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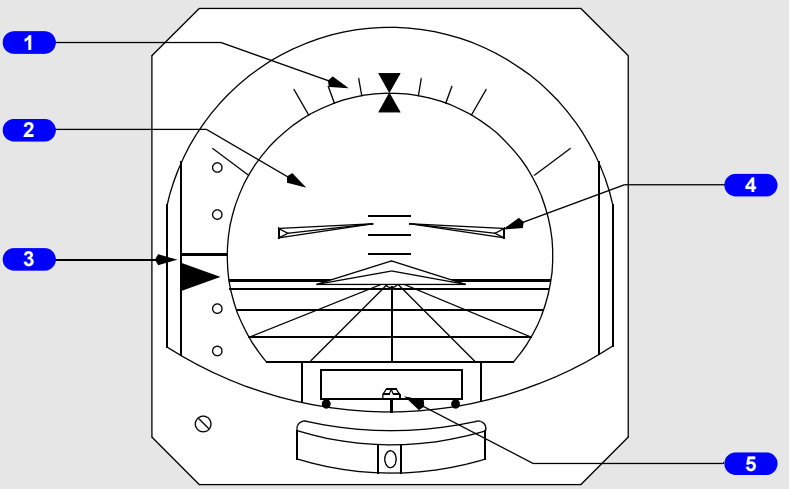
Attitude Director Indicator (ADI)



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Bank Indicator and Scale

- index indicates roll angle against calibrated scale
- scale has minor markings at 10 degrees and 20 degrees and major markings at 30 degrees and 60 degrees.

2 Attitude Display

- tape moves relative to symbolic airplane, displaying pitch and roll signals from the vertical gyro
- pitch up scaled in 5 degree increments to 15 degrees then with marks at 30, 50, 70, and 90 degrees
- pitch down scaled with marks at 5, 10, 20, 30, 50, 70, and 90 degrees.

3 Glideslope Pointer and Deviation Scale

- pointer indicates glideslope position
- scale indicates deviation
- glideslope flag covers the display when the signal is not valid.

Pointer out of view – a VOR frequency is tuned.

4 Flight Director Command Bars

(yellow) – Displays computed pitch and/or roll commands.

Biased out of view –

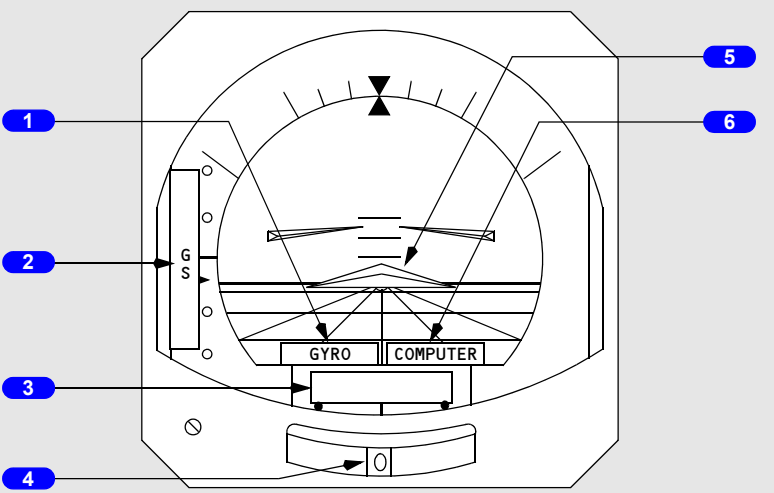
- flight director switch is positioned OFF
- the required signal inputs are unreliable.

Refer to Chapter 4, Automatic Flight.

5 Localizer Symbol and Deviation Scale

In view –

- localizer frequency is tuned and localizer signal is valid
- scale indicates localizer deviations of one dot or less (one dot is one degree displacement).



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 GYRO Warning Flag

In view –

- display is unreliable (some failures cause indications of 90 degrees left bank)
- electrical power loss.

2 Glideslope (GS) Warning Flag

In view –

- glideslope information is unreliable with ILS frequency tuned
- parallels the glideslope warning flag on the HSI.

3 Localizer Symbol Shutter

In view –

- glideslope not captured
- glideslope capture but VOR LOC flag on HSI in view.

4 Slip/Skid Indicator

Ball monitors slip or skid for coordinated flight.

5 Symbolic Airplane

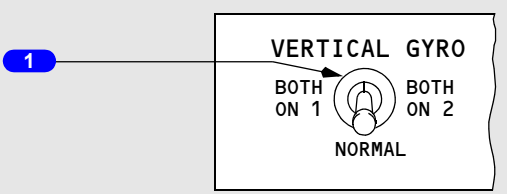
(orange) – Represents airplane attitude relative to the horizon.

6 Flight Director COMPUTER Warning Flag

In view –

- vertical gyro information unreliable
- electrical power loss
- causes flight director command bars to retract.

Vertical Gyro Transfer Switch

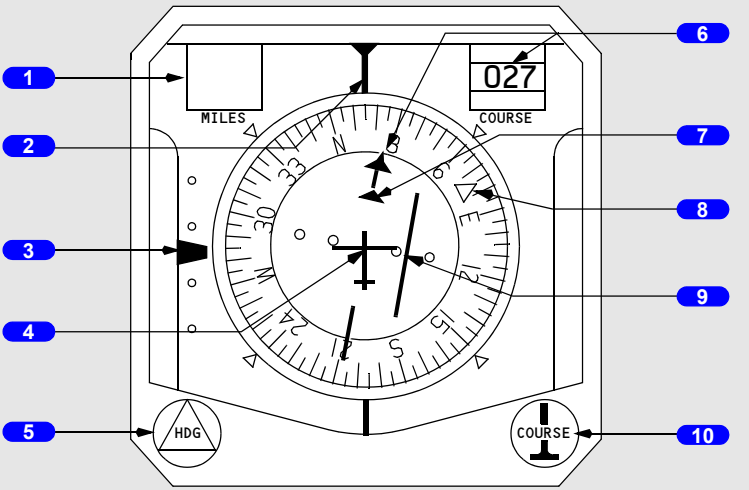


FORWARD OVERHEAD PANEL

1 VERTICAL GYRO Transfer Switch

- BOTH ON 1 – switches both attitude sources to vertical gyro No. 1
- NORMAL – captain's attitude source vertical gyro No. 1; first officer's attitude source vertical gyro No.2
- BOTH ON 2 – switches both attitude sources to vertical gyro No. 2.

Horizontal Situation Indicator (HSI)



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 DME MILES Window

Inoperative.

2 Lubber Line

Displays heading on compass card.

3 Glideslope Pointer and Scale

Indicates displacement above or below glideslope.

Pointer in view – localizer frequency tuned and HSI powered.

4 Airplane Symbol

- fixed in the center of the instrument
- displays position of the airplane in relation to movable portions of the indicator.

5 HSI Heading (HDG) Selector

- selects desired flight director heading
- captain's selector can set desired heading for autopilot.

6 Course Pointer and COURSE Counter

Reflects the course set by the HSI course selector.

7 To/From Ambiguity Indicator

Displays direction to a VOR station along the radial selected by the HSI course selector.

8 Heading Marker

Displays the heading set by the HSI heading selector.

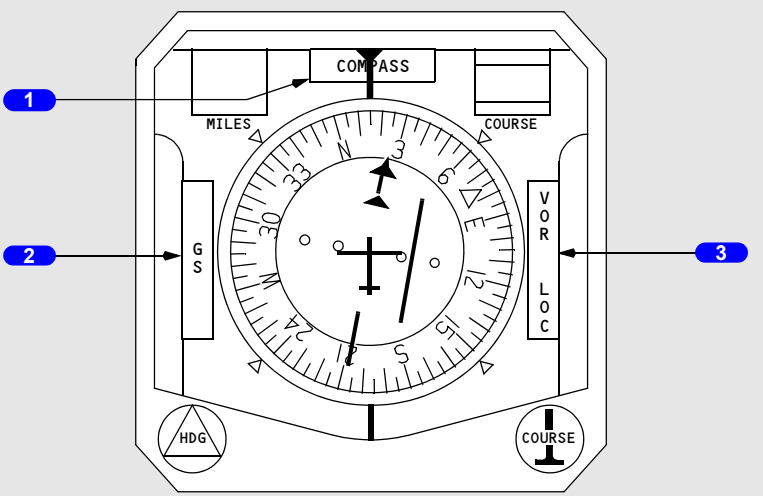
9 Course Deviation Bar

VOR: 1 dot = 5 degrees.

LOC: 1 dot = 1 degree.

10 HSI COURSE Selector

- selects VOR radial or LOC course for flight director
- captain's selector can set VOR radial or localizer course for autopilot.



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 COMPASS Failure Flag

In view –

- selected compass is invalid
- electrical power loss to HSI
- compass card malfunction.

2 Glideslope (GS) Failure Flag

In view – only with localizer frequency tuned

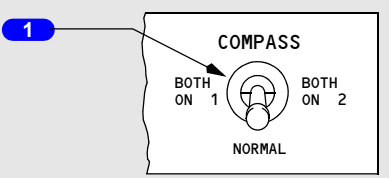
- glideslope signal below acceptable level
- failed glideslope receiver
- electrical power loss.

3 VOR LOC Failure Flag

In view –

- VOR or LOC signal below acceptable level
- NAV receiver malfunction
- electrical power loss.

Compass Transfer Switch

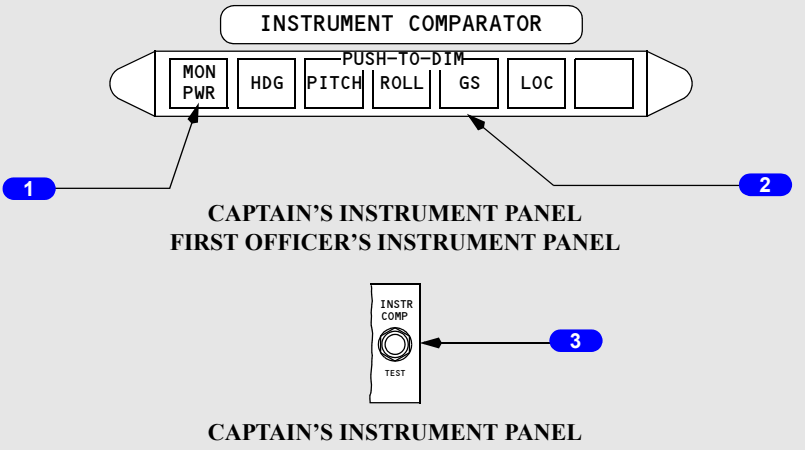


FORWARD OVERHEAD PANEL

1 COMPASS Transfer Switch

- BOTH ON 1 – switches both compass sources to the No. 1 compass system
- NORMAL – captain's compass source is the No. 1 compass system; first officer's compass source is the No. 2 compass system
- BOTH ON 2 – switches both compass sources to the No. 2 compass system.

Instrument Comparator



1 Monitor Power Light

Illuminated (amber) – 115 volt ac power loss to comparator unit.

2 Instrument Comparator Lights

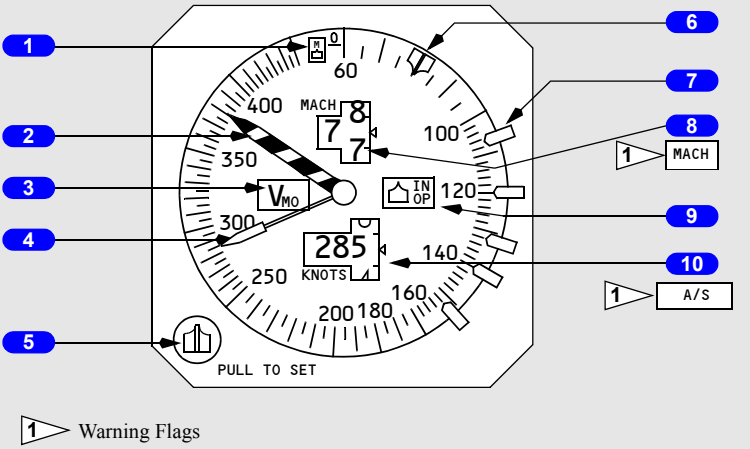
Illuminated (amber) – instrument being compared have exceeded established tolerances.

3 Instrument Comparator Test (INSTR COMP TEST) Switch

Push – illuminates all instrument comparator lights, except MON PWR.

Mach/Airspeed Indicator

Electric Mach/Airspeed Indicator



CAPTAIN'S INSTRUMENT PANEL

1 Airspeed Cursor Mode Annunciator

- auto mode: out of view
- manual mode: in view.

2 Vmo Pointer

Indicates the maximum operating (indicated) airspeed in knots.

3 Vmo Flag

In view – indicates the Vmo pointer is inoperative.

4 Airspeed Pointer

Indicates airspeed in knots.

5 Airspeed Cursor Control

Push in –

- auto mode
- airspeed cursor is positioned from the PDCS.

Pull out –

- manual mode
- airspeed cursor is positioned by rotating the control.

6 Airspeed Cursor

- indicates target airspeed
- positioned manually or automatically, as selected by the airspeed cursor control.

7 Airspeed Reference Markers (Bugs)

Positioned manually to the desired airspeed reference.

8 MACH Digital Counter

- shows Mach number, from .40 to .99 Mach, in digital form
- masked below .40 Mach
- digits are covered by a warning flag when the display is unreliable.

9 Airspeed Cursor Flag

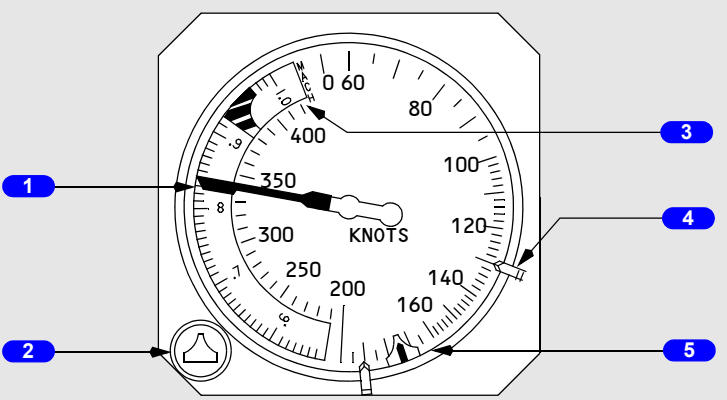
Manual mode: flag retracted.

Auto mode: flag in view if airspeed cursor signals, as determined by the PDCS, are unreliable.

10 Airspeed Digital Counter

- digital display of indicated airspeed in knots
- warning flag covers the counter when the airspeed pointer and airspeed digital counter are unreliable.

Pneumatic Mach/Airspeed Indicator



FIRST OFFICER'S INSTRUMENT PANEL

1 Mach/Airspeed Pointer

Indicates Mach and airspeed in knots.

2 Airspeed Cursor Control

Rotate – manually positions the airspeed cursor.

3 MACH Dial

Rotates – Mach number read under Mach/Airspeed pointer.

4 Airspeed Reference Markers (Bugs)

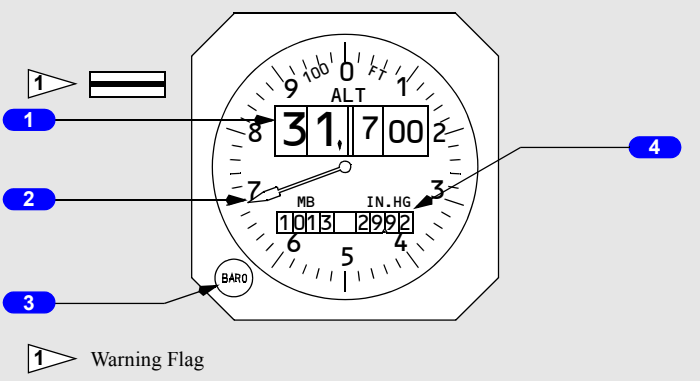
Positioned manually to the desired airspeed reference.

5 Airspeed Cursor

- indicates target airspeed
- positioned manually by the airspeed cursor control.

Altimeter

Electric Altimeter



CAPTAIN'S INSTRUMENT PANEL

1 Digital Altitude Counter

Indicates current altitude in increments of thousands, hundreds, and twenty feet.

- warning flag appears whenever the ADC signal is lost or a malfunction exists
- blue flag appears in the left window when the altitude is below 10,000 feet
- a NEG flag appears in the two left–hand windows when altitude below zero feet is displayed.

2 Altitude Pointer

Makes one revolution each one thousand feet.

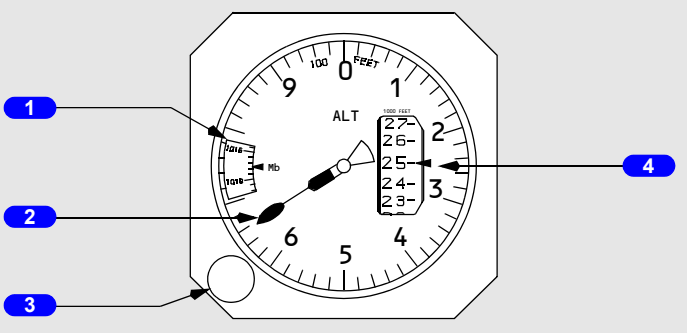
3 Barometric (BARO) Setting Control

Rotate – adjusts barometric settings.

4 Barometric Setting Window

Displays barometric correction (in millibars and inches of mercury) as set by the barometric setting control.

Pneumatic Altimeter



FIRST OFFICER'S INSTRUMENT PANEL

1 Barometric Setting Window

Displays barometric correction (in millibars of mercury) as set by the barometric setting control.

2 Altitude Pointer

Makes one revolution each one thousand feet.

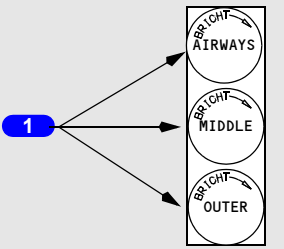
3 Barometric Setting Control

Rotate – adjusts barometric settings.

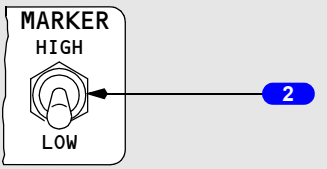
4 Digital Altitude Counter

Indicates current altitude in increments of thousands of feet.

Marker Beacon



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL



CAPTAIN'S INSTRUMENT PANEL

1 Marker Beacon Lights

AIRWAYS (white) – illuminates over an inner or airways marker beacon.

MIDDLE (amber) – illuminates over a middle marker beacon.

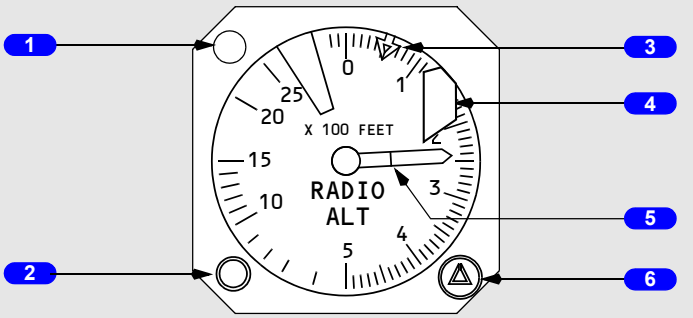
OUTER (blue) – illuminates over an outer marker beacon.

2 Marker Beacon Sensitivity Switch

HIGH – selects high sensitivity of receiver.

LOW – selects low sensitivity of receiver.

Radio Altimeter



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Minimum Descent Altitude (MDA) Light

Illuminated (amber) – altitude pointer is at or below MDA cursor.

2 Radio Altimeter Test Switch

Push –

- altitude pointer drives to 100 feet
- warning flag in view
- the MDA light illuminates if the altitude pointer drives to a position at or below the altitude indicated by the minimum descent altitude cursor.

3 Minimum Descent Altitude (MDA) Cursor

Displays selected altitude reference selected by the MDA cursor control.

4 Warning Flag

In view –

- power failure
- loss of return signal below 2500 feet
- incorrect altitude tracking
- radio altimeter test switch pushed.

5 Altitude Pointer

Power off – pointer moves to the top of the scale under the mask.

Power on –

- up to 2500 feet – pointer reads true altitude above ground level
- above 2500 feet – pointer is behind the mask.

6 Minimum Descent Altitude (MDA) Cursor Control

Rotate – sets the MDA cursor.

Radio Altimeter Lights

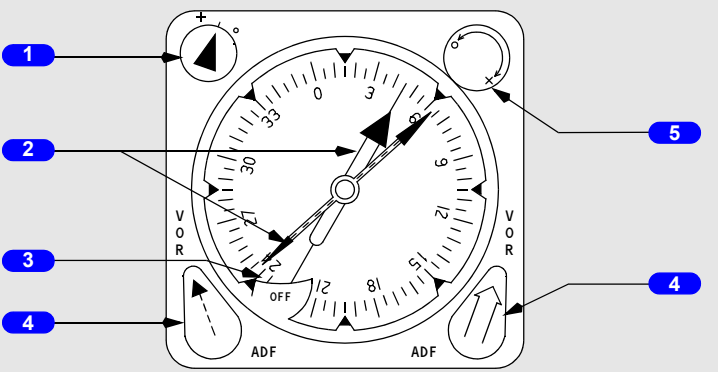
Minimum Descent Altitude Light

CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Minimum Descent Altitude (MDA) Light

Illuminated (amber) – altitude pointer is at or below MDA cursor setting.

Radio Magnetic Indicator (RMI)



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Synchronizing Annunciator

Indicates the compass is out of synchronization if arrow is pointed toward dot or cross.

2 ADF/VOR Bearing Pointers

- narrow pointer uses signals from selected ADF or VOR receiver No. 1
- wide pointer uses signals from selected ADF or VOR receiver No. 2.

3 Compass Warning Flag

In view – electrical power failure to compass system.

4 ADF/VOR Bearing Pointer Switches

Rotate – selects ADF or VOR bearing.

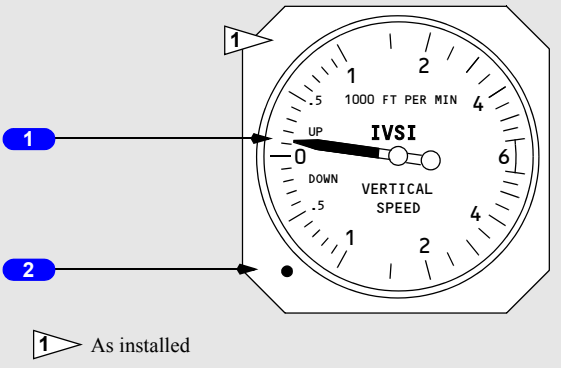
Note: Instrument transfer switching table provides VHF NAV signal sources to pointer.

5 Synchronizing Control

Rotate –

- synchronizes RMI with compass system
- direction of rotation determined by synchronizing annunciator.

Vertical Speed Indicator



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

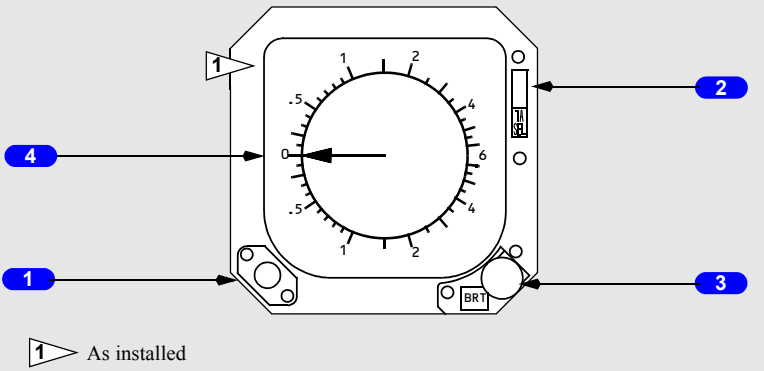
1 Vertical Speed Pointer

Displays rate of climb or descent from 0 to 6,000 feet per minute.

2 Zero Adjustment Screw

Used to set vertical speed pointer to zero.

Note: Airplane should be on the ground or stabilized in level flight during adjustment.



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Light Sensor

Automatically adjusts display contrast for ambient light conditions.

2 TA Select Push–button

Push – changes display between modes:

- full–time mode – traffic information is displayed full–time
- popup mode – traffic information is displayed only when a TA or RA is generated. Display remains for the duration of the alert.

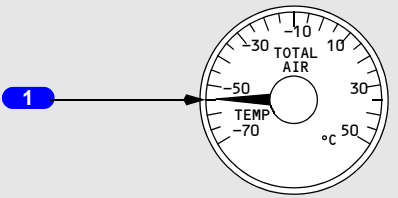
3 Brightness Control

Rotate – adjusts brightness of the VSI display.

4 Vertical Speed Pointer

Displays rate of climb or descent from 0 to 6,000 feet per minute.

Total Air Temperature

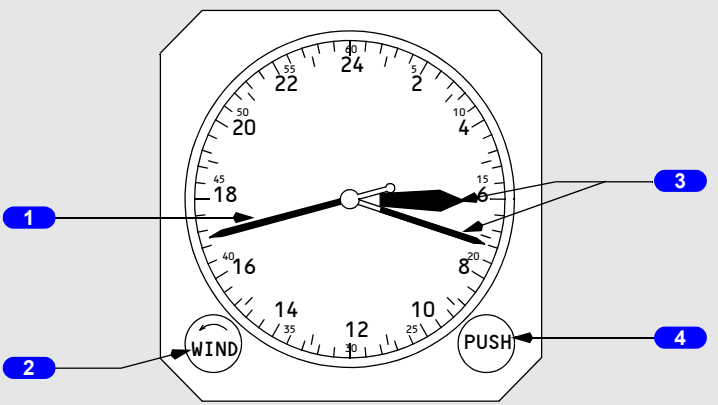


FIRST OFFICER'S INSTRUMENT PANEL

1 Total Air Temperature Indicator

Displays TAT from -70 degrees C to +50 degrees C.

Clock



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Sweep Second Hand

- controlled by push button
- rotates once each minute.

2 Winding (WIND) and Setting Control

Rotate counter clockwise –

- winds clock
- one winding powers clock for 8 days.

Pull – sets hour and minute hands.

3 Hour and Minute Hands

Twenty–four hour format.

4 PUSH Control

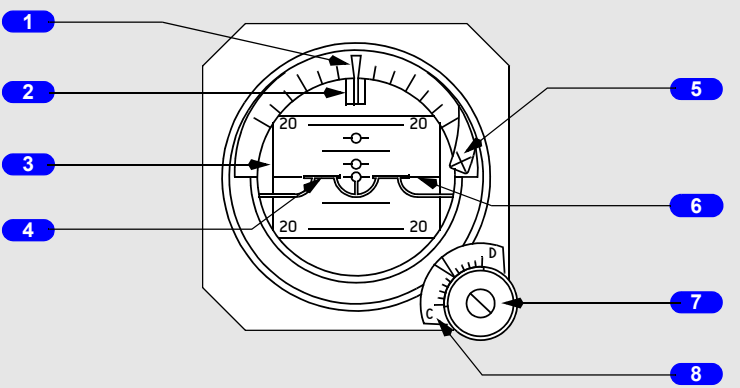
Controls sweep hand.

With sweep second hand at zero (60):

- Push – starts sweep hand timing
- Push again – stops sweep hand timing
- Push again – resets sweep second hand to zero.

Standby Flight Instruments

Standby Horizon



CENTER INSTRUMENT PANEL

1 Bank Angle Scale

Measures bank angles up to 60° in 10° increments (freedom of roll 360°).

2 Bank Angle Indicator

Indicates airplane bank angle against bank angle scale.

3 Horizon Drum

Provides indication of airplane pitch attitude (freedom of pitch 90°).

4 Symbolic Airplane

Provides an adjustable attitude reference.

5 Warning Flag

In view – loss of power.

6 Horizon Bar

7 Pitch Trim and Gyro Caging Control

In – rotate to adjust symbolic airplane pitch presentation.

Pull (momentary) – provides fast erection (caging) of gyro.

Release – control retracts.

Note: Airplane should be level during procedure.

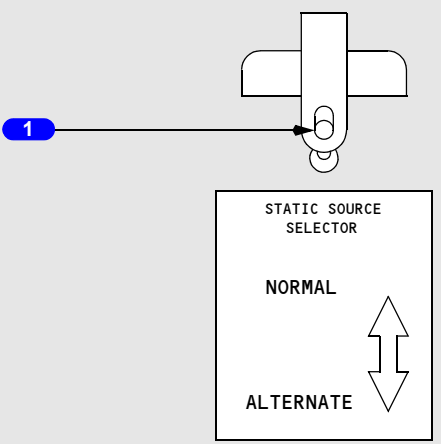
8 Pitch Trim Scale

Provides a reference for adjusting the symbolic airplane pitch presentation.

Marked in 1 degree increments

- C – climb
- D – dive.

Static Source Selector

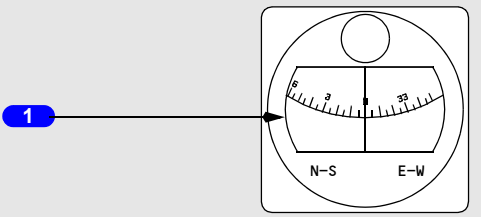


CAPTAIN'S SIDEWALL
FIRST OFFICER'S SIDEWALL

1 Static Source Selector Switch

- NORMAL (guarded position) – primary pitot–static system is providing static inputs to respective pilot's system
- ALTERNATE – alternate static system is providing static inputs to respective pilot's system.

Standby Magnetic Compass



CENTERPOST ABOVE GLARESHIELD

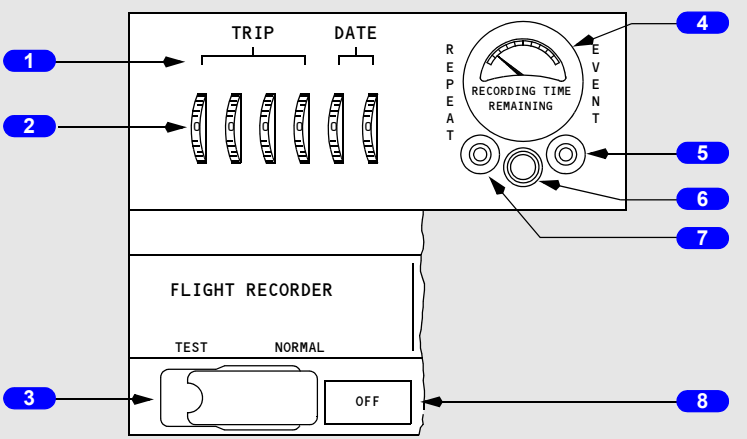
1 Standby Magnetic Compass

Displays magnetic heading.

