CHAPTER 6

A. STARTING SYSTEM

1. General Description

a. The starting system consists of a pneumatic starter, an air duct network (pneumatic manifold) supplying air to the starter with valves and their controls, fuel and ignition supply ant their controls, and controls of the other systems used in conjunction with the starting system.

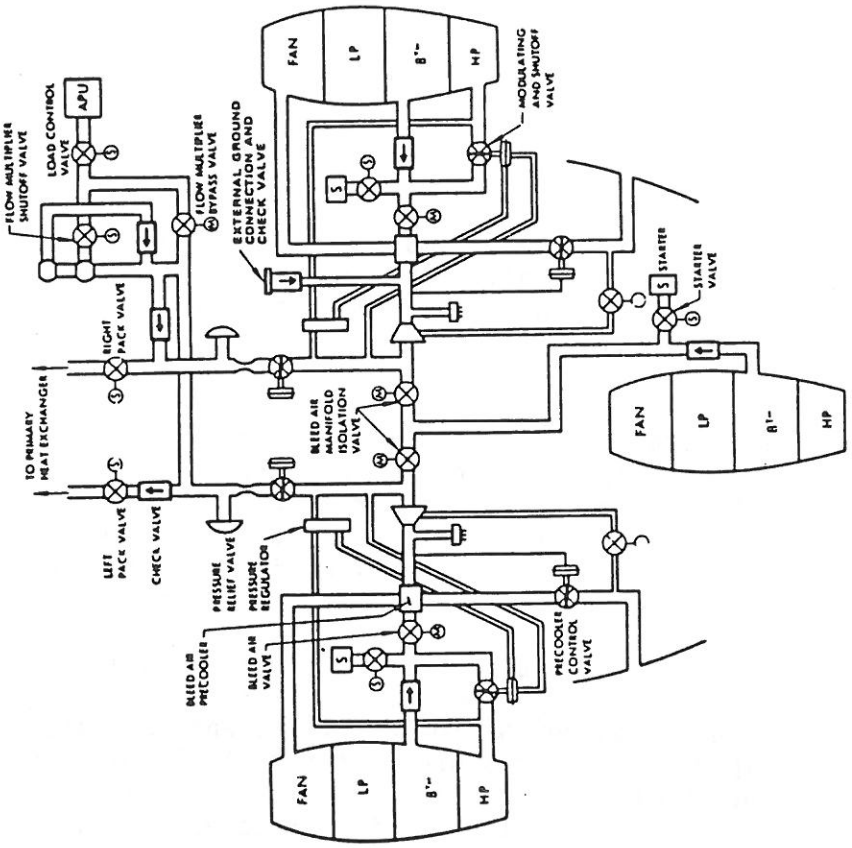
b. An air turbine driven starter geared to the N2 compressor is utilized for all engine ground starts. The pneumatic starter is mounted on the LF aft face of the N2 gearbox. The starter converts energy of the compressed air into rotative force for accelerating the engine to an rpm at which starting may be accomplished when flow of air through the engine is established.

c. Low pressure air and electrical power are required for starter operation. The inlet air flow to the starter is regulated by a solenoid operated shutoff valve controlled by the engine start switch. It is equipped with a pressure switch that illuminates a light on the P2 panel when the valve is open. This valve is fully open when inlet air pressure, at the starter, reaches 12 psi. A manual override button allows the solenoid to be overridden manually if it fails. The starter valve may also be controlled manually by inserting an Allen wrench in the valve position indicator shaft and turning the engine start valve to open. Engine start controlled from the ground must be coordinated with the control cabin through the interphone.

d. Rotation of the N2 compressor also drives the engine fuel pump and the fuel control unit to meter fuel under pressure to the combustion chamber. An ignition system provides a high energy discharge for ignition of the fuel/air mixture.

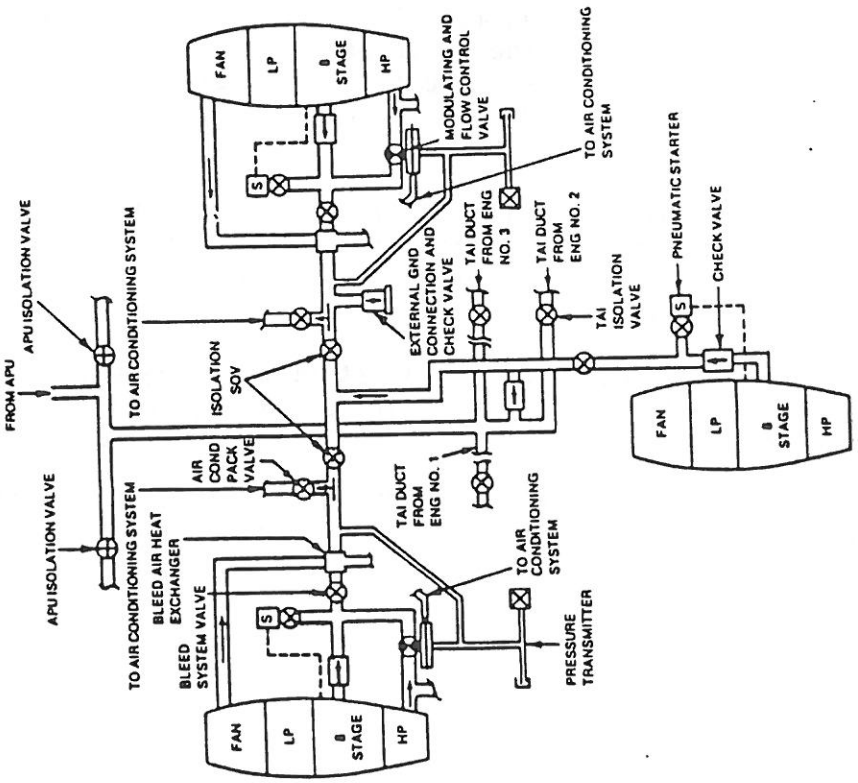
When the engine has accelerated to the starting speed and with the engine start lever advanced to the start position, fuel ignites resulting in an engine start.

