



# HERCULES

## ABOUT THIS MANUAL

VERSION: 11 AUGUST, 2008

**WARNING: THIS MANUAL IS DESIGNED FOR MICROSOFT® FSX USE ONLY. DO NOT USE FOR FLIGHT.**

The 'C-130 X-perience' FLIGHT MANUAL is organized into four Parts:  
Each Part is provided as a separate Acrobat® PDF document available via:

Click START > Programs > Captain Sim > C-130 X-perience'> Manuals >

Part I – User' Manual

**Part II – Systems and Equipment - this document**

Part III – Normal Procedures

Part IV – Flight Characteristics and Performance Data

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# 'C-130 X-PERIENCE' FLIGHT MANUAL

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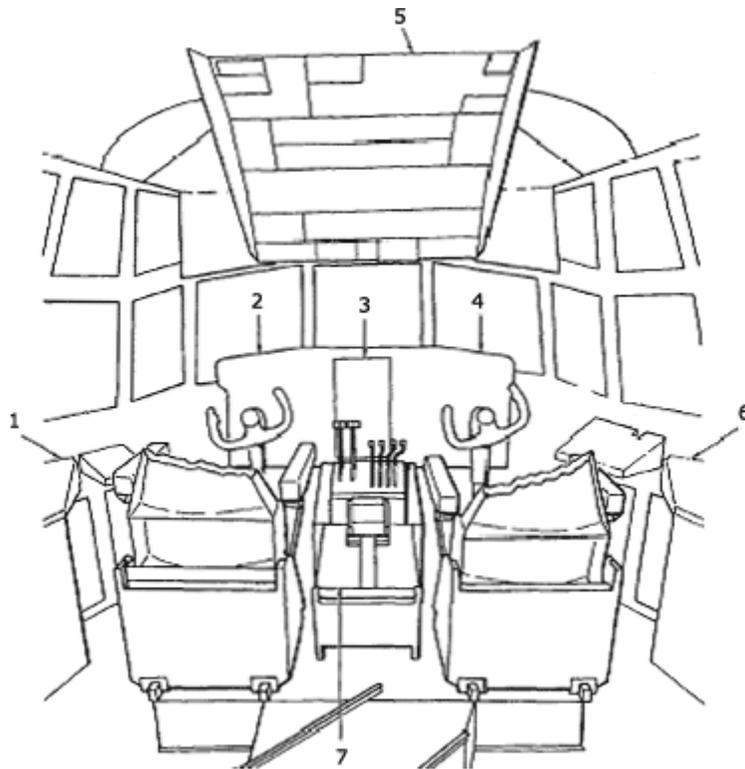
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**CREW STATIONS**

**FLIGHT STATION FORWARD**



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2. Pilot's Instrument Panel
3. Engine Instrument Panel
4. Copilot's Instrument Panel
5. Overhead Control Panel
6. Copilot's Side Shelf
7. Flight Control Pedestal

**IMPORTANT FOR PROPER SYSTEMS INITIALIZATION:  
MAKE SURE TO CYCLE THROUGH THE FOLLOWING C-130 VIEWS BEFORE WORKING WITH  
SYSTEMS: 2D PANEL > VC > EXTERIOR SPOT VIEW**

**2D PANELS**

**PILOT'S 2D INSTRUMENT PANEL**



1. Master Door Open Warning Lights
2. Clock
3. Airspeed Indicator
4. Master Warning Light
5. Attitude Director Indicator
6. Altimeter
7. Cabin Pressure Altitude indicator
8. Master Fire Warning Light
9. Nav Mode Select Panel
10. Tab Position Indicators (click cycles Elevator, Rudder, Aileron Tab Position Indicators)
11. Lights Test Panel
12. Standby Attitude Indicator
13. Radar Altimeter
14. BDH Indicator
15. SELCAL Indicator
16. RMI Indicator
17. AUTOPILOT DISENGAGED Light
18. Horizontal Situation Indicator
19. Electronic Fuel Correction Lights
20. Vertical Velocity Indicator
21. Compass Display Selector Panel
22. Marker Lights

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**COPILOT'S 2D INSTRUMENT PANEL**

1. Cabin Pressure Indicator
2. Nacelle Overheat Test Panel
3. Airspeed Indicator
4. Attitude Selector Switch and Indicator Light
5. Attitude Director Indicator
6. Horizontal Situation Indicator
7. Pressure Altimeter
8. BDHI Pointer Select Switch Panel
9. Rate Of Climb Indicator
10. Clock
11. RMI Indicator
12. Oxygen Quantity Low Warning Light
15. Landing and Taxi Lights Control Panel
16. Landing Gear Control Panel
17. BDH Indicator
18. Accelerometer
19. Wing Flap Position Indicator

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**OVERHEAD INSTRUMENTS 2D PANELS**

**OVERHEAD INSTRUMENTS 2D PANEL 1 (LOWER)**



1. Fuel Control Panel
2. Fire Emergency Control Panel
3. Oil Cooler Flaps Control Panel
4. Control Boost Switch Panel
5. Ice Detection Panel
6. Fuel Enrichment Control Panel
7. Engine Starting Control Panel
8. Engine Warning System Test Panel

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

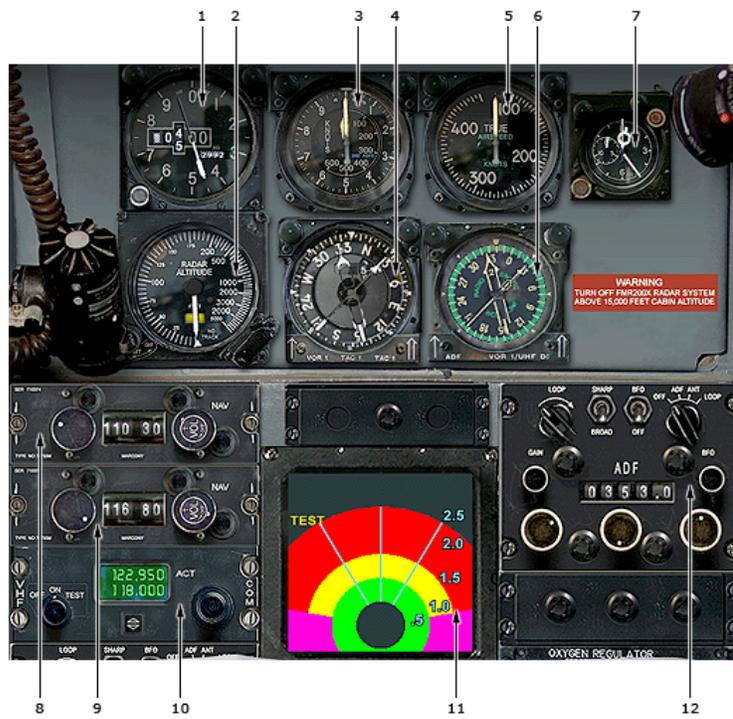
**OVERHEAD INSTRUMENTS 2D PANEL 2 (UPPER)**



1. Anti-Icing Systems Control Panel
2. Electrical Control Panel
3. Exterior Lights Control Panel
4. Air Conditioning and Pressurization Control Panel

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**NAVIGATOR PANEL**



1. Altimeter
2. Radar Altitude
3. Airspeed Indicator
4. BDH Indicator
5. True Airspeed Indicator
6. RMI Indicator
7. Clocks
8. No.1 COMM-NAV Control Panel
9. No.2 COMM-NAV Control Panel
10. COMM1 Control Panel
11. Radar Indicator
12. ADF Radio Control Panel

**ADDITIONAL 2D POP-UP PANELS**

**SYSTEM PANELS**

Radar Control panel



Radio Control panel



Throttle Quadrant panel



Co-Pilot Aux panel



Ramp and Door Control panel



Autopilot panel



Notes Clip panel



Wing Flaps Control panel



SSF/IFF Control panel



Control Wheel panel



**SIMICON PANEL**

Shift+2

The SimIcon Panel is designed to:

- Switch easily between the full size 2D panels by clicking on the corresponding icon.
- Call and hide any of the custom 2D pop-up panels by clicking on the corresponding icon.
- Call and hide any of the default MSFS 2D pop-up panels and windows (GPS, Map, Notepad, ATC) by clicking on the corresponding icon.



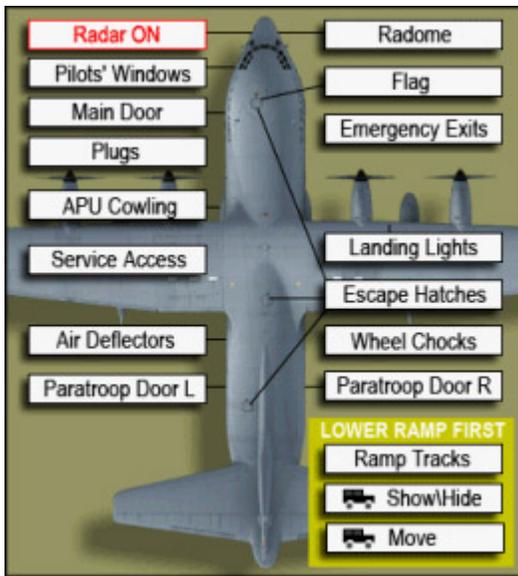
*The icons legend:*

	Keys
1A -- Left Seat Pilot panel	Shift+1
1B -- Upper Overhead panel	Shift+6
1C -- Right Seat Pilot panel	Shift+4
2A -- Yoke	-
2B -- Lower Overhead panel 2	Shift+5
2C -- Hydraulics panel	-
3A -- Notes Clip panel	-
3B -- Radar Control panel	Shift+9
3C -- Navigator panel	-
4A -- Autopilot panel	Shift+8
4B -- Radio Control panel	Shift+7
4C -- SSF/IFF Control panel	-
5A -- MSFS Notepad window	-
5B -- Throttle Quadrant panel	-
5C -- Wing Flaps Control panel	-
6A -- MSFS Map window	-
6B -- MSFS ATC window	Menu>World>Map or ~
6C -- MSFS GPS panel	-
7A -- Ramp and Door Control panel	-
7B -- Fire Infra-Red Flares	-
7C -- Animations Control Panel	Shift+3
8A -- Exit the Control panel	Shift+2
8B -- Panel Drag-n-Drop area	-
8C -- External Power On/Off	-

See CHAPTER 2 'Systems and Equipment' of this Manual for more information.

**MODEL ANIMATION CONTROL PANEL**

Press Shift+2 then corresponding icon to show/hide the panel OR Shift+3



Press any white label/button to initiate the corresponding animation of the Exterior Model.

**Notes:**

- You cannot set the WHEEL CHOCKS if your speed is more than 0 KIAS
- You cannot show and move RAMP TRACKS inflight
- You cannot open Service Access inflight
- You cannot open Radar Radome inflight

**VC ENGINE INSTRUMENT PANEL**



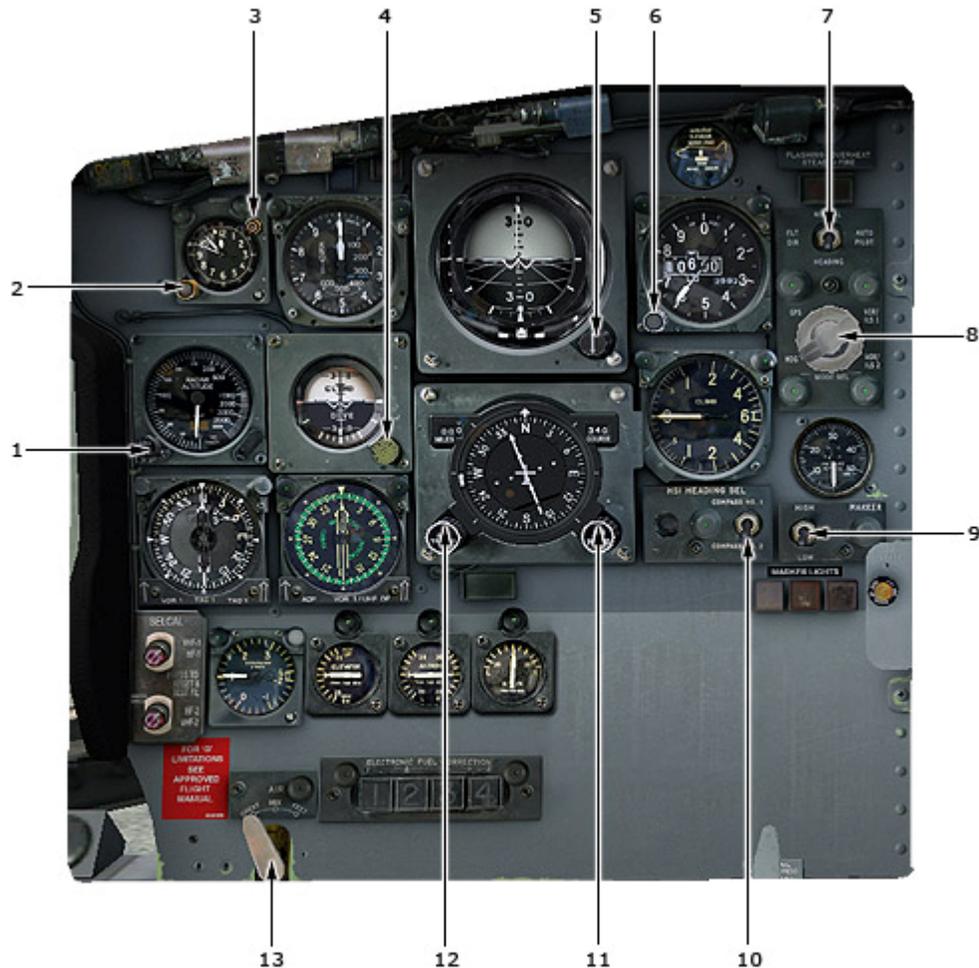
1. Torquemeters.
2. Tachometers.
- 3 Turbine Inlet Temperature Indicators.
4. Fuel Flow Indicators
5. Oil Temperature Indicators
6. Oil Pressure Indicators
7. Oil Quantity Indicators
8. Oil Cooler Flaps Position Indicators
9. Engine Low Oil Quantity Warning Light
10. Radar Low Altitude Warning Indicator
11. Propeller Low Oil Quantity Master Warning Light

*(See 'Engine Instruments' section of this manual for details).*

**3D VIRTUAL COCKPIT (VC) IN DETAILS**

Layouts of the Virtual Cockpit panels may vary from the 2D panels due to monitor size, resolution and readability limitations of the 2D panels' bitmaps.

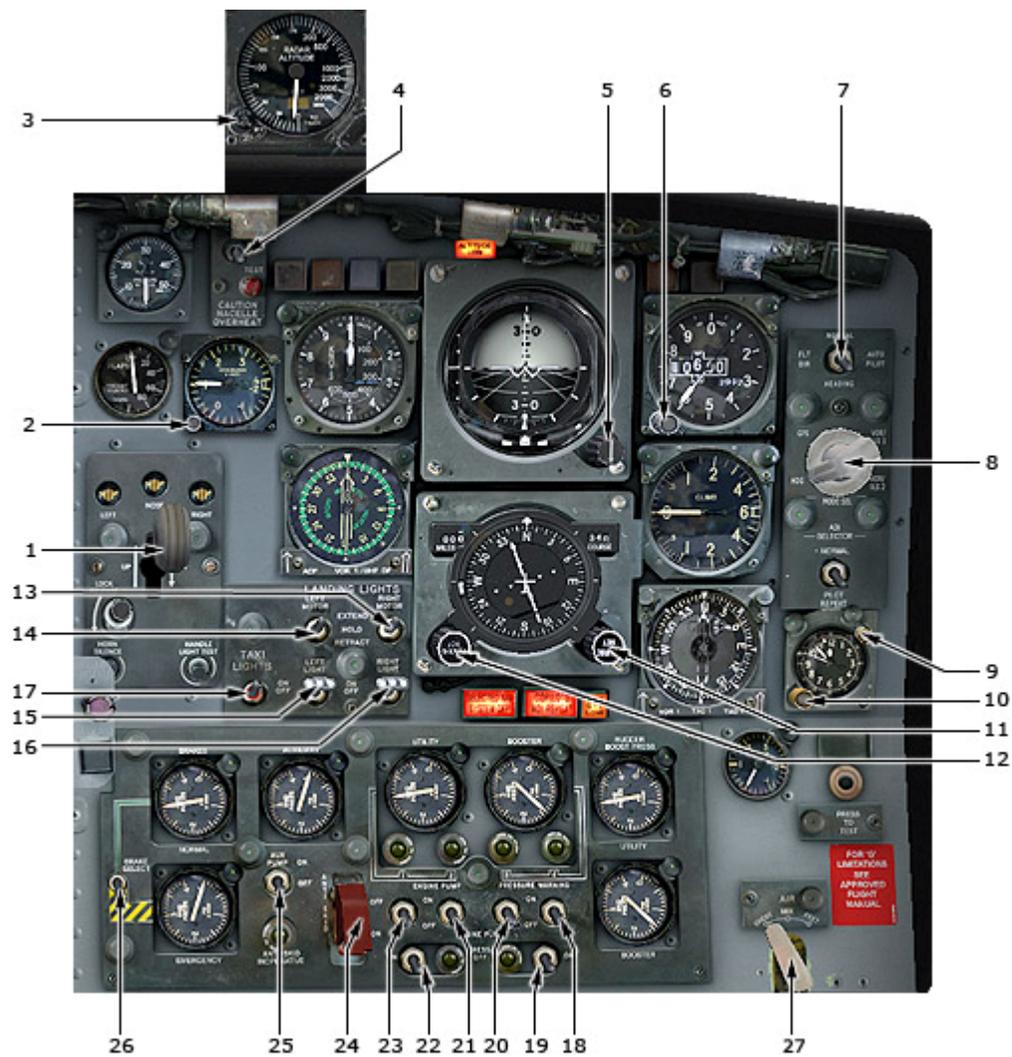
This section of the manual describes all features of the 3D Virtual Cockpit.

**CUSTOM 3D ANIMATION OF THE VIRTUAL COCKPIT****PILOT INSTRUMENT PANEL 3D CLICKABLE CONTROLS**

1. Radar Altitude Knob
2. Second Hand Reset Knob
3. Time Set Knob
4. Standby ADI Adjustment Knob
5. Attitude Director Indicator Pitch Trim Knob
6. Altimeter Knob
7. Agent Discharge Switch
8. Mode Selector Switch
9. Marker Switch
10. HSI Heading Selector Switch
11. HSI Course Set Knob
12. HSI Heading Bug
13. Air Diverter Handle

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

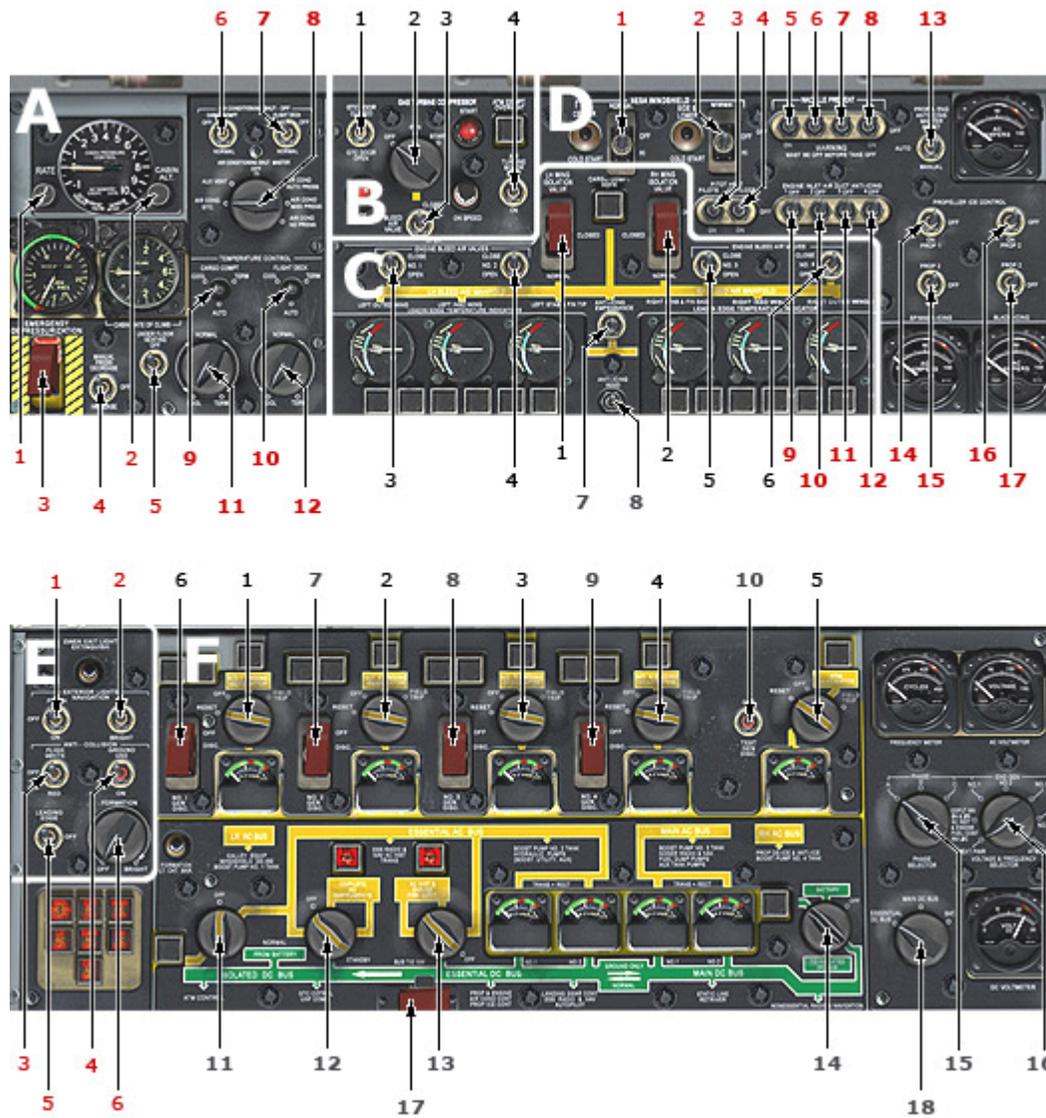
**COPILOT'S INSTRUMENT PANEL 3D CLICKABLE CONTROLS**



- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. Landing Gear Control Handle</li> <li>2. Accelerometer Reset Button</li> <li>3. Radar Altimeter Knob</li> <li>4. Nacelle Overheat Switch</li> <li>5. Attitude Director Indicator Pitch Trim Knob</li> <li>6. Altimeter Knob</li> <li>7. Agent Discharge Switch</li> <li>8. Mode Selector Switch</li> <li>9. Time Set Knob</li> <li>10. Second Hand Reset</li> <li>11. HSI Course Set Knob</li> <li>12. HSI Heading Bug</li> <li>13. Landing Lights Extension and Retraction Switch</li> <li>14. Landing Lights Extension and Retraction Switch</li> </ol> | <ol style="list-style-type: none"> <li>15. Landing Lights Illumination Switch</li> <li>16. Landing Lights Illumination Switch</li> <li>17. Taxi Lights Switch</li> <li>18. Engine Pump Pressure Warning Light Switch</li> <li>19. Utility Suction Boost Pump Switch</li> <li>20. Engine Pump Pressure Warning Light Switch</li> <li>21. Engine Pump Switch</li> <li>22. Utility Suction Boost Pump Switch</li> <li>23. Engine Pump Switch</li> <li>24. Anti-Skid Switch</li> <li>25. Auxiliary Hydraulic Pump Switch</li> <li>26. Booster Suction Boost Pump Switch</li> <li>27. Air Diverter Handle</li> </ol> |
|--|---|

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**OVERHEAD INSTRUMENTS PANEL 2 (UPPER) 3D CLICKABLE CONTROLS**



**PANEL 'A' - AIR CONDITIONING AND PRESSURIZATION CONTROL PANEL**

1. Rate Selector Knob
2. Cabin Alt Setting Indicator
3. Emergency Depressurization Switch
4. Manual Press Control Switch
5. Underfloor Heating Fan Switch
6. Cargo Compartment Air Conditioning Shutoff Switch
7. Flight Deck Air Conditioning Shutoff Switch
8. Air Conditioning Master Switch
9. Cargo Compartment Temperature Control Switch
10. Flight Deck Temperature Control Switch
11. Cargo Compartment Temperature Rheostat
12. Flight Deck Temperature Rheostat

**PANEL 'B' - GTC CONTROL PANEL**

1. GTC Door Switch
2. GTC Main Switch
3. Bleed Air Valve Switch
4. ATM Control Switch

PANEL 'C' - ENGINE BLEED AIR VALVE CONTROL PANEL

1. LH Wing Isolation Valve Switch
2. RH Wing Isolation Valve Switch
3. No.1 Engine Bleed Air Valve Switch
4. No.2 Engine Bleed Air Valve Switch
5. No.3 Engine Bleed Air Valve Switch
6. No.4 Engine Bleed Air Valve Switch
7. Wing Anti Icing
8. Empennage Anti Icing

PANEL 'D' - ANTI-ICING AND DE-ICING SYSTEMS CONTROL PANEL

- 1 Center Windshield Anti-Icing Switch
- 2 Side and Lower Windshield Anti-Icing Switch
- 3 Pitot Heat Switch: Pilot
- 4 Pitot Heat Switch: Copilot
- 5-8 Nacelle Preheat Switch
- 9-12 Engine Inlet Air Duct Anti-Icing Switch
- 13 Prop & Eng Anti-Icing Master Switch
- 14-17 Propeller Ice Control Switch

PANEL 'E' - EXTERIOR LIGHTS CONTROL PANEL

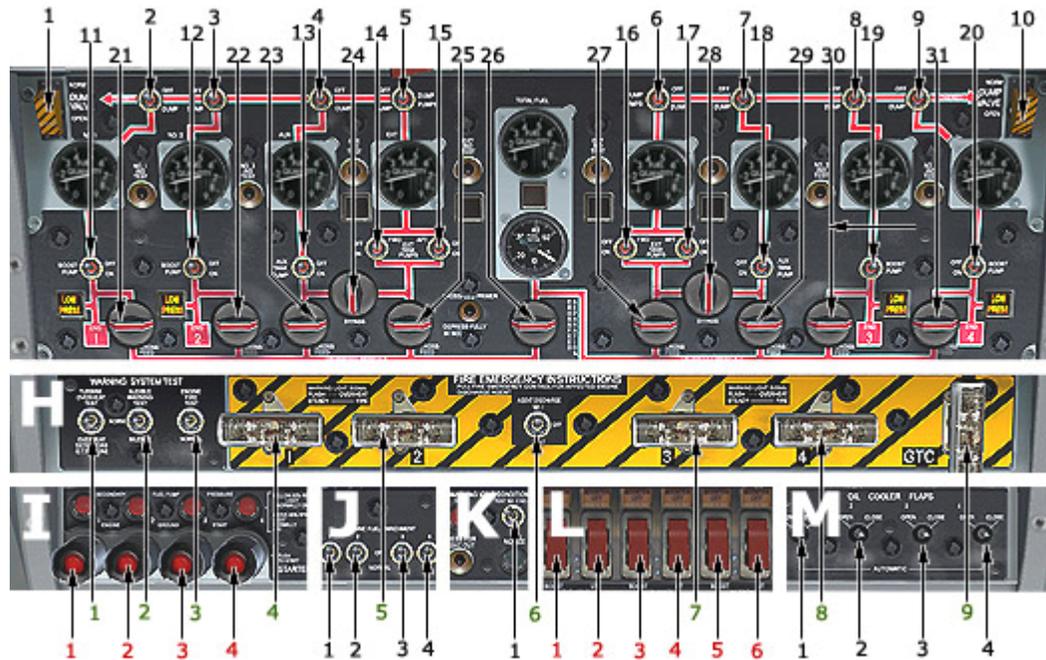
- 1,2 Navigation Lights Selector Switch
- 3,4 Anti-Collision/Strobe Lights Selector Switch
- 5 Wing Leading Edge Lights Selector Switch
- 6 Formation Lights Selector Switch

PANEL 'F' - OVERHEAD ELECTRICAL CONTROL PANEL

- 1-4 Generator Selector Switch
- 5 ATM Generator Switch
- 6-9 Generator Disconnect Switch
- 10 Generator Disconnect Test Switch
- 11 External Power Selector Switch
- 12-14 Battery Selector Switch
- 15 Phase Selector Switch
- 16 Voltage and Frequency Selector Switch
- 17 AC Bus Tie Switch
- 18 AC Voltmeter and Frequency Phase Selector Switch

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**OVERHEAD INSTRUMENTS PANEL 1 (LOWER) 3D CLICKABLE CONTROLS**



**PANEL 'G' - FUEL CONTROL PANEL**

- 1, 10 Fuel Dump Switch
- 11-20 Boost Pump Switch
- 21-23,25,27,29-31 Crossfeed Valve Switch
- 24,28 Bypass Valve Switch
- 26 Crossfeed Separation Valve Switch

**PANEL 'H' - WARNING SYSTEM TEST PANEL**

- 1 Turbine Overheat Detector Test Switch
- 2 Audible Warning Test Switch
- 3 Fire Detection System Test Switch
- 4,5,7-9 Fire Emergency Control Handle
- 6 Agent Discharge Switch

**PANEL 'I' - ENGINE STARTING CONTROL PANEL**

- 1-4 Engine Ground Start Button

**PANEL 'J' - ENGINE FUEL ENRICHMENT PANEL**

- 1-4 Engine Fuel Enrichment Switch

**PANEL 'K' - ICING CONDITION TEST PANEL**

- 1 Icing Condition Test Switch

**PANEL 'L' - CONTROL BOOST SWITCH PANEL**

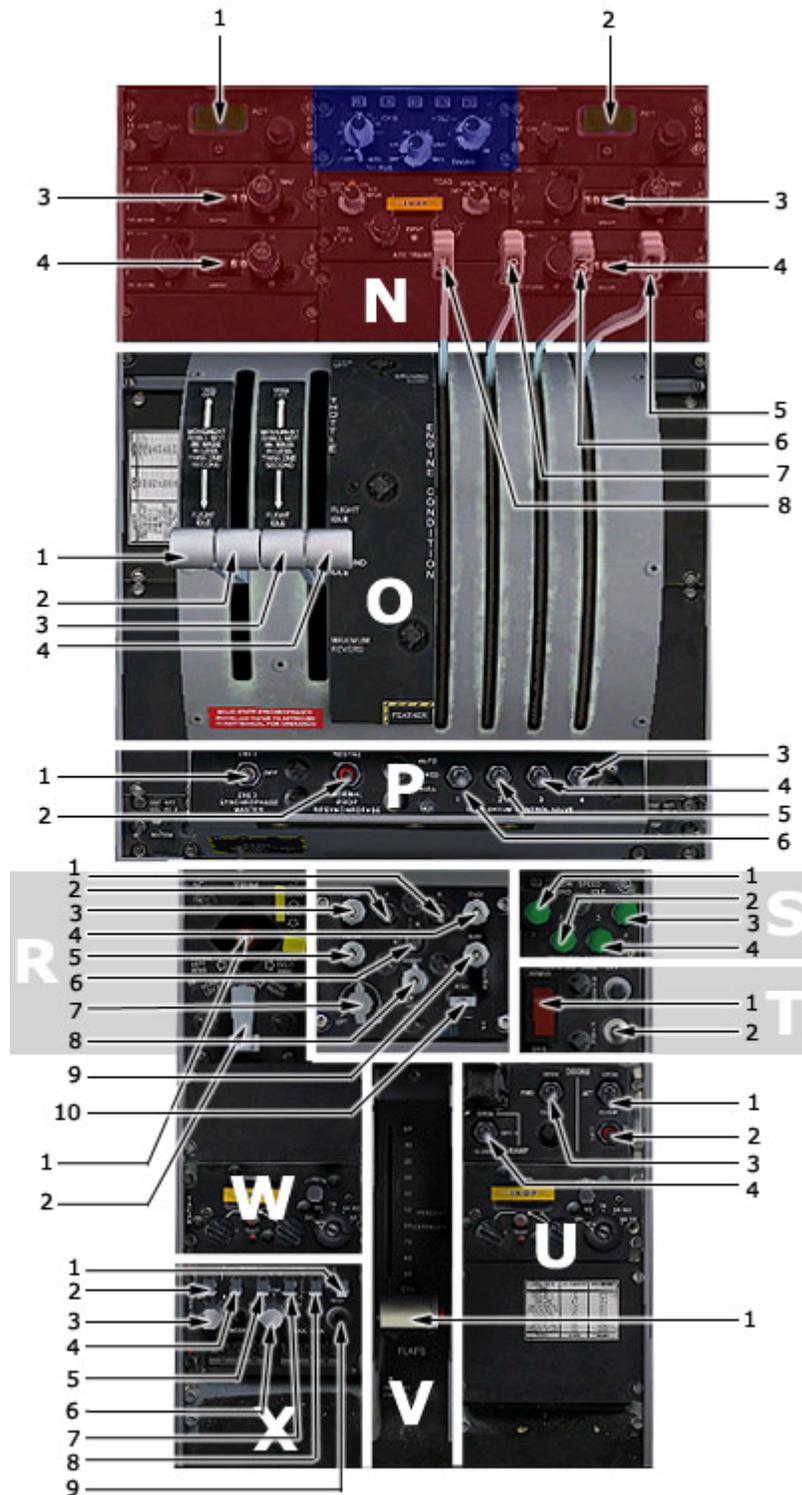
- 1-6 Control Boost Switch

**PANEL 'M' - OIL COOLER FLAPS PANEL**

- 1-4 Oil Cooler Flaps Position Switch

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**FLIGHT CONTROL PEDESTAL 3D CLICKABLE CONTROLS**



**PANEL 'N' - RADIO CONTROL PANELS**

Red Area click calls 2D Radio Control panel  
 Blue Area click calls 2D Radar Control panel

1. COMM 1 Frequency Display
2. COMM 2 Frequency Display
3. NAV 1 Frequency Display
4. NAV 2 Frequency Display

PANEL 'O' - ENGINE CONTROL QUADRANT

- 1-4 Engine #1-4 Throttles
- 5-8 Engine #4-1 Condition Levers

PANEL 'P'

- 1 Synchrophase Master Switch
- 2 Prop Resynchrophase Switch
- 3-6 Temp Datum Control Valve Switches