The magnetic compass may be folded out of view for an unobstructed view through the windshield.

A standby magnetic compass correction card provides appropriate heading corrections.

Flight Recorder



AFT OVERHEAD PANEL

1 TRIP and DATE Encoder

2 Trip and Date Selectors

Rotate – sets trip number and date.

3 FLIGHT RECORDER TEST Switch

NORMAL (guarded position) –

- in flight – the recorder operates anytime electrical power is available
- on the ground – either engine must also be operating.

TEST – bypasses the engine oil pressure switches and the air ground switch to power the flight recorder on the ground.

Allow 15 seconds for complete test.

4 RECORDING TIME REMAINING Indicator

- Displays the number of recording hours remaining on tape
- full scale deflection indicates more than 200 hours.

5 EVENT Switch

Push (5 seconds) – transcribes a mark on the tape to identify the time of an event. Do not use until 5 minutes after the trip and date light is extinguished.

6 Trip and Date Light

Illuminated (amber) –

- trip and date information is being recorded
- the 15 minute transcribing cycle does not interfere with the recording of other information.

7 REPEAT Switch

Push (5 seconds) – initiates or repeats transcribing of the trip and date information.

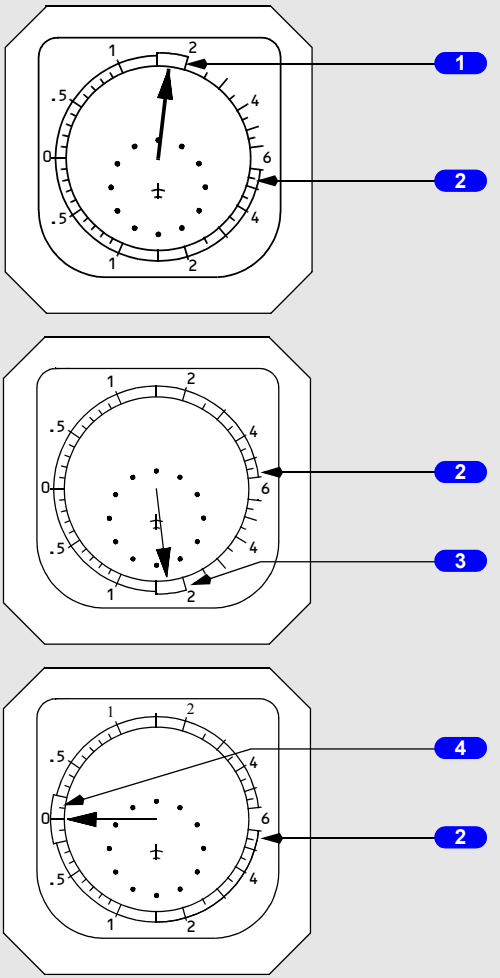
8 OFF Light

Illuminated (amber) –

- indicates the recorder is not operating or the test is invalid
- may indicate power failure, broken tape or not moving, or access door open.

TCAS

TCAS Resolution Advisory Commands



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 RA Pitch Command (green) (UP Advisory)

Indicates vertical speed range to ensure traffic separation.

2 Command Arc (red)

Indicates vertical speed range to avoid.

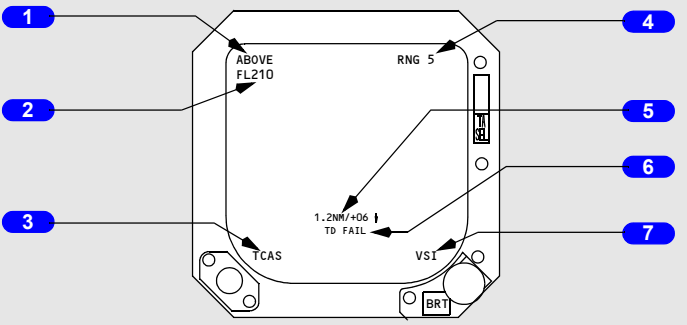
3 RA Pitch Command (green) (DOWN Advisory)

Indicates vertical speed range to ensure traffic separation.

4 RA Pitch Command (green) (LEVEL Advisory)

Indicates vertical speed range to ensure traffic separation.

TCAS VSI Messages



CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 ABOVE/NORM/BELOW Annunciation

Shows the position of the TAU envelope switch on the transponder control panel

- ABOVE (blue) – vertical display range for other traffic is biased above the airplane
- BELOW (blue) – vertical display range for other traffic is biased below the airplane
- Blank – NORM is selected on the transponder control panel. Vertical display range for other traffic is equal above and below the airplane.

2 Ownship Altitude Readout (blue))

Shows FL followed by the first three numbers of the airplane's altitude if the FL switch is selected on the transponder control panel.

3 TCAS Mode Display

Indicates current TCAS mode/system status

- TCAS (amber) – TCAS system has failed
- TA ONLY (blue) – TCAS TA only mode is selected
- TCAS STBY (blue) – TCAS standby mode is selected
- TEST (amber) – TCAS is in test mode.

4 TCAS Range

Displays TCAS range in nautical miles.

5 NO BEARING Messages

Displayed when no bearing information is available for traffic (distance, altitude, trend arrow).

6 Fault Annunciations

TD FAIL (amber) – failure in the operation of the traffic display.

RA FAIL (amber) – RA information is not available.

7 VSI Flag (amber)

Indicates that vertical speed is unreliable.

TCAS Symbology

SYMBOL	NAME	REMARKS
	RA traffic symbol (R)	Displayed during TCAS Resolution Advisory when traffic selected on the VSI or Weather Radar Indicator.
	RA off–scale traffic symbol (A)	Displayed when traffic selected on the VSI or Weather Radar Indicator and traffic is not within the display range.
	TA traffic symbol (A)	Displayed during TCAS Traffic Advisory when traffic selected on the VSI or Weather Radar Indicator.
	TA off–scale traffic symbol (A)	Displayed when traffic selected on the VSI or Weather Radar Indicator and traffic is not within the display range.
	Proximate traffic symbol (W)	Displayed when traffic selected on the VSI or Weather Radar Indicator and traffic is within 1200 feet vertical and 6 miles horizontal from present position.
	Other traffic symbol (W/outlined)	Displayed when traffic selected on the VSI or Weather Radar Indicator and traffic is greater than 1200 feet vertical or 6 miles horizontal from present position.
	Relative altitude (R,A,W)	With traffic selected on the VSI or Weather Radar Indicator, displays relative traffic altitude in hundreds of feet.
	Vertical motion arrow (R,A,W)	Displayed when traffic vertical speed is greater than 500 feet per minute and traffic selected on the VSI or Weather Radar Indicator.
	No bearing data (Red for RA; Amber for TA)	Displayed when no bearing information is available. Displays distance and altitude and trend arrow.

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Introduction

The flight instruments provide information to aid the pilots in controlling the airplane throughout its flight regime. The electric flight instruments receive input from an air data computer. The pneumatic flight instruments receive input directly from the pitot–static system. An alternate static system is also available and may be selected from the flight deck.

Air Data System

The air data system consists of the pitot–static system and one or two air data computers. The system provides pitot and/or static pressure information to various flight instruments and airplane systems. The pressure information is provided in one of two ways; either directly from the pitot–static system, or indirectly from an air data computer.

Pitot Static System

The pitot–static (P/S) system provides pitot and static pressure inputs to pressure–sensing instruments and systems which have functions that vary with altitude and/or airspeed.

There are four primary P/S systems; the Captain's, the First Officer's, No. 1 auxiliary, and No. 2 auxiliary. The pilots' systems are used by the flight instruments and air data computer(s). The auxiliary systems are used by various airplane systems.

An alternate static system provides each pilot with a standby source of static pressure that may be selected with the related static source selector. The alternate static system cannot be connected to the auxiliary systems. There is no alternate pitot system.

Pressure inputs to the primary P/S systems are provided by four combination pitot and static probes located on the forward fuselage. Each probe provides one pitot and two static outputs. The alternate static ports are located on each side of the fuselage. All static systems are cross–connected for dynamic balance.

A separate pitot system with probes mounted on the vertical stabilizer is provided for the elevator feel system.

A blocked or frozen pitot and/or static system may affect the following primary airplane system:

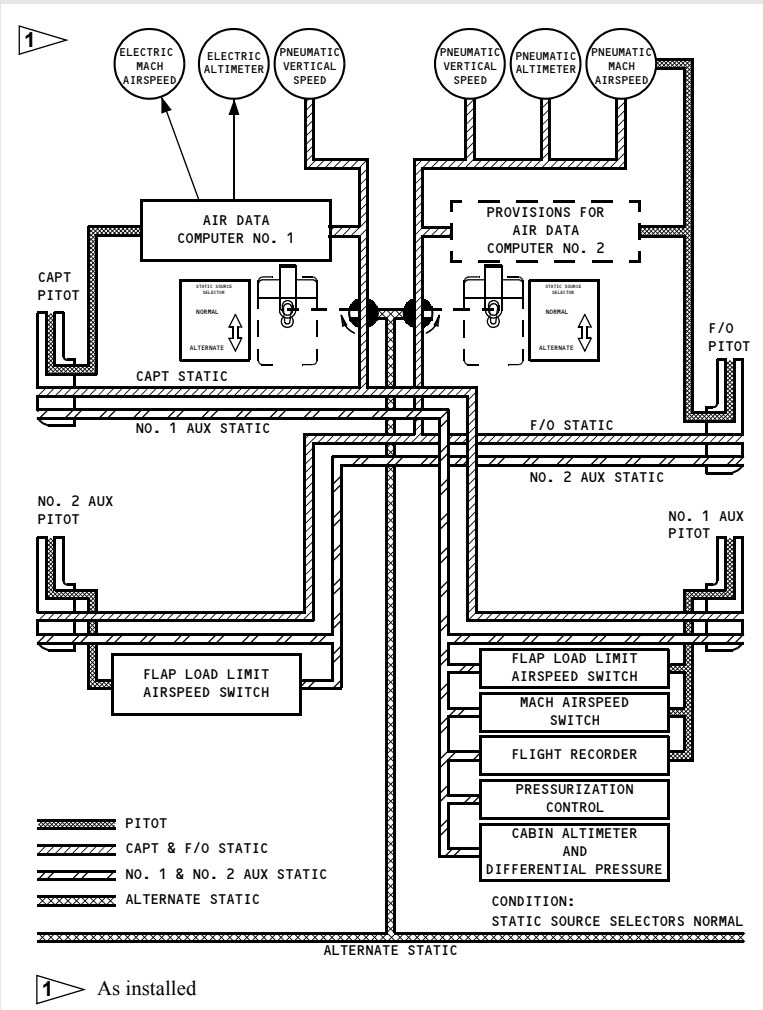
- Mach/airspeed indicator
- Vmo/Mmo warning

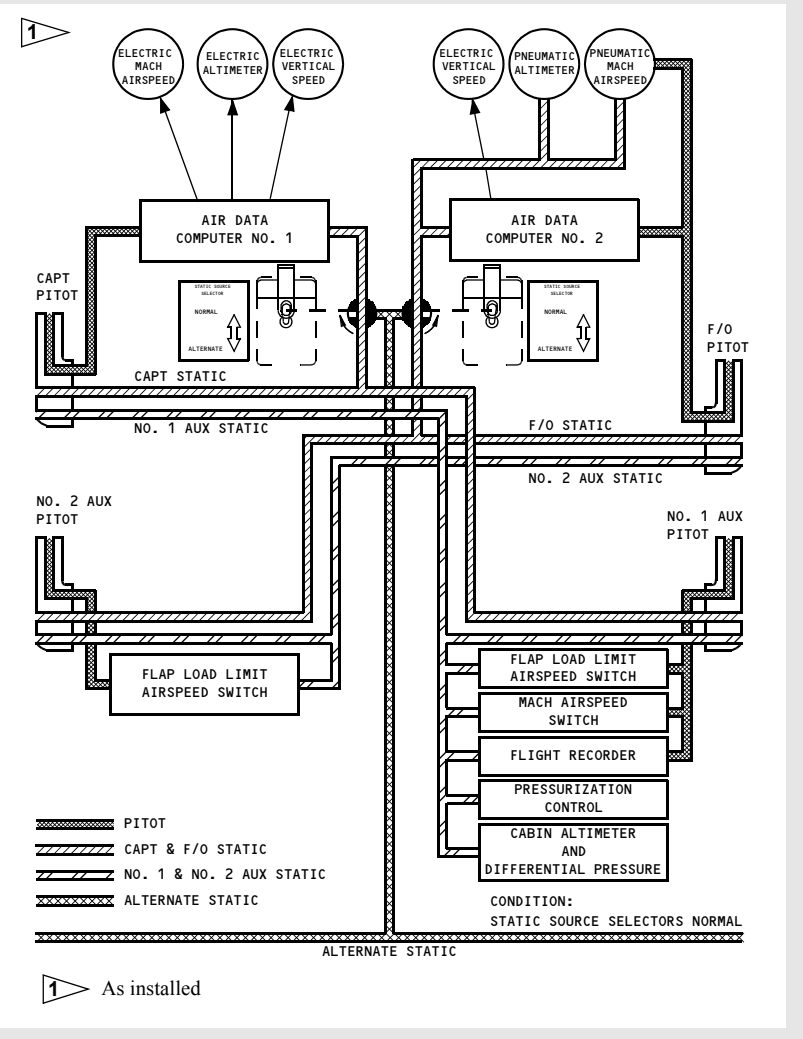
- altimeter
- vertical speed indicator
- true airspeed
- static air temperature
- flap load relief system
- elevator feel system
- autopilot
- ground proximity warning system
- altitude alert
- cabin pressure
- flight recorder
- transponder altitude reporting
- flight director altitude hold
- TAT or TAT/EPRL
- yaw damper
- Mach trim

Air Data Computer

One or two air data computers (ADCs) are installed. The ADC receives pitot and static pressure inputs from the respective pilot's P/S system, or from the alternate static system, if selected. The ADCs converts these pressure inputs to electrical signals used to operate various flight instruments and airplane systems. The ADC computers are powered whenever the AC busses are powered.

Pitot–Static System Schematic

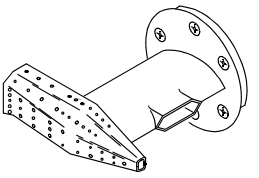




Total Air Temperature (TAT) System

One externally–mounted TAT probe is installed. The TAT indicator receives temperature information from the probe.

TAT indications are only valid in flight.



TAT PROBE

LEFT FORWARD FUSELAGE

The inflight TAT indication is comprised of outside air temperature (OAT) plus all of the ram rise. On the ground, the TAT indication is approximately OAT if pitot heat is OFF. In flight, the following table is used to convert indicated TAT to true OAT.

	INDICATED MACH NUMBER										
	.30	.40	.50	.60	.70	.73	.76	.78	.80	.82	.84
IND TAT - °C	TRUE OUTSIDE AIR TEMPERATURE - DEGREES C										
70				47	39	37	35	33	31	29	27
65			49	42	35	33	30	28	26	25	23
60		49	44	37	30	28	25	24	22	21	19
55	49	45	40	33	26	24	21	19	18	16	14
50	45	40	35	28	21	19	17	15	13	11	10
45	40	35	30	23	17	15	12	11	9	7	5
40	35	30	25	19	12	10	8	6	4	3	1
35	30	26	20	14	8	6	3	1	0	- 2	- 3
30	25	21	16	10	3	1	- 1	- 3	- 5	- 6	- 7
25	20	16	11	5	- 2	- 3	- 6	- 7	- 9	-11	-12
20	15	11	6	0	- 6	- 8	-10	-12	-13	-15	-16
15	10	6	2	- 5	-11	-13	-15	-16	-18	-19	-21
10	5	1	- 3	- 9	-15	-17	-19	-21	-22	-24	-25
5	0	- 3	- 8	-14	-20	-21	-24	-25	-27	-28	-29
0	- 5	- 8	-13	-18	-24	-26	-28	-30	-31	-33	-34
- 5	-10	-13	-18	-23	-29	-31	-33	-34	-35	-37	-38
-10	-15	-18	-22	-28	-33	-35	-37	-39	-40	-41	-43
-15	-20	-23	-27	-32	-38	-39	-42	-43	-44	-46	-47
-20	-24	-27	-32	-37	-42	-44	-46	-47	-49	-50	-51
-25	-29	-32	-36	-42	-47	-49	-51	-52	-53	-55	-56
-30	-34	-37	-41	-46	-51	-53	-55	-57	-58	-59	-60
-35	-39	-42	-46	-51	-56	-58	-60	-61	-62	-63	-65
-40	-44	-47	-51	-56	-61	-62	-64	-65	-66	-68	-69

NOTE: Probe Recovery Factor is 100%.

Angle–of–Attack

There is one angle–of–attack sensor, located on the left side of the forward fuselage. The vane measures airplane angle–of–attack relative to the air mass.

Primary Flight Instruments

Attitude Director Indicator

An attitude director indicator (ADI), on each pilot's panel, displays a view of the pitch and roll attitude of the airplane. The attitude display is shown on a colored tape with pitch and roll reference provided by vertical gyros.

Computed steering commands from the flight director computer are presented on the ADI by command bars. These commands are viewed with respect to a fixed symbolic airplane.

When the GYRO warning flag is in view, use the Vertical Gyro transfer switch to transfer the associated systems to an operating vertical gyro. When the GS flag is in view, use the VHF NAV switch to transfer to an operating system.

The localizer symbol moves left or right to indicate deviation from localizer centerline. The localizer signal is covered by a mask until the flight director captures the glideslope. After glideslope capture, a VOR LOC failure flag on the HSI will cause the mask to cover the localizer symbol.

The localizer pointer and warning flag remain out of view with VOR frequencies selected.

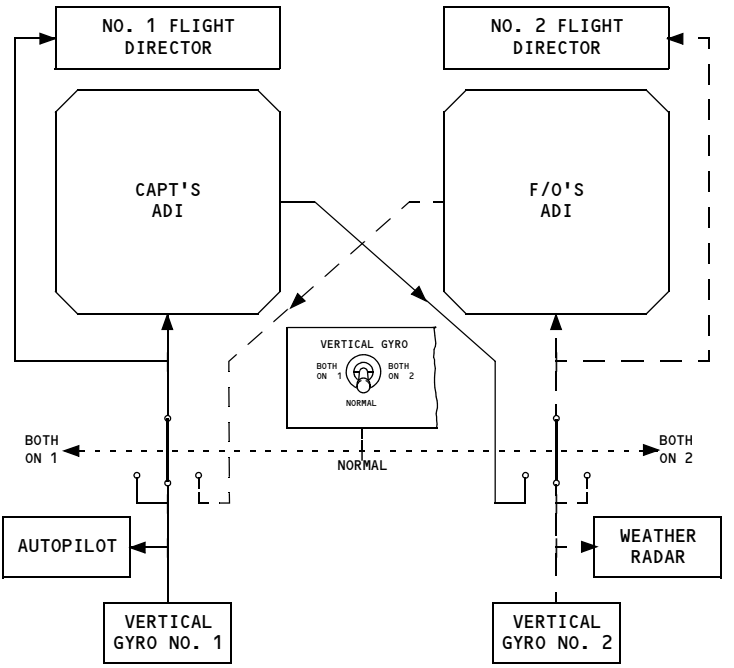
The COMPUTER flag monitors the flight director system. Switching is not installed for this problem.

Attitude Systems

Two attitude systems are installed. The vertical gyros (VGs) provide attitude information.

Whenever a vertical gyro is unable to provide proper attitude reference, the Vertical Gyro transfer switch should be moved to an operating vertical gyro.

Attitude System Schematic



Attitude Switching Table

VERTICAL GYRO TRANSFER

VERTICAL GYRO (BOTH ON 1 / BOTH ON 2 / NORMAL)	EQUIPMENT/INPUT					
	CAPT ADI	F/O ADI	AUTO-PILOT	WEATHER RADAR	NO. 1 FD	NO. 2 FD
NORMAL	1	2	1	2	1	2
BOTH ON 1	1	1	1	INOP	1	1
BOTH ON 2	2	2	INOP	2	2	2

Compass Systems

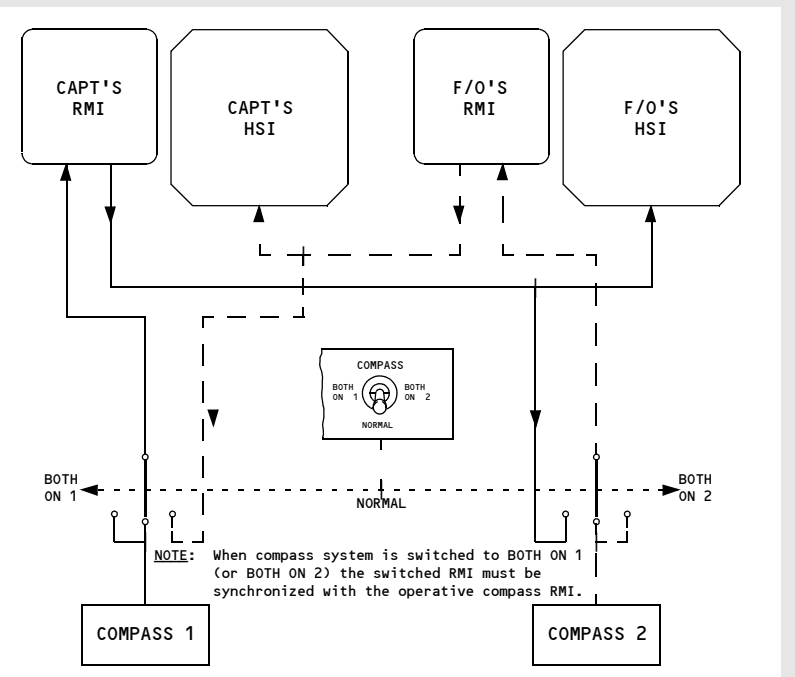
Two compass systems are installed. Directional gyros are connected to the RMI compass cards. The RMI compass card is then connected to the HSI compass card. The flux valves are installed in the vertical stabilizer.

The flux valves sense the direction of the earth's magnetic field. The directional gyros have random drift. Therefore, the flux valves are used to align the directional gyros with magnetic north and provide a stable compass system.

Synchronizing the flux valves and directional gyro can be observed with the synchronizing annunciator on the RMI.

The synchronizing process is relatively slow. The synchronizing control on the RMI can be used to manually provide rapid synchronizing of the flux valve and directional gyro.

Compass System Schematic



Compass Switching Table

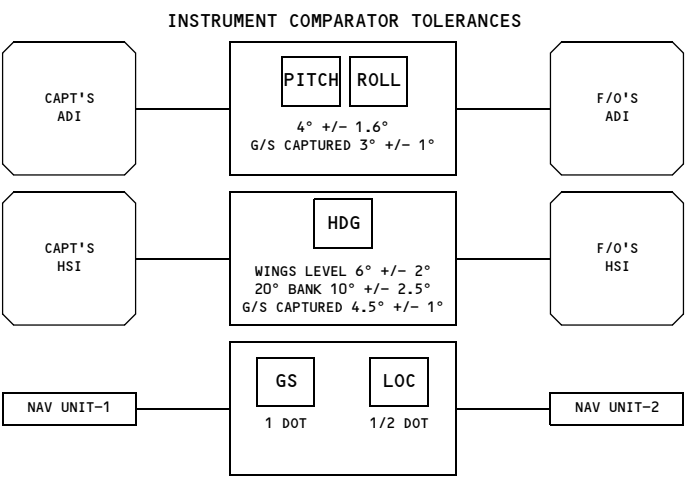
COMPASS TRANSFER

COMPASS (BOTH ON 1 / NORMAL / BOTH ON 2)	EQUIPMENT/INPUT									
	CAPT RMI	F/O RMI	CAPT HSI	F/O HSI	AUTO-PILOT	NO. 1 FD	NO. 2 FD	FLIGHT RECORDER	NO. 1 VHF NAV	NO. 2 VHF NAV
NORMAL	1	2	2	1	1	1	2	2	1	2
BOTH ON 1	1	1	1	1	1	1	1	1	1	1
BOTH ON 2	2	2	2	2	2	2	2	2	2	2

NOTE: When compass system is switched to BOTH ON 1 (or BOTH ON 2) the switched RMI must be synchronized with the good compass RMI.

Instrument Comparator

An instrument warning system is installed which provides comparison of the captain's and first officer's compass headings, pitch and roll attitude indications, localizer, and glideslope deviation outputs from the No. 1 and No. 2 VHF navigation unit.



Mach/Airspeed Indicators

Two Mach/airspeed indicators display indicated airspeed, Mach, and Vmo.

The electric Mach/Airspeed indicator displays information derived from the air data computer.

The pneumatic Mach/Airspeed indicators derives information from the respective captain's or first officer's pitot–static system (or an alternate static input, if selected).

Altimeters

An electric altimeter is installed on the captain's instrument panel. Altitude is derived from the air data computer.

A pneumatic altimeter is installed on the first officer's instrument panel. It utilizes the first officer's pitot–static source (or alternate static system, if selected).

Radio Altimeter

One low range radio altimeter and two indicators provide indication of airplane height above the ground up to 2500 feet absolute altitude. A radio altimeter indicator is located on each pilot instrument panel.

When the captain's radio altimeter is inoperative, all modes of the GPWS are inoperative.

Vertical Speed Indicators

Two pneumatic vertical speed indicators display vertical speed derived from the respective pilots' static system (or alternate static, if selected). On some airplanes, vertical speed information is displayed by two electric vertical speed indicators that receive information derived from their respective air data computer.

On some airplanes, a TCAS VSI display shows air traffic information detected by the TCAS system.

Marker Beacons

Each pilot has a set of marker beacon lights that show airways, middle, and outer beacon passage. Both sets are operated by one marker beacon receiver.

The marker beacon sensitivity switch is used to adjust the sensitivity of the receiver.

Clocks

Two spring powered, eight day clocks are installed.

Each clock displays time in a 24–hour format and has a stop–watch timer.

Standby Flight Instruments

Standby Horizon Indicator

The standby horizon indicator provides attitude information that is independent of the primary attitude displays. The indicator is powered by the battery bus and remains powered after the loss of all normal AC power as long as battery power is available. The gyro reaches operational speed approximately 60 seconds after power is applied. The indicator requires three minutes to achieve accuracy requirements.

Standby Magnetic Compass

A standard liquid–damped magnetic standby compass is provided. A card located near the compass provides heading correction factors.

Flight Recorder

The flight recorder provides a permanent record on tape of selected operational and systems information such as altitude, heading, and airspeed. The recorder is housed in a sealed, fire–resistant container located behind an access door in the aft cabin ceiling.

The pilots manually enter the trip number and date for subsequent transcribing onto the tape.

Operational and systems information is automatically recorded whenever the flight recorder is powered. Electrical power is provided from the transfer bus No. 1 and the battery bus. On the ground, the recorder begins operating as the low oil (35psi) pressure switch closes during either engine start. Oil pressure switches are bypassed in the air, and the flight recorder is powered, even with both engines shut down, as long as electrical power is available.

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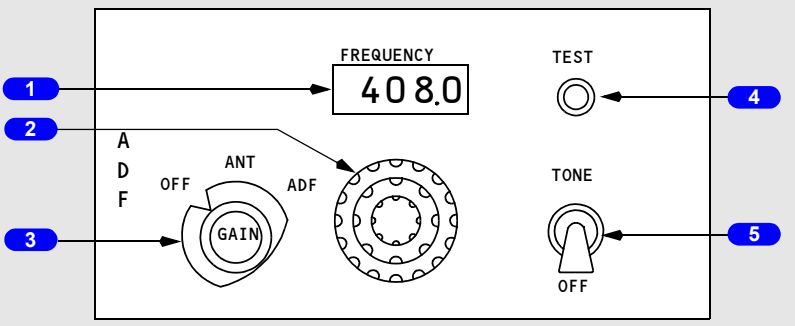
Radio Navigation Systems

Automatic Direction Finding (ADF) Control



FORWARD ELECTRONIC PANEL

1 FREQUENCY Indicator

Indicates the frequency selected with the related frequency selector.

2 Frequency Selector

Rotate –

- outer knob sets the hundreds number
- middle knob sets the tens number
- inner knob sets the tenths and ones number.

3 ADF Mode Selector

OFF – removes power from selected receiver.

ANT – only station audio received.

ADF – ADF bearing and station audio received.

GAIN – adjusts receiver gain.

4 TEST Switch

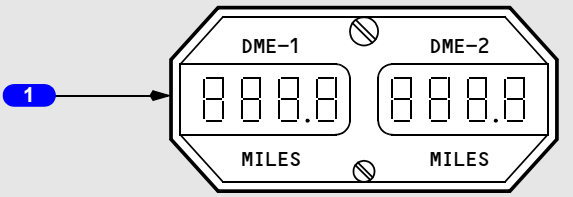
Push – ADF bearing pointer indicates 45 degrees left of lubber line.

5 TONE Switch

TONE – adds tone to receiver audio.

OFF – disables tones.

Distance Measuring Equipment (DME)

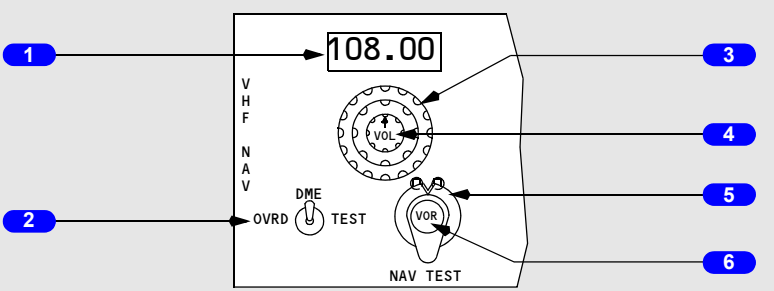


CAPTAIN'S INSTRUMENT PANEL
FIRST OFFICER'S INSTRUMENT PANEL

1 Digital DME Indicator

- displays slant range to DME station
- blank with electrical loss
- dashes when not receiving DME station
- brightness controlled by center knob located on pilot's light control panel.