Release of the starter switch to the OFF position will deenergize the starter valve, shutting off bleed air to the starter.



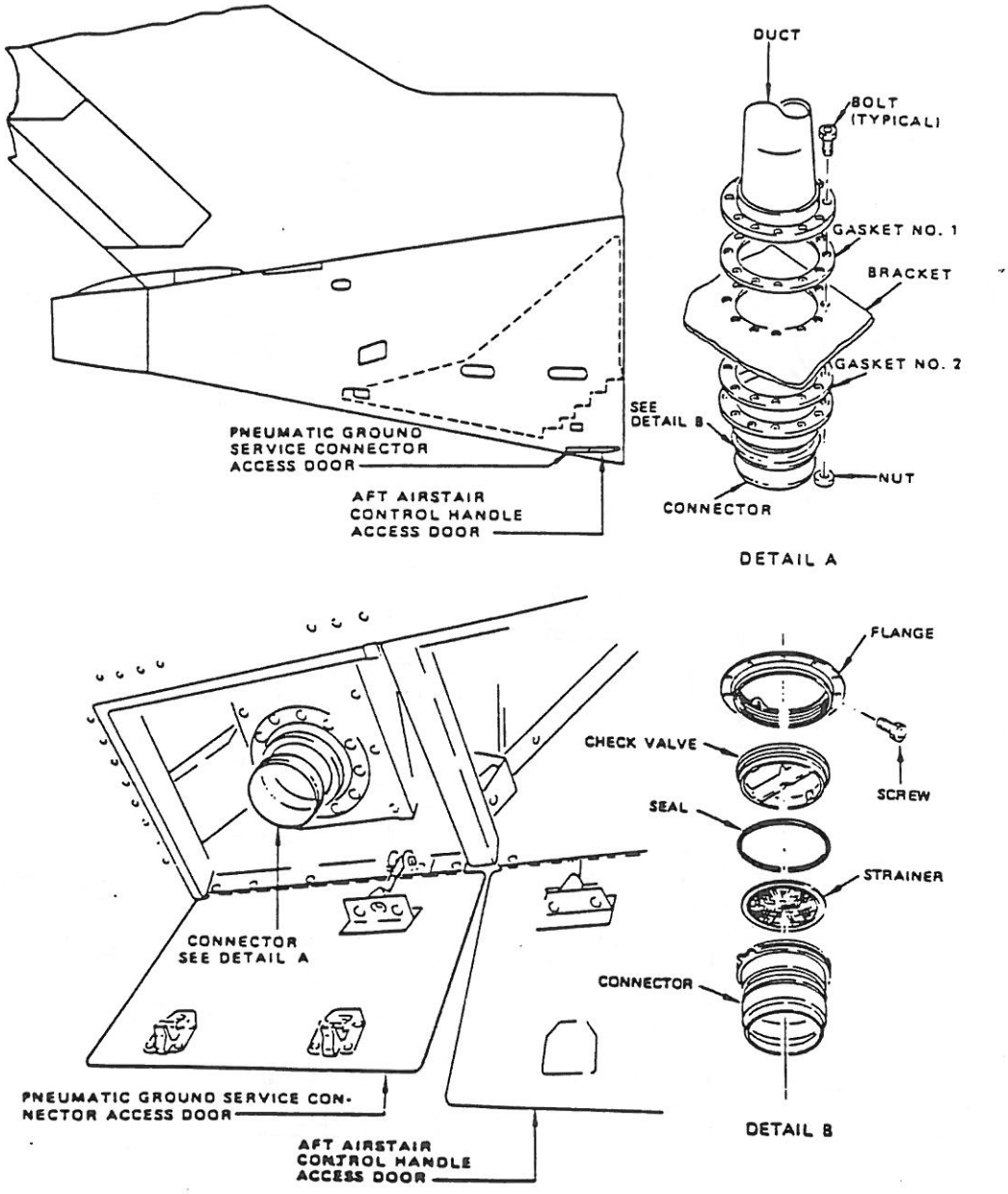
727-200

Pneumatic Starter System Flow Diagram

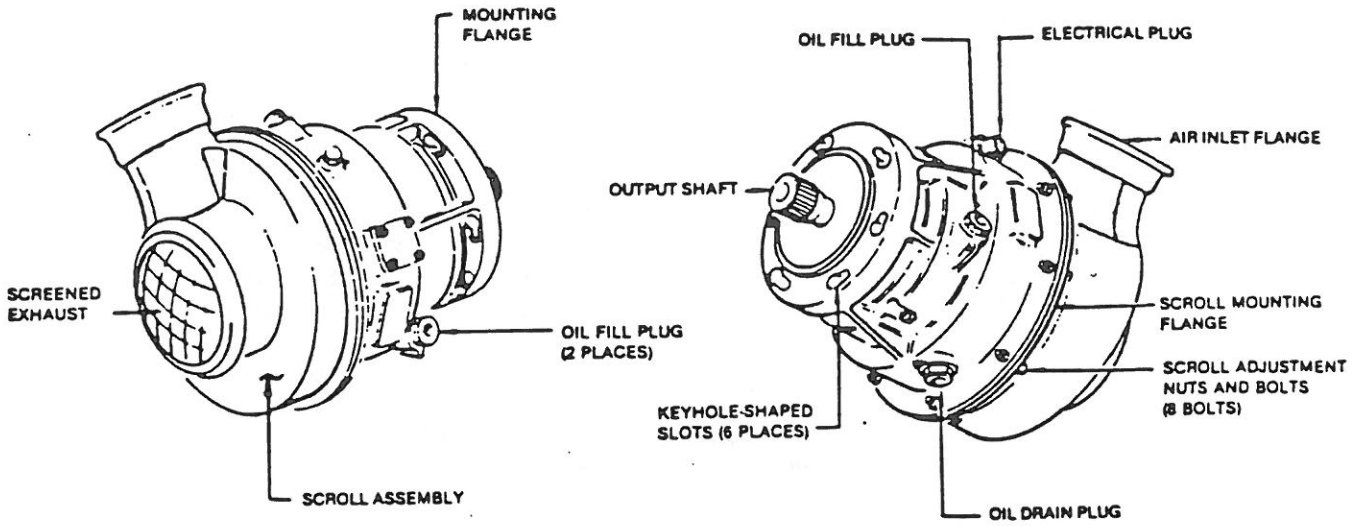


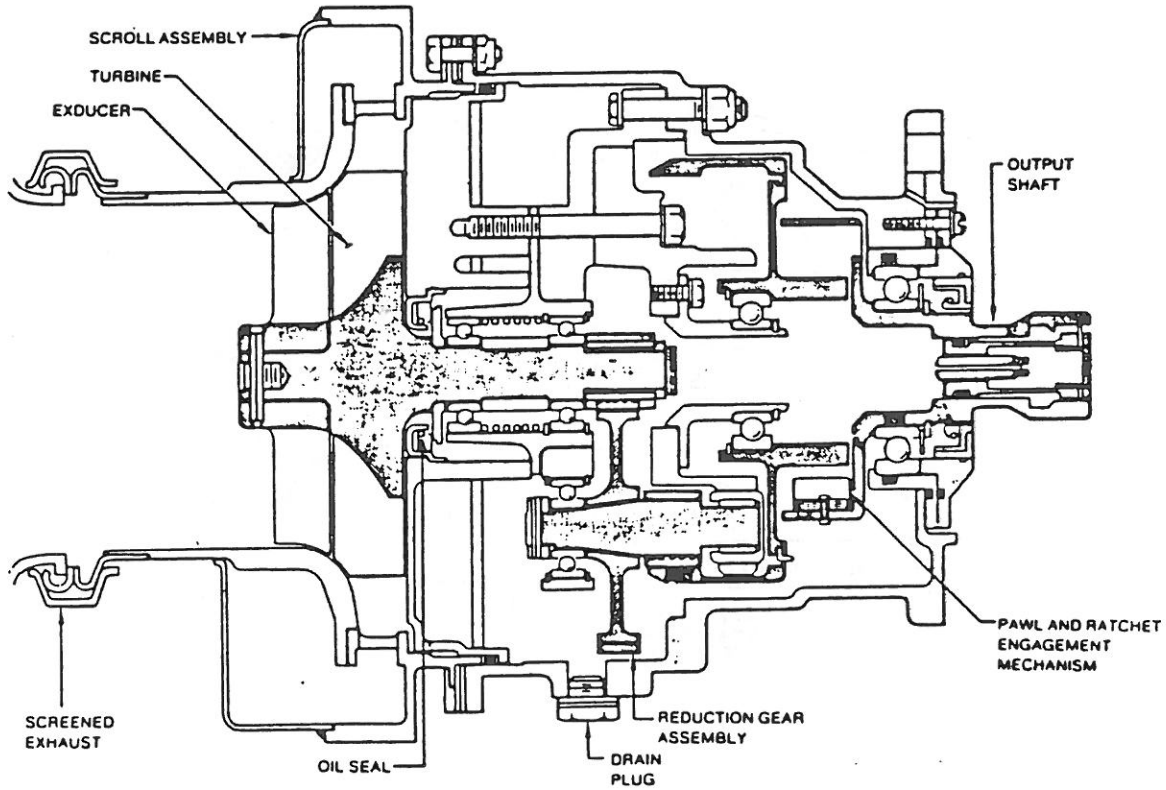
727-100

Pneumatic Starter System Flow Diagram



Pneumatic Ground Service Connector





PNEUMATIC STARTER

e. Low pressure air from the following sources is used for starter operation:

External air source
Cross bleed air from an operating engine
Compressed air from the auxiliary power unit
The access door for the pneumatic ground service connection is on the bottom at the fuselage immediately forward of the airstairs.