PANEL 'R' - AUTOPILOT CONTROL PANEL

- 1 Aileron Motors Button
- 2 Elevator Motors Button
- 3 POWER Button
- 4 Navigation Mode Button
- 5 Autopilot Master Switch
- 6 Rudder Motor Switch
- 7 BANK T R Switch
- 8 HEIGHT / IAS Button
- 9 Approach Hold Switch
- 10 Pitch Control

PANEL 'S' - (LSGI) LOW SPEED GROUND IDLE CONTROL PANEL

- 1-4 LSGI Buttons

PANEL 'T' - ASSISTED TAKEOFF CONTROL PANEL (works with JATO model only)

- 1 ARM/SAFE Switch
- 2 JATO FIRE Button

PANEL 'U' - AERIAL DELIVERY SYSTEM (ADS) CONTROL PANEL

- 1 FWD Doors Control Switch
- 2 Right/Left Aft Doors Selector Switch
- 3 Aft Doors Control Switch
- 4 Ramp Control Switch

PANEL 'V' - FLAP CONTROL QUADRANT

- 1 Flaps Control Lever

PANEL 'W' - TRIM TAB CONTROL PANEL

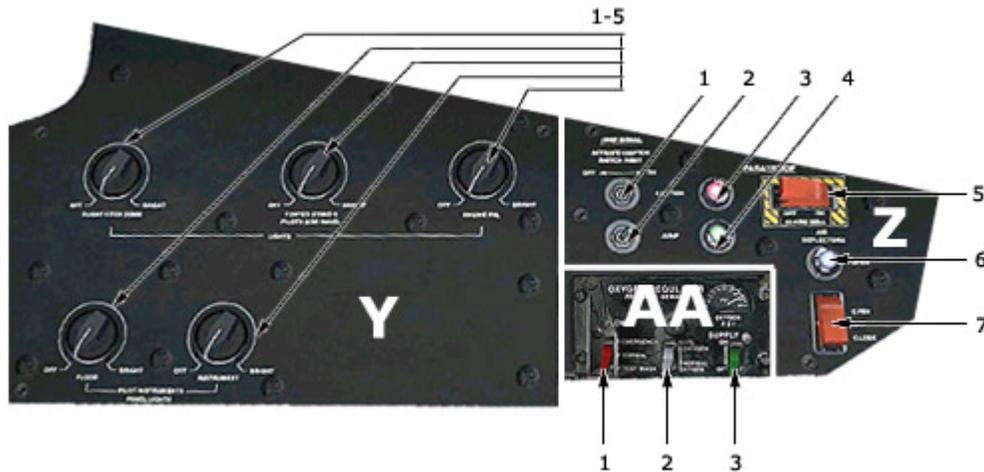
- 1 Elevator/Aileron Trim tab Control
- 2 Rudder Trim Tab Control

PANEL 'X' - IFF/SSR TRANSPONDER CONTROL PANEL

- 1 I/P Switch
- 2 M-1 Switch
- 3 M-3/A Switch
- 4 M-2 Switch
- 5 M-C Switch
- 6 MASTER Control
- 7 Mode D Switch
- 8 CIV/MIL Switch
- 9 Test Indicator

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**PILOT'S SIDE SHELF 3D CLICKABLE CONTROLS**

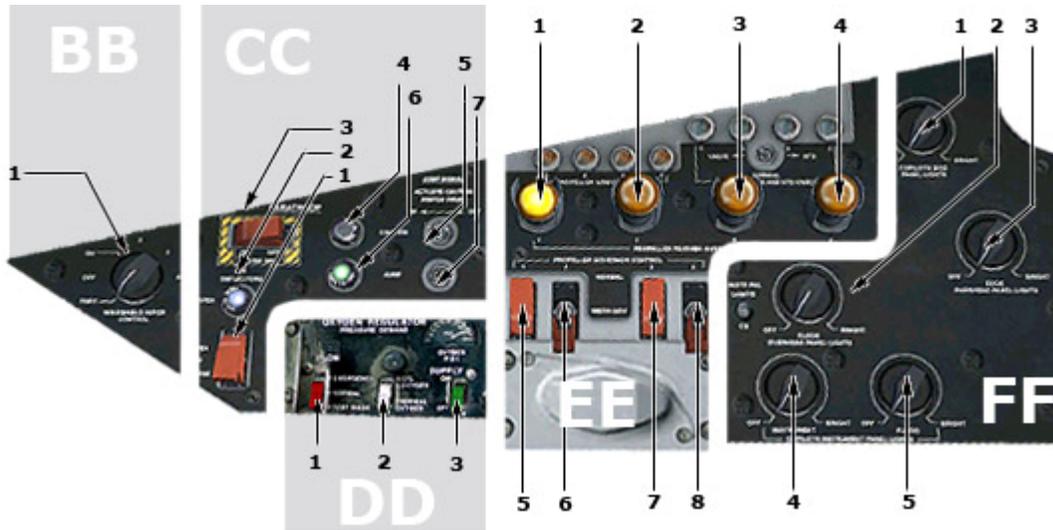


**PANEL 'Y' - LIGHTING CONTROLS PANEL**  
 1-5 Interior Lighting Control Switch

**PANEL 'Z' - PARATROOP PANEL**  
 1 Caution Switch  
 2 Engine Panel Lights Switch  
 3 Center Stand and Pilots Side Panel Lights Switch  
 4 Pilots Instrument Panel Lights: Flood  
 5 Paratroop Alarm Bell Switch  
 6 Air Defectors Warning Light  
 7 Air Defectors Switch

**PANEL 'AA' - OXYGEN REGULATOR PANEL**  
 1 Oxygen Supply Lever  
 2 Regulator Diluter Lever  
 3 Emergency Toggle Lever

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**COPILOT'S SIDE SHELF 3D CLICKABLE CONTROLS****PANEL 'BB' - WINDSHIELD WIPER CONTROL PANEL**

- 1 Windshield Wiper Control Switch

**PANEL 'CC' - COPILOT PARATROOP PANEL**

- 1 Air Deflectors Switch  
 2 Caution Light  
 3 Paratroop Alarm Bell Switch  
 4 Caution Switch  
 5 Air Deflectors Warning Light  
 6 Jump Light  
 7 Jump Switch

**PANEL 'DD' - OXYGEN REGULATOR PANEL**

- 1 Emergency Toggle Lever  
 2 Regulator Diluter Lever  
 3 Oxygen Supply Lever

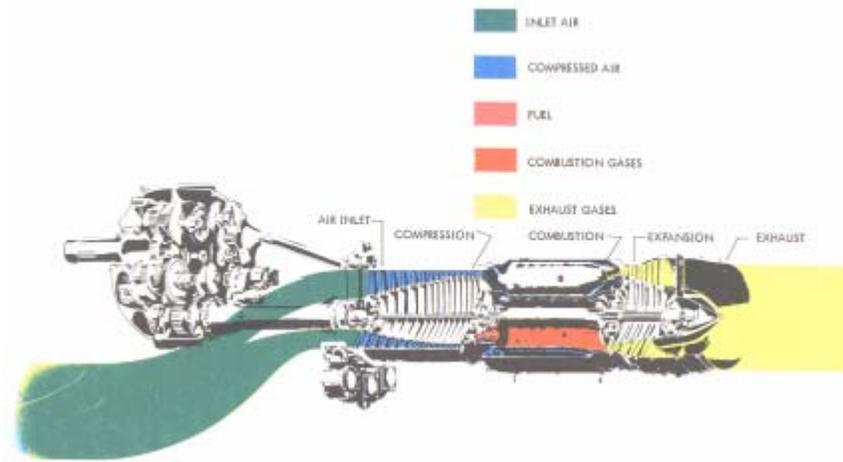
**PANEL 'EE' - PROPELLER CONTROLS**

- 1-4 Feather Override Button  
 5-8 Propeller Governor Control Switch

**PANEL 'FF' - COPILOTS INTERIOR LIGHTS PANEL**

- 1-5 Interior Lighting Control Switch

See CHAPTER 2 'Systems and Equipment in Details' of this Manual for more information.

**CHAPTER 2 - SYSTEMS AND EQUIPMENT IN DETAILS****ENGINES**

The aircraft is powered by four Allison T56-A-7 or T56-A-16 turboprop engines. The basic engine consists of two major assemblies - a power section and a reduction gear assembly - that are attached to each other by an extension shaft assembly and two supporting struts. The engine is provided with fuel, oil, starting, ignition, and control systems. The engine operates at a constant speed; therefore, engine power is related to TIT that varies according to the rate of fuel flow. An increase in fuel flow causes an increase in TIT and a corresponding increase in energy available at the turbine. The turbine then absorbs more energy and transmits it to the propeller in the form of torque. In order to absorb the increased torque, the propeller increases blade angle to maintain constant engine rpm. A decrease in torque results in a decrease in propeller blade angle to maintain engine speed. Thrust is obtained from the propeller, and a small amount of additional thrust (approximately 10 percent at takeoff) is created by the tailpipe exhaust.

**ENGINE CONTROLS AND CONTROL SYSTEMS****Throttles**

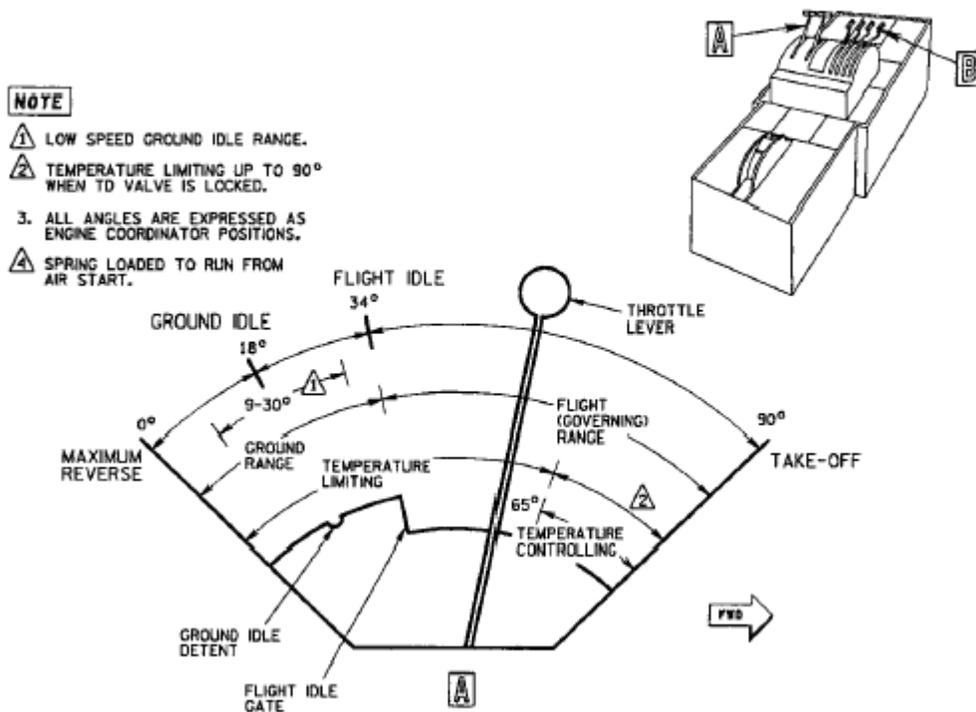
The throttles are quadrant mounted on the flight control pedestal. Throttle movements are transmitted through mechanical linkage to an engine-mounted coordinator. The coordinator transmits the movements through mechanical linkage to the propeller and to the engine fuel control, and it also actuates switches and a potentiometer which affect electronic temperature datum control system operation. Each throttle has two distinct ranges of movement, taxi and flight, which are separated by a stop. Both ranges are used for ground operation, but the taxi range must not be used in flight. In the taxi range, the throttle position selects a propeller blade angle and a corresponding rate of fuel flow. In the flight (governing) range, throttle position selects a rate of fuel flow, and the propeller governor controls propeller blade angle. The throttles have four placarded positions as follows:

1. MAXIMUM REVERSE - (0° travel) gives maximum reverse thrust with engine power approximately 40 percent of take-off power.
2. GROUND IDLE - (Approximately 18 ° travel) is a detent position. This is the ground starting position at which blade angle is set for minimum thrust.

**Note**

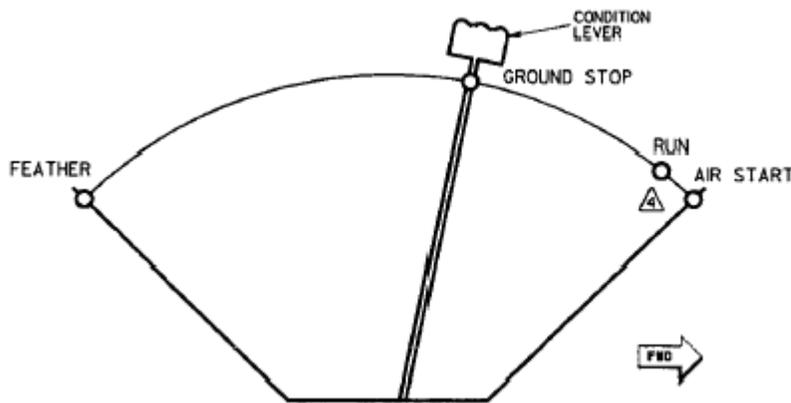
Throttles must not be moved out of GROUND IDLE detent during ground starting because the resultant increase in propeller blade angle might overload the starter, reducing the rate of engine acceleration.

3. FLIGHT IDLE - (34° travel) is the transition point between the taxi and flight (governing) ranges. A step in the quadrant limits aft travel of the throttle at this position until the throttle is lifted.
4. TAKE-OFF - (90° travel) is the maximum power position.



The throttle quadrant is also divided into two unmarked ranges with respect to control of the electronic temperature datum control system. The crossover point is at 65° throttle travel, at which point the switches in the coordinator are actuated. Below this point, the electronic temperature datum control system is limiting turbine inlet temperature. Above this point, it is controlling turbine inlet temperature if the TD valve switches are in the AUTO position.

**Engine Condition Levers**



Four pedestal-mounted, condition levers are primarily controls for engine starting and stopping and propeller feathering and unfeathering. They actuate both mechanical linkages and switches that provide electrical control. Each lever has four placarded positions as follows:

1. RUN is a detent position. At this position, the lever closes a switch that places engine fuel and ignition systems under control of the speed-sensitive control.
2. AIR START is a position attained by holding the lever forward against spring tension. In this position, the lever closes the same switch closed by placing the lever at RUN, and in addition closes a switch that causes the propeller feathering pump to operate.
3. GROUND STOP is a detent position. In this position, the lever actuates a switch that causes the electrical fuel shutoff valve on the engine fuel control to close only if the landing gear touchdown switches are closed. The switch also closes the nacelle preheat control circuit making this system operable.

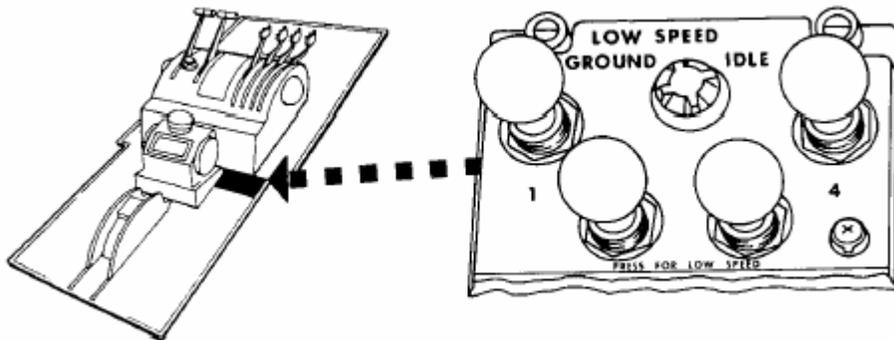
4. FEATHER - A detent position. When the lever is pulled toward this position, mechanical linkages transmit the motion to the engine-mounted coordinator and from the coordinator to the propeller and the shutoff valve on the engine fuel control. Switches are also actuated by the lever as it is pulled aft. The results of moving the lever to FEATHER are the following:

- a. The propeller receives a feather signal and mechanically and electrically energizes the feather solenoid valve.
- b. The fuel shutoff valve on the engine fuel control is closed both mechanically and electrically.
- c. The propeller feathering pump is turned on.
- d. The nacelle preheat system remains operable only when the aircraft is on the ground (if installed).

**CAUTION**

When pulling a condition lever to FEATHER, pull it all the way to the detent to assure that the propeller is fully feathered when the engine fuel is shut off. If the lever is left at midposition, and the NTS is inoperative, an engine decoupling is possible.

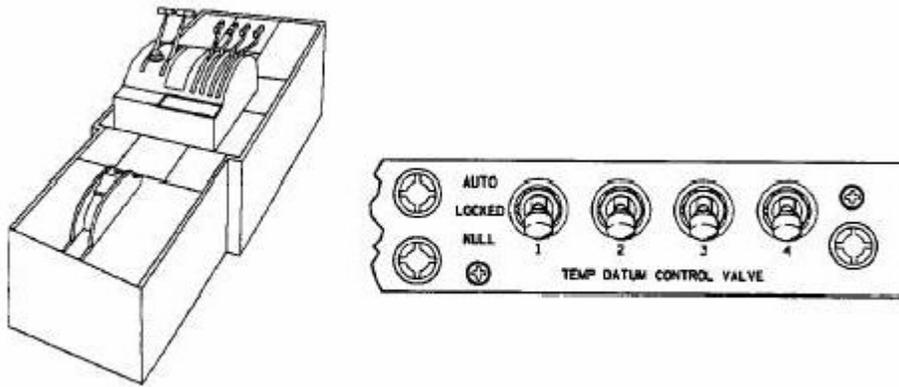
**Low Speed Ground Idle Control Buttons**



Four low speed ground idle control buttons on the control pedestal may be pushed in to reduce engine rpm to approximately 72 percent at any time the throttles are in the range between 9° and 30°. Moving the throttles out of this range will automatically disengage the low speed ground idle buttons.

- With engines in low-speed ground idle, movement of throttles beyond the limits of 9° to 30° (coordinator angle) at ambient temperatures above 80° F may cause engine stall and overtemperature. Therefore, the recommended procedure for coming out of low-speed ground idle is to disengage the buttons manually with the throttles in GROUND IDLE detent.

**Temp Datum Control Valve Switches**



Four temperate datum control valve switches are mounted on a control panel on the flight control pedestal. Each switch has AUTO, LOCKED, and NULL position. The switch positions are used as follows:

The AUTO position permits normal operation of the electronic temperature datum control system by applying single-phase, AC power to the amplifier.

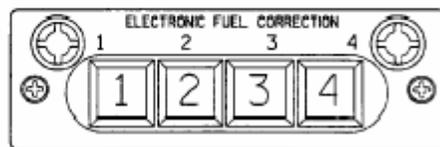
The LOCKED position may be set when the throttles are in temperature-controlling range, to provide a fixed percentage correction on the metered fuel flow throughout the engine operating range and will permit the fuel control to compensate for changes in ambient temperatures in order to maintain a symmetrical shaft horse power at flight idle. If the TD control valve switch is then positioned at LOCKED, the TD valve is locked at whatever position it is in at the time. The TD valves remain locked and the fuel correction lights remain out through all throttle movements, unless an overtemperature condition is sensed by the amplifier. When the switch is in the AUTO or LOCKED position, the temperature datum valve for an engine is unlocked and set to a "take" position if turbine inlet temperature for the engine exceeds approximately 1083°C. If a valve is unlocked by its control system to correct an overtemperature condition, the fuel correction light for that engine comes on to indicate that the valve is unlocked.

The NULL position removes AC power from the control system amplifier; the TD valve, receiving no control signals, returns to its null position so that it does not correct the fuel flow according to turbine inlet temperature. The TD valve brake is released by dc power. The NULL position of these switches is used to deactivate the control systems when erratic fuel scheduling is suspected or when the engines are not operating.



**Electronic Fuel Correction Lights**

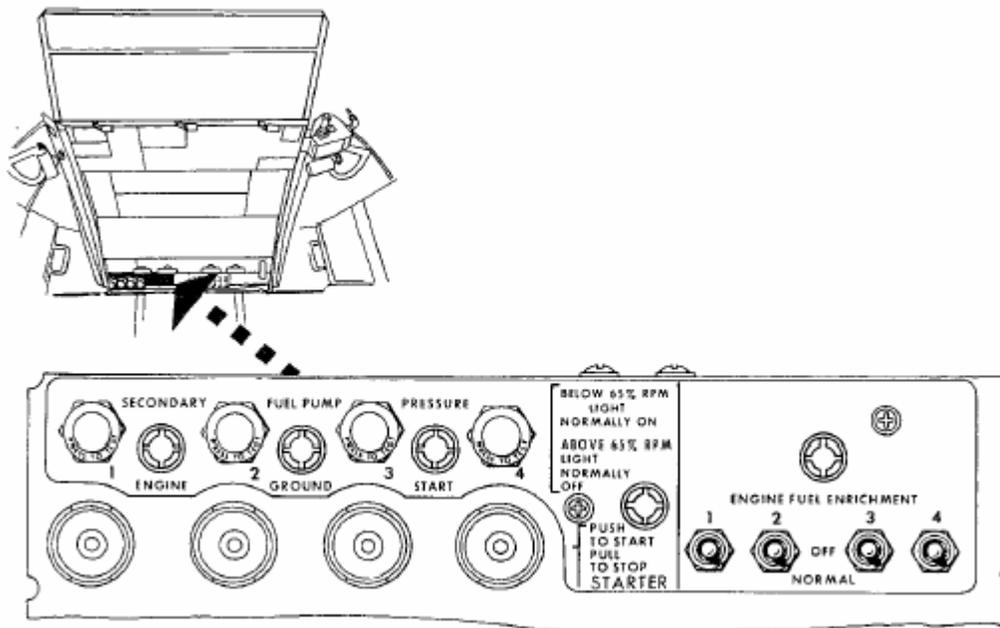
Four amber press-to-test ELECTRONIC FUEL CORRECTION lights are located on the pilot instrument panel.



The lights are on while the throttles are in temperature-limiting range (below 65°) and go out when the throttles are advanced to the temperature-controlling range (above 65°).

**Engine Ground Start Buttons**

The ENGINE GROUND START buttons are located on the engine starting control panel on the overhead control panel. Depressing the ENGINE GROUND START buttons opens the starter regulator valve to permit bleed air from the bleed-air manifold to drive the engine starter turbine. An amber light in the button illuminates as long as the button is depressed. The button can be released at any time to discontinue the start and should be released at 60-percent engine rpm.



**Engine Fuel Enrichment Switches**

The ENGINE FUEL ENRICHMENT switches are located on the engine starting panel. They are toggle switches with NORM and OFF positions. In NORM, each switch allows the engine fuel enrichment valve to be controlled by the speed-sensitive control and manifold pressure switch during starting. The OFF position is provided to permit deactivating the fuel enrichment system for any engine. During the engine starting cycle the fuel enrichment system furnishes unmetered fuel to the TD valve to supplement normal flow through the fuel control. This enriching starts at 16-percent rpm and lasts only until fuel manifold pressure reaches approximately 50 psi.

**Engine Bleed Air Valve Switches**



The ENGINE BLEED AIR switches, located on the anti-icing and de-icing control panel (*Overhead 2*), are two-position (OPEN CLOSE) toggle switches. Each switch controls a pressure-actuated, dual solenoid-controlled pressure regulator. When the bleed air switch is in OFF, the regulator shuts off all airflow to or from the engine.

When the switch is in the ON position, the regulator regulates air flow from the engine to the bleed air manifold to approximately 50 psi and prevents air flow into the engine nacelle if the bleed air manifold pressure is above approximately 50 psi. Low bleed air manifold pressure will allow airflow into an engine nacelle. A check valve is provided to prevent backflow into the engine diffuser.

**ENGINE INSTRUMENTS**

The engine instruments are located on a panel at the center of the main instrument panel. Indicator lights for fuel pressure warning are on the overhead control panel.



**1. Torquemeters**

Each of the four torquemeters indicates positive and negative torque in inch-pounds. The indicated torque is detected at the extension shaft between the engine power section and reduction gear assembly.

**2. Tachometers**

Each of the four tachometers indicates engine speed in percent of normal engine rpm. Normal speed (100 percent) equals 13,820 engine rpm. A vernier dial on each indicator makes it possible to read to the nearest percent. The tachometer system uses a separate engine-driven tachometer generator, mounted on each engine that is not dependent upon the aircraft electrical system for operation.

**3. Turbine Inlet Temperature Indicators**

Each of the TIT indicators indicates temperature sensed by thermocouples in the engine turbine inlet casing. Each indicator registers temperature in degrees Centigrade and contains a vernier scale graduated in degrees.

**4. Fuel Flow Gauges**

Each of the four fuel flow gauges indicates flow in pounds per hour. Flow is measured at the point where fuel enters the manifold on the engine.

**5. Oil Temperature Gauges**

The four oil temperature gauges indicate oil temperature in the oil inlet lines in degrees Centigrade.

**6. Oil Pressure Gauges**

Four oil pressure gages register oil pressure for both the engine power sections and reduction gears.



**Secondary Fuel Pump Pressure Lights**

Four Secondary Fuel Pump Pressure lights are located on the engine starting and fuel electrical panel. Each light is controlled by a pressure switch on the engine fuel pump and filter assembly. The light is normally ON while the two gear pumps in the assembly are operating in parallel during engine starting (prior to 65-percent rpm).

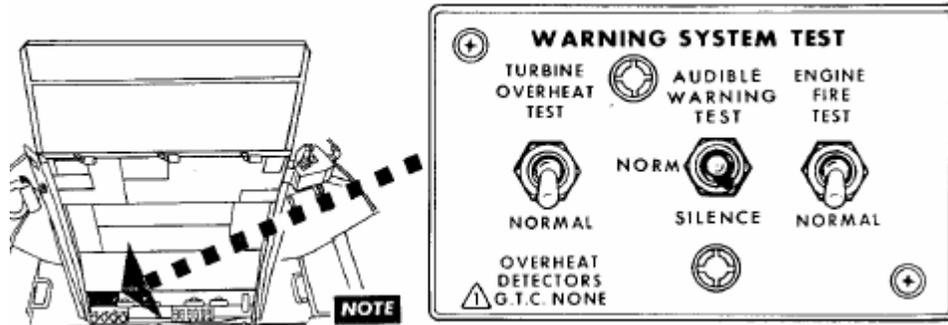
**FIRE AND OVERHEAT DETECTION SYSTEMS**

A fire detection system is provided for each engine and the GTC. An overheat detection system is provided for the engine turbine and nacelle, anti-icing, and air conditioning.

**FIRE DETECTION SYSTEM**

The fire detection system for each engine and GTC consists of a continuous loop detector, an amplifier, and warning lights in the flight station. When a high temperature is detected, the amplifier unit initiates a signal to the warning lights. These lights give a steady red glow when activated.

**Fire Detection System Test Switch**



The fire detection test switch is located on the warning system test panel on the overhead control panel. The test system is provided to test the operation of the detectors and the warning lights. When the test switch is placed in the TEST position, all five fire detection systems are activated and the warning lights will go on. Failure of a warning light to go on indicates a break in continuity in the warning circuit.

**Turbine Overheat Detector Test Switch**

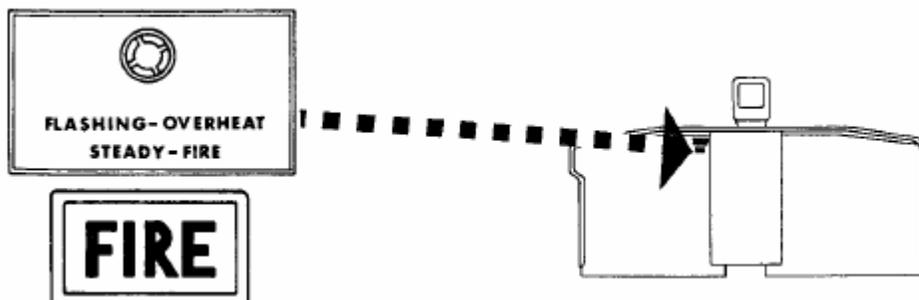
The OVERHEAT DETECTORS test switch is located on the warning system test panel on the overhead control panel. The switch has NORMAL and TEST positions. When positioned at TEST, it closes all four of the overheat warning system circuits in the same manner as if they were closed by detectors sensing an overheat condition. If the indicator lights all come on and flash when the switch is operated, circuit continuity and flasher operation are satisfactory.

**FIRE DETECTION SYSTEM WARNING LIGHTS**

The fire detection system warning lights consists of the master fire warning light and the lights in the fire emergency control handles.

**Master Fire Warning Light**

A red master fire warning light and an edge-lighted panel are located on the pilot instrument panel. If a fire is detected by any one of the detection systems, the warning light and panel light will glow steadily. The steady light distinguishes the signal from an overheat warning indication that is a flashing of the same light. When the master light indicates a fire, the lights in one of the fire emergency control handles will be on also to indicate the location of the fire.



### Fire Emergency Control Handle Lights

Each fire emergency control handle contains two red indicator lights that glow steadily when a fire is detected in the corresponding engine. The lights glow steadily to distinguish the indication from the flashing overheat warning indication.

### TURBINE OVERHEAT WARNING SYSTEM

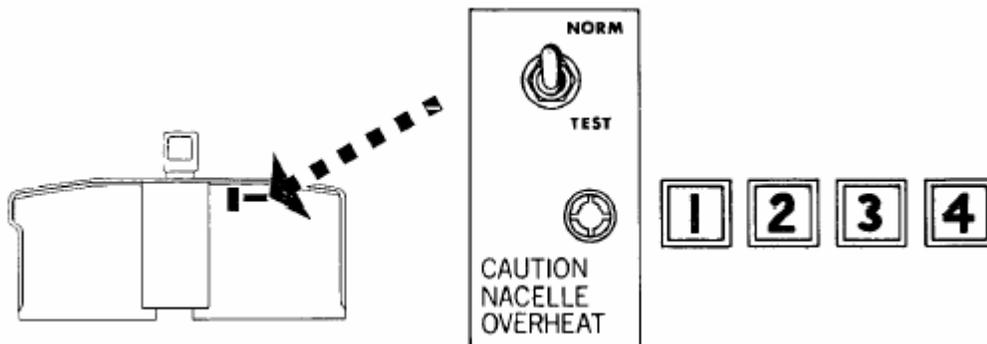
An overheat warning system is provided for each engine turbine. Each system consists of four thermal-switch detector units mounted in the "hot section" of the nacelle aft of the firewall, a flasher, and indicator lights. These components are interconnected so that an overheat condition sensed by any one of the detectors causes the lights to flash. The detectors are connected in parallel to a loop, and, if part of the detectors is inoperable, the remaining detectors can still close the circuit to turn on the lights. A test switch permits testing all four systems at the same time. The setting at which the detector lights will give an overheat warning is approximately 371 °C (700 °F).

### Turbine Overheat Warning Lights

Overheat warning of the engine turbine is indicated by the *flashing* of the master fire warning light and the lights in the fire emergency control handles.

### NACELLE OVERHEAT WARNING SYSTEM

An overheat warning system is provided for each nacelle. Each system consists of thermal-switch detector units, mounted in the nacelle area forward of the fire wall, and a warning light on the copilot instrument panel. A test switch is provided for testing all four warning systems simultaneously. The purpose of each system is to warn of an overheat condition in the area around the engine compressor section. Overheat in this area can result from the nacelle preheat valve being opened, or a rupture occurring in the bleed-air system ducts. The overheat condition could also result from fire. The overheat condition can be detected by any one of the six detectors, which are connected in parallel to a loop. The setting at which the detector lights will give an overheat warning is approximately 149 °C (300 °F).



### Nacelle Overheat Test Switch

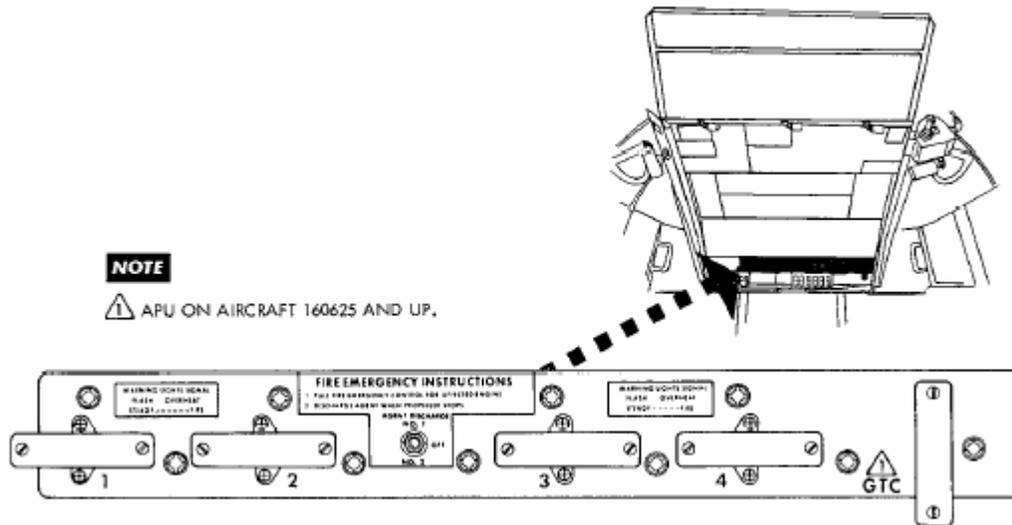
A NACELLE OVERHEAT test switch is located on the copilot instrument panel next to the warning lights. Operation of the test switch closes all four nacelle overheat warning circuits simultaneously, causing all four warning lights and the panel lights to glow as long as the switch is held in TEST. Failure of a light to go on indicates a break in continuity in the warning circuit.

**FIRE EXTINGUISHING SYSTEM**

A two-shot BT fire extinguishing system is connected through a series of directional-flow valves to each of the four engine nacelles and to the GTC compartment. The extinguishing agent is contained in two bottles mounted in the left wheel well. Each bottle contains approximately 27 pounds of agent. One bottle is discharged each time the system is actuated. A check valve prevents a discharged bottle from being recharged when a fresh bottle is fired. Each bottle is charged to approximately 600 psi with nitrogen, the nitrogen acting as a propellant for the BT. Individual pressure gauges on each bottle show charged pressure.

**FIRE EXTINGUISHING SYSTEM CONTROLS**

The fire extinguishing system controls are located on the fire emergency control panel forward of the overhead electrical control panel.