VHF Navigation Control



AFT ELECTRONIC PANEL

1 Frequency Indicator

Indicates the frequency selected by the frequency selector.

2 DME Mode Selector

OVRD – DME searches to 390 nm.

DME – DME searches to 200 nm. Search limited to 50 nm for TVOR.

TEST – Digital DME indicator is:

- blank for one second
- dashes for one second
- zeros for as long as held in test position.

3 Frequency Selector

Rotate – manually selects the desired frequency.

4 Volume (VOL) Selector

Rotate – controls volume of selected station.

5 Navigation Test (NAV TEST) Switch

With an ILS frequency selected:

Rotate Knob Left –

- the glideslope indicates one dot up
- localizer indicates one dot left.

Rotate Knob Right –

- the glideslope indicates one dot down
- localizer indicates one dot right.

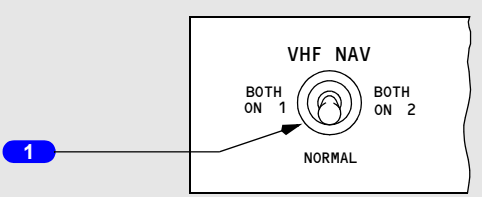
6 VOR TEST Switch

With a VOR frequency tuned and a course of 000 selected:

Push –

- course deviation bar centers
- VOR bearing pointer indicates 180 degrees
- TO–FROM ambiguity indicator show a FROM indication.

VHF NAV Transfer Switch



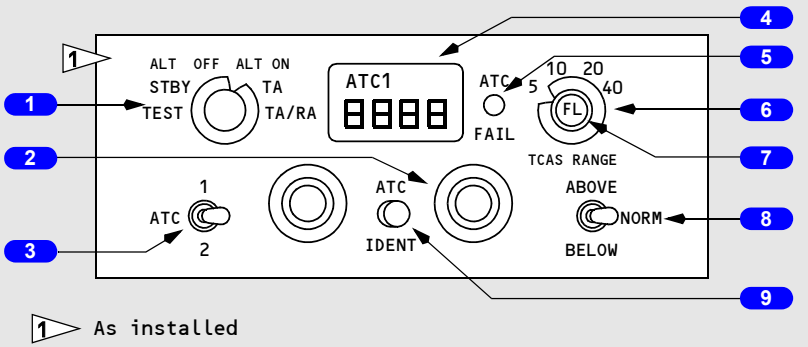
FORWARD OVERHEAD PANEL

1 VHF NAV Transfer Switch

- BOTH ON 1 – switches the VHF navigation source to VHF NAV receiver No. 1
- NORMAL – VHF navigation source is from default VHF NAV receiver
- BOTH ON 2 – switches the VHF navigation source to VHF NAV receiver No. 2.

Secondary Navigation Systems

Transponder Panel



FORWARD ELECTRONIC PANEL

1 Transponder Mode Selector

TEST – starts ATC transponder functional test.

STBY – does not transmit.

Note: Transponder modes are enabled only when the airplane is airborne, except for mode S, which operates continuously when the transponder mode selector is out of STBY.

ALT OFF – deactivates altitude reporting.

ALT ON – enables altitude reporting.

TA – enables display of traffic advisory TCAS targets. Refer to Chapter 15, Warning Systems.

TA/RA – enables display of traffic advisory and resolution advisory TCAS targets. Refer to Chapter 15, Warning Systems.

2 Air Traffic Control (ATC) Code Selector

Rotate – sets transponder code in transponder.

3 Transponder (ATC) Switch

1 – selects transponder No. 1.

2 – selects transponder No. 2.

4 ATC Code Indicator

Displays transponder code.

Displays operating transponder (1 or 2).

Displays response indicator (R).

5 Transponder FAIL (ATC FAIL) Light

Illuminated – indicates transponder malfunction.

6 Traffic Collision Avoidance System (TCAS) Range Selector

Selects range for TCAS operation.

7 Flight Level (FL) Switch

Push – displays relative altitude of TCAS information for 15 seconds.

8 TAU Envelope Switch

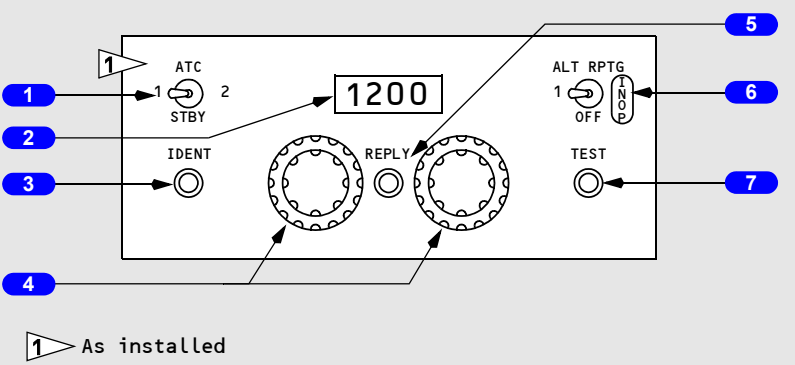
ABOVE – sets TCAS display at upper elevation limit.

NORM – sets TCAS display for normal limit.

BELOW – sets TCAS display at lower elevation limit.

9 Identification (ATC IDENT) Switch

Push – transmits an identification signal.



FORWARD ELECTRONIC PANEL

1 Transponder Air Traffic Control (ATC) Switch

1 – selects transponder No. 1.

STBY – does not transmit.

2 – selects transponder No. 2.

2 ATC Code Indicator

Displays transponder code.

3 Identification (IDENT) Switch

Push – transmits an identification signal.

4 ATC Code Selectors

Rotate – sets transponder code in transponder.

5 REPLY Light

Illuminated (green) –

- transponder replying to ground interrogation
- test in progress.

6 Altitude Reporting (ALT RPTG) Switch

1 – enables altitude reporting from air data computer No. 1.

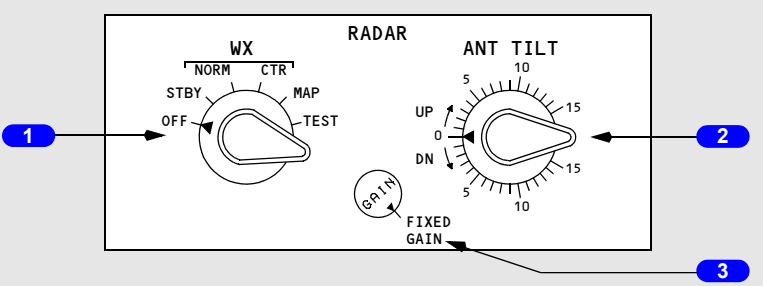
OFF – transponder operates without altitude reporting.

2 – inoperative.

7 TEST Switch

Push – with the transponder air traffic control (ATC) switch in position 1 or 2, the reply light illuminates to indicate the selected transponder is operational.

Weather Radar Panel



FORWARD ELECTRONIC PANEL

1 Weather (WX) Radar Function Selector

OFF – removes power to the radar system.

STBY (Standby) – apply warm–up power for 3 minutes prior to operation.

NORM (Normal) –

- antenna radiates symmetrical beam
- weather area of greatest intensity appears as brightest return.

CTR (Contour) –

- identifies areas of greatest intensity reversed
- weather area of greatest intensity appears as darkest return.

MAP – antenna radiates wide beam for ground mapping.

TEST – de–energizes transmitter and tests system. Displays test pattern.

2 Antenna Tilt (ANT TILT) Control

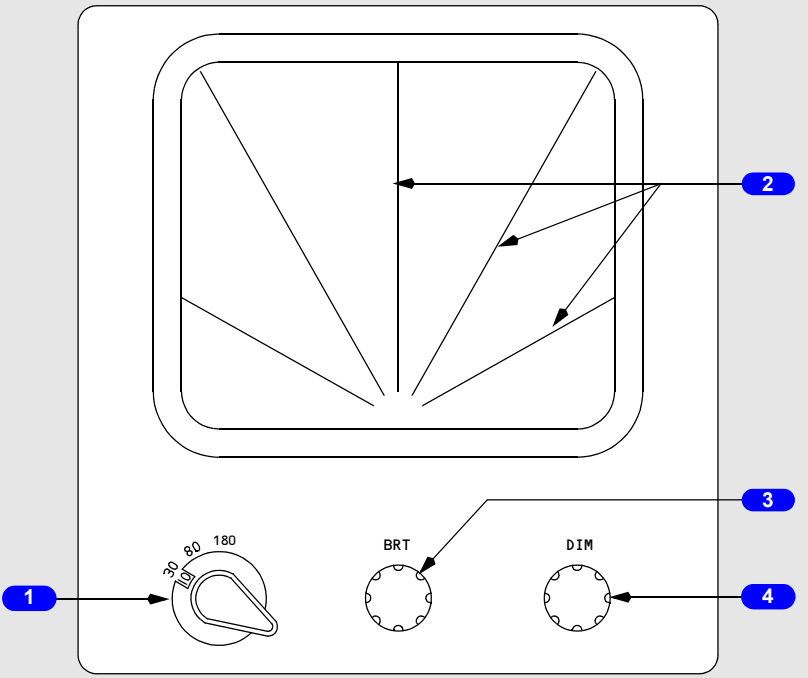
Rotate – radar antenna tilts 0 to 15 degrees above or below horizon.

Stabilization from vertical gyro maintains antenna sweep at a constant tilt angle relative to the earth's horizon.

3 GAIN Control

Rotate – manually sets receiver sensitivity.

FIXED GAIN (detent) – used in NORM or CTR modes.



FORWARD ELECTRONIC PANEL

1 Range Selector

Rotate – selects desired range for weather radar indicator.

- 30 Miles – Three 10 mile range marks
- 80 Miles – Three 25 mile range marks
- 180 Miles – Seven 25 mile range marks.

2 Azimuth Marks

3 Brightness (BRT) Control

Rotate – controls brightness of display.

4 Dimmer (DIM) Control

Rotate – controls intensity of background panel lights.

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Introduction

Navigation systems include the radio navigation systems, transponder, and weather radar.

Radio Navigation Systems

Automatic Direction Finding (ADF)

An automatic direction finding (ADF) system enables automatic determination of magnetic and relative bearings to selected facilities.

Two ADF receivers are installed. The No. 1 receiver uses the narrow pointer on the RMIs. The No. 2 receiver uses the wide pointer. The audio is heard by using the ADF receiver control on the audio selector panel.

ADF bearing pointers will not display correct magnetic bearing when the compass information is lost or invalid. Relative bearings are indicated by pointers if the receiver is operating.

VHF Navigation System (VHF NAV)

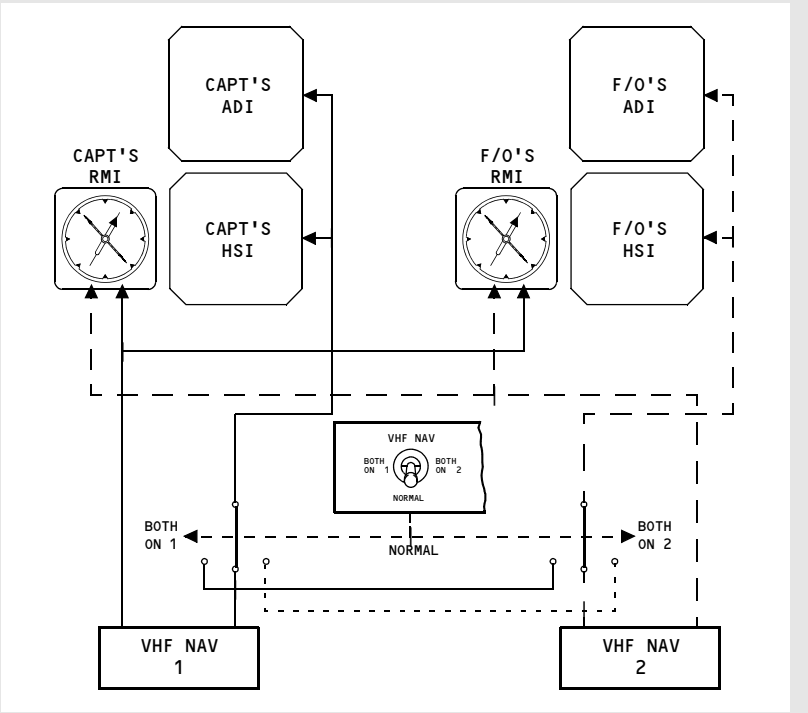
Two NAV receivers and controls panels are installed. The VHF navigation control panel is used to tune VOR and ILS frequencies.

VOR information is displayed on the RMIs when a valid in–range VOR station is tuned. The HSI displays course deviation when operating in the VOR mode.

Should either VHF NAV receiver fail, the VHF NAV transfer switch enables selection of the opposite VHF NAV receiver for display.

The deviation bar and glideslope pointer are controlled by the controls for the operating system.

VHF Navigation System Schematic



VHF Navigation Switching Table

VHF NAVIGATION TRANSFER

VHF NAV (BOTH ON 1 / BOTH ON 2 / NORMAL)	EQUIPMENT/INPUT								
	CAPT HSI	F/O HSI	CAPT ADI	F/O ADI	RMI'S ⇨	RMI'S ⇛	NO. 1 FD	NO. 2 FD	AUTO-PILOT
NORMAL	1	2	1	2	1	2	1	2	1
BOTH ON 1	1	1	1	1	1	2	1	1	1
BOTH ON 2	2	2	2	2	1	2	2	2	2

Secondary Navigation Systems

ATC Transponder

Two ATC transponders are installed and controlled by a single control panel. The ATC transponder system transmits a coded radio signal when interrogated by ATC ground radar. Altitude reporting capability is provided allowing altitude information from the air data computer to be transmitted to an ATC radar facility.

Transponders may also transmit information, such as flight number, airspeed or groundspeed, magnetic heading, altitude, GPS position, etc., depending on the level of enhancement. Airport equipment monitors airplane position on the ground when the transponder is active through Mode S capability (mode selector not in STANDBY or OFF). TCAS modes should not be used on the ground for ground tracking.

On airplanes with TCAS, TCAS is controlled from the transponder panel. The TCAS system is described in Chapter 15.

Weather Radar

The weather radar system detects and locates various types of precipitation bearing clouds along the flight path of the airplane and gives the pilot a visual indication of the clouds' intensity.

In NORM mode, the radar displays a cloud's rainfall intensity by displaying areas of greatest intensity with the brightest returns.

In CTR mode, the areas of strongest return are inverted. This mode clearly defines the location and extent of a storm cell by blacking out all radar returns above a predetermined level. Weather areas of greatest intensity appear as a "black hole".

In MAP mode, a wide radar beam is used to display ground surfaces (the most reflective surfaces appear brighter).

These displays enable identification of coastlines, hilly or mountainous regions, cities, or large structures. Ground mapping mode can be useful in areas where ground–based navigation aids are limited.

The radar system performs only the functions of weather detection and ground mapping. It should not be used or relied upon for proximity warning or anticollision protection.

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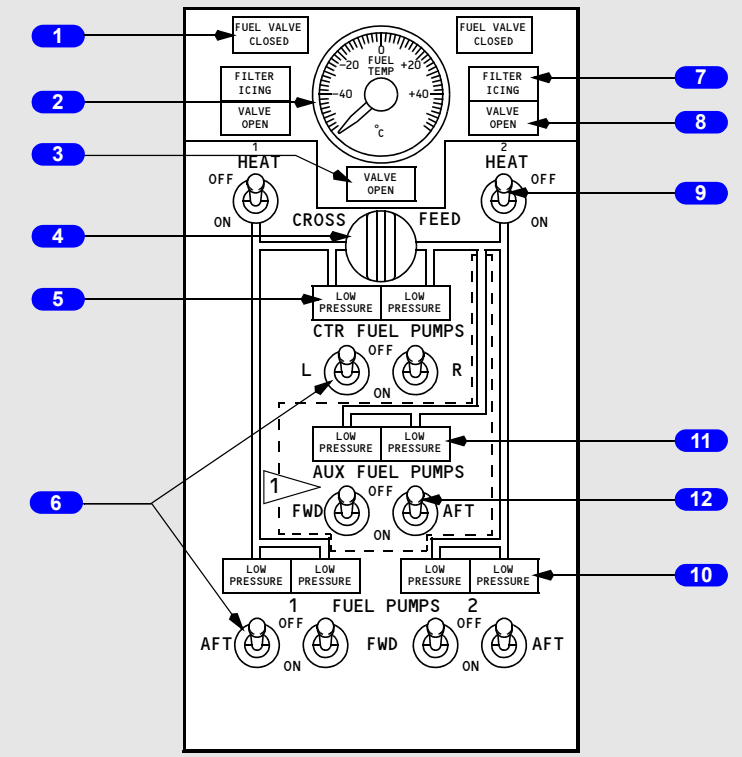
Fuel Control Panel



1 As installed

FORWARD OVERHEAD PANEL

1 FUEL VALVE CLOSED Light

Extinguished – related engine fuel shutoff valve is open.

Illuminated (blue) –

- bright – related fuel shutoff valve is in transit, or valve position and engine start lever or engine fire warning switch disagree.
- dim – related fuel shutoff valve is closed.

2 Fuel Temperature (FUEL TEMP) Indicator

Indicates fuel temperature in No. 1 tank.

3 Crossfeed VALVE OPEN Light

Illuminated (blue) –

- bright – crossfeed valve is in transit, or valve position and CROSSFEED selector disagree.
- dim – crossfeed valve is open.

Extinguished – crossfeed valve is closed.

4 CROSSFEED Selector

Controls fuel crossfeed valve.

Closed – isolates engine No. 1 and No. 2 fuel feed lines.

Open – connects engine No. 1 and No. 2 fuel feed lines.

5 Center Tank Fuel Pump LOW PRESSURE Light

Illuminated (amber) – fuel pump output pressure is low and FUEL PUMP switch is ON.

Note: With both Center(CTR) tank FUEL PUMP switches ON, illumination of both LOW PRESSURE lights illuminates MASTER CAUTION and FUEL system annunciator lights. Illumination of one LOW PRESSURE light illuminates MASTER CAUTION and FUEL system annunciator lights on MASTER CAUTION light recall.

Note: With one CTR tank FUEL PUMP switch OFF, illumination of opposite CTR tank LOW PRESSURE light illuminates the MASTER CAUTION and FUEL system annunciator lights.

Extinguished – fuel pump output pressure is normal, or FUEL PUMP switch is OFF.

6 FUEL PUMP Switch

ON – activates fuel pump.

OFF – deactivates fuel pump.

7 FILTER ICING Light

Extinguished – fuel filter operating normally.

Illuminated (amber) – indicates an iced or contaminated filter.

8 Fuel Heat VALVE OPEN Light

Illuminated (blue) –

- bright – fuel heat valve is in transit, or valve position and fuel HEAT switch disagree.
- dim – fuel heat valve is open.

Extinguished – fuel heat valve is closed.

9 Fuel HEAT Switch

ON – The solenoid switch opens the respective engine fuel heat valve allowing bleed air to heat the fuel and de-ice the fuel filter. The switch automatically moves to OFF after one minute.

10 Main Tank Fuel Pump LOW PRESSURE Light

Illuminated (amber) – fuel pump output pressure is low, or FUEL PUMP switch is OFF.

Note: Two LOW PRESSURE lights illuminated in same tank illuminates MASTER CAUTION and FUEL system annunciator lights. One LOW PRESSURE light causes MASTER CAUTION and FUEL system annunciator lights to illuminate on MASTER CAUTION light recall.

Extinguished – fuel pump output pressure is normal.

11 Aux Tank Fuel Pump LOW PRESSURE Light

Illuminated (amber) – fuel pump output pressure is low, or FUEL PUMP switch is OFF.

Note: Illumination of two LOW PRESSURE lights illuminates MASTER CAUTION and FUEL system annunciator lights. One LOW PRESSURE light causes MASTER CAUTION and FUEL system annunciator lights to illuminate on MASTER CAUTION light recall.

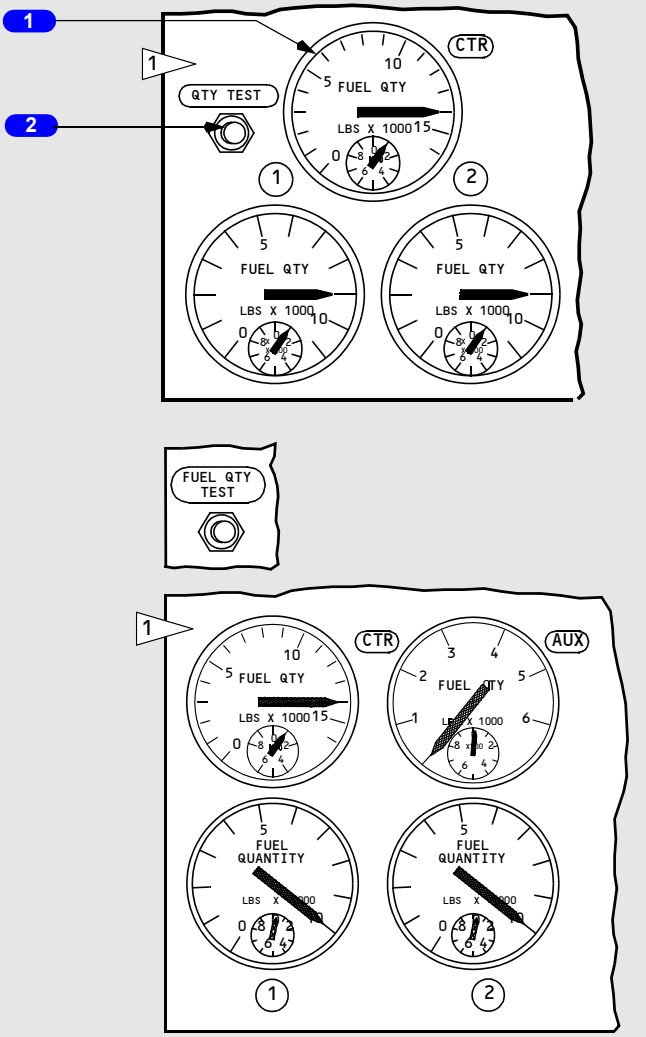
Extinguished – fuel pump output pressure is normal, or the FUEL PUMP switch is OFF.

12 Aux Tank FUEL PUMP Switch

ON – activates fuel pump.

OFF – deactivates fuel pump.

Fuel Quantity Indications



1 As installed

CENTER INSTRUMENT PANEL

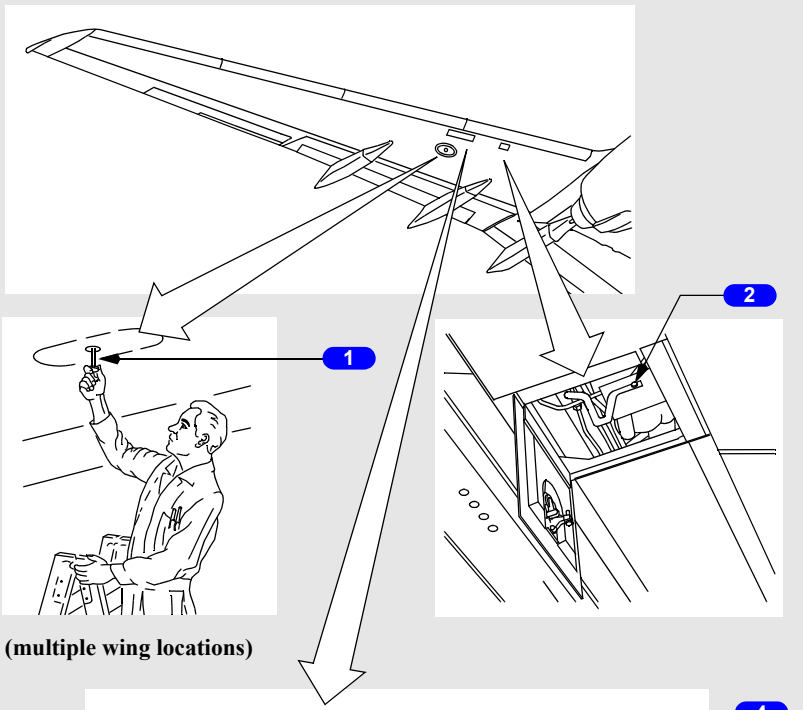
1 Fuel Quantity Indicator

- indicates usable fuel in the related tank.
- standby AC power is required.

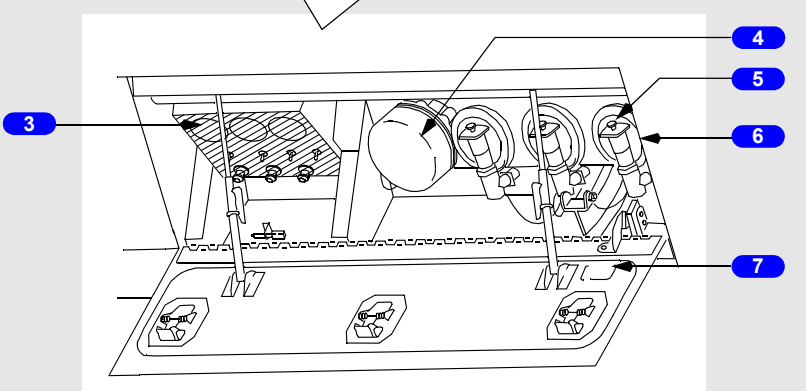
2 Fuel Quantity Test (QTY TEST) Switch

Indicator test is described in Supplementary Procedures.

Fueling / Defueling / Measurement



(multiple wing locations)



RIGHT WING LEADING EDGE

1 Fuel Measuring Stick

Allows comparison of fuel quantity or weight as determined from measuring stick reading and fuel weight indicated by fuel quantity indicators.

- five fuel measuring sticks are installed in each main tank
- reading is obtained by withdrawing measuring stick from tank until a steady drip of fuel commences at the drip hole near the base.

2 Manual Defueling Valve

Open – interconnects engine feed system and fueling station for:

- defueling
- ground transfer of fuel.

Closed – isolates engine feed system from fueling station.

3 TEST GAUGES & FUELING Panel

See Test Gauges and Fueling Panel section.

4 Fueling Receptacle

Hose connection receptacle for single point underwing fueling.

5 Solenoid Override

Mechanically opens solenoid operated valve. Fuel valve opens if fuel pressure is available.

6 Fueling Valves

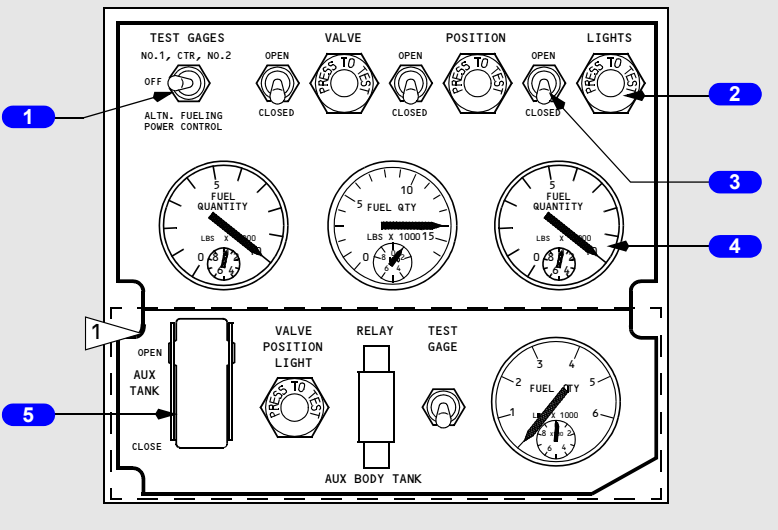
With battery switch ON, fuel pressure opens valve, if energized.

7 Fueling Power Control Switch

Door closed – proximity sensor deactivates power to fueling system.

Door open – the fueling system is powered and panel lights illuminate.

Test Gauges & Fueling Panel



RIGHT WING LEADING EDGE

1 TEST GAUGES & FUELING Switch

(spring–loaded to OFF position)

TEST GAUGES – checks operation of fuel quantity indicators.

AUX FUELING POWER CONTROL – energizes the fueling system if the fueling power control switch fails to activate the system when the door is open.

2 Fueling VALVE POSITION Lights

Extinguished –

- fueling valve switch is OPEN and related tank is full
- fueling valve switch is CLOSED.

Illuminated (blue) – fueling valve switch is OPEN and related tank is not full.

3 Fueling Valve Switches

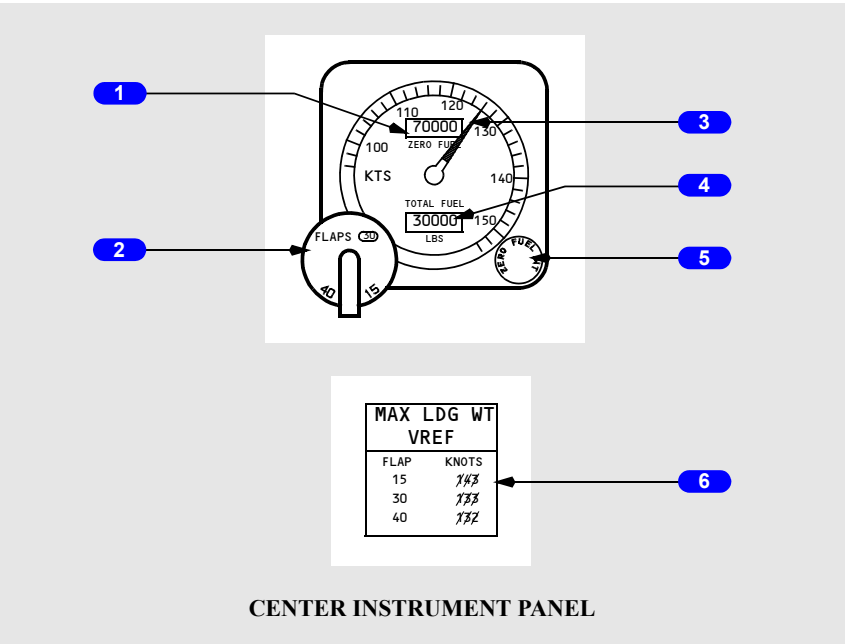
OPEN – energizes fueling valve in related tank.