f. Engine No. 2 Duct Access Door Light

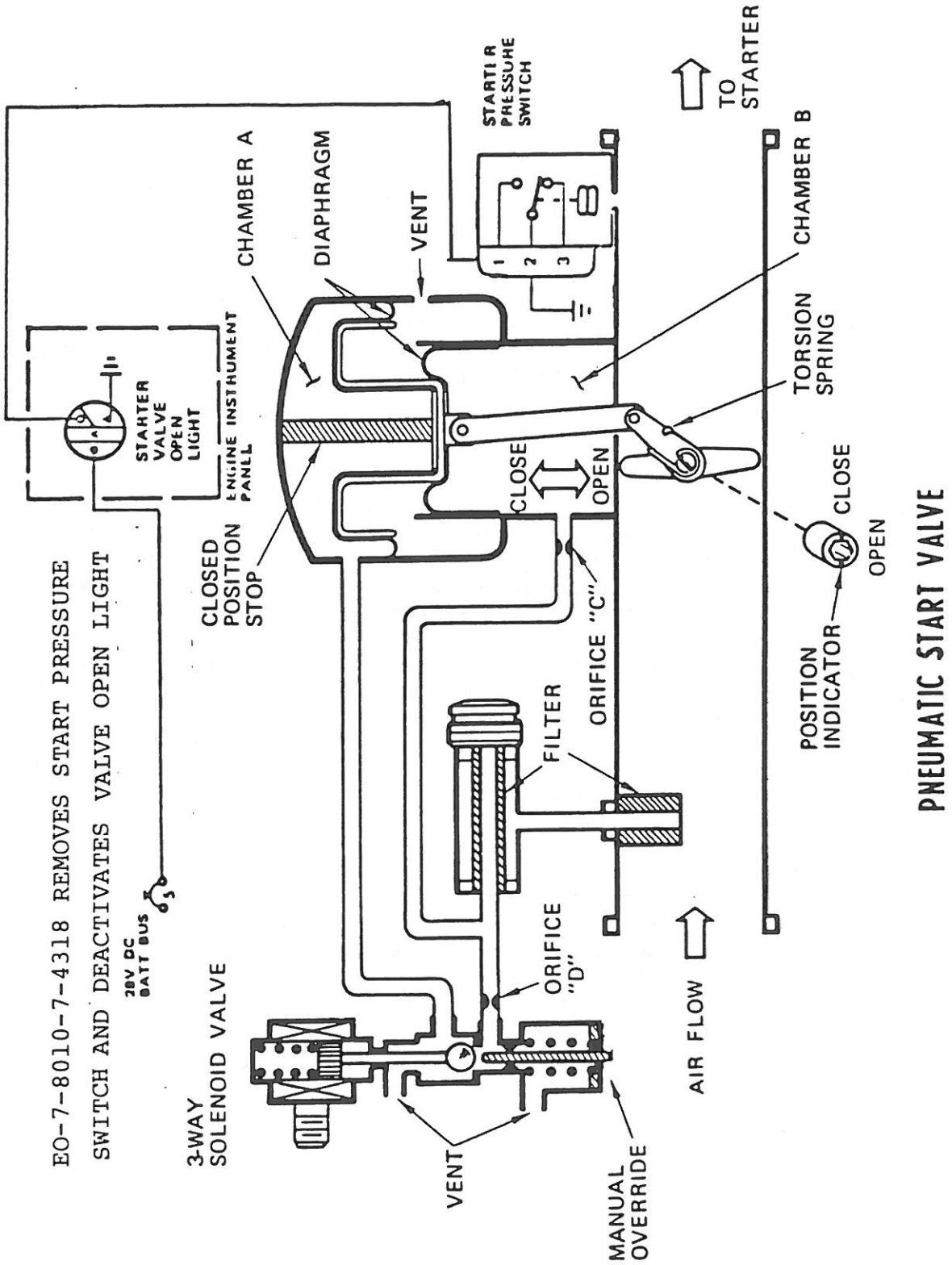
This amber light marked ENG ACCESS DOOR is on the overhead panel. When this light is illuminated the engine No. 2 duct access door is not locked, consequently engine No. 2 should not be started. With the duct access door locked the light is extinguished.

2. PNEUMATIC STARTER (ATA 80-11-0)

a. The pneumatic starter is a lightweight turbine type air motor which converts the kinetic energy of compressed air into starting torque sufficient to accelerate the engine to starting speed. Low pressure air and electrical power are required for starter operation. The starter will continue to assist the engine until starter cutout speed is attained.

b. The starter consists of a scroll assembly, turbine wheel, reduction gear assembly, engaging mechanism and an output shaft. The starter is fitted with a starter valve to control the inlet air flow. When the valve is open, it admits air to the starter valve open light pressure switch and continues to the inlet connection on the starter scroll assembly; the air then passes through the starter vanes of the scroll assembly and power is directed radially inward through the turbine wheel imparting high speed rotation. The reduction gear train translates the high speed, low torque of the turbine wheel into low speed, high torque. This output is transmitted through a pawl and ratchet engagement mechanism to the output shaft. From the starter output shaft, the cranking torque is transmitted to the N2 compressor by way of the accessory drive gears. A clutch mechanism provides engagement of the reduction gear train with the output shaft for engine starting; when the speed of the output shaft exceeds the speed of the internal gear hub, the clutch mechanism overruns, thus providing automatic disengagement. Turbine overspeed is prevented by the operator releasing the START switch at prescribed starter cutout speed.