**Agent Discharge Switch**

A three-position (No. 1, OFF, No. 2) toggle switch located on the fire emergency control panel controls the discharge of the bottles. The AGENT DISCHARGE switch is spring-loaded to the OFF position. The agent will not discharge unless a fire emergency control handle is pulled. The fire emergency handle circuit powers the correct sequence of solenoid directional control valves in the system to direct flow of agent to the selected engine when one of the bottles is fired. The control valves move in the same order as the handles are pulled. If two fire emergency control handles are pulled, the agent will be routed to the engine for the last handle pulled. In order to route agent to the engine for the first handle pulled, the first handle must be pushed in and pulled again.



**Fire Emergency Control Handles**

The five plastic fire emergency control handles are mounted on the fire emergency control panel. They operate emergency shutdown switches for the GTC and the four engines.

When an engine handle is pulled out, it closes dc circuits to operate valves which isolate the engine as follows:

1. The shutoff valve on the engine fuel control is closed.
2. The engine oil shutoff valve is closed.
3. The firewall fuel shutoff valve is closed.
4. The firewall hydraulic shutoff valves are closed.
5. The engine bleed-air valve is closed.
6. Engine starting control circuits are de-energized.
7. The propeller is feathered.
8. The fire extinguisher system control valves are positioned for routing agent to the engine.
9. The extinguishing AGENT DISCHARGE switch is armed.

When the GTC handle is pulled, the GTC is isolated as follows:

1. The GTC fuel shutoff valve is closed.
2. The GTC oil shutoff valve is closed.
3. The GTC bleed-air valve is closed.
4. The fire extinguisher system control valve is positioned for routing agent to the GTC.
5. The extinguisher AGENT DISCHARGE switch is armed.
6. The GTC door will remain where it was when the handle was pulled.

## **PROPELLERS**

Each engine is equipped with a Hamilton Standard, four-blade, electro-hydromatic, full-feathering, reversible-pitch propeller. The propeller operates as a controllable-pitch propeller for throttle settings below flight idle and as a constant-speed propeller for throttle settings of flight idle or above. The major components of the propeller system are the propeller assembly, the synchrophasing system, the control system, and the anti-icing and deicing system.

### **PROPELLER SPEED CONTROL SYSTEM**

The speed of the propeller is controlled by the propeller governing system and the synchrophasing system.

### **PROPELLER GOVERNING SYSTEM**

The principal function of the propeller governing system is to maintain constant engine operating rpm. Propeller governing is accomplished by the action of the flyweight speed-sensing pilot valve.

### **SYNCHROPHASING SYSTEM**

The synchrophasing system is an electronic system for controlling the blade position relation between all four engines.

### **ELECTRONIC PROPELLER GOVERNING**

The synchrophaser electronic unit provides circuits for the following governing functions: speed stabilization (derivative), throttle anticipation, and synchrophasing. The propeller mechanical governor will hold a constant speed in the flight range but throttle changes will cause the governor to overspeed or underspeed while trying to compensate for the change in power.

### **NTS LOCKOUT SYSTEM**

The propeller is equipped with a lockout system to deactivate the NTS system for throttle settings below flight idle. When the throttle is moved below flight idle, a cam moves the actuator away from the NTS plunger and renders the system inoperative. This is necessary to prevent a propeller from receiving a possible negative torque signal at high landing speeds when the throttles are moved toward reverse, with resultant asymmetrical power problems.

### **PROPELLER CONTROLS**

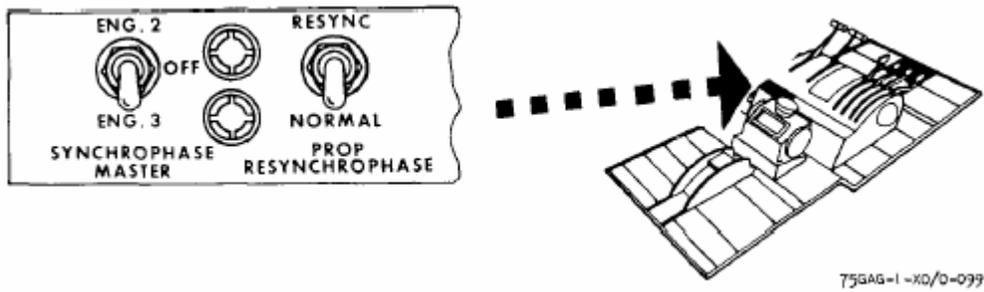
#### **Throttles**

Each throttle is mechanically linked through the engine coordinator to an input shaft on the propeller control assembly. When the throttle is in the governing range, between FLIGHT IDLE and TAKE-OFF positions, the input shaft rotates with throttle movement but has no effect on propeller speed. When the throttle is in the range below FLIGHT IDLE, any movement of the throttle is transmitted to the speed sensing pilot valve to increase or decrease blade angle. The maximum negative blade angle is obtained when the throttle is at MAXIMUM REVERSE. Approximate minimum thrust angle is obtained when the throttle is at GROUND IDLE. When the throttle is moved below FLIGHT IDLE, a cam locks out tie NTS system and a switch interrupts synchrophaser signals to the propeller.

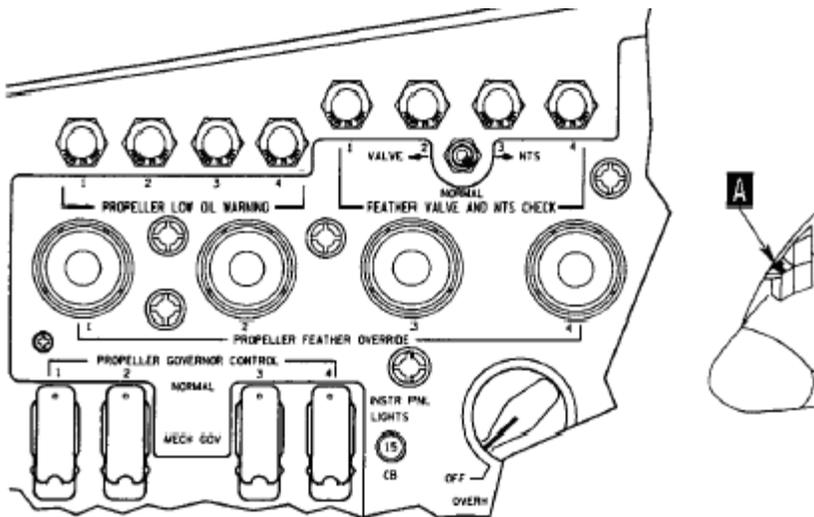
#### **Engine Condition Levers**

The engine condition levers serve primarily as feathering and unfeathering controls. Each lever is mechanically linked to the engine coordinator, which transmits the motion of the lever to the propeller linkage only when it is moved to the FEATHER position. When pulled to FEATHER, the condition lever also actuates switches to turn on the electrically driven auxiliary pump in the propeller control assembly, and the propeller blades are moved to the feather angle. For unfeathering, the engine condition lever is held in the AIR START position. A switch is actuated to turn on the propeller auxiliary pump, and the pump continues to operate as long as the lever is held in this position. When the engine condition lever is in the AIR-START position and the auxiliary pump is operating, fluid is routed to the aft side of the dome assembly piston to move the blades to low-pitch angle. When the condition lever is in GROUND STOP or RUN positions, the propeller is controlled normally and the lever has no effect on its operation.

**Synchrophase Master Switch**



The SYNCHROPHASE MASTER switch is located on the flight control pedestal. This three-position (ENG 2, OFF, ENG 3) toggle switch controls the operation of the synchrophase system and selects the engine to be used as the master. When the switch is in the ENG 2 position, the No.2 engine is selected as the master and the other propeller phase angles are referenced to this engine. When the switch is in the OFF position and the propeller governor control switches are in the NORMAL position, the synchrophasing system is turned off and the propellers operate in normal governing. If the propeller governor control switches are in the MECH GOV position, the propellers operate in mechanical governing. When the switch is in the ENG 3 position, the No.3 engine is the Master and the other propeller phase angles are referenced to this engine.



**Propeller Low Oil Level Warning Lights**

A PROPELLER LOW OIL WARNING light for each propeller is located on the copilot side shelf. A PROP LOW OIL QUANTITY light that acts as a master warning light is located on the engine instrument panel. The propeller low oil warning system is controlled by a float-actuated switch in each propeller control assembly. When the oil quantity for any propeller drops approximately 2 quarts below normal, the float-actuated switch closes and illuminates the PROPELLER LOW OIL WARNING light for that engine and the PROP LOW OIL quantity light. If the oil quantity becomes low for another propeller, the only indication will be from the PROPELLER LOW OIL WARNING light for that engine.

**Propeller Governor Control Switches**



The four PROPELLER GOVERNOR CONTROL switches are two-position (NORMAL, MECH GOV) guarded toggle switches located on the copilot side shelf. When the switches are in the NORMAL position the throttle anticipation and speed stabilization (derivative) circuits are operative, and if the SYNCHROPHASE MASTER switch is positioned to either master engine the blade rotational position of the slave engines is related to the master by the synchrophasing system. Placing a

switch in the MECH GOV position disconnects the electrical speed control to that propeller, and the speed of the propeller is controlled by basic mechanical governing.

### Feather Override Buttons



Four FEATHER OVERRIDE buttons are located on the copilot side shelf to provide a means of manually stopping the propeller auxiliary pump. When a condition lever is moved to FEATHER, electrical circuits are completed to the feather solenoid valve, propeller auxiliary pump, pressure cutout

switch, and a holding circuit to the feather override button.

If a FEATHER OVERRIDE button is manually pulled after a condition lever is placed in FEATHER, the electrical circuits for propeller feathering are interrupted. If a FEATHER OVERRIDE button does not pop out after the feather cycle is complete, it should be pulled manually to prevent damage to the propeller auxiliary pump

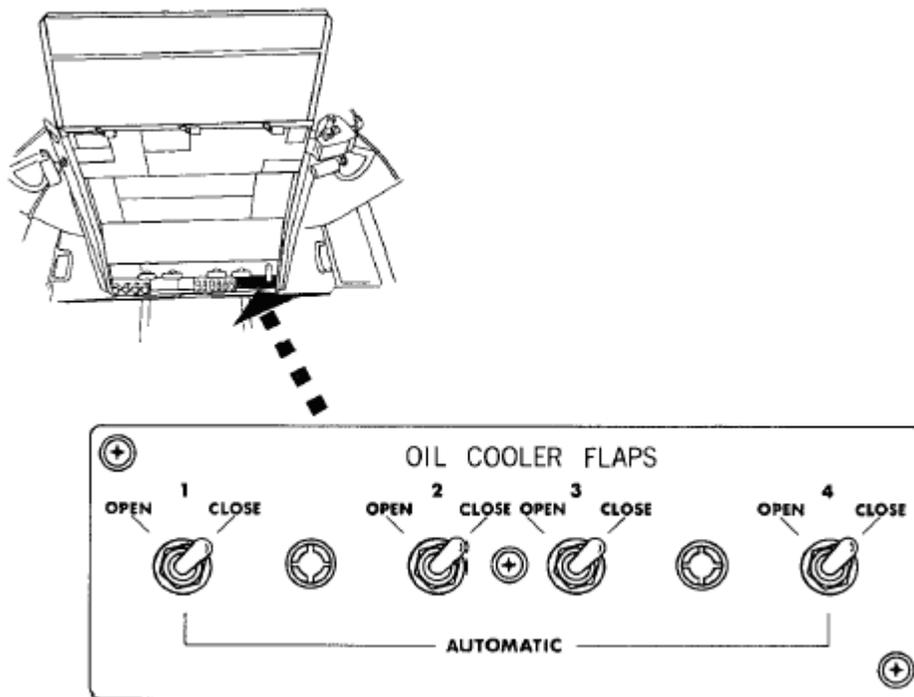
**OIL SYSTEM**

Independent oil systems, one for each engine, supply lubrication to the engine power section and the reduction gear assembly. An oil tank with a 12-gallon usable oil capacity is located in each nacelle above the engine. The oil tanks are provided with a pendulum tube oil pickup to prevent loss of oil pressure under negative "g" conditions. The pendulum will accompany the oil in a negative "g" condition, assuring positive oil pressure. Oil from the tank enters the power section and the reduction gear assembly, where it is circulated and returned by scavenger pumps through a heat exchanger and oil cooler back into the oil tank. Hot oil passing through the heat exchanger heats the engine fuel and prevents ice from forming in the fuel filter. Air flowing through an oil cooler duct and over the coils of the oil cooler absorbs excess heat from the oil. Four motor-operated valves provide an emergency means of shutting off oil flow to the engines when the fire emergency control handles are pulled.

**OIL SYSTEM CONTROLS**

Oil system controls available to the flight crew are the oil cooler flap switches and the fire emergency control handles.

**Oil Cooler Flap Switches**



Airflow through the oil cooler is governed by a controllable oil cooler flap which restricts the opening of the oil cooler air exit duct. Four three-position (AUTOMATIC, OPEN, CLOSE) toggle switches control the electrical circuits of the oil cooler flap actuators. When the switch is in the AUTOMATIC position, the position of the oil cooler flap is regulated by a thermostatic unit to cool the oil. In the spring-loaded OPEN or CLOSE positions, the thermostat is bypassed in the circuit, and the actuator is directly energized to open or close the oil cooler flap.

The AUTOMATIC position provides for all normal operation of the oil cooler flaps. The OPEN, CLOSE positions are used to control the oil cooler flap actuator manually if the thermostatic control unit is not operating properly.

## **OIL SYSTEM INDICATORS**

The oil system indicators are an oil quantity gage for each engine, a low oil quantity warning light, and an oil cooler flap position indicator for each engine. All of the indicators are located on the engine instrument panel.

### **Oil Quantity Gages**



Four OIL QUANTITY gages one for each engine oil system, are located on the engine instrument panel. Each indicator is calibrated from 0 (empty) to F (full) in increments of 1 gallon.

### **Low Oil Quantity Warning Light**



A low oil quantity warning light is located on the engine instrument panel. A microswitch in each engine oil tank quantity transmitter, actuated by the tank float arm, will cause the light to illuminate when any oil tank level drops to 4 gallons. Operation of the light is independent of quantity indicators; however, no additional warning is supplied should a second tank reach a low level.

### **Oil Cooler Flap Position Indicators**



Four OIL COOLER FLAP position indicators one for each engine oil system, are located on the engine instrument panel. The indicators are electrically connected to position transmitters geared to the oil cooler flap actuators. The indicator dials, calibrated from 0 to OPEN in increments of 10 percent, indicate the percent of opening of the oil cooler flaps.

## FUEL SYSTEMS

The fuel system is a modified manifold flow type, incorporating a fuel crossfeed system, a single point refueling and defueling system, an inflight refueling system, and a fuel dump system. The system provides fuel supply for the four engines and auxiliary power unit.

### FUEL FLOW

Each engine may be supplied fuel either directly from the main respective fuel tank or through the crossfeed manifold system from any tank. Fuel for the GTC is routed directly from the No.2 fuel tank.

### REFUELING AND DEFUELING

All wing tanks and the fuselage tank (if installed) may be refueled or defueled from the single point ground refueling and defueling receptacle located in the right main landing gear fairing. When refueling, fuel is routed from the single point receptacle through the refueling manifold to each tank through separate supply lines from the manifold.

Fuel level in the tanks is controlled by float shutoff valves. All tanks except No.1 and No.4 contain one shutoff valve which allows the tanks to be filled to their maximum capacity maintaining a minimum of 3 percent expansion space. Two shutoff valves in both the No.1 and No.4 tanks are located at different levels. These valves are controlled by the refueling pods disconnects.

TANK	USABLE FUEL		UNUSABLE FUEL	
	GAL	LB	GAL	LB
MAIN NO.1	1350	9044	10	67
MAIN NO.2	1240	8307	10	67
LEFT EXT	1400	9379	40	268
LEFT AUX	910	6096	9	60
RIGHT EXT	1400	9379	40	268
RIGHT AUX	910	6096	9	60
MAIN NO.3	1240	8307	10	67
MAIN NO.4	1350	9044	10	67
<b>TOTALS</b>				
MAIN TANKS ONLY	5180	34702	40	268
MAIN AND AUX TANKS	7000	46894	58	388
MAIN AND EXT TANKS	2800	53460	120	804
MAIN, AUX AND EXT TANKS	9800	65652	138	924

### INTERNAL TANKS

Six fuel tanks are located within the wing. The No.1, 2, 3 and 4 tanks are integral and use sealed wing structure for tank walls. The left and right auxiliary fuel tanks are each comprised of units of three bladder cells. The three cells are interconnected to form one assembly and laced within the center wing section. Each of the six tanks has a three-phase, AC-powered boost pump to ensure fuel flow. The water removal system, located in each main tank, maintains the fuel level around the boost pump when the aircraft is in a nose-down attitude with low fuel level in the tank. The No. 1, 2, 3, and 4 tanks have, in addition, a dump pump which is used for fuel dumping and transfer.

#### Note

One more additional virtual tank is technically required for the fuel system programming in the MS FS.

### WATER REMOVAL SYSTEM

The water removal system provides continual water removal from the tank low points during boost pump operation. The system consists of two ejectors, a check valve, a strainer, and associated plumbing in each main tank. The ejectors are connected by plumbing to the boost pump discharge line and a part of the boost pump fuel flow is routed through each ejector housing and discharged through its nozzle. This fuel flow through the ejectors causes a differential pressure and additional fuel is drawn from between the lower wing

panel risers and is ejected into the surge box. Anytime the fuel boost pump is operating, the fuel will be continually stirred preventing water from settling in the bottom of the tank.

### **VENT SYSTEM**

All of the six wing fuel tanks are vented to the atmosphere to equalize pressure at all times. Tanks No.2 and 3 and the left and right auxiliary tanks have a wraparound vent system. The wrap-around system permits venting for these tanks even though the aircraft is not in a wing-level attitude.

### **CROSSFEED PRIMER SYSTEM**

A press-to-actuate CROSSFEED PRIMER VALVE button is located on the fuel control panel. This button, when pressed, moves the motor-operated crossfeed fuel primer valve to the open position and opens the motor-driven crossfeed separation valve. This allows fuel to flow through the manifold into the No.2 fuel tank to remove any trapped air. Releasing the button actuates the primer valve to the closed position and closes the crossfeed separation valve.

### **EXTERNAL TANKS**

Two all-metal external fuel tanks are mounted under the wings on pylons between the inboard and outboard engines. The tanks are partially compartmented for center-of-gravity control. All fuel flows into the center compartment through check valves. A surge box in the tank center compartment contains a forward and an aft boost pump, providing dual reliability and an increased fuel dumping rate if both pumps are operated during fuel dumping. Both pumps have overriding output pressures which under normal operation ensure depletion of fuel from the external tanks before the main tanks are affected.

### **FUEL DUMP SYSTEM**

A fuel dump system is provided to enable all fuel, except approximately 1,600 pounds each from the No.1 and No.4 wing tanks, 1,500 pounds each from the No.2 and No.3 wing tanks, 65 pounds from each external tank, and approximately 1,000 pounds from the fuselage tank, to be dumped overboard.



Eight two-position (OFF, DUMP) toggle switches for the wing tanks are located on the engine fuel control panel. Two-position (NORM, DUMP) guarded toggle switches and two rotary interconnect switches are located on the auxiliary fuel control panel. The dump rate is approximately 3,900 pounds per minute from the wing tanks with all pumps operating and at least 5,100 pounds per minute from the fuselage tank with both pumps operating. All tanks feed into a common manifold in the wing, then to a dump mast in each wing tip. Check valves at each tank dump outlet prevent reverse flow.

The four main wing tanks have individual integral pumps specifically, for fuel dumping. The two auxiliary and two external tanks use the same pumps for dumping that are used for normal boost operation. The fuselage tank uses the in-flight refueling pumps for dumping. Actuation of the tank dump switch will open the tank dump valve and turn the pump on for the selected tank.

To complete the dump operation, the interconnect switches on the auxiliary fuel panel are turned to the flow condition and the two guarded dump switches on the auxiliary fuel control panel are placed in the DUMP position. When the auxiliary tanks dump switches are actuated the auxiliary tanks crossfeed valves will close.

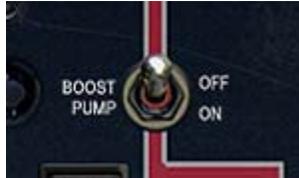
### **FUEL STRAINER AND HEATER UNIT**

A combination fuel strainer and heater is located in the right side of each nacelle. Heat is transferred from engine oil to the fuel in the heater unit, and the temperature is controlled thermostatically.

## **FUEL SYSTEM CONTROLS**

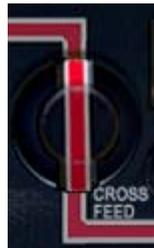
Controls for normal inflight management of engine fuel are located on the fuel control panel

### **Boost Pump Switches**



Ten BOOST PUMP switches are located on the fuel control panel. The No.1, 2, 3, and 4 fuel tank boost switches control the internal boost pumps for their respective tanks. The left and right AUX TANK PUMP switches control the pump in each of the auxiliary tanks. Four BOOST PUMP switches, one forward and one aft for each external tank control the pumps in the external tanks.

### **Crossfeed Valve Switches**



Eight CROSSFEED valve switches are located on the fuel control panel. When the switches are placed in the flow position (switch markings aligned with the fuel control panel markings), the valve motors are energized to open the valves. When the switches are placed in the no-flow position (switch markings at right angles to the panel markings), the valve motors are energized to close the valves. In case of power failure, the valves hold the last energized position.

### **Bypass Valve Switches**



Two bypass valve switches are located on the fuel control panel to permit an alternate path for fuel from the left and right auxiliary and external fuel tanks if cross-feed or dump valves fail to open.

These two-position rotary switches route power to motor-operated bypass valves.

When switches are placed in bypass position, (switch markings aligned with fuel control panel markings), valve motors are energized to open the valves and allow external tank fuel to be crossfeed or jettisoned through the auxiliary tank crossfeed or jettison valves, and vice versa.

The bypass valves may be used to jettison main tank fuel in the event of main tank dump valve/pump failure. When switches are placed in the off position (switch markings at right angles to panel markings), valve motors are energized to close the valves. In case of power failure, the valves hold the last energized position. The bypass valves can also be used as an alternate path for fuselage tank fuel flow.

### **Crossfeed Separation Valve Switch**



The CROSSFEED separation switch is located on the fuel control panel. The crossfeed separation valve is provided in the crossfeed manifold system to permit additional control on fuel routing. With the crossfeed separation valve closed, the left wing tanks supply fuel to engines No.1 and No.2 while the right wing tanks supply fuel to engines No. 3 and No. 4. This procedure ensures a more even fuel consumption when operating from the auxiliary tanks through the crossfeed manifold.

Since there may be a slight variation in boost pump pressure, and if both pumps were supplying the manifold, the pump operating at the highest pressure would feed the manifold if not prevented by the separation valve. However, the crossfeed separation valve is used primarily for fuel balancing between the left- and right-hand fuel tanks, and when crossfeeding from the fuselage tank.

## **FUEL SYSTEM INDICATORS**

Quantity gages and warning lights are located on the fuel control panel and the auxiliary fuel control panel, to give the crew a continuous visual indication of the status of the fuel system.

### **Total Fuel Quantity Indicator**



A TOTAL FUEL QUANTITY indicator is located in the center of the fuel control panel. The indicator continuously shows the total fuel quantity (in pounds) in the fuel tanks when the single-point refueling master switch is in the OFF position. When the master switch is in any position other than OFF, the TOTAL FUEL QUANTITY indicator is de-energized. The indicator is tested when an individual tank quantity indicator is tested as described in paragraph titled Fuel Quantity Indicators and Test Switches.

### **Fuel Quantity Indicators and Test Switches**



Six individual wing tank fuel quantity indicators are located on the fuel control panel.

Each tank indicator, connected to a capacitance gauge in one of the wing fuel tanks, gives a continuous visual indication of the pounds of fuel contained in that tank.

Quantity IND TEST switches are provided to test the quantity indicating system. When depressed, these PRESS-TO-TEST switches provide a ground to their associated indicator causing those indicator pointers to move toward zero.

### **Aux and Ext Tank Empty Lights**



Two AUX TANK EMPTY lights and two EXT TANK EMPTY lights are located on the fuel control panel in the flight station. If the BOOST PUMP switch associated with a given auxiliary or external tank is positioned at ON and there is no source of higher pressure to that side of the manifold, the associated tank empty light will be illuminated whenever output flow pressure is below approximately 23 psi. Illumination of the light indicates either depleted tank quantity or an inoperative boost pump or (in the case of the external tanks only) failure of the fuel level control valve in the open position.

### **Fuel Low Press Warning Lights**



Four fuel LOW PRESS warning lights are located on the fuel control panel. Each light goes on when pressure in the fuel supply line to the engine pump drops below approximately 8.5 psi. When a light goes on, it indicates a possible booster pump failure, valve failure, fuel line failure, or a malfunctioning pressure switch.

**Manifold Press Indicator**

A MANF PRESS indicator, located on the fuel control panel indicates fuel pressure in the crossfeed manifold. The indicator is used to check fuel boost pumps before starting engines and used during flight only to determine if a pump is operating. This indicator is electrically connected to a fuel pressure transmitter. The transmitter measures the pressures of the crossfeed manifold. Thus, when the fuel boost pumps are turned on individually, the pressure supplied the crossfeed system by any pump is measured by the transmitter and shown by the indicator.

## **ELECTRICAL POWER SUPPLY SYSTEMS**

The internal electrical power supply for aircraft use comes from five AC generators or from the battery. Each engine drives one 40-kilovolt ampere (kVA) AC generator and the air turbine motor (ATM) drives one 20-kVA AC generator. The air turbine motor-driven generator is basically rated at 20kVA. However, because the air turbine motor fan provides sufficient cooling air, the generator is rated in this installation at 30 kVA for continuous operation.

Power from these AC generators is used to provide electrical power for aircraft use:

- 28V dc;
- 200/115V, 380/420-Hz, three-phase primary AC;
- 115V, 400-Hz, single-phase, secondary and primary AC.

The four engine-driven AC generators are connected through a series of relays to four AC buses;

- the left-hand AC bus,
- the essential AC bus,
- the main AC bus,
- and the right-hand AC bus.

The relay system operates in such a manner that any combination of two or more of the engine-driven AC generators will power all four of the buses. If only one generator is operating, it will power only the essential AC bus and the main AC bus. The air turbine motor-driven AC generator will power only the essential AC bus at any time. All in-flight controls for operation of the electrical system are located on the electrical control panel on the overhead panel in the flight station.

## **EXTERNAL POWER PROVISIONS**

Both dc and AC external power receptacles are located on the left side of the fuselage just aft of the battery compartment. DC power from the external source is supplied through two current limiters to the main dc bus. Any dc electrically operated equipment on the aircraft, except equipment connected to the battery bus can be supplied from an external dc power source. The battery is disconnected from all dc buses except the battery bus when external dc power is being used.

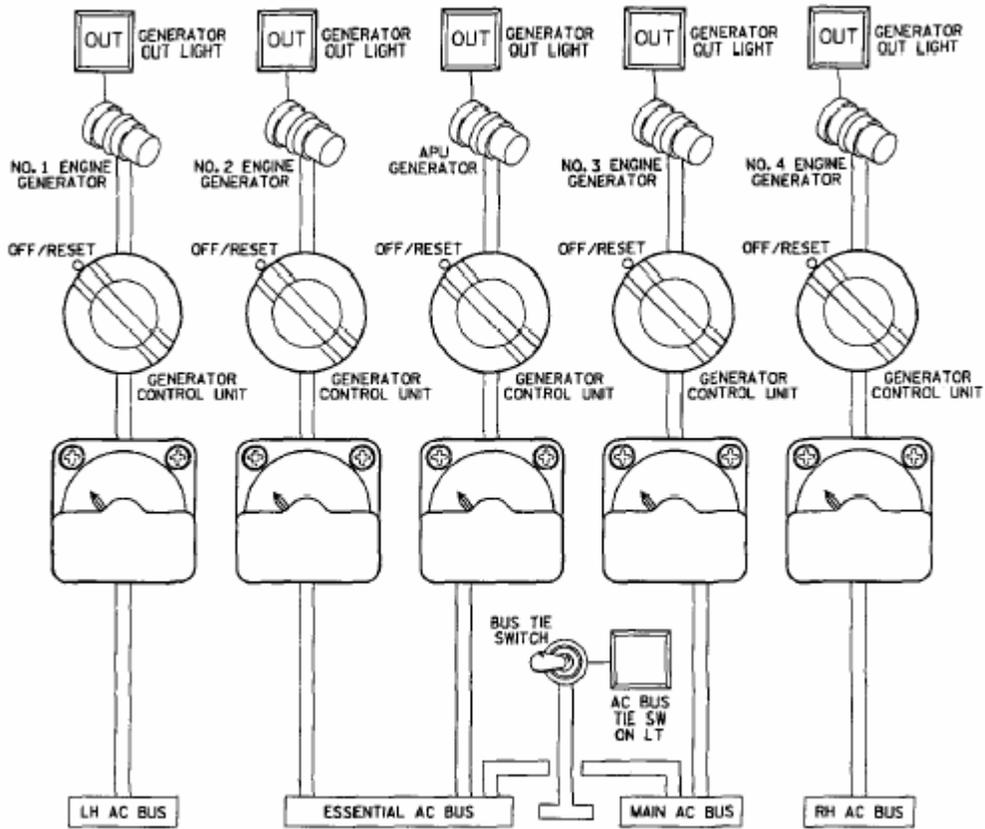
When an external AC power source is connected to the aircraft, power is supplied to all AC buses, to the dc buses through transformer-rectifier units, and to the battery bus to charge the battery if the dc power switch is in the BATTERY position.

### **Note**

The ATM generator switch must be in the OFF position before external AC power can be fed into the aircraft system.

## **PRIMARY AC SYSTEM**

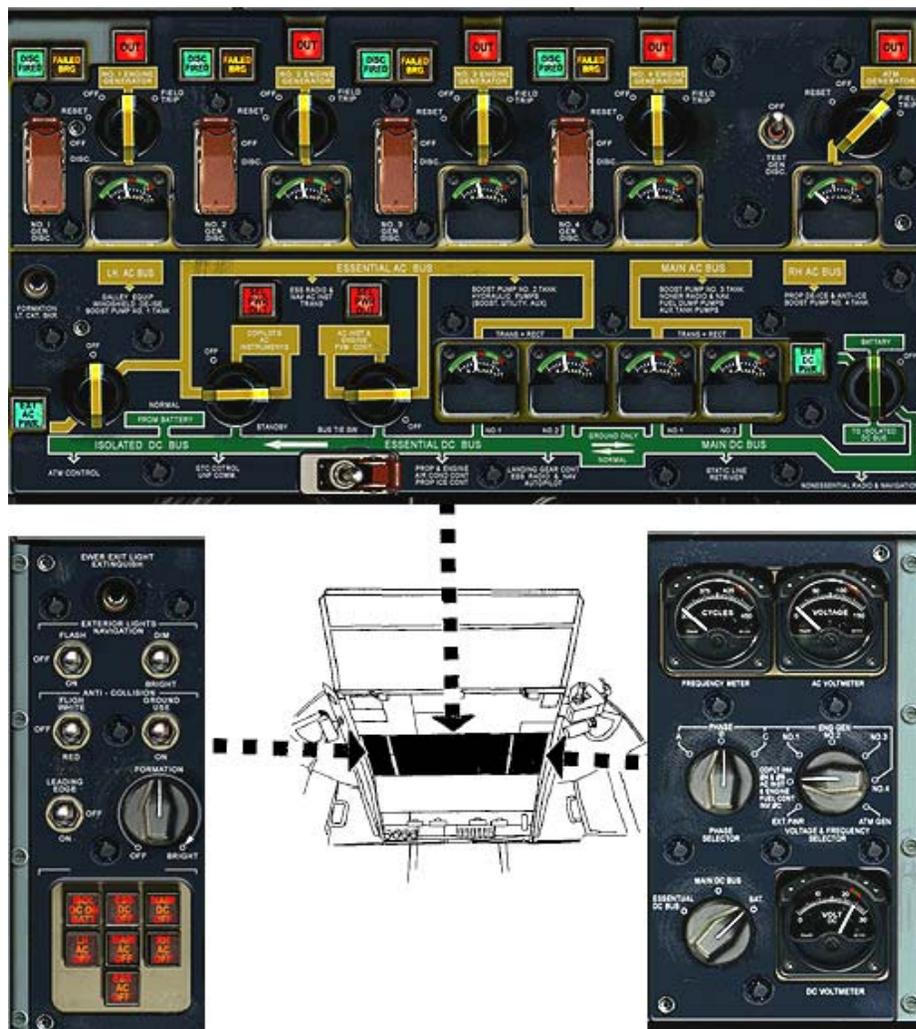
Power for the primary AC system is supplied by five AC generators. This power supply is also used to operate the secondary AC systems and the dc system.



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**PRIMARY AC SYSTEM CONTROLS**

The AC system controls, with the exception of a manual reset lever on each generator control panel, are located aft of the overhead electrical control panel in the flight station.



**Generator Switches**



The generator switches consist of five four-position rotary-type switches located on the overhead electrical control panel in the flight station. When a switch is in the ON position (knob stripe aligned with panel stripe), a relay closes contacts to connect the generator to the buses if the generator is operating normally.

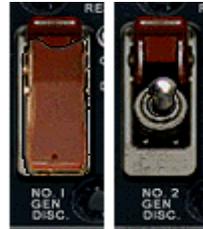
All engine generators are off line when the low-speed ground idle buttons are engaged; therefore, the ATM must be used to provide power to the essential AC bus, which is the only bus it supplies.

When the switch is placed in the OFF position, the relay disconnects the generator from the system. If the switch is turned to FIELD TRIP, the field circuit of the generator is opened by a field relay to remove generator excitation. No voltage, except residual voltage, is then produced by the generator.

The RESET position of the switch is used to operate the field relay to its reset position after it has been tripped. The relay then closes the generator field circuit to allow the generator to build up voltage.

The RESET position of the generator switch knob is spring loaded. The generator switch knob must be pulled out to move it to the FIELD TRIP position.

**Generator Disconnect Switches**



Each engine-driven generator is provided with a spring-loaded, two-position OFF, DISC guarded switch. When the switch is held in the DISC position (approximately 2 seconds), a direct short in the firing mechanism causes the fused portion of the plunger to bum through and be actuated by spring tension. As the plunger of the firing mechanism passes over the generator disconnect fired light switch, the generator DISC FIRED light will illuminate, indicating the firing mechanism has been fired. The plunger then engages a wing on the generator stub shaft causing it to shear.

