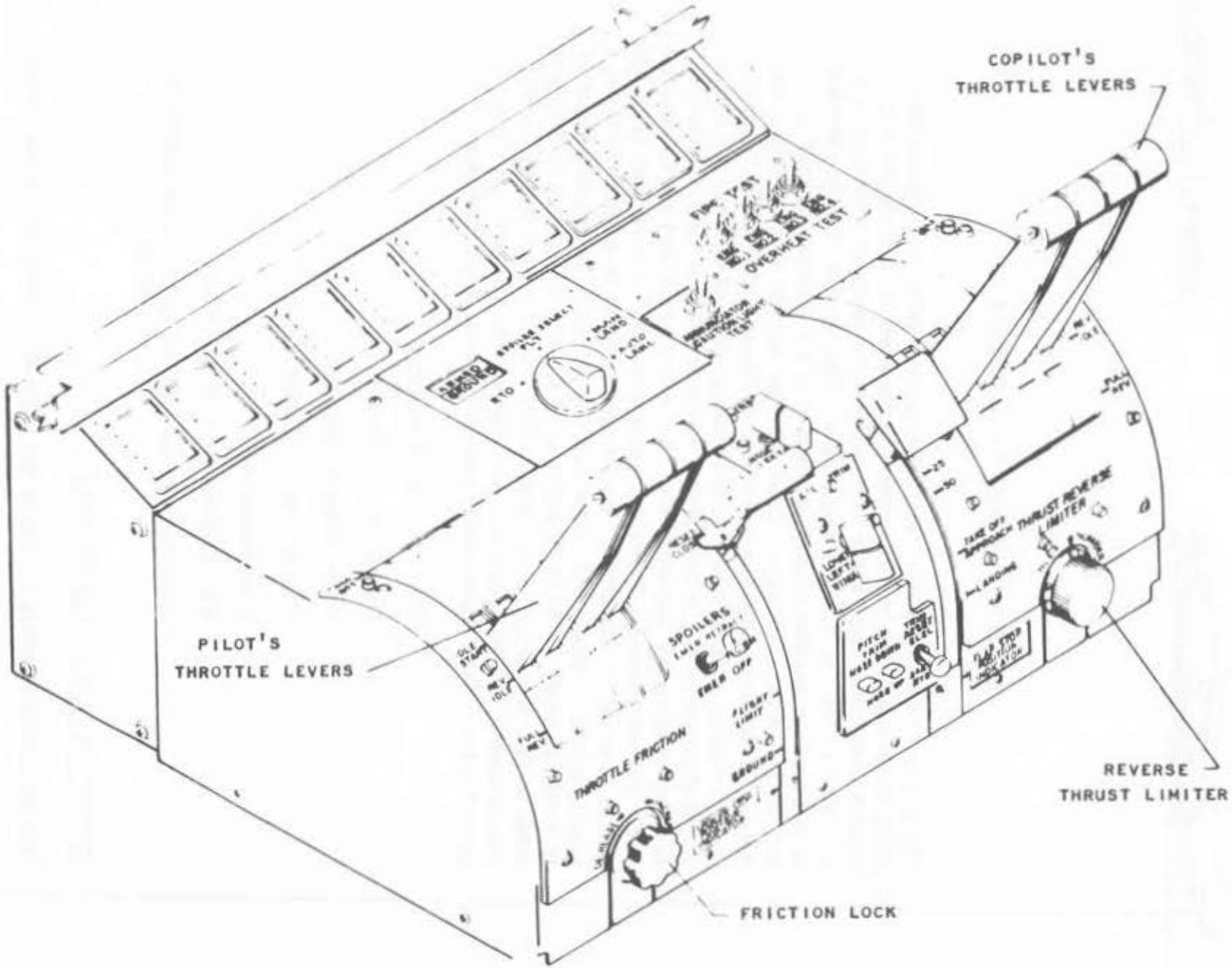
ENGINE CONTROL SYSTEM

The two basic ranges of operation of the engine control system are the flight range and thrust reverse range. Inadvertent movement of the throttle control lever from flight range to thrust reverse range is prevented by a cam incorporated in the throttle quadrant. The throttle must be retarded to idle position and then raised approximately 1 1/8 inches and pulled aft into the thrust reverse range. Control by the throttle over the thrust reverser system is provided by a mechanical linkage to the thrust reverser control valve. A thrust reverser mechanical lock-out prevents the application of engine power, when reverse thrust is selected, until the thrust reverser doors have been extended. A reverse thrust limiter, incorporated in the throttle quadrant, limits the engine power to the equivalent of 18,000 pounds of gross thrust so that the pilot does not have to monitor EPR and adjust throttles. Range of throttle travel from full reverse (zero degrees) to maximum flight power is 80 degrees. A friction adjustment knob is provided on the throttle quadrant. Engine fuel shutoff is provided by a separate system, the fuel shutoff actuator, and a cable actuated fuel supply shutoff valve. The engine control system consists of the following:

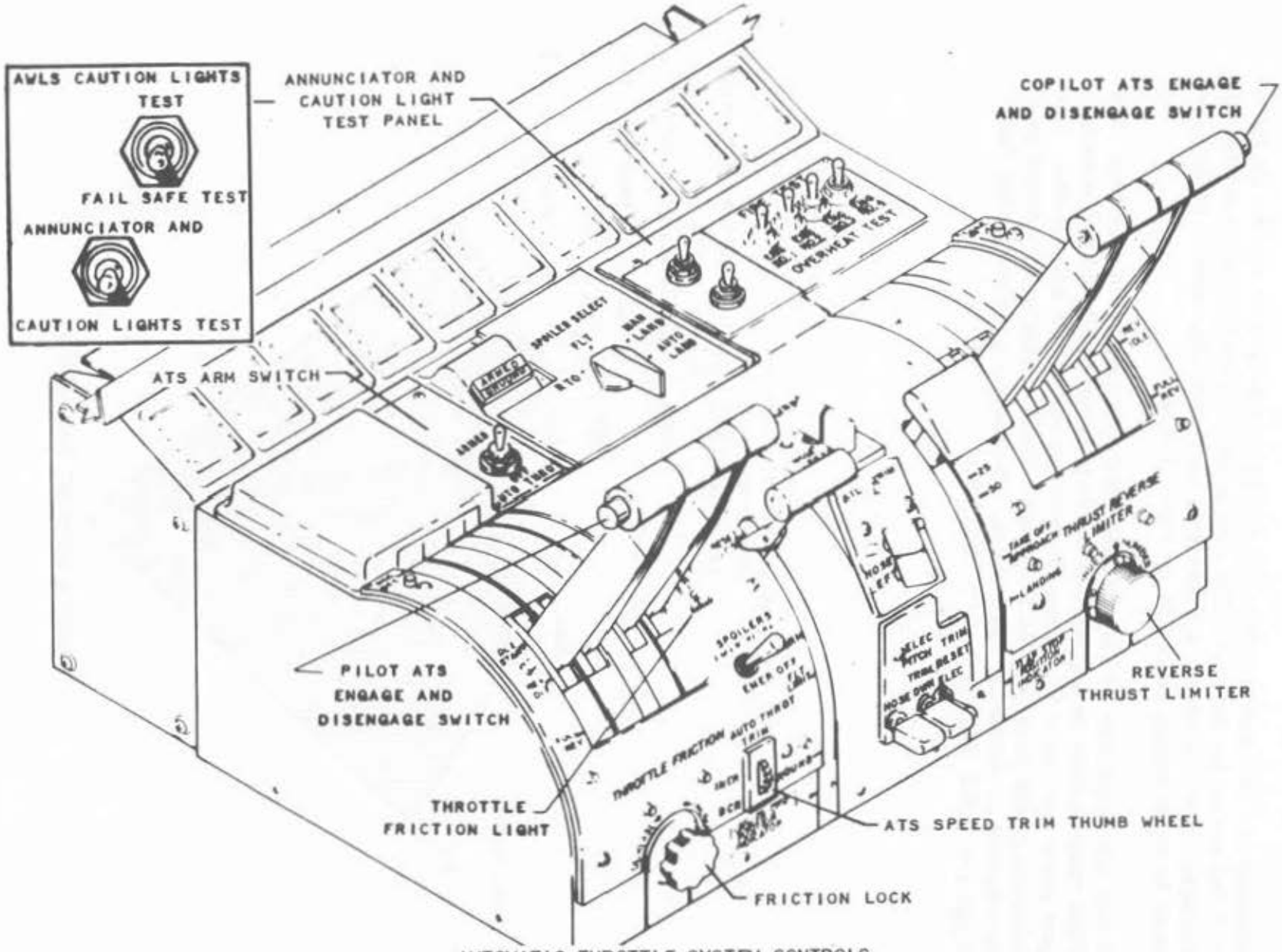
- Throttle Control Quadrant
- Engine Control Cables
- Cable Tension Regulator
- Engine Control Linkage
- Fuel Shutoff Actuator
- Thrust Reverser Control Linkage
- Automatic Throttle System (aircraft equipped with AWLS)

THROTTLE CONTROL QUADRANT.

The throttle quadrant is located on the flight station center console. This

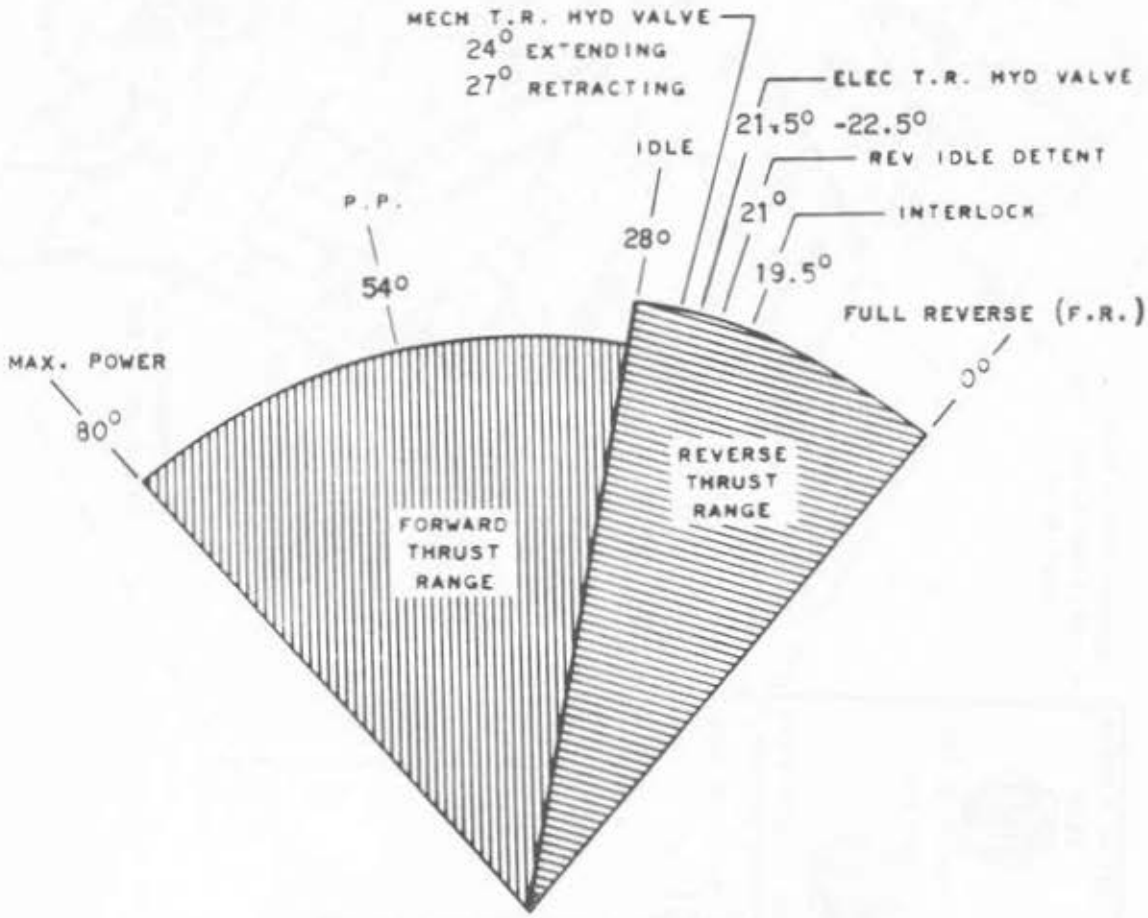


COVER ASSEMBLY - CENTER CONSOLE


AWLS CAUTION LIGHTS TEST
FAIL SAFE TEST
ANNUNCIATOR AND
CAUTION LIGHTS TEST
ANNUNCIATOR AND CAUTION LIGHT TEST PANEL
COPILOT ATS ENGAGE AND DISENGAGE SWITCH
ATS ARM SWITCH
PILOT ATS ENGAGE AND DISENGAGE SWITCH
REVERSE THRUST LIMITER
THROTTLE FRICTION LIGHT
ATS SPEED TRIM THUMB WHEEL
FRICTION LOCK
AUTOMATIC THROTTLE SYSTEM CONTROLS

assembly is a dual unit providing two sets of throttle levers: one set for the co-pilot and one set for the pilot. The pilot's and copilot's throttle levers are interconnected by torque tubes. Linkage from the torque tube connects to the cable drum for cable system control to the engine linkage.

A cam plate separates the throttle quadrant into two ranges of operation. The flight range is from 28 degrees (idle start) to 80 degrees (maximum power). A part power position of 54 degrees provides for engine trim adjustments. The minimum cruise position is 41.5 degrees. The flap warning and landing gear microswitch is actuated at this position. The placard positions for the flight range are "IDLE START " and "TAKE OFF."



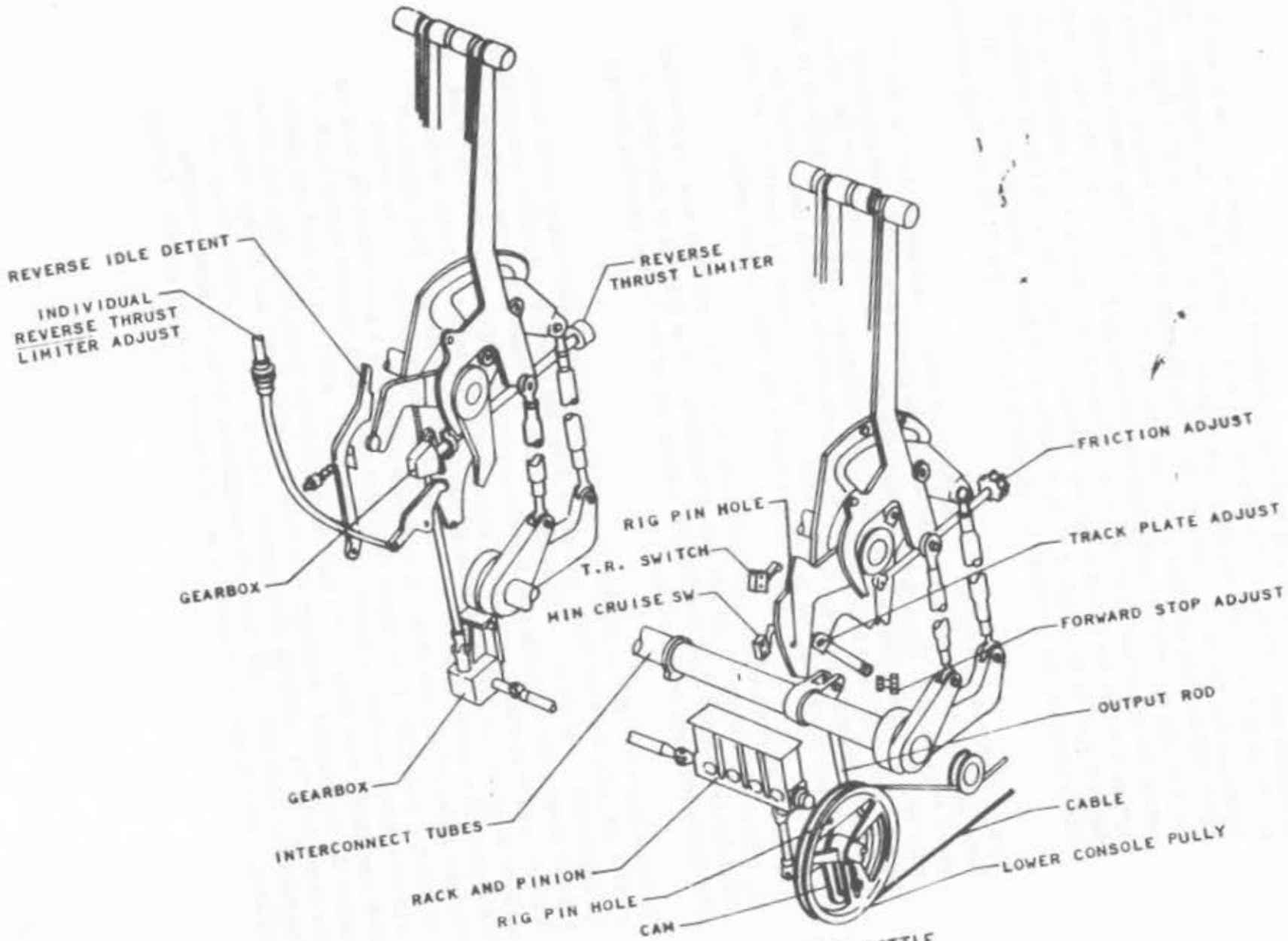
THROTTLE QUADRANT SCHEMATIC

The reverse thrust range is from zero degrees to 28 degrees. The placard positions are "FULL REV" (zero degrees) and "REV IDLE" (21 degrees). The mechanical thrust reverse hydraulic control valve is actuated at 24 degrees for extending the thrust reverser doors as the throttle is moved toward the "FULL REV" position and actuated at 27 degrees for retraction of the thrust reverse doors as the throttle is moved forward toward the flight range. The electrical control for the thrust reverser control valve is actuated at 21.2 degrees to 22.2 degrees through the thrust reverser pressurization switch. A thrust reverser interlock system is actuated at 19.5 degrees. A thrust reverser mechanical lockout prevents the reverser thrust application until the doors are fully extended.