WARNING: FAILURE TO RELEASE THE STARTER SWITCH AT THE PRESCRIBED SPEED (40% N2) WILL RESULT IN STARTER DISINTEGRATION AND SERIOUS DAMAGE OR PERSONAL INJURY.


EO-7-8010-7-4318 REMOVES START PRESSURE SWITCH AND DEACTIVATES VALVE OPEN LIGHT
28V DC BATT BUS
3-WAY SOLENOID VALVE
STAHTER VALVE OPEN LIGHT
ENGINE INSTHUMENT PANLL
CHAMBER A
DIAPHRAGM
VENT
STARTI R PRESSUHE SWITCH
TO STARTER
CHAMBER B
TORSION SPRING
CLOSE
OPEN
CLOSED POSITION STOP
ORIFICE "C"
FILTER
ORIFICE "D"
VENT
MANUAL OVERRIDE
AIR FLOW
POSITION INDICATOR
CLOSE
OPEN
PNEUMATIC START VALVE

c. The pneumatic starter is mounted on the accessory drive gear case beneath the engine.

d. The 727-200 aircraft had a turbine wheel containment assembly attached to the starter air exhaust. THIS ASSEMBLY IS NOW REMOVED BY EO -7-8010-7-4315.

3. STARTER VALVE (ATA 80-11-0)

a. The starter shutoff valve controls air flow to the pneumatic starter during engine starting. The valve is pneumatically operated and solenoid controlled. It consists essentially of three assemblies; a valve body assembly with lever operated butterfly valve, and a piston type pneumatic actuator assembly and a pressure switch for starter valve open lights. The valve is located in the pneumatic duct to the starter, and is attached to the duct and starter inlet flange by clamps.

4. OPERATION (ATA 80-100)

a. Starting Pneumatics

(1) The pneumatic system can be pressurized from three sources: the APU, a pneumatic GPU, or an operating engine. Normally, the APU is used while an engine source is seldom used.