**Generator Disconnect Test Switch**



A spring-loaded, two-position OFF, TEST GEN DISC switch is provided to check the continuity of the firing mechanism. If the continuity check is good, the generator DISC FIRED lights will illuminate.

**AC Bus Tie Switch**



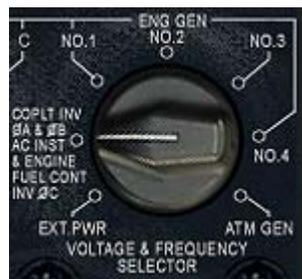
A two-position (OFF, ON) AC BUS TIE switch on the overhead electrical control panel provides a means for powering the main AC bus from the ATM generator during ground operation with no engine-driven generators supplying power.

**AC External Power Switch**



A two-position, AC external power switch is located immediately below the LH AC bus loadmeter on the overhead electrical control panel. The OFF position of the switch disconnects external power from the AC distribution system. The external power position (stripe on knob aligned with stripe on panel) connects external power to the AC distribution system.

**Voltage & Frequency Selector Switch**



A seven-position (ENG GEN NO. 1, ENG GEN NO. 2, ENG GEN NO. 3, ENG GEN NO. 4, ATM GEN, EXT PWR, COPLT INV øA AC INST & ENG FUEL CONT INV øC) rotary switch is used to isolate a chosen source of AC power for measurement.

**Phase Selector Switch**



A three-position PHASE SELECTOR switch selects one of the three phases of AC generator output to be measured by the AC meters on the panel. Placing the switch in a given position determines which phase is measured by the five AC loadmeters, the AC voltmeter, and the frequency meter on the overhead electrical control panel. The switch can be used in conjunction with the VOLTAGE & FREQUENCY SELECTOR switch to test a given AC power source.

**Primary AC System Indicators**



Indicators for the primary AC power system are located in the overhead electrical control panel in the flight station.

**Generator-Out Indicator Lights**



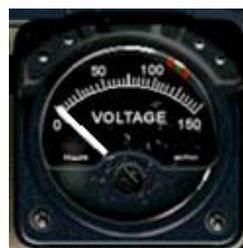
Each generator is provided with a generator-out press-to-test indicator light. This light will illuminate when the generator control switch is in the on position and one or more of the following conditions exist: the generator is not developing sufficient voltage, the generator output is below proper frequency, or the field-trip relay has opened the field circuit of the generator. The field relay will trip when the generator switch is turned to the TRIP position, when the generator output voltage is too high, or when a fault exists in the generator output circuit.

**AC Loadmeters**



Five AC loadmeters, one for each generator, give a continuous indication of the percent of rated current flow of any one PHASE SELECTOR switch from their respective generators.

**AC Voltmeter**



The AC VOLTMETER can be used to measure the output voltage of the generator or inverter which has been selected with the VOLTAGE & FREQUENCY SELECTOR switch. Each of the three phases of generator output, or the appropriate phase of inverter output, can be measured by selectively positioning the PHASE SELECTOR switch.

**Frequency Meter**



A frequency meter permits measuring the frequency of the output power of the generator selected with the VOLTAGE & FREQUENCY SELECTOR switch. Each of the three phases of the generator output power can be measured by selecting the appropriate position on the PHASE SELECTOR switch.

**AC External Power On Indicator Light**



An AC external power-on (EXT AC PWR) press-to-test indicator light is energized by dc power through small pins in the AC external power receptacle and through the closed contacts of a phase sequence relay on the lower main AC distribution panel when the relay is energized. The phase sequence panel relay is energized when three-phase external AC power with correct phase sequence and no open phases is connected to the aircraft.

**Generator Disconnect Fired Indicator Lights**



Each engine-driven generator is provided with a generator disconnect fired (DISC FIRED) indicator light that will illuminate when one of the following conditions exists: a generator disconnect switch is held in the DISC position and the firing mechanism is fired, or when the generator disconnect test switch is held in the TEST GEN DISC position.

**Generator Bearing Failure Indicator Lights**



Each engine-driven generator is provided with a generator bearing failure (FAILED BRG) warning indicator light. Each generator stator contains a soft wire winding which grounds out the stator when contact is made with the rotor. When this occurs, a circuit is completed for illumination of the generator bearing failure indicator light. Once the indicator light is illuminated, it will remain illuminated until dc power to the circuit is removed.

**SECONDARY AC SYSTEM**

The secondary AC power is comprised of two systems, the copilot AC instrument system and AC instrument and engine fuel control system.

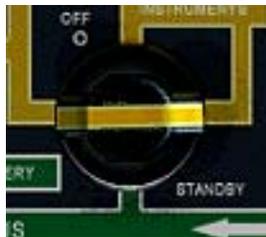
**AC INSTRUMENT AND ENGINE FUEL CONTROL SYSTEM**

The AC instrument and engine fuel control bus is powered by a 115-volt, 400-Hz, single-phase AC instrument and engine fuel control bus. Power for the bus is supplied from one of two sources. One source of power is a 2,500-volt-ampere inverter supplying 115-volt, 400-Hz single-phase AC power. The other source of power is phase A of the essential AC bus through the AC INST and ENG FUEL CONT PWR circuit breaker.

**SECONDARY AC SYSTEM CONTROLS**

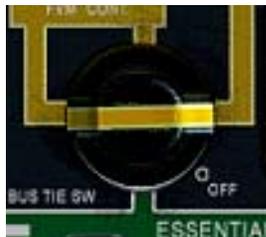
Controls for the secondary AC power system are located on the overhead electrical control panel.

**Copilot AC Instruments Switch**



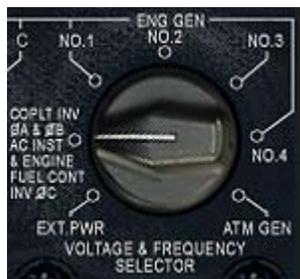
The COPILOTS AC INSTR switch is a three-position (STANDBY, OFF, NORMAL) rotary switch. In the STANDBY position, power is routed from the isolated dc bus to operate the copilot’s AC instrument inverter for the copilot’s AC instrument power system. In the OFF position no power is supplied to the system.

**AC instrument and Engine Switch**



The AC INST and ENG switch is a three-position (STANDBY, OFF, NORMAL) rotary switch. In the STANDBY position, power is routed from the essential dc bus to operate the AC instrument and engine fuel control inverter for the AC instrument and fuel control bus. In the OFF position no power is supplied to the bus.

**Voltage & Frequency Selector Switch**



The VOLTAGE & FREQUENCY SELECTOR switch has seven positions for measuring the output voltage and frequency of the AC power supply sources. Placing the switch in the COPLT INV 0A AC INST & ENG FUEL CONT INV 0C position, while simultaneously placing the PHASE SELECTOR switch in the PHASE A position, provides an indication of the frequency and voltage of the copilot inverter on the frequency meter and the AC voltmeter respectively. Positioning the PHASE SELECTOR switch to PHASE C provides an indication of the output frequency and voltage of the AC instrument and engine fuel control inverter. If the switch is at the COPLT INV 0A AC INST & ENG FUEL CONT INV 0C position and essential AC power is being used in place of the inverter, the frequency meter and the AC voltmeter will not indicate output frequency.

**Phase Selector Switch**

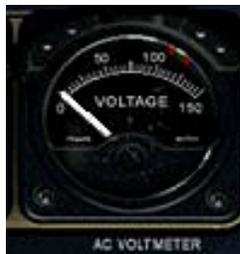


A three-position PHASE SELECTOR switch permits selection of the appropriate phase of electrical power when measuring the out-put voltage and frequency of either of the inverters.

**SECONDARY AC SYSTEM INDICATORS**

Indicators for the secondary AC power system are located on the overhead electrical control panel.

**AC Voltmeter**



An AC voltmeter permits measuring the output voltage of that phase of inverter power selected with the PHASE SELECTOR switch. In order for the voltmeter to measure inverter output voltage, the VOLTAGE & FREQUENCY SELECTOR switch must be in the COPLT INV øA AC INST & ENG FUEL CONT INV øC position. If the switch is at either position and a bus source of power is being used in place of the inverter, however, the voltmeter will not indicate output voltage.

**Frequency Meter**



A frequency meter permits measuring the frequency of the output power of that phase of inverter output selected with the PHASE SELECTOR switch. In order for the frequency meter to measure the frequency of the inverter output power, the VOLTAGE & FREQUENCY SELECTOR switch must be in the COPLT INV øA AC INST & ENG FUEL CONT INV øC position. If the switch is at either position and a bus source of power is being used in place of the inverter, however, the frequency meter will not indicate output frequency.

**Selected Power Out Lights**



Two selected power OUT press-to-test lights are located on the electrical control panel. If the copilot AC instrument SEL PWR OUT light comes on, it indicates that no power is being supplied to the pilot and copilot AC instruments. When the AC INST & ENG switch is in the vertical position and its SEL PWR OUT light glows, the inverter has failed; however, the 115-volt AC instrument and eng bus is then automatically connected to the standby power source (the essential/essential avionics AC bus). The light does not glow when the corresponding selector switch is OFF.

## DC POWER SYSTEM

Power from the essential AC bus and the main AC bus operates four transformer-rectifier units (two from each AC bus) to provide dc power to the respective dc buses for the aircraft

The four transformer-rectifier units, mounted on the electronic control and supply rack, convert the power from the AC buses to 28-volt dc. Both the essential AC bus and the main AC bus may be powered by any of the engine driven generators. The essential AC bus is powered from the APU generator also, so it may be used as a source of dc power for ground operation, The transformer- rectifier units feed current through reverse-current relays to the main dc bus and the essential dc bus.

### DC SYSTEM BUSES

There are four buses in the dc power system: essential dc bus, battery bus, main dc bus, and isolated dc bus. The main and essential buses are connected through a reverse-current relay, which in flight allows current to flow from the main bus to the essential bus, but limits current flow in the opposite direction.

When the aircraft is on the ground, a touchdown switch is actuated to complete a circuit which overrides the reverse-current limiting features of the reverse-current relay and permits current flow in either direction between the main and essential buses. The essential and isolated buses are similarly connected through another reverse-current relay which limits current flow from the isolated bus to the essential bus inflight.

When the aircraft is on the ground, the touchdown switch completes a circuit so that manual positioning of the dc bus tie switch overrides the reverse- current limiting features of the reverse-current relay and permits current flow in either direction between the isolated and essential buses.

The isolated bus is connected to the battery bus by the dc power switch through the battery relay. During ground operation with no engines operating, all of the dc buses may be connected and powered through either the battery or the essential dc bus, which can utilize APU AC generator output to the essential AC bus as a power supply. External dc power is fed through the main dc bus and will supply all dc buses, except the battery, when the dc power switch is in the EXT DC PWR position.

### BATTERIES

Two 24-volt, 34-ampere-hour batteries are located in a fuselage compartment forward of the crew entrance door. The first battery supplies power to the battery bus and to the isolated bus. A reverse current cutout is connected between the isolated bus and the essential and main dc buses.

During flight it prevents the battery from powering equipment connected to the essential and main dc buses and permits power from the essential and main dc buses to be used to power equipment connected to the isolated bus, and to charge the battery.

### DC SYSTEM CONTROLS

The dc electrical system is powered directly by the AC electrical system and is controlled from the overhead electrical control panel.

#### **DC BUS Tie Switch**



The DC bus Tie switch is a two-position, guarded toggle switch which functions in conjunction with the touchdown switch. When the aircraft is on the ground, the DC BUS TIE switch can connect the isolated dc bus and the essential dc bus for current flow in either direction. This allows battery power to feed all dc buses and circuits when the dc power switch is in the BATTERY position.

**DC Power Switch**



The dc power switch is a three-position, rotary-type switch. When the switch is in the EXT DC PWR position, the external power relays will close when external power is applied in the correct polarity, to connect the external power receptacle to the main dc bus.

When the switch is in the BATTERY position, the battery relay is closed and the battery is connected to the isolated bus. This position of the switch permits power to flow from the main dc bus or the essential dc bus through the reverse-current relay to the isolated bus to charge the battery.

When the switch is in the OFF position, the external power relay is opened, and the external power receptacle is disconnected from the main dc bus and from the isolated bus.

When the dc power switch is in the EXT DC PWR position, 24-volt dc control power is supplied from the dc external power source through the aircraft DC EXT PWR control circuit breaker in the aircraft battery compartment.

**DC SYSTEM INDICATORS**

The dc system indicators are located on the overhead electrical control panel.

**Loadmeters**



Four loadmeters, one for each transformer-rectifier unit, indicate percent of rated current load flowing from each unit.

**Voltmeter and Bus Selector Switch**



The voltmeter is connected to the main dc bus, essential dc bus, or battery bus by means of the bus selector switch adjacent to the voltmeter on the overhead electrical control panel. The switch is a rotary selector with three positions: ESSENTIAL DC BUS, MAIN DC BUS, and BAT. Selected bus voltage will be indicated on the voltmeter.

**External DC Power Indicator**



The EXT DC PWR press-to-test light illuminates when external dc power is connected to the external dc power receptacle in the correct polarity.

**HYDRAULIC POWER SUPPLY SYSTEMS**

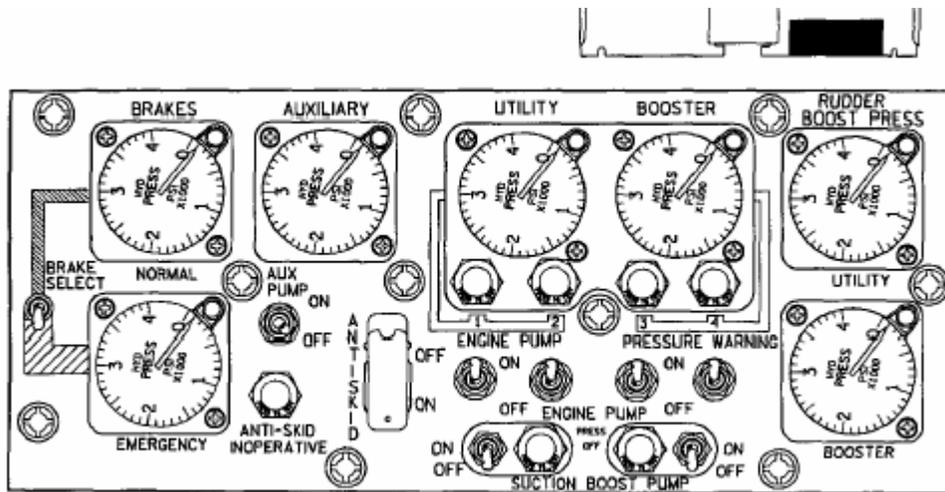
A booster hydraulic system, a utility hydraulic system, and an auxiliary hydraulic system comprise power supply sources for all hydraulic component operation on the aircraft. The booster system furnishes hydraulic power to a portion of the flight control boost system only. The utility system normally operates the landing gear, wing flaps, brakes, nose wheel steering, a portion of the flight control boost system, and the inflight refueling reels.

The auxiliary system operates the ramp and cargo door, provides emergency pressure for brake operation, and provides pressure for emergency extension of the nose landing gear and emergency pressure for the air refueling reels.

**UTILITY HYDRAULIC SYSTEM**

The utility hydraulic system operates from the output of number one and number two engine-driven hydraulic pumps, and supplies hydraulic power to the wing flap hydraulic motor, the main landing gear hydraulic motors, the nose landing gear hydraulic system, the main landing gear brakes, and the nose wheel steering, and to a portion of the aileron, rudder, and elevator control boost system, and the inflight refueling reels.

The engine-driven variable-displacement pumps are supplied hydraulic fluid under electric suction boost pump pressure from a 6.5-gallon reservoir mounted on the left side of the cargo compartment. The engine-driven pumps are provided with internal control mechanisms to vary their output volume with system demand, and to control pressure to maintain approximately 3,000 psi output pressure. If the pump is not operating, the low-pressure warning light will illuminate.



**Utility Suction Boost Pump Switch**



The utility system SUCTION BOOST PUMP switch is a two-position (OFF, ON) toggle switch, which furnishes 28-volt dc power to the suction boost pump motor.

**Suction Boost Pump Pressure Warning Light**



The suction boost pump low-pressure warning light is an amber warning light controlled by a pressure-sensitive switch. The warning light will illuminate if pressure output of the suction boost pump drops below approximately 20 psi.

**Engine Pump Switch**



The ENGINE PUMP switch is a two-position (OFF, ON) toggle switch which controls two hydraulic shutoff valves. One of these valves shuts off supply flow to the engine-driven pump, and the other shuts off pump output. These are the same valves operated by the fire emergency handle. Since the engine pump continues to turn after both the supply and output valves are closed, normal flow from the pump case drain passes through a check valve back into the suction port of the pump to form a run-around circuit. This feature is provided to prevent damage to those engine-driven pumps that require a run-around system.

**Engine Pump Pressure Warning Light**



The engine pump pressure amber warning lights are controlled by pressure-actuated switches which sense the engine-driven pump output pressures. When either engine pump output pressure drops below approximately 1,000 psi, its light will illuminate. The pressure warning light will also illuminate when the engine pump switch is placed in the OFF position.

**Utility Hydraulic Pressure Gage**



The utility hydraulic pressure gage is controlled by a remote transmitter and indicates utility system pressure.

**BOOSTER HYDRAULIC SYSTEM**

The booster hydraulic system operates from the output of number three and number four engine-driven hydraulic pumps, and supplies hydraulic power to a portion of the elevator, rudder, and aileron control boost system. The engine-driven variable-displacement pumps are supplied hydraulic fluid under electric suction boost pump pressure from a 2-gallon reservoir mounted on the right side of the cargo compartment. The engine-driven pumps are provided with internal control mechanisms to vary their output volume with system demand, and to control pressure to maintain approximately 3,000 psi output pressure.

If the pump is not operating, the low-pressure warning light will illuminate. The pressurized output fluid of each pump passes through a filter, an electrically operated shutoff valve, and a one-way check valve before merging as system pressure. The one-way check valve allows the system to continue to function in case of failure of a single-pump. Fluid supply and output of the engine-driven pumps can be cut off by actuation of the fire emergency handle or engine pump switch for that particular engine. The supply fluid and output are cut off by the closing of electrically actuated shutoff valves. Provisions are included in the system for manual overboard draining of the system fluid.

**Booster Hydraulic Pressure Gage**



The booster system hydraulic pressure gage is controlled by a remote transmitter, and indicates booster system pressure.

**AUXILIARY HYDRAULIC SYSTEM**

The auxiliary hydraulic system operates from a three-phase, AC electrically driven hydraulic pump. The pump is air cooled and can be operated continuously. It powers the cargo door and ramp system; provides emergency pressure for the main landing gear brakes, nose gear emergency extension and air refueling reels. The system is located in the cargo compartment and may be manually or electrically operated. A handpump in the system provides an optional source of system pressure for ground or in-flight operation.

The electrically driven system pump, supplied hydraulic fluid from a 5.8-gallon reservoir, is a variable-volume-output type which will maintain approximately 3,000 psi output pressure. Check valves allow handpump pressure to operate the system when the handpump is operated and the electric pump is off. A manually operated shutoff valve is provided to furnish overboard drain provisions.

Controls and indicators for the auxiliary hydraulic system are on the hydraulic control panel and the ramp control panel.

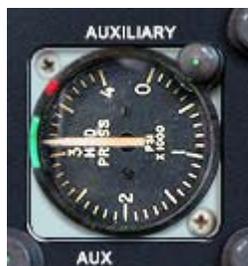
**Auxiliary Hydraulic Pump Switches**



The auxiliary hydraulic pump may be controlled by either of two ON-OFF toggle switches located on the hydraulic control panel and the ramp control panel. When either switch is placed in the ON position, 28-volt dc power is supplied to energize the auxiliary hydraulic pump relay.

When the relay is energized, 115/200-volt, 3-phase, AC power is supplied to drive the auxiliary hydraulic pump motor. When both switches are placed in the OFF position, the relay is de-energized and power is removed from the auxiliary hydraulic pump motor.

**Auxiliary Hydraulic Pressure Gages**



The auxiliary hydraulic system pressure is indicated by the gage located on the hydraulic control panel and by the gage located in the cargo compartment near the handpump. The gage located in the cargo compartment is a direct-reading instrument and shows system pressures at all times, whether from the handpump or from the electric pump.

**FLIGHT CONTROL SYSTEMS**

The flight controls include the main surface control systems (aileron, rudder, and elevator), the trim tab control systems, and the flap control system. The main surfaces are controlled by mechanical systems with hydraulic boost. The trim tabs are controlled by electrical control systems. The autopilot, when operating, controls the main surfaces and elevator trim tabs. The flaps are controlled by hydraulic pressure.

**MAIN SURFACE CONTROL SYSTEMS**

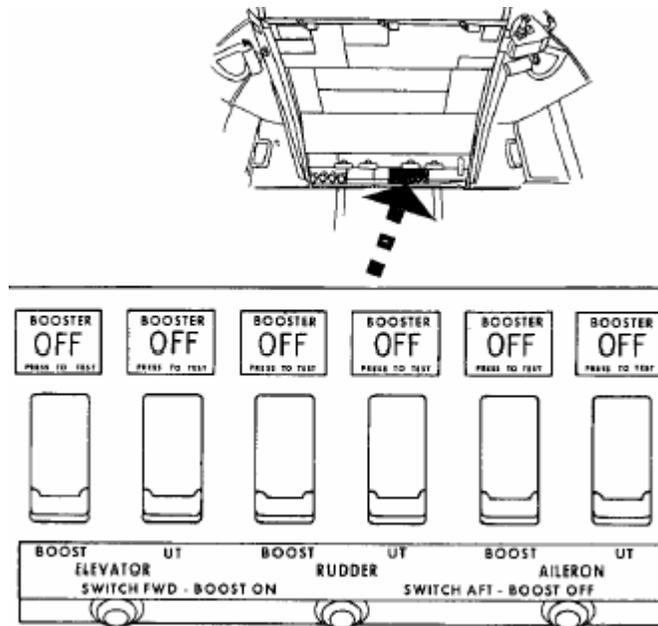
The main surfaces (ailerons, rudder, and elevators) are controlled by mechanical control systems consisting of cables, pushrods, bellcranks, and torque tubes. Hydraulically driven booster units provide most of the force required to move the surfaces. The booster units are driven by hydraulic pressure supplied simultaneously by the booster and utility hydraulic systems each of which serves to power one portion of the booster units.

System operation is such that failure or malfunction of any component of either system in any booster unit will allow normal function of the other system powering the same unit. A loss of hydraulic pressure in either hydraulic system results in a corresponding loss in the booster unit, and a proportionate loss of power to operate the unit.

The aircraft may be controlled with complete loss of booster unit power by the use of trim tabs and engine power, plus coordinated increased efforts of the pilot and copilot. Solenoid-operated shutoff valves in each surface control system can be actuated by switches on the control boost switch panel at the flight station to shut off supply pressure to either of the systems. The valves are spring-loaded and will open when de-energized (control boost switches in the ON position).

A booster-off warning light for each switch is also powered by the solenoid shutoff valve switch, and will illuminate when the switch is in the OFF position. An autopilot servomotor is cable-rigged to each booster unit to substitute for manual control during autopilot operation.

**Control Boost Switches and Warning Lights**



The control booster unit shutoff valve actuating switches are located on the control boost switch panel on the overhead control panel. There are six guarded two-position toggle switches (ON with cover down, de-energized) which will actuate the shutoff valves to isolate the corresponding booster package and energize six hooded warning lights which illuminate BOOSTER OFF when their respective switches are placed in the OFF position.

The panel switches supply power to the warning lights directly through the copilot lower circuit breaker panel when in the OFF position, and therefore furnish no independent indication directly of boost unit failure or that

the shutoff valves are closed. The warning light only indicates that the switch is in the OFF position and dc power is routed to the solenoid shutoff valve. Individual pressure control from both the booster and utility systems is available to each boost package.

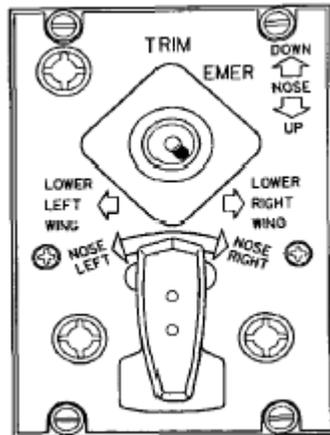
28 volt dc power for the lights and valves is supplied from the essential dc bus through the SHUTOFF VALVES circuit breakers on the copilot lower circuit breaker panel.

### **TRIM TAB CONTROL SYSTEMS**

Trim tabs are provided on the control surfaces to aid in trimming the aircraft during flight. Lateral trim is obtained through operation of a trim tab on the left aileron. A ground adjustable tab is located on the right aileron to compensate for any inherent imbalance about the longitudinal axis of the aircraft.

Nose-up and nose-down trim is obtained through operation of the trim tabs on the elevators, one trim tab on each elevator control surface. Left and right trim is obtained by operation of the rudder trim tab.

During autopilot operation, operation of the ELEV TRIM switch located on either of the control wheels will cause the autopilot to disengage. The autopilot elevator servo will function only when the elevator tab switch is placed in the NORMAL position.



### **TRIM TAB SYSTEM CONTROLS AND INDICATORS**



### **FLAP CONTROL SYSTEM**

The aircraft is equipped with four flaps, consisting of an outboard and an inboard flap in each wing. The flaps are of the Lockheed-Fowler high-lift type, in which the flap motion is a combination of an aft movement to increase wing area and a downward tilting movement to alter the airfoil section to increase lift and drag.

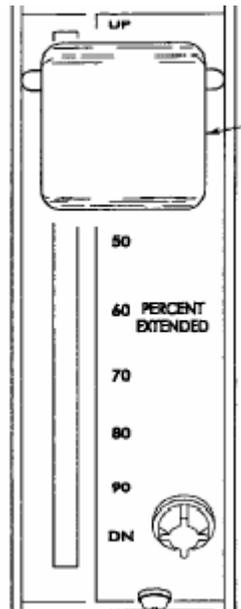
The time required for full extension of the flaps is between 8 and 15 seconds. Full retraction time is between 10 and 15 seconds. When 100 percent extended, the flaps form an angle of approximately 35° with the wings.

The flaps are operated by a reversible hydraulic motor, a cam-actuated microswitch followup mechanism, torque tubes, gearbox, and drive screw assemblies. Hydraulic pressure is directed through a check valve to the emergency flap brake valve and the wing flap selector valve, where pressure is directed to the up or down system. The hydraulic motor operates the torque shaft section extending outboard to the gearbox, which rotates ball bearing drive screws for actuation of the flaps.

Disk-type, spring-loaded flap brakes hold the flaps in the selected position and prevent movement by aerodynamic loads. The brake is released by fluid pressure supplied to the system for operation of the flap drive motor. Emergency flap brakes are splined to the outer ends of the flap drive torque shaft to prevent unequal actuation of the flaps during normal extension and retraction of the flaps. Utility hydraulic system pressure is used for operation of the flap system.

**FLAP SYSTEM CONTROLS AND INDICATOR**

**Flap Lever**



A flap lever is located on the aft end of the flight control pedestal. It is a manually actuated control lever, with the lever range calibrated from UP to DN in increments of 10 percent. There is a detent at approximately the 50 percent position, but the flaps can be extended to any desired position by placing the lever at the selected percent of flap extension. The lever is attached by cables to a movable cam inside a flap control unit mounted on the center section wing rear beam in the cargo compartment. Movement of this cam closes limit switches which close a 28-volt dc control circuit for the wing flap selector valve. The actuated valve directs a flow of hydraulic fluid to drive the flap motor in the selected direction. A rudder pressure diverter valve, electrically actuated by a switch on the flap control lever mechanism, controls the pressure available for operation of the rudder. Pressure available for rudder operation of flap settings from 0 to 15 percent is approximately 1,300 psi as compared to approximately 3,000 psi for flap settings from 15 to 100 percent. The pressure control system is provided to prevent excessive air loads at high speeds. When the selected position of the flaps is reached, the limit switches open, the selector valve shuts off hydraulic flow, and a spring-loaded hydraulic brake locks the flaps in the selected position.

**Flaps Position Indicator**



A flaps position indicator is located on the copilot instrument panel. The indicator is connected to a transmitter that is mounted on the flap drive control unit located on the aft face of the wing rear beam. The indicator dial is calibrated from UP to DOWN in increments of 10 percent.

## **LANDING GEAR SYSTEM**

The landing gear system includes a dual-wheel, steerable nose gear and two tandem-mounted main landing gears. Normal operation of the system is through the utility hydraulic system. The nose gear retracts forward into the nose section of the fuselage; the main landing gears retract vertically into the left and right wheel wells on the sides of the fuselage. In the retracted position, all landing gears are enclosed by mechanically operated flush doors.

A landing gear position-indicating system gives a visual indication of the position of each gear, and gives a visual and audible indication of an unlocked condition of the landing gear. Under normal operation, retraction or extension time of both nose and main landing gears is 19 seconds or less.

### **MAIN LANDING GEAR**

The main landing gear system consists of four wheels, two mounted in tandem on each side of the fuselage. Each wheel has a separate strut. The landing gear actuation system is normally supplied hydraulic fluid under pressure from the utility system. Fluid from the utility system flows through a landing gear selector valve to each of the two main landing gear motors. Each pair of struts is raised and lowered in vertical tracks by screwjacks driven by torque shafts which are powered by the hydraulic motor through a gearbox. The gearbox contains a spring-loaded brake assembly.

After the landing gear contacts the up-limit switch, the landing gear selector valve remains energized allowing landing gear up hydraulic pressure to be continuously applied to the main landing gear motors. In the event of loss of hydraulic pressure, the main landing gear spring-loaded retraction brakes are applied.

With the main gear down and the aircraft on the ground, friction washers on the screwjack assemblies serve as down-locks. Mechanical linkage between the aft main landing gear struts and the doors causes the doors to open and close as the main landing gears are extended and retracted.

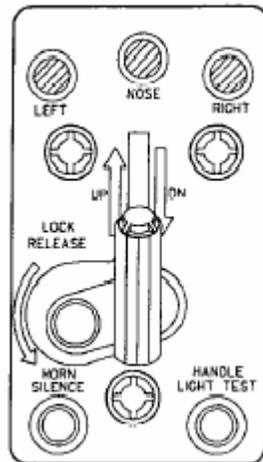
### **NOSE LANDING GEAR**

The nose landing gear is a swing-type gear, extending down and aft, actuated by a hydraulic cylinder and secured in the up and down positions by locks. The gear is normally supplied with hydraulic fluid under pressure by the utility supply system; however, during an emergency it can be supplied by the auxiliary hydraulic system (for extension only). Hydraulic fluid from either the up or down side of the landing gear selector valve flows to the nose landing gear uplock and downlock cylinders and to the nose landing gear actuating cylinder.

The landing gear selector valve remains energized open in the up position, allowing landing gear up pressure to be continuously applied to the nose landing gear actuating cylinder and uplock. In the event of loss of hydraulic pressure, the nose landing gear is held in place mechanically by the uplock. Fluid for the nose landing gear steering control valve is supplied from the landing gear selector valve in the down position only. A shuttle valve connects the utility pressure down line to the auxiliary system pressure line, permitting auxiliary pressure: to be used to place the nose landing gear in the down-and-locked position when the utility system is inoperative.

## **LANDING GEAR SYSTEM CONTROLS AND INDICATORS**

### **Landing Gear Lever**



A landing gear lever is located on the left side of the copilot instrument panel. It is a two-position (UP, DN) lever which directs the gear actuating mechanism to raise or lower the nose and main landing gears.

When the lever is moved to UP position, a solenoid-operated selector valve directs pressure from the utility hydraulic system to release the nose gear downlock, to the up side of the nose landing gear actuating cylinder, to both main landing gear hydraulic motors, and the landing gears retract. When the lever is moved to the DN position, the nose landing gear uplock is released, the main landing gear motors are reversed, and the landing gear extends.

A mechanical locking device is engaged when the landing gear lever is moved to the DN position, so that the lever stays in the DN position until released. During take-off or in flight, the energized position of the touchdown relay energizes the landing gear lever release solenoid to reduce the locking device to a simple detent.

At other times, the LOCK RELEASE finger latch must be pulled down before the landing gear lever can be moved to the UP position. When the landing gear lever is in the UP position, 28-volt dc power is routed from the LANDING GEAR CONTROL circuit breaker to energize the normal brake selector valve to prevent application of normal brakes. When the landing gear lever is in the DN position, the normal brake selector valve is de-energized to allow brake application regardless of main landing gear strut compression.

### **Landing Gear Position Indicators**



A left main gear position indicator, a nose gear position indicator, and a right main gear position indicator are located on the landing gear control panel. These indicators give a visual indication of position of the landing gear.

When the letters UP appear on the face of an indicator, it means that the gear represented by that indicator is retracted and locked. When the picture of a landing gear wheel appears on the face of an indicator, it means that the landing gear represented by that picture is extended and locked. Diagonal lines on the face of a indicator indicates that a gear is somewhere between the extended and retracted positions or that the indicator is inoperative.

### **Landing Gear Warning Horn and Silence Switch**



The landing gear warning horn is located above and to the left of the pilot seat.

Two things will cause the landing gear warning horn to sound:

- Retarding a throttle to a position within 5° forward of the FLIGHT IDLE position with the landing gear up
- Extending the flaps more than approximately 80 percent with the landing gear up.

A HORN SILENCE switch is located on the landing gear control panel. It is a press-type switch used to silence the landing gear warning horn when a throttle is retarded. It will not silence the horn when flaps are extended more than 80 percent.

When the switch is pressed, the horn-silencing relay is actuated, and the warning horn electrical circuit is broken. Cycling of the landing gears or advancement of an engine throttle will reset the horn-silencing relay so that the horn can sound again.