Two pushrods are connected to each throttle lever. One pushrod is the throttle lever power interconnecting rod to the torque tube crank. This rod transmits power requirements through the torque tube and connecting linkage to the cable drum and the cable system to the fuel control linkage. The second pushrod is the throttle lever lift interconnecting rod that connects to a crank that rotates an intershaft through the torque tube. This system provides for the lift movement of 1 1/8-inch of the throttle at both the pilot's and copilot's quadrants.

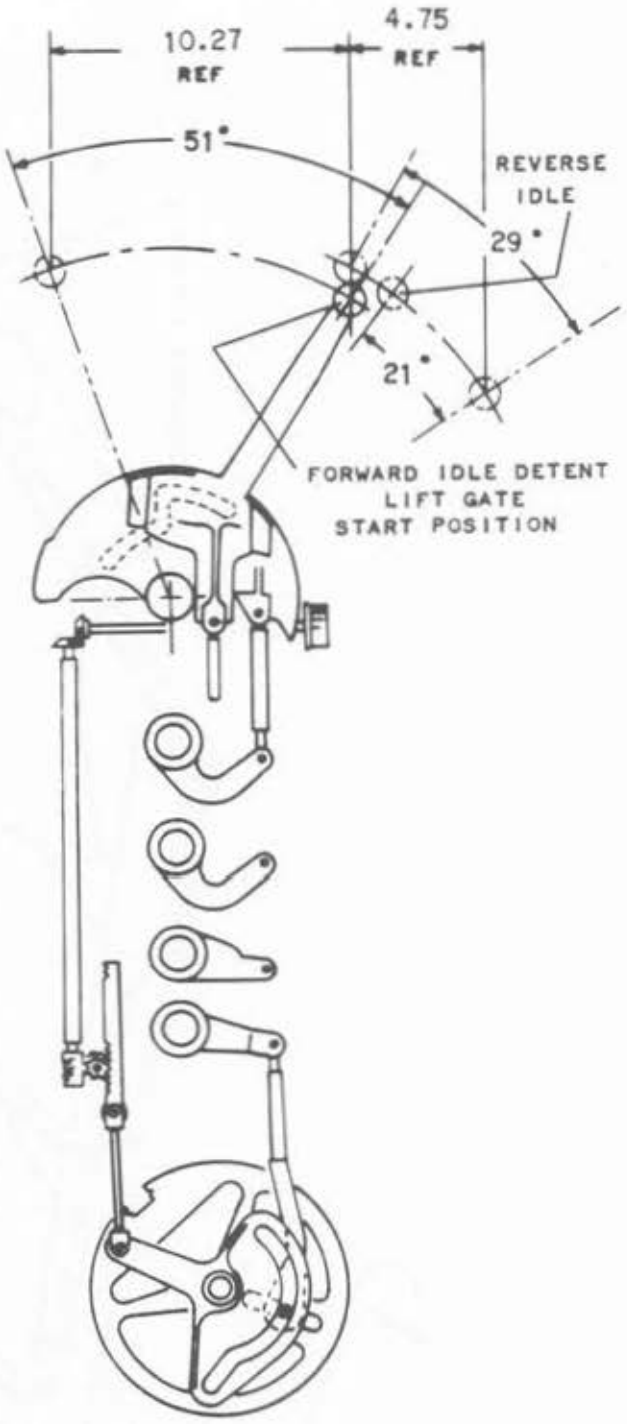
A friction adjustment knob, located below the pilot's throttle levers, is provided for desired friction adjustments for all throttles. The friction in the copilot's throttles is obtained from the friction adjustment of the pilot's throttles through the interconnecting torque tubes.

A thrust reverser limiter is incorporated in the throttle quadrant to limit thrust so that the pilot does not have to monitor EPR and adjust his throttles accordingly. An adjustable index thrust limiter control knob is located below the copilot's throttle lever. This adjustment is performed by the flight crew. To adjust the limiter, a special chart is consulted and the selected setting is based on the ambient temperature and barometric pressure on the runway. This adjustment limits the full reverse thrust of all four engines simultaneously. The system consists of the adjustment knob, an indicator assembly, a gear assembly rotating a horizontal torque shaft, an upper 90-degree gearbox, a vertical torque shaft, a lower 90-degree gearbox, a lower horizontal torque shaft, and a rack and pinion which operates a cam plate on the throttle cable drum assembly. This adjustment changes the mechanical advantage between the throttle lever and the fuel control lever throughout the operating environment of the aircraft. Provisions are incorporated for each individual engine to compensate for differences in engine variations. The adjustment is made at periodic intervals on the ground. Ground



PILOT'S AND COPILOT'S THROTTLE

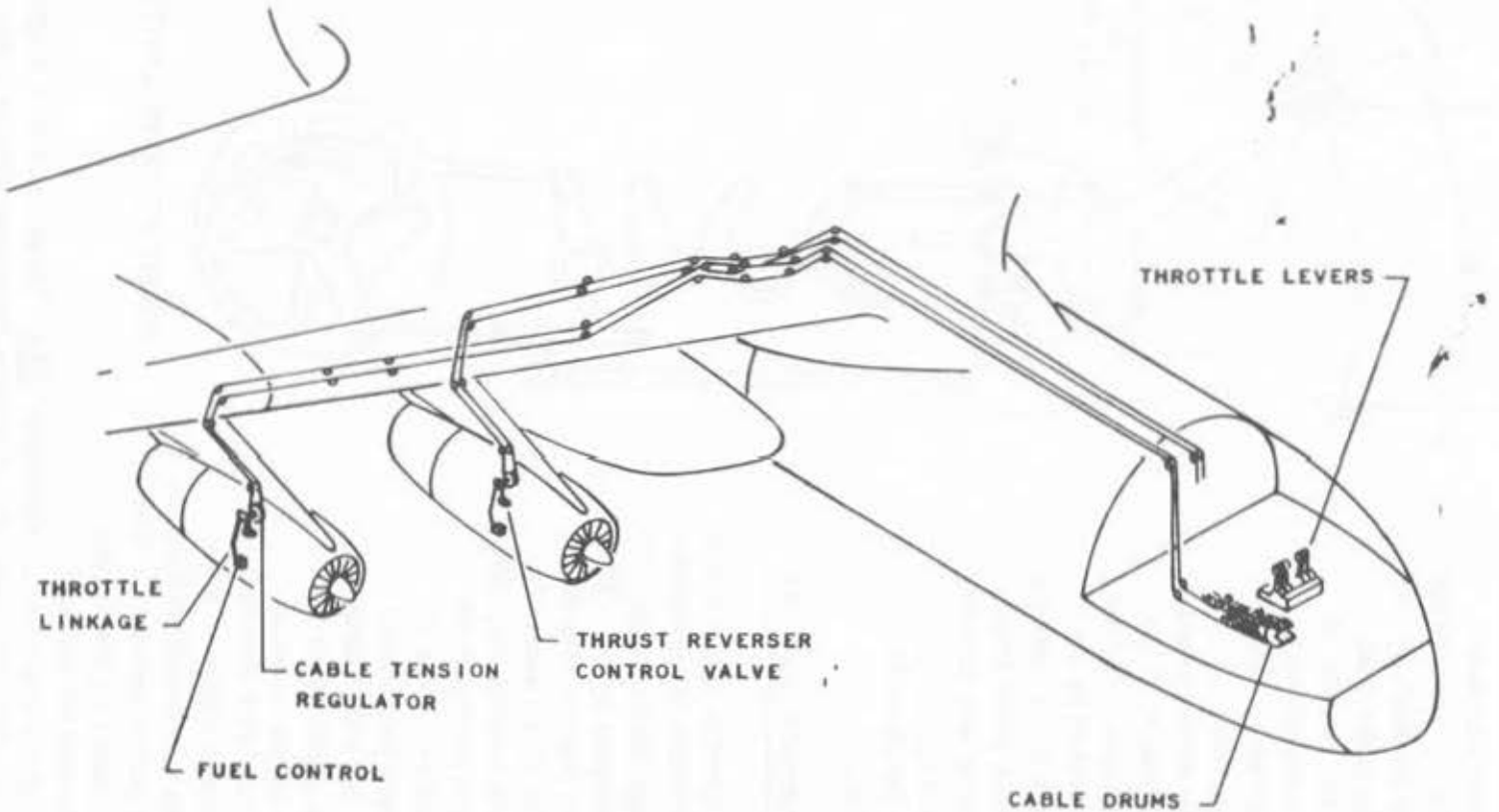
adjustments provide for the accomplishment of adjusting all four engines simultaneously by the reverse thrust limiter adjusting knob by the aircrew. The individual thrust reverser limiter of each engine consists of a adjustment screw, a flexible shaft, and a master stop lever. These adjustments are located forward of the copilot's throttles. Rig pin holes are provided in the pilot's throttle lever carrier and the throttle lever track. An inclinometer and throttle bracket assembly are used to establish the throttle lever position.



THRUST REVERSER LIMITER

ENGINE CONTROL CABLES.

The engine throttle cable system transmits throttle lever movements through the fuselage and wing to the engine pylon. The cable system begins with the throttle cable drum and ends with the cable tension regulator located on the engine pylon strut. A pushrod from the throttle torque tube crank connects to the cable drum crank. The cable drum consists of the lower console pulley and cam with connecting upper and lower cables. Riging pin holes are provided through the console pulley and cam. The cam is positioned by the thrust reverser limiter adjustment knob. All cables are coded. Example: T1A Throttle, No. 1 Engine, Increase Thrust Cable. T1B Throttle, No. 1 Engine Decrease Thrust Cable. No. 2 Engine Cables would be T2A, and T2B etc. These 3/16-inch flexible steel cables are



ENGINE CONTROL GENERAL ARRANGEMENT

routed below the floor of the flight crew compartment, then up the 436.5 bulkhead to the top of the fuselage, and back to the front beam of the wing. The cable system then extends out the leading edge of the wing to the pylon, where it is routed down the leading edge of the pylon to a tension regulator. The tension regulator is the termination point of the cable and pulley system.

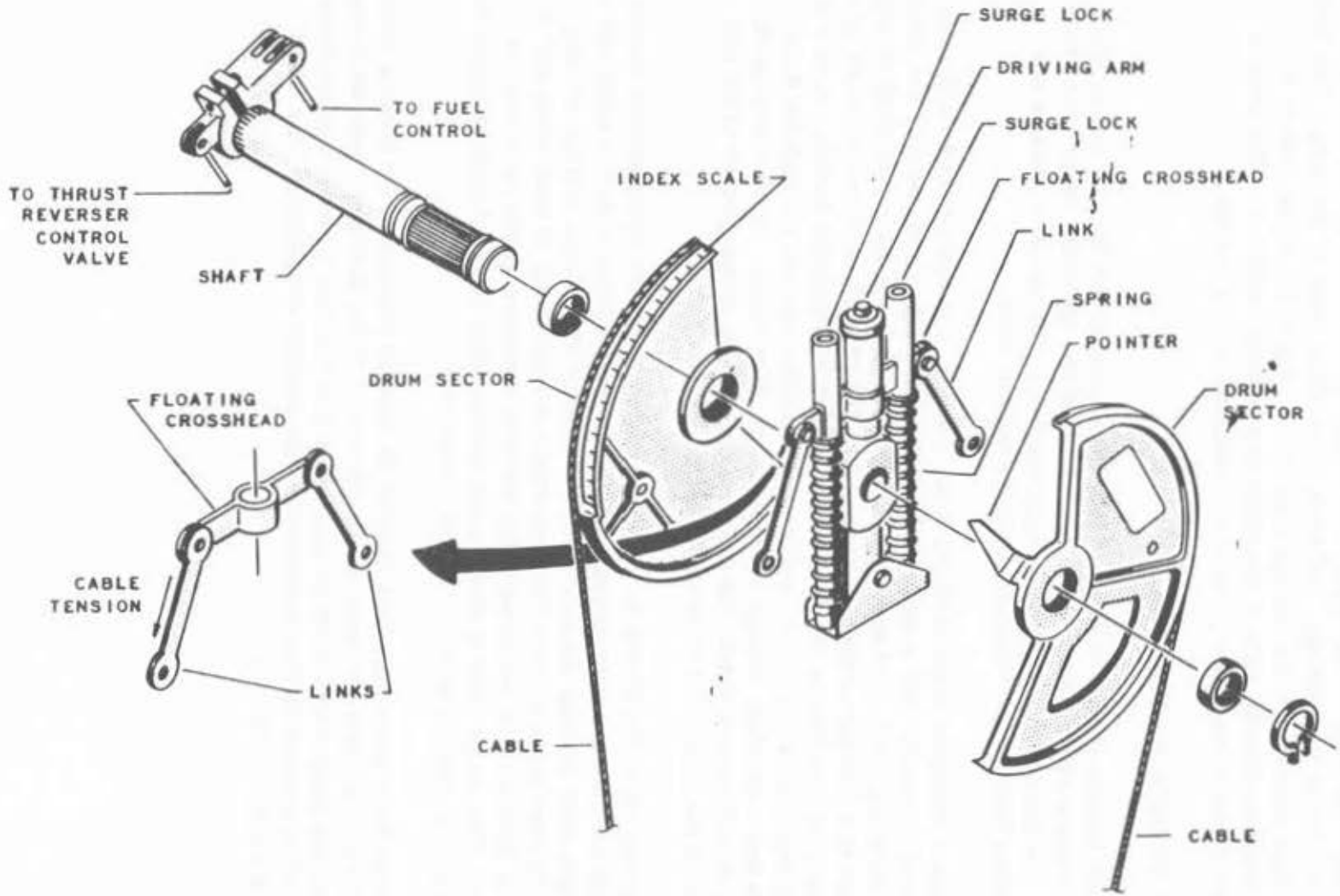
CABLE TENSION REGULATOR.

The cable tension regulator ensures that the tension in the throttle cables will always remain within required limits throughout the operating range of the aircraft. The tension regulator will compensate for differential expansion and contraction between the aircraft structure and the cable.

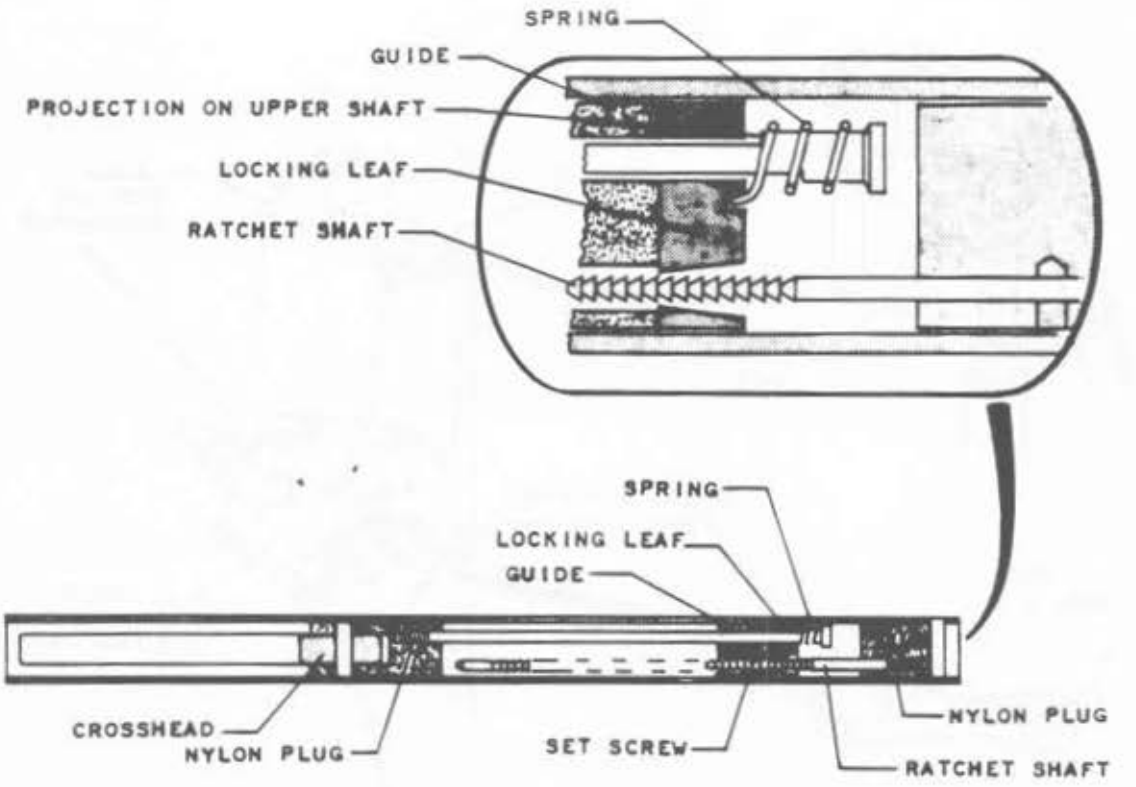
The tension regulator consist of two drum sectors, a mounting shaft, a floating crosshead assembly, and a surge lock mechanism. The drum sectors are located on the mounting shaft, and are connected mechanically to the output shaft through a linkage to a floating crosshead assembly. The crosshead is free to move up or down until an equilibrium is established between two opposing forces. A pair of springs represents one force, and the cable tension exerted through the drum sectors and connecting linkage represents the other force. In the event the throttle cables should become slack, the force on the springs is the greater of the two and moves the crosshead up to re-establish tension.