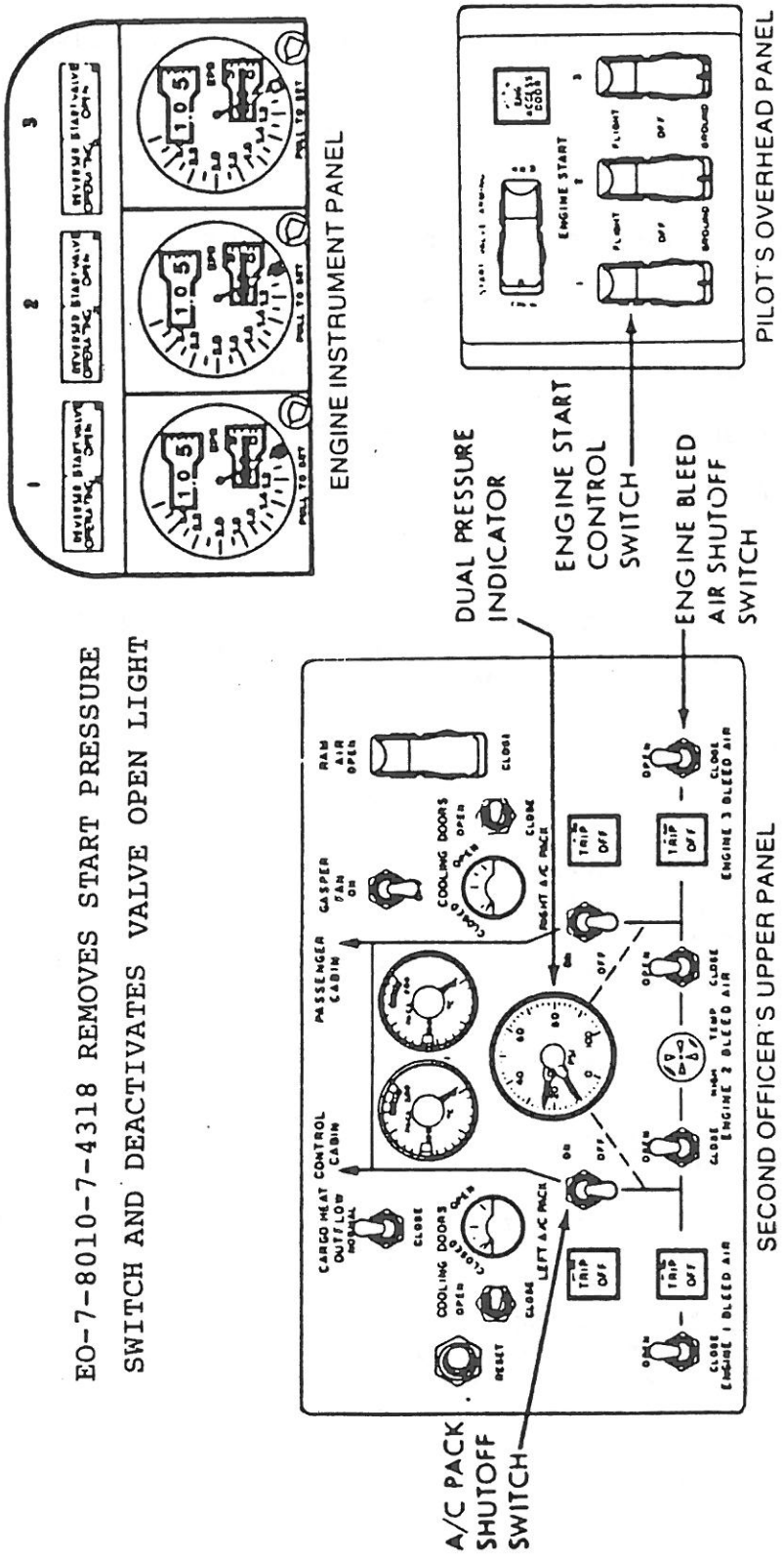
b. Control and Indication

(1) A dual needle duct pressure gage is installed in the air conditioning section of the second officer's upper panel. It is used during starting to monitor pressure available for cranking and also as an indication of starter valve closure when the start switch is released. Starter valve closing is indicated by a sharp rise in duct pressure back to unloaded supply pressure. It senses pressure at two different points.

(2) Noting starter valve closure is especially important on this system. Once an engine is running, its own pressure is at the starter valve and there is no way to isolate it. If a failure-to-close went undetected, starter failure would result.

(3) To ensure enough air for starting, other air users must be isolated. To isolate air conditioning , the pack valves must be CLOSED. The

(4) To start all switch, all engine bleed valves and both manifold isolation valves must be open. To start less than three, all valves do not have to be open. The ones that must be open are determined by the engine(s) to be started and the pressure source being used. These valves are all controlled by the engine bleed air switches on the air conditioning control panel.