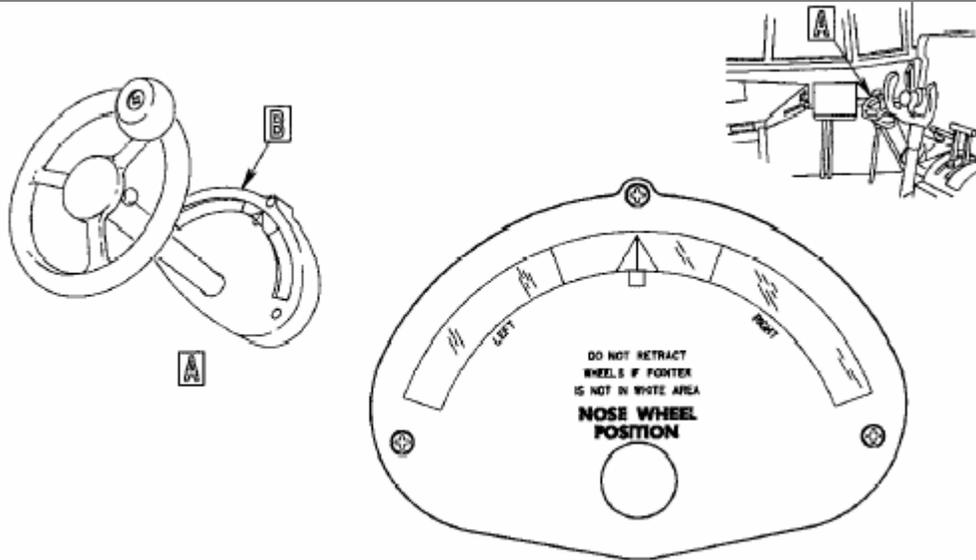
#### **Landing Gear Warning Light and Warning Light Test Switch**



The landing gear warning lights are connected to the landing gear retraction system and the throttle warning switches; they will illuminate whenever the landing gear is not in a locked position, or when an engine throttle is retarded to within 5° of the FLIGHT IDLE position and the landing gear is not fully extended. The HANDLE LIGHT TEST switch is a press-type switch, used to test the continuity of the landing gear warning light electrical circuit.

When the switch is pressed, the landing gear warning light bulbs in the landing gear lever handle will illuminate. Failure of the bulbs to illuminate shows a defective circuit.

## NOSE WHEEL STEERING SYSTEM



The aircraft is steered during taxiing by directional control of the nose wheel. The nose wheel is hydraulically actuated and governed by a steering control valve in the utility hydraulic system. The steering control valve is connected by a cable to a manually operated nose steering wheel located in the flight station at the left of the pilot control column. Directional control of the nose wheel is limited by means of mechanical stops to 60° right and left of center.

## BRAKE SYSTEM

The main landing gear brake system utilizes a hydraulically operated, multiple-disk-brake on each of the four main landing gear wheels. The nose landing gear wheels do not have brakes. The brakes normally operate from utility hydraulic system pressure, with an alternate supply available through the auxiliary hydraulic system. If electrical power is off, the system with the highest pressure will supply pressure to operate the brakes.

Fluid for the normal brake system flows through a brake pressure selector valve to the right- and left-hand brake control valves. When the fluid leaves the brake control valves, it flows through the dual anti-skid valves, brake fuses, and shuttle valves to the brakes. Each brake is controlled by a brake control valve, an anti-skid valve, and brake shuttle valve.

The auxiliary system supply flows through the emergency brake pressure selector valve. When the emergency brake system is actuated, fluid is directed to the brake control valves, then through hydraulic fuses and shuttle valves directly to the brakes, bypassing the anti-skid valves. Utility or auxiliary system pressure is selected by manually positioning a brake pressure selector switch.

### **BRAKE SYSTEM CONTROLS AND INDICATORS**

#### **Brake Pedals ( . and F11, F12 keys)**

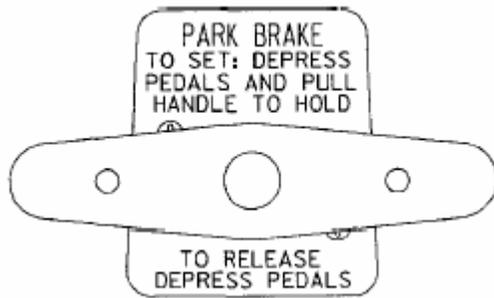
Actuation of the brakes is through application of toe pressure on the rudder pedals at either the pilot or copilot station. The amount of braking force is proportional to the force applied to the brake pedals. The right pedals actuate the right-hand brakes, and the left pedals actuate the left-hand brakes. This arrangement allows directional control of the aircraft through differential braking. When the anti-skid system is energized, application of brake pressure before touchdown is prevented by a locked-wheel signal through the touchdown relays.

#### **Brake Pressure Selector Switch**

A two-position (NORMAL, EMERGENCY) BRAKE SELECT toggle switch located on the hydraulic control panel provides selection of either normal or auxiliary hydraulic pressure for applying the brakes.

The NORMAL position will supply utility hydraulic pressure to the brakes, and the EMERGENCY position will supply auxiliary hydraulic pressure to the brakes.

**Parking Brake Handle (VC Only or Ctrl+. Key)**



A parking brake handle is located in front of the pilot seat, to the right of the pilot right foot rest. The control handle is mounted on a panel support and is attached to a flexible cable. This cable pulls a pawl into a detent in the brake control lever to lock the pedals in a depressed (brakes on) position.

**Brake Pressure Indicators**



Two brake pressure indicators are located on the hydraulic control panel at the bottom of the copilot instrument panel. The indicators, which are connected to pressure transmitters in the pressure lines of the brake control system, register the hydraulic pressure available in the brake sections of both the utility and auxiliary hydraulic systems.

## **ANTI-SKID SYSTEM**

The anti-skid system, an integral part of the main landing gear brake system, consists of four wheel-speed transducers, an electrical control box, and two dual type electro-hydraulic servo brake pressure control (anti-skid) valves.

### **ANTI-SKID SYSTEM OPERATION**

The system prevents skidding of wheels when too much brake pressure is in effect during aircraft decelerations. This is done through a brake-releasing system, controlled by signals from wheel-speed transducers.

### **SKID-DETECTOR OPERATION**

The wheel-speed transducer unit mounted in the axle of each main landing gear wheel applies controls to the braking operation through the anti-skid valves when the landing gear wheel begins to approach a skid condition. One dual anti-skid valve is located above the booster hydraulic reservoir on the forward right-hand wheel well wall, and the other is on the left-hand hydraulic panel forward of the utility hydraulic reservoir.

Each wheel-speed transducer unit contains a frequency generator which senses wheel rotational speed and wheel speed change. The transducers form part of an electrical circuit which prevents landing with brakes on, and which releases brakes in case of a locked condition.

Should the wheel speed decrease rapidly, indicating approach of a skid condition, the control box sends an electric impulse to an anti-skid valve which reduces pressure to the affected brake below the pressure which caused sensing of the skid. As subsequent skids are sensed, they are electronically compared with the amount the hydraulic pressure had to be reduced to eliminate earlier skids detected. This comparison results in a more accurate determination of the minimum reduction in brake pressure required to eliminate the skid.

The skid detection and control function is independent for each wheel. The skid control system will not function when the brake system is operating from the auxiliary hydraulic system or when the parking brakes are set.

### **ANTI-SKID SYSTEM CONTROLS AND INDICATORS**

#### **Anti-Skid Switch**



An ANTI-SKID two-position (OFF, ON) guarded toggle switch is located on the hydraulic control panel.

When the switch is in the ON position and the ANTI-SKID INOPERATIVE light is extinguished, the anti-skid system is operative and becomes an integral part of the wheel brake system. When the switch is in the OFF position, the landing gear brake system operates as a standard brake system.

#### **Anti-Skid Inoperative Light**

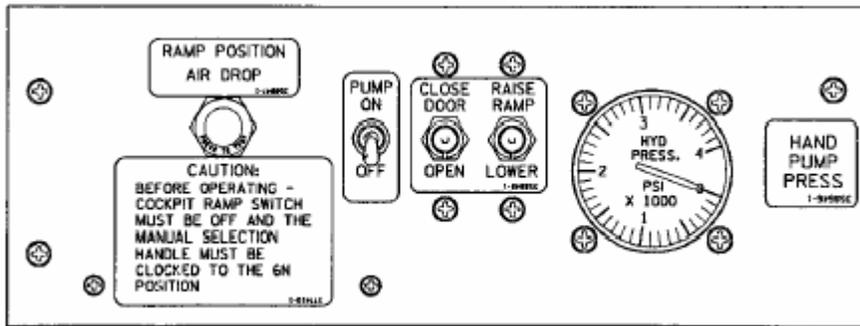


An ANTI-SKID INOPERATIVE light, located on the hydraulic control panel glows whenever the anti-skid system is not operating as an integral part of the landing gear brake system. It warns the pilot that skid protection has been lost on all wheels. This light will also illuminate when the parking brake is set.

**CARGO DOOR AND RAMP SYSTEM**

The cargo door and ramp, providing entry for wheeled vehicles and large loads, are used also for egress during aerial delivery system operations. Normal operation of the door and ramp is achieved by hydraulic pressure supplied through the auxiliary hydraulic system alternatively; the operating pressure can be supplied in an emergency by a handpump connected to the reservoir of the auxiliary hydraulic system. Control of the system is accomplished electrically or manually from a ramp control panel, electrically from the airdrop system (ADS) control panel on the flight control pedestal, or using Concorde Nose Key.

**CARGO DOOR AND RAMP CONTROLS**



**Door Control Switch**



A door control switch is located on the ramp control panel. This three-position (CLOSE, unmarked neutral, OPEN) toggle switch spring-loaded to the neutral position, controls the normal ground operation of the cargo door. When the switch is held in the OPEN position the control valve directs hydraulic pressure to the open side of the cargo door actuating cylinder to unlock the downlocks and open the cargo door. As the door reaches the open position, it engages the cargo door uplock assembly which latches mechanically.

When the switches held in the CLOSE position, hydraulic pressure is directed to the cargo door uplock cylinder, which unlatches the uplock. The control valve also directs pressure to the close side of the cargo door actuating cylinder, and the door swings downward to the closed position and locks in place. When the switch is released, the cargo door circuit de-energizes and the valves return to a neutral position.

**Ramp Control Switch**



A ramp control switch is located on the ramp control panel aft of the left paratroop door. This three-position (RAISE, unmarked neutral, LOWER) toggle switch, spring-loaded to the neutral position controls the normal ground operation of the ramp. When the switch is held in the LOWER position the control valve directs hydraulic pressure to the up side of the ramp actuating cylinders and to the unlock side of the ramp uplock cylinder, until the uplock is unlatched. The hydraulic pressure then is directed to the down side of the ramp actuating cylinders to lower the ramp.

When the switch is held in the RAISE position, the ramp control valve directs hydraulic pressure to the up side of the ramp actuating cylinders to raise the ramp. At the same time, pressure is directed into the unlock side of the ramp uplock cylinder to unlock the ramp uplock until the ramp is raised into the normal raised position. Pressure then is directed to the lock side of the ramp uplock cylinder to lock the ramp in place. When the switch is released, the ramp circuit is de-energized, and the valves return to a neutral position.

**Ramp and Door Open Light**

A RAMP POSITION AIR DROP light is located on the ramp control panel. The light illuminates when the ramp is lowered to the airdrop position.

**CARGO DOOR AND RAMP OPERATION**

Aerial delivery system ramp supports (grass-hopper arms), located on either side of the ramp, prevent it from lowering beyond the horizontal position in flight. When ground operations require the ramp to be lowered beyond the horizontal position, these arms automatically disconnect at their attachment points on the ramp.

**CAUTION**

- Whenever the ramp is resting against a solid object: ground, truck bed, etc., do not use the ramp for loading or unloading unless the handpump pressure gage indicates a minimum of 500 psi. Serious damage may result if the locking action of the ramp cylinders is lost because of reduced pressure.
- Do not raise or lower the cargo door unless the aft anchor line arms are in the stowed position. Severe structural damage could result. Ensure the auxiliary hydraulic pump switches (flight station and control panel) are OFF and that the cargo door and ramp manual controls are in their neutral positions before applying electrical power to the aircraft.

**Note**

Concord Nose default keys (should be assigned) provide the Ramp and Doors control to the following fixed positions:

1. Door – Closed, Ramp - Raised
2. Door – Open, Ramp – Air Drop Position
3. Door – Open, Ramp – Ground Lowered Position

**OPERATION OF THE CARGO DOOR AND RAMP FROM THE RAMP CONTROL PANEL**

Open the cargo door and ramp as follows:

1. Place the auxiliary hydraulic PUMP switch in the ON position.
2. Hold the cargo DOOR switch in the OPEN position until the door is up and locked.
3. Hold the RAMP switch in the LOWER position until the ramp moves to the desired position. If the ramp is being lowered against a solid object, ensure the handpump pressure gage indicates a minimum of 500 psi when the ramp is in its desired position.

**Note**

The ramp may be stopped in any position by releasing the RAMP switch to the spring-loaded neutral position. Stop the ramp at a position above horizontal and disconnect the aerial delivery system ramp supports, if the desired final position is below the horizontal.

4. Place the auxiliary hydraulic PUMP switch in the OFF position.

Close the cargo door and ramp as follows:

1. Place the auxiliary hydraulic PUMP switch in the ON position.
2. Hold the RAMP switch in the RAISE position until the ramp is up and locked. Visually inspect the locks for proper closure.

**Note**

The aerial delivery system ramp supports reconnect automatically.

**CAUTION**

Before lowering the cargo door, visually inspect for adequate clearance from cargo or equipment loaded on the ramp.

3. Hold the cargo DOOR switch in the CLOSE position until the door is closed and locked.

4. Check that the DOOR OPEN warning light have extinguished.
5. Place the auxiliary hydraulic PUMP switch in the OFF position.

**Note**

The sequence of opening the cargo door first and closing it last is important to follow. This will provide the maximum clearance for cargo loaded on the ramp.

**INFLIGHT OPERATION**

**WARNING**

- Do not open the ramp in flight unless the aerial delivery system ramp supports are properly attached. Movement of the ramp below the horizontal position could result in the loss of control of the aircraft.
- Before opening the cargo door and ramp in flight, ensure all loose gear in the cargo compartment is properly secured. Personnel aft of the wheel wells should wear restraining harnesses or parachutes.
- Do not open the cargo door and ramp in flight at speeds above the limiting airspeed of 150 knots IAS.

If the cargo door and ramp are to be operated from the ramp control panel, proceed as follows:

1. Establish communications with the pilot. Ensure the aircraft has been depressurized and slowed to a suitable airspeed.
2. Clear the ramp area and cargo compartment of all unnecessary personnel.
3. When cleared by the pilot, operate the cargo door and ramp in the same manner as for ground operations. Use auxiliary hydraulic pump pressure, if possible. If the situation requires, the cargo door and ramp can be operated in flight using handpump pressure.

**OPERATION OF THE CARGO DOOR AND RAMP FROM THE ADS CONTROL PANEL (Pedestal in VC)**



Open the cargo door and ramp as follows:

1. Depressurize the aircraft.
2. Slow to 150 knots IAS or less.
3. Ensure the cargo compartment is clear of all unnecessary personnel.
4. Place the cockpit auxiliary hydraulic pump switch on the hydraulic control panel to ON.
5. Move the RAMP switch to the OPEN position.

6. Illumination of the green RAMP AIR DROP light on the Ramp control panel will occur when the door is up and locked and the ramp is in the aerial delivery position. When the light illuminates, place the RAMP switch in the OFF position.
7. Turn the cockpit auxiliary hydraulic pump switch to OFF.

Close the cargo door and ramp as follows:

1. Turn the cockpit auxiliary hydraulic pump switch on the hydraulic control panel to ON.
2. When the drop master signals the cargo has been dropped, and the ramp and door area is clear, move the RAMP switch on the ADS panel to the CLOSE position.
3. The master door warning light will extinguish when the cargo door and ramp are fully closed and locked. When the light goes out, move the RAMP switch on the ADS panel to the OFF position.
4. Turn the cockpit auxiliary hydraulic pump switch to OFF.

## BLEED AIR SYSTEM

The bleed air system consists of high-pressure, stainless steel ducts and air shutoff valves which direct compressed air to pneumatically operated systems of the aircraft. The entire system of ducts serves as a plenum from which air is distributed to other systems. The following pneumatic systems are served by the bleed air system:

1. Engine starting system
2. Air conditioning system
3. Cabin pressurization system
4. Windshield defogging system
5. Engine air inlet scoop anti-icing system
6. Leading edge anti-icing system
7. Urinal dram ejectors (aircraft prior to 162785)
8. Oil cooler augmentation system (aircraft 163310 and up)

Compressed air is supplied to the bleed air system from the engines when they are running, or compressed air is supplied from either the auxiliary power unit or from an external pressure source when the aircraft is on the ground and the engines are not running. The normal procedure is to supply air from the auxiliary power unit or from an external source until the first engine is started; then, engine bleed air is used. The main bleed air manifold extends across the leading edge of the wing. Air enters the main manifold through five ports, four from the engines and one from the auxiliary power unit or an external source.

Check valves installed in each engine bleed air manifold, the auxiliary power unit supply duct, and the external pressure supply duct; prevent reverse flow when any of these sources of supply are inoperative.

### Engine Bleed Air Pressure Regulator Controls



Four ENGINE BLEED AIR switches on the anti-icing systems control panel control the opening, closing, and regulation of the engine bleed air pressure regulators. The control circuit for each regulator is connected through a switch actuated by the fire emergency control handle.

### Wing Bleed Air Isolation Valves



Two wing isolation valves are installed in the bleed air manifold near the inboard section of the wing. These valves are electrically closed by the WING ISOLATION VALVE switches on the anti-icing system control panel they are opened manually by individual handles mounted in the top of the cargo compartment forward of the wing butt on the left and right wheelwell walls.

### CHECKOUT OF THE BLEED AIR SYSTEM

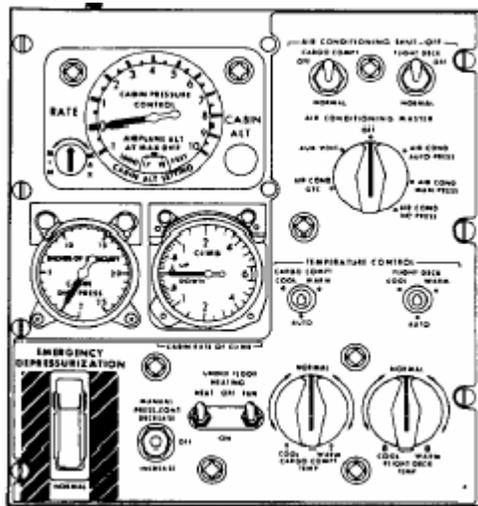
The bleed air pressure gage can be used to check the bleed air system. Use the following steps to check out the system with external AC or dc power and with air supplied by the auxiliary power unit.

1. Make sure that the bleed air circuit breakers on the copilot side circuit breaker panel are closed.
2. Place the ENGINE BLEED AIR switches to OPEN and turn off all systems that use bleed air.
3. Open the GTC bleed air valve.
4. Check the system pressure for a reading of 35 psi minimum. Failure to reach this pressure indicates that a valve in the system has not closed, that a duct is leaking, or that the compressor output is low.
5. Close the GTC bleed air valve.
6. As pressure in the system drops, time the drop from 30 to 15 psi. This time should be not less than 8.5 seconds.

Use the following steps to check out the bleed air system with air supplied by an engine.

1. Place the ENGINE BLEED AIR switches to OFF and turn off all systems which use bleed air.
2. Place the bleed air switch for one operating engine and all engines not operating to OPEN.
3. When the system pressure reaches 70 psi or higher, place the bleed air switch of the operating engine to OFF. Pressure should begin to drop almost immediately. If pressure does not drop, the engine bleed air has failed to shut off.
4. The time required for the pressure to drop from 65 to 35 psi should not be less than 10 seconds.

**AIR CONDITIONING SYSTEMS**



The aircraft is equipped with two independently operating air-conditioning systems, one for the flight deck and the other for the cargo compartment. Both are operated by bleed air supplied from the engine compressors, or they may be operated on the ground by air supplied from the GTC or by the attachment of an external ground compressor unit.

Each system keeps the air at a required temperature and removes excess moisture from it before sending it through a system of ducts into the respective crew or cargo compartments. The principal components of each system comprise a venturi-type airflow regulator, an electrical temperature control system, a water separator, a refrigerating unit, auxiliary vent valve and controls, and distribution ducts.

The flight deck system includes a windshield defogging system and controls; the cargo compartment system includes a heating system for the cargo compartment floor. Both systems are similar except for flow capacity; the higher capacity system serves the cargo compartment, and the lower capacity systems used for the flight deck.

**AIR-CONDITIONING SYSTEM CONTROLS AND INDICATORS**

The main controls for the two air-conditioning systems are located on the air-conditioning and pressurization control panel.

**Air Conditioning Master Switch**



The AIR CONDITIONING MASTER switch, located on the air-conditioning and pressurization control panel is a six-position (AIR COND GTC, AUX VENT, OFF, AIR COND AUTO PRESS, AIR COND MAN PRESS, AIR COND NO PRESS) rotary switch that selects the type of air-conditioning and pressurization desired. The control functions of the master switch are as follows:

1. AIR COND GTC
  - a. Airflow regulators open and provide reduced airflow.
  - b. Auxiliary ventilation valves close.
  - c. Outflow valve opens.
  - d. Safety valve opens.
  - e. Thermostat blowers are turned on.
2. AUX VENT
  - a. Airflow regulators shut off flow of bleed air.
  - b. Auxiliary ventilation valves open.
  - c. Outflow valve opens.
  - d. Safety valve opens.
3. OFF
  - a. Airflow regulators shut off flow of bleed air.
  - b. Auxiliary ventilation valves open.
  - c. Outflow valve opens.
  - d. Safety valve closes.

4. AIR COND AUTO PRESS
  - a. Airflow regulators provide normal airflow.
  - b. Safety valve closes.
  - c. Outflow valve is modulated automatically.
  - d. Auxiliary ventilation valves close.
  - e. Thermostat blowers are turned on.
  
5. AIR COND MAN PRESS
  - a. Airflow regulators provide normal airflow.
  - b. Safety valve closes.
  - c. Outflow valve is modulated manually.
  - d. Auxiliary ventilation valves close.
  - e. Thermostat blowers are turned on.
  
6. AIR COND NO PRESS
  - a. Airflow regulators provide normal airflow.
  - b. Safety valve opens.
  - c. Outflow valve opens.
  - d. Auxiliary ventilation valves close.
  - e. Thermostat blowers are turned on.

#### Flight Deck and Cargo Compartment Temperature Controls



The FLIGHT DECK and CARGO COMPARTMENT TEMPERATURE controls consist of two toggle switches and two rheostats on the air-conditioning and pressurization control panel. One switch and one rheostat are used to control temperature conditions within the flight deck, and the second switch and rheostat control temperature within the cargo compartment.

The toggle-type temperature control switches are used to select warm, cool, or automatically controlled temperature conditions, but they function only when the AIR CONDITIONING MASTER switch is set to one of the four AIR COND positions. Each switch may be moved from the center (OFF) position upward to COOL or WARM or downward to AUTO.

With the TEMPERATURE CONTROL switch set to AUTO, the temperature control valve is controlled automatically to maintain the compartment temperature selected on the temperature rheostats. When the switch is moved to the COOL position, the temperature control valve moves toward the extreme cold setting; the switch must be held for approximately 35 seconds for the valve to move from the extreme hot position to the extreme cold setting.

With the switch at WARM, the valve moves toward the extreme hot setting. Complete movement of the valve from the extreme cold setting to the extreme hot position takes approximately 4 minutes. The switch may be released at any time from either the WARM or COOL positions, and is spring loaded to return to the center (off) position; the temperature control valve will remain at the setting achieved when the switch is released.

The system thermostat blowers are activated whenever the AIR CONDITIONING MASTER switch is at one of the four AIR COND positions.

The two temperature rheostats, located below their respective temperature control switches, are used to select the temperature conditions desired within the FLIGHT DECK and CARGO COMPARTMENT during automatic temperature control. The settings of each rheostat cover a temperature range from COOL through NORMAL to WARM.

**Recirculating Fan Switch**



(labeled UNDERFLOOR HEATING fan) is a two-position (ON, OFF) toggle switch located on the air-conditioning and pressurization control panel. The switch provides control of the cargo compartment recirculating fan without operating the underfloor heating.

The AIR CONDITIONING MASTER switch must be in a position other than OFF or AUX VENT and the UNDERFLOOR HEATING switch must be in the OFF position before the RECIRCULATING FAN switch will operate the fan. The recirculating fan will operate when UNDER FLOOR HEAT switch is ON regardless of FAN switch position.

**Air Diverter Controls**



A lever at each side of the main instrument panel controls a valve through which the conditioned airflow may be directed, by way of a louver, toward each pilot's chest or through floor level outlets toward each pilot's feet; a central position for the lever, marked MIX, divides the available airflow between the upper and lower outlets.

**Air Conditioning Shut-Off Switches**



Two shutoff switches, at the top of the air-conditioning and pressurization control panel override the AIR CONDITIONING MASTER switch and enable either air-conditioning system to be shut down individually. Each switch may be set to either OFF or NORMAL. If the FLIGHT DECK switch is set to OFF, the airflow regulator for the flight deck air-conditioning system stops the flow of bleed air regardless of the setting of the AIR CONDITIONING SYSTEM MASTER switch.

Similarly, if the CARGO COMPT switch is placed to OFF, the airflow regulator closes off the supply of bleed air to both the cargo compartment air-conditioning system and the under floor heating system. With either switch set to NORMAL, the associated airflow regulator maintains the normal flow of air to the air-conditioning system. In an emergency, the flight deck system airflow regulator may be closed, to stop the entry of bleed air, by pulling the OVERRIDE FLT DECK REFRIG SHUTOFF VALVE handle on the floor of the navigator station.

**Emergency Depressurization Switch**



Emergency Depressurization Switch is a guarded two-positioned toggle switch on the air-conditioning and pressurization control panel. When the switch is moved from NORMAL to EMERGENCY DEPRESSURIZATION, an electrical circuit closes both air-conditioning system flow regulators and opens the outflow and safety valves to the pressurization system.

**NORMAL OPERATION OF AIR-CONDITIONING SYSTEMS**

The air-conditioning systems can be operated from bleed air supplied by the GTC or by the engines while the aircraft is on the ground, or an external conditioning unit may be attached. The engines supply the bleed air for operating the air-conditioning systems in flight.

**GROUND AIR-CONDITIONING****AIR-CONDITIONING WITH AIRCRAFT SYSTEMS**

1. Place the ENGINE BLEED AIR switches in the OFF position.
2. Start the GTC.
3. Place the GAS TURBINE COMPRESSOR BLEED AIR switch in OPEN.
4. Check the bleed air pressure gauge.
5. Position the AIR CONDITIONING SHUTOFF switches to NORMAL.
6. Position the EMERGENCY DEPRESSURIZATION switch to NORMAL.
7. Turn the AIR CONDITIONING MASTER switch to AIR COND GTC.

**CAUTION**

If the ENGINE BLEED AIR switches are in the OVRD position and the air-conditioning master switch is in the AIR COND GTC position, the cargo compartment airflow regulator will go to the full flow position. In this position, sufficient air may not be available to operate the ATM and the flight deck air-conditioning system.

Do not turn the MASTER switch to AIR COND GTC while the engines are supplying bleed air in OVRD, because the increased pressure can damage the airflow regulators.

8. Hold the TEMPERATURE CONTROL switches in COOL or WARM, as desired, for 30 seconds, then return to AUTO. This procedure will position the temperature control valve to the approximate desired position more rapidly and minimize the amount of hot bleed air entering the compartment when the temperature rheostats are in COOL.
9. Position the temperature rheostats as desired.
10. Turn the AIR CONDITIONING MASTER switch to OFF before starting an engine.
11. With one or more engines operating, place the AIR CONDITIONING MASTER switch in AIR COND NO PRESS.

**IN-FLIGHT AIR-CONDITIONING**

1. Place the AIR CONDITIONING MASTER switch in AIR COND AUTO PRESS, AIR COND MAN PRESS, or AIR COND NO PRESS as desired.
2. Position TEMPERATURE CONTROL switches to AUTO.
3. Position temperature rheostats as desired.
4. Place CARGO UNDER FLOOR HEATING switch to ON.

**PRESSURIZATION SYSTEM**

Pressurization of the flight deck and cargo compartment for high-altitude flight is achieved by air supplied from the bleed air system and ducted through the air conditioning system.

The cargo compartment distribution system incorporates a check valve to prevent rapid loss of cabin pressure in case of failure in the recirculating duct system. The outflow valve, which opens to relieve excess pressure, is used with the pressure controller to maintain cabin pressure automatically at a constant level or to limit the cabin-to-atmosphere differential pressure. The safety valve, gives excess pressure relief if the combination of the pressure controller and outflow valve fails to regulate the cabin pressure properly.

**CABIN PRESSURIZATION CHART**

○ ICAO STANDARD ATMOSPHERE

**NOTE**

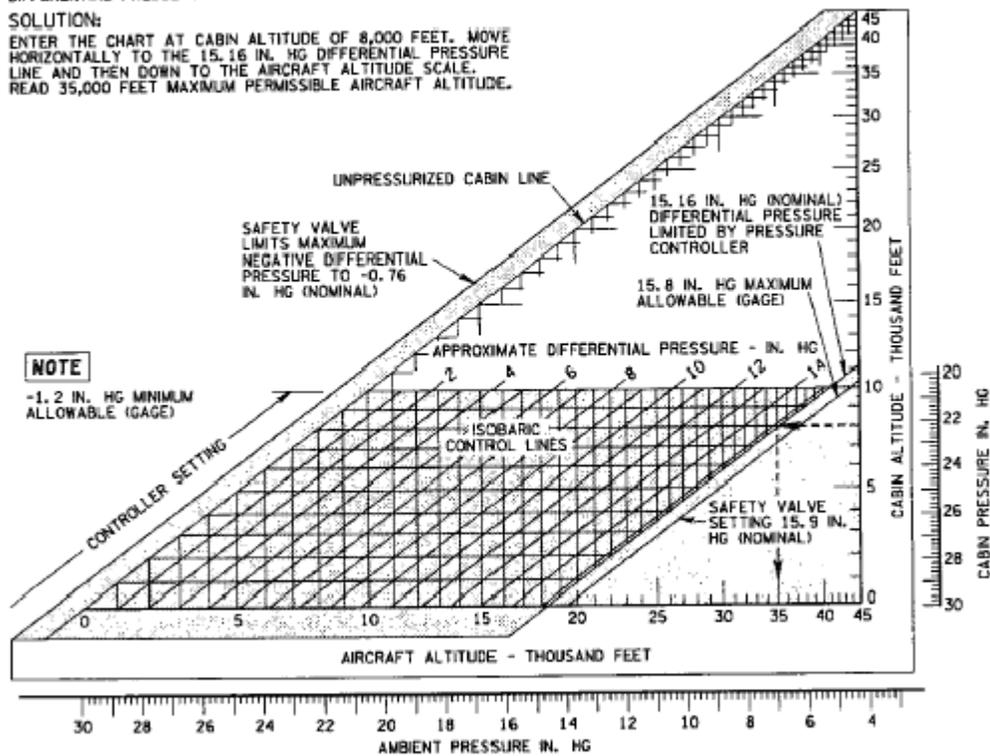
FOR MAXIMUM DIFFERENTIAL RANGE OF CABIN PRESSURE, READ CABIN ALTITUDE AT JUNCTION OF AIRCRAFT ALTITUDE AND MAXIMUM DIFFERENTIAL PRESSURE LINE. REFER TO PART I FOR LIMITS.

**SAMPLE PROBLEM**

**GIVEN:**  
LONG RANGE MISSION WITH PASSENGERS ON BOARD.  
CABIN ALTITUDE LIMITED TO 8,000 FEET.

**FIND:**  
MAXIMUM PERMISSIBLE AIRCRAFT ALTITUDE WITH NOMINAL DIFFERENTIAL PRESSURE LIMITED BY PRESSURE CONTROLLER.

**SOLUTION:**  
ENTER THE CHART AT CABIN ALTITUDE OF 8,000 FEET. MOVE HORIZONTALLY TO THE 15.16 IN. HG DIFFERENTIAL PRESSURE LINE AND THEN DOWN TO THE AIRCRAFT ALTITUDE SCALE. READ 35,000 FEET MAXIMUM PERMISSIBLE AIRCRAFT ALTITUDE.



**NOTE**

-1.2 IN. HG MINIMUM ALLOWABLE (GAGE)

ISOBARIC RANGE - READ DIFFERENTIAL PRESSURE AT JUNCTION OF CONTROLLER SETTING (CABIN ALTITUDE) AND AIRCRAFT ALTITUDE LINES.

EXCESSIVE DIFFERENTIAL PRESSURE

**PRESSURIZATION SYSTEM CONTROLS AND INDICATORS**

Controls and indicators for the cabin pressurization system are located on the air conditioning and pressurization control panel.

**Master Switch**



The air conditioning master switch on the air conditioning and pressurization control panel is used to select the type of operation of the air conditioning and pressurization systems. It controls operation of the outflow valve under conditions of pressurized and nonpressurized operation. For functions of the switch positions, refer to Air Conditioning System Controls and Indicators.

**Cabin Pressure Controller**



The cabin pressure controller, on the air conditioning and pressurization control panel includes the cabin DIFF PRESS indicators, cabin rate of climb indicator, a CABIN ALT selector knob, a RATE selector knob, and a CABIN ALT setting indicator. The CABIN ALT selector knob and pointer are used to preset the required cabin altitude. For the chosen altitude, shown by the pointer on the indicator and selected by turning the knob, a window on the indicator dial face indicates the maximum aircraft altitude which can be reached before cabin differential pressurization begins.

**CAUTION**

Do not force the CABIN ALT knob below a setting of -1,000 feet or above 10,000 feet. To do so may damage the pressure controller.

The RATE selector knob is used to determine the rate of cabin pressure change until the cabin altitude, as shown by the pointer, is reached. The knob is turned from MIN (30 to 200 feet per minute) clockwise to MAX (1,600 to 2,900 feet per minute).

**Manual Press Cont Switch**



The MANUAL PRESS CONT switch is a three-position (INCREASE, OFF, DECREASE) toggle switch, located on the air conditioning and pressurization control panel. It has a center spring-loaded OFF position and momentary INCREASE and DECREASE positions. The switch controls the electric actuator of the outflow valve when the air conditioning master switch is in the MAN PRESS position.

When the switch is held in the INCREASE position, the actuator turns the outflow butterfly valve toward its closed position. When the switch is held in the DECREASE position, the actuator turns the butterfly valve toward its open position.