CLOSED – de–energizes fueling valve in related tank.

4 FUEL Quantity Indicators

Indicates total usable fuel tank quantity in related tank.

Total Fuel and VREF Indicator



CENTER INSTRUMENT PANEL

1 ZERO FUEL Weight Counter

Indicates airplane zero fuel weight selected by the ZERO FUEL weight selector.

2 Landing Flap Selector

Adjusts the VREF pointer for the landing flap setting.

3 Vref Pointer

Indicates VREF speed for landing.

4 TOTAL FUEL Weight Counter

Indicates the total usable fuel remaining in all tanks.

5 ZERO FUEL Weight Selector

Used to set the ZERO FUEL weight counter to the correct zero fuel weight.

6 Maximum Landing Weight VREF (MAX LDG WT VREF) Placard

Airspeeds on this placard depend on the maximum allowable landing gross weight of the airplane.

Introduction

The fuel system supplies fuel to the engines and the APU. Fuel is contained in three tanks located within the wings and wing center section.

Refer to Engine and APU chapter for a description of the engine and APU fuel systems.

Airplanes with Auxiliary Fuel Tank

With an auxiliary fuel tank installed, fuel is contained in four tanks located within the wing, wing center section, and aft lower body. The auxiliary tank is comprised of two rubber bladder cells located at the forward end of the aft cargo compartment.

Fuel Feed

Both engines are normally pressure fed from the center tank until the center tank quantity decreases to near zero. The engines are normally then pressure fed from their respective main tanks. Check valves are located throughout the fuel system to ensure the proper direction of fuel flow and to prevent transfer of fuel between tanks.

Fuel Pumps

Each fuel tank uses two AC powered fuel pumps which are fuel cooled and lubricated. Center tank check valves open at a lower pressure than do the main tank check valves. This ensures that center tank fuel is used before main tank fuel, even though all fuel pumps are operating. Individual pressure sensors monitor the output pressure of each pump.

Mechanical engine–driven fuel pumps provide suction feed in the event that normal electrical fuel pump operation is not available. The engine pumps draw fuel through bypass valves located in main tanks No. 1 and No. 2. The main tank bypass valves may also be used for suction defueling. No bypass valves are provided in the center tank.

Fuel Crossfeed

The engine fuel manifolds are interconnected by use of the crossfeed valve. The valve is DC motor operated from the battery bus. The valve provides a means of directing fuel to both engines from any tank.

Fuel Shutoff Valves

Fuel shutoff valves are located at the engine–mounting wing stations. The valves are DC motor operated from the hot battery bus. They close whenever the respective engine fire warning switch is pulled or engine start lever is placed to CUTOFF.

Fuel Vent System

The purpose of the fuel vent system is to prevent damage to wings due to excessive buildup or positive or negative pressures inside the fuel tanks and to provide ram air pressure within the tanks. The tanks are vented into surge tanks which vent through a single opening at each wing tip.

Fuel Temperature

The FUEL TEMP indicator located on the fuel control panel displays fuel temperature. A sensor in main tank No. 1 allows monitoring of fuel temperature. The temperature indicating system uses AC electrical power.

APU Fuel Supply

When AC fuel pumps are operating, fuel for the APU is supplied from the left side of the fuel manifold. If the AC fuel pumps are not operating, fuel is suction fed from main tank No. 1.

DC Operated APU Fuel Pump

The DC operated APU fuel boost pump is installed to ensure positive fuel pressure to the APU fuel control unit. The pump operates automatically.

Fueling/Defueling/Ground Transfer

Rapid fueling and defueling is accomplished at the single–point pressure fueling station in the right wing. The fueling station is also used for the ground transfer of fuel between tanks.

Standard overwing fueling receptacles for main tanks No. 1 and No. 2 are provided for gravity fueling. In the absence of underwing pressure fueling facilities, center tank servicing can only be accomplished through the ground tank to tank fuel transferring operation.

The manual defueling valve, located outboard of engine No. 2, interconnects the engine feed system and the fueling station. It is opened for defueling and tank to tank transfer operations.

A shutoff system is used during fueling to automatically close the fueling valve in each fuel tank when the tank is full.

Fuel Quantity Indication

The fuel quantity indication system calculates the usable fuel quantity in each tank. The fuel quantity in each tank is displayed on the center instrument panel and on the fueling station panel.

Total Fuel and VREF Indicator

This instrument uses airplane weight (zero fuel weight plus total fuel remaining) and landing flap selected to give the pilot a constant VREF speed indication.

The pilot can calculate airplane weight at any time by adding the zero fuel weight and total fuel weight counters. The instrument itself electronically sums the preset zero fuel weight and the existing total fuel weight.

Selection of desired landing flap on the flap selector knob biases the VREF pointer to the correct VREF speed.

Maximum landing weight VREF for the flaps selected may be read from a placard adjacent to the indicator.

Power for the instrument is 115V AC. A power failure will result in the pointer remaining at its last position to give an increasingly conservative VREF as more fuel is used.

Fuel Tank Location and Capacities (Usable Fuel)

Main tanks No. 1 and No. 2 are integral with the wing structure. The center tank lies between the wing roots within the fuselage area and extends out into the wing structure.

These figures represent approximate amounts of usable fuel. The appropriate weight and balance control and loading manual gives exact figures for all conditions.

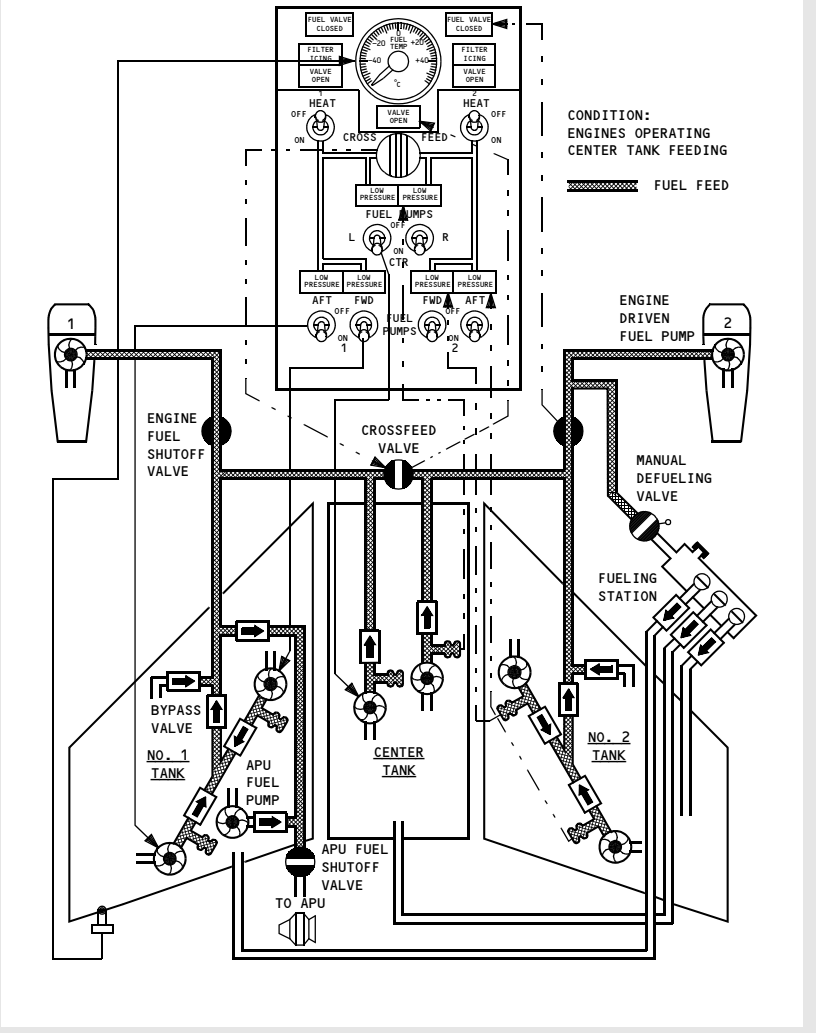
TANK	GALLONS	POUNDS*
NO. 1	1,430	9,580
NO. 2	1,430	9,580
CENTER	2,303	15,430
TOTAL	5,163	34,590

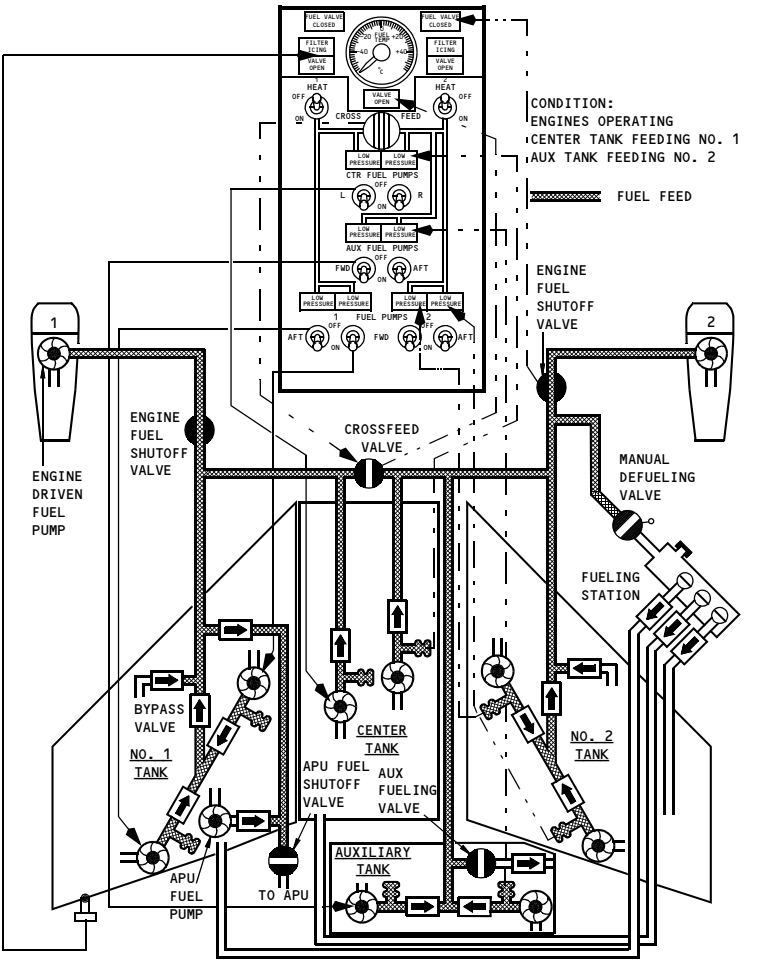
* Usable fuel at level attitude, fuel density = 6.7 pounds per US gallon

TANK	GALLONS	POUNDS*
AUXILIARY	810	5,429
TOTAL	5,973	40,019

* Usable fuel at level attitude, fuel density = 6.7 pounds per US gallon

Fuel Schematic





Airplanes with Auxiliary Tank

Hydraulics
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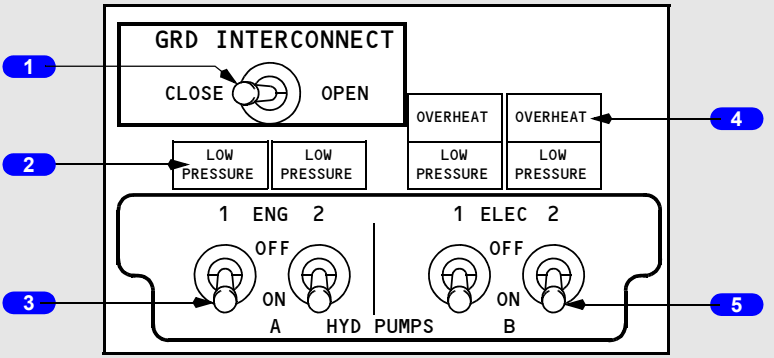
Hydraulic Panel



FORWARD OVERHEAD PANEL

1 GROUND INTERCONNECT Switch

CLOSE – isolates system A using units from system B output.

OPEN – connects system A pressure to system B pressure for ground functional checks. The ground interconnect valve will open only if the parking brake is set, the airplane is on the ground and electrical power is available.

2 Hydraulic Pump LOW PRESSURE Lights

Illuminated (amber) – output pressure of associated pump is low

Note: When an engine fire warning switch is pulled, the associated engine-driven hydraulic pump low pressure light is deactivated.

3 Engine Hydraulic Pump Switches

ON – de–energizes blocking valve in pump to allow pump pressure to enter system.

Note: Should remain ON at shutdown to prolong solenoid life.

OFF – energizes blocking valve to block pump output.

4 Electric Hydraulic Pump OVERHEAT Lights

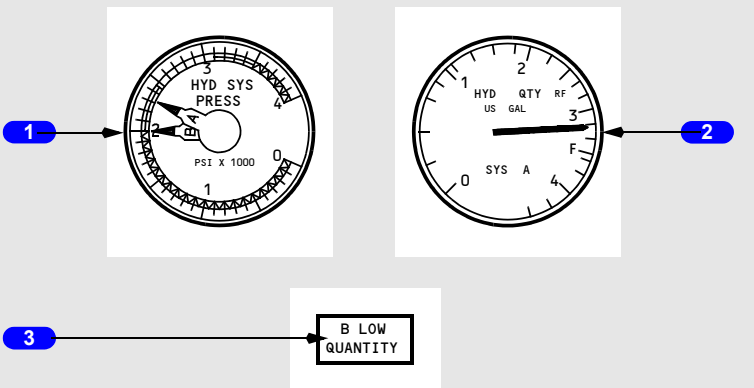
Illuminated (amber) – hydraulic pump or fluid used to cool and lubricate the corresponding electric motor driven pump has overheated.

5 Electric Hydraulic Pump Switches

ON – provides power to corresponding electric motor–driven pump.

OFF – electrical power removed from pump.

Hydraulic Indications



F/O INSTRUMENT PANEL

1 HYDRAULIC System PRESSURE Indications

Indicates system A and B pressures:

- Normal pressure – 3000 psi
- Maximum pressure – 3500 psi.

Note: When both pumps for a system are OFF, respective pointer reads zero.

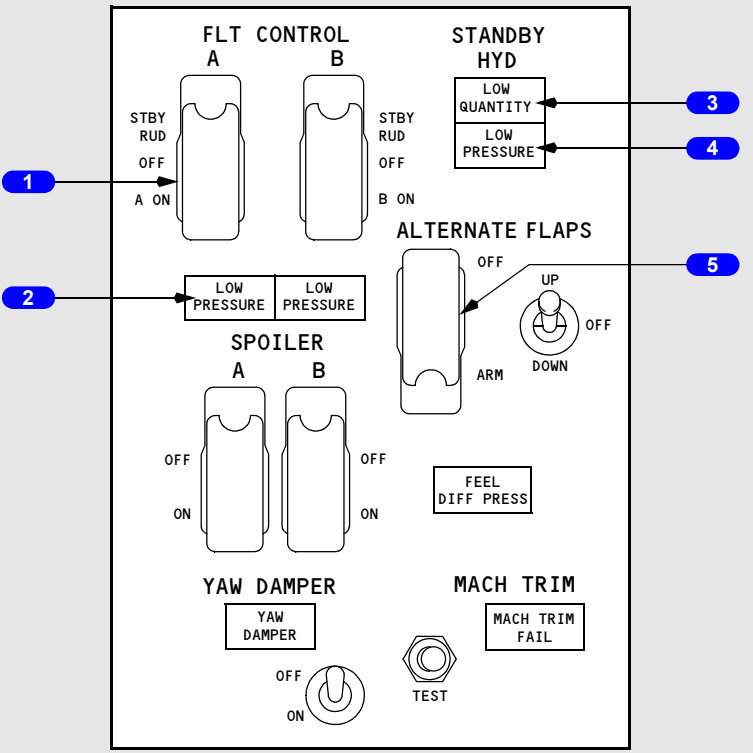
2 SYSTEM A HYDRAULIC QUANTITY Indicator

- Full – 3.5 U.S. gallons.
- Refill – 2.4 U.S. gallons.

3 Hydraulic System B LOW QUANTITY Light

Illuminated (amber) – indicates reservoir fluid level is low

Flight Control Panel (before Rudder System Enhancement Program (RSEP) modification)



FORWARD OVERHEAD PANEL

1 FLIGHT CONTROL Switches

STBY RUD – activates standby pump and opens standby rudder shutoff valve to pressurize standby rudder power control unit.

OFF – closes flight control shutoff valve isolating ailerons, elevators and rudder from associated hydraulic system pressure.

ON (guarded position) – normal operating position.

2 Flight Control LOW PRESSURE Lights

Illuminated (amber) –

- indicates low hydraulic system (A or B) pressure to ailerons, elevator and rudder.
- deactivated when associated FLIGHT CONTROL switch is positioned to STBY RUD and standby rudder shutoff valve opens.
- on airplanes with the rudder pressure reducer installed, indicates A system pressure is low when normal system pressure is commanded.

Note: On airplanes with the rudder pressure reducer installed, the A system light will remain illuminated for approximately five seconds after A hydraulic system has been activated.

3 STANDBY HYDRAULIC LOW QUANTITY Light

Illuminated (amber) –

- indicates low quantity in standby hydraulic reservoi.r
- always armed.

4 STANDBY HYDRAULIC LOW PRESSURE Light

Illuminated (amber) –

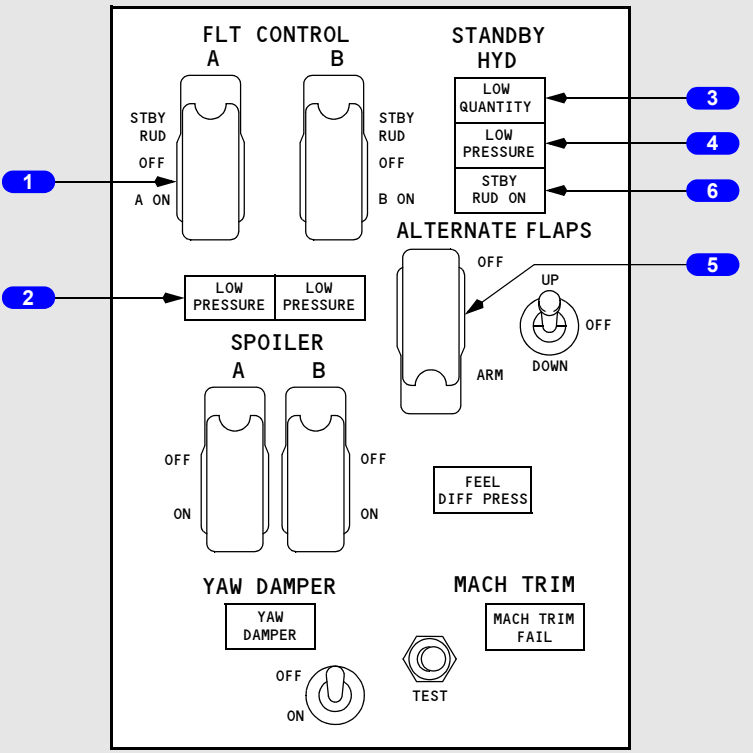
- indicates output pressure of electric motor driven standby pump is low.
- armed only when standby pump operation has been selected.

5 ALTERNATE FLAPS Master Switch

OFF (guarded position) – normal operating position.

ARM – closes trailing edge flap bypass valve, activates standby pump, and arms ALTERNATE FLAPS position switch.

Flight Control Panel (after Rudder System Enhancement Program (RSEP) modification)



FORWARD OVERHEAD PANEL

1 FLIGHT CONTROL Switches

STBY RUD – activates standby pump and opens standby rudder shutoff valve to pressurize standby rudder power control unit.

OFF – closes flight control shutoff valve isolating ailerons, elevators and rudder from associated hydraulic system pressure.

ON (guarded position) – normal operating position.

2 Flight Control LOW PRESSURE Lights

Illuminated (amber) –

- indicates low hydraulic system (A or B) pressure to ailerons, elevator and rudder.
- deactivated when associated FLIGHT CONTROL switch is positioned to STBY RUD and standby rudder shutoff valve opens.
- indicates A system pressure is low when full RPR pressure is commanded.

Note: The A system light will remain illuminated for approximately five seconds after A hydraulic system has been activated.

3 STANDBY HYDRAULIC LOW QUANTITY Light

Illuminated (amber) –

- indicates low quantity in standby hydraulic reservoi.r
- always armed.

4 STANDBY HYDRAULIC LOW PRESSURE Light

Illuminated (amber) –

- indicates output pressure of electric motor driven standby pump is low.
- armed only when standby pump operation has been selected.

5 ALTERNATE FLAPS Master Switch

OFF (guarded position) – normal operating position.

ARM – closes trailing edge flap bypass valve, activates standby pump, and arms ALTERNATE FLAPS position switch.

6 STBY RUD ON Light

Illuminated (amber) - indicates the standby hydraulic system is commanded on to pressurize the standby rudder power control unit.

Introduction

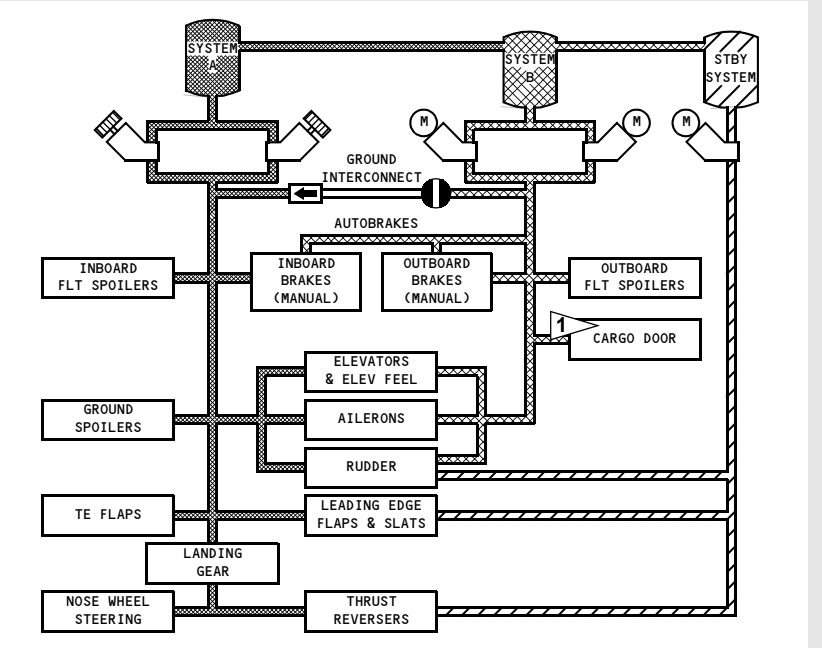
The airplane has three hydraulic systems: A, B and standby. The standby system is used if system A and/or B pressure is lost. The hydraulic systems power the following airplane systems:

- flight controls
- leading edge flaps and slats
- trailing edge flaps
- spoilers
- landing gear
- wheel brakes
- nose wheel steering
- thrust reversers
- yaw damper
- autopilots
- cargo door (cargo airplanes only)

Each hydraulic system has a fluid reservoir located in the main wheel well area. The reservoirs are pressurized by engine bleed air directed into the system A reservoir. Fluid balance lines interconnect all reservoirs. Pressurization of all reservoirs ensures positive fluid supply to all hydraulic pumps and controls the fluid level in the reservoirs.

The ground interconnect valve allows system B to pressurize system A for systems check when the airplane is on the ground, the parking brake is set and electrical power is available.

Hydraulic Power Distribution Schematic



A and B Hydraulic Systems

Components powered by hydraulic systems A and B are:

System A

- ailerons
- rudder
- elevator
- inboard flight spoilers
- inboard brakes
- ground spoilers
- thrust reversers
- nose wheel steering
- landing gear
- leading edge flaps and slats
- trailing edge flaps

System B

- ailerons
- rudder
- elevator
- outboard flight spoilers
- outboard brakes
- yaw damper
- autobrakes
- autopilot B
- cargo door (cargo airplanes only)

Hydraulic System A

System A pressure is provided by an engine driven pump on each engine. The ENG 1 and ENG 2 pump ON/OFF switch controls the engine–driven pump output pressure. Positioning the switch to OFF isolates fluid flow from the system components. However, the engine–driven pump continues to rotate as long as the engine is operating. Pulling the engine fire warning switch shuts off the fluid flow to the engine–driven pump and deactivates the related LOW PRESSURE light.

Hydraulic fluid used for cooling and lubrication of the pumps passes through a heat exchanger before returning to the reservoir. The heat exchanger is located in main fuel tank No. 1 and must be covered with fuel for operation of the pumps.

Pressure switches, located in the pump output lines, send signals to illuminate the related LOW PRESSURE light if pump output pressure is low. A check valve, located in each output line, isolates each pump from the system. The A system pressure transmitter sends the combined pressure of the pumps to the A HYDRAULIC SYSTEM PRESSURE indicator needle.

Hydraulic System B

System B pressure is provided by two electrically driven hydraulic pumps. The ELEC 1 or ELEC 2 pump ON/OFF switch controls the related electric motors.

The system B reservoir is connected to the system A reservoir and the standby reservoir through balance lines for single point pressurization and servicing. The B LOW QUANTITY light illuminates when reservoir fluid is low.

Hydraulic fluid used for cooling and lubrication of the pumps passes through a heat exchanger before returning to the reservoir. The heat exchanger for system B is in main fuel tank No. 2. If a pump or the fluid becomes overheated, the OVERHEAT light illuminates.

CAUTION: Minimum fuel for ground operation of electric pumps is 760 Kgs (1675 Lbs) in fuel tank No. 2.

Pressure switches, located in the pump output lines, send signals to illuminate the related LOW PRESSURE light if pump output pressure is low. Check valves isolate the two pumps. The system pressure transmitter sends the combined pressure of the electric motor–driven pumps to the B HYDRAULIC SYSTEM PRESSURE indicator needle.

The automatic load shedding feature deactivates the respective system B hydraulic pump when a generator is lost. The LOW PRESSURE light illuminates and the pump switch remains in the on position. When the bus is powered again, the pump is activated and the LOW PRESSURE light extinguishes

Standby Hydraulic System

The standby hydraulic system is provided as a backup if system A and/or B pressure is lost. The standby system reservoir is connected to the System B reservoir through a balance line for pressurization and servicing. The standby system LOW QUANTITY light is always armed and indicates low quantity in the standby reservoir. The LOW PRESSURE light is armed only when standby pump operation has been selected. The standby system uses a single electric motor–driven pump to power:

- thrust reversers
- rudder
- leading edge flaps and slats (extend only)

System Operation

Positioning either FLT CONTROL switch to STBY RUD:

- activates the standby electric motor–driven pump
- shuts off the related hydraulic system pressure to ailerons, elevators and rudder by closing the flight control shutoff valve
- opens the standby rudder shutoff valve
- deactivates the related flight control LOW PRESSURE light when the standby rudder shutoff valve opens
- allows the standby system to power the rudder.
- (after RSEP modification) illuminates the STBY RUD ON, Master Caution, and Flight Controls (FLT CONT) lights.

Positioning the ALTERNATE FLAPS master switch to ARM (see the Flight Controls chapter for a more complete explanation):

- activates the standby electric motor–driven pump
- arms the ALTERNATE FLAPS position switch
- allows the standby system to power the leading edge flaps and slats and thrust reversers.

With the loss of System A the standby system will provide pressure to operate the thrust reversers.

Automatic Operation (after RSEP modification)

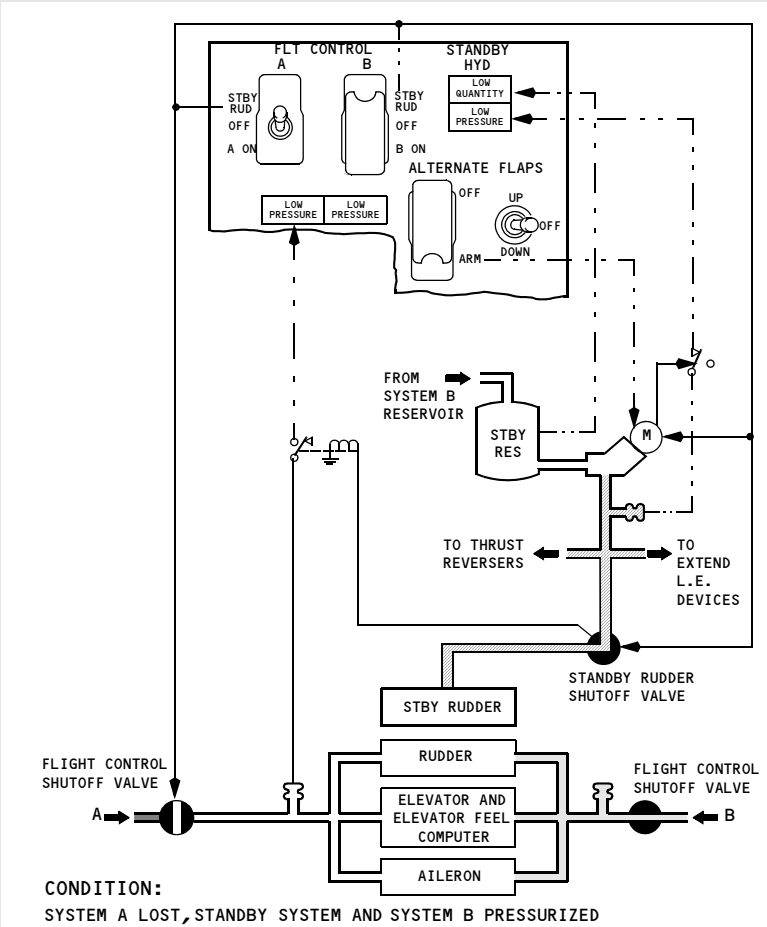
Automatic operation is initiated when the following conditions exist:

- FLT CONTROLS switch A is not in the STBY RUD position,
- FLT CONTROLS switch B is in the ON position,
- ALTERNATE FLAPS arming switch is in the OFF position
- the main PCU Force Fight Monitor (FFM) trips.