Pneumatic Starter Control Equipment Location

(5) There are four engine bleed air switches: one each for engines No. 1 and No. 3, and two for engine No. 2. ENGINE No. 1 BLEED AIR and ENGINE No. 3 BLEED AIR switches control only their respective engine bleed valves. ENGINE No. 2 BLEED AIR switches have multiple functions as follows:

(1) Either switch will open engine No. 2 bleed valve.
(2) Either switch will open the APU load control valve if the APU is operating.
(3) The left switch will open the left manifold isolation valve.
(4) The right switch will open the right manifold isolation valve.

(6) To promote understanding of system control, three examples are shown, eaching using one of the three possible pneumatic sources:

(a) Pneumatic starter operation using auxiliary power unit,

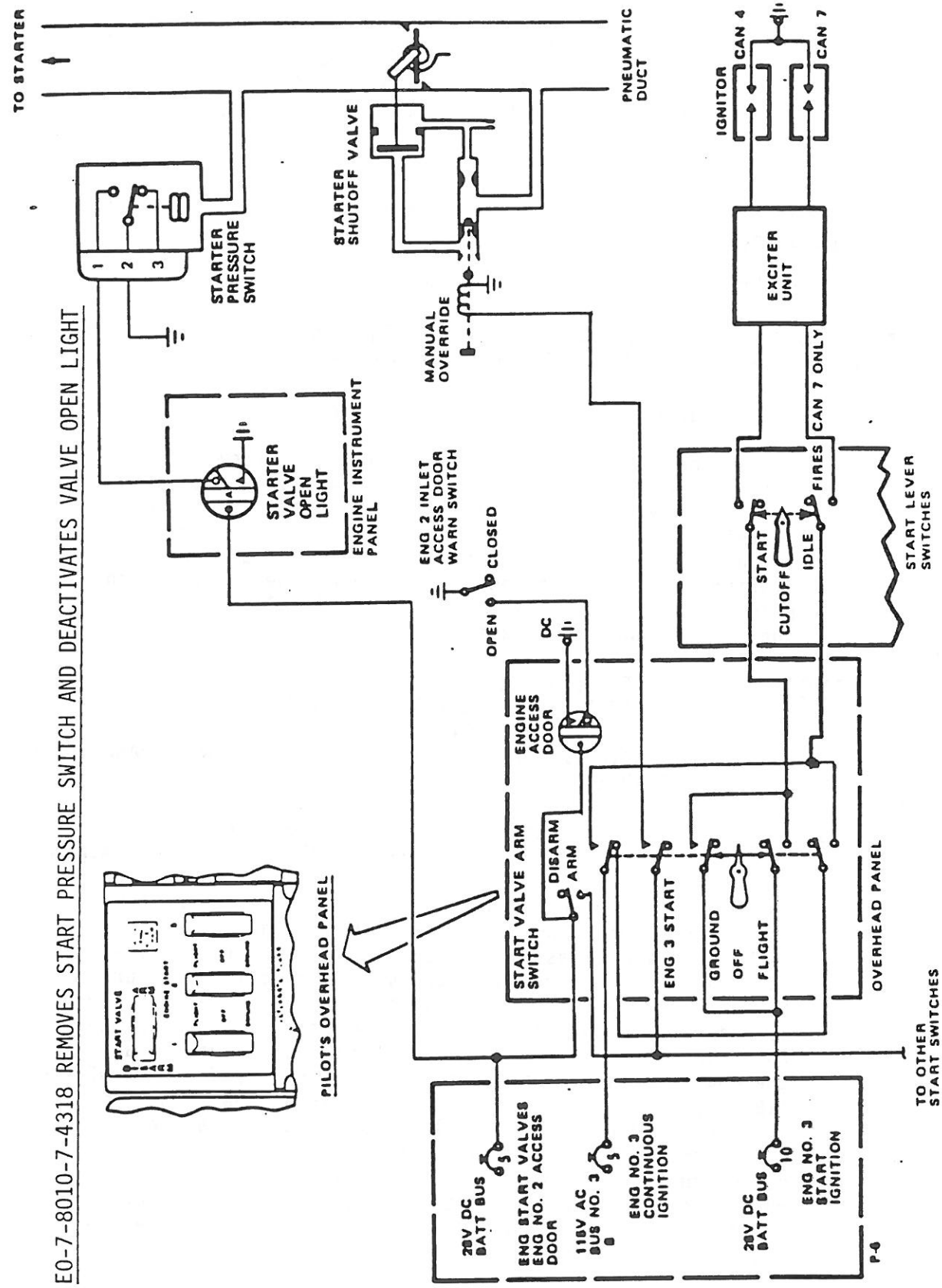
The engines can be started using bleed air from the APU. Air output from the APU is directed into the airplane pneumatic manifold. When the left and right air conditioning pack shutoff valves are closed and the engine bleed air shutoff valves are opened, low pressure air is available at the starter valves. When the applicable engine start switch is held in the "GROUND START" position, 28 volt DC power is supplied to open the starter valve.