When operating the system manually, the cabin vertical velocity indicator will give the first indication of pressurization.

**Emergency Depressurization Switch**



The emergency depressurization switch is a two-position (NORMAL, EMERGENCY DEPRESSURIZATION) guarded toggle switch. When the switch is positioned to EMERGENCY DEPRESSURIZATION, battery power from the battery bus (through the EMER DEPRESS circuit breaker on the pilot side circuit breaker panel) is used to override the normal control circuit to open the outflow and safety valves, to close both air conditioning shutoff valves, and to close the cargo underfloor heat shutoff valve.

**Differential Pressure Gage**



The differential pressure gage, located on the air conditioning and pressurization control panel senses both cabin and atmospheric pressures and indicates the pressure differential in inches of mercury.

**Cabin Rate-Of-Climb Indicator**



Cabin Rate-Of-Climb Indicator, which shows the rate of change of cabin altitude in feet per minute, is mounted on the air conditioning and pressurization control panel.

**Cabin Altimeter**



The cabin altimeter in the pilot and copilot instrument panels indicates cabin air pressure altitude within the range 0 to 50,000 feet.

**NORMAL OPERATION OF THE PRESSURIZATION SYSTEM**

**PRESSURIZED FLIGHT - AUTOMATIC PRESSURE CONTROL**

**WARNING**

To allow rapid egress in event of an emergency, do not pressurize the aircraft during taxi or take-off operations.

**Before Take-off.**

1. Turn the RATE knob to MIN.
2. Set the CABIN ALT knob to desired cabin cruise altitude, but never less than field elevation.
3. Set the air conditioning master switch to AUTO PRESS.

**After Take-Off Climb.**

1. Set the RATE knob to the desired rate. Adjust the rate setting as required during climb so that the cabin reaches the selected altitude at the same time the aircraft reaches cruise altitude. Thus, the rate-of-climb pressure change is held to a minimum. The rate-of-cabin pressure change is held constant only up to pressure controller differential limit.

**Note**

Monitor cabin altitude against aircraft altitude to make sure that cabin altitude stays within the isobaric range.

**Cruise.** During pressurized flight, monitor the cabin differential pressure and cabin altitude. Do not allow cabin differential pressure to exceed the maximum allowable for the aircraft.

**Descent.**

1. Set the CABIN ALT knob for the desired cabin altitude.
2. Set the RATE knob to desired rate.

**Before Landing.** Check the cabin differential pressure before landing. If more than 1.5 inches of mercury is indicated, the CABIN ALT knob and the RATE knob should be adjusted to higher settings to increase the rate of depressurization.

**Note**

Cabin differential pressure will be zero for landing. If the differential pressure is less than 0.5 inch of mercury, no discomfort will be experienced if the air conditioning master switch is turned to a nonpressure position.

**PRESSURIZED FLIGHT - MANUAL PRESSURE CONTROL****Before Take-Off.**

1. Set the air conditioning master switch to MAN PRESS.
2. Hold the MANUAL PRESS CONT switch to the INCREASE position until a pressure indication is noted on the cabin rate-of-climb indicator.
3. Set the cabin altitude select knob to 10,000 feet.

**After Take-Off Climb.** Hold the MANUAL PRESS CONT switch in the INCREASE position until an indication of cabin pressure is observed on the cabin vertical velocity indicator. Exercise caution during manual pressure control in order to prevent excessive rate-of-cabin pressure changes which can cause extreme discomfort to passengers and crew.

Operation of the MANUAL PRESS CONT switch by momentarily holding it in desired position and then releasing it to OFF position will provide satisfactory control. Monitor the aircraft vertical velocity indicator, cabin vertical velocity indicator, the cabin differential pressure gage, and the cabin altimeter. Establish as closely as possible a constant cabin rate of climb by intermittently positioning the MANUAL PRESS CONT switch momentarily to the INCREASE position. By reaching the normal differential pressure at the desired cabin altitude when the aircraft reaches cruise altitude, the minimum rate-of-cabin pressure change will be attained.

**Note**

- After switching from automatic to manual pressure control, the MANUAL PRESS CONT switch must be held in the DECREASE position for approximately 40 seconds to open the outflow valve fully.
- Monitor cabin altitude against aircraft altitude to make sure that cabin altitude stays within the isobaric range.

**Cruise.** When the aircraft has reached stabilized cruise conditions, adjust the outflow valve with the manual control switch to maintain a constant differential pressure and constant cabin pressure altitude. Monitor the cabin differential pressure gage and the cabin altimeter so as not to exceed the allowable limits.

**Descent.** As soon as the aircraft starts the descent, position the MANUAL PRESS CONT switch momentarily to the INCREASE position in order to establish a decrease of cabin pressure altitude. Maintain a comfortable rate-of-cabin pressure change by intermittently positioning the outflow valve until the desired altitude is reached. Allow cabin differential pressure to decrease by positioning the MANUAL PRESS CONT switch to open the outflow valve.

**Before Landing.** Check the cabin differential pressure prior to landing. If more than 1.5 inches of mercury differential pressure exists, momentarily position the MANUAL PRESS CONT switch to the DECREASE position, to control the rate of cabin depressurization. Set air conditioning master switch (as required).

**Note**

Cabin differential pressure will be zero for landing. If cabin differential pressure does not exceed 0.5 inch of mercury, no discomfort will be experienced if the aircraft is depressurized by turning the air conditioning master switch to a nonpressure position.

**NON-PRESSURIZED FLIGHT**

Before take-off.

1. Set the air conditioning master switch to NO PRESS or AUX VENT.

**TRANSITION FROM NON-PRESSURIZATION TO PRESSURIZATION DURING FLIGHT**

1. Turn RATE knob to MIN.
2. Set CABIN ALT knob to desired cabin altitude.
3. Turn air conditioning master switch to AUTO PRESS.

Allow cabin differential pressure to build up to approximately 2 inches of mercury to provide sufficient pressure for the pneumatically actuated controller to stabilize and maintain a selected rate.

4. Turn RATE knob to desired rate.

Adjust the rate setting so that the cabin reaches the selected altitude at the same time the aircraft reaches cruise altitude. The rate of cabin pressure change is thus held to a minimum.

**TRANSITION FROM PRESSURIZATION TO NON-PRESSURIZATION DURING FLIGHT**

1. Set RATE knob to desired rate.
2. Set CABIN ALT knob to aircraft altitude at altitudes below 10,000 feet.
3. When above 10,000 feet, turn the air conditioning master switch to MAN PRESS, and hold the MANUAL PRESS CONT switch in the DECREASE position.

Cabin altitude will increase at the rate selected until cabin pressure equals atmospheric pressure. The differential pressure is thus reduced at a controlled rate.

4. Turn air conditioning master switch to NO PRESS (as soon as differential pressure reaches zero).

## ANTI-ICING AND DE-ICING SYSTEMS



Anti-icing systems, which can be used to prevent the formation of ice on critical areas of the aircraft; and de-icing systems, which will remove ice after it is formed, are installed on the aircraft. Heat for the systems is obtained either by the use of electrical heating elements or by heated air drawn from the compressor of each engine.

Anti-icing systems using heated air from the bleed air system serve the wing and empennage leading edges, the nose radome, and the engine inlet air and oil cooler scoops. Anti-icing of the engine compressor inlet vanes also is accomplished by heated air, but this is supplied directly from the engine compressor and not through the bleed air system.

Anti-icing systems using heat from electrical sources are installed for the windshield, pitot tubes, and the forward section and afterbody of the propeller spinner. De-icing of the propeller blades and rear section of the propeller spinner also is accomplished electrically. An ice detection system may be used to achieve automatic operation of the following anti-icing and de-icing systems:

1. Engine inlet air scoop anti-icing.
2. Compressor inlet vane anti-icing.
3. Propeller spinner forward section and after-body anti-icing.
4. Propeller blade de-icing.
5. Propeller spinner middle and rear section de-icing.
6. Propeller spinner plateaus de-icing.

## WING AND EMPENNAGE LEADING EDGE ANTI-ICING SYSTEM

The leading edge anti-icing system is divided into six sections, each consisting of a shutoff valve, ejectors, and control components. The shutoff valves control the flow of air from the bleed air system to the ejectors, where it is ejected through small nozzles into mixing chambers. The hot bleed air at approximately 600°F is mixed with the ambient air drawn into the mixing chambers. The resultant mixed air at approximately 350°F flows through passages next to the leading edge skin.

Since some of the air leaving the passages is drawn back in for recirculation, a lower percentage of bleed air is required for continuous anti-icing. An overheat warning system is installed in the leading edge area. When the temperature in the leading edge area reaches approximately 200°F, the overheat warning light for that area is energized and the light illuminates.

### Wing and Empennage Anti-Icing Switches



The WING and EMPENNAGE ANTI-ICING switches are two-position (ON, OFF) toggle switches, located on the anti-icing and de-icing system control panel.

When the switches are placed in the ON position, solenoids on the anti-icing shutoff valves are energized and the valves control the flow of bleed air to the leading edge air ejectors.

When the switches are in the OFF position, the anti-icing regulators shut off the flow of bleed air.

### Leading Edge Temperature Indicators



Six leading edge temperature indicators, one for each section of the anti-icing system are located on the anti-icing and de-icing system control panel. Each indicator is connected to a resistance bulb located in the leading edge area. The resistance bulbs are placed so that they sense temperature of the air in the area aft of the leading edge skin, not the hot air passed next to the skin.

### Leading Edge Overtemperature Warning Lights



Twelve OVERTEMPERATURE WARNING lights, one for each section of the leading edge anti-icing system, are located below the temperature indicators on the anti-icing and de-icing system control panel. When the temperature in the leading edge reaches approximately 200°F, the warning light for that area illuminates.

### NORMAL OPERATION OF LEADING EDGE ANTI-ICING SYSTEM

The wing and empennage leading edge anti-icing system is turned on or off by the ANTI-ICING switches on the anti-icing and de-icing system control panel. Regulation of temperatures within the leading edges is achieved automatically by thermostatic control of the valves permitting entry of bleed air to the system ejectors. The temperature indicators on the control panel, however, should be monitored while the system is operating, since an emergency condition will exist if either the associated indicators or the warning lights show an overheated condition in any section.

#### CAUTION

The leading edge anti-icing system must not be used to remove ice from surfaces when the aircraft is on the ground. With no airflow over the surface, the air within the leading edge area quickly rises in temperature, and the excessive heat damages fuel tank sealants, paint, structure, and other equipment. If the system is operated for testing, constant monitoring of the temperature indicators must be maintained, and the system must not remain on more than 30 seconds.

## ENGINE INLET AIR DUCT ANTI-ICING SYSTEMS

Two systems are provided for engine inlet air duct anti-icing. One system routes bleed air from the bleed air system to passages in the engine inlet air scoop and oil cooler scoop to heat the scoops.

The other system routes air from the compressor diffuser section of the engine to passages in the compressor inlet vanes. The scoop anti-icing airflow is shut off by a solenoid valve which is energized closed. The air flows when the valve is de-energized open. The vane anti-icing airflow is controlled by two pressure-actuated valves, which are controlled by a single solenoid valve. When the solenoid valve is energized, the pressure-actuated valves shut off the airflow, and when the solenoid valve is de-energized, the pressure-actuated valves open.

Both the scoop and vane anti-icing systems are termed fail-safe, meaning that anti-icing is provided when the system power supply is lost. The electrical control circuits are interconnected with the ice detection system so that the duct anti-icing can be turned on automatically when the detection system senses icing.

### Engine Inlet Air Duct Anti-Icing Switches



Four ENGINE INLET AIR DUCT ANTI-ICING switches are located on the anti-icing and de-icing systems control panel. Each switch has ON and OFF positions. If a switch is in the ON position, the scoop and vane anti-icing systems for that engine are turned on if the PROP & ENG ANTI-ICING MASTER switch is in MANUAL.

If the master switch is in the AUTO position, anti-icing is turned on when the ice detection system detects ice. When an ENGINE INLET AIR DUCT ANTI-ICING switch is in the OFF position, both scoop and vane anti-icing valves for that engine close to shut off the anti-icing airflow.

### NORMAL OPERATION OF ENGINE INLET AIR DUCT ANTI-ICING SYSTEMS

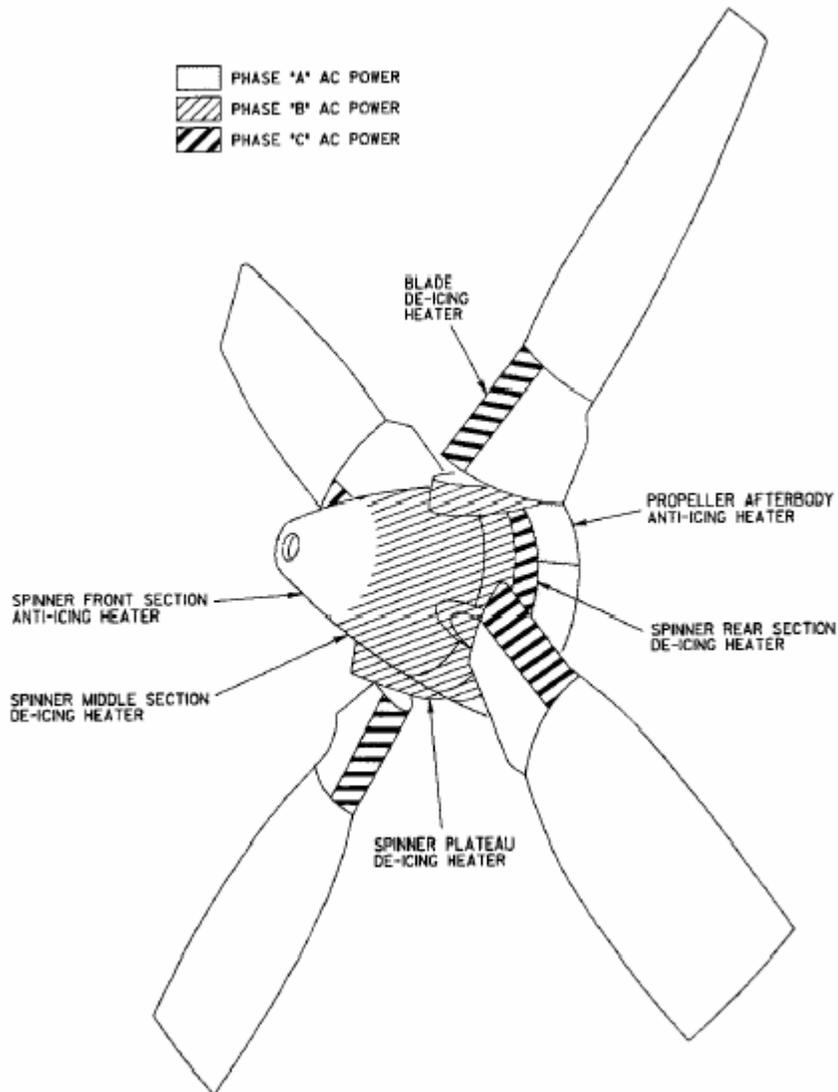
1. To turn the systems on manually, position the PROP & ENGINE ANTI-ICING MASTER switch to MANUAL and the ENGINE INLET AIR DUCT ANTI-ICING switches to ON.
2. To allow the system to be turned on automatically by the ice detection system, position the PROP & ENGINE ANTI-ICING MASTER switch to AUTO and the ENGINE INLET AIR DUCT ANTI-ICING switches to ON.
3. To shut the systems off while leaving them subject to automatic control, move the PROP & ENGINE ANTI-ICING MASTER switch to RESET and let the ENGINE INLET AIR DUCT ANTI-ICING switches remain in the ON position.
4. To shut the systems off, place the ENGINE INLET AIR DUCT ANTI-ICING switches in the OFF position.

#### Note

If an engine is shut down during flight, the inlet duct anti-icing should be left on if icing conditions exist. However, this will not be possible if the fire emergency handle is pulled.

**PROPELLER ANTI-ICING AND DE-ICING SYSTEMS**

The propeller spinner and blades are equipped with heating elements for anti-icing and de-icing.

**PROPELLER ANTI-ICING SYSTEM**

The forward section of the spinner and the propeller afterbody are covered by electrical-resistance heating elements to provide anti-icing. Phase A primary AC power is applied to the heating elements to warm the surface of the spinner and prevent the formation of ice.

### **PROPELLER DE-ICING SYSTEM**

The aft portion of the front spinner section, the rear rotating spinner section, the spinner plateaus, and the leading edges and fairing of the propeller blades contain heating elements for de-icing the surfaces.

The aft portion of the front spinner section, along with the forward part of the rear rotating spinner section and the spinner plateaus, use phase B primary AC power. The aft portion of the rear rotating spinner section and the leading edges and fairing of the propeller blades use phase C primary AC power.

The heating elements are supplied with 115-volt AC power from the RH AC bus. The control circuits for the propeller de-icing, like the control circuits for the propeller anti-icing system, are connected to the ice detection system so that they may be turned on automatically. The application of spinner and blade de-icing power to the heating elements is controlled by the de-icing timer.

The timer applies power to the heating elements of only one propeller at a time; the elements of each propeller are energized 15 seconds during each one-minute cycle.

#### **Propeller Ice Control Switches**



Four PROPELLER ICE CONTROL switches are located on the anti-icing and de-icing systems control panel. These two-position (ON, OFF) toggle switches control the propeller anti-icing and de-icing systems.

When a switch is placed in the ON position and the PROP & ENG ANTI-ICING MASTER switch is in the MANUAL position, the anti-icing and de-icing systems for the corresponding propeller are energized.

If a switch is positioned to ON while the PROP & ENGINE ANTI-ICING MASTER switch is in the AUTO position, the anti-icing and de-icing systems are energized only when the ice detection system detects icing.

When a switch is placed in the OFF position, the anti-icing and de-icing systems for the corresponding propeller are de-energized.

#### **Anti-Icing and De-Icing Ammeters**



Three ammeters located on the anti-icing and de-icing systems control panel indicate the amperage of the various phases of primary AC power drawn for the propeller anti-icing and de-icing systems. The SPINNER ANTI-ICING ammeter indicates the amperage of phase A power drawn for anti-icing; the spinner de-icing ammeter indicates the amperage of phase B power drawn for de-icing; and the BLADE DE-ICING ammeter indicates the amperage of phase C power drawn for de-icing.

### **NORMAL OPERATION OF PROPELLER ANTI-ICING AND DE-ICING SYSTEMS**

1. To turn on the anti-icing and de-icing systems manually, place the PROP & ENG ANTI-ICING MASTER switch in the MANUAL position and the PROPELLER ICE CONTROL switches in the ON position.

#### **Note**

To allow the system to be turned on automatically by the ice detection system, place the PROP & ENG ANTI-ICING MASTER switch in the AUTO position and the PROPELLER ICE CONTROL switches in the ON position.

2. To turn off the systems and leave them subject to automatic control by the ice detection system, move the PROP & ENG ANTI-ICING MASTER switch to the RESET position and release it to the AUTO position.
3. To turn off the propeller anti-icing and de-icing systems, place the PROPELLER ICE CONTROL switches in the OFF position.

**CAUTION**

Do not operate the propeller anti-icing or de-icing for an engine that is not running, when the aircraft is on the ground. The engine must be running in order to dissipate the heat generated by the heating elements to prevent damage to the elements. Never operate the system for more than two cycles while the aircraft is on the ground. Anti-icing and de-icing may be used for a propeller feathered in flight.

**WARNING**

A hazardous condition exists if one propeller blade de-icing system malfunctions and the propeller de-icing is turned on after ice has accumulated on the propeller. The resultant unbalance could cause structural damage to the nacelle before the propeller could be feathered. Check the propeller blade de-icing system on the ground before each mission in accordance with the preceding paragraph. If the BLADE DE-ICING ammeter reading is not within limits, abort all missions requiring flight into known or suspected icing conditions. Check the propeller blade de-icing system in flight before the aircraft is flown into known or suspected icing conditions. If the BLADE DE-ICING ammeter reading falls below 65 amperes for a period not exceeding 15 seconds in each 1-minute de-icing cycle (indicating one propeller malfunctioning), leave the PROP & ENG ANTI-ICING MASTER switch in MANUAL. Feather the propeller on the first indication of unusual vibration. If the BLADE DE-ICING ammeter reading falls below 65 amperes for more than 15 seconds in each 1-minute de-icing cycle (indicating more than one propeller malfunctioning), do not fly into known or suspected icing conditions.

**Note**

A preflight check of propeller de-icing can be made with the engines running. Turn on all the PROPELLER ICE CONTROL switches and check for continuous indications on the two de-icing ammeters. If an ammeter pointer drops for a period of 15 seconds, the de-icing system is not operating properly for one propeller. To determine which propeller has an inoperative phase, the propeller circuits can be energized individually and the ammeters monitored.

**ICE DETECTION SYSTEM**

The ice detection system is used as an automatic control for turning on the engine inlet air duct anti-icing, and propeller anti-icing and de-icing systems. The detection system consists of a PROP & ENG ANTI-ICING MASTER switch, two sets of detector units, indicator lights, a test switch, and control relays. Each set of detection units has a detector and an interpreter. Each detector includes a probe: one is mounted in the No. 2 engine inlet air duct, and the other is in the No. 3 engine duct.

The detection units are armed by dc power applied through the engine starting circuits, and they are operative when the No.2 or No.3 engine is running and the PROP & ENG ANTI-ICING MASTER switch is at AUTO. If either probe becomes iced over while the engine in which it is installed is running, and if the PROP & ENG ANTI-ICING MASTER switch is at AUTO position at that time, the detection units trigger a control relay. This relay turns on the anti-icing and de-icing systems if the switches for those systems are at ON or AUTO positions. The relay also turns on an indicator light.

The ice detection system does not turn off the anti-icing and de-icing systems automatically when icing conditions no longer exist, but the master switch can be held at RESET position to turn them all off simultaneously. Timers in the ice detection system operate after the No.2 and No.3 engines are shut down and disarm the detection system. If any of the anti-icing or de-icing systems have been left in automatic operation, they are turned off upon disarming of the detection system at engine shutdown.

**Prop & Engine Anti-Icing Master Switch**

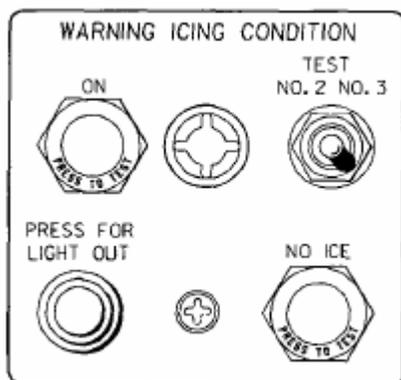


The PROP & ENG ANTI-ICING MASTER switch is located on the anti-icing and de-icing systems control panel. It has three positions: AUTO, MANUAL, and RESET.

When at AUTO position, it permits control of the engine inlet air duct anti-icing, and propeller anti-icing and de-icing systems by the ice detection system. The AUTO position is also used to permit testing of the ice detection system.

When at MANUAL position, the switch permits control of the anti-icing and de-icing systems by the individual control switches for the systems. The RESET position is a momentary position used to turn off the anti-icing and de-icing systems when icing conditions no longer exist. When the switch is positioned at RESET and allowed to return to AUTO, the ice detection system remains armed; therefore, it will automatically turn on the anti-icing and de-icing systems again if it senses icing.

**Test Switch**



The TEST switch is located on the ice detection panel. It has No.2 and No.3 momentary positions and a center off position. It is used to test operation of the two sets of ice detector units by simulating ice detections.

If it is held at No.2 position while the No.2 engine is running and the PROP & ENG ANTI-ICING MASTER switch is at AUTO, the ON indicator light on the ice detection panel goes on to indicate that the ice detection system has triggered the control relay which turns on the anti-icing and de-icing systems.

The No.3 position of the switch is used in the same manner to test operation of the other set of detector units. After the TEST switch is operated to either position, the PROP & ENG ANTI-ICING MASTER switch must be held at RESET momentarily to unlock the control relay and to re-arm the detection system.

### On Light and Press For Light Out Switch



The ON light and the PRESS FOR LIGHT OUT switch is located on the ice detection panel. The indicator light is turned on by the ice detection system whenever it detects ice while the PROP & ENG ANTI-ICING MASTER switch is in the AUTO position.

When lighted, it indicates that icing has been detected by probes in the engine inlet air scoops and that anti-icing systems have been turned on automatically if the individual system switches are at ON or AUTO. It also lights when the TEST switch is operated and, then indicates that the detection units are functioning.

The momentary light out switch can be operated to turn the light off. If the PROP & ENG ANTI-ICING MASTER switch is held in the RESET position to turn off the anti-icing and de-icing systems, the light remains off if icing no longer exists.

### No Ice Light



The NO ICE light is on the ice detection panel. It is turned on when the probes of the detection system are no longer icing and indicates that the anti-icing and de-icing systems can be turned off. If the PROP & ENG ANTI-ICING MASTER switch is held in the RESET position to turn the anti-icing and de-icing systems off, the light also goes off.

**PITOT TUBE ANTI-ICING SYSTEM**

Pitot tube anti-icing is provided by dc electric heating elements on the two tubes. The pilot pitot tube heater uses power from the essential dc bus through the PILOT PITOT HEATER circuit breaker, and the copilot and navigator pitot tube heater uses power from the isolated dc bus through the COPILOT AND NAVIGATOR PITOT HEATER circuit breaker.

This arrangement permits power to be drawn from the battery to heat the copilot and navigator pitot tube when normal dc power sources have failed. The PILOT PITOT HEATER circuit breaker is located on the copilot lower circuit breaker panel, and the COPILOT AND NAVIGATOR PITOT HEATER circuit breaker is located on the pilot's side circuit breaker panel.

**Pitot Heat Switches**



The pilot and copilot PITOT HEAT switches are located on the anti-icing and de-icing systems control panel. These two-position toggle switches have ON and OFF positions. When a switch is placed in the ON position, the heating element for the corresponding pitot tube is energized. When the switch is in the OFF position, the heating element is de-energized.

**WINDSHIELD ANTI-ICING SYSTEM**

The three windshields, the two windows on each side of the windshields, and the two lower windows in front of the pilot are NESAs-type. These panels are heated by applying unregulated AC power from the left-hand AC bus to a resistance material between the layers of glass. The AC power is applied by automatic dc control systems which cycle to maintain window temperature within specific limits.

A center windshield system controls heating of the three center windshields, and a side and lower system controls heating of the side and lower windows. The two systems are identical except for the amount of total AC power provided. Provisions are made for selecting either normal or high rate of heating. When high rate is selected, higher voltage is applied for shorter periods of time so that the NESAs heats more rapidly, but not to a higher temperature. Provisions are also made for controlling the temperature increase manually when the NESAs panels are extremely cold. The control systems do not function automatically when window temperature is below -45 °F.

**NESA Windshield Switches**



NESA Windshield Switches are on the anti-icing and de-icing systems control panel. Each switch has NORMAL, OFF, and HI positions. When the center windshield switch is in the NORMAL position, the three center windshields are heated at the normal rate. If the switch is positioned to HI, the three center windshields have higher voltage applied to the heating material so that they heat more rapidly. Heating of the side and lower windows is controlled in the same manner by the side and lower windshield switch.

**NESA Windshield Cold Start Switches**



NESA Windshield Cold Start Switches are located on the anti-icing and de-icing systems control panel next to the NESA WINDSHIELD control switches. The COLD START switches are push-type momentary switches. The purpose of the switches is to provide manual control of windshield heating to raise the windshield temperature gradually from extremely cold temperature so as to prevent damaging the glass panels. If the temperature of the windshield panels is below -45 °F, the control systems do not function automatically. Pressing the COLD START

switches causes the control systems to apply AC power to the windshield panels while the switches are held.

### **NORMAL OPERATION OF WINDSHIELD ANTI-ICING SYSTEM**

1. When the outside air temperature is below 81 °F (27 °C), turn the NESA WIND-SHIELD anti-icing switches to NORMAL before taxi.

#### **Note**

Operation of NESA anti-icing when outside air temperature is above 81 °F (27 °C) will increase the possibility of delamination within the NESA panels. Always place the NESA WINDSHIELD anti-icing switches in the NORMAL position before take-off to reduce thermal shock and the possibility of cracking the windshield.

Monitor operation of the anti-icing systems by feeling the glass and observing ice formation on the panels. Turn off the system if any of the following conditions is noticed:

- Panels feel excessively hot.
  - Electrical arcing is observed in one of the panels.
  - One of the panels containing thermistors is not heating. This might cause the other panels in the same system to overheat.
2. If ice is forming on the windshields at a rate higher than it can be removed by operating the anti-icing system in NORMAL, set the switches to HI until out of the extreme icing conditions. Do not use the HI position when turning on a system initially.
  3. When ambient temperature is below -45 °F, use the COLD START switch by operating it 5 seconds on, 10 seconds off, to raise the temperature of the windshields until it is above -45°F. The system will then function to control windshield temperature automatically.

#### **CAUTION**

Do not exceed the operating limits of 5 seconds on, 10 seconds off, when operating the COLD START switch. To do so might cause the windshield panels to be damaged.

### **NACELLE PREHEAT SYSTEM**

The nacelle preheat system allows hot air from the bleed air system to flow into the nacelle to heat the engine and nacelle equipment before starting the engine. A solenoid valve and diffuser in each nacelle controls the air flow.

The engine bleed air regulator in a nacelle must be open before bleed air can flow to the preheat valve; the ENGINE BLEED AIR switch must be in OPEN. The preheat valves are controlled by four nacelle preheat switches on the anti-icing and de-icing systems control panel.

#### **Nacelle Preheat Switches**



The four NACELLE PREHEAT switches, located on the anti-icing and de-icing systems control panel are two-position ON, OFF toggle switches.

When a switch is placed in the ON position while the aircraft is on the ground and the corresponding engine condition lever is at GROUND STOP or FEATHER, the nacelle preheat valve (when installed) is energized open and remains open as long as the switch is in the ON position.

Placing the NACELLE PREHEAT switch in the OFF position de-energizes the valve closed.

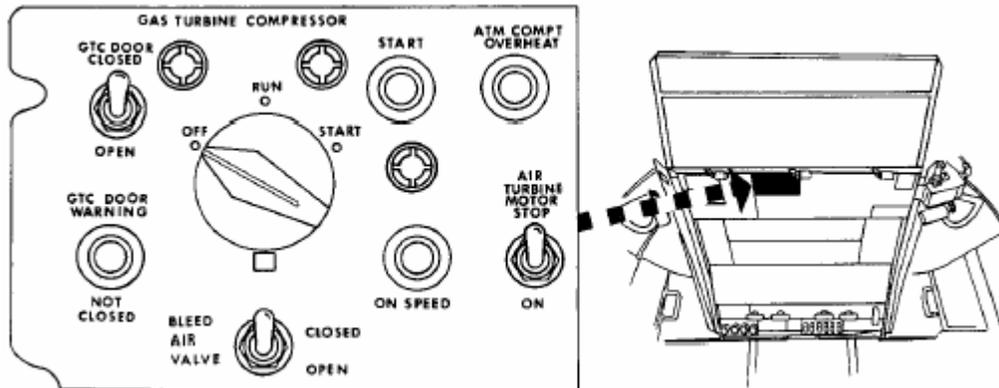
**GTC (GAS TURBINE COMPRESSOR)**

The GTC located forward in the left wheelwell, supplies air for ground operation of the air turbine motor, engine starting, nacelle preheat, and air-conditioning systems. The unit is composed of a compressor assembly, power turbine assembly, and an accessory assembly.

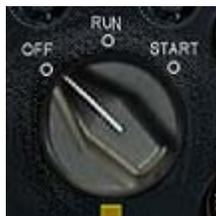
The GTC starter, ignition, and electrical controls are energized by 28-volt dc power from the isolated dc bus through the GTC CONTROL circuit breaker on the pilot side circuit breaker panel.

**GTC CONTROLS**

All GTC controls are located on the GTC control panel on the overhead control panel.



**GTC Control Switch**



A selector switch for the GTC is located on the GTC control panel. This three-position (OFF, RUN, START) rotary switch controls the operation of the GTC.

Holding the selector switch in the spring-loaded START position energizes the self-holding starter relay. This relay will remain closed until the circuit is broken by the 35-percent speed switch or by moving the selector switch to the OFF position.

When the switch is released, it moves to the RUN position. In this position, all GTC circuits are energized to the various automatic controls. These oil-pressure and speed-sensitive switches control their respective circuits to accomplish starting and running of the GTC. In the OFF position, all circuits are de-energized.

**GTC Door Switch**



A two-position (OPEN, CLOSED) toggle switch, located on the GTC control panel controls the opening and closing of the GTC intake door.

When the switch is placed in the OPEN position, the GTC door is actuated to the open position. When the door is fully open, a limit switch de-energizes the actuator.

When the switch is placed in the CLOSED position, the door closes and the close limit switch de-energizes the actuator.

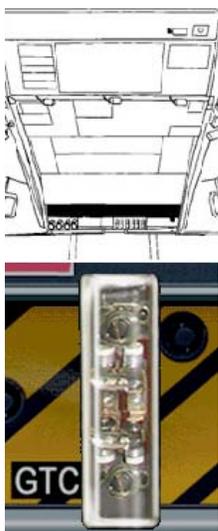
**Bleed Air Valve Switch**



A BLEED AIR VALVE switch is located on the GTC control panel. After the compressor reaches operating speed (*95 percent rpm*), this two-position (OPEN, CLOSED) toggle switch controls the normally closed, solenoid-operated bleed-air valve. With the valve closed, air is supplied to the power turbine combustion chamber only. With the valve open, air is supplied to both the combustion chamber and the bleed-air system of the aircraft.

Applying a bleed-air load to the compressor before it reaches operating speed is prevented by the 95-percent speed switch that completes the circuit to the BLEED AIR VALVE switch only after operating speed is reached.

**Fire Emergency Control Handle**



The GTC fire emergency handle located on the overhead control panel provides for emergency shutdown of the GTC. This handle, when pulled, breaks the circuit to the GTC control switch. When the circuit to the control switch is broken, the solenoid-operated shutoff valves are de-energized to the closed position. With these valves closed, fuel and oil into the GTC and bleed air from the GTC are shut off.

**CAUTION**

Do not use the fire emergency handle for normal shutdown of the GTC. Bearing damage may result because the supply of oil is shut off.

**GTC INDICATORS**

The indicators for the GTC are located on the GTC control panel that is part of the overhead control panel.

**Start Light**



A START light is located on the GTC control panel. This light goes on to indicate that the starter motor is energized and engaged with the GTC drive train. The light stays on until the compressor reaches approximately 14,900 rpm (*35 percent rpm*), when a centrifugal switch de-energizes the starter and the START light. The light will also go off if the GTC control switch is placed in the OFF position to discontinue the start.

**On-Speed Light**



An ON-SPEED light is located on the GTC control panel. This light is energized through the 95-percent speed switch, and it indicates that the compressor has reached or is maintaining operating speed.

### GTC Door Warning Light



A GTC door warning light is located on the GTC control panel. This light is on when the GTC intake door is not closed.

### NORMAL OPERATION OF THE GTC

The GTC can be operated on the ground only. The air intake door and the GTC are operated from the GTC control panel on the overhead control panel.

#### **CAUTION**

During starting and operation of the GTC, personnel must stand clear of the air intake and exhaust and the plane of rotation of the compressor and turbine. Exercise extreme care to prevent foreign material from entering the air intake, as turbine failure may be sufficiently violent to damage equipment and endanger nearby personnel.

### **STARTING THE GTC**

Start the GTC as follows:

1. Turn on dc power. (If external dc power is available, turn the battery switch to EXT D-C PWR position. If external AC power is available, turn the external AC power switch to the EXT A-C PWR position. If no external power is available, turn the battery switch to the BATTERY position.)
2. Open the GTC air intake door by placing the GTC DOOR switch in the OPEN position.

#### **Note**

A limit switch prevents starting of the GTC unless the air intake door is fully open.

3. Tie the bus tie switch.
4. Route fuel to the GTC by opening a crossfeed valve.
5. Place the BLEED AIR VALVE switch in the CLOSED position.
6. Turn the GTC control switch to the spring-loaded START position. The START light should go on immediately.
7. Release the control switch. The spring return will move the switch to the RUN position.

#### **CAUTION**

As soon as the GTC starter disengages, the START light will go off. If the light does not go off within 1 minute, move the control switch to the OFF position, and wait 4 minutes before making another start attempt. The starter duty cycle is 1 minute on and 4 minutes off.

After the GTC control switch is placed in the START position, the start cycle is automatically controlled by the oil-pressure and speed-sensitive switches.

### **LOADING OPERATION**

#### **Note**

When possible, allow the GTC to warm up for 3 to 5 minutes at governed speed before applying load.

Apply the load to the GTC as follows:

1. Ensure that the unit is on speed.
2. Place the BLEED AIR VALVE switch in the OPEN position.
3. Check the bleed-air manifold to ensure proper operating pressure.

### **STOPPING THE GTC**

Stop the GTC as follows:

1. Place the BLEED AIR VALVE switch in the CLOSED position.
2. Turn the GTC control switch to the OFF position.

**CAUTION**

Do not use the fire emergency handle for normal shutdown of the GTC. Bearing damage may result because the supply of oil is shut off.

3. Place the GTC intake door switch in the CLOSED position and check that the GTC DOOR WARNING light is off.

**AIR TURBINE MOTOR**

The ATM, located in the left wheel well above and aft of the GTC, is a single-stage, axial-flow turbine used to drive a 20 kVA, AC generator to supply 115/200-volt, three-phase, AC power. With the aircraft on the ground and at an ambient temperature of 40 °C (104 °F) or less, the ATM-driven AC generator is rated at 30 kVA (1.0 reading on loadmeter). Compressed air for operation of the ATM is furnished from the bleed-air manifold.

The speed of the unit is controlled by a speed-sensing butterfly valve in the turbine inlet that meters the amount of air supplied to the turbine and provides automatic shutdown in case of overspeed and which must be manually reset in the ATM compartment. A cooling fan for the AC generator, energized by generator output, is included in the unit. A plug assembly for the ATM cooling fan is stowed in the miscellaneous stowage box.

The ATM generator can be operated with the fan failed as follows:

1. During flight – 1.0 (100 percent), no time limit.
2. Ground operation - 20 kVA (66 percent load) (0.66), no time limit.

**ATM Control Switch**

The ATM control switch is located on the GTC control panel. This two-position (ON, STOP) toggle switch controls a shutoff valve in the ATM inlet line.

When the switch is placed in the ON position, the shutoff valve is opened and compressed air is admitted to drive the ATM.

**ATM Compartment Overheat Warning Light**

A red light, located on the GTC control panel is provided to warn the pilot of an overheat condition in the ATM compartment.

When an overheat condition exists, the warning light will go on and the overheat condition must be corrected to extinguish the light.

**ATM OPERATION**

Operation of the ATM is possible only when the bleed-air manifold is pressurized, whether from an external pressure source or from bleed air from the GTC or the engines. The unit is started by placing the ATM control switch in the ON position; it is stopped by placing the switch in the STOP position.

**INSTRUMENTS**

**PITOT-STATIC INSTRUMENTS**

Ram air (pitot) pressure and atmospheric (static) pressure to operate the vertical velocity, airspeed, and altimeter indicators are supplied by the pitot-static system. Static pressure is supplied for the cabin differential pressure indicator, cabin pressure controller, cabin pressure safety valve, and the flight station air conditioning unit airflow regulator.

**Vertical Velocity Indicators**



The vertical velocity indicators, one mounted on the pilot instrument panel and the other mounted on the copilot instrument panel sense the rate of pressure change as the aircraft climbs or descends and indicate it as a rate of change of altitude in feet per minute.

**Airspeed Indicators**



Two airspeed indicators, one mounted on the pilot instrument panel one on the copilot instrument panel and one on the navigator instrument panel are instruments which use differential air pressure to determine airspeed.

Each of the indicators is calibrated in knots.

**True Airspeed Indicator**



True Airspeed Indicator is mounted on the navigator instrument panel, is instrument which use differential air pressure to determine airspeed. The indicator is calibrated in knots.

**Altimeters**

The three altimeters, one mounted on the pilot instrument panel one on the copilot instrument panel and one on the navigator instrument panel, are barometric-type instruments measuring variations in pressure by means of aneroid units. Each altimeter is calibrated in feet.



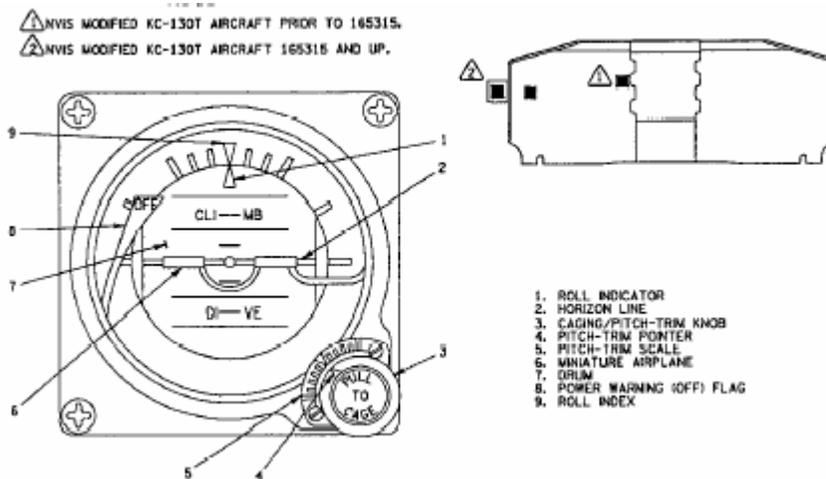
The pilot altimeter combines a conventional barometer altimeter and an altitude-reporting encoder in one self-contained unit. In aircraft modified by AFC 352 the altimeter encoder is located on the copilot's instrument panel. A 10,000 and 1,000-foot digital counter indicator and a 100 foot drum indicator provide a direct digital output and readout of altitude in increments of 100 feet, from -1,000 to 50,000 feet. The encoder digital output is referenced to 1,013 millibars and to 29.92 inches of mercury and is not affected by changes in barometric setting.

A pointer repeats the indications of the 100-foot drum, and serves both as a vernier for the drum and as a quick indication of the rate and sense of altitude changes. Two methods may be used to read indicated altitude on the counter-drum-pointer altimeter:

1. Read the digital counter indicator and the 100-foot drum indicator, without reference to the pointer, as shown by a direct digital readout in thousands and hundreds of feet; or
2. Read the thousands of feet on the two digital counter indicators, without referring to the drum indicator, and then add the 100-foot pointer indication.

**MISCELLANEOUS INSTRUMENTS**

**Standby Attitude Indicator**



A standby attitude indicator is provided on the pilot's instrument panel. The indicator contains an electrically driven vertical gyro which maintains vertical orientation through use of a mechanical erection system. The erection system incorporates automatic erection cut-off when subjected to fore-aft or lateral accelerations exceeding approximately 0.16 g. The display of attitude information is accomplished by mechanical coupling from the vertical gyro to the display drum. Roll indication is 360° with 10° markings through 30°, 60°, and 90°, pitch indications are in 5° graduations. A caging pitch trim knob is provided on the lower right corner of the indicator. A warning (OFF) flag appears when power is removed from the indicator.

The warning flag drives out of view on application of power and appears immediately when power is removed. A switch actuated by the caging knob causes the warning flag to appear when the caging knob is pulled. The gyro wheel speed and the unique nature of the erection mechanism combine to provide a minimum of 9 minutes of attitude information after a loss of power to the indicator. The warning flag being in view during this time period does not invalidate the attitude information.

Caging the indicator by pulling the caging/pitch trim knob to its fully extended position orients the gyro spin axis to the position of the case. If the indicator case is misoriented during caging operation, the spin axis will not be caged to true vertical and will require time to erect to true vertical. This erection rate is a nominal 2.5° per minute. Caging of the attitude indicator after power is off during shutdown is recommended.

### Magnetic Compass



A magnetic compass is mounted on the pilot instrument panel. It is a standard floating card compass that indicates the direction the aircraft is headed with respect to magnetic north.

#### Note

The magnetic compass is intended as a standby compass and should not be used except in case of emergency. For the most reliable operation of the magnetic compass, the pitot heat should be turned on and the HSI set to correspond with the aircraft heading.

### Accelerometer



Two accelerometers on the pilot instrument panel give instantaneous readings and maximum positive and negative readings of the g forces exerted on the aircraft. The gage is calibrated from plus 4 g to minus 2 g. The maximum indication needles will remain at their highest readings until the push-to-set button on the gage case is pushed; then they will both return to plus 1 g and immediately register maximum value until again reset.

### Clocks



Four clocks are mounted in the aircraft, one each on the following: pilot and copilot instrument panel, navigator instrument panel, and radio operator control panel.

## COMMUNICATION AND NAVIGATION EQUIPMENT

The communication and associated electronic equipment consists of radio and intercommunication equipment to provide aircraft-to-aircraft communication, aircraft-to-ground communication, and intra-aircraft communication; navigation sets for guidance; and radar sets for identification and warning.

### VHF-AM RADIO

Two sets of the VHF command radio (COMM 1 and COMM 2) provide voice transmission and reception in the frequency range of 116.0 to 149.95 MHz with reception possible up to 151.95. There are 680 crystal-controlled frequencies available in steps of 50 kHz.

#### VHF COMMAND RADIO CONTROLS



The VHF command panel is located on the 2D Radio Control Panel, on the Navigator 2D panel and flight control pedestal in VC (Click on the panel in VC calls 2D Radio Panel).

The 2D Radio Panel provides the operating controls for the VHF command radio:

- 1 - Master Knob
- 2 - Frequency Display
- 3 - ACTIVE/STANDBY Frequency Selector
- 4 - Volume Control Knob

#### NORMAL OPERATION OF THE VHF COMMAND RADIO

To put the VHF command radio into operation:

1. Rotate the Master knob clockwise to ON position
2. Select the desired STANDBY frequency by clicking on the display numbers.
3. Make the STANDBY frequency ACTIVE by clicking on ACTIVE/STANDBY frequency selector.
4. Select the desired STANDBY frequency by clicking on the display numbers.
5. Use ACTIVE/STANDBY frequency selector to switch between the frequencies.

To turn the VHF command radio off:

6. Rotate the Master knob to the OFF position.

### VHF NAVIGATION AND DME

Two independent VHF navigation systems are installed. Each system receiver performs dual functions. When tuned to a VOR frequency, the receiver furnishes VOR magnetic bearing to the pilot and copilot HSIs and BDHIs and to the navigator right-hand BDHI.

When VOR/ILS is selected on the NAV SEL switch, VOR course deviation, to-from indication, and system validity are provided to the flight control system for display and flight computer steering.

Tuning the receiver to an ILS frequency activates the localizer and glide-slope sections of the receiver. With VOR/ILS selected on the NAV SEL switch, horizontal and vertical position information is furnished by the receiver to the flight control system for display on the HSIs and ADIs and for use by the flight computers to compute steering signals for the autopilot and AD1 command bars.

**VHF NAVIGATION/DME CONTROLS**



- 1 – Whole-MHz frequency Selector Knob
- 2 – Frequency Display
- 2 - Fractions of -MHz frequency Selector Knob
- 4 – Volume Control Knob

The VHF Navigation/DME panels are located on the 2D Radio Control Panel, on the Navigator 2D panel and the flight control pedestal in VC (click on the panel in VC calls 2D Radio Panel)

The 2D Radio Panel provides the operating controls for the VHF Navigation/DME:

**NORMAL OPERATION OF THE VHF NAVIGATION/DME**

To put the VHF command radio into operation just select the desired frequency (VOR, DME or ILS) by turning the selector knobs.

**AD360 AUTOMATIC DIRECTION FINDER**

The ADF systems provide automatic direction finding with continuous indication of the bearing to the selected radio station.

The control panels are located on the 2D Radio Control Panel, on the Navigator 2D panel and on the flight control pedestal in VC (click on the panel in VC calls 2D Radio Panel). The 2D Radio Panel provides the operating controls for the ADF. Each ADF system operates independently, with the No.1 system positioning the No.1 needles and the No.2 system positioning the No.2 needles of the pilot and copilot RMI, and navigator left-hand BDHI.

The ADF systems operate in the low to medium frequency range of 0.19 to 1.75 MHz in three bands: 0.19 to 0.40, 0.40 to 0.84 kHz, and 0.84 to 1.75 MHz.

**AUTOMATIC DIRECTION FINDER CONTROLS**



A function switch (3) with OFF, ADF, ANT, and LOOP positions selects the type of operation of the ADF.

The LOOP control knob (1) provides for rotation of the loop antenna.

The Tuning Knobs (4-6) provide frequency tuning. The frequency selected in the indicator window (is displayed in whole and fractions of megahertz.

The BFO switch (2) is used for tuning a received signal for best reception by tuning out high and low tones on either side of center frequency.

**NORMAL OPERATION OF THE AUTOMATIC DIRECTION FINDER**

To put the ADF into operation and use the for automatic position finding:

1. Place the function switch in the ADF position.
2. Place the BFO switch in the desired position.
3. Select the operating frequency with the TUNING knobs.

To turn the ADF off:

4. Place the function switch in the OFF position.

**APN-22 RADAR ALTIMETER**

A radar altimeter is provided to indicate the terrain clearance of the aircraft. Altitude above terrain is indicated in feet, on a calibrated indicator located on the pilot and copilot instrument panel. Radar altimeter indications are unreliable when flying over areas of deep snow and ice such as Polar Regions.

**RADAR ALTIMETER CONTROLS**

The only controls for the radar altimeter are the ON-LIMIT/TEST knobs on the pilot and copilot height indicators. Rotating an on-limit knob above zero sets the clearance altitude below which warning will be given.

The clearance altitude can be set independently on each indicator.

A yellow flag on the indicator will appear whenever the aircraft is below the preset altitude of that indicator or it is OFF/out of service.

**NORMAL OPERATION OF THE RADAR ALTIMETERS**

To put the radar altimeter into operation:

1. Rotate either on-limit knob clockwise.
2. Set the desired clearance altitude for each indicator.

To turn the radar altimeter off:

3. Rotate both on-limit knobs to the extreme counterclockwise position.

**IFF/SSR TRANSPONDER (AN/APX)**

The IFF/SSR transponder provides automatic radar identification of the aircraft when interrogated by surface or airborne radar sets. Also the system enables friendly aircraft to identify themselves apart from other friendly aircraft and provides a means of transmitting a special coded signal known as an emergency reply. In addition to the identification information, the reply signal reports the altitude of the aircraft.

The IFF/SSR transponder system consists of a transponder control panel and a receiver-transmitter. Antennas are provided on the top and bottom of the fuselage. There are space provisions for a KIT-IA/T SEC computer transponder on the left-hand underdeck rack. An altimeter-encoder is installed on the pilot instrument panel.

The radar identification system receives, decodes, and responds to the characteristic interrogations of operational modes 1,2,3/A and C and D (when the computer is encoded). The receiver operates on a frequency of 1,030 MHz, and the transmitter operates on a frequency of 1,090 MHz. Specially coded identification of position (IP) and emergency signals may be transmitted to interrogating stations when conditions warrant.

Signals, consisting of pairs of pulses spaced to form a code, are transmitted from the interrogating station, and received by the receiver-transmitter. These signals are transferred to the decoder, where they are checked for valid code and proper mode (except for mode D interrogations, which are sent directly to the mode D board). If valid, the decoded signals are sent to the encoder board, which prepares the coded reply. The coded reply is sent through the transmitter and antenna to the interrogating station.

The radar identification system can be operated in any one of the following categories of operation, each of which may be selected by the pilot or copilot at the control panel:

1. Normal (sensitivity) operation.
2. Identification of position (I/P).
3. Emergency operation.

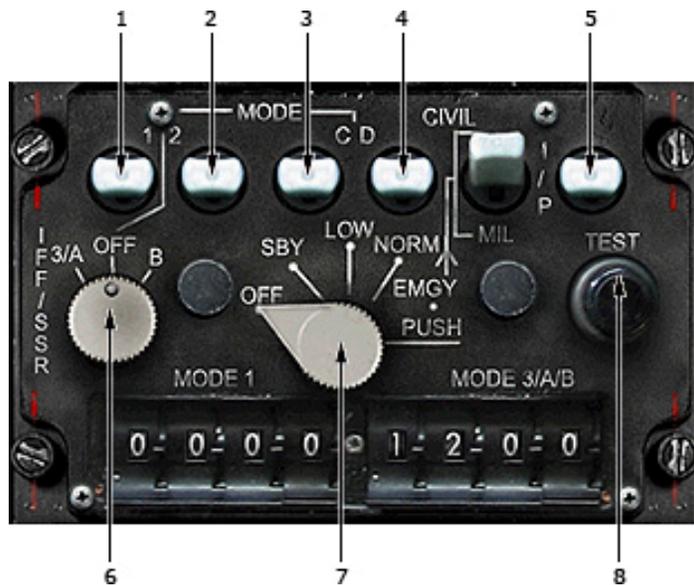
Five independent coding modes are available. The first three modes may be used independently or in combination. Mode 1 and 2 provides 4,096 possible code combinations, but only one is available for operation in flight, since the selection dials must be preset at the receiver-transmitter before flight.

Mode 3/A/B provides 4,096 possible codes, any one of which may be selected from the control panel. Mode C (when the system is connected to the altimeter encoder) will indicate the pressure altitude of the aircraft interrogated.

Mode D (when the system is connected to the computer) can be selected to display any one of many classified operational codes for security identification.

The range of the system is limited to line-of-sight transmission, since its frequency of operation is in the UHF band. This makes the range of operation dependent on the altitude of the aircraft.

**IFF/SS RADAR IDENTIFICATION SYSTEM CONTROLS**



#	CONTROL	POSITION	FUNCTION
1	M-1 Switch	ON	Allows system to reply to mode 1 interrogations.
		OUT	Prevents reply to mode 1 interrogations.
2	M-2 Switch	ON	Allows system to reply to mode 2 interrogations.
		OUT	Prevents reply to mode 2 interrogations.
3	M-C Switch	ON	Allows system to reply to mode C interrogations.
		OUT	Prevents reply to mode C interrogations.
4	Mode D Switch	ON	Allows system to reply to mode 4 interrogations.
		OUT	Prevents reply to mode 4 interrogations.
5	1/P Switch	ON	When spring-loaded switch is momentarily actuated, it initiates identification of position reply for approximately 30 seconds.
		OUT	Prevents triggering to mode 1 interrogations.
6	M-3/A Switch	3A	Allows system to reply to mode 3/A interrogations.
		OFF	Prevents reply to mode 3 interrogations.
		B	Allows system to reply to mode 3/B interrogations.

7	MASTER Control	OFF	Denergizes the system.
		STDBY	Places system in warm-up (standby) condition.
		NORM	Allows operation of system at normal receiver sensitivity.
		EMER	Allows system to transmit emergency replies to mode 1, 2 or 3/A interrogations regardless of mode control setting.
8	Test Indicator		Illuminates when system responds properly to self-test

### **NORMAL OPERATION OF THE IFF/SS RADAR IDENTIFICATION SYSTEM**

To put the system in operation:

1. Set the MASTER switch to OFF.
2. Set the required operational code in the MODE 1 and 3/A/B code select switches and ensure proper code insertion has been made for modes 2 and 4.
3. Set the MASTER switch to STBY and allow a 1 -minute warm-up for standard temperature, or a 2-minute warm-up for cold weather operation.
4. Set the MASTER switch to NORM.
5. Set the 1, 2, 3A/B, C and mode D switches to ON, as required by the operational codes being used.
6. Set the CIVIL-MIL switch as required by the operational codes being used.

To check that the system is operating properly:

7. Press momentarily the TEST button, and check that the test indicator illuminates.

### **IDENTIFICATION OF POSITION (IP) OPERATION**

Turn ON the I\P switch. The system will automatically transmit the reply during the time that the switch is held, and for 30 seconds after the switch is released.

### **EMERGENCY OPERATION**

1. Push the MASTER switch in and rotate it to the EMER position.
2. Let the MASTER switch remain in the EMER position during the emergency. When the master switch on the control panel is set to EMER, the system transmits an emergency signal, which is displayed as four dashes on the interrogating radar indicator.
3. When the emergency is over, return the MASTER switch to NORM.

To turn the system off:

4. Set the master switch to OFF.

**TCAS II (TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM)**

TCAS II is a system used for detecting and tracking aircraft in the vicinity of your own aircraft. By interrogating their transponders it analyzes the replies to determine range, bearing, and if reporting altitude, the relative altitude of the intruder. Should the TCAS II processor determine that a possible collision hazard exists, it issues visual and audio advisories to the crew for appropriate vertical avoidance maneuvers.

The Traffic Advisory (TA) display shows the intruding aircraft's relative position and altitude with a trend arrow to indicate if it is climbing or descending at greater than 500 feet per minute. This TA display is provided on the Radar indicator. The TA display identifies the relative threat of each intruder by using various symbols and colors. Complementing the displays, TCAS II provides appropriate synthesized voice announcements.

ATC procedures and the "see and avoid concept" will continue to be the primary means of ensuring aircraft separation. However, if communication is lost with ATC, CAS II adds a significant backup for collision avoidance.

**TCAS II OPERATION**

The TCAS II system monitors the airspace surrounding your aircraft by interrogating the transponder of intruding aircraft. The interrogation reply enables TCAS II to compute the following information about the intruder:

1. Range between your aircraft and the intruder.
2. Relative bearing to the intruder.
3. Altitude and vertical speed of the intruder, if reporting altitude.
4. Closing rate between the intruder and your aircraft.

Using this data TCAS II predicts the time to, and the separation at the intruders closest point of approach (CPA). Should TCAS II predict that certain safe boundaries may be violated it will issue a Traffic Advisory (TA) to alert the crew that closing traffic is in the vicinity.

If the intruder continues to close, TCAS II will issue a Resolution Advisory (RA) to obtain or maintain safe vertical separation between your aircraft and the intruder. TCAS II bases the alarms on a five second crew reaction time to begin the separation maneuver. Increase or reversal of an RA requires a reaction in two and one half seconds.

**TYPICAL TCAS II ENCOUNTER**

Two TCAS II equipped aircraft will coordinate their resolution advisories using a Mode S transponder air-to-air data link. The coordination ensures that complementary advisories are issued in each aircraft. The crew should promptly but smoothly follow the advisory. Since maneuvers are coordinated, the crew should never maneuver in the opposite direction of the advisory.

TCAS II can track as many as 45 aircraft, display up to 30 of them and can coordinate a resolution advisory for up to three intruders at once. The advisories are always based on the least amount of deviation from the flight path while providing safe vertical separation.

**TCAS II TRAFFIC DISPLAY SYMBOLS**

TCAS II will display four different traffic symbols on the Traffic Advisory displays. The symbols change shape and color to represent increasing levels of urgency.

The traffic symbols may also have an associated altitude tag which shows relative altitude in hundreds of feet, indicating whether the intruder is climbing, flying level or descending.

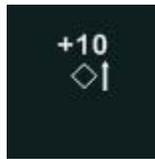
A + sign and number above the symbol means the intruder is above your altitude.

A - sign and number beneath indicates it is below your altitude.

A trend arrow appears when the intruder's vertical rate is 500 feet per minute or greater.

If the intruder is Non-Altitude Reporting (NAR) the traffic symbol appears without an altitude number or trend arrow. The type of symbol selected by TCAS II is based on the intruder location and closing rate.

NON-THREAT TRAFFIC



An open white diamond indicates that an intruder’s relative altitude is greater than plus or minus 1200 feet vertically or its distance is beyond 6 nm range. It is not yet considered a threat. This one is 1000 feet above your own altitude, climbing at 500 feet per minute or greater.

PROXIMITY INTRUDER TRAFFIC



A filled white diamond indicates that the intruding aircraft is within plus or minus 1200 feet vertically and within 6 nm range, but is still not considered a threat. This intruder is now 200 feet above your aircraft and climbing.

TRAFFIC ADVISORY (TA)



A symbol change to a filled yellow circle indicates that the intruding aircraft is considered to be potentially hazardous. Depending on your altitude TCAS II will display a TA when the time to CPA is between 20 and 48 seconds.

Here the intruder is 200 feet below your aircraft, climbing at 500 feet per minute or greater. A voice announcement is heard in the cockpit, advising, “Traffic, Traffic”

Under normal conditions a TA will precede an RA by 10 to 15 seconds. The crew should attempt to gain visual contact with the intruder and be prepared to maneuver should an RA be sounded 10 to 15 seconds later. The crew should take no evasive actions based solely on the TCAS II display.

RESOLUTION ADVISORY (RA)



A solid red square indicates that the intruding aircraft is projected to be a collision threat. TCAS II calculates that the intruder has reached the point where a Resolution Advisory is necessary. The time to closest approach with the intruder is now between 15 and 35 seconds depending on your altitude. The symbol appears together with an appropriate audio warning.

This aircraft is now 1000 feet below your altitude and still climbing. A synthesized voice announces a vertical maneuver command, such as, “Climb, Climb, Climb”.

The pilot should smoothly but firmly initiate any required vertical maneuver within 5 seconds from the time the RA is posted. An intruder must be reporting altitude in order to generate an RA. Therefore, the RA symbol will always have an altitude tag.

**MULTIMODE RADAR SET**

The multimode color radar set consists of the following components: an antenna, a receiver-transmitter, a pilot and navigator indicator (display), and a radar display control panel.

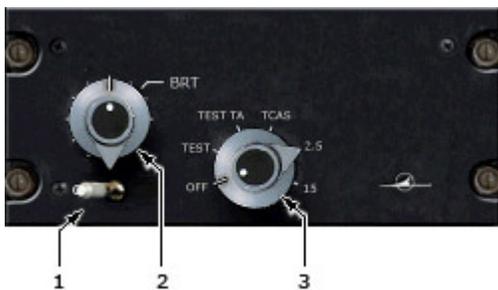
The multimode radar features include air-to-air mapping capability, and Traffic Alert and Collision Avoidance System (TCAS II).

In the air-to-air mapping function, the set presents a display of other aircraft in the immediate vicinity of the present flight path.

**CONTROLS AND INDICATORS**

The radar indicators are located at both the pilot and navigator station. The pilot radar indicator is mounted on the pilot instrument panel glareshield. A navigator radar indicator is located at the navigator station.

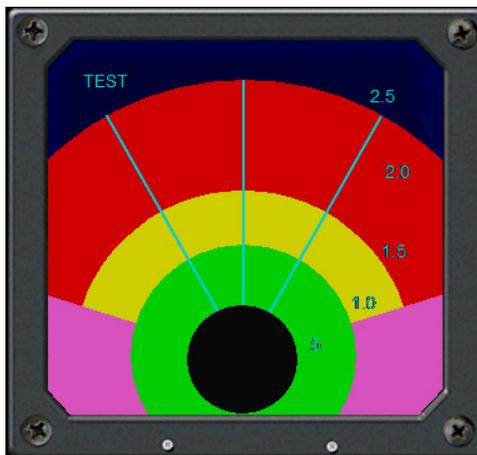
**Control Panel**



The radar set 2D operating control panel is available from the Control Panel icon (Shift+2)

1. Show\Hide aircraft labels (in Map mode only)
2. Display Brightness Control knob. The BRT control adjusts brightness (intensity) of presentation on radar indicator for best signal visibility and contrast.
3. Function Selector Switch. In OFF, all power is removed from the radar set.

**RADAR DISPLAY FUNCTIONS**



**TEST**

In TEST, the radar set radiates into a dummy load, a test pattern is displayed on the radar indicator and the system executes an internal test sequence.

The ANT and/or RT fault indicators may light to signal detected faults.



TEST TA

Displays this TCAS II Test pattern and the following synthesized voice announcements are issued by TCAS II over the aircraft audio system:

- If self test passed: 'TCAS System Test OK'
- If self test failed: 'TCAS System Test Fail'



TCAS

Typical radar display in TCAS mode.

*See TCAS II (traffic alert and collision avoidance system) section of this manual for details.*



MAP 2.5 Mode

The 2.5 mode selects 2.5 nautical miles (NM) range displayed on the radar indicator and 0.5 NM distance between fixed range markers.

The MAP 2.5 position is recommended for short-range (up to 2.5NM), air-to-air operation.



#### MAP 15 Mode

The 15 mode selects 15 nautical miles (NM) range displayed on the radar indicator and 3 NM distance between fixed range markers.

The MAP 15 (NM) position is recommended for medium-range (up to 15NM), air-to-air operation.

### **NORMAL OPERATION OF THE RADAR SET**

#### **WARNING**

Before placing the function selector switch in TCAS, 2.5 or 15 make sure that all personnel are clear of the antenna radiation hazard area. Avoid directing the energy beam toward inhabited structures, personnel, or areas where aircraft are being refueled or defueled.

1. Function selector switch - TEST.
  - Check test pattern.
2. Adjust radar display brightness using BRT knob.
3. Function selector switch - TEST TA.
  - Check TCAS II test pattern.
  - 'TCAS System Test OK' audio message must be issued by TCAS.
4. Function selector switch - 2.5
  - Check range markers and traffic target marks if available.
5. Function selector switch - 15
  - Check range markers and traffic target marks if available.
6. Function selector switch - AS REQUIRED.

RADAR TURN OFF. To turn off the radar system equipment after use:

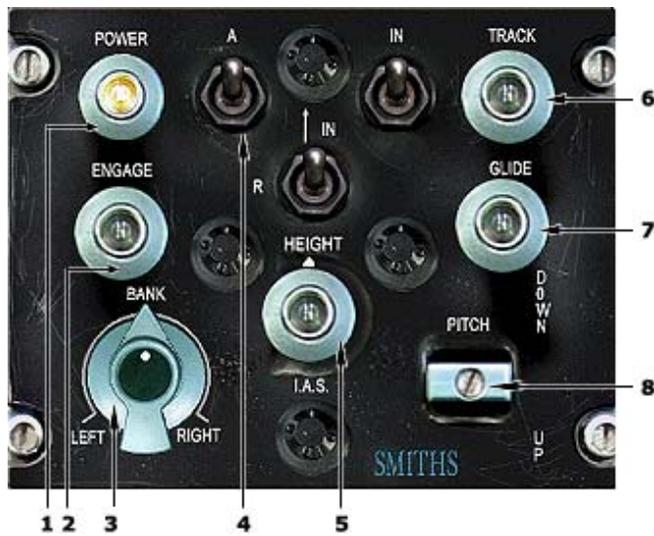
7. Function selector switch - OFF.

## SMITHS MARK 10 AUTOPILOT

The SMITHS MARK 10 autopilot operates the flight control system of the aircraft to maintain normal stabilized attitudes automatically. The autopilot also maintains any desired heading by using compass information. The system provides coordinated turn control, automatic elevator trim, constant-pressure altitude control, automatic VOR and tacan tracking, and automatic ILS approach control for instrument landing system approaches.

### AUTOPILOT CONTROLS

The Autopilot Controls are located on 2D Autopilot Control Panel and on the Flight Control Pedestal in VC. Both the 2D and the VC Control Panels are synchronized.



1. **POWER button** turns the power ON or OFF to the AP.

2. **Autopilot Master Switch** Engages or disengages the AP.

3. **BANK T R Switch.** This controls the bank function, (Aileron) and is not self-centering.

*If you want for example to bank left you move the bank button to the left. The more left you move it the more bank angle the aircraft will have. The maximum is 30 degrees. When you want the bank to stop you move the knob back to the middle. The aircraft will maintain the bank angle you have set on the knob and then when you move the knob back to the center the aircraft will roll level.*

4. **Aileron Motors, Elevator Motors and Rudder Motor Buttons** turn ON or OFF the autopilot motors at the flight surfaces for the Aileron "A", Rudder "R", and Elevators "E". They are normally all ON (Forward) and are only turned OFF if on of the that particular control system in the AP or AP control surface motor fail.

5. **HEIGHT / IAS Button** controls the Indicated Air Speed (IAS) **OR** the Altitude of the aircraft. The autopilot holds the current speed by the *pitch change*.

To engage the Altitude Hold you twist the pointer up (anti-clockwise) to 'HEIGHT' position and press the knob. The pitch of the aircraft will control current aircraft altitude.

To engage the IAS Hold you must first stabilize the aircraft at the desired speed and pitch angle. Then turn the pointer down (Clockwise) to 'I.A.S.' position and press the button. The autopilot will maintain the same flying speed and will alter it by pitch.

#### Note

Autopilot is unable to maintain altitude and speed simultaneously.

6. **Approach Hold Switch.** When pulled up to engage, this function will take whatever the heading information is selected on the Nav Mode Selector Panel and maintain that heading:

- **HDG Mode** - heading mode selector button engages the autopilot's heading mode, and commands the aircraft to turn to and maintain the heading indicated by the heading bug on the Horizontal Situation Indicator (HSI). Any change in the position of the heading bug results in the aircraft turning to and maintaining that heading.
- **GPS Mode** - When the Nav Mode Selector is in the GPS position, the autopilot will follow the programmed GPS course to each lateral waypoint in sequence. The GPS does not provide vertical guidance to the autopilot.
- **VOR/ILS Mode** - when the Nav Mode Selector is in the VOR1 (VOR2) position, the autopilot will track a VOR1 (VOR2) course or localizer for enroute navigation.

7. **Navigation Mode Button.** It engages the autopilot's Approach mode, enabling automatic tracking of a ILS Glideslope and localizer. For stable capturing of a glideslope always intercept glideslope from below.

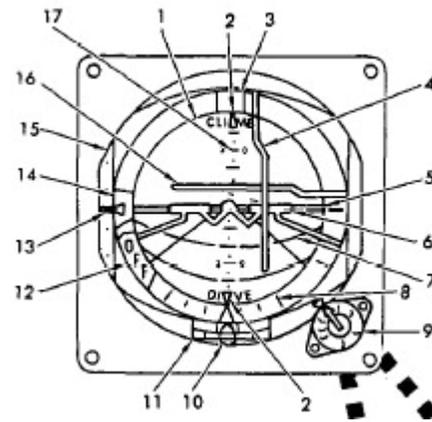
#### Note



**Range Indicator** - Indicates distance in nautical miles from the aircraft to a selected VOR1 (FSX NAV1) station.

### Attitude Director Indicator

The ADIs present the forward display of the aircraft and are the primary attitude instruments for combining roll and pitch, turn and slip, and computed steering information. The ADI is made up of the following items:



- |                             |                                |
|-----------------------------|--------------------------------|
| 1. Attitude sphere          | 10. Turn needle                |
| 2. Bank pointer             | 11. Slip indicator             |
| 3. Course warning flag      | 12. Attitude warning flag      |
| 4. Bank steering bar        | 13. Glideslope indicator       |
| 5. Horizon bar              | 14. Glideslope warning flag    |
| 6. Miniature aircraft       | 15. Glideslope deviation scale |
| 7. Ground perspective lines | 16. Pitch steering bar         |
| 8. Bank index scale         | 17. Pitch reference scale      |
| 9. Pitch trim knob          |                                |

**Attitude Sphere** - Provides an artificial horizon which relative to the miniature aircraft, shows roll and pitch attitudes of the aircraft.

**Bank Pointer** - Rotates with the roll gimbal to indicate bank angle against the bank index scale.

**Pitch Trim Knob** - Used to adjust the position of the attitude sphere in the pitch axis.

**Bank Steering Bar**- Supplies an indication for steering to and maintaining a selected heading, with the FLT DIR switch in the MANUAL position.

**Slip Indicator** - Indicates an aimrat slip or skid information.

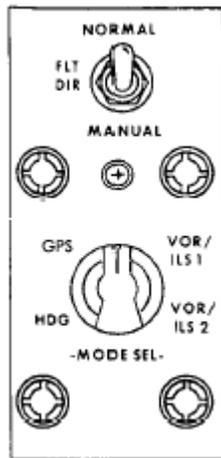
**Turn Needle** - Used in conjunction with the slip indicator to indicate coordinated turn.

**Pitch Steering Bar** - Supplies an indication for steering to intercept and maintain the glideslope beam.

**Glideslope Indicator** - Presents aircraft position relative to the glideslope, as indicated on the glideslope deviation scale. Each dot on the deviation scale equals 0.25 °.

**Warning Flags** - Each AD1 contains three warning flags: the course warning flag, the glideslope warning flag, and the attitude warning flag. The course warning flag indicates loss of signal and monitors information from the VOR/ILS or tacan system and the flight director computer. The glideslope warning flag indicates loss of signal or invalid signal from the glideslope receiver. The attitude warning flag indicates loss of power to the indicator.

### Instrument Selector Control Panels



Each of the two instrument selector control panels contains a FLT DIR switch, a MODE SEL switch, and a POINTER SELECTOR switch. The copilot panel is also equipped with an ADI selector switch.

1. FLT DIR – AUTO PILOT Switch - The two-position (NORMAL, HEADING) FLT DIR switch controls the manner in which information selected by the MODE SEL switch will be supplied to the flight director computer and the attitude director indicator.
2. MODE SEL Switch - The multipurpose MODE SEL switches are provided to connect a navigation system to the HSIs and the flight director computers. The switch has four positions (HDG, GPS, VOR/ILS-1 and VOR/ILS-2) corresponding to the navigation system information to be displayed.

### NORMAL OPERATION OF THE FLIGHT DIRECTOR SYSTEM

**Mode Selector Operation.** In the following paragraphs, each position of the MODE SEL switch will be discussed with the FLT DIR switch in both the NORMAL and HEADING positions.

**HEADING Selection.** With the MODE SEL switch in HDG and FLT DIR switch in NORMAL, the flight director computer operates in the auto nav mode. No radio aid is used in this mode, and the ADI operates as a basic attitude indicator. The HSI will function only as a compass repeater, with the range indicator connected to tacan. The course arrow is slaved to the respective compass heading signal, thus always pointing straight up. This gives a continuous digital indication of aircraft heading in the course selector window.

By switching the FLT DIR switch to HEADING, the flight director is in a manual heading mode. The HSI continues to operate as in auto nav, except that the heading set knob can be used to select a heading to fly as directed by the flight director computer on the bank steering bar of the ADI. The flight director computer combines heading error and bank angle so that a selected heading may be intercepted and maintained, by centering the bank steering bar and keeping it centered. The course warning flag remains out of view as long as the computer functions properly.

**VOR/ILS 1, VOR/ILS 2 Selection.** With the MODE SEL switch in VOR/ILS 1 or VOR/ILS 2 and the FLT DIR switch in NORMAL, the flight director will be in the radio track mode when the corresponding omni receiver is tuned to a VOR frequency.

The course arrow on the associated HSI is set to the selected VOR radial to supply a course error signal to the flight director and to resolve the signals from the VOR receiver. The flight director combines the course error signal with course deviation and bank angle to drive the bank steering bar on the ADI so that an asymptotic intercept of the selected radial can be made and then maintained. The course warning flag remains out of view as long as the computer functions properly and is receiving valid information.

All other pointers in the ADI remain out of view. Information displayed on the HSI consists of course deviation in degrees on the course deviation indicator, bearing to the selected VOR station on the bearing indicator, distance to the station on the range indicator, ambiguity on the to-from indicator, and heading.

By switching the FLT DIR switch to HEADING, the flight director computer selects the manual heading mode. The ADI will display steering information on the bank steering bar for a selected heading as set by the HEADING SET knob on the HSI. The course warning flag remains out of view while a valid signal from the VOR set is maintained. The COURSE SET knob still controls the selection of the desired radial, and all other functions of the HSI remain the same as when the FLT DIR switch is in the NORMAL position.

When an ILS frequency is selected, with the MODE SEL switch in VOR/ILS 1 or VOR/ILS 2 and the FLT DIR switch in NORMAL, the flight director computer selects the ILS mode and the corresponding glideslope receiver is tuned to a frequency corresponding with the selected ILS frequency. The flight director now uses information from the localizer course. The localizer course supplies the flight director computer with a heading error signal that is combined with localizer deviation and bank angle to drive the bank steering bar on the ADI so that an intercept of the localizer beam can be made and maintained. The localizer warning flag remains out of view as long as valid information is being received and the flight director computer is

functioning properly. The glideslope warning flag remains out of view until the computer automatically switches to the ILS approach mode. No ambiguity or bearing information is available.

When the FLT DIR switch is placed in HEADING, the flight director computer selects the ILS manual mode. The GSI continues to give glideslope information. The HSI display remains the same as described with the FLT DIR switch in the NORMAL position.

The flight director computer will automatically switch from the ILS mode to the ILS approach mode when the aircraft is within approximately one needle width of the center of the glideslope while making an ILS approach from beneath the glideslope.

If the aircraft moves off the glidepath on localizer by approximately two dots, the computer will automatically switch back to ILS mode, and the pitch steering bar will disappear. It will be necessary to descend below the glideslope to reswitch the flight director automatically to the ILS bar.

The flight director computer combines heading error, localizer deviation, and bank angle to drive the bank steering bar on the ADI. The flight director computer also combines glideslope deviation and pitch angle, which is displayed on the pitch steering bar as information to intercept and maintain the glideslope beam. The GSI and all information on the HSI continues to operate as in the ILS mode. If the FLT DIR switch is placed in the MANUAL position, the flight director computer goes into the ILS manual mode.

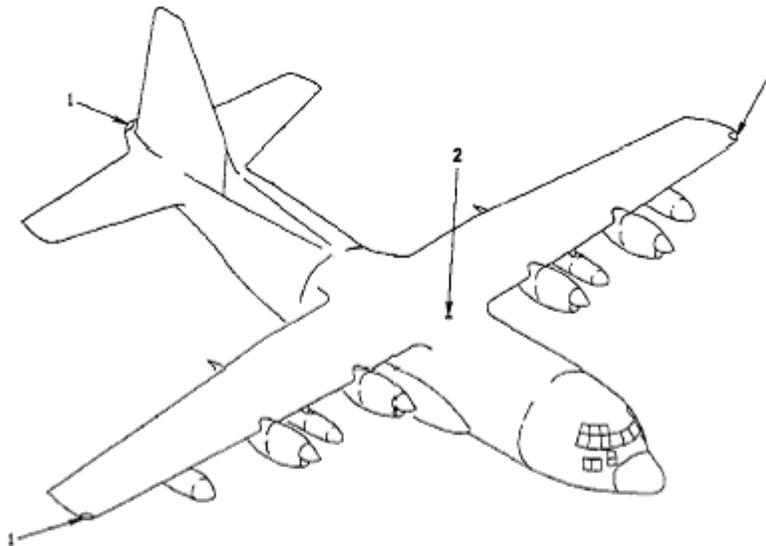
**LIGHTING SYSTEM**

**Note:**

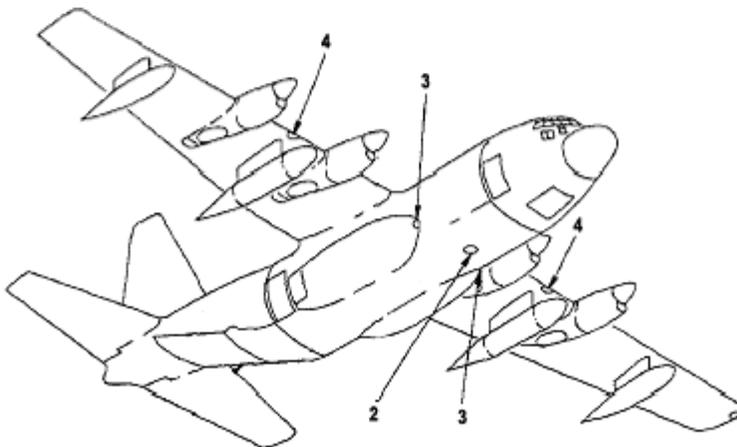
Due to MSFS limitations only very limited number of light effects can be displayed simultaneously. So some light effects may disappear if you turn to many various lights ON.

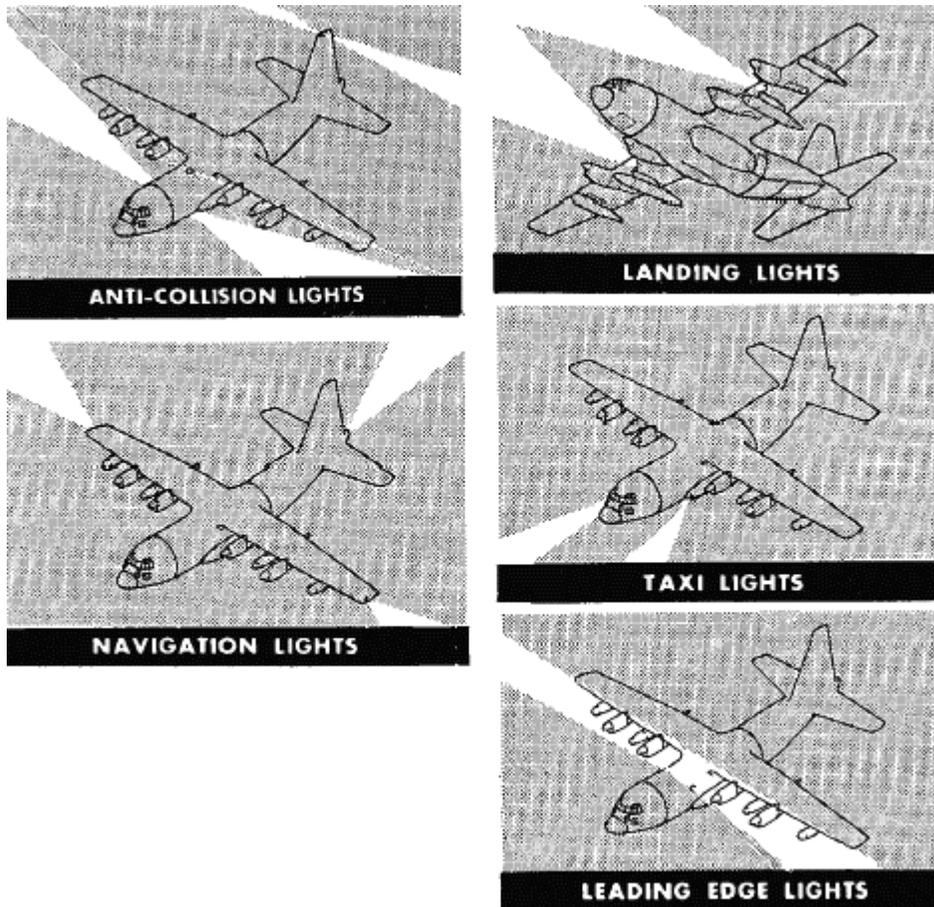
The lighting system is composed of exterior and interior groups of lights and their controls. Receptacles are also provided on the sides of the pilot and copilot side shelves for connecting a signal light. The pilot and copilot instrument lights and the engine instrument lights operate on AC power and all others operate on dc power.

**EXTERIOR LIGHTS**



- 1 -- Navigation Lights
- 2 - Anti-Collision/Strobe Lights
- 3 - Taxi Lights
- 4 - Landing Lights

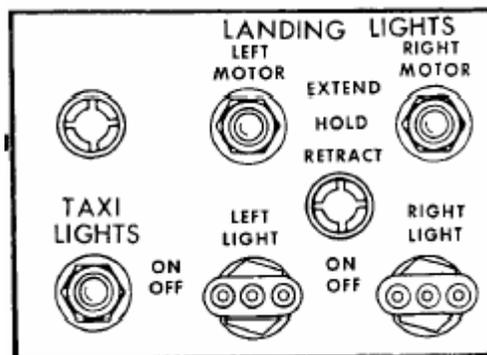




The exterior group of aircraft lights comprises a landing light on the undersurface of each wing; two taxiing lights on the main landing gear doors; six navigation, and two anti-collision lights disposed around the aircraft, and a light on each side of the fuselage to illuminate the wing leading edges.

Power for all these lights is supplied from the essential and main dc buses through the EXTERIOR LIGHTS circuit breakers on the copilot lower circuit breaker panel.

**LANDING LIGHTS**



A retractable landing light is mounted in the underside of each wing, in the leading edge and approximately midway between the inboard and outboard nacelles. Switches for extension and retraction and illumination control are located on the landing lights control panel.

The two extension and retraction switches, labeled right and left, are three-position (EXTEND, HOLD, RETRACT) toggle switches. The right switch energizes the right-hand landing light actuator, retracting or extending the light when the switch is moved to RETRACT or EXTEND positions.

The left switch energizes the left-hand light actuator in the same manner. When either switch is moved to the HOLD position, the landing light actuator motor is de-energized, and the light will lock in position. Two two-position (ON, OFF) toggle switches control the illumination of the LANDING LIGHTS. When either switch is moved to the ON position, the corresponding light illuminates. When either switch is moved to OFF, the corresponding light is de-energized.

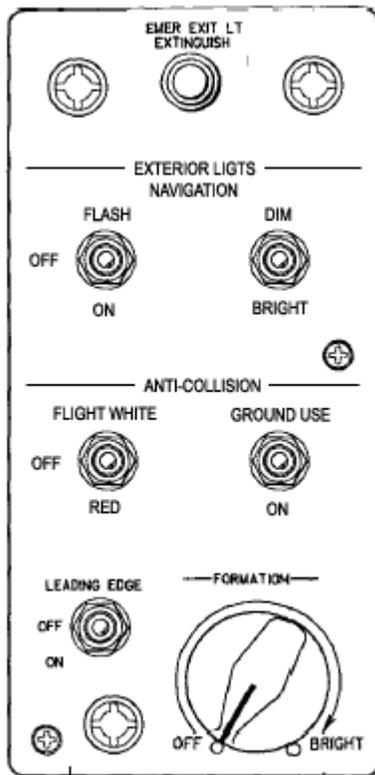
**CAUTION**

Do not operate the landing lights for prolonged periods while the aircraft is on the ground, since these lights have no cooling facility.

**TAXIING LIGHTS**

Illumination of the two taxiing lights, one mounted on the inside of each main landing gear door, is controlled by a two-position (ON, OFF) toggle switch on the landing light control panel. Power is supplied from the main dc bus through the EXTERIOR LIGHTS TAXI circuit breaker on the copilot lower circuit breaker panel.

**NAVIGATION LIGHTS**



The navigation lighting system consists of six lights: a red light on the left wingtip, a green light on the right wingtip, two white lights on the trailing edge of the tail cone, a white light on top of the fuselage forward of the wing, and a white light on the lower surface of the fuselage.

All lights can be set dim or bright. The red and green wingtip lights and the white tail lights can also be set to flash or to glow continuously. The white lights on the top and bottom of the fuselage, however, will only illuminate continuously.

The navigation lights selector switch turns the lights on and off and controls the flashing mechanism, and the navigation lights dimming switch controls the intensity of the lights.

The selector switch is a three-position (STEADY, OFF, FLASH) toggle switch, located on the exterior lights control panel. When the switch is in the STEADY position, the lights glow continuously.

When the switch is in the FLASH position, the wingtip lights and the white tail lights flash simultaneously. The navigation lights dimming switch is a two-position (BRIGHT, DIM) toggle switch and is located on the exterior lights control panel.

**ANTI-COLLISION/STROBE LIGHTS**

The aircraft is equipped with two combination anti-collision/strobe lights, one on top of the vertical stabilizer and the other on the underside of the center fuselage. Each light contains a high-intensity, white, xenon arc-discharge light and a high-intensity red light. The dual anti-collision/strobe lights are controlled by two toggle switches on the exterior lights control panel. The left-hand select switch has three positions (GRD TEST, T & B, TOP).

When the select switch is placed to the T & B position, both upper and lower red or white lights will function in flight, but only the upper red light will function when the aircraft is on the ground. Auxiliary touchdown relay No. 3 disables the upper white light and the lower red and white lights when the aircraft is on the ground.

When the select switch is placed to the TOP position, only the upper light will function. When the select switch is placed to the GRD TEST position both upper and lower red or white lights will function on the ground. The right-hand control switch has three positions (OFF, RED, WHT), and is used along with the select switch to control the light color under various weather conditions. In the OFF position, the lights are de-energized.

### WING LEADING EDGE LIGHTS



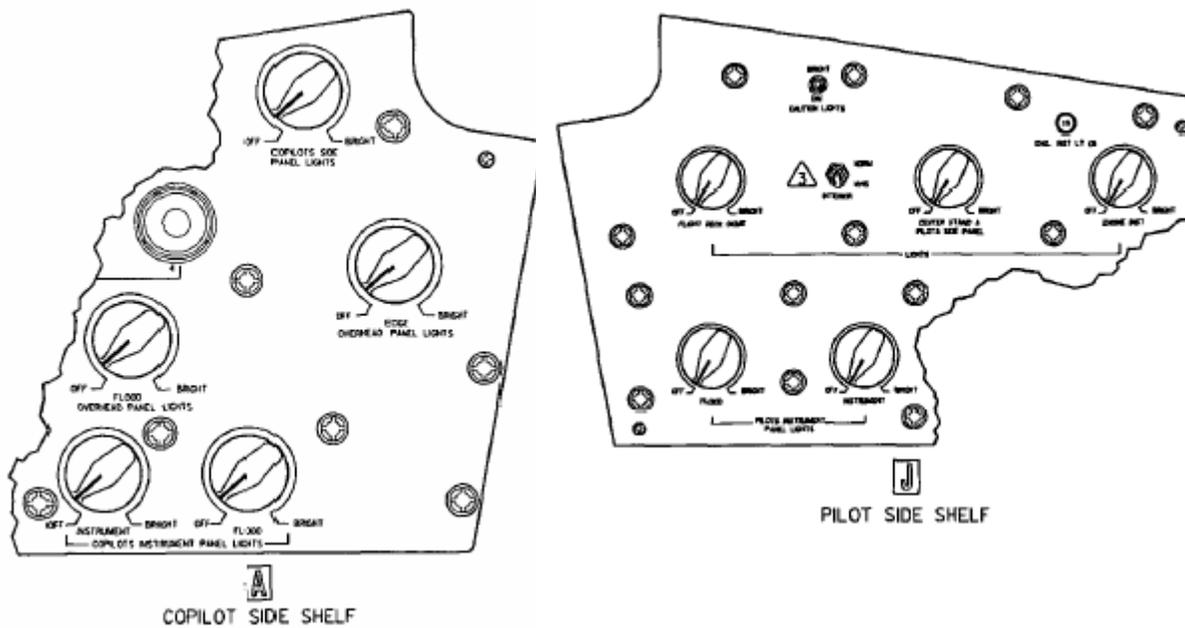
A light is installed on each side of the fuselage in a position which will illuminate the engine nacelles and the immediate leading edge area of each wing.

The lights are controlled through a two-position (ON, OFF) toggle switch on the exterior lights control panel.

### INTERIOR LIGHTING

Interior lighting consists of flight station and cargo compartment lighting.

Use Lightning Control Panels on the Pilot and Copilot Side Shelves and/or L, Shift+L keys to control the interior lighting.



**TROOP CARRYING EQUIPMENT**

When the C- 130 aircraft is used as a troop carrier, seating accommodations are provided for 64 paratroops or 78 ground troops. When the C-130-30 aircraft is used as a troop carrier, seating accommodations are provided for 92 paratroops or 114 ground troops. By using the seat attachment provisions on the wheel well walls, 14 additional ground troops can be carried. For paratroop airdrop missions, the seats are installed on 24-inch spacing. For ground troops or personnel transport, the seats are installed on 20-inch spacing. The installed seats form a single row down each side of the cargo compartment and a double row (back-to-back) down the center of the cargo compartment.

*See ACE Utility section of this manual for details.*

**CASUALTY CARRYING EQUIPMENT**

Casualty transport facilities for 60 litters and 6 attendants, or 64 litters and 2 attendants are provided with the aircraft. Casualty transport facilities for 93 litters and 8 attendants or 97 litters and 4 attendants are provided with the C-130T-30 aircraft. The litters are carried aboard the aircraft through the aft cargo door; they are installed in four rows in the cargo compartment.

*See ACE Utility section of this manual for details.*

**PARATROOP EQUIPMENT**

Paratroop equipment consists of seats, paratroop doors, jump platforms, anchor lines, jump signals, and air deflectors.

**SEATS**

Seats are provided for installation in the cargo compartment. When the seats are in use, they are installed in a single row down each side of the cargo compartment and a double row (back-to-back) down the center of the cargo compartment. Seat belts are provided and may be installed with 24-inch spacing to accommodate paratroops or with 20-inch spacing to accommodate ground troops or personnel. The number of seats available is as follows:

	C-130	C-130-30
Ground Troops	78	114
Ground Troops (including wheel well seats)	92	128
Paratroops	64	92

*See ACE Utility section of this manual for details.*

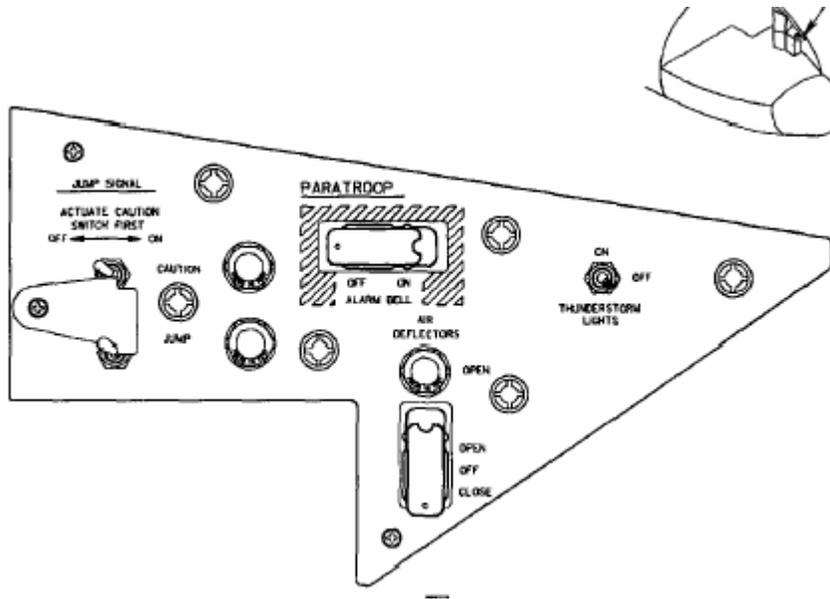
**AIR DEFLECTORS**



Air deflectors are located on each side of the fuselage, forward of the paratroop doors, forming the rear section of the main landing gear wheel well fairing.

The air deflectors are opened to approximately 30°.

**AIR DEFLECTORS CONTROLS AND INDICATORS**



The air deflectors are opened to approximately 30° by actuation of a three-position (OPEN, OFF, CLOSE) guarded toggle switch on the pilot and copilot paratroop panel.

A warning light above the AIR DEFLECTORS switch is illuminated when the doors are not closed.

**DOOR OPEN WARNING SYSTEM**

The door open warning system consists of a master DOOR OPEN warning light on the pilot glare shield and a light and master light shutoff switch for each door.

Power for operation of the door warning system is supplied from the main dc bus through the DOOR WARNING LIGHT circuit breaker on the copilot lower circuit breaker panel.

**Master Door Open Warning Lights**



The master DOOR OPEN warning light is located on the pilot glare shield. It will go on whenever any one of the doors is not closed and locked.

**FLARE DISPENSING SYSTEM**



The flare dispensing system consists of flare storage boxes, a dispensing rack, an ejector rod, and the aerial delivery system. The aerial delivery kit is installed for airdrops with the flare storage boxes secured to aerial delivery pallets. Prior to reaching the target area the aircraft is depressurized, the load prepared for possible emergency jettison and the dispensing rack installed between the ramp and door.

**OPERATION OF FLARE DISPENSING SYSTEM**

After the aircraft is safely airborne, the restraining chains will be removed and the load prepared for possible emergency jettison. The flare dispensing system shall be operated in accordance with the following procedures:

1. Depressurize aircraft and decelerate to 150 KIAS.

**CAUTION**

Flares dispensed at speeds in excess of 170 KIAS may rise on ejection and strike the ramp door or horizontal stabilizer.

2. Click 'IR FLARES' icon to eject the flares - "Mark."

**LIST OF ABBREVIATIONS/ACRONYMS****A**

AAPS. Altitude alerter/preselect system.  
 ac. Alternating current  
 ACN. Aircraft classification number.  
 ACU. Antenna coupler unit.  
 ADF. Automatic direction finder.  
 ADI. Attitude director indicator.  
 ADIZ. Air defense identification zone.  
 ADS. Aerial delivery system.  
 AGL. Above ground level.  
 AIMS. Airborne identification mobile system.  
 ALT/P/R. Altitude/pitch/roll  
 AME. Amplitude modulation equivalent.  
 AP. Autopilot.  
 APU. Auxiliary power unit.  
 ATM. Air turbine motor.  
 ATO. Assisted takeoff.

**B**

BAROSET. Barometric pressure setting.  
 BDHI. Bearing distance heading indicator.  
 BFO. Beat frequency oscillator.  
 BIT. Built-in test.  
 BIT/ACK. Built-in-test/acknowledgment  
 BITE. Built-in test equipment.  
 BRT/DIM. Bright/dim  
 BSU Bus switching unit  
 BT. Bromotrifluoromethane.  
 BTU. British thermal unit.

**C**

°C. Temperature in degrees Centigrade.  
 CADS. Central air data computer  
 CARA. Combined altitude radar altimeter.  
 CAS. Calibrated airspeed.  
 CBR. California bearing ratio.  
 CCU Converter control unit  
 CDS. Countermeasure dispenser system.  
 CDU. Control display unit.  
 CEC. Centicycle.  
 CG Center of gravity  
 CI. Control indicator.  
 CP. Copilot.  
 C-PGM Copilot program mode  
 CPI. Crash-position indicator.  
 CPS. Control power supply.  
 CU. Control unit.  
 CW. Continuous wave.

**D**

DASC. Direct air support center.  
 dc. Direct current.  
 DCLT. Declutter  
 DECM. Defensive electronic countermeasures.  
 DF. Direction finder.  
 DG. Directional gyro.  
 DH. Decision height.  
 DME. Distance measuring equipment.  
 DR. Dead reckoning.  
 DU Display unit

**E**

EAS. Equivalent airspeed.  
 EFI Electronic flight instrument  
 EGT. Exhaust gas temperature.  
 EID. Emitter identification data.  
 ESWL. Equivalent single-wheel load.  
 ETA. Estimated time of arrival.  
 ETD. Estimated time of departure.  
 ETE. Estimated time of enroute.  
 ETP. Equivalent time point

**F**

°F. Temperature in degrees Fahrenheit.  
 FAA. Federal Aviation Administration.  
 Fc. Climb factor.  
 FE. Flight engineer.  
 FLIP. Flight information publication.  
 FM. Flight mechanic.  
 FOD. Foreign object damage.  
 fpm. Feet per minute.  
 FS. Fuselage station.  
 ft.o. Takeoff factor.

**G**

G/A. Go-around.  
 GCA. Ground controlled approach,  
 GI. Ground idle.  
 GMT. Greenwich mean time.  
 gpm. Gallons per minute.  
 GPWS. Ground proximity warning system.  
 GS. Groundspeed.  
 GSI. Glideslope indicator.  
 GTC. Gas turbine compressor.  
 GTP. Grid transport procession  
 GW. Gross weight.

**H**

Hd. Density altitude.  
 Hp Pressure altitude.  
 hp. Horsepower.  
 HF. High frequency.  
 HIU HUD interface unit  
 HSI. Horizontal situation indicator.  
 Hz. Hertz.

**I**

IAS. Indicated airspeed.  
 ICAO. International Civil Aviation Organization.  
 ICS. Intercommunication system.  
 IFF. Identification friend or foe.  
 IFR. Instrument flight rules; in-flight refueling.  
 ILS. Instrument landing system.  
 INS. Inertial navigation system.  
 INU. Inertial navigation unit.  
 IOAT. Indicated outside air temperature.  
 IR. Infrared.  
 IRCM. Infrared countermeasures.  
 IRO. In-flight refueling observer.

**K**

KHz. Kilohertz.

KIAS. Knots indicated airspeed.  
kVA. kilovolt-ampere.

**L**

LCN. Load classification number  
LED. Light emitting diode.  
LM. Loadmaster.  
LOC. Line of communication  
LOP. Line of position.  
LSB. Lower sideband.

**M**

MAC. Mean aerodynamic chord.  
MAF. Maintenance action form.  
MDA. Minimum descent altitude.  
MHz. Megahertz.  
MLG. Main landing gear.  
MLS. Microwave landing system.  
MRC. Maintenance requirement card.  
MSU. Mode selector unit.  
MWS. Missile warning system.

**N**

NAV. Navigator.  
NLG. Nose landing gear.  
NM. Nautical miles.  
NOTAM. Notice to airmen.  
NTS. Negative torque signal.  
NVIS. Night vision imaging system.

**O**

OALS. Optimum approach line space.  
OAT. Outside air temperature.  
OFP. Operational flight program.  
OFT. Operation flight trainer.  
ONS. Omega navigation system.  
OU. Optical unit

**P**

PA. Public address.  
PAR. Precision approach radar.  
PCMLS. Pulse coded microwave landing system.  
PCN. Pavement classification number.  
PIK. Pilot in command.  
PGM NXT/SEL. Program mode next page/select.  
P-PGM. Pilot-program mode.  
pph. Pounds per hour.  
PPI. Plan position indicator.  
ppm. Pounds per minute.  
PSCU. Power supply and calibration unit.  
psi. Pressure in pounds per square inch.  
psig. Gauge pressure, pounds per square inch.  
PSR. Point of safe return.

**Q**

QTWLTA. Quadrant threat warning level translation assembly.

**R**

R/C. Rate of climb.  
RCR. Runway condition reading.  
R/D. Rate of descent.

RMI. Radio magnetic indicator.  
RO. Radio operator.  
RON. Remain over night.  
rpm. Revolutions per minute.  
RPU. Receiver-processor unit.  
RSC. Runway surface covering.  
RT. Receiver transmitter.  
RWR. Radar warning receiver.  
RWS. Radar warning system.

**S**

SAL. Standby attitude indicator.  
SDC. Signal data converter  
shp. Engine shaft horsepower.  
STC. Sensitivity time control.

**T**

TAS. True airspeed.  
TD. Temperature datum.  
TIT. Turbine inlet temperature.

**U**

UCI. Unit construction index.  
UDM. User data module.  
USB. Upper sideband.

**V**

VCEF. Critical engine failure speed,  
VD. Maximum permissible speed.  
VFR. Visual flight rules.  
VMCA. Air minimum control speed.  
VMCG. Minimum control speed on ground.  
VR. Refusal speed.  
VS. Power-off stall speed.  
VT/WF. Nautical miles per pound of fuel.  
VALI. Variable altitude limit index.  
VFR. Visual flight rules.  
VLF. Very low frequency.  
VOR. VHF omnidirectional range.  
VS. Stall speed.

**Y**

YD. Yaw damper.

## **CUSTOMER SUPPORT**

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Thank you,

Enjoy your flight!

Captain Sim Customer Support Team

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