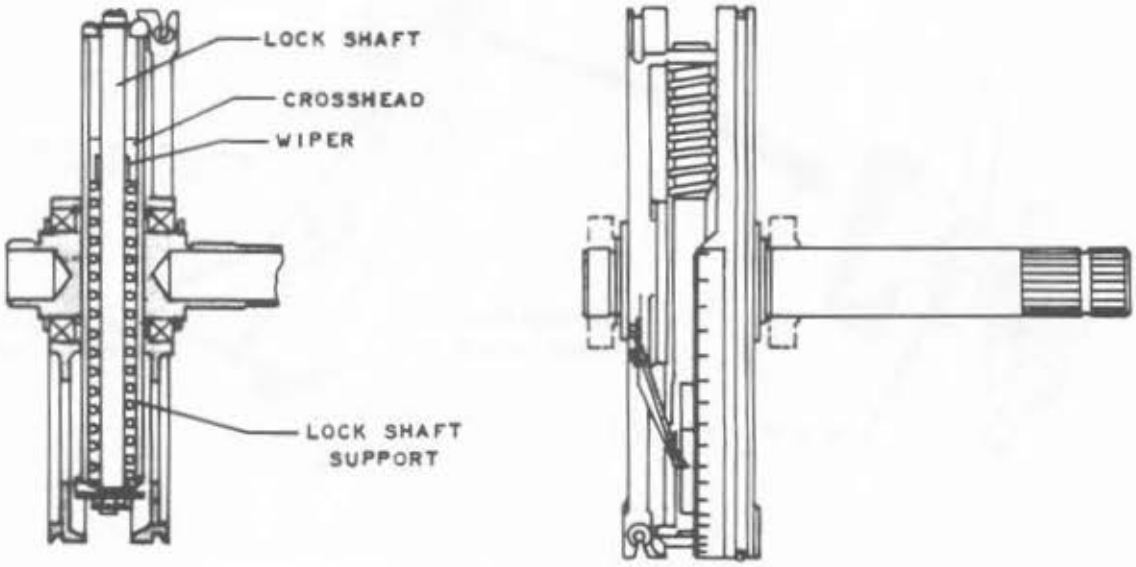
With movement of the throttles, increase or decrease, the cable system causes the drum sectors to rotate as one unit. The rotary motion is then transmitted to the output shaft through the two links, the floating crosshead, and the driving arm. The two drum sectors can also rotate independently of each other and in opposite directions to compensate for thermal expansion in the cable control system. Two surge locking devices are incorporated to guard against undesirable engine power changes in case of cable breakage.

The surge locks permit gradual changes in relative position of the floating crosshead due to expansion or contraction. However, if the floating crosshead moves rapidly, the surge locks allow no more than five degrees of drum rotation before they lock to prevent further movement of the floating crosshead. This would occur if a cable did break.

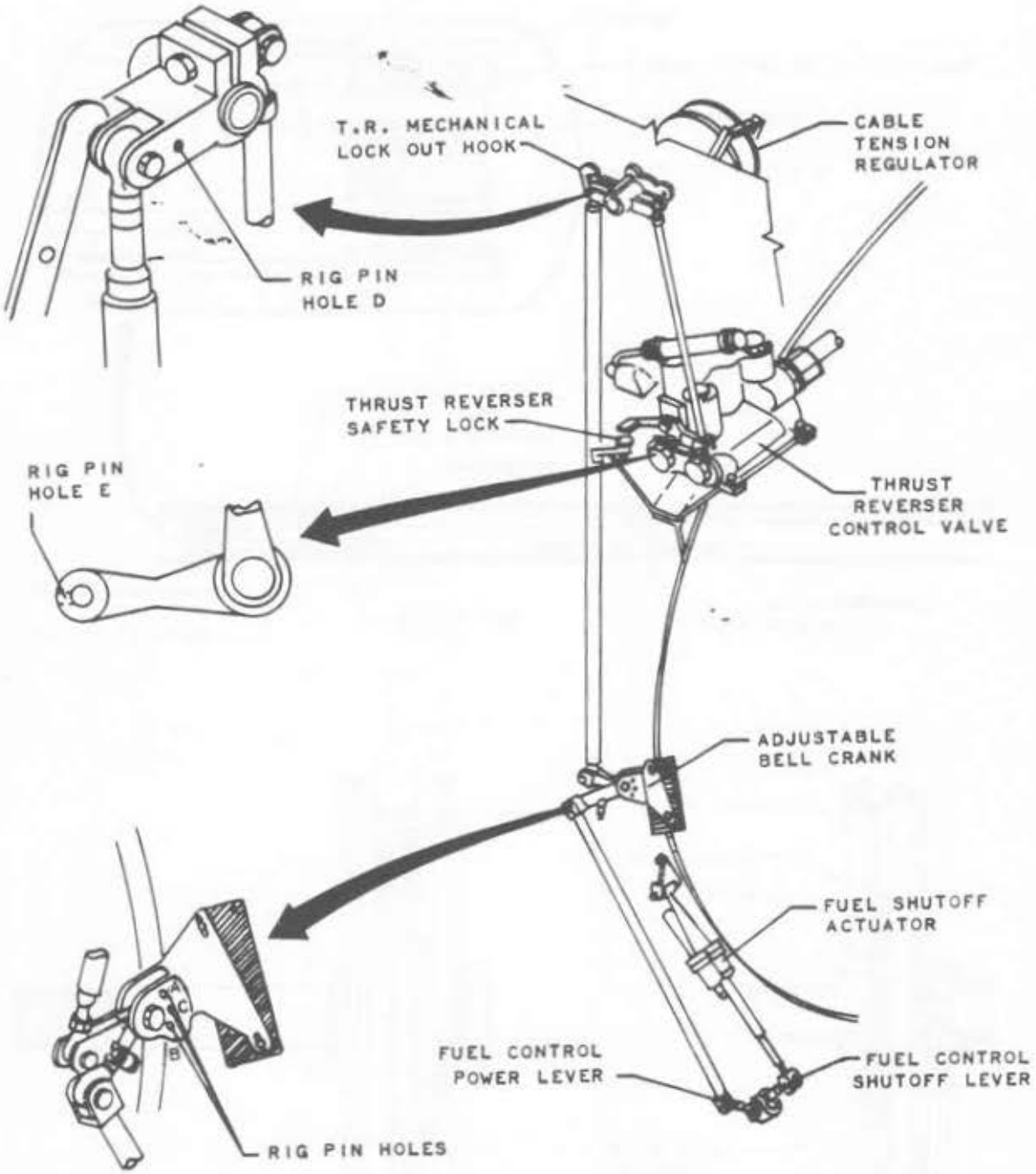


CABLE TENSION REGULATOR

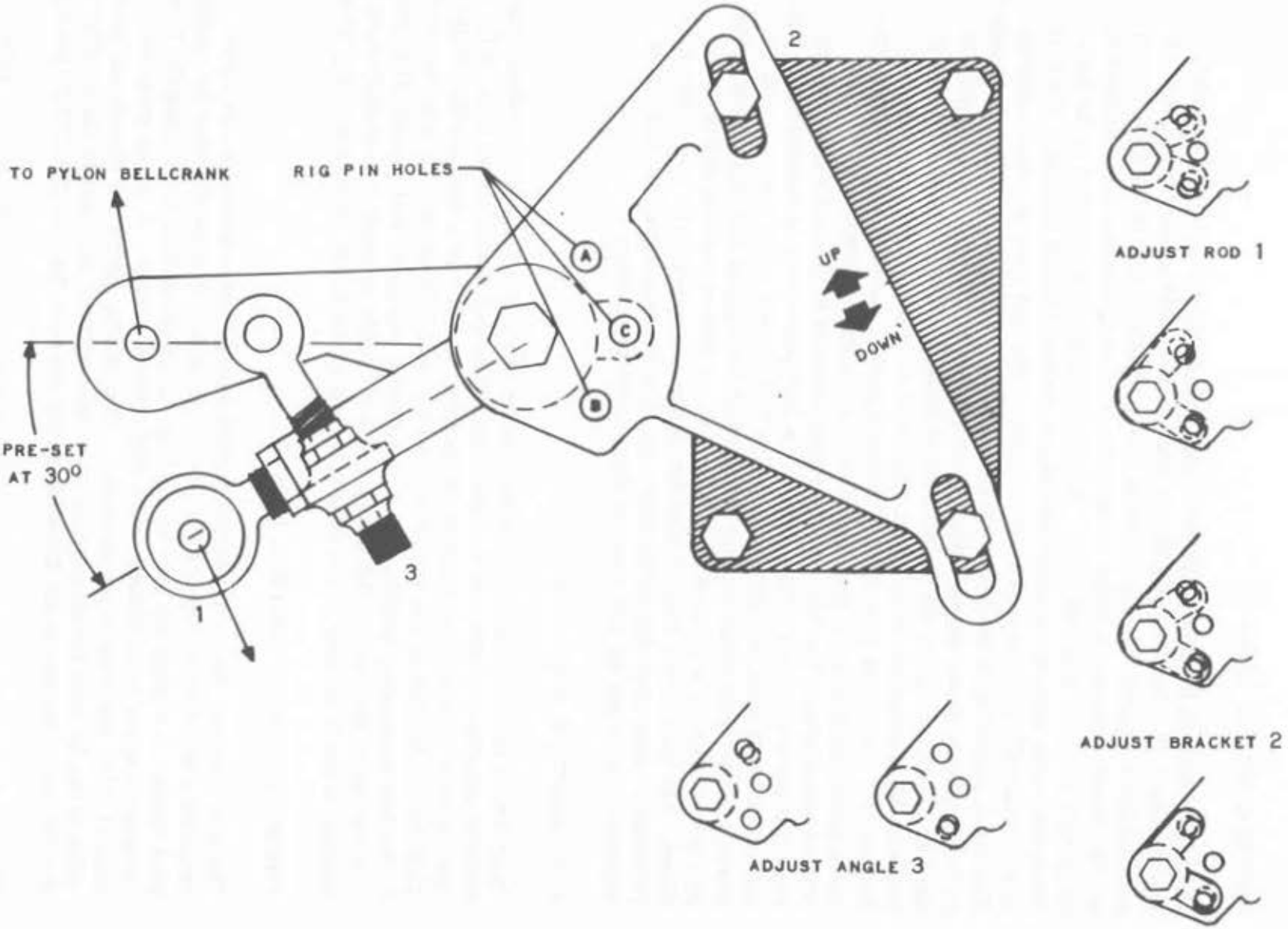




TENSION REGULATOR SURGE LOCK



NACELLE THROTTLE LINKAGE



THROTTLE LINKAGE ADJUSTABLE BELLCRANK

ENGINE CONTROL LINKAGE.

The engine control linkage begins with the cable tension regulator bellcrank. The bellcrank is attached to the output shaft of the cable tension regulator. A pushrod and a linkrod transmit throttle power requirements to the fuel control and the thrust reverser control valve. The bellcrank also has a roller hook for the thrust reverser lock-out latch. A rigging pin hole is provided in the bellcrank for cable tension regulator and engine control linkage rigging. The fuel control pushrod from the bellcrank connects to the fuel control crank assembly. The crank assembly is mounted to a serrated plate and bracket which is attached to the right side of the engine compressor section at flange G. Serrations are used as an aid in rigging the engine control linkage. There are three rigging holes in the bracket and plate which align with the lobe of the crank when the fuel control crank arm is in the full forward power, partial power, and full reverse power positions. A push rod connects the crank assembly to the fuel control crank arm. The fuel control crank connects to the fuel control power shaft through a serrated mating device. A part power stop is located on the fuel control which is used in rigging the engine fuel control crank position with the use of a power level angle rigging tool. After the rigging and adjustment of the part power stop, it is rotated 180 degrees to its stowed position and is safety wired. The part power stop is used for engine part power trim by maintenance personnel. Also provided on the fuel control is the maximum forward thrust adjustment stop and the full reverse thrust adjustment stop.

FUEL SHUTOFF ACTUATOR.

Operation of the fuel shutoff crank arm on the fuel control is accomplished by an electric actuator. There are two positions of the fuel shutoff crank arm, fully open or fully closed. The actuator is operated by the FUEL AND START IGNITION switch located on the pilot's overhead panel. The actuator is also controlled by the fire emergency handle. When this handle is pulled, fuel is shut off at the fuel control by the fuel shutoff actuator and the cable actuated fuel shutoff valve, located on the front spar of the wing at the top of the pylon, is mechanically closed.

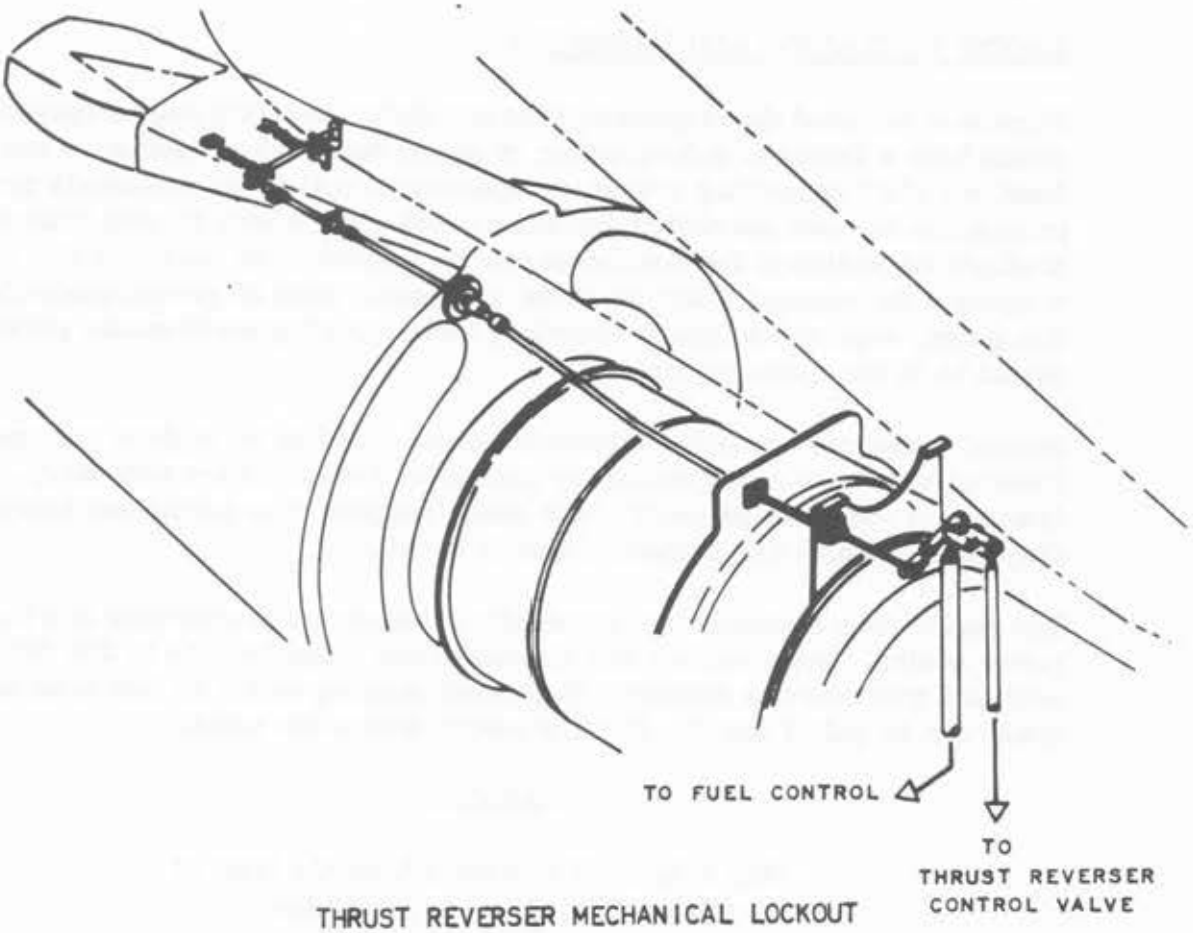
THRUST REVERSER CONTROL LINKAGE.

The link rod from the cable tension regulator bellcrank connects to the thrust reverser control valve crank arm. This mechanical linkage operates the manual pilot valve. A rigging pin lobe is provided at the crank arm for rigging the thrust reverser control valve linkage to the fuel control linkage. A thrust reverser control valve interlock is incorporated. This system keeps the directional control valve in the forward thrust position while the engine is operated in the FLIGHT RANGE which maintains the thrust reverser doors in the "RETRACTED" position.

The interlock consists of a striker lever on the thrust reverser control valve

assembly, a lock for the directional control valve spool, a striker lever, and a striker button attached to the fuel control upper pushrod. The striker lever is spring-loaded to "LOCK." When the throttle is moved to the thrust reverse range, the thrust reverser interlock is actuated and unlocks the spool of the directional control valve so that hydraulic power is ported to the thrust reverser target door actuators on the extend end.