CAUTION: IF THE STARTER SWITCH IS INADVERTENTLY RELEASED, PLACE THE START LEVER TO CUTOFF, AND ALLOW THE ENGINE TO STOP ROTATION. AN ATTEMPT TO ENGAGE THE STARTER WHILE THE ENGINE IS ROTATING WILL DAMAGE THE STARTER SYSTEM,

NOTE: To ensure an adequate supply of compressed air, electrical loading on the APU should be held to a minimum.

The starter valve open light will illuminate on the P-2 panel and starter should now accelerate the engine and, when the N2 tachometer indicates 20% rpm and N1 tachometer indicates 3%, fuel and ignition are supplied by advancing the starter lever to the start detent. Engine light-up should occur within 25 seconds after advancing the start lever. Refer to Chapter 5, for start lever operation. The starter continues to assist the engine until the starter switch is released at 40% N2 rpm (18% N1). Electrical power to the starter valve will be interrupted and the valve will close, ending starter operation. The indication of starter valve closure is a sudden recovery of duct pressure, which can be observed by monitoring the dual pressure indicator on the third crewman's upper panel and the light extinguishing starter valve open light extinguishing.

PNEUMATIC STARTER ELECTRICAL CIRCUIT



EO-7-8010-7-4318 REMOVES START PRESSURE SWITCH AND DEACTIVATES VALVE OPEN LIGHT

CAUTION: DO NOT EXCEED THE RECOMMENDED STARTER DUTY CYCLE FOR STARTER DUTY CYCLE. SHOULD THE ENGINE FAIL TO START AND ACCELERATE NORMALLY, DO NOT ATTEMPT ANOTHER STARTING OPERATION UNTIL THE ENGINE HAS COMPLETELY STOPPED ALL ROTATION (ALLOW APPROXIMATELY 15 SECONDS AFTER THE TACHOMETER READS ZERO).

A manual override button on starter valve permits opening the valve if it fails to open electrically. When the override button is actuated, the valve solenoid is overridden, and the valve opens pneumatically. The valve manual override button must be released when the N2 tachometer indicator reads 40% rpm. The valve then closes, and the starting cycle is terminated.

WARNING: IF THE MANUAL OVERRIDE BUTTON IS NOT RELEASED WHEN THE N2 TACHOMETER INDICATES 40% RPM. THE STARTER WILL OVERSPEED AND CAN BE SEVERELY DAMAGED. THE INTERPHONE SHALL BE USED FOR COMMUNICATIONS WITH THE CONTROL CABIN. FAILURE TO HEED THIS "WARNING" COULD RESULT IN PERSONAL INJURY.

(b) Starter Operation Using External Air Source

This type of starter operation is dependent upon having internal low pressure air source connected to the pneumatic ground service connection. The procedure for starting is the same as using the APU.

(c) Pneumatic Starter Operation Using Engine Cross Bleed Air

When necessary, cross bleed starting of an engine can be accomplished by using bleed air from an operating engine. The engine bleed air shutoff valves are opened. Adequate pressure for cross bleed starting is provided by operating engines No. 1 or No. 3 at approximately 75% N2 RPM. When using engine No. 2, the engine must be operated at 85% N2 RPM or above to maintain adequate bleed air pressure for cross bleed starting. When the dual pressure indicator on third crewman's upper panel indicates 35-45 psig, the start switch for the engine to be started is placed in the "GROUND START" position.

(7) Starter Control Circuit

Starter control is quite simple, consisting of one switch for each engine and one master start valve arming switch for all three engines. By positioning the start valve arming switch to the armed position, power is supplied to all three start switches. By positioning an ENGINE START switch to the GROUND position, 28V DC is supplied to its starter valve. Power comes from the battery bus, through the upper section of the switch, to the valve. The FLIGHT position of the switch does not operate the starter. In flight, the engine is windmilling and a starter is not needed.

(8) Ignition Control

(a) Starting not only involves starter operation, but also pneumatics, ignition and fuel control.

(b) Positioning an ENGINE START switch to GROUND supplies 28V DC to a start lever ignition (start) switch. When the start lever is placed to the START position, this voltage is supplied to the ignition exciter. This ignition circuit is also used for flight by positioning the switch to FLIGHT which gives ignition only.

(c) The remaining circuitry in this illustration is not too closely related to starting. There is a circuit supplying 115V AC for continuous ignition. It is used in flight for automatic relight of engines that may flame out because of turbulence or other unusual conditions. It relights the fire before the engine slows down to the point where it would have to be restarted. Continuous ignition can only be used while the start lever is in the IDLE position. It also functions when the start lever is inadvertently place in the idle position during normal ground start.

(9) Motoring

Motoring procedures are used when checking engine components for operation or leakage. Dry motoring is starter operation without fuel or ignition. Wet motoring requires starter operation for certain fuel system checks. It involves opening the fuel valve while cranking just as if the engine were to be started. It is done without ignition, however, to prevent the engine from starting. The ignition breakers START and CONT to disable ignition.

(10) Pneumatic Starter Duty Cycle

(a) Normal Start - 30 seconds ON, 60 seconds OFF

(b) Slow Starting - 60 seconds ON, 60 seconds OFF

(c) Extended or Motoring - 2 minutes ON, 5 minutes OFF

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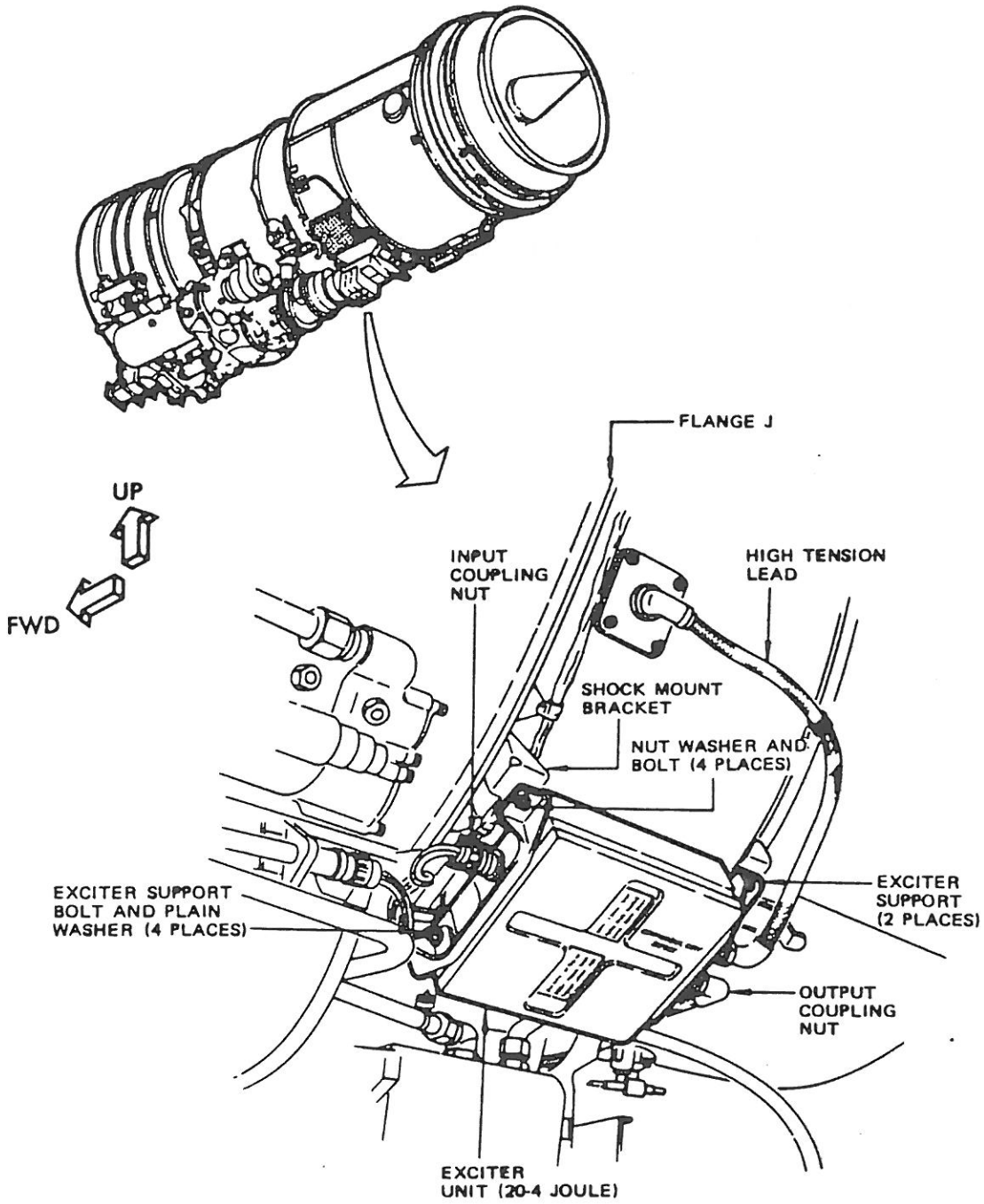

Ignition Exciter Unit Installation