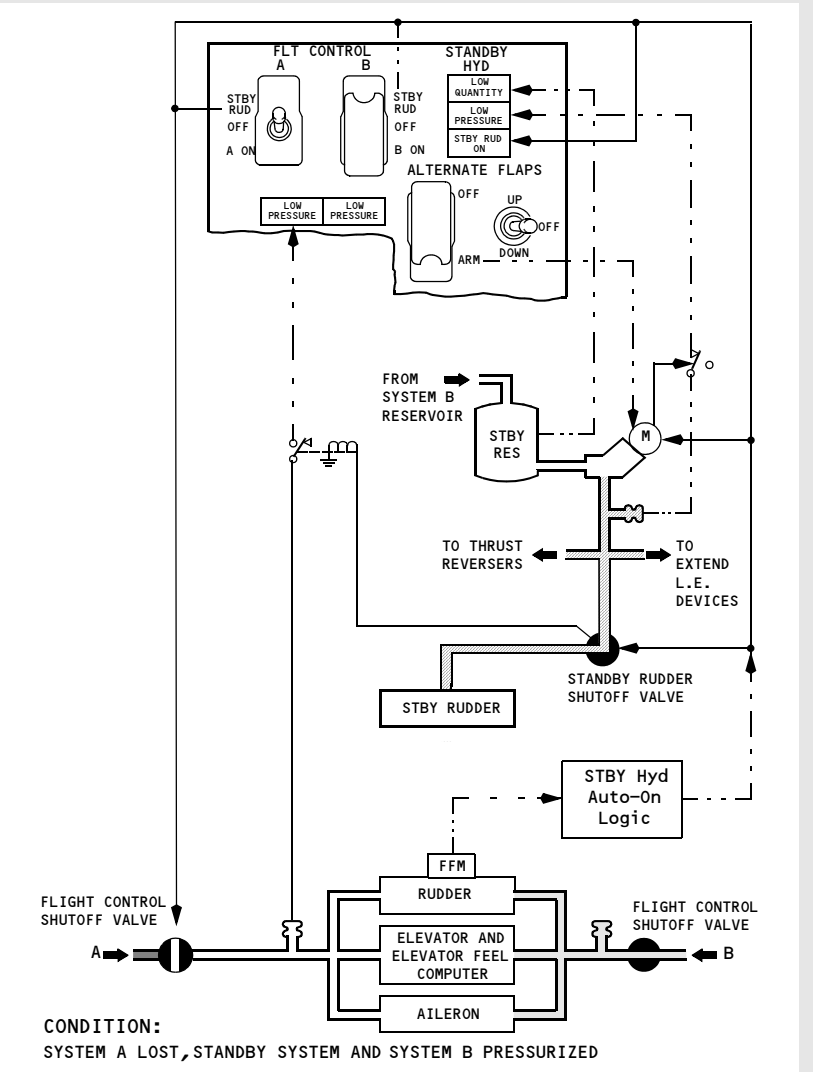
Automatic operation:

- opens the standby rudder shutoff valve
- activates the standby electric motor-driven pump
- allows the standby system to power the rudder
- illuminates the STBY RUD ON, Master Caution, and Flight Controls (FLT CONT) lights.

Standby Hydraulic System Schematic (before RSEP modification)



Standby Hydraulic System Schematic (after RSEP modification)



Variations in Hydraulic Quantity Indications

During normal operations, variations in System A hydraulic quantity indications occur when:

- the system becomes pressurized after engine start
- raising or lowering the landing gear or leading edge devices
- cold soaking occurs during long periods of cruise.

These variations have little effect on systems operation.

If the hydraulic system is not properly pressurized, foaming can occur at higher altitudes. Foaming can be recognized by pressure fluctuations and the blinking of the related LOW PRESSURE lights.

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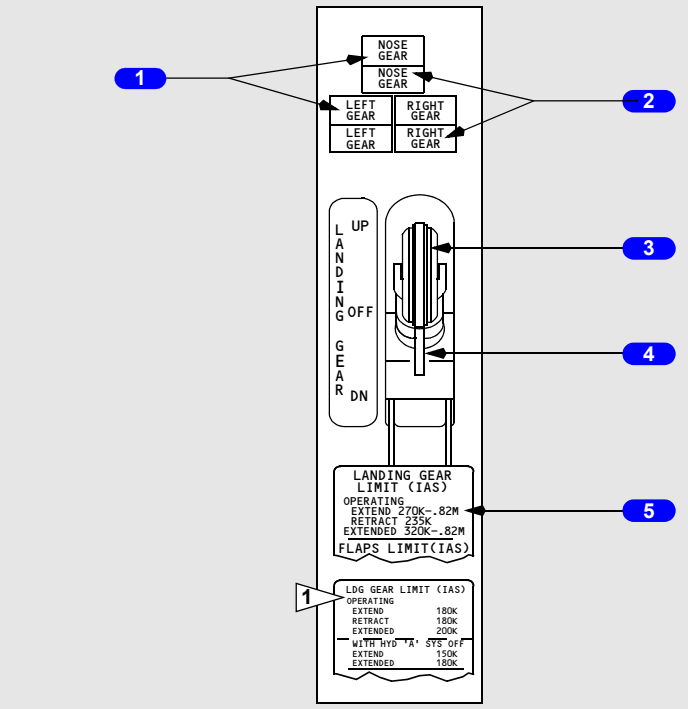
Landing Gear Panel



1 Airplanes with Gravel Deflector

CENTER INSTRUMENT PANEL

1 Landing Gear Indicator Lights (top)

Illuminated (red) –

- landing gear is not down and either thrust lever is retarded to idle
- related landing gear is in disagreement with LANDING GEAR lever position (in transit or unsafe)
- gear is down and locked and lever is not in the down detent

Extinguished –

- landing gear is up and locked with landing gear lever UP or OFF
- landing gear is down and locked with landing gear lever DN.

2 Landing Gear Indicator Lights (bottom)

Illuminated (green) – related gear down and locked.

Note: Landing gear warning horn is deactivated with all gear down and locked.

Extinguished – landing gear is not down and locked.

3 LANDING GEAR Lever

UP – landing gear retract.

OFF – hydraulic pressure is removed from landing gear system.

DN – landing gear extend.

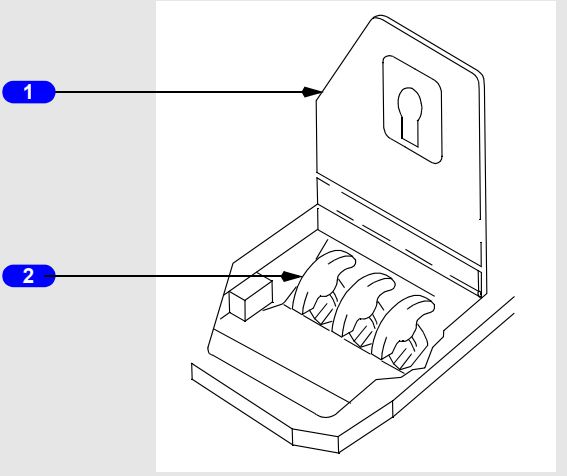
4 Override Trigger

Allows LANDING GEAR lever to be raised, bypassing lever lock.

5 LANDING GEAR LIMIT Speed Placard

Indicates maximum speed while operating landing gear and after gear extension.

Manual Gear Extension



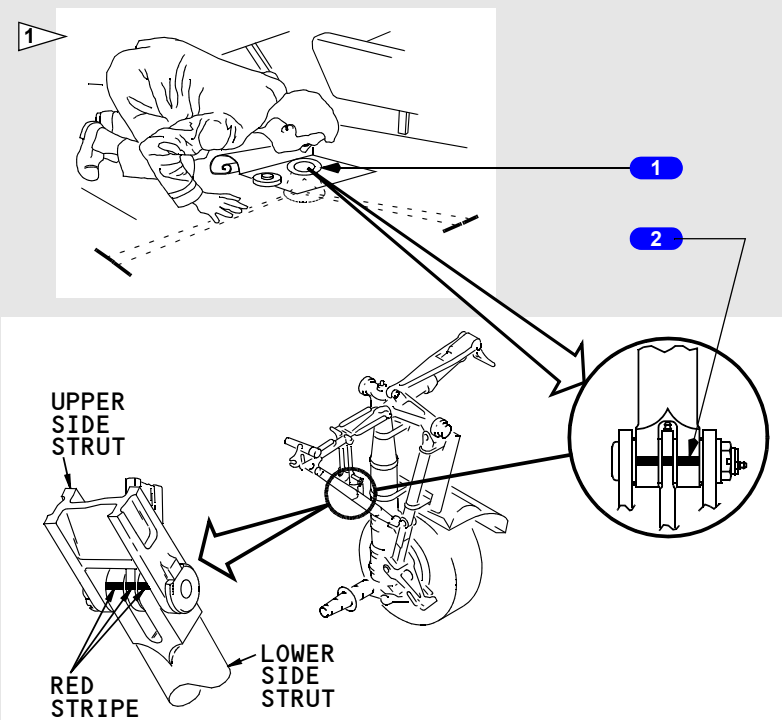
FLIGHT DECK FLOOR

1 **Manual Extension Access Door**

2 **Manual Gear Extension Handles**

Right main, nose, left main– With LANDING GEAR lever in the OFF position, each landing gear uplock is released when related handle is pulled to its limit, approximately 18 inches (45 cm) for the main gear, approximately 8 inches (20 cm) for the nose gear.

Main Gear Viewer



1 Passenger Airplanes only

PASSENGER CABIN FLOOR and MAIN LANDING GEAR

1 **Main Gear Viewer Access (Passenger airplanes only)**

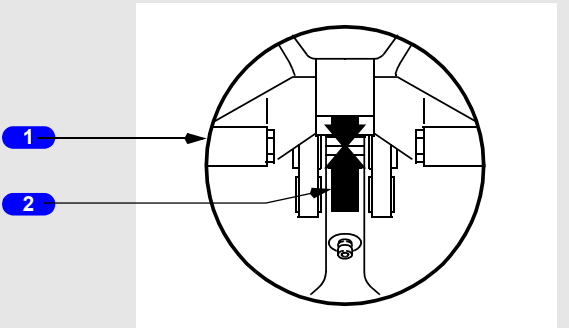
Opposite the 3rd window behind the aft overwing exit and one foot left of center. Pull up the carpet identified by a metal button to sight through viewer. Before leaving the cockpit, position the WHEEL WELL light switch ON.

Note: In some installations viewer may be under the aisle seat.

2 Paint Stripes (red)

Indication that the landing gear is down and locked is provided by observing the alignment of red paint stripes, located on the down lock and the side struts.

Nose Gear Viewer



FLIGHT DECK FLOOR

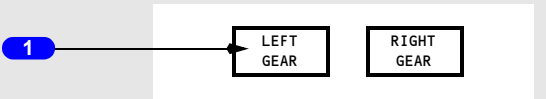
1 Viewer Access –

Cover plate for the nose landing gear viewer is located on the floor just inside the cockpit door. The WHEEL WELL light switch must be ON.

2 Arrow Head (red) –

Indication that the nose gear is down and locked is provided by observing the two red arrow heads on the down lock strut are in contact.

Alternate Gear Safe Lights (Cargo Airplanes only)



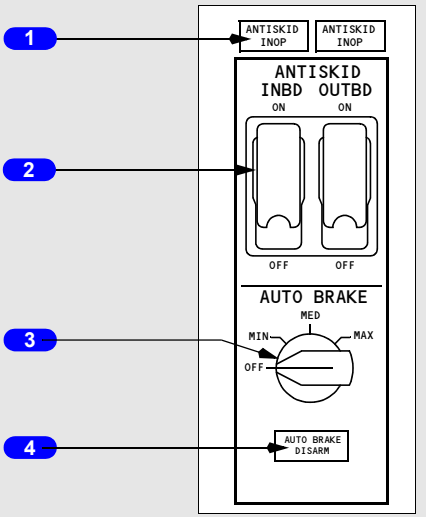
AFT OVERHEAD PANEL

1 Alternate Gear Safe Lights

Illuminated (green) – provides alternate indication that the main gear is down and locked

Extinguished – main gear is not down and locked.

Autobrake and Antiskid Controls



CENTER INSTRUMENT PANEL

1 Antiskid Inoperative (ANTISKID INOP) Light

Illuminated (amber) – a system fault is detected by antiskid monitoring system.

Extinguished – antiskid system operating normally.

2 ANTISKID Control Switch

ON – guarded position.

OFF – turns off antiskid system to respective wheels and illuminates respective ANTISKID INOP light.

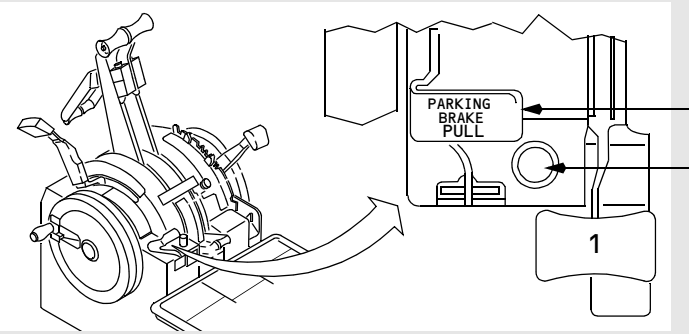
3 AUTO BRAKE Select Switch

Used to select the level of desired braking. The switch must be pulled out to select MAX deceleration.

4 AUTO BRAKE DISARM Light

Illuminated (amber) – a malfunction exists in the automatic braking system.

Parking Brake



CONTROL STAND

1 PARKING BRAKE Lever

Forward – parking brake is released.

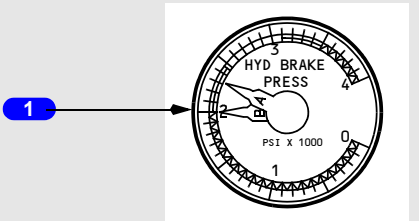
Aft – sets parking brakes when either Captain's or First Officer's brake pedals are fully depressed.

2 Parking Brake Warning Light

Illuminated (red) – parking brake is set (lights operate from battery power).

Extinguished – parking brake is released.

Hydraulic Brake Pressure Indicator



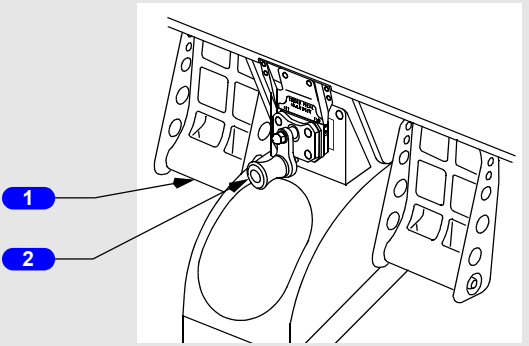
FIRST OFFICER'S INSTRUMENT PANEL

1 Hydraulic (HYD) BRAKE Pressure (PRESS) Indicator

Indicates system A and B brake system pressure:

- normal pressure – 3000 psi
- normal precharge – 1000 psi.

Rudder/Brake Pedals



CREW STATION

1 Rudder/Brake Pedals

Push full pedal – turns nose wheel up to 7 degrees in either direction.

Push top of pedal only – activates wheel brakes.

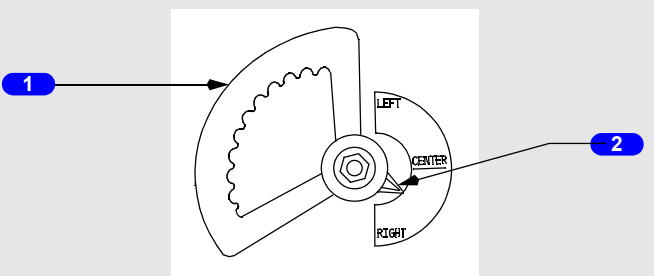
Refer to Chapter 9 Flight Controls for rudder description.

2 RUDDER PEDAL ADJUSTMENT Crank

AFT (counter–clockwise) – adjusts rudder pedals aft.

FWD (clockwise) – adjusts rudder pedals forward.

Nose Wheel Steering Wheel



CAPTAIN'S SIDE PANEL

1 Nose Wheel Steering Wheel

Rotate –

- turns nose wheel up to 78 degrees in either direction
- overrides rudder pedal steering.

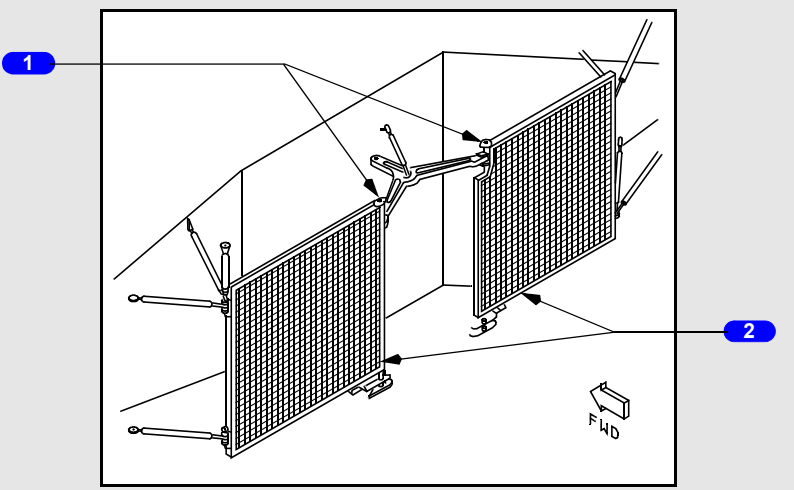
2 Nose Wheel Steering Indicator

LEFT – indicates nose wheel steering displacement left of center position.

CENTER – normal straight ahead position.

RIGHT – indicates nose wheel steering displacement right of center position.

Tire Screens



WHEEL WELL

FORWARD OVERHEAD PANEL

1 Screen Locking Pins

If unlocked, will cause illumination of the Tire Screen light.

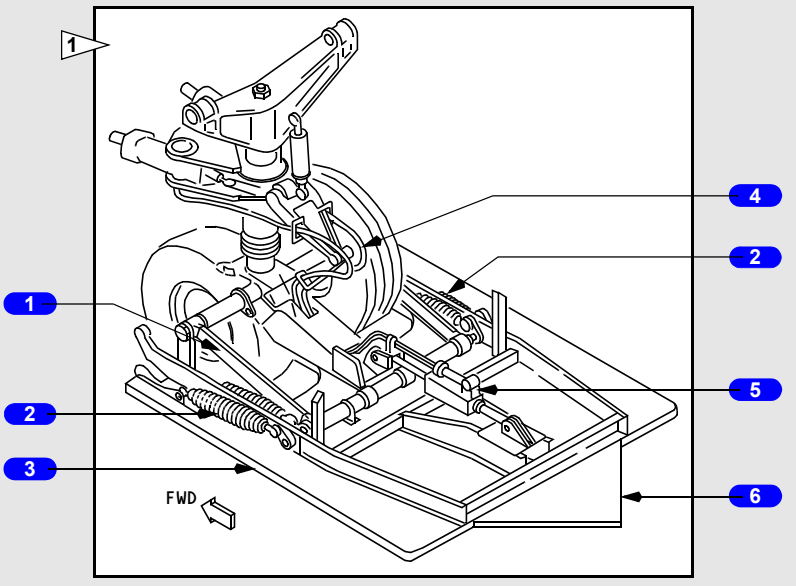
2 Tire Screen

Provides protection for critical hydraulic and flight control equipment in the event of tire burst upon landing gear retraction.

3 TIRE SCREEN Light

Illuminated (amber) – indication that the tire screens are not secure.

Nose Gear Gravel Deflector



NOSE WHEEL

1 Side Brace

2 Tension Spring

3 Airfoil (Typical)

4 Hydraulic Lines

5 Hydraulic Actuator

6 Deflector Shield

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Introduction

The airplane has two main landing gear and a single nose gear. Each main gear is a conventional two–wheel landing gear. The nose gear is a conventional steerable two–wheel unit.

Hydraulic power for retraction, extension, and nose wheel steering is normally supplied by hydraulic system A. A manual landing gear extension system is provided.

Normally, brakes are powered by hydraulic systems A and B. Antiskid protection is provided on all brakes. When autobrakes are selected, pressure is automatically applied in conjunction with the antiskid system.

Landing Gear Operation

The landing gear are normally controlled by the LANDING GEAR lever. On the ground, a landing gear lever lock prevents the LANDING GEAR lever from moving to the up position. An override trigger in the lever may be used to bypass the landing gear lever lock. In flight, the air/ground system energizes a solenoid which opens the lever lock.

Landing Gear Retraction

When the LANDING GEAR lever is moved to UP, the landing gear begins to retract. During retraction, the brakes automatically stop rotation of the main gear wheels. After retraction, the main gear are held in place by mechanical uplocks. Rubber seals and oversized hubcaps complete the fairing of the outboard wheels.

The nose wheels retract forward into the wheel well and nose wheel rotation is stopped by snubbers. The nose gear is held in place by an overcenter lock and enclosed by doors which are mechanically linked to the nose gear

Hydraulic pressure is removed from the landing gear system with the LANDING GEAR lever in the OFF position.

Landing Gear Extension

When the LANDING GEAR lever is moved to DN, hydraulic system A pressure is used to release the uplocks. The landing gear extends by hydraulic pressure, gravity and air loads. Overcenter mechanical and hydraulic locks hold the gear at full extension. The nose wheel doors stay open when the gear is down.

Landing Gear Manual Extension

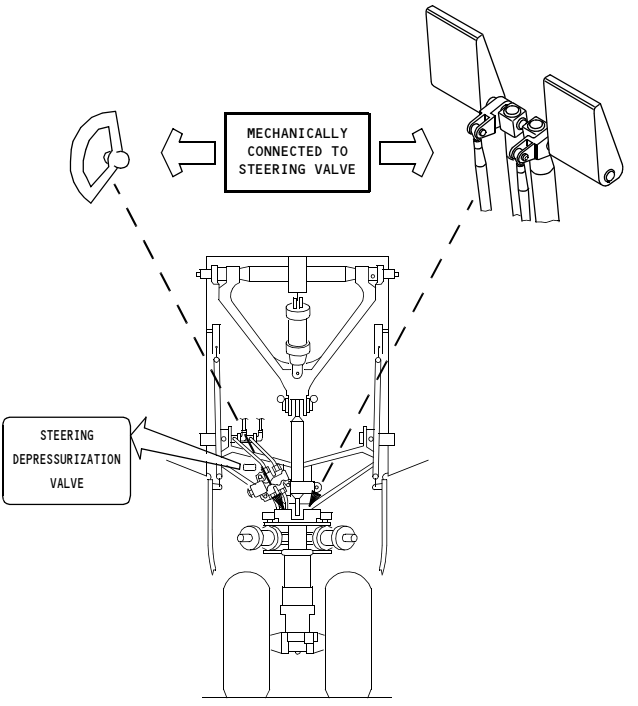
If hydraulic system A pressure is lost, the manual extension system provides another means of landing gear extension. Manual gear releases on the flight deck are used to release uplocks that allow the gear to free–fall to the down and locked position. The forces that pull the gear down are gravity and air loads.

Nose Wheel Steering

The airplane is equipped with nose wheel steering which is powered by hydraulic system A. Nose wheel steering is operative only when hydraulic system A is pressurized and the landing gear lever is in the down position.

Primary steering is controlled through the nose wheel steering wheel. Limited steering control is available through the rudder pedals. A pointer on the nose steering wheel assembly shows nose wheel steering position relative to the neutral setting. Rudder pedal steering is deactivated as the nose gear strut extends.

A lockout pin may be installed in the towing lever to depressurize nose wheel steering. This allows airplane pushback or towing without depressurizing the hydraulic system.



NOSE WHEEL STEERING

Nose Gear Gravel Deflector (As Installed)

The gravel deflector shield prevents engine gravel ingestion and reduces damage to the underside of the airplane. The deflector consists of a plywood sheet faced with corrosion resistant steel, a hydraulic actuator and four springs. The hydraulic actuator is supplied by hydraulic system A and functions to keep the deflector streamlined during gear retraction or extension.

The deflector shield covers the forward portion of the nose wheel well when the gear is retracted; the remaining portion is enclosed by clamshell doors mechanically linked to the nose gear. The four tension springs hold the deflector in the proper position during gear transit in the event that system A pressure is not available. The deflector is in effect an airfoil.

In the event that manual extension is required, the airspeed must be restricted to 150 knots for extension and 180 knots for gear-extended operation to insure that the springs maintain the deflector in the desired position.

The nose gear spray pattern is directly affected by taxi speed, runway condition and use of nose wheel steering. Under normal conditions, spray patterns become inherently safer as speed increases, deep ruts or soft gravel increase the nose gear spray, and large nose wheel steering inputs aggravate spray patterns.

Tire Burst Protection

The tire screens provide protection for critical hydraulic and flight control equipment in the event of tire burst when the main landing gear is retracted.

The TIRE SCREEN light monitors the screen locking pins in the wheel well.

Illumination of the TIRE SCREEN amber caution light activates the DOORS system annunciator and MASTER CAUTION lights on the light shield, indicating the screens are not secure. Pushing either MASTER CAUTION light to RESET extinguishes the DOORS annunciator and MASTER CAUTION lights. The TIRE SCREEN amber caution light remains illuminated until the fault is cleared.

CAUTION: If the tire screen light is illuminated and the cause is a tire burst screen not secure, equipment damage could result when the gear is retracted.

Brake System

Each main gear wheel has a multi–disc hydraulic powered brake. The brake pedals provide independent control of the left and right brakes. The brakes are powered by the two independent hydraulic systems. Hydraulic system A supplies pressure to the inboard brakes and hydraulic system B supplies pressure to the outboard brakes. The nose wheels have no brakes. The brake system includes:

- brake accumulator
- antiskid protection
- autobrake system
- parking brake

Brake Accumulators

Each brake system has an accumulator which stores hydraulic pressure and is used as a backup system in the event of a system hydraulic failure. If normal system pressure is lost, trapped hydraulic pressure in the brake accumulator can still provide several braking applications or parking brake application.

Antiskid Protection

The brake system provides each main gear wheel with individual antiskid protection. The ANTISKID control switches control power to the antiskid controllers. When the system detects a skid, the associated antiskid valve modulates brake pressure until skidding stops. The antiskid system also provides locked wheel, touchdown, and hydroplane protection.

An ANTISKID INOP light illuminates anytime there is a system malfunction. Both ANTISKID INOP lights illuminated indicates there is a disagreement between the PARKING BRAKE lever position and the parking brake shutoff valve position.

Antiskid protection is available even with loss of hydraulic pressure.

Autobrake System

The autobrake system uses hydraulic system B pressure to provide automatic braking at preselected deceleration rates immediately after touchdown. The system operates only when the normal brake system is functioning. Antiskid system protection is provided during autobrake operation.

Landing

The digital autobrake system arms for landing when:

- air/ground safety sensor is in the flight mode
- ANTISKID control switches are ON
- AUTO BRAKE selector switch is positioned to MIN, MED, or MAX.

Three levels of deceleration can be selected for landing. However, on dry runways, the maximum autobrake deceleration rate in the landing mode is less than that produced by full pedal braking.

After landing, autobrake application begins when:

- both Thrust Levers are retarded to near IDLE, and
- the main wheels spin–up.

To maintain the selected landing deceleration rate, autobrake pressure is reduced as reverser thrust is applied. The total deceleration of reverse thrust and braking is equal to the selected deceleration rate. The autobrake system brings the airplane to a complete stop unless the braking is terminated by the pilot.

Autobrake – Disarm

The pilots may disarm the autobrake system by moving the selector switch to the OFF position. This action does not cause the AUTO BRAKE DISARM light to illuminate. After braking has started, any of the following pilot actions disarm the system immediately and illuminate the AUTO BRAKE DISARM light:

- moving the SPEED BRAKE lever to the down detent
- advancing the Thrust Levers (as for go-around), or
- applying manual brakes.

Parking Brake

The parking brake is set by depressing both brake pedals, pulling the PARKING BRAKE lever back, then releasing the pedals. This mechanically latches the pedals in the depressed position and commands the parking brake valve to close.

The parking brake is released by depressing the pedals until the PARKING BRAKE lever releases. A fault in the parking brake system may cause the ANTISKID INOP lights to illuminate.

Air/Ground System

In–flight and ground operation of various airplane systems are controlled by the air/ground system.

The system receives air/ground logic signals from sensors located on the right main gear and on some airplanes on the nose gear. These signals are used to configure the airplane systems to the appropriate air or ground status.