A thrust reverser lock-out mechanism is provided to prevent the application of engine power in the "REVERSE THRUST" range until the thrust reverser target doors are extended. This system consists of a teleflex cable assembly connected to the actuating linkage on the thrust reverser target doors and to a lock-out latch at the cable tension regulator bellcrank. The mechanism is spring-loaded to the "LOCK" position. Quick disconnects are provided in the cable and conduit assembly so that the engine exhaust assembly can be changed without disturbing the rigging of the thrust reverser system.



THRUST REVERSER MECHANICAL LOCKOUT

AUTOMATIC THROTTLE SYSTEM (ALL WEATHER LANDING SYSTEM ONLY).

The major components of the Automatic Throttle System (ATS) are the computer/amplifier unit, servomotor assembly, clutch pack assembly, and speed trim assembly. The ATS uses the airspeed hold signal from the Central Air Data Computer (CADC) as the airspeed source. A clutch-operated synchromotor is used to present a zero error signal to the computer until the ATS is engaged. When the pilot engages the system, a CADC signal engages the synchroclutch to the indicated airspeed shaft. Thereafter, until disengaged, the signals through the computer/amplifier to the servomotor are proportional to aircraft speed changes.

The servomotor positions the throttles to maintain the speed of the aircraft at the time the system was engaged. The pilot, by adjusting the speed trim signal, can command a change in aircraft speed up to ± 5 knots of the original engaged speed without disconnecting the ATS system. Additional information is shown in Chapter 5, Volume IX of the StarLifter manual series.

ENGINE OPERATION AND TRIMMING.

Personnel assigned the responsibilities and duties involving engine operation should have a thorough understanding of engine design characgeristics and the functions of all supporting systems. Operational maintenance manuals provide procedures for safe operations including check lists of step by step functions. A preflight inspection of the aircraft should be performed to ascertain that it is safe to operate the engines. Only essential personnel, such as ground controller, fire guard, support equipment operator, and supporting maintenance personnel, should be in the operating vicinity.

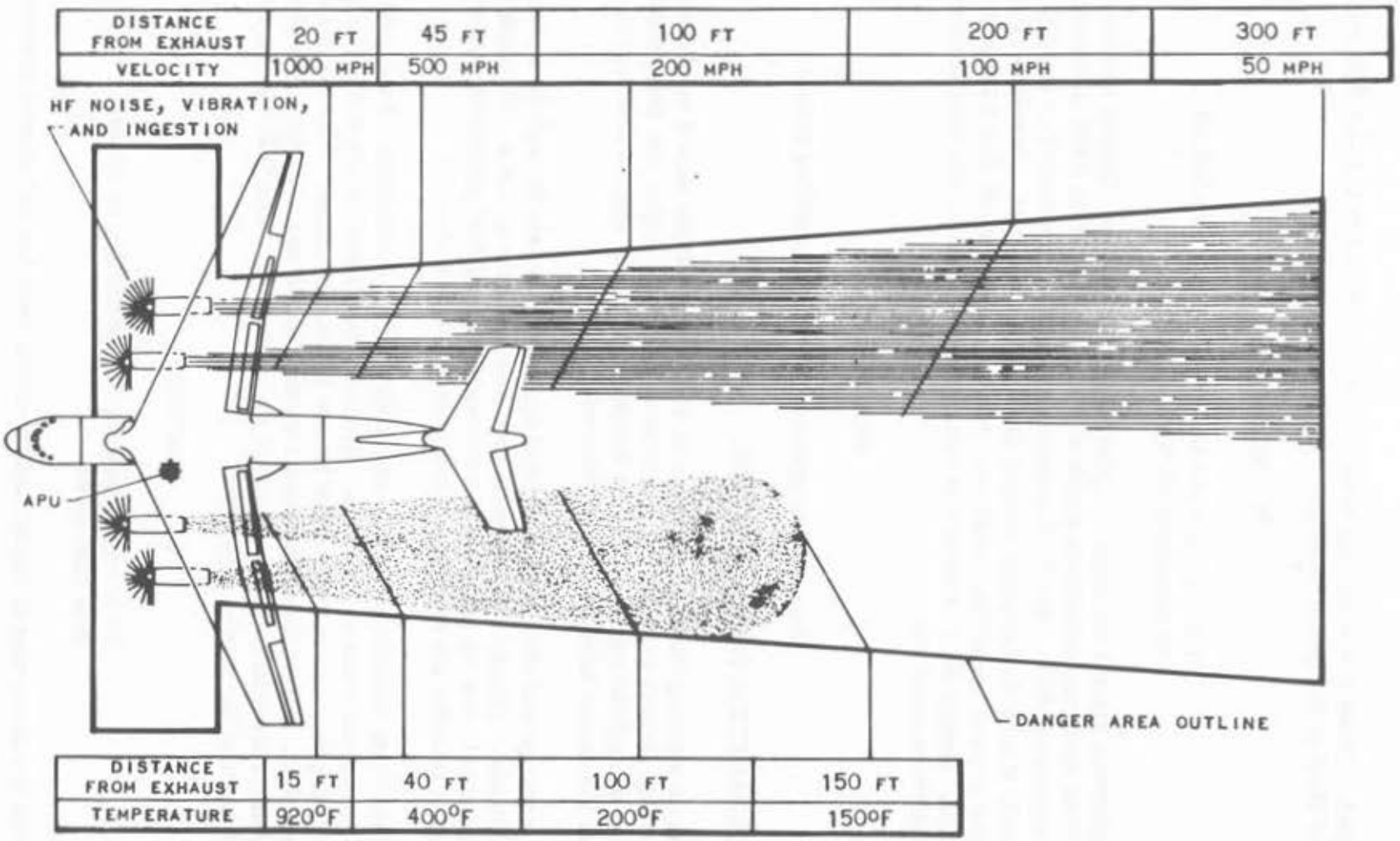
Several dangerous areas and factors are involved when jet engines are operated. Knowledge of these areas and safety precautions required are necessary. Noise intensity of operating jet engines can cause temporary or permanent hearing damage. Adequate ear protection should be utilized.

The engine inlet is dangerous, especially if the engine is operating at a high, power setting. Mass airflow into the intake can range from 50 to 300 PSI and acts as a giant vacuum cleaner. Personnel standing within 25 feet of an engines intake can be pulled into it: Death is nearly always the result.

WARNING

Stay at least 35 feet away from the front of
the intake of an operating jet engine.

Similarly, high-velocity gases are ejected through the exhaust nozzle of the



DANGER AREAS - MAXIMUM POWER

engine. These gases usually have a temperature of 500°C and a flow velocity of 1000 MPH at full power settings.

WARNING

Stay at least 150 to 200 feet away from behind an operating jet engine.

Engine and starter turbines are potential hazard areas. Engine turbines under normal operating conditions rotate at approximately 8000 RPM at temperatures in excess of 500°C. Should this assembly become overheated or should it overspeed, it may disintegrate through the side of the engine. Turbines of starters, under normal operating conditions, rotate in excess of 60,000 RPM's before cutoff. Should the starter fail to cutoff, an overspeed would result; consequently, the turbine could fail.

WARNING

Stay out of alignment with turbine rotating planes.

PREPARATION FOR ENGINE RUN.

Before starting the engines, several safety precautions should be observed. Foreign objects around or in the inlet of a turbojet engine are detrimental. The area around the engine should be inspected, and any objects that may be drawn into the engine inlet should be removed.

A static ground should be connected and should remain throughout entire ground operation. Checks and tiedowns should be securely in place. Firefighting equipment must be available and manned with qualified personnel. Aircraft status records and engine servicing should also be checked.

Prior to an initial run, engine oil quanity should be checked. Fuel from any tank to the engine must be available. Hydraulic pump suction lines must be pressurized by using the suction boost pump for the applicable engine. The electrical, fire detection, fire extinguishing, instrumentation, thrust reverser, and bleed air systems must be properly prepared for engine run. The CSD disconnect should be checked for proper connection.

CAUTION

Do not disengage the CSD statically or at less than idle speed.

With the above checks accomplished and all switches and circuit breakers engaged,

the aircraft and engines are in a ready-state for an engine run.

ENGINE LIMITATIONS.

Engine limitations are established by the manufacturer and must be applied to ensure the integrity of the engine. Engine operators must be capable of quickly recognizing normal and adnormal conditions.

All abnormal conditions must be recorded in the applicable forms for maintenance disposition. Engine operating conditions are measured by engine pressure ratio, engine RPM, exhaust gas temperature, fuelflow, oil pressure, oil temperature, and engine vibration.

ENGINE LIMITATIONS

Duration of Power Setting

Power Setting	Acceleration	Takeoff	Climb	Normal Rated
Duration	2 minutes	5 minutes	30 minutes	Continuous
EGT °C (max indicated)	554*	554*	510	488

Engine Speed Limits

Low-Pressure Compressor (N1)	Overspeed is 101.1%
High-Pressure Compressor (N2)	Overspeed is 104.5 %

*Whenever the gas temperature exceeds 565°C for 5 seconds or longer, the engine throttle should be retarded to idle power for 5 minutes and then shut down. Maintenance directives must be consulted for required inspections.

When an overspeed is experienced, the indicating system should be checked for accuracy. If overspeed is confirmed, maintenance directives must be checked for subsequent action.

START LIMIT - If the engine's EGT exceeds 455°C on starting for any length of time, the start should be discontinued and recorded as a "Hot Start." An over-

TF33-P-7 JT3D-5A FUEL GRADE JP-4

OPERATING CONDITION		OPERATING LIMITS		
THRUST SETTING	(MINUTES)	MAXIMUM OBSERVED EXHAUST GAS TEMPERATURE (°C) (4)	OIL PRESSURE (PSIG) NORMAL	MAXIMUM OIL TEMPERATURE (°C) (5)
TAKE-OFF (1)	5	555	40-50 (6)	121
MILITARY	30 (8)	510	40-50	121
NORMAL RATED	(7) CONTINUOUS	488	40-50	121
IDLE	CONTINUOUS	340 (2)	35 MINIMUM	121
STARTING	—	455	—	—
ENGINE ACCELERATION	5	555	40-50	121

(1) TO BE USED FOR TAKE-OFF ONLY.

(2) THIS TEMPERATURE IS NOT A LIMIT. IT IS GIVEN AS A GUIDE TO INDICATE THE EGT, WHICH, IF EXCEEDED, MAY SIGNIFY AN ENGINE MALFUNCTION. THE EGT LIMITS FOR THROTTLE SETTINGS BELOW NORMAL RATED THRUST ARE THE SAME AS THE TEMPERATURE LIMIT FOR NORMAL RATED THRUST.

(3) DELETED.

(4) WHENEVER THE EGT EXCEEDS 565°C FOR ANY TIME, EITHER THE ENGINE SHOULD BE SHUT DOWN OR A LANDING SHOULD BE MADE AS SOON AS POSSIBLE. WHEN SHUTTING THE ENGINE DOWN FOR THIS REASON, ALLOW A COOLING PERIOD OF 5 MINUTES AT IDLE PRIOR TO SHUTDOWN IF ENGINE CONDITIONS AND FLIGHT CIRCUMSTANCES PERMIT.

(5) PROVIDING ENGINE OPERATION IS OTHERWISE NORMAL, NO MINIMUM OIL INLET TEMPERATURE NEED BE OBSERVED BEFORE TAKE-OFF.

(6) THE OIL PRESSURE MAY EXCEED 50 PSIG BUT NOT 55 PSIG, DURING TAKE-OFF ONLY.

(7) ANY POWER SETTING ABOVE NRT WILL BE LIMITED TO 30 MINUTES.

(8) ANY POWER SETTING ABOVE NRT WILL BE LIMITED TO 5 MINUTES.

ENGINE OPERATING LIMITS

temperature inspection must be performed before a restart is attempted.

FALSE START - If an engine ignites normally but does not accelerate, the start must be discontinued and a second start attempted. If the second start is unsatisfactory, the engine must be shut down and an investigation made.

A false start may be the result of insufficient power to the starter or early starter cutout. The starter must assist the engine up to 35 percent speed for a successful start. (The indication of the starter valve light during the second start should be noted.)

NOTE

After a false start, rotate the engine with the starter for 10 to 15 seconds to remove accumulated fuel or vapor from the engine before attempting a restart.

STARTER DUTY CYCLE - The starter duty cycle follows:

One minute "ON," 30 seconds "OFF"

One minute "ON," 30 seconds "OFF"

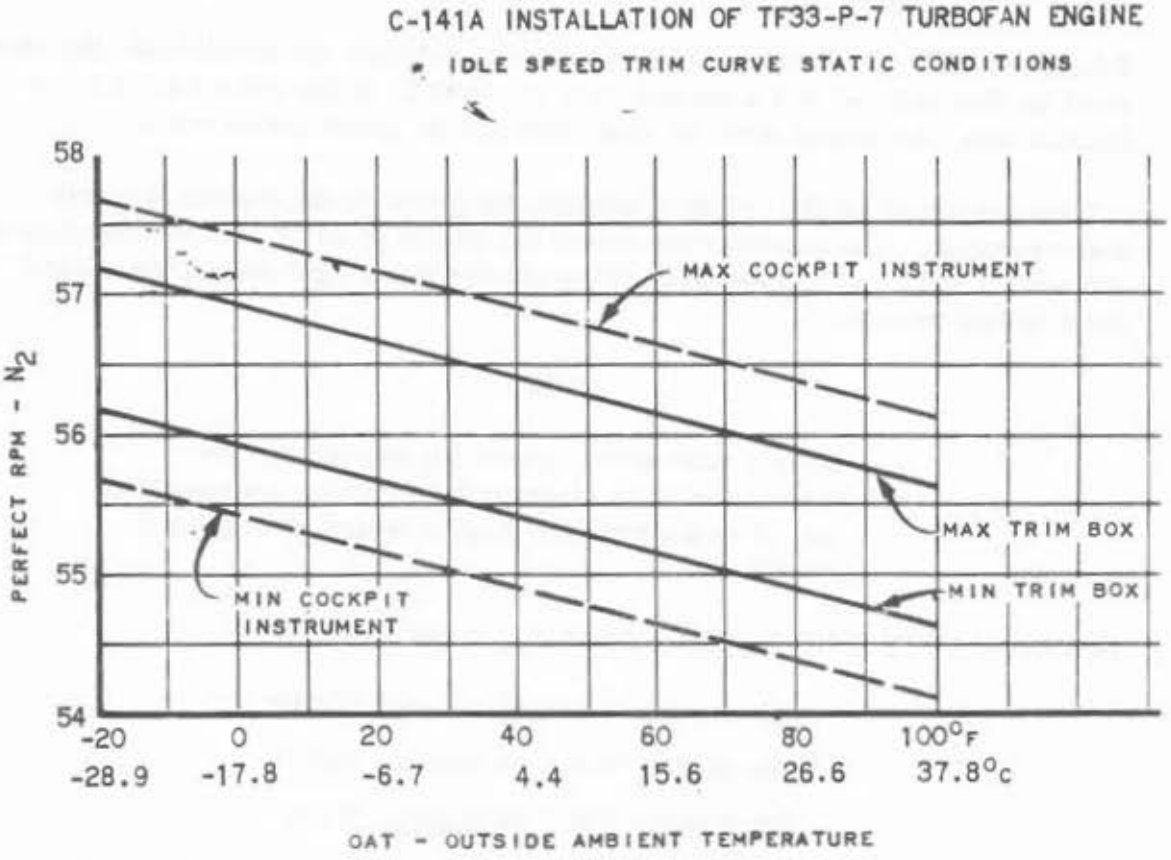
One minute "ON," 30 minutes "OFF"

The starter may be operated for 1.5 minutes "ON," and 10 minutes "OFF" for any number of duty cycles.

FUEL AND OIL LEAKAGE - During engine operation, the drain mast and lower cowl area must be observed for liquid leakage. If any leakage is observed, the engine should be shut down and an investigation made. After engine run, the nacelle cowling must be inspected for leakage.

ENGINE STARTING.

Before the starting operation is begun, the parking brakes should be set by using the No. 3 hydraulic system pump until the engine is started. The pump need not be run continuously, but accumulator pressure must be kept above 2000 PSI. With the fuel and ignition switch in the "STOP" position, the throttle lever is placed in "IDLE START." The pylon bleed air duct and the APU valves, if required, should be opened. The fuel boost pump should then be turned on and the corresponding low-pressure fuel light should go out. Thrust reverser lights should be "OFF." If the thrust reverser NOT-LOCKED light is "ON," the reverser should LOCK as the engine is started.



IDLE SPEED TRIM CURVE

The engine start button should now be depressed. The button will hold in and the button and starter valve light will illuminate. If oil pressure and N1 RPM do not indicate within 20 seconds, the engine must be shut down.

Only the N2 rotor section is driven by the starter. Air is pumped into the engine through N1 which results in N1 rotation. The engine must be rotated by the starter to approximately 10 percent RPM to provide sufficient airflow for combustion. At 10 percent N2 RPM, the ignition and fuel switch should be positioned to "RUN." Fuelflow and EGT will be indicated and the N2 RPM will continue to accelerate.

NOTE

Maximum EGT at start is 455°C not to exceed 15 seconds. If EGT does exceed these limits, shut down the engine immediately.

The engine's RPM will continue to accelerate by both starter power and heat energy driving the engine's turbines. The fuel control provides the fuel metering in accordance with the changing engine parameters.

At 35 to 45 percent RPM, the starter button will pop out, and the button and starter valve position lights will go out. If the button does not pop out by 45 percent RPM, the button should be pulled manually and the starter system checked. The engine's operation is now self-sustaining. The fuel control provides for the continued acceleration to idle speed, 54 to 58 percent depending on the ambient air temperature. The following table shows the normal engine idle configuration:

NORMAL ENGINE IDLE CONFIGURATION

ITEM	CONDITION
N2 RPM	54 to 58 percent
N1 RPM	25 to 30 percent (reference only)
Oil Pressure	35 to 45 PSI
Oil Temperature	40 to 121°C
Hydraulic Pressure	3000 PSI ± 150
Generator	400 Hertz ± 4
EPR	Bottom of scale
Fuelflow	700 to 1500 PPH (reference only)
CSD Oil Temperature	40 to 150°C

ENGINE SHUTDOWN.

If the engine has been operated at normal rated power or above for 1 minute or more, the engine must be run at "IDLE" for 5 minutes to allow the enging to cool and to prevent possible rotor seizure during coastdown. The engine throttle should be moved to "IDLE" and, after sufficient cooling, the fuel and ignition switch should be positioned to "STOP." The fuel boost pump switch should also be positioned to "OFF." Engine RPM, EGT, and engine oil pressure should decrease. Fuel should drain from the drain mast immediately thus indicating that the fuel dump valve has opened.

N1 and N2 RPM gages should indicate free deceleration of the compressors. N1 will require approximately 2 to 3 minutes to reach zero RPM.

ENGINE TRIM.

The primary purpose of engine trimming is to ensure that the engine produces its rated thrust within a wide range of atmospheric conditions. Trimming is based upon the measurement and adjustment of exhaust nozzle pressure (P+7). The adjustments on the fuel control enable the governed speed to be varied within specified limits. Varying the engine RPM results in a proportional change in engine exhaust gas pressure and thrust. A manifold pressure gage is used in trimming the engine, as are the EPR gage, RPM and EGT indicators. Trimming should be accomplished whenever a new or overhauled engine is installed on the aircraft and when a fuel control has been replaced or rerigged.

The aircraft must be headed directly into the wind and wind velocity must not exceed 8 to 10 knots. Trimming should never be attempted when icing conditions prevail. It is also necessary that all engine controls be properly rigged or checked before engine trimming is attempted. The appropriate maintenance directives should be consulted for proper throttle rigging procedure.

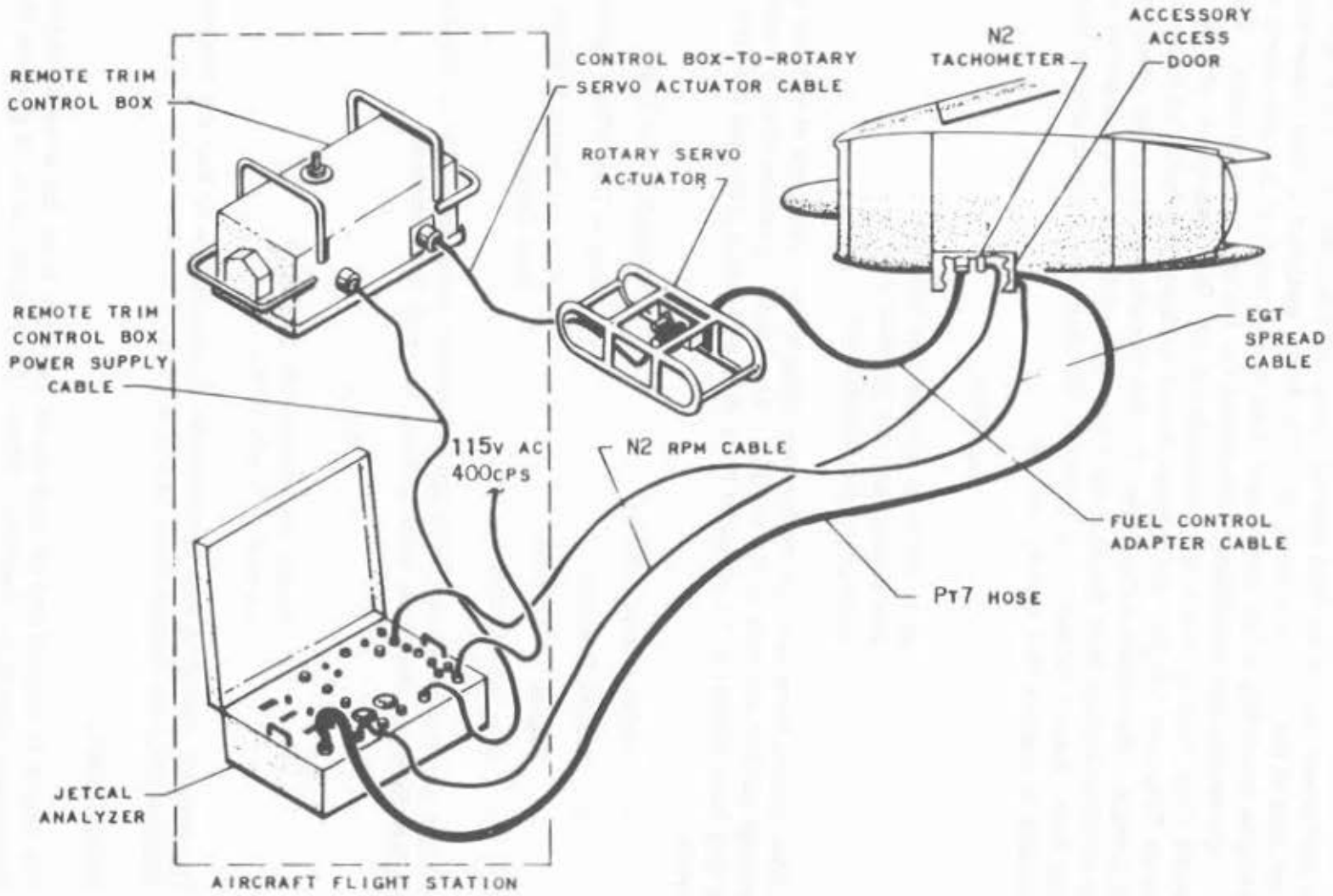
Testing equipment needed for engine trim follows:

o Jetcal Analyzer (Howell Instruments Inc.) (H120-5119)	This unit is used to measure EGT, RPM and pressures during engine trim. The unit checks out the engine instrument system as well as the engine's performance.

CAUTION

Do not use aircraft instruments for trimming.

o Remote Trim Control Box (FSN 4920-589-9624)	This box is used to remotely adjust the fuel control trim screw.
o Remote Trim Servo Rotary Actuator (FSN 4920-654-8434)	This unit is used in conjunction with the remote trim control box to provide power to adjust the fuel control trim screws.
o Remote Trimmer Adapter (FSN 4920-344-3027)	This unit connects the remote trim servo rotary actuator to the fuel control.



REMOTE ENGINE TRIMMING EQUIPMENT

PREPARATION.

The part power stop of the fuel control should be positioned with the stop in the direct path of the throttle crank arm. The Jetcal analyzer is then connected to the engine according to the instruction plate on the inside of the analyzer's cover lid. Operational and maintenance directives for the unit must be used. The Remote Trim Control Box is then connected to the Jetcal analyzer, and the Remote Trimmer Adapter and Remote Power Actuator are installed to the engine's fuel control. Maintenance directives for this installation should be consulted. The electrical cable from the Remote Trim Control Box is then connected to the Trim Servo Rotary Actuator. A 115-volt, 400 Hertz A-C power source must be available to operate this test equipment.

CAUTION

Make all trim adjustments with the Jetcal analyzer and not with the aircraft engine instruments.

A trim record form is required for recording all test readings at various power settings and for analysis of the results. The following information is required on this form which can be obtained from the engine data plate and the aircraft forms.

- Engine Serial Number
- Engine Position
- Engine Total Time
- Aircraft Number
- Aircraft Total Time
- Engine Data Plate Speed
- Part and Serial Number of Fuel Control

Outside Air Temperature (OAT) and barometric pressure within 30 minutes of engine trimming should be read by using accurate instruments.

NOTE

Do not use barometric pressure corrected to sea level.

The trim kit should be kept in the shade of the airplane so that the temperature obtained from the thermometer is a true reading of OAT.

PROCEDURE.

The engine is started and all instrument readings from the aircraft engine instruments should be observed. When "IDLE" RPM (54 to 58 percent N2 RPM)

is reached, all engine instruments must be checked for correct reading. The throttle should then be advanced to the part power stop to fully inflate the fan seals. The throttle is then retarded to "IDLE." The fan discharge ducts and pneumatic ducts must be checked for leakage in all accessible areas with the engine running at "IDLE" prior to the trim procedure. Air bleed must be "OFF." Accessory loads must be reduced to a minimum.

With the engine idling, the N2 RPM should be read from the analyzer and should be recorded on the Engine Trim form. COLD IDLE RPM is the initial reading after the engine start before the engine has been stabilized and trimmed.

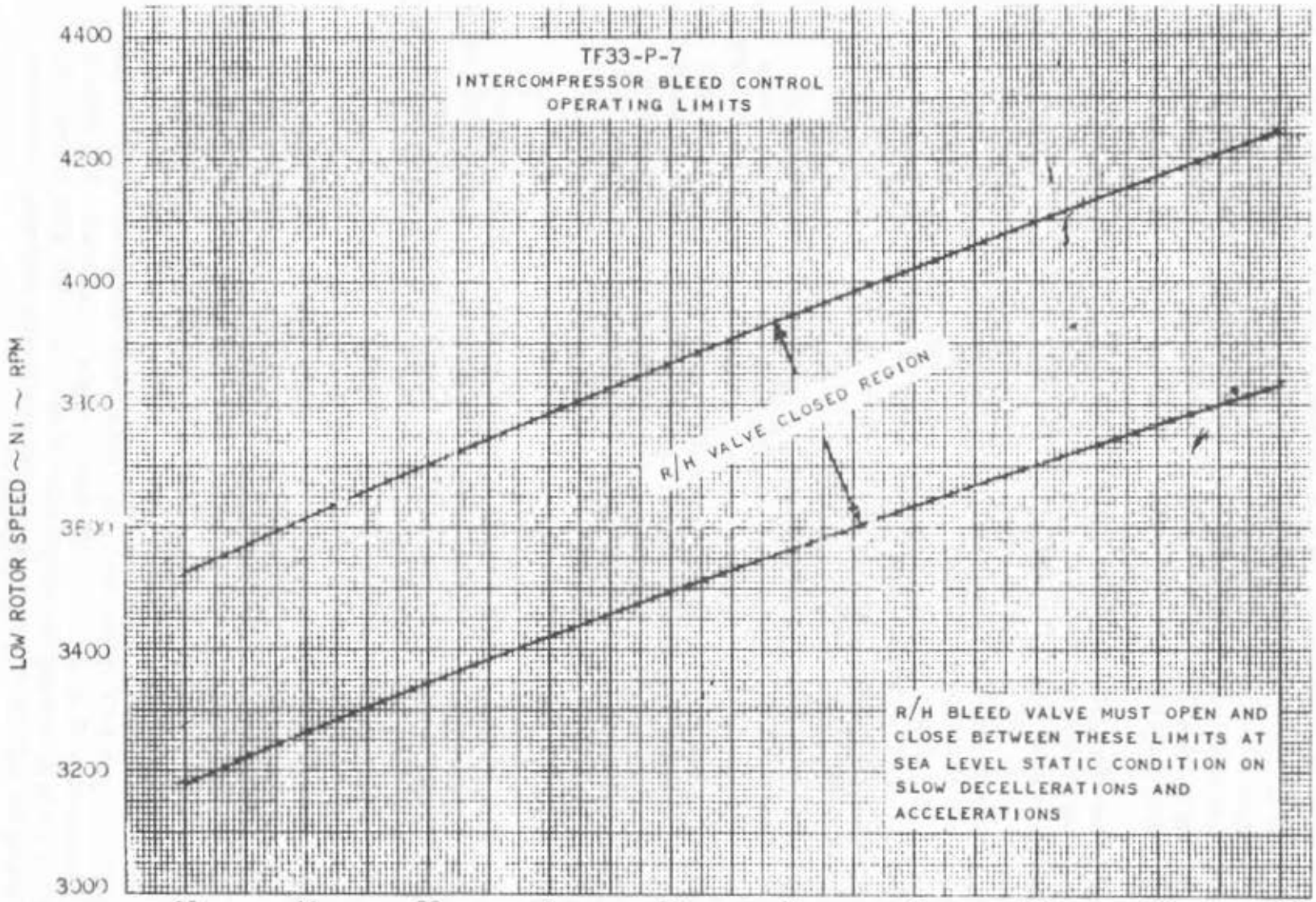
The throttle control is then moved slowly rearward through the throttle gate. This movement should be stopped when the RPM stops decreasing and begins increasing. The change indicates that the throttle control is on the fuel control cam idle flat. If N2 RPM should drop more than 2 percent, the throttle control rigging must be checked. If the throttle rigging is correct, the fuel control unit is at fault and should be replaced.

From the idle position, the throttle should be moved until the N2 tachometer indicates 80 percent. At this point, the throttle is moved forward very slowly until an increase in EPR is observed. If this increase is observed, the N1 RPM should be recorded. Advancing the throttle to the part power stop at this time ensures full inflation of the nacelle seals. While the throttle is slowly retarded from the part power position toward 80-percent N2 RPM, the EPR should be observed closely. When EPR drops, the N1 RPM should be recorded. This check determines the closing and opening range of the right-hand Bleed Control Function chart.

A stabilization period allows the engine to expand until the engine parts stop expanding and hold steady. This action is accomplished by the throttle being set at the part power position and being held there for a minimum of 5 minutes. Stabilization is indicated by a constant EGT and EPR. Status of the engine during the transition is classified as a change of the engine from cold to hot. When the engine reaches a steady stabilized condition, the following must be read and recorded on the work sheet:

- o EPR
- o EGT, Fuelflow
- o Pt 7 (inches of mercury)
- o N1 and N2 RPM
- o Oil Pressure and Temperature
- o Vibration, High and Low

By performing an EGT spread test with a Jetcal Analyzer during a "hot" engine run, excessive EGT of any individual thermocouple is indicated. The spread check is made by reading the temperature of each individual EGT thermocouple and noting the difference between the lowest and highest readings. Excessive



COMPRESSOR BLEED VALVE OPERATING LIMITS

EGT spread can be an indication of defective fuel nozzles. A stabilization period of 1 minute is required for the engine to stabilize at idle RPM before the N2 speed is recorded. This is the Hot Idle RPM. If the recorded readings obtained during the engine run are within the limits of the trim charts, idle RPM charts, and bleed valve charts, the engine is properly trimmed.

TRIM ADJUSTMENTS.

If trim adjustments are necessary, the "MIL PWR" adjustment screw on the fuel control is turned either to increase or decrease Pt 7 while the engine is running at part power speed. The actual Pt 7 should be within the limits of the desired Pt 7 for the existing ambient conditions of the day. When Pt 7 is changed, the idle RPM changes. Necessary adjustments should be made to correct the N2 idle RPM.

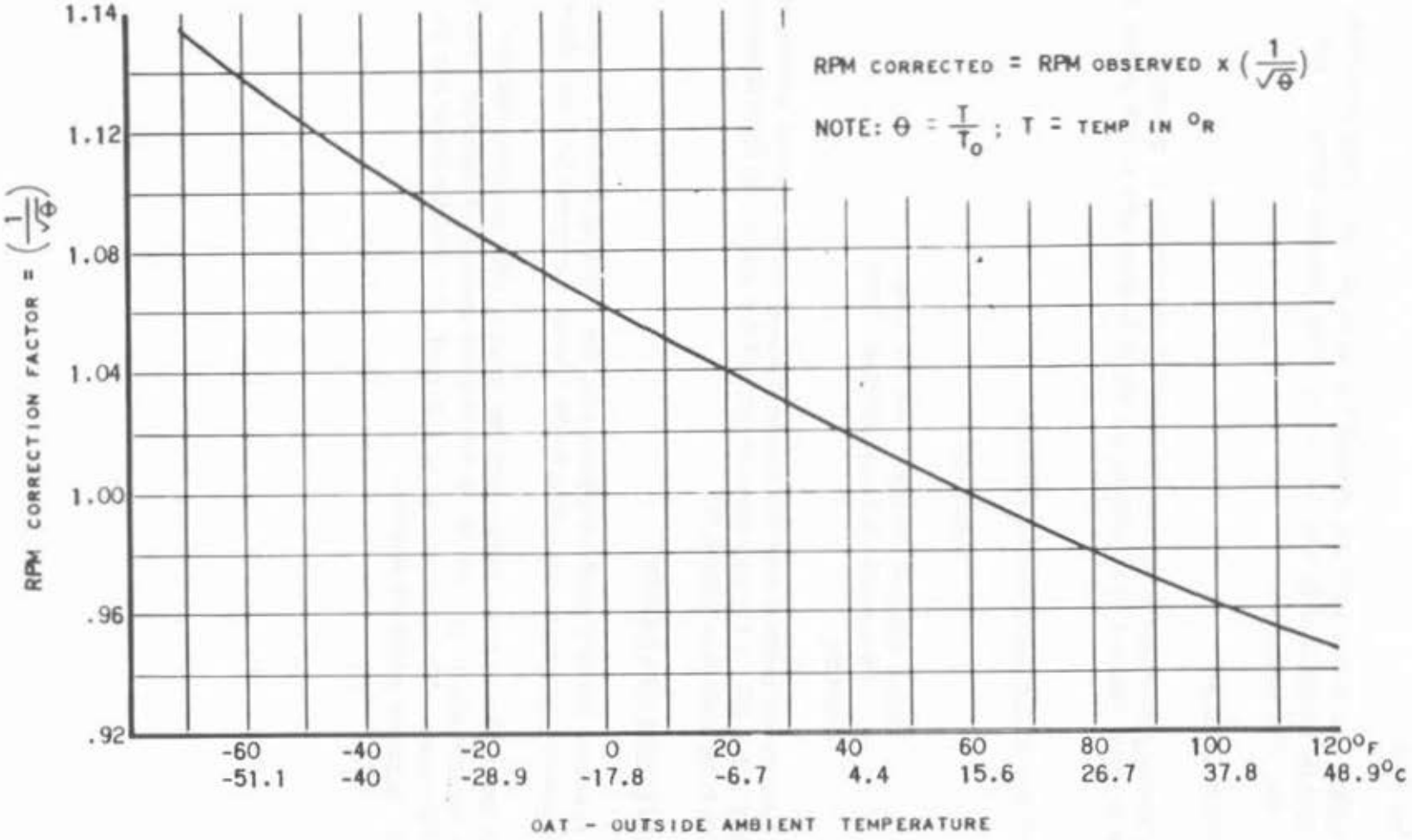
Before a takeoff power check can be made, the part power stop on the fuel control must be removed and safetied in the stowed position. The OAT and barometric pressure must be obtained and used to determine the correct EPR for the takeoff power check. The EPR is set to 1.48 and engine speed is allowed to stabilize. By reading the N2 EPM from the Jetcal Analyzer, the value observed should be within 2.1 percent of the engine data plate speed. The takeoff power check should be within the limits of EPR, EGT, and RPM.

BAR. PRESSURE IN. HG ABSOLUTE	TEMP DEG F	HOT DAY 116.0	117.0	118.0	119.0	120.0		
24.5	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.15	31.07	30.99	30.90	30.82		
24.6	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.28	31.20	31.11	31.03	30.95		
24.7	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.41	31.32	31.24	31.16	31.07		
24.8	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.54	31.45	31.37	31.28	31.20		
24.9	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.66	31.58	31.49	31.41	31.32		
25.0	EPR	1.272	1.268	1.265	1.261	1.258		
	TRIM PT7	31.79	31.70	31.62	31.53	31.45		

BAR. PRESSURE IN. HG ABSOLUTE	TEMP DEG F	STANDARD DAY 53.0	54.0	55.0	56.0	57.0	58.0	59.0
29.8	EPR	1.502	1.498	1.493	1.489	1.485	1.481	1.477
	TRIM PT7	44.75	44.63	44.51	44.38	44.26	44.14	44.02
29.9	EPR	1.502	1.498	1.493	1.489	1.485	1.481	1.477
	TRIM PT7	44.90	44.78	44.66	44.53	44.41	44.29	44.17
30.0	EPR	1.502	1.498	1.493	1.489	1.485	1.481	1.477
	TRIM PT7	45.05	44.93	44.80	44.68	44.56	44.44	44.31
30.1	EPR	1.502	1.498	1.493	1.489	1.485	1.481	1.477

BAR. PRESSURE IN. HG ABSOLUTE	TEMP DEG F	COLD DAY -66.0	-65.0	-64.0	-63.0	-62.0	-61.0	-60.0
30.9	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	59.79	59.79	59.79	59.79	59.79	59.79	59.79
31.0	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	59.98	59.98	59.98	59.98	59.98	59.98	59.98
31.1	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	60.18	60.18	60.18	60.18	60.18	60.18	60.18
31.2	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	60.37	60.37	60.37	60.37	60.37	60.37	60.37
31.3	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	60.57	60.57	60.57	60.57	60.57	60.57	60.57
31.4	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	60.76	60.76	60.76	60.76	60.76	60.76	60.76
31.5	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	60.95	60.95	60.95	60.95	60.95	60.95	60.95
31.6	EPR	1.935	1.935	1.935	1.935	1.935	1.935	1.935
	TRIM PT7	61.15	61.15	61.15	61.15	61.15	61.15	61.15

PART POWER TRIM DATA



RPM CORRECTION CURVE

VIBRATION CHECK.

Vibration at either position should not exceed 4 mils at any operating condition. Vibration is usually checked while the throttle is being retarded from the take-off position to the idle position.

ACCELERATION CHECK.

Each engine should accelerate from idle to takeoff power within 12 seconds. Acceleration is accomplished by advancing the throttle from idle to full power in 1 second.

ENGINE AND NACELLE ANTI-ICING CHECK.

CAUTION

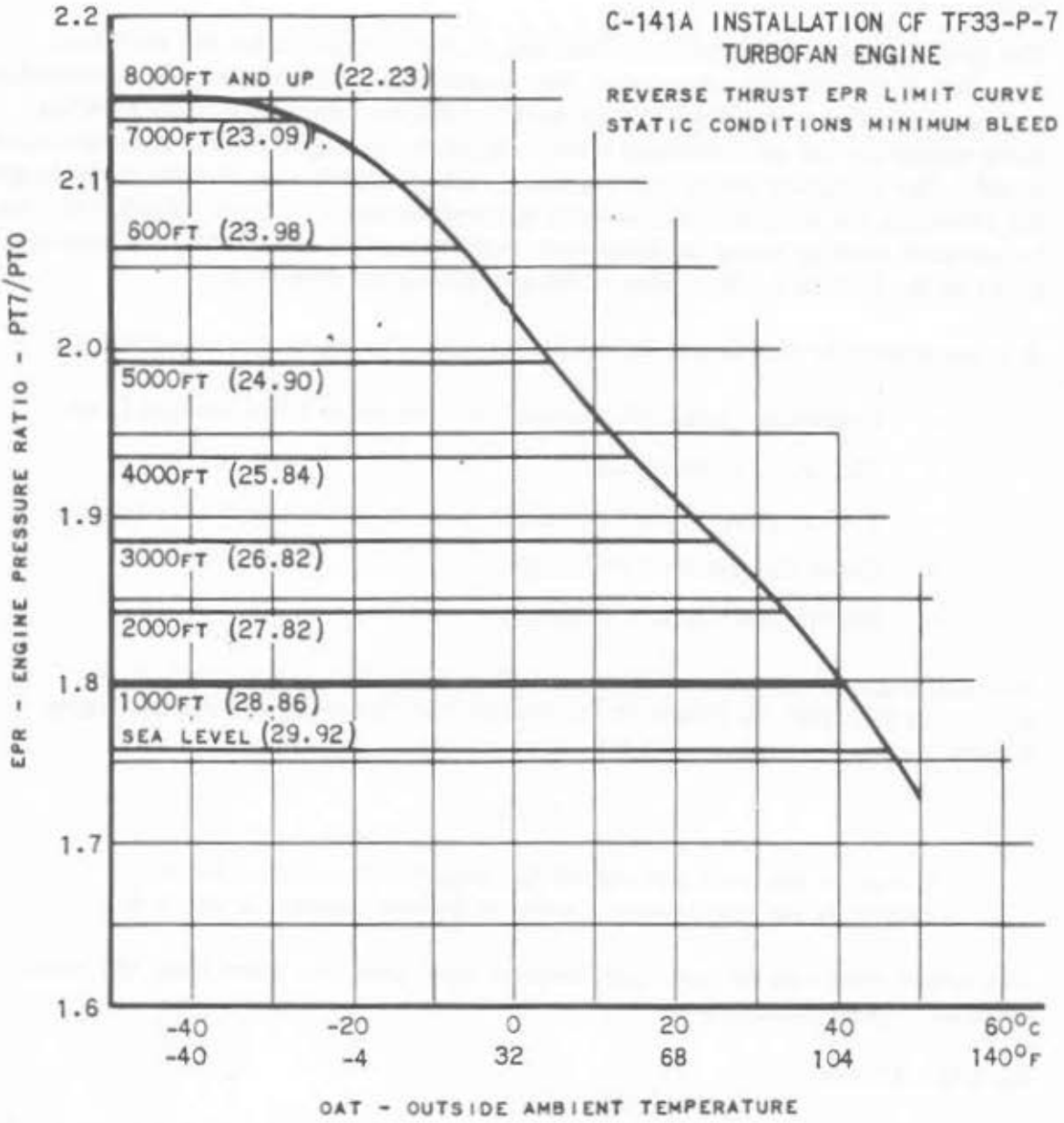
Do not operate the anti-icing for longer than 10 seconds at temperatures above freezing.

This check must be performed with the engine running and at a power setting of approximately 1.5 EPR. EPR indication drops and the anti-icing light illuminates when the anti-icing switch is turned on.

THRUST REVERSER OPERATION.

The thrust reverser limiter must be adjusted for the existing ambient temperature and field barometric pressure according to the Thrust Reverser Limiter chart.

The throttle lever should move easily into the reverse idle position, but the mechanical lockout should prevent the throttle from moving aft until the reverser doors are fully open. When the lockout is released, the throttle lever can be moved aft to increase power as desired.



REVERSE THRUST EPR LIMIT CURVE

POWER PLANT REMOVAL AND INSTALLATION.

REMOVAL.

The power plant is removed and installed on the aircraft using the removal/installation trailer with adapters. The adapters mount to the engine intermediate and turbine out cases. They can be used for engine removal with an overhead sling assembly but are normally used to support the engine on the transportation stand. The side cool doors and fan ducts must be opened for access to the engine for attaching the adapters and several quick-disconnect fittings. Each door can be secured open by using the hold-open rods stowed on each door. An access panel at the bottom leading edge of the pylon must be removed.

It is necessary to disconnect the following items for an engine removal:

- Hydraulic, fuel, pylon drain, and pressure ratio sensing lines
- Electrical connections
- Fuel control, thrust reverser, and feedback control linkage
- Bleed air manifold couplings
- Nacelle and cooling air hoses

With the engine removal/installation trailer under the power plant, it is necessary to adjust the height of the trailer until the weight is off the engine mounts before the mount bolts can be removed.

CAUTION

It may be necessary to adjust the height of the trailer while removing the engine mount bolts to prevent damage to the bolts.

The power plant can be carefully lowered away from the pylon after the mount bolts have been removed.

INSTALLATION.

Prior to engine installation, all mount bolt thread surfaces must be coated with anti-seize compound, and the thread protectors from the engine mount bolt installation kit must be installed. When the power plant is in place, the bolts, washers, and nuts can be installed in their proper position in the mounts.

NOTE

The gap between the links of the left and right forward mounts and aft mount is intended and should not be shimmed.

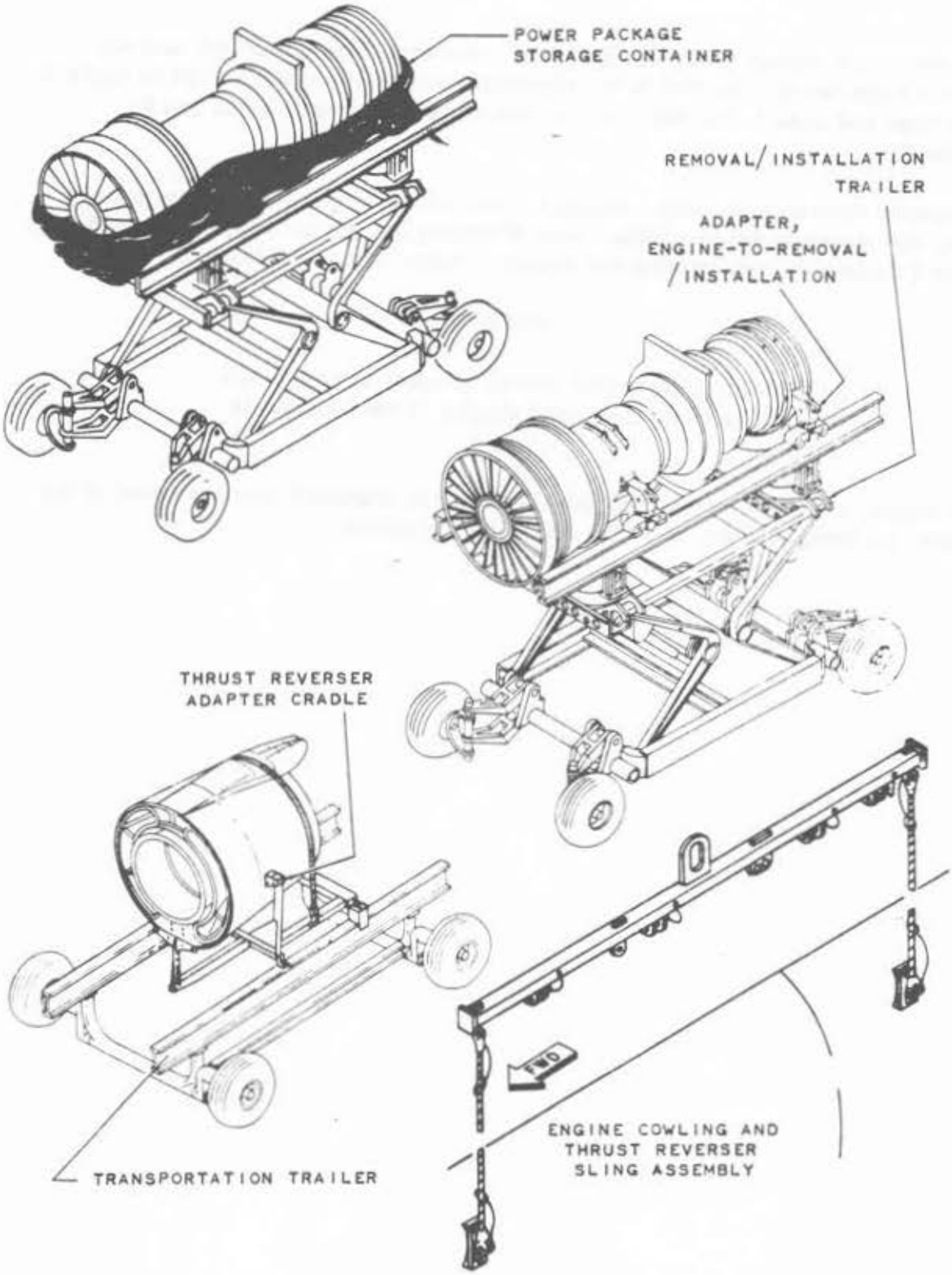
All electrical wiring, fuel, and hydraulic lines should be connected, and any torque required as specified in the applicable technical manual should be applied. The push rod links to the fuel control, and thrust reverser lockout can be connected.

Pressure ratio sensing lines, ambient pressure sensing line and pylon drain line, fire detector sensing lines, Zone II cooling ejector air supply line, and Zone I cooling system sensing and pressure lines, can all be connected.

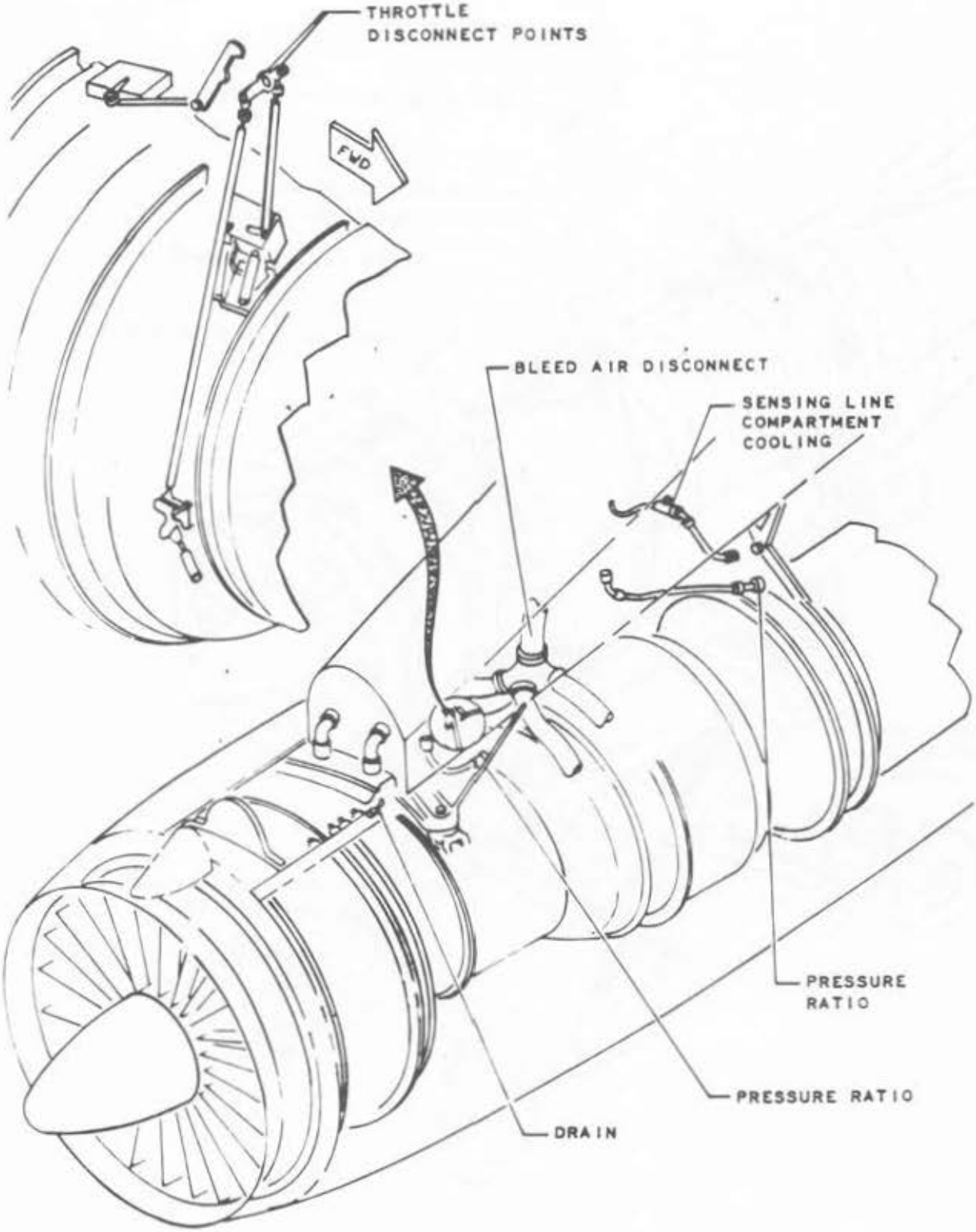
NOTE

A recheck of the engine should be made to ensure that everything is complete and rigging of the controls is correct.

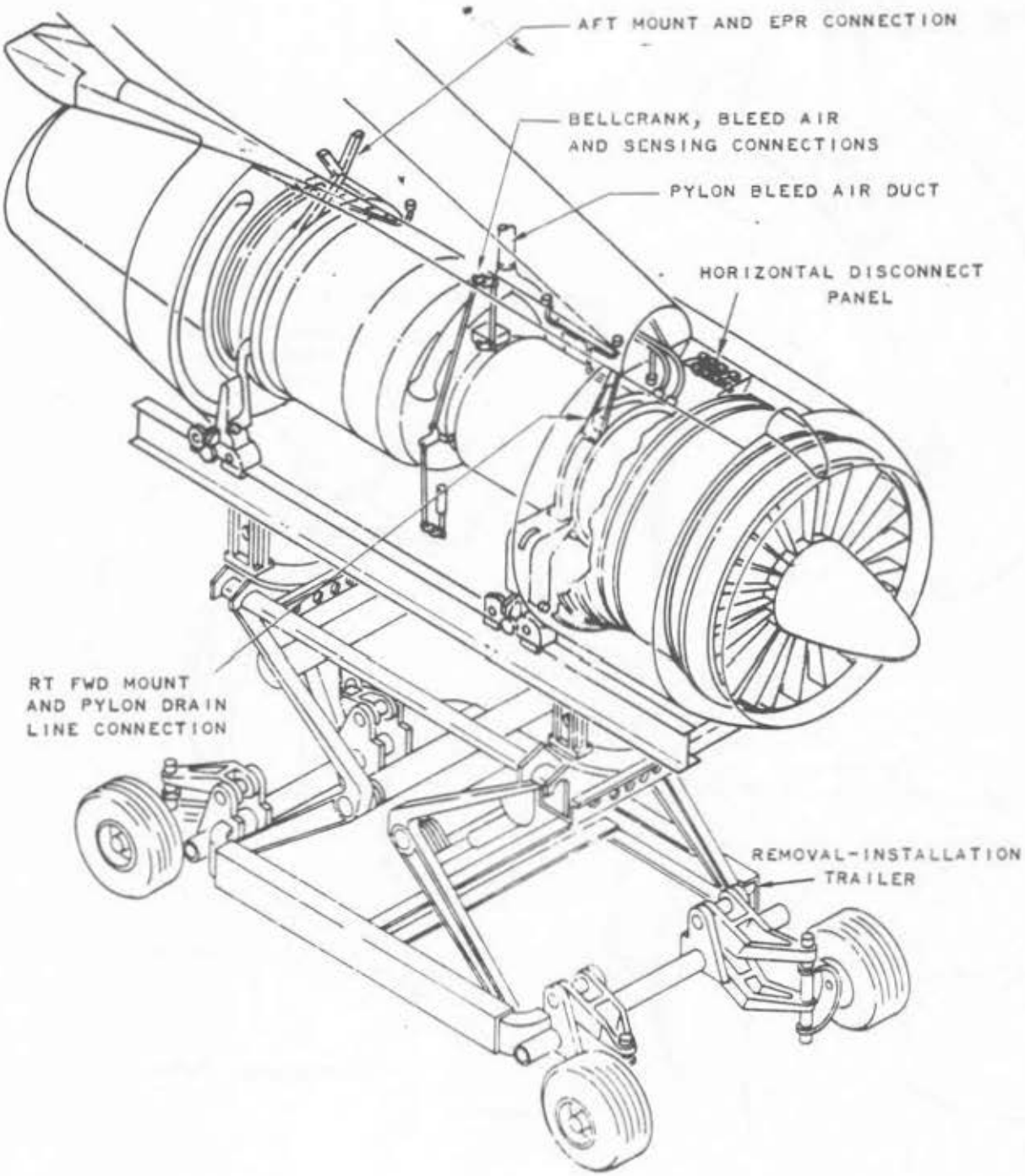
All doors, cowlings, and access panels should be installed, and servicing of the engine oil tank, starter, and CSD should be completed.



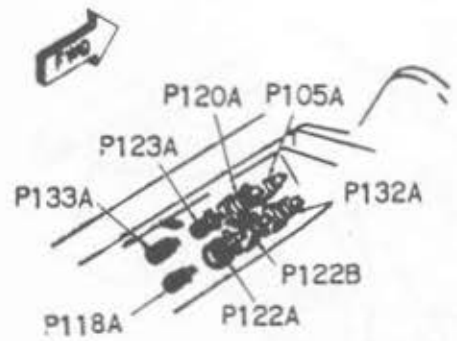
GROUND SUPPORT EQUIPMENT



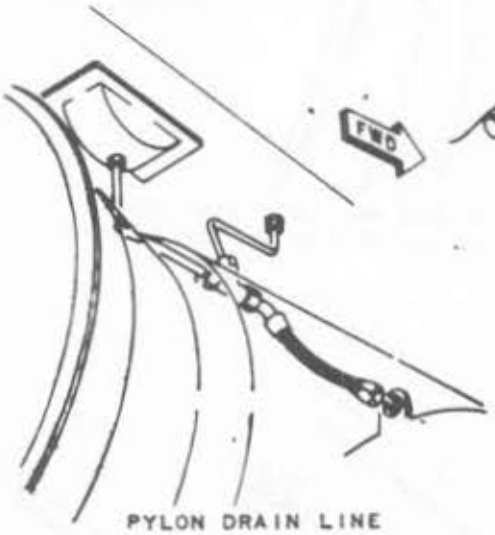
ENGINE TO PYLON THROTTLE AND DUCT DISCONNECTS



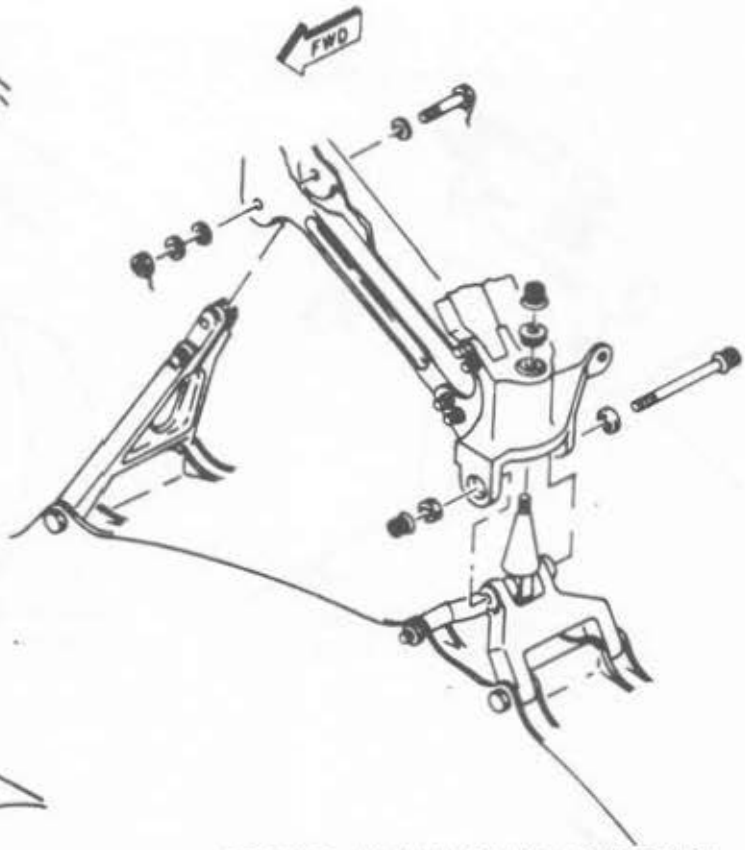
POWER PLANT INSTALLATION



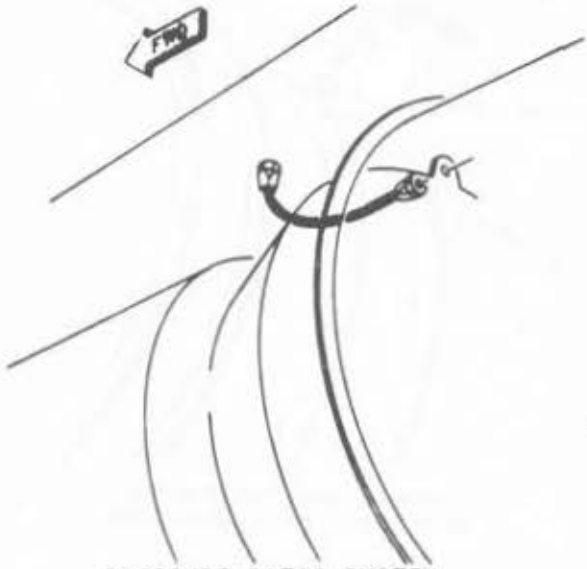
ELECTRICAL DISCONNECT PANEL



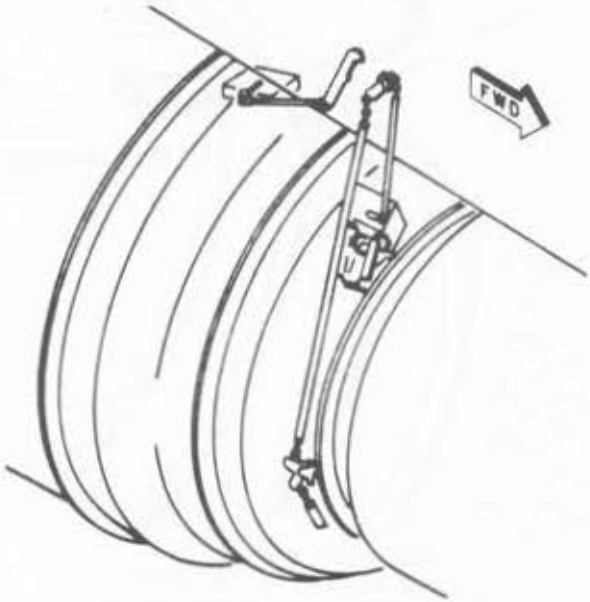
PYLON DRAIN LINE



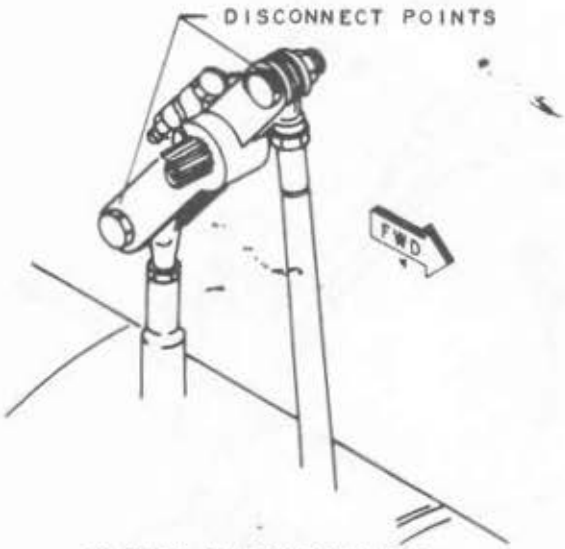
FORWARD ENGINE MOUNT CONNECTION



PRESSURE RATIO SYSTEM, LINE CONNECTION

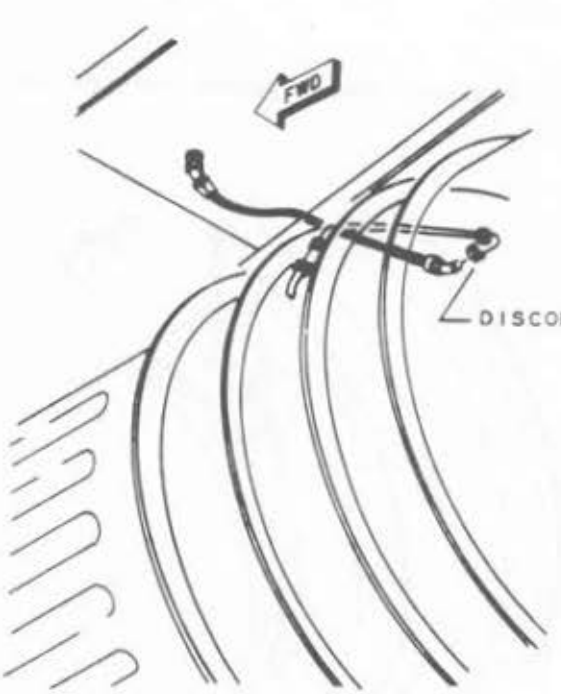


ENGINE CONTROLS CONNECTIONS

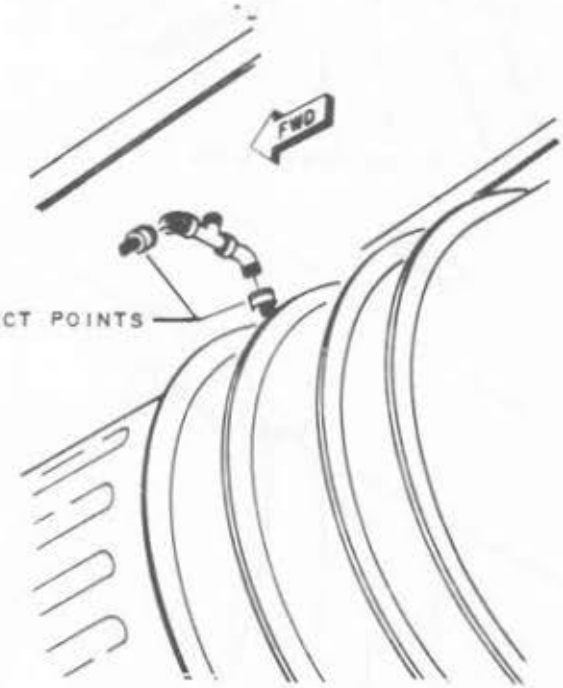


THRUST REVERSER VALVE
PUSHROD SAFETY WIRING

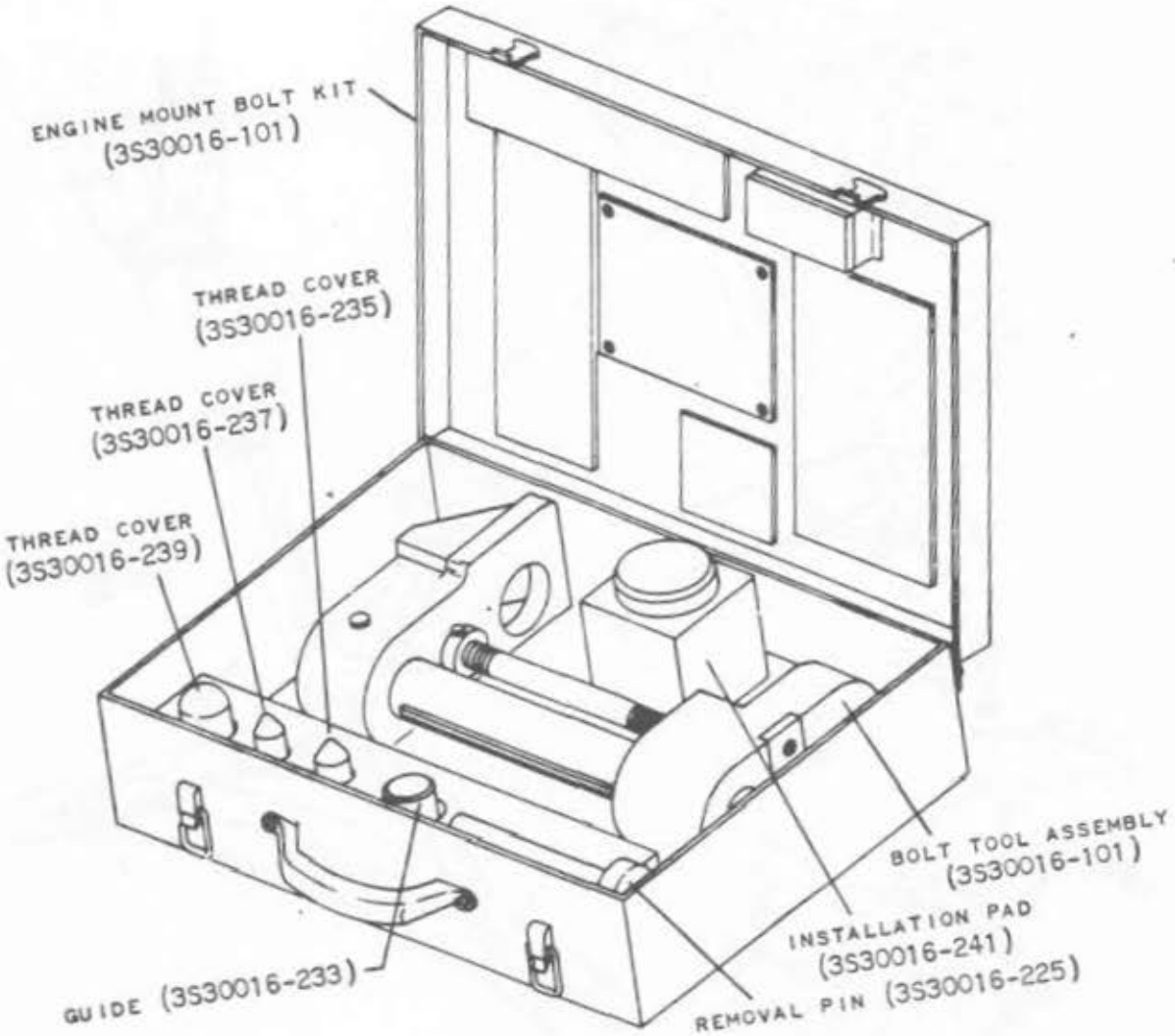
BLEED AIR MANIFOLD AND ZONE 1
COOLING VALVE AIR PRESSURE LINE



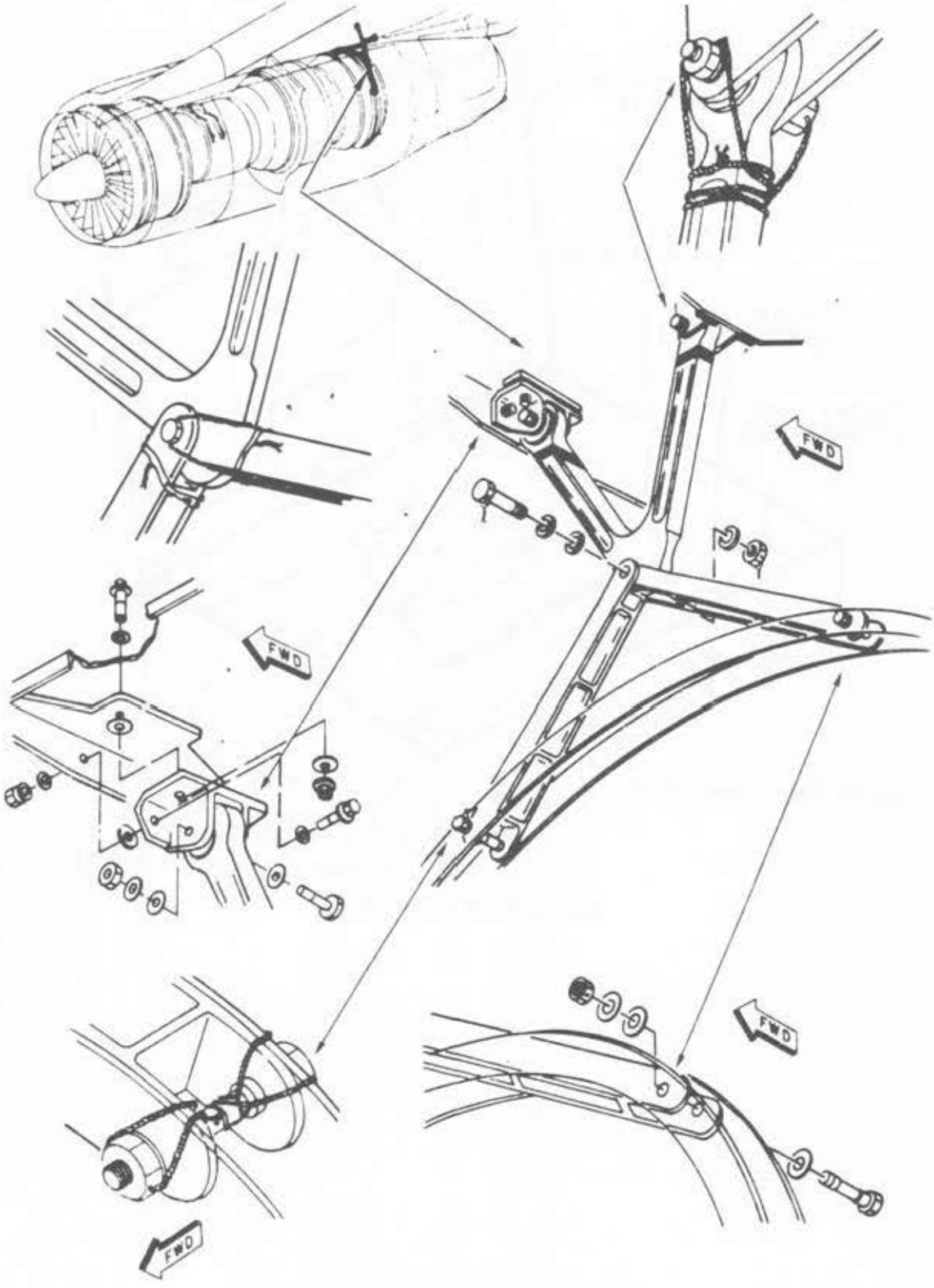
PRESSURE RATIO
SENSING LINE CONNECTION



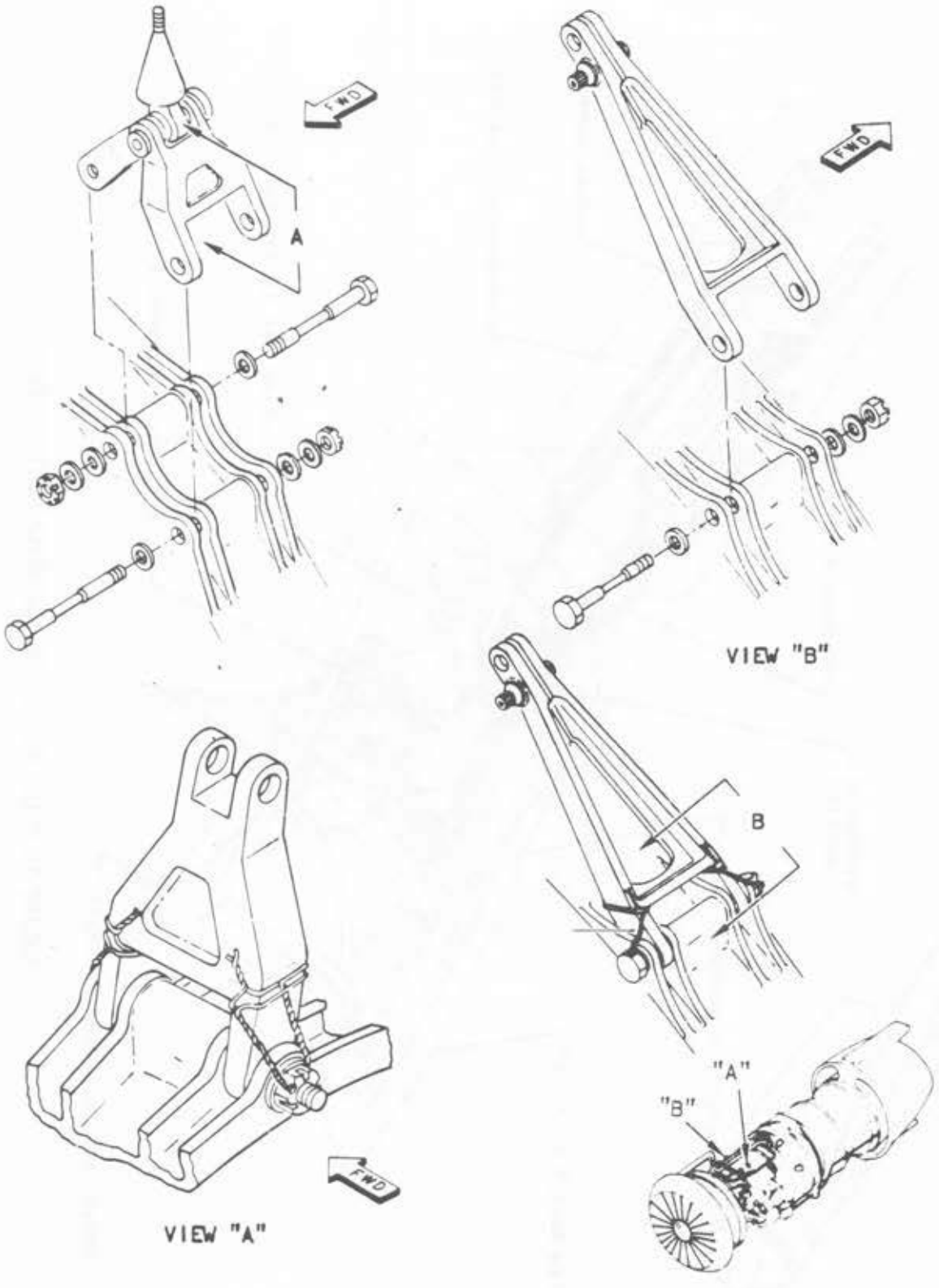
ZONE 1 COOLING SYSTEM
SENSING LINE CONNECTION



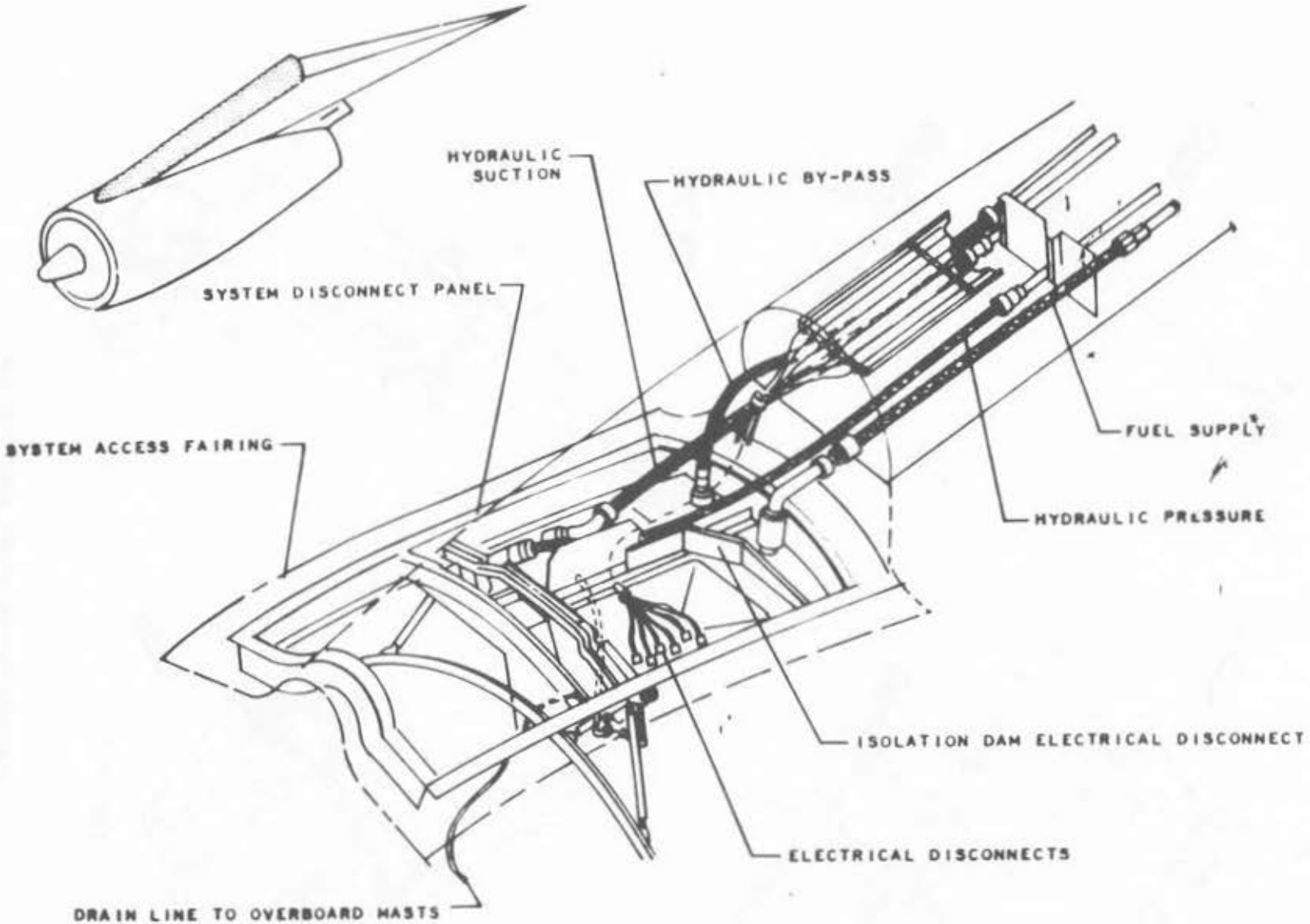
ENGINE MOUNT BOLT KIT



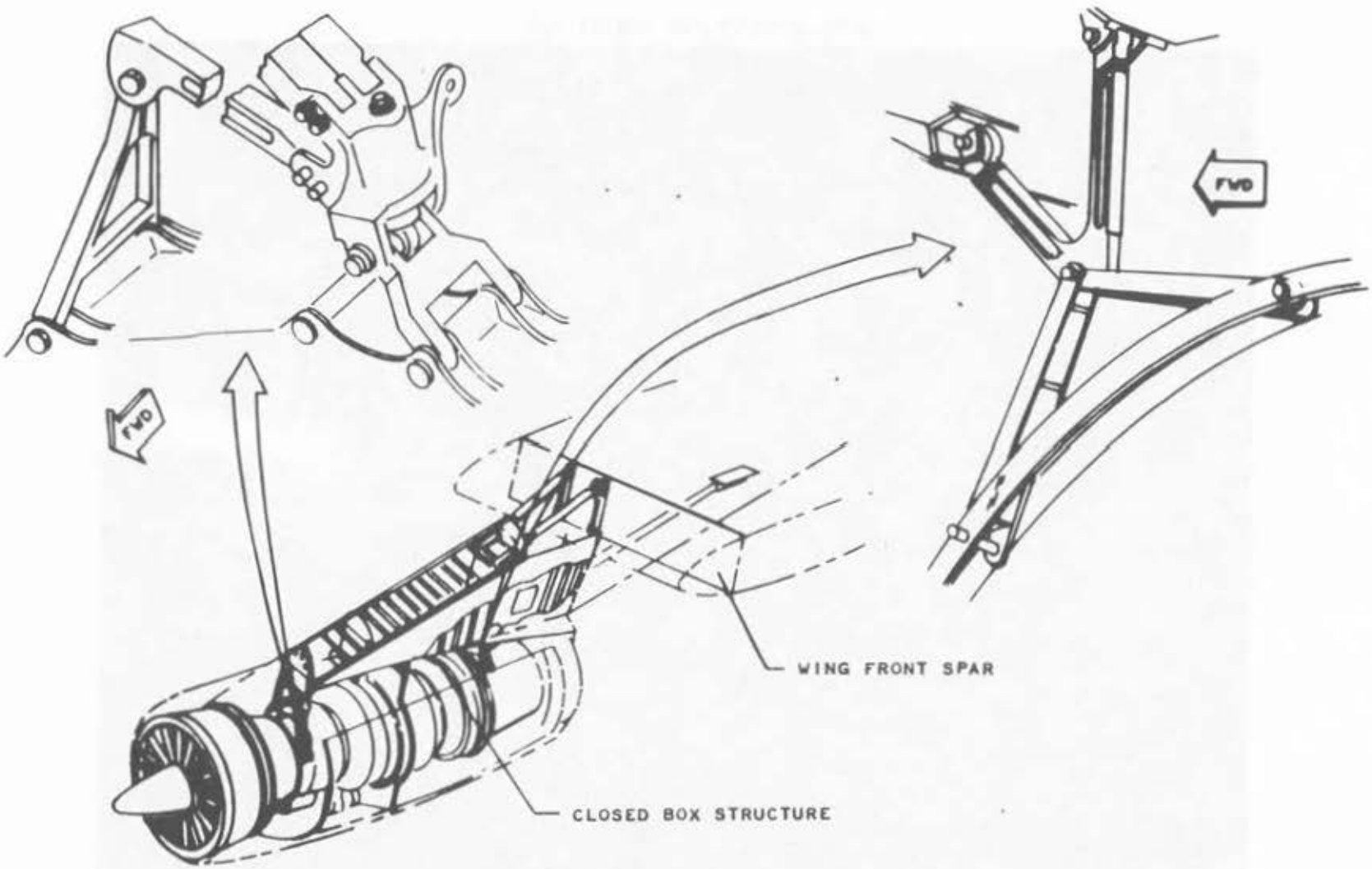
AFT ENGINE MOUNT INSTALLATION



FORWARD ENGINE MOUNT INSTALLATION



ENGINE TO PYLON FLUID AND ELECTRICAL DISCONNECTS



PYLON STRUCTURE AND ENGINE MOUNT

APU INTAKE AND EXHAUST DOOR