will decrease the fuel flow so that the power provided to the power turbine will be substantially reduced.

c. The throttle lever operates a cam which depresses an internal lever when the throttle is opened. A spring connects this cam follower lever to the governor lever. The governor lever is pivoted and operates against a restrictor to form a variable orifice (Pg). The overspeed lever pivots at the same point as the governor lever and operates against a restrictor to form a variable orifice (Py). A ball bearing follower on the end of the governor lever assembly contacts the end of the bearing assembly.

d. As the control drive shaft revolves, it rotates a table on which the governor weights are mounted. Small levers on the inside surface of the weights contact the bushing assembly. As power turbine speed increases, centrifugal force causes the weights to apply increasing force against the bushing assembly. This tends to move the bushing assembly outward on the shaft causing the bushing assembly to exert force on the ground lever assembly. When power turbine speed reaches its desired value, governor weight force overcomes opposing spring force and the Pg restrictor is opened. This allows Pg to bleed off to Pa.

e. Any change in power turbine speed (from the desired value) will result in a larger or smaller orifice opening in the Pg restrictor. The power turbine governor, therefore, provides power turbine speed governing in the fuel controlling system.

2-18. OVERSPEED SECTION.

2-19. The overspeed section consists of a lever, spring, and a Py to Pa orifice. When the power turbine speed is less than the overspeed setting, the lever is positioned so that the Py to Pa orifice is closed. If the power turbine RPM exceeds 114% N2, the governor flyweights move the governor lever against the governor spring to pick up the overspeed lever and move it against its spring to open the Py to Pa bleed. This bleeds Py air to Pa which allows the Py-Px differential acting on the governor bellows to start moving the metering valve to reduce fuel flow. This then will reduce the power turbine RPM to prevent the overspeed. The overspeed lever remains closed unless a power turbine overspeed occurs.

2-20. The electronic power turbine overspeed control system is a backup for the overspeed protection system in the power turbine governor. It provides overspeed protection for the power turbine in the event of a malfunction of either the governor or the gear train that provides the governor speed sense. The electronic system consists of a gearbox-mounted, monopole speed sensing device that produces an electrical signal that is directly related to power turbine shaft speed, a control box, and a solenoid-operated Py vent valve. The vent valve reduces Py pressure to cause the gas turbine fuel flow to go to minimum in the event of a power turbine overspeed. The solenoid Py

vent valve is energized by a signal from the control box when N2 RPM exceeds 122 $\pm$ 1.2% minus 1% for each 10%/sec. rate of change of N2.

2-21. DOUBLE CHECK VALVE.

NOTE

> The Double Check Valve is not used in all helicopter installations. Where used, the Double Check Valve supplements the Model DP-T3 Turbine Engine Main Fuel Control and the Model AL-AC1 Power Turbine Governor to provide a complete engine fuel controlling system.

2-22. The check valve assembly is to dampen torsional vibrations encountered in helicopter rotor systems. Very slight changes in the N2Nr RPM will alter the flyweight force acting on the power turbine governor lever. With the same governor spring force and a varying flyweight force, the governor lever will move. Any movement of the governor lever alters the Pg to Pa orifice and, consequently, Pg pressure will change. If the Pg pressure change is great enough, there will be a Pg' pressure change which will result in a fuel flow change and a power output variation. Very small changes in Pg, due to the power turbine governor sensing torsional vibrations, will be dampened out by the check valve assembly and the accumulators. The check valve prevents small changes in Pg from affecting the Pg' pressure. If the check valve does open, the volume of the accumulator is such that Pg' pressure change is gradual rather than abrupt. Abrupt changes in Pg' pressure will result in abrupt changes in fuel flow and power output. If the power output is affected during torsional vibrations, N2Nr RPM vibration becomes greater and the power fluctuations will become greater. By dampening out the Pg' pressure to the gas producer fuel control governor reset assembly, the engine does not respond to torsional vibrations.

2-23. OPERATION OF THE COMPLETE FUEL CONTROL SYSTEM.

2-24. STARTING THE ENGINE.

a. The engine will be cranked with the DP-T3 fuel control throttle in the cutoff position. At approximately 12 to 14 percent N1, the twist grip handle on the pilot's collective pitch lever will be moved to "start" (idle), which will move the DP-T3 fuel control throttle lever to the 40 degree position. The engine should light-off and begin to accelerate. Acceleration will be proportional to the rise in compressor discharge pressure (Pc) until speed enrichment occurs at approximately 47 percent N1. When N1 reaches approximately 63 percent RPM, the DP-T3 fuel control will start to govern and maintain idle RPM.

b. The DP-T3 fuel control has a start derichment assembly which incorporates a bellows for sensing Pc pressure. During the initial stages of starting, when Pc is low, the bellows will expose a hole from the Py portion of the bellows chamber. The exposed hole will bleed off Py pressure from the bellows assembly to atmospheric pressure and move the metering valve toward the minimum flow stop. As Pc pressure increases the derichment bellows will elongate and close this bleedoff hole. This will allow the Py pressure at the head end of the bellows assembly to build up as it did in the earlier controls and move the metering valve away from the minimum flow stop. With the start derichment device, low turbine outlet temperatures can be maintained immediately after lightoff while the basic acceleration schedule can be richened so there will be no tendency toward stagnation before idle RPM is attained.

2-25. ACCELERATION.

a. For acceleration above idle, the twist grip on the pilot's collective pitch control will be moved to its maximum position.

This will cause the throttle lever on the DP-T3 fuel control to go from 40 to 100 degrees. Speed enrichment will be completed at approximately 73 percent N1, after which the acceleration rate will again be proportional to the rise in compressor discharge pressure.

b. As far as the DP-T3 fuel control is concerned, acceleration would continue until 105 percent N1 has been reached. The AL-AC1 governor will terminate acceleration by resetting the DP-T3 fuel control to provide only enough N1 to maintain an N2.

2-26. LOAD APPLICATION.

a. Application of load requires increasing the pitch of the helicopter rotor blades. A load application will tend to cause a decrease in N2. The AL-AC1 governor will sense this decrease in N2 and remove reset force from the DP-T3 fuel control and cause N1 to increase. As load is increased by movement of the collective control, the AL-AC1 throttle lever is advanced to compensate for the "droop" characteristic of the system.

b. If the load is decreased, N2 will tend to overspeed and the AL-AC1 governor will again reset the DP-T3 fuel control to lower N1.

c. Various power turbine speeds (N2) may be selected by repositioning the throttle lever on the AL-AC1 governor through manipulation of a "beeper" switch.

2-27. DECELERATION.

a. Deceleration occurs when the pitch of the helicopter rotor blades is decreased. Removing the load on the power turbine will result in an N2 increase, and governor reset action will reduce N1.

b. For further deceleration it will be necessary to bring the DP-T3 fuel control throttle lever back to the idle ("start") position. This will rotate the governor cam to a lower rise position, and less spring force will be exerted by the governor spring in the DP-T3 control. N1 will decelerate to approximately 63 percent with an accompanying decrease in N2.

2-28. STOPPING THE ENGINE. The engine is shut down by moving the throttle lever on the DP-T3 fuel control to the cutoff position by action of the twist grip handle on the pilot's collective pitch lever.

2-29. ALTITUDE COMPENSATION. Altitude compensation is automatic with this fuel control system since fuel metering is on a fuel flow/compressor discharge pressure basis. The acceleration bellows is evacuated and affords an absolute pressure reference. Compressor discharge pressure is a measure of engine speed and air density. Px and Py are proportional to compressor discharge pressure so they will decrease with a decrease in air density. This is sensed by the bellows which acts to reduce fuel flow.

SECTION III
ADJUSTMENTS

3-1. GENERAL.

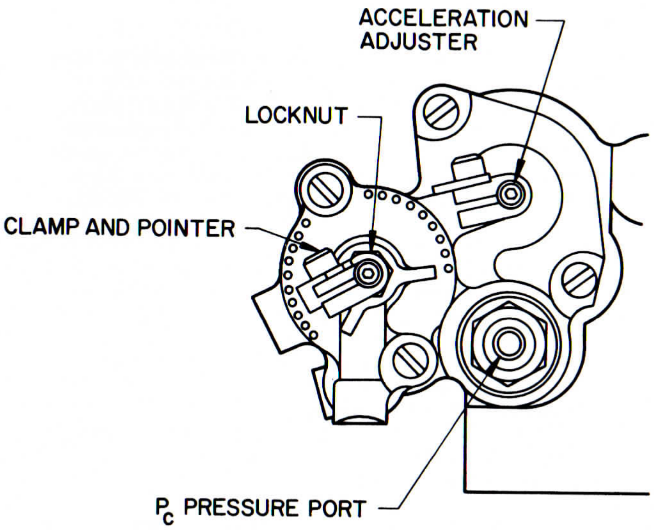
3-2. The fuel control system components are calibrated to exacting requirements at the time of manufacture. Many of the adjustments made at that time can only be made on special test equipment and are not designed to be made in the field. The following adjustments and procedures can normally be made in the field.

CAUTION

The following adjustments and procedures are the only ones normally required with the fuel control and governor installed on the engine. Locations of other adjustments in the illustrations are included for reference only.

3-3. START DERICHMENT ADJUSTMENT. An adjustment is provided on the start derichment device to increase or decrease the flow during the start range. Refer to figure 3-1. Loosen locknut so that the clamp and pointer can be turned. A clockwise adjustment will increase the flow while the counterclockwise adjustment will decrease the flow in the starting range. After an adjustment has been made, the locknut should be tightened to 20-25 pound-inches and resafety wired.

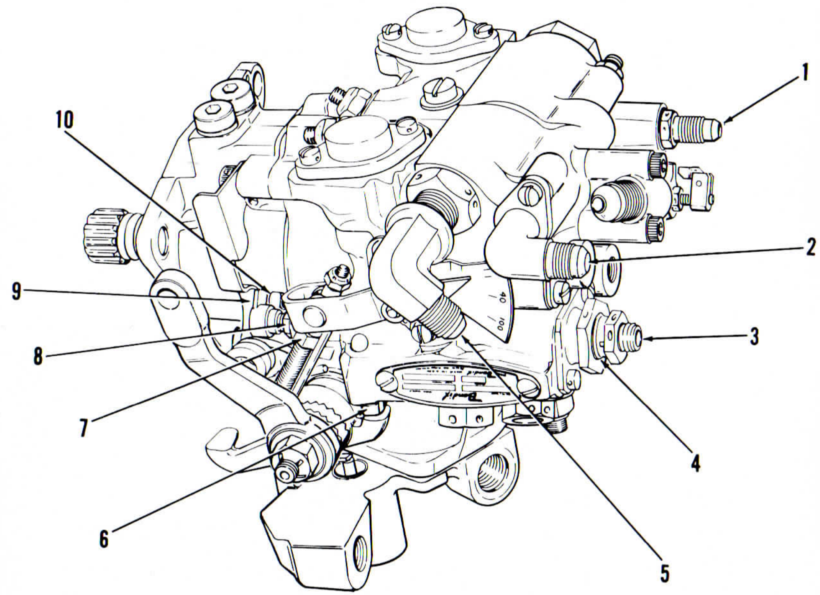
3-4. IDLE SPEED ADJUSTMENT. Idle speed is set on the DP-T3 fuel control. Turn adjusting screw clockwise to increase N1 and counterclockwise to decrease N1 as viewed from the head of the screw; 1/8 turn will change RPM approximately five percent N1.



LA-6118

Figure 3-1. Start Derichment Valve Assembly Adjustment Acceleration Adjuster

3-5. MAXIMUM GAS PRODUCER SPEED (N1) ADJUSTMENT. This adjustment on the DP-T3 fuel control is made to provide a maximum of 104 percent N1. One turn clockwise of adjusting screw (10, figure 3-2) will increase N1 approximately one percent.



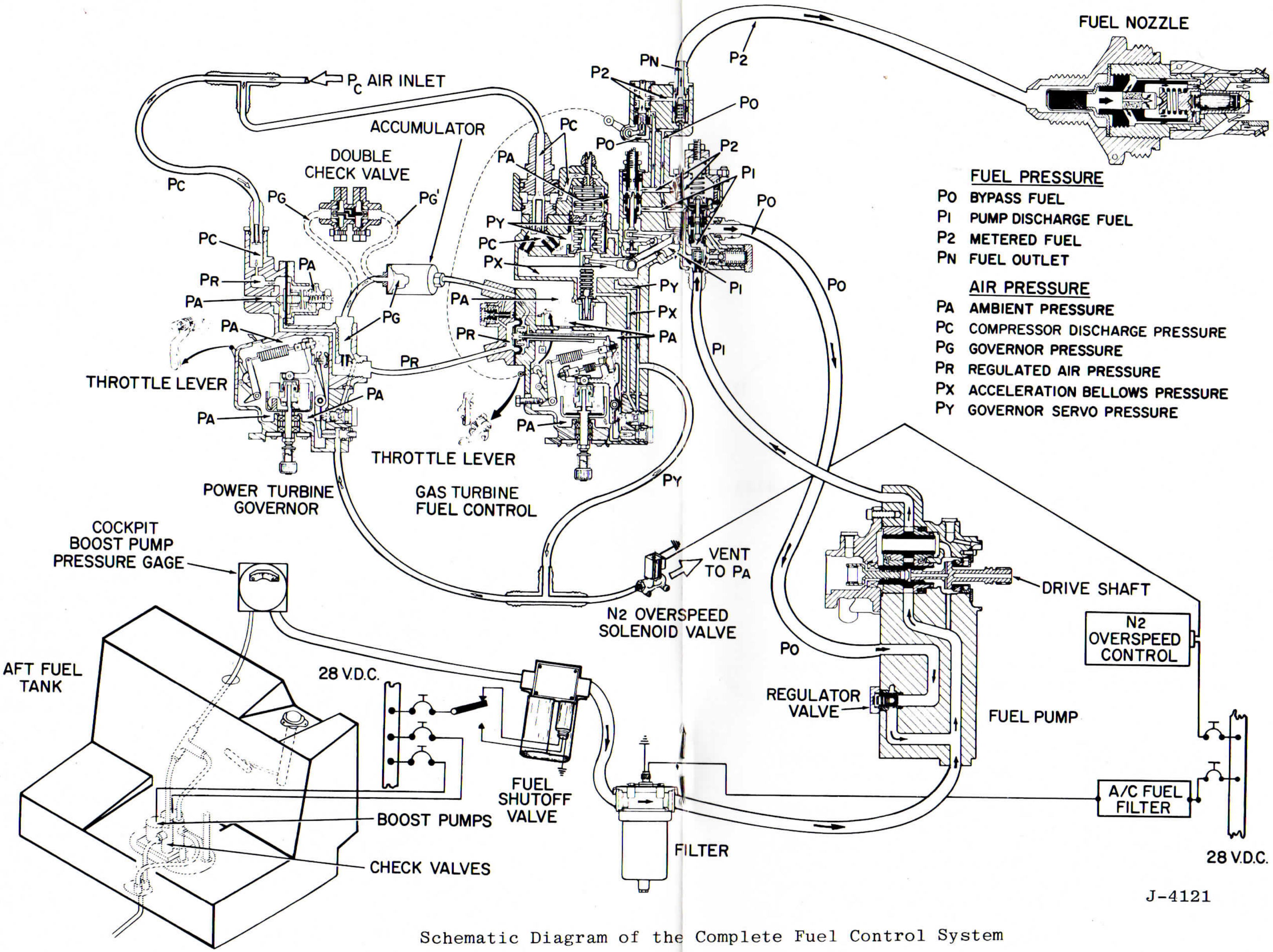
J-4150

1. Pc pressure port
2. Fuel outlet port
3. Minimum flow stop
4. Metering valve sleeve (orifice) adjustment
5. Fuel inlet port
6. Minimum throttle stop
7. Cutoff override lever adjustment
8. Maximum flow stop
9. Dial assembly
10. Maximum throttle stop

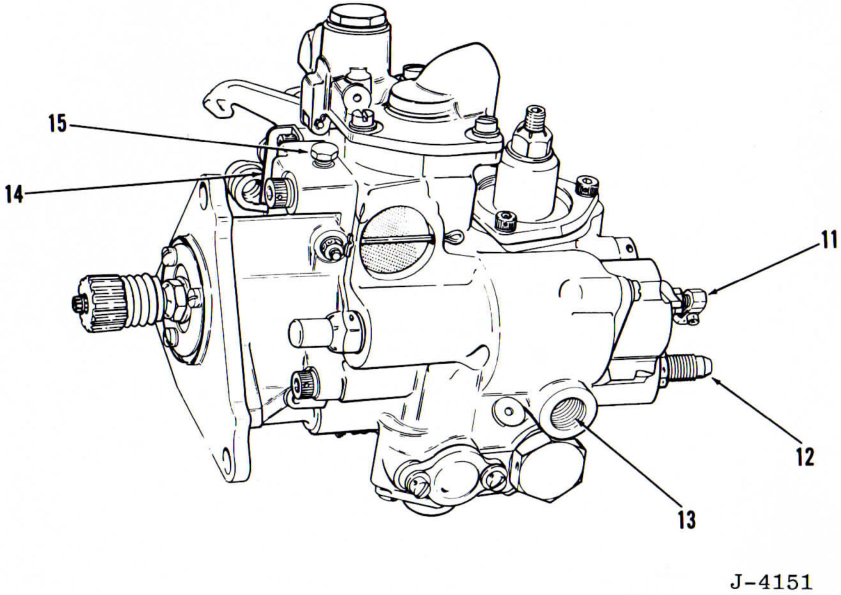
Figure 3-2. Model DP-T3 Turbine Engine Main Fuel Control - External View (View 1)

NOTE

Midgrip Heli-Coil inserts are employed to prevent speed adjustment screws from turning. No locknuts are used.



Schematic Diagram of the Complete Fuel Control System



11. Derichment valve clamp and pointer
12. Pc pressure port
13. Py pressure port
14. Quadrant
15. Idle adjusting screw

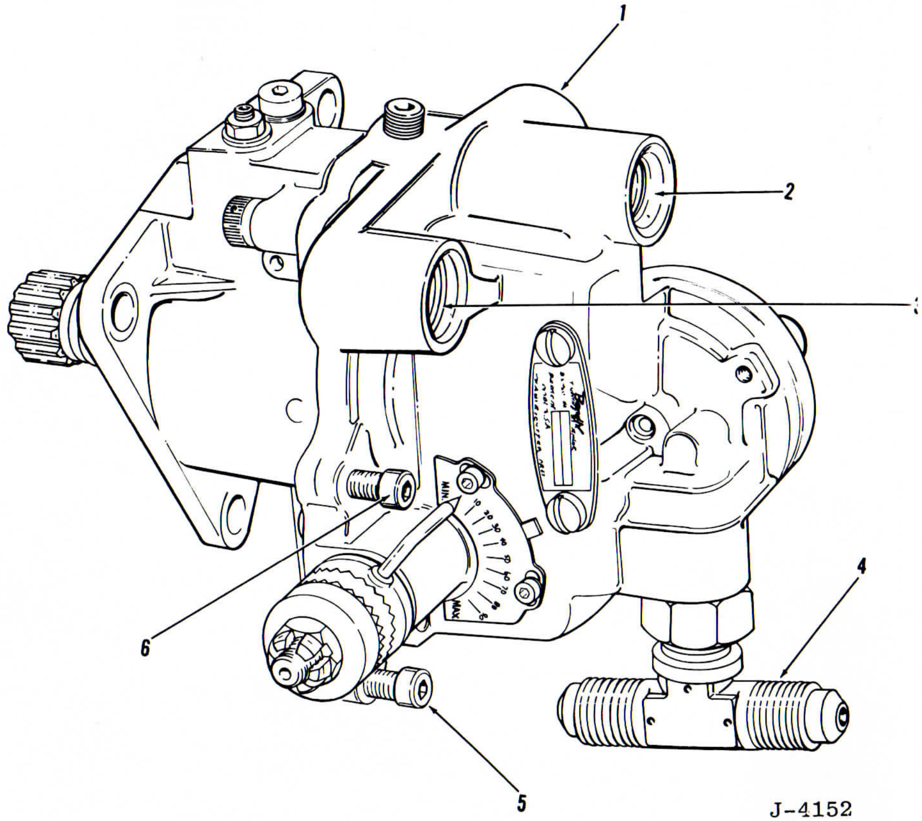
Figure 3-2. Model DP-T3 Turbine Engine Main Fuel Control - External View (View 2)

3-6. MAXIMUM FLOW ADJUSTMENT. The maximum flow adjustment (8, figure 3-2) is located near the forward end of the fuel control. Adjustment screw is located near the drive end of the control and a pointer is attached to the screw with a fixed protractor attached to the drive body. The pointer must be set to the applicable setting (HI or LO) depending on engine and airframe combination. Set the

pointer to the applicable setting, by removing the lockwire on the adjusting screw jam nut. Loosen the nut, insert an Allen wrench, and turn pointer to desired setting (HI or LO). Tighten jam nut to 20-25 pound-inches torque and lockwire.

3-7. ACCELERATION ADJUSTMENT. On late model controls, an adjustment is provided on the start derichment housing to increase or decrease the flow during acceleration. Refer to figure 3-1. Where this adjustment is provided, it is only necessary to turn the adjustment clockwise to increase and counterclockwise to decrease the fuel flow. Each click of the adjustment changes the fuel flow approximately one pound per hour. Only one click of the adjustment should be used at a time to preclude the possibility of hot starts or compressor stalling.

3-8. POWER TURBINE SPEED (N2) ADJUSTMENT. The output shaft maximum speed adjustment in some cases can be made on the AL-AC1 governor. Turn adjusting screw (6, figure 3-3) counterclockwise to increase or clockwise to decrease maximum output shaft speed as viewed from the head of the screw.



1. Pr port
2. Pg port
3. Py port
4. Pc fitting
5. Minimum throttle stop screw
6. Maximum throttle stop screw

Figure 3-3. Model AL-AC1 Power Turbine Governor - External View

SECTION IV
TROUBLESHOOTING CHART

Item	Trouble	Probable Cause	Remedy
1	Engine fails to reach 15 percent cranking speed.	Inadequate torque at starter pad.	Check output of starter and battery. Try using an APU.
2	Engine fails to light-off.	Air in the gas producer fuel control and lines.	Purge air from system at fuel nozzle and try a second start.
		Preservation oil fouling the spark igniter.	Try a second start.
		Faulty circuit to ignition unit.	Listen for ignition operation. Observe for fuel vapor coming out of the exhaust. Check input power to ignition unit. Isolate and replace defective part.
		Faulty ignition exciter.	Listen for igniter operation. Observe for fuel vapor coming out of exhaust. Replace with known satisfactory unit.

Item	Trouble	Probable Cause	Remedy
2 Cont.	Engine fails to light-off. Cont.	Faulty spark igniter.	Listen for igniter operation. Observe for fuel vapor coming out of exhaust. Replace with known satisfactory unit.
		Insufficient fuel in tanks.	Fill tanks with correct fuel.
		Gas producer fuel control remains in cutoff.	Check linkage.
		Insufficient fuel pressure to fuel pump.	Turn on aircraft boost pump.
		Spark igniter firing intermittently.	Check input voltage to exciter. Check ignition exciter by replacing temporarily with a known satisfactory unit.
		Fuel nozzle valve stuck.	Replace fuel nozzle.
		Fuel pump inoperative. (Fuel vapor will not be observed leaving the exhaust.)	Check pump for sheared drives or internal damage; check for air leaks at inlet or fluid leaks at outlet.

Item	Trouble	Probable Cause	Remedy
2 Cont.	Engine fails to light-off. Cont.	Water or other contaminant in fuel.	Check a sample of fuel from the bottom of the tank as follows: Obtain an unchipped spotlessly clean, white enamel bucket (approximately ten quarts). Drain about four to five inches of fuel into the bucket from the sump to be tested. Test for solids then test for water. With a clean mixing paddle, stir the fuel into a swirling "tornado-shaped" cone. Remove the paddle. As the swirling stops, the solid contaminants will gather at the center of the bucket bottom.

Item	Trouble	Probable Cause	Remedy
2 Cont.	Engine fails to light-off. Cont.	Water or other contaminant in fuel. Cont.	Add several drops of household red food dye. The dye will mix with water and the solids in the bottom of the bucket. It will not mix with fuel. If no water is present, the dye will settle to the bottom of the bucket.
			If contaminated disconnect the fuel line prior to the fuel pump, drain all fuel, clean filters and strainers, flush system with clean fuel, recheck filters and strainers, flush system again purging all air from the system.
		Fuel nozzle orifice clogged.	Replace nozzle.
3	Engine lights off but will not accelerate to idle speed at a normal rate.	Improper pneumatic signal to gas producer fuel control.	Check air lines and fittings for looseness.

Item	Trouble	Probable Cause	Remedy
3 Cont.	Engine lights off but will not accelerate to idle speed at a normal rate. Cont.	Improper pneumatic signal to gas producer fuel control. Cont.	Check for crack in air tubes or outer combustion case. Check for air seal leaks.
		Dirty Pc filter.	Clean Pc filter.
		Insufficient fuel supply to gas producer fuel control.	Check fuel system to ensure all valves are open and pumps are operative.
		Insufficient fuel pressure to fuel pump.	Turn on aircraft boost pump.
		Gas producer fuel control bypass valve stuck open.	Place throttle in cutoff. Remove fuel inlet line and fuel bypass line. Blow through the fuel control inlet. A slight reduction should be felt. If there is no restriction tap the top of bypass valve until a restriction is felt. Reconnect lines.

Item	Trouble	Probable Cause	Remedy
3 Cont.	Engine lights off but will not accelerate to idle speed at a normal rate. Cont.	Fuel nozzle partially clogged with carbon.	Clean fuel nozzle.
		Fuel nozzle check valve stuck partially open.	Replace fuel nozzle.
		Gas producer fuel control incorrectly adjusted or calibration has shifted.	Comply with the Engine Maintenance Manual.
		Anti-icing valve open and cabin heat on.	Close anti-icing valve and turn off cabin heat.
		Faulty power turbine governor.	Cap off Py line at fuel control to isolate.
		Gas producer fuel control start derichment too lean.	Adjust start derichment pointer in a clockwise direction.
4	Acceleration temperature too high during start.	Insufficient time allowed for draining after an unsuccessful starting attempt.	Purge the engine by motoring with the gas producer lever and ignition switch in OFF for approximately ten seconds before attempting a second start.

Item	Trouble	Probable Cause	Remedy
4 Cont.	Acceleration temperature too high during start. Cont.	Reduced battery capacity. This can produce low cracking speed.	Recharge or replace battery.
		High residual TOT in excess of 150 degrees C (302 degrees F).	Motor engine with starter leaving gas producer lever and ignition OFF.
		Depreciated starter which is not capable of dry motoring gas producer (N1) above 15 percent.	Replace starter.
		Gas producer lever (twist grip) in ground idle (start) position prior to and during starter engagement.	Review starting procedure.
		Dirty compressor.	Clean compressor and bleed valve.
		Fuel nozzle valve stuck full open.	Replace fuel nozzle.
		Excessive compressor air leaking.	Check for leaks. Be sure that anti-ice valve is fully closed.

Item	Trouble	Probable Cause	Remedy
4 Cont.	Acceleration temperature too high during start. Cont.	Bleed control valve stuck closed.	Replace bleed control valve.
		Gas producer fuel control incorrectly adjusted or calibration has shifted.	Comply with the Engine Maintenance Manual.
		Gas producer fuel control start derichment too rich.	Adjust start derichment pointer in a counterclockwise direction.
5	Acceleration temperature too low during starting.	Fuel control system air sensing lines leaking.	Check air lines and fittings for leaks.
		Gas producer fuel control incorrectly adjusted or calibration has shifted.	Comply with the Engine Maintenance Manual.
		Gas producer fuel control start derichment too lean.	Adjust start derichment pointer in a clockwise direction.

Item	Trouble	Probable Cause	Remedy
6	Engine speed cycles at idle.	Gas producer fuel control bypass valve not operating freely.	Disconnect the fuel bypass line at the fuel pump, flush system with clean fuel. Inspect and clean the fuel control fuel filter. Tap bypass valve cover while flushing system. If the same condition still exists, remove control.
7	Engine instability above idle speed.	Stuck double check valve.	Reverse double check valve. If condition persists, go on to next step.
		Contamination in the pneumatic section of the gas producer fuel control and power turbine governor.	Check Pg port in the governor and the Pc port in both control and governor. Clean bleeds and orifices as required.
8	Idle speed too low.	Incorrect gas producer lever setting.	Check lever position and rigging.
		Malfunctioning tachometer.	Replace tachometer.
		Excessive generator load.	Reduce electrical load requirement.

Item	Trouble	Probable Cause	Remedy
8 Cont.	Idle speed too low. Cont.	Dirty compressor.	Clean compressor and bleed valve.
		Gas producer fuel control idle adjustment incorrectly set.	Correct the setting. Adjust CW to increase N1 speed - 1/8 turn equals approximately five percent.
		Air sensing lines leaking.	Check for leaks. Tighten coupling nuts as required.
		Accumulator leaking.	Check for cracks in sheet metal or braze. Replace accumulator if leaks are found.
9	Idle speed too high.	Incorrect gas producer lever setting.	Check lever position and rigging.
		Malfunctioning tachometer.	Replace tachometer.
		Gas producer fuel control idle adjustment incorrectly set.	Correct the setting. Adjust CCW to decrease N1 speed - 1/8 turn equals approximately five percent.

Item	Trouble	Probable Cause	Remedy
10	Low power with high TOT.	Compressor foreign object damage.	Replace compressor if damage exceeds limits.
		Dirty compressor.	Clean compressor and bleed valve.
		Bleed control valve has failed to close.	Check compressor discharge pressure sensing line for leaks and for security. Replace bleed control valve.
		Excessive air leaks.	Repair leaks.
		Faulty TOT indicator.	Replace indicator.
		Anti-icing valve leaking.	Check linkage or replace valve.

NOTE

The effect of anti-icing air flow on engine performance is as follows:

Type of Operation	Approximate Effect on Performance Available at Power Levels Above 40,000 N1 Speed
Constant TOT, 741 degrees C, (1365 degrees F) at sea level, 4.44 degrees C day (40 degrees F day, cruise power.	A 98.8 decrease accompanied by only a slight decrease in N1 speed.
Constant HP (500 and constant collective pitch (load) operation.	A 52 degrees C, (126 degrees F) increase in TOT.

Item	Trouble	Probable Cause	Remedy
10 Cont.	Low power with high TOT. Cont.	Heat control valve leaking.	Cap off engine bleed manifold to isolate trouble.
		Faulty torquemeter indicating system.	Replace gage or transmitter.
11	Low power with TOT below maximum limit.	Gas producer control lever does not reach maximum speed adjustment stop.	Adjust linkage to the gas producer fuel control.
		Gas producer control lever maximum speed adjustment stop not properly set.	Correct the maximum speed adjustment setting. Adjust CW to increase N1 speed - one turn equals approximately one percent.
		Gas producer control fuel flow is set too low.	Reset maximum fuel flow.

Item	Trouble	Probable Cause	Remedy
11 Cont.	Low power with high TOT. Cont.	Loose pneumatic fitting, cracked accumulator, or cracked pneumatic line causing air leak in control system.	Pressurize the system to check for leaks.
12	Low measured TOT at normal or high power.	Faulty TOT indicator.	Replace indicator.
		Faulty TOT thermocouple assembly.	Replace thermocouple assembly.
13	Engine N1 or N2 overspeeds.	Gas producer fuel control linkage not properly set.	Check linkage for proper operation and adjustment.
		Defective gas producer fuel control or power turbine fuel governor.	Isolate the governor from the system by removing Pc fitting from governor and capping off one port.
		Faulty N1 or N2 tachometer.	Replace generator or in indicator.

NOTE

During ground run after overspeed incident note the idle speed with the twist grip at 30 degrees position. If idle speed is normal, suspect the governor - if idle speed is high, suspect the gas producer fuel control as the faulty component.

Item	Trouble	Probable Cause	Remedy
14	Excessive exhaust torching during transients.	Fuel nozzle malfunction.	Replace fuel nozzle.
		Excessively rich gas producer fuel control.	Contamination in pneumatic circuit. Clean the bypass valve. Clean bleeds and orifices.
		Leaking accessory bleed lines.	Repair or replace lines.
15	Slow to accelerate from idle to power.	Dirty compressor.	Clean compressor and bleed valve.
		Hung Pr-Pg valve.	Check valve action by monitoring good cam to valve action, if condition persists, continue to next step.
		Loose pneumatic fittings.	Tighten or replace as required.
		Excessive generator load.	Reduce electrical load.
		Excessive compressor air leakage.	Check for leaks and repair.
		Gas producer control acceleration schedule too lean.	Comply with the Engine Maintenance Manual.

Item	Trouble	Probable Cause	Remedy
16	Slow to accelerate to power while in flight.	Same as preceding trouble.	Correct as in preceding trouble.
		Governor linkage incorrectly rigged.	Check rigging. Correct linkage as required.
17	TOT approximately 30 degrees C (86 degrees F) than normal at idle.	Bleed control valve stuck closed.	Replace bleed control valve.
18	Compressor surge during starting or near the idle speed.	Dirty compressor.	Clean compressor and bleed valve.
		Excessively rich gas producer fuel control.	Contamination in pneumatic circuit. Clean circuit.
		Bleed control valve stuck closed.	Replace bleed control valve.
19	Compressor surge during starting.	Bleed control valve stuck closed.	Replace bleed control valve.
		Excessively rich gas producer fuel control.	Contamination in pneumatic circuit. Clean circuit.
20	Compressor surge during acceleration.	Bleed control valve has failed to open.	Replace bleed control valve.

Item	Trouble	Probable Cause	Remedy
20 Cont.	Compressor surge during acceleration.	Excessively rich gas producer fuel control.	Contamination in pneumatic circuit. Clean circuit.
		Compressor erosion.	Inspect compressor. Correct as required.
21	Compressor surge during low power operation.	Bleed control valve has failed to open.	Replace bleed control valve.
22	Unable to stop engine.	Gas producer fuel cutoff valve not closed.	Close the aircraft fuel shutoff valve to stop the engine. Then check control linkage rigging or replace gas producer fuel control if faulty.
23	Afterfire	Burner drain valve line obstruction.	Check the drain lines. Clean or replace as necessary.
		Sticking burner drain valve.	Replace valve.
		Fuel nozzle valve stuck open.	Replace fuel nozzle.
		Gas producer fuel control cutoff valve not fully closed.	Check linkage or replace fuel control.

Item	Trouble	Probable Cause	Remedy
24	N2 Slow to respond.	Improper governor setting.	Contamination in pneumatic circuit. Clean circuit.
25	N2 tends to overshoot.	Improper governor setting.	Contamination in pneumatic circuit. Clean circuit.

SECTION V

PRODUCT SUPPORT

5-1. Bendix Energy Controls Division maintains a network of Authorized Warranty and Certificated Repair Stations worldwide in addition to Field Service Engineers strategically located both domestically and overseas. These repair stations provide the following services:

a. Warranty repair.

b. Exchange fuel controls and governors.

c. Complete overhaul and repair capability.

d. Trained Field Service Representatives.

e. Training.

NOTES