Air/Ground System Logic Table

SYSTEMS	NORMAL INFLIGHT OPERATION	NORMAL ON GROUND OPERATION	REFER TO CH
Main Cargo Door (as installed)	Electric door control inoperative.	Door system control fully operative.	1
Control Cabin Fan	Does not operate	Operates whenever only one air conditioning pack is operating.	2
Pressurization	Allows programmed pressurization in the standby and automatic modes.	Allows pressurization on the ground as determined by the FLT/GRD switch.	2
Ram Air	Turbofan(s) operate only when air conditioning packs operate and flaps are not up.	Turbofans operate whenever air conditioning packs operate. Deflectors are extended.	2
Wing Anti–ice (As Installed)	Control valves open when switch is ON.	Control valves do not open except during ground test.	3
Wing Anti–ice Ground Operating System (As Installed)	Control valves open when switch is ON. Thrust setting and duct temperature logic are bypassed.	With switch ON, valves cycle open and closed. Switch trips to OFF at lift-off.	3
Voice Recorder	Prevents tape erasure.	Allows tape erasure when parking brake is set.	5
Standby Inverter	Automatically activated if either AC transfer bus No. 1 or DC bus No. 1 is lost.	Automatic operation disabled.	6

SYSTEMS	NORMAL INFLIGHT OPERATION	NORMAL ON GROUND OPERATION	REFER TO CH
APU Control	APU operation possible with battery switch OFF.	APU shutdown if battery switch is positioned OFF.	7
APU Generator	May be connected to only one generator.	May be connected to two generator buses.	7
Thrust Reverser	Deflector deployment prevented if override is not used.	Deflector doors may be deployed.	7
Vortex Dissipator (as installed)	ON position disabled.	ON position enabled.	7
APU Fire Horn	Wheel well horn disabled.	Wheel well horn enabled.	8
Speed Brake Lever Actuator	Can be armed to raise ground spoilers for landing.	Activates SPEED BRAKE lever on landing if armed. Rejected take–off feature available. Drives to DOWN when thrust lever advanced.	9
Flight Recorder	Operates anytime electric power is available.	Operates anytime electric power is available and either engine is operating.	10
Hydraulic Ground Interconnect	System disabled.	System enables when parking brake is set.	13
Antiskid	Releases normal brakes for touchdown protection.	Allows normal antiskid braking after wheel spin–up.	14
Autobrakes	Allows selection of landing mode.		14
Landing Gear Lever Lock	Lever Lock solenoid released.	Lever Lock solenoid latched.	14
Stall Warning	Enabled.	Disabled.	15
Takeoff Warning	Disabled.	Enabled.	15

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Warning Systems
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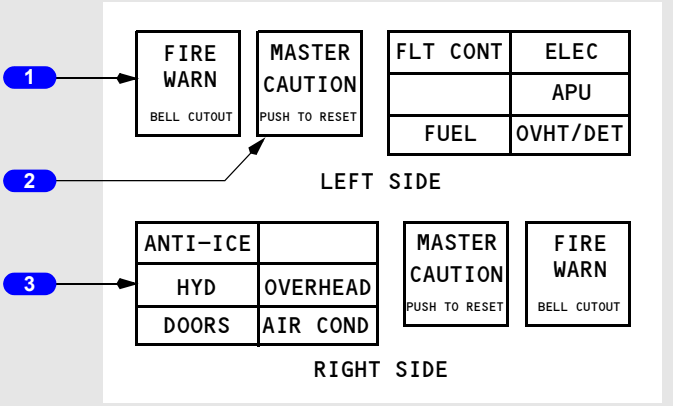
Fire Warning and Master Caution System



LIGHT SHIELD

1 FIRE WARN Lights

Illuminated (red) – indicates a fire warning (or system test) in engine, APU or main gear wheel well

- fire warning bell sounds
- if on ground, remote APU fire warning horn sounds.

Push – extinguishes both master FIRE WARN lights

- silences fire warning bell
- silences remote APU fire warning horn
- resets system for additional warnings.

Note: Pushing fire warning bell cutout switch on overheat/fire protection panel results in same actions.

2 MASTER CAUTION Lights

Illuminated (amber) – a system annunciator light has illuminated.

Push – extinguishes both MASTER CAUTION lights

- system annunciator light(s) extinguish
- resets system for additional master caution conditions.

3 System Annunciator Panel

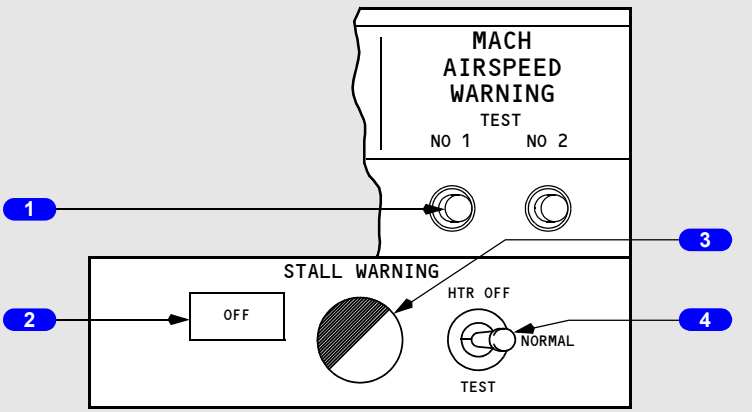
Illuminated (amber) – an amber light, relating to illuminated system annunciator, has illuminated on forward overhead, aft overhead or overheat/fire protection panel.

To extinguish – push either MASTER CAUTION light.

To recall – push and release either System Annunciator Panel

- if a master caution condition exists, appropriate system annunciator(s) and MASTER CAUTION lights illuminate.

Mach/Airspeed Warning and Stall Warning Test Switches



AFT OVERHEAD PANEL

1 MACH AIRSPEED WARNING TEST Switch

Push –Tests respective Mach/Airspeed warning system

- clacker sounds
- inhibited while airborne.

2 STALL WARNING OFF Light

Illuminated (amber)– indicates a failure of the angle airflow sensor heater, a system signal failure, or a power failure.

3 TEST INDICATOR

Rotating – indicates electrical continuity through the angle airflow sensor and flap position transmitter during TEST.

4 STALL WARNING SWITCH

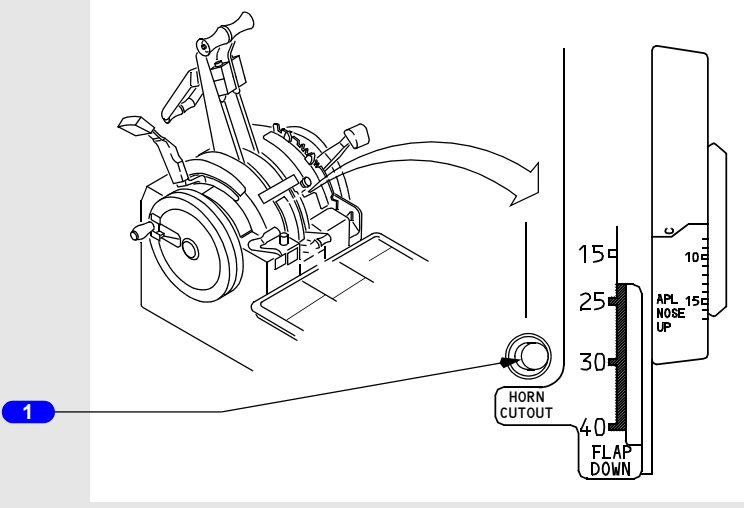
Normal – heater power for the angle airflow sensor is available only if engine 1 is operating or the air ground safety sensor is in the air mode.

Test – with engine 1 not operating: OFF light extinguishes, Test Indicator rotates, and the control columns vibrate.

– with engine 1 operating: OFF light remains extinguished, Test Indicator rotates, and the control columns vibrate.

HTR OFF (Heater Off) – locked toggle position--for maintenance checks only.

Landing Gear Warning Cutout Switch



CONTROL STAND

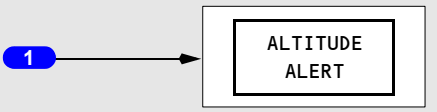
1 Landing Gear Warning Cutout Switch

Push – silences landing gear configuration warning aural indication:

- at flaps 1 through 10
- at flaps 15 or 25, when either forward thrust lever is between idle and approximately 10° and opposite forward thrust lever is greater than approximately 30°.

Note: Aural indication cannot be silenced with cutout switch at flaps greater than 25.

Altitude Alert

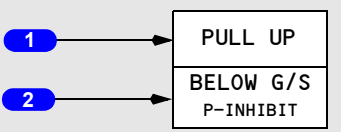


CAPT INST PANEL
F/O INST PANEL

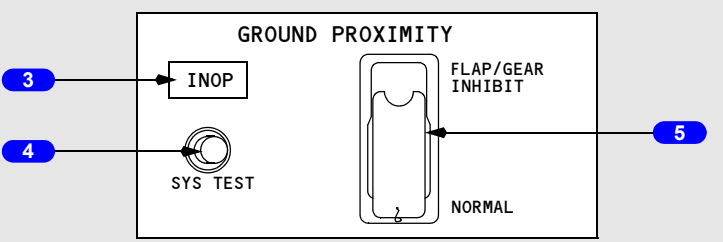
1 ALTITUDE ALERT Annunciation

Illuminated (amber) – Airplane is within the range of 1000 to 375 feet of the selected altitude.

GPWS Controls and Indicators



CAPT AND F/O INST PANELS



FIRST OFFICER'S INSTRUMENT PANEL

1 PULL UP WARNING LIGHT

Illuminated (red) – indicates one or more of the following exist:

- excessive descent rate
- excessive terrain closure rate
- altitude loss after takeoff or go–around
- unsafe terrain clearance when not in the landing configuration

2 BELOW Glide Slope (G/S) Alert Light

Illuminated (amber) – airplane is more than 1.3 dots below glide slope.

Push – inhibits or cancels below glide slope alerting if pushed while in alerting area

3 GPWS Inoperative (INOP) Light

Illuminated (amber) – GPWS computer malfunction or power loss

- invalid inputs are being received from the VHF NAV receiver, ADC, or radio altimeter.

4 Ground Proximity System (SYS TEST) Switch

Push –

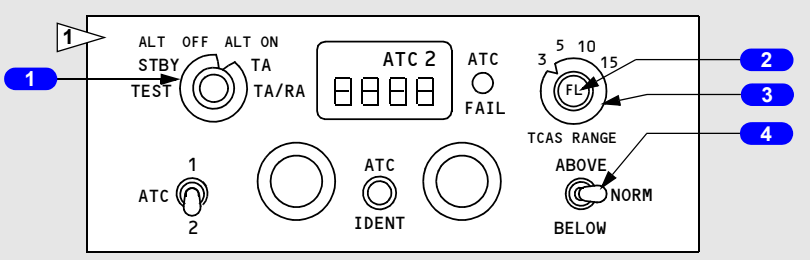
- momentarily on ground--with landing gear not in landing configuration--or above 1,000 feet radio altitude in flight--with gear up and flaps in any configuration:
  - illuminates BELOW G/S, PULL UP and INOP lights, and causes the "GLIDE SLOPE" and "WHOOP, WHOOP, PULL UP" aurals to sound
- at least 10 seconds, on ground – above indications always occur first, followed by any additional aurals, as installed
- system test is inhibited from lift–off to 1000 feet radio altitude.

5 Ground Proximity FLAP/GEAR Inhibit Switch

FLAP/GEAR INHIBIT – inhibits or cancels warnings/alerts caused by flaps not in 30 or 40 position or landing gear not down.

NORMAL (guarded position) – flap and landing gear position logic is provided for GPWS.

Transponder Panel (TCAS)



AFT ELECTRONIC PANEL

1 As installed

1 Transponder Mode Selector

TEST – tests transponder units.

STBY – disables transponder modes.

Note: Transponder modes are enabled only when airplane is airborne except for Mode S, which operates continuously when the Transponder Mode Selector is out of STBY.

ALT OFF – deactivates altitude reporting.

ALT ON – transponder operates with altitude reporting.

TA – enables display of Traffic Advisory TCAS targets.

TA/RA – enables display of Traffic Advisory and Resolution Advisory TCAS targets.

2 Absolute Altitude Display Selector

Press – displays absolute altitudes of TCAS targets for 15 seconds.

3 TCAS Range Switch

Selects range for TCAS display when weather radar is operating in TCAS mode only.

4 Altitude Range Switch

Allows shifting of TCAS coverage up and down from baseline:

- ABOVE – sets TCAS display at upper elevation limit.
- NORM – sets TCAS display for normal limit.
- BELOW – sets TCAS display at lower elevation limit.

Introduction

Aural, tactile and visual warning signals alert the flight crew to conditions requiring action or caution in the operation of the airplane. The character of the signals varies, depending upon the degree of urgency or types of hazards involved. Aural, tactile, and visual signals are used singularly or in combination to simultaneously provide both warnings and information regarding the nature of the condition.

Mach/airspeed warnings, landing gear warnings, takeoff configuration warnings, windshear warnings, and ground proximity warnings are discussed in this section. Cabin altitude warning is discussed in this section and in the Air Systems chapter, and autopilot and autothrottle disconnect warnings are discussed in the Automatic Flight chapter. The conditions which excite the fire warning bell are discussed in the Fire Protection chapter.

Conditions which require the immediate attention of the flight crew are indicated by red warning lights located in the area of the pilots' primary field of vision. These lights indicate APU, engine, or wheel well fires; autopilot and unsafe landing gear conditions.

Conditions which require the timely attention of the flight crew are indicated by amber caution lights.

Blue lights inform the flight crew of electrical power availability, valve position, equipment status, and flight attendant or ground communications. Blue lights are for information and do not require immediate flight crew attention. Some system blue lights indicate a transitional state by illuminating bright as valves or components reposition, then returning to a dim blue when the required configuration is reached.

Green lights indicate a fully extended configuration, e.g., landing gear and leading edge devices.

For specific information regarding red, amber, blue, and green lights refer to the appropriate systems chapters.

Stall warning is provided by a control column shaker on the captain's control column, or--as installed--on each control column.

Various aural signals call attention to warnings and cautions. An aural warning for airspeed limits is given by a clacker, the autopilot disconnect by a warning tone, takeoff configuration and cabin altitude by an intermittent horn, and landing gear positions by a steady horn. The fire warning is given by a fire warning bell. Ground proximity warnings and alerts--as well as windshear warnings and alerts--are given by voice warnings.

Generally, aurals automatically silence when the associated non–normal condition no longer exists.

Master Fire Warning Lights

Two master FIRE WARN lights illuminate when any fire warning condition occurs. The lights remain illuminated as long as the condition exists. Pushing either master FIRE WARN light or fire warning bell cutout switch extinguishes both lights, silences the fire warning bell and resets the system for future warnings. Further information appears in the Fire Protection chapter.

Master Caution Lights

Two MASTER CAUTION lights illuminate when any caution occurs outside the normal field of vision of the flight crew. The lights remain illuminated as long as the caution condition exists, or until the crew resets the system. Pushing either MASTER CAUTION light extinguishes both lights and resets the master caution system for further cautions. Pushing either annunciator light panel recalls all existing fault annunciations.

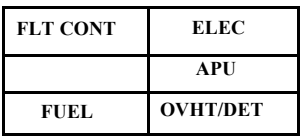
A single fault in certain redundant systems--or some simple faults--do not illuminate the MASTER CAUTION or system annunciator lights. These faults, however, are stored in the master caution system. Pushing the system annunciator recalls the single fault on the system annunciator panel.

System Annunciator Lights

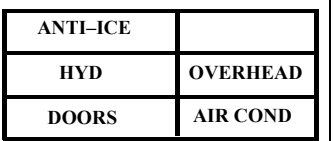
Two system annunciator light panels are located on the glare shield. The annunciator light panels include only those systems located on the forward overhead, aft overhead, and fire control panels. If a caution condition exists, the appropriate system annunciator(s) and MASTER CAUTION lights illuminate.

When MASTER CAUTION recall is pressed, all twelve system lights should illuminate while the press-to-test feature is held. If a system annunciator light does not illuminate, refer to the dispatch deviation procedures guide (DDPG).

System Annunciators and Related Amber Lights – Left Side

FLT CONT FEEL DIFF PRESS LOW PRESSURE LOW QUANTITY MACH TRIM FAIL YAW DAMPER	 LEFT SIDE LIGHT SHIELD	ELEC BUS OFF HIGH OIL TEMP LOW OIL PRESSURE STANDBY PWR OFF TRANSFER BUS OFF
		APU HIGH OIL TEMP LOW OIL PRESSURE OVERSPEED
FUEL FILTER ICING LOW PRESSURE		OVHT/DET ENGINE 1 OVERHEAT ENGINE 2 OVERHEAT APU DET INOP

System Annunciators and Related Amber Lights – Right Side

ANTI–ICE WINDOW OVERHEAT PITOT HEAT		
HYD OVERHEAT LOW PRESSURE	 RIGHT SIDE LIGHT SHIELD	OVERHEAD EMER EXIT LIGHTS–NOT ARMED EQUIP COOLING–OFF FLIGHT RECORDER–OFF ISOLATION VALVE–THRUST REVERSER PASS OXY–ON STALL WARNING–OFF
DOORS EQUIP FWD/AFT ENTRY FWD/AFT CARGO FWD/AFT SERVICE AIRSTAIR TIRE SCREEN		AIR COND DUCT OVERHEAT DUAL BLEED PACK TRIP OFF WING–BODY OVERHEAT BLEED TRIP OFF AUTO FAIL OFF SCHED DESCENT

Warning Systems

Intermittent Cabin Altitude/Configuration Warning

The takeoff configuration warning is armed when the airplane is on the ground and either or both forward thrust levers are advanced for takeoff. An intermittent warning horn sounds if:

- Leading Edge devices are NOT configured for takeoff, or
- Speed Brake lever is NOT in the DOWN position, or

- Stabilizer Trim is NOT set in the takeoff range, or
- Trailing Edge flaps are NOT in the flaps 1 through 25 takeoff range.

The warning indication is cancelled when the configuration error is corrected.

The Cabin Altitude Warning Horn activates when cabin altitude exceeds 10,000 feet. An intermittent warning horn is heard. The Cabin Altitude Warning Horn may be silenced by momentarily pressing the ALT HORN CUTOUT switch on the Cabin Altitude Panel.

Landing Gear Configuration Warnings

Visual indications and aural warnings of landing gear position are provided by the landing gear indicator lights and landing gear warning horn.

Visual Indications

The landing gear indication lights are activated by signals from each gear, the LANDING GEAR lever, and the forward thrust lever position as follows:

Green light illuminated – landing gear is down and locked.

Red light illuminated –

- landing gear is in disagreement with LANDING GEAR lever position (in transit or unsafe).
- landing gear is not down and locked (with either or both forward thrust levers retarded to idle).

All lights extinguished – landing gear is up and locked with the LANDING GEAR lever UP or OFF.

Aural Indications

A steady warning horn is provided to alert the flight crew whenever the airplane is in a landing configuration and any gear is not down and locked. The landing gear warning horn is activated by forward thrust lever and flap position as follows:

Flaps 1 through 10–

- with either or both forward thrust levers between idle and approximately 10 degrees thrust lever angle, the landing gear warning horn can be silenced (reset) with the landing gear warning HORN CUTOUT switch.

Flaps 15 or 25–

- with either--but not both--forward thrust lever retarded to idle, the landing gear warning horn can be silenced (reset) with the landing gear warning HORN CUTOUT switch.
- with both forward thrust levers set below approximately 30 degrees, the landing gear warning horn cannot be silenced with the landing gear warning HORN CUTOUT switch.

Flaps greater than 25–

- regardless of forward thrust lever position, the landing gear warning horn cannot be silenced with the landing gear warning HORN CUTOUT switch.

The warning indication is cancelled when the configuration error is corrected.

Mach/Airspeed Warning System

Two independent Mach/airspeed warning systems provide a distinct aural warning--a clacking sound--any time the maximum operating airspeed of Vmo/Mmo is exceeded. Each system operates from a mechanism internal to the respective pilot's Mach/airspeed indicator. The warning clacker can be silenced only by reducing airspeed below Vmo/Mmo and can be tested at any time with the test switch.

Stall Warning System

Natural stall warning (buffet) usually occurs at a speed prior to stall. In some configurations the margin between stall and natural stall warning is less than desired. Therefore, an artificial stall warning device--a stick shaker--is used to provide the required warning.

The stall warning "stick shaker" consists of an eccentric, weighted motor on the captain's control column. Designed to alert the pilot before a stall develops, the warning is given by vibrating the control column. The system is armed in flight at all times. The system is deactivated on the ground.

The stall warning system consists of:

- a control column shaker,
- a heated angle of airflow sensor,
- a flap position sensor,
- a stall warning amplifier,
- an air-ground safety sensor, and
- a stall warning test panel on the aft overhead panel.

A test switch is installed in the aft overhead panel. Pushing the switch initiates a self-test of the stall warning channel.

Altitude Alerting System

Altitude alerting compares the altitude selected on the ALTITUDE ALERT CONTROLLER with the altitude shown in the captain's altimeter. Alerting consists of a two-second tone and the illumination of the ALTITUDE ALERT lights--located on the captain's and first officer's instrument panels--when 1000 feet above or below the selected altitude. The lights extinguish when 375 feet from the selected altitude.

Ground Proximity Warning System (GPWS)

WARNING: Do not deactivate the GPWS (by pulling the circuit breaker or using the inhibit switch) except for an approved procedure--where use of flaps at less-than-normal-landing-flap position, or leaving landing gear up is specified.

The GPWS provides alerts for potentially hazardous flight conditions. GPWS alerts--to the extent they are installed--are for imminent impact with the ground, detected windshear condition, excessive angle of bank, and glideslope deviation.

GPWS may also provide radio altitude and decision height callouts.

Note: GPWS does not provide alerts for flight toward vertically sheer terrain, or of shallow descents when the airplane is in landing configuration.

Alert Conditions

GPWS provides warnings and/ or alerts if one of the following conditions exists:

- excessive barometric descent rate
- excessive terrain closure rate
- altitude loss after takeoff or go–around
- unsafe terrain clearance (when not in the landing configuration)
- excessive deviation below glideslope

The GPWS alerts and the condition which causes each alert are presented on the following GPWS annunciation chart.

GPWS Annunciations

AURAL ALERT	VISUAL ALERT	DESCRIPTION
MODE 1, MK II “SINK RATE”	PULL UP lights	Excessive descent rate.
MODE 1, MK II (cont) “WHOOP WHOOP PULL UP”	PULL UP lights	Follows “SINK RATE” if sink rate becomes severe. Also follows “TERRAIN” alert if excessive terrain closure rate continues and landing gear and/or flaps not in landing configuration.
MODE 2, MK II “TERRAIN”	PULL UP lights	Excessive terrain closure rate.
MODE 3, MK II “DON’T SINK”	PULL UP lights	Excessive altitude loss after takeoff or go–around.

MODE 4A, MK II “TOO LOW GEAR” or “TOO LOW TERRAIN”	PULL UP lights	Unsafe clearance during approach with landing gear up.
MODE 4B, MK II “TOO LOW FLAPS” or “TOO LOW TERRAIN”	PULL UP lights	Unsafe clearance during approach with flaps not in landing configuration.
MODE 5, MK II “GLIDESLOPE”	BELOW G/S w/ P–INHIBIT lights	Deviation below glideslope. The volume and repetition rate increase as deviation continues.

Yaw Control Schematic (after RSEP modification) 9.20.13
Speed Brakes 9.20.14
In Flight Operation 9.20.14
Ground Operation 9.20.14
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Alternate Extension 9.20.17
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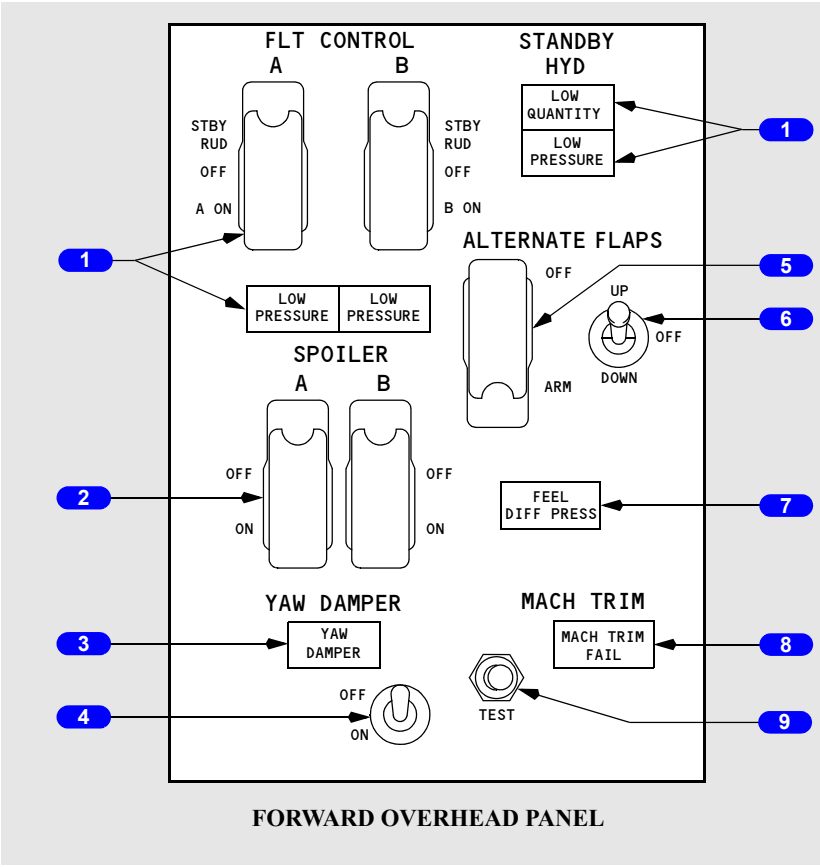
Flight Control Panel (before Rudder System Enhancement Program (RSEP) modification)



FORWARD OVERHEAD PANEL

1 Refer to Chapter 13 – Hydraulics

2 Flight SPOILER Switches (guarded to ON)

Used for maintenance purposes only.

OFF – closes the respective flight spoilers shutoff valve.

3 YAW DAMPER Light

Illuminated (amber) – yaw damper is not engaged.

4 YAW DAMPER Switch

OFF – disengages yaw damper.

ON – engages yaw damper to rudder power control unit.

5 ALTERNATE FLAPS Master Switch (guarded to OFF)

OFF – normal operating position.

ARM – closes trailing edge flap bypass valve, activates standby pump, and arms the ALTERNATE FLAPS position switch.

6 ALTERNATE FLAPS Position Switch

Functions only when the ALTERNATE FLAPS master switch is in ARM.

UP –

- electrically retracts trailing edge flaps
- leading edge devices remain extended and cannot be retracted by the alternate flaps system.

OFF – normal operating position.

DOWN (spring loaded to OFF)–

- (momentary) fully extends leading edge devices using standby hydraulic pressure
- (hold) electrically extends trailing edge flaps.

7 Feel Differential Pressure (FEEL DIFF PRESS) Light

- Armed when the trailing edge flaps are up.

Illuminated (amber) – indicates excessive differential pressure in the elevator feel computer.

8 MACH TRIM Failure (FAIL) Light

Armed when the trailing edge flaps are up.

Illuminated (amber) –

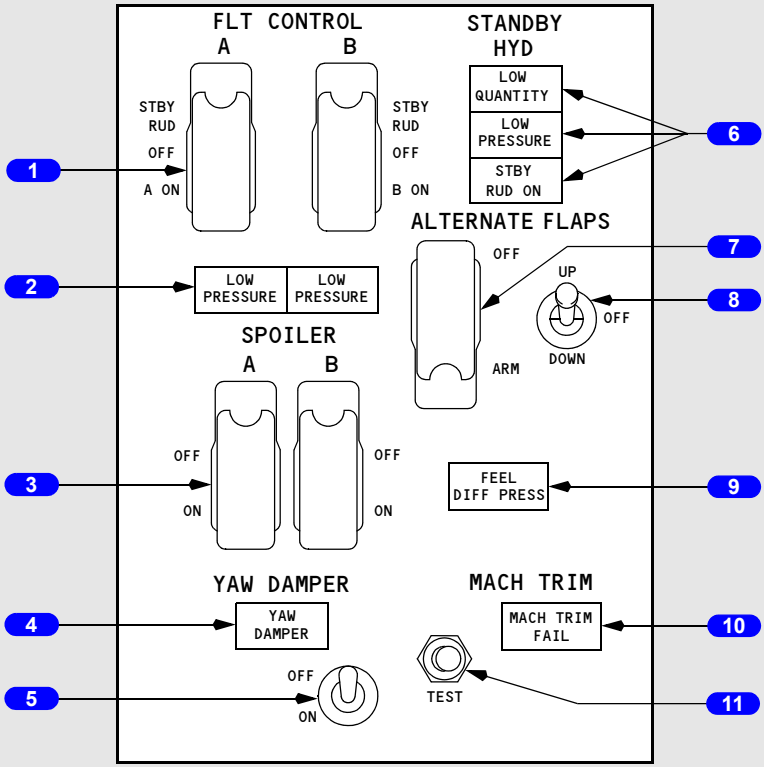
- indicates unreliable Mach Trim system or Mach Trim test in progress

9 MACH TRIM TEST switch

Press – tests Mach Trim system

- MACH TRIM FAIL light illuminates
- elevator surfaces moves up
- control column moves aft.

Flight Control Panel (after RSEP modification)



FORWARD OVERHEAD PANEL

1 FLIGHT CONTROL Switches

STBY RUD - activates standby pump, opens standby shutoff valve to pressurize standby rudder power control unit, and illuminates amber STBY RUD ON light.

OFF - closes flight control shutoff valve isolating ailerons, elevators and rudder from associated hydraulic system pressure.

ON (guarded position) - normal operating position.

2 Flight Control LOW PRESSURE Lights

Illuminated (amber) -

- indicates low hydraulic system (A or B) pressure to ailerons, elevator and rudder.
- deactivated when associated FLIGHT CONTROL switch is positioned to STBY RUD and standby rudder shutoff valve opens.
- indicates A system pressure is low when normal system pressure is commanded.

Note: The A system light will remain illuminated for approximately five seconds after A hydraulic system has been activated.

3 Flight SPOILER Switches (guarded to ON)

Used for maintenance purposes only.

OFF – closes the respective flight spoilers shutoff valve.

4 YAW DAMPER Light

Illuminated (amber) – yaw damper is not engaged.

5 YAW DAMPER Switch

OFF – disengages yaw damper.

ON – engages yaw damper to rudder power control unit.

6 STANDBY HYD Lights

STANDBY HYD LOW QUANTITY Light

Illuminated (amber) –

- indicates low quantity in standby hydraulic reservoi.r
- always armed.

STANDBY HYDRAULIC LOW PRESSURE Light

Illuminated (amber)

- indicates output pressure of standby pump is low
- armed only when standby pump operation has been selected or automatic standby function is activated.

STBY RUD ON Light

Illuminated (amber) - indicates the standby hydraulic system is commanded on to pressurize the standby rudder power control unit.

7 ALTERNATE FLAPS Master Switch (guarded to OFF)

OFF – normal operating position.

ARM – closes trailing edge flap bypass valve, activates standby pump, and arms the ALTERNATE FLAPS position switch.

8 ALTERNATE FLAPS Position Switch

Functions only when the ALTERNATE FLAPS master switch is in ARM.

UP –

- electrically retracts trailing edge flaps
- leading edge devices remain extended and cannot be retracted by the alternate flaps system.

OFF – normal operating position.

DOWN (spring loaded to OFF)–

- (momentary) fully extends leading edge devices using standby hydraulic pressure
- (hold) electrically extends trailing edge flaps.

9 Feel Differential Pressure (FEEL DIFF PRESS) Light

- Armed when the trailing edge flaps are up.

Illuminated (amber) – indicates excessive differential pressure in the elevator feel computer.

10 MACH TRIM Failure (FAIL) Light

Armed when the trailing edge flaps are up.

Illuminated (amber) –

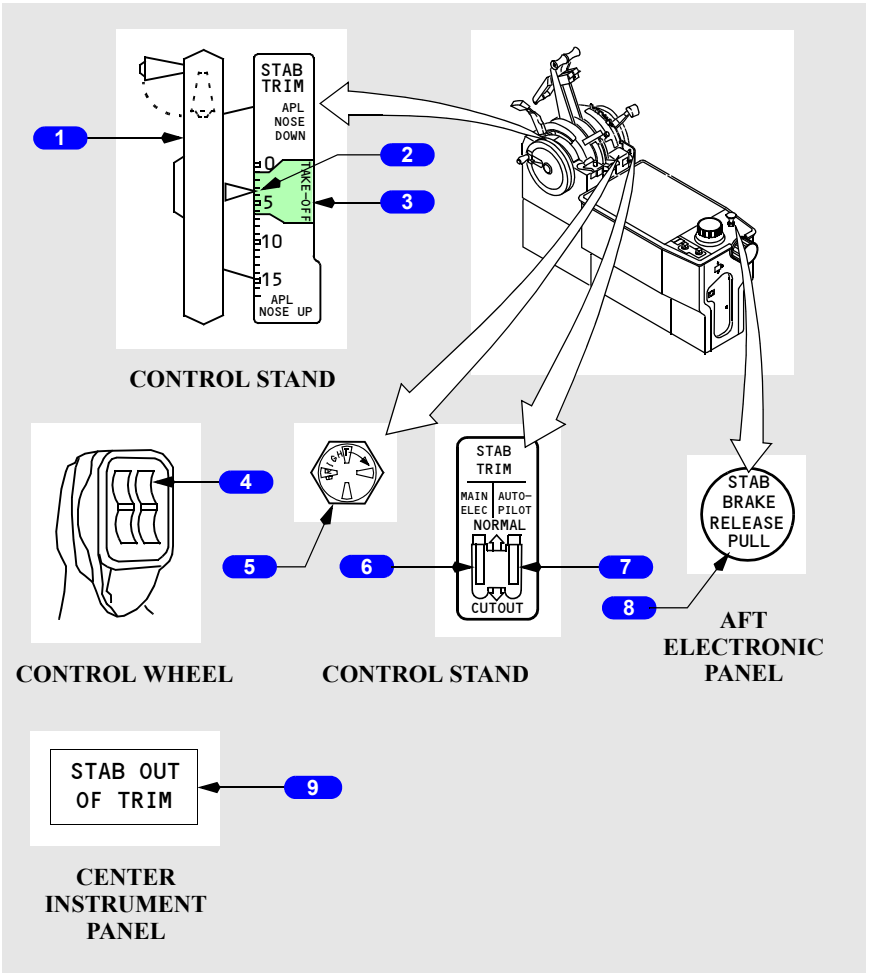
- indicates unreliable Mach Trim system or Mach Trim test in progress

11 MACH TRIM TEST switch

Press – tests Mach Trim system

- MACH TRIM FAIL light illuminates
- elevator surfaces moves up
- control column moves aft.

Stabilizer



1 Stabilizer Trim Wheel

- provides for manual operation of stabilizer
- overrides any other stabilizer trim inputs
- rotates when stabilizer is in motion.

Note: handle should be folded inside stabilizer trim wheel for normal operation

2 Stabilizer Trim Indicator

Indicates units of airplane trim on the adjacent scale.

3 Stabilizer Trim Green Band Range

Corresponds to allowable range of trim settings for takeoff.

4 Stabilizer Trim Switches (spring–loaded to neutral)

Push (both) –

- electrically commands stabilizer trim in desired direction
- autopilot disengages if engaged.

5 Stabilizer Trim Light

Illuminated (amber) – indicates main electric trim motor is operating.

6 Stabilizer Trim Main Electric (MAIN ELECT) Cutout Switch

NORMAL – normal operating position.

CUTOUT – removes power from stabilizer main electric trim motor.

7 Stabilizer Trim AUTOPILOT Cutout Switch

NORMAL – normal operating position.

CUTOUT – removes autopilot servo power to stabilizer drive.

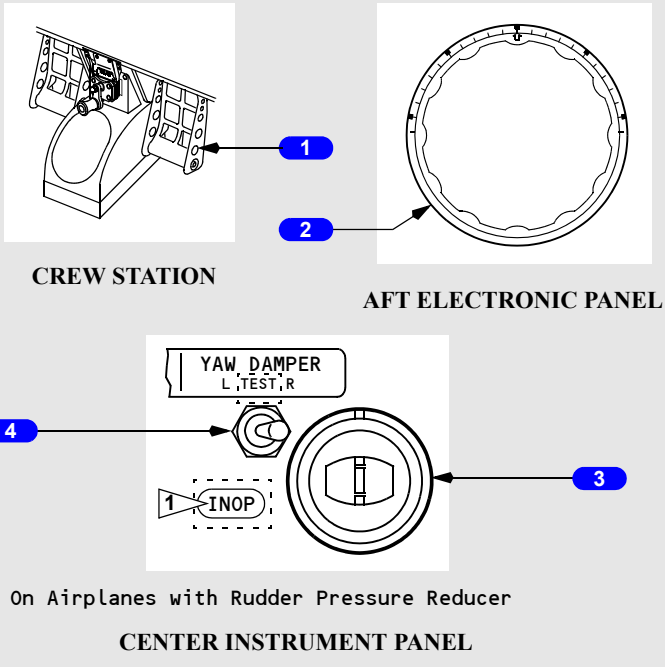
8 Stabilizer BRAKE RELEASE Knob

Pull – releases stabilizer brake.

9 STAB OUT OF TRIM Light

Refer to Chapter 4 – Automatic Flight.

Rudder



1 Rudder Pedals

Push –

- controls rudder position
- permits limited nose gear steering up to 7 degrees each side of center.

2 Rudder Trim Wheel

Rotate – repositions the rudder neutral control position.

3 YAW DAMPER Indicator

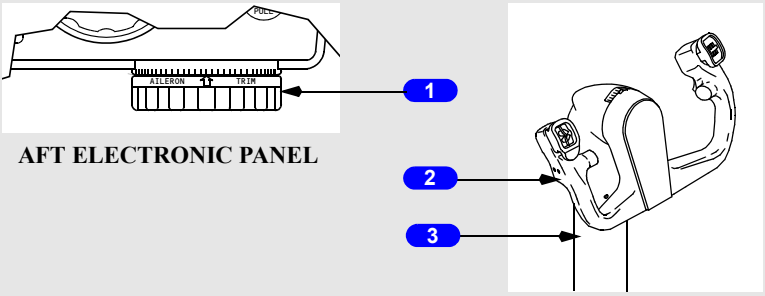
- indicates yaw damper movement of rudder due to yaw damper input on the ground, in the air and during test.
- pilot rudder pedal inputs are not indicated.

4 YAW DAMPER TEST Switch

With the yaw damper engaged and hydraulic power available:

- L – the YAW DAMPER indicator moves left; the YAW DAMPER indicator moves right when the TEST switch is released
- R – the YAW DAMPER indicator moves right, the YAW DAMPER indicator moves left when the TEST switch is released

Aileron / Elevator / Flight Spoilers



AFT ELECTRONIC PANEL

CREW STATION

1 AILERON TRIM Wheel

Rotate – repositions the aileron neutral control position.

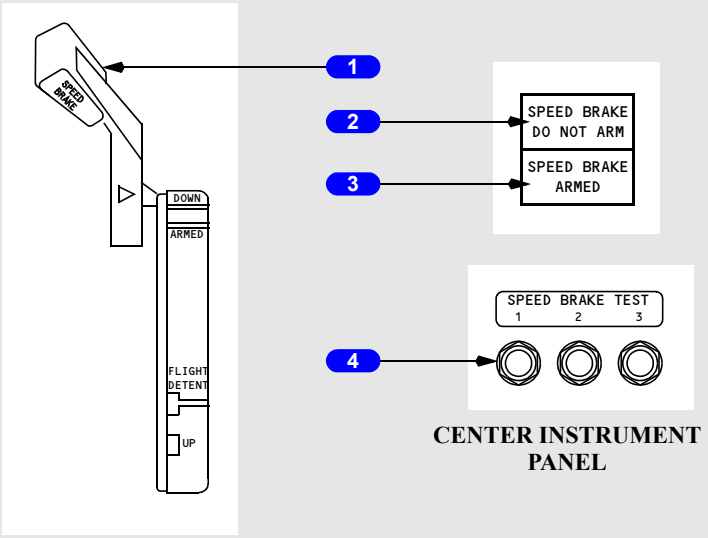
2 Control Wheel

Rotate – operates ailerons and flight spoilers in desired direction.

3 Control Column

Push/Pull – operates elevators in the desired direction. Movement opposing stabilizer trim stops electric trimming.

Speed Brakes



1 SPEED BRAKE Lever

DOWN (detent) – all flight and ground spoiler panels in faired position.

ARMED –

- automatic speed brake system armed
- upon touchdown, the SPEED BRAKE lever moves to the UP position, and all flight and ground spoilers extend.

FLIGHT DETENT – all flight spoilers are extended to their maximum position for inflight use.

UP – all flight and ground spoilers are extended to their maximum position for ground use.

2 SPEED BRAKE DO NOT ARM Light

Light deactivated when SPEED BRAKE lever is in the DOWN position.

Illuminated (amber) – indicates abnormal condition or test inputs to the automatic speed brake system.

3 SPEED BRAKE ARMED Light

Light deactivated when SPEED BRAKE lever is in the DOWN position.

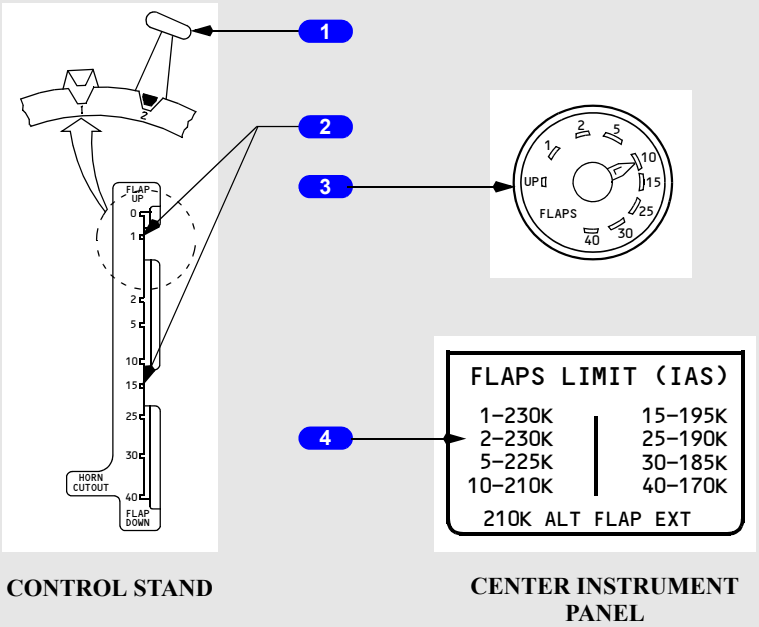
Illuminated (green) – indicates valid automatic speed brake system inputs.

4 SPEED BRAKE Test Switches

Used for maintenance purposes only.

Tests fault detection circuits of the automatic speed brake system.

Trailing Edge Flaps



CONTROL STAND

CENTER INSTRUMENT PANEL

1 Flap Lever

- selects position of flap control valve, directing hydraulic pressure for flap drive unit
- position of the leading edge devices is determined by selecting trailing edge flap position
- At flaps position 40, arms the flap load relief system, which automatically will cause flap retraction to position 30 in the event of excess airspeed.

2 Flap Gates

Prevents inadvertent flap lever movement beyond:

- position 1 – to check flap position for one engine inoperative go–around
- position 15 – to check flap position for normal go–around.

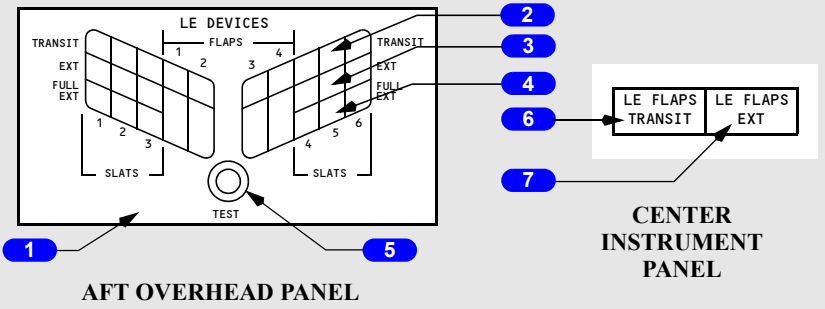
3 Flap Position Indicator

- indicates position of left and right trailing edge flaps
- provides trailing edge flaps asymmetry protection circuit.

4 FLAPS LIMIT Placard

Indicates maximum speed for each flap setting.

Leading Edge Devices



1 Leading Edge Devices (LE DEVICES) Annunciator Panel

Indicates position of individual leading edge flaps and slats.

Extinguished – corresponding leading edge device retracted.

2 Leading Edge Devices TRANSIT Lights

Illuminated (amber) – corresponding leading edge device in transit.

3 Leading Edge Devices Extended (EXT) Lights

Illuminated (green) – corresponding leading edge slat in extended (intermediate) position.

4 Leading Edge Devices FULL Extended (FULL EXT) Lights

Illuminated (green) – corresponding leading edge device in full extended position.

5 Leading Edge Annunciator Panel TEST Switch

Press – tests all annunciator panel lights.

6 Leading Edge Flaps Transit (LE FLAPS TRANSIT) Light

Illuminated (amber) – any leading edge device in transit, or not in programmed position with respect to trailing edge flaps.

7 Leading Edge Flaps Extended (LE FLAPS EXT) Light

Illuminated (green) –

- all leading edge flaps extended and all leading edge slats in extended (intermediate) position (trailing edge flap positions 1, 2 and 5)

OR:

- all leading edge devices fully extended (trailing edge flap positions 10 through 40).

Intentionally
Blank

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APU Shutdown 7.30.2
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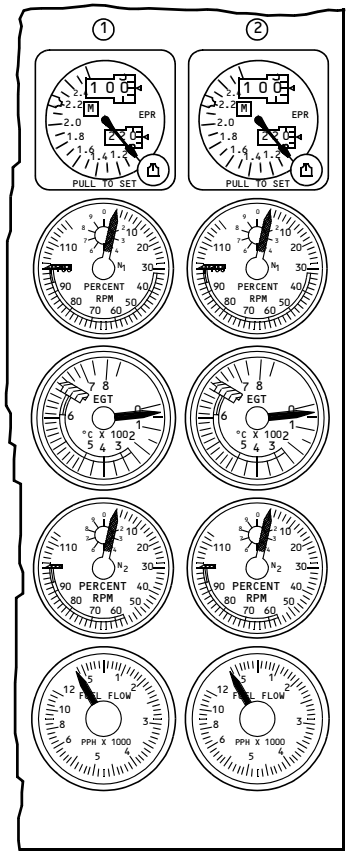
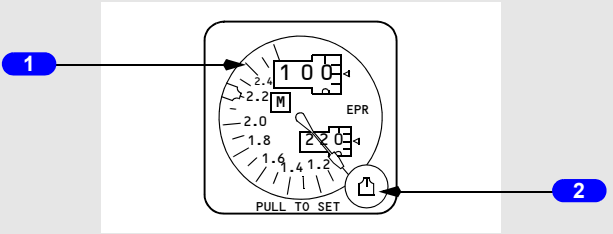
Engine Instruments Primary Panel



CENTER INSTRUMENT PANEL

Engine Pressure Ratio (EPR) Indications



1 Engine Pressure Ratio (EPR) Indicator

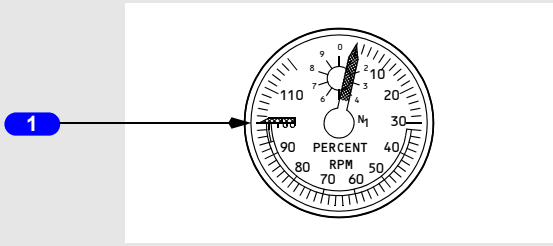
- Indicates the ratio of turbine discharge pressure (Pt7) to compressor inlet pressure (Pt2)
- Used as the primary thrust setting reference
- Provides digital display of indicated EPR; Read EPR on outer scale and in the large upper digital display for thrust settings
- Warning flag covers the indicated EPR digital display with electrical power loss or instrument failure. Failure of the PDC will result in a flag covering the lower digital window.

2 EPR Reference Selector

ROTATE – Positions the EPR reference “bug” and changes the reference EPR digital readout in the lower window correspondingly

- When the reference selector is pushed in, the lower digital window and “bug” will be set by an input signal from the PDC
- Pulling out the reference selector disconnects the PDC, and an “M” (indicating manual mode) appears on the dial face
- When pulled out, the reference selector can be rotated to set desired EPR in the lower digital window, the “bug” moves to the corresponding position on the outer scale.

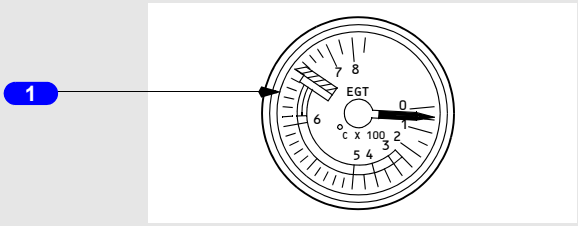
N1 Indications



1 N1 RPM Indicator

- Indicates low pressure compressor speed in percent of RPM
- Self-powered.

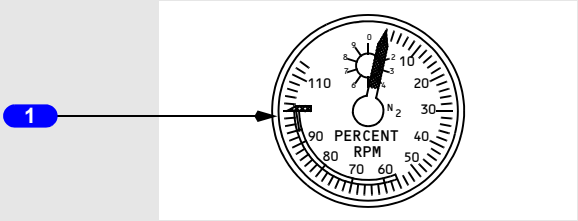
EGT Indications



1 Exhaust Gas Temperature (EGT) Indicator

- Indicates turbine exhaust gas temperature in degrees C as sensed by thermocouples
- Uses AC power from the Standby Bus.

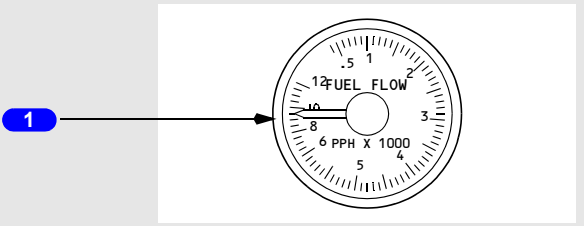
N2 Indications



1 N2 Indicator

- Indicates high pressure compressor speed in percent of RPM
- Self-powered.

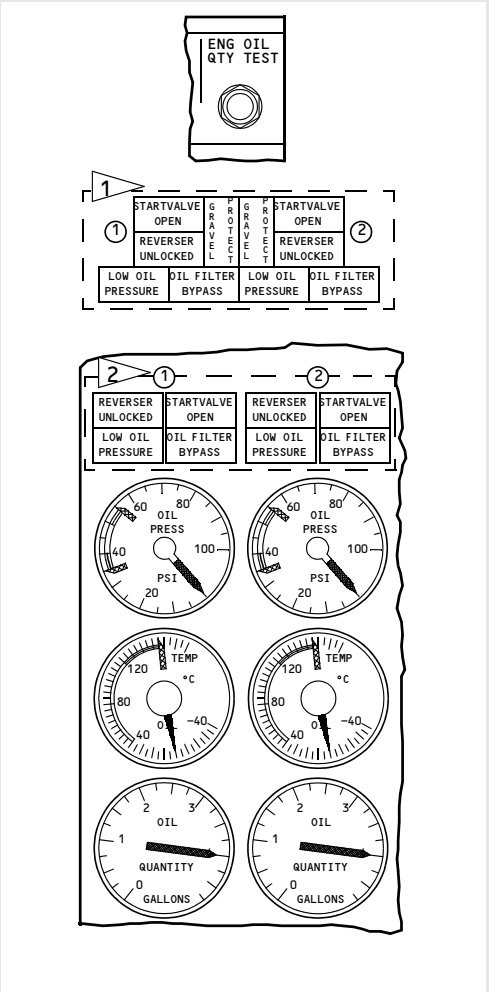
Fuel Flow Indications



1 Fuel Flow Indicator

Indicates fuel consumption rate in pounds per hour.

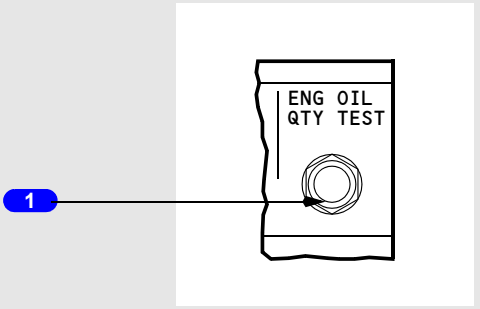
Engine Instruments Secondary Panel



As installed

CENTER INSTRUMENT PANEL

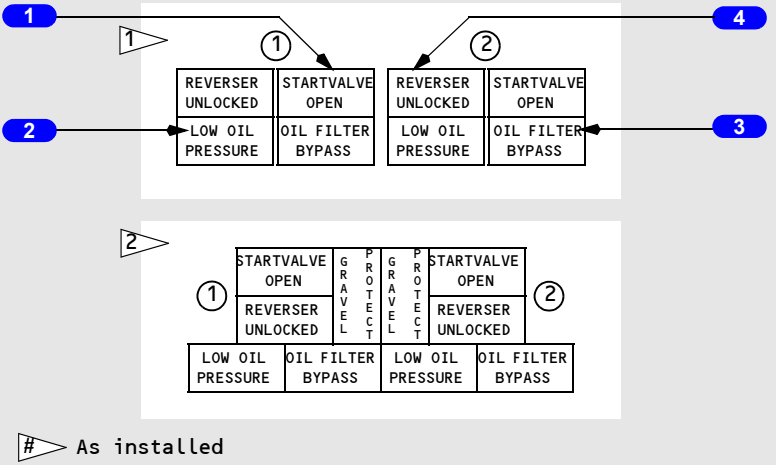
Engine Oil Quantity Test Switch



1 Engine Oil Quantity Test (ENG OIL QTY TEST) Switch

Push – oil quantity indicators move toward zero.

Caution Lights



1 START VALVE OPEN Light

Illuminated (amber) – indicates the engine starter valve is open and air is being supplied to the starter motor.

2 LOW OIL PRESSURE Light

Illuminated (amber) – indicates engine oil pressure is below 35 psi.

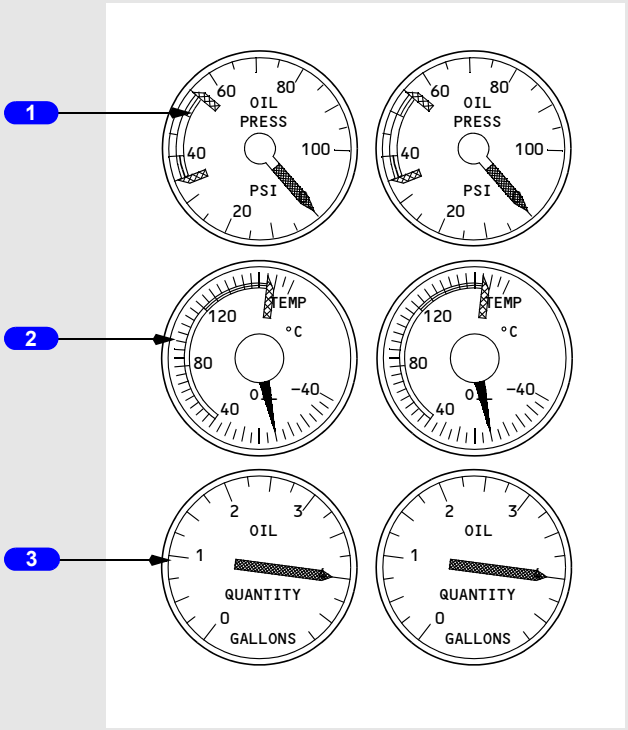
3 OIL FILTER BYPASS Light

Illuminated (amber) – indicates an impending bypass of the main oil filter.

4 REVERSER UNLOCKED Light

Illuminated (amber) – indicates the thrust reverser doors are not locked.

Engine Oil Indications



1 Oil Pressure (OIL PRESS) Indicator

Displays engine oil pressure in psi.

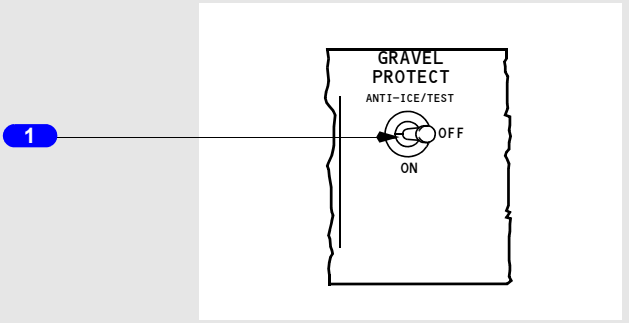
2 Oil Temperature (OIL TEMP) Indicator

Displays engine oil temperature in degrees C.

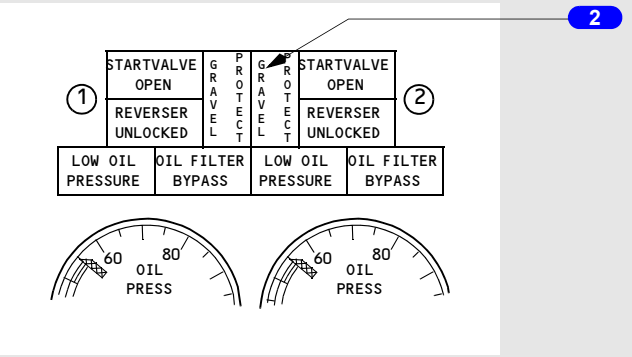
3 Oil Quantity (OIL QTY) Indicator

Displays engine oil quantity in gallons.

Gravel Protection (As Installed)



FORWARD OVERHEAD PANEL



CENTER INSTRUMENT PANEL

1 GRAVEL PROTECT Switch

ANTI-ICE TEST – activates the vortex dissipator for anti-icing or test of the system.

ON –

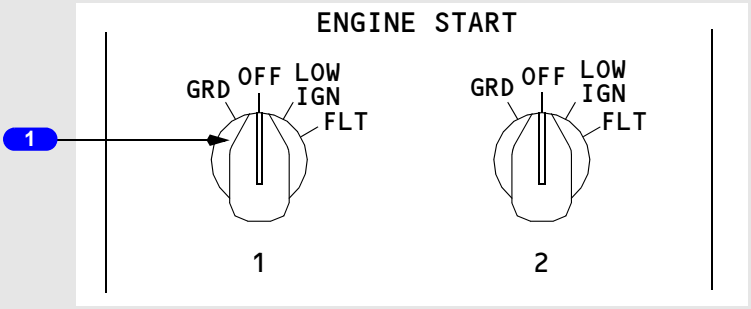
- Arms the vortex dissipator system in the air for actuation on touchdown
- The vortex dissipator operates only when the airplane is on the ground with the engines running.

OFF – The vortex dissipator system is deactivated.

2 GRAVEL PROTECT Light

Illuminated (green) – Vortex dissipators are operating.

Engine Start Switches



FORWARD OVERHEAD PANEL

1 ENGINE START Switch

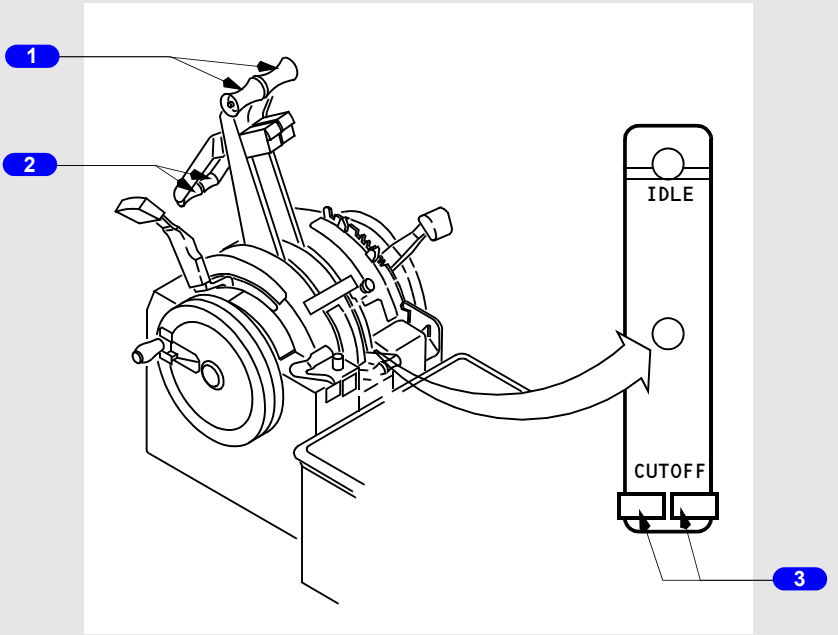
GRD – (solenoid held – spring loaded to OFF) Opens the starter valve and provides high energy ignition to two igniters when the Engine Start Lever is moved from CUTOFF to IDLE

OFF – No ignition

LOW IGN– Provides low energy ignition to one igniter with the Engine Start Lever in IDLE

FLT – Provides high energy ignition to two igniters when the Engine Start Lever is in IDLE.

Engine Controls



CONTROL STAND

1 Forward Thrust Lever

- Controls engine thrust
- Cannot be advanced if the reverse thrust lever is in the reverser deployed position.

2 Reverse Thrust Lever

- Controls engine reverse thrust
- Reverse thrust cannot be selected unless the forward thrust levers are in IDLE.

Note: When the reverse thrust levers are moved out of IDLE towards reverse thrust, pawls are forced into openings locking the forward thrust levers in the idle position.

Note: The ability of each reverse thrust lever and its corresponding forward thrust lever to move depends on the position of the other lever because each is capable of “locking out” the other pawl attached to the forward thrust levers.

3 Engine Start Lever

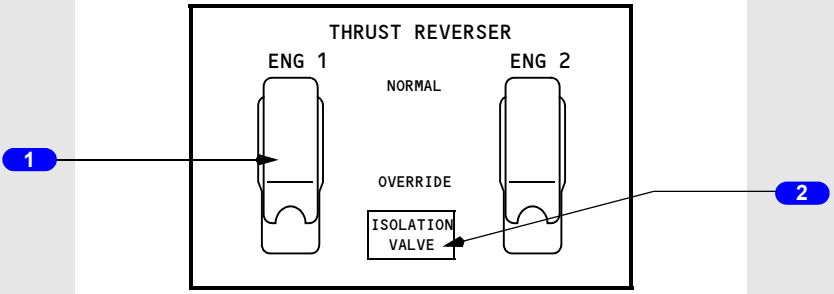
IDLE

- Controlled fuel flow is supplied to the engine, and ignition circuits are energized.

CUTOFF

- Closes the main fuel shutoff valve and the main engine control shutoff valve
- Ignition system is de-energized.

Thrust Reverser Override Switches



AFT OVERHEAD PANEL

1 OVERRIDE Switch

NORMAL

- The thrust reverser may be operated if the engine oil pressure is more than 35 psi, the fire switch is down and the air/ground safety sensor is in the ground mode (if hydraulic pressure is available).

OVERRIDE

- Bypasses the engine oil pressure switch and the air/ground safety sensor
- Opens the isolation valve directing available hydraulic pressure to the thrust reverser selector valve.

2 ISOLATION VALVE LIGHT (amber)

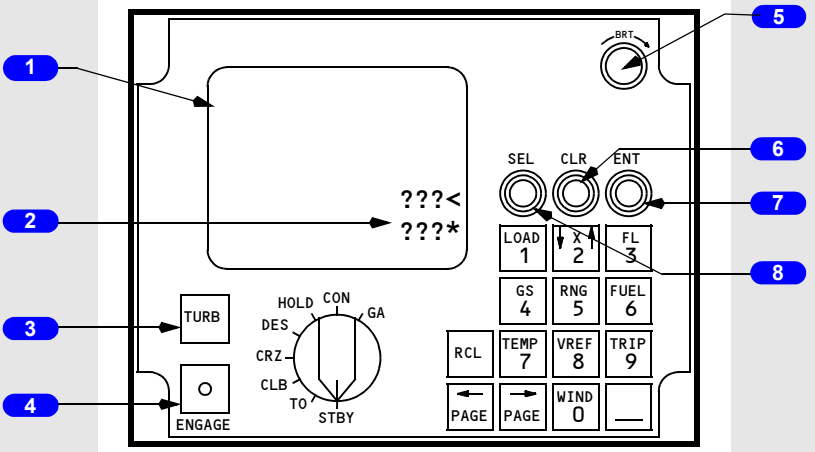
ILLUMINATED IN FLIGHT

- Hydraulic pressure is available to either or both thrust reverser selector valve
- The isolation valve is open.

ILLUMINATED ON THE GROUND

- Hydraulic pressure is not available to either or both thrust reverser selector valves
- The isolation valve is closed.

PDCS Control Display Unit (CDU)



FORWARD ELECTRONIC PANEL

1 Cathode Ray Tube (CRT) Display

- Displayed data is called a page
- Each page can display 6 lines, 13 characters per line.

2 CRT Display Symbols

??? (question marks)

- Indicates lines of unentered data.

CARET

- Indicates the place where information is to be inserted
- Displaces the asterisk on that line.

* (asterisk) - Identifies the line where an ENT (entry) can be made.

3 TURB (turbulence) KEY

PRESS –

- Causes the CRT to display the turbulent air penetration speed, pitch attitude and N1 settings
- The EPR indicator bugs move to values corresponding to the N1 values
- Overrides the CRZ flight mode position.

4 ENGAGE KEY

PRESS (with a flight mode selected) –

- Drives the EPR and/or airspeed bugs to the displayed values
- The key light extinguishes and the engaged mode is displayed on the flight mode annunciator
- Other CDU displays can be selected without changing the engaged mode.

ILLUMINATED –

- Indicates the data displayed is not driving the bugs
- When a performance function is displayed, the Engage Key does not illuminate since performance functions cannot be engaged.

5 BRT (brightness) Control

ROTATE – Controls CRT brightness.

6 CLR (Clear)

PRESS –

- Causes data on the line corresponding to the Caret to be removed from the display
- The CLR key must be pressed any time a new numeric entry is desired.

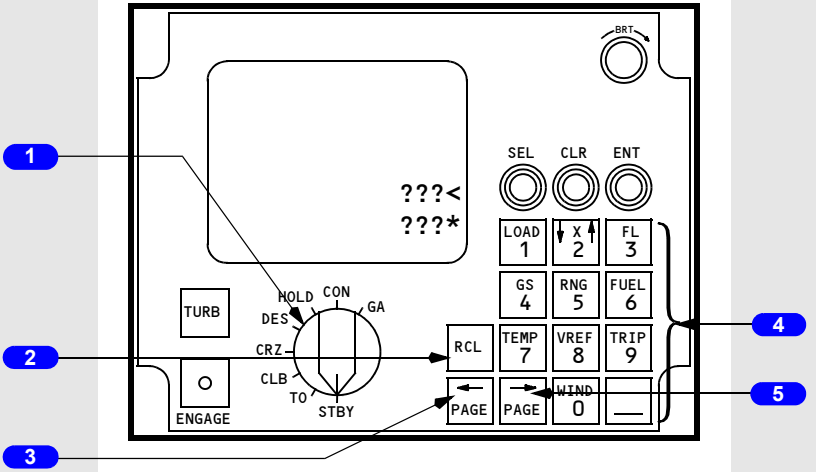
7 ENT (Enter)

PRESS – Commands the computer to accept the data which has been keyed in and displayed.

8 SEL (Select)

PRESS –

- Moves the Caret down one line each time it is pressed
- The possible Caret positions are limited to those lines which display an asterisk
- The Caret cycles to the top line if at the lowest line.



FORWARD ELECTRONIC PANEL

1 FLIGHT MODE SELECTOR

ROTATE – Selects the phase of flight for which data is desired.

STBY (Standby) – Used for data entry and automatic system verification.

TO (Takeoff) – Displays takeoff EPR limits for the temperature entered.

CLB (Climb) – Displays climb EPR and speeds for the desired climb profile: Best economy, maximum rate or crew selected speeds.

CRZ (Cruise) – Displays cruise EPR and speeds for the desired cruise schedule: Best economy, LRC (long range cruise) or crew selected speeds.

DES (Descent) – Provides descent speed, time and distance for best economy or crew selected speeds.

HOLD (Holding) – Used to obtain holding EPR, speed and endurance time.

CON (Continuous) – Provides maximum continuous EPR limit and engine out data.

GA (Go Around) – Displays go-around EPR limit for existing altitude and temperature.

2 RCL (Recall)

PRESS (with performance function displayed) – Changes the display to the selected flight mode.

3 PAGE REVERSE KEY

PRESS –

- Reverse the display one page for both flight modes and performance functions wit multiple pages.
- After the first page is reached, the system cycles back to the last page.

4 KEYBOARD

- The keyboard contains double function keys for entering numerics and selecting performance functions for display.

LOAD key – Permits flight data entry to enable the system to compute takeoff EPR, gross weight, optimum descent distance, and airspeeds.

ALTITUDE INTERCEPT key – Used to solve time, distance, and flight level intercept problems during climb and descent.

FL (Flight) key – Used to determine optimum flight level, maximum altitude capability and wind altitude trade considerations.

GS (Ground Speed) key – Computes ground speed and wind, or time and distance to a waypoint or destination.

RNG (Range) key – Displays total endurance, distance and time remaining to reserve fuel quantity or empty tanks at any flight level.

FUEL key – Displays total fuel, fuel reserves and fuel over destination.

TEMP (Temperature) key – Displays ISA deviation, TAT, SAT, TAS.

VREF key – Displays reference speeds for landing flaps and the current gross weight.

TRIP key – Displays most economical cruise flight level for trip distances, ISA deviation, and wind, if known.

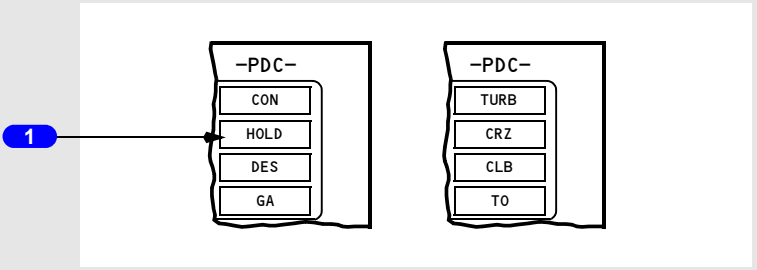
WIND key – Displays automatically computed or manually entered wind data.

5 PAGE FORWARD KEY

PRESS –

- Advances the display one page for both flight modes and performance functions with multiple pages.
- After the last page is reached, the system cycles back to the first page.

Flight Mode Annunciator

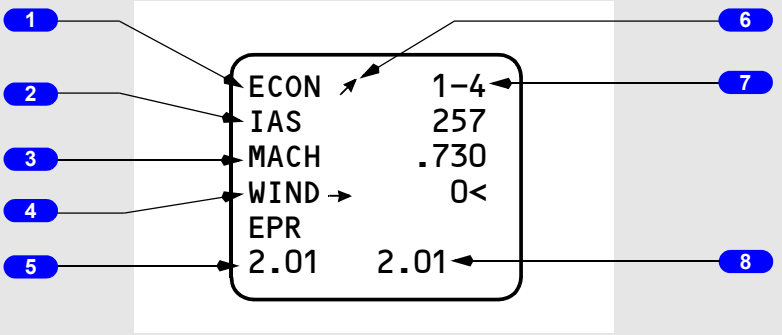


CAPTAIN'S AND FIRST OFFICER'S INSTRUMENT PANEL

1 Flight Mode Annunciator

Indicates the flight mode to which the driven airspeed and EPR bugs are engaged.

PDCS Displays (Typical)



FLIGHT MODE – CRUISE

1 Page Title

2 Target Airspeed

3 Target MACH

4 Wind Component

Unless a wind is entered the component reads zero.

5 **No. 1 Engine Target/Limit EPR**

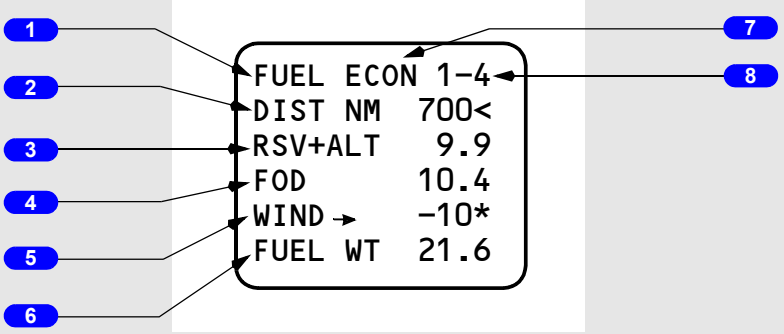
6 **Indicating Arrow**

IN VIEW –

- Optimum altitude is still more than 2000 feet above (or below if down arrow is showing)
- Arrow disappears when within 2000 feet of optimum altitude.

7 **Page 1 of 4**

8 **No. 2 Engine Target/Limit EPR**



PERFORMANCE FUNCTION – FUEL

1 **Performance Function**

2 **DIST NM (Distance Nautical Miles**

Distance to go as entered. May be to a checkpoint or over destination.

3 **RSV+ALT (Reserve + Alternate)**

Reserve and alternate fuel quantity (LBS X 1000).

4 **FOD (Fuel over distance)**

Fuel remaining over destination or waypoint at the CRZ ECON speed for the present altitude and entered distance to go (LBS X 1000).

5 **Wind**

Wind component entered into computer (based on 10 kt. headwind).

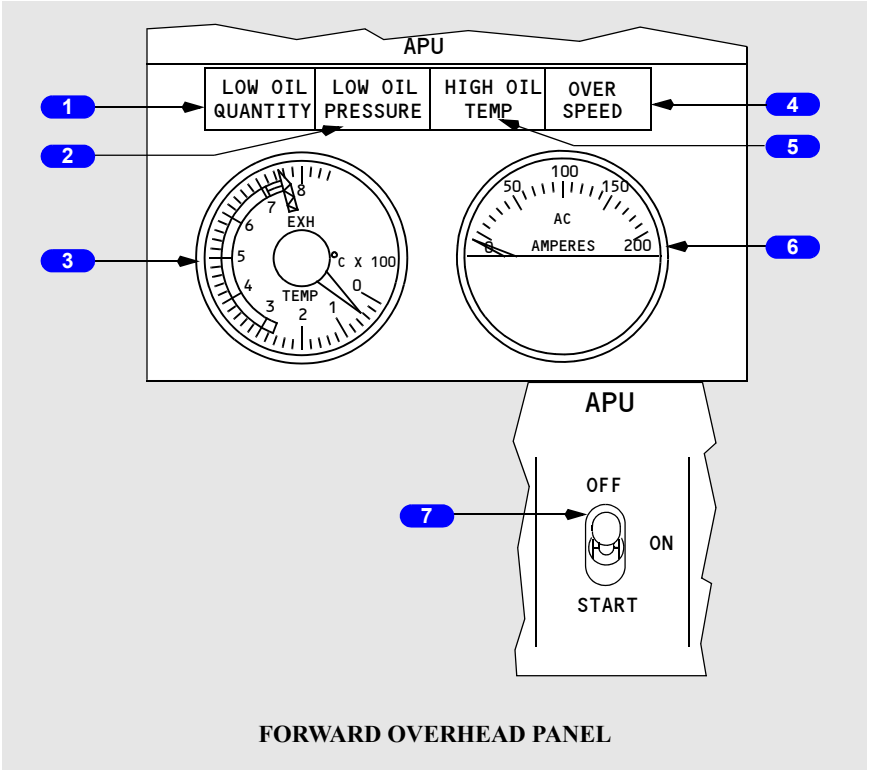
6 **Total fuel quantity remaining**

(LBS X 1000)

7 **Page Title**

8 **Page 1 of 4**

APU



FORWARD OVERHEAD PANEL

1 **LOW OIL QUANTITY Light**

Illuminated (blue) –

- APU oil quantity is insufficient for extended operation.
- light is disarmed when APU switch is OFF.

2 APU LOW OIL PRESSURE Light

Illuminated (amber) –

- during start until the APU oil pressure is normal
- oil pressure is low causing an automatic shutdown (after start cycle is complete)
- light is disarmed when APU switch is OFF.

3 APU Exhaust Gas Temperature (EGT) Indicator

Displays APU EGT

4 APU OVERSPEED Light

Illuminated (amber) –

- APU RPM limit has been exceeded resulting in an automatic shutdown
- overspeed shutdown protection feature has failed a self–test during a normal APU shutdown
- APU start is aborted prior to reaching governed speed (light will extinguish following a normal start)
- light is disarmed when APU switch is OFF.

5 APU HIGH OIL TEMPERATURE Light

Illuminated (amber) –

- APU oil temperature is excessive, causing APU to initiate an automatic shutdown
- light is disarmed when APU switch is OFF.

6 APU Generator AC Ammeter

Displays APU generator load current

7 APU Switch

OFF – normal position when APU is not running.

- positioning switch to OFF with APU running initiates APU shutdown, trips APU generator off the bus(es), if connected, and closes APU bleed air valve.

ON – normal position when APU is running.

START (momentary) – positioning APU switch from OFF to START and releasing it to ON initiates an automatic start sequence.

Intentionally
Blank

System Description

The airplane is equipped with two Pratt and Whitney JT8D ducted turbofan engines having two rotors in series – N1 and N2.

This is a forward fan type engine with a twin spool axial compressor, consisting of a low pressure unit (N1) and a high pressure unit (N2). The low pressure unit is connected by a through shaft to the turbine wheels for the low pressure compressor, and the high pressure compressor is connected independently by a hollow shaft to the turbine wheel for the high pressure compressor. The compressors deliver highly compressed air to the engine burner section, where a fuel/air mixture is ignited. The resulting high energy gasses enter the turbines, producing the power to drive the compressors and accessories as well as the fan at the front of the engine. Propulsion is produced by the forces within the engine that result in the discharge of high velocity gasses through the nozzle at the rear. A fuel controller schedules fuel flow to provide the thrust called for by the thrust lever setting in the cockpit.

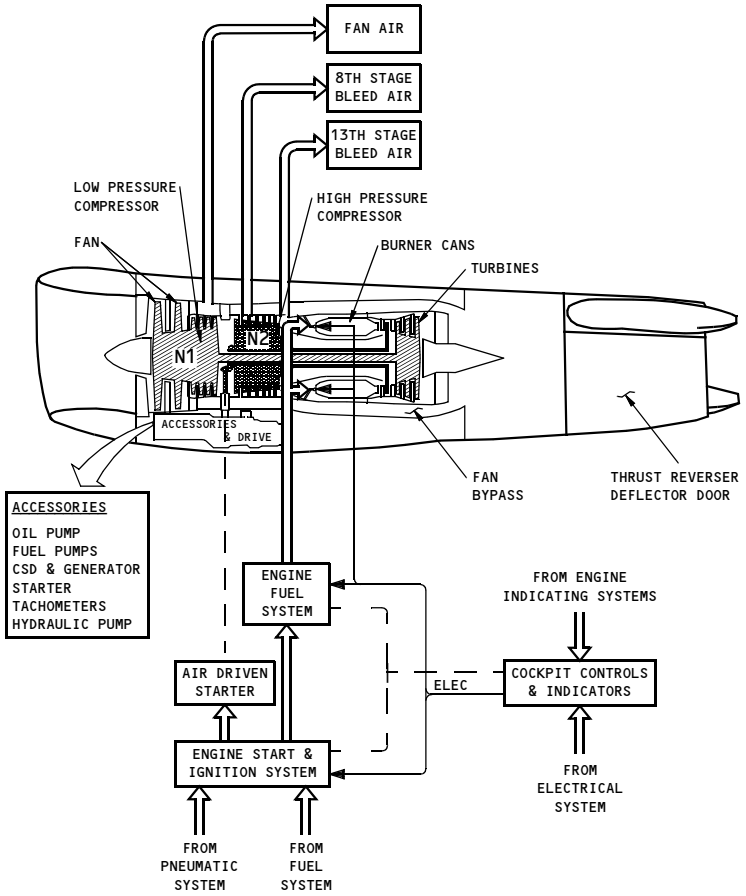
The accessories are driven by the N2 compressor through a gear train and cooled by the fan duct air. A thrust reverser provides reverse thrust by blocking the engine exhaust gas flow and deflecting the flow forward.

Each engine has individual flight deck controls. Thrust is set by positioning the thrust levers. The forward thrust levers control forward thrust from idle to maximum. Advancing the thrust levers full forward provides some overboost and should be considered only during emergency situations when all other available actions have been taken and terrain contact is imminent. The reverse thrust levers control thrust from reverse idle to maximum reverse.

In the event of an N2 signal fail to the fuel control unit, engine RPM may change to or remain at high thrust with no observable movement of thrust lever and no engine response to thrust lever movement. This may be due to either complete or partial loss of the N2 signal to the fuel control unit (FCU). The FCU is designed to ensure the engine delivers high power during a critical phase of flight, such as takeoff or go-around should one of these conditions occur. Thrust will be set to 90–95% N2 (complete loss) or the FCU will add fuel in an attempt to reach target N2 (partial loss). Either of these conditions can occur any time, in-flight or on the ground and the only control the flight crew has is to shutdown the affected engine with the engine start lever or engine fire warning switch. This malfunction may be difficult to identify because, depending upon thrust setting at the time of occurrence, thrust on the affected engine may increase, decrease or remain nearly the same.

Note: It is recommended the flight crew not attempt to shut down the engine until a safe altitude is achieved, flight path is stabilized and the malfunctioning engine has been positively identified. If this condition occurs during ground maneuvers, landing rollout or rejected takeoff, thrust lever response will be lost and the engine must be shut down immediately to prevent possible loss of directional control.

Power Plant Schematic



Engine Fuel System

Fuel is delivered to the engines at pressures and flow rates required to obtain desired engine thrust. Fuel leaves the fuel tank and enters through the engine fuel shutoff valve. The engine fuel shutoff valve is controlled by the engine start lever and the engine fire warning switch. When the engine fuel shutoff valve is closed, the FUEL VALVE CLOSED light located on the forward overhead panel will illuminate dim.

Fuel passes from the first stage of the engine driven fuel pump to a fuel heater and fuel filter. The heater uses 13th stage bleed air to increase fuel temperature and prevent blocking of the filter due to icing. The FILTER ICING light will illuminate when the filter is blocked. Provisions are made to bypass the first stage of the pump, the heater, or the filter in the event of failure or blockage.

The second stage of the fuel pump provides high pressure fuel to the fuel control unit (FCU). The FCU uses thrust lever position, diffuser case pressure, compressor inlet temperature, and N2 RPM to meter the correct amount of fuel to the burner cans. A fuel flow transmitter measures the rate of fuel flow from the FCU and provides an indication on the fuel flow indicator located on the center instrument panel. Fuel from the FCU passes through an oil cooler which is used to cool engine oil. Oil temperature varies with fuel flow or fuel temperature.

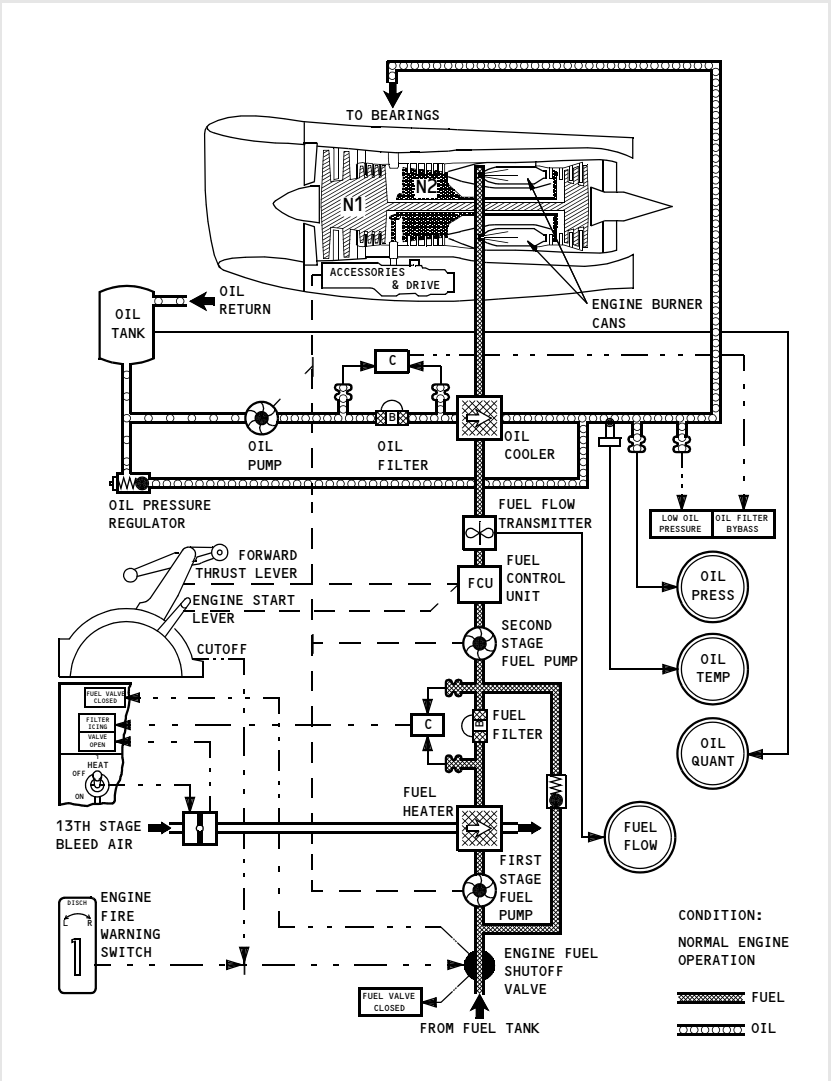
Oil System

Oil from the individual engine tank is circulated under pressure, through the engine to lubricate the engine bearings and accessory gearbox. Oil quantity is displayed on the oil quantity indicator located on the center instrument panel.

The oil system is pressurized by the engine driven oil pump. The oil leaves the oil pump, passes through an oil filter, and continues to the engine bearings and gearbox. Should the filter become saturated with contaminants, oil will automatically bypass the filter. Prior to the oil bypassing the filter, the OIL FILTER BYPASS light, located on the center instrument panel, will illuminate.

The oil then passes through an oil cooler which requires fuel flow through the cooler to maintain proper oil temperature. The oil leaves the oil cooler, where sensors for the oil temperature indicator, oil pressure indicator and the LOW OIL PRESSURE light are located, and continues to the engine bearings and gearbox.

Engine Fuel and Oil system Schematic



Engine Start System

Low pressure air, a pneumatic starter, and electrical power are required for starter operation. The engines may be started with air from the APU, from a ground source, or by using engine crossbleed. Engine bleed air valves must be open to allow air from any source to reach the selected engine starter.

The Engine Start Switch GRD position uses DC power from the battery bus to open the starter valve and allow pressure from the pneumatic manifold to rotate the starter. When the starter valve is open, the amber START VALVE OPEN light, located on the center instrument panel, will illuminate. Should the engine start switch fail to open the starter valve, a manual control handle on the engine may be used to open the valve. The starter is a turbine-type air motor which rotates the N2 compressor through the accessory drive gear system. At cutout speed (35 to 40% N2 RPM), power is interrupted to the start switch holding solenoid, allowing the engine start switch to return to the OFF position and the starter valve to close.

Starter valve closure is indicated by a rapid rise in duct pressure. The START VALVE OPEN light monitors air pressure downstream of the starter valve. The light extinguishes shortly after closure of the starter valve.

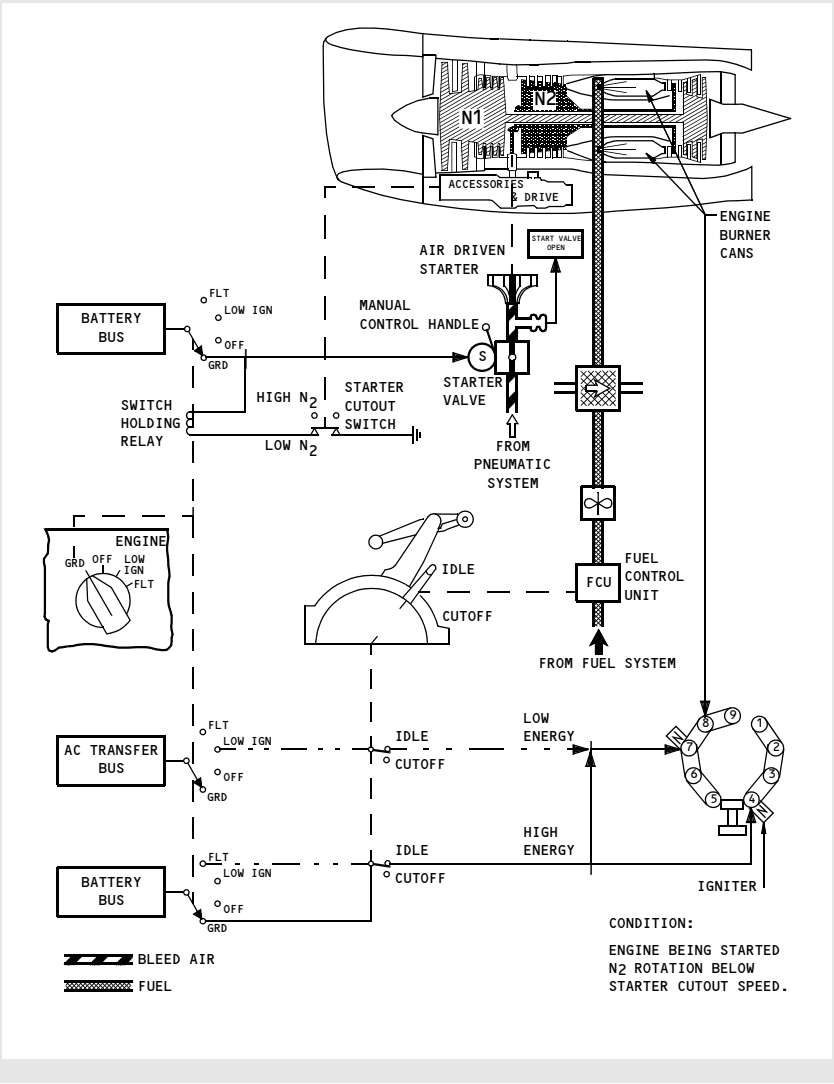
When the engine has accelerated to the starting speed, and with the engine start lever advanced to the IDLE position, fuel ignites, resulting in an engine start.

Engine Ignition System (4-Position Start Switch)

Two systems are provided. A high energy system is energized with the engine start switch in either the GRD or FLT position when the engine start lever is placed to the IDLE position. The high energy system furnishes pulsating power to ignitors in both No. 4 and No. 7 burner cans. The high energy system is used for all engine starts.

Low energy continuous ignition is provided when the engine start switch is in the LOW IGN position and the engine start lever is in the IDLE position. The low energy system furnishes continuous ignition through one plug only in the No. 7 burner can. The low energy system is used to improve igniter service life while minimizing the possibility of an engine flameout during takeoff and landing, in turbulence, or in icing conditions.

Engine Start and Ignition System Schematic



Thrust Reverser

Reverse thrust is accomplished by two doors which block engine exhaust and deflect the exhaust flow forward. The doors operate by system A hydraulic pressure through the gear down hydraulic line. Alternate operation at a reduced rate is available with the standby hydraulic system (the reverser may not stow). A REVERSER UNLOCKED light located on the center instrument panel will illuminate when either thrust reverse door is not in the stowed and locked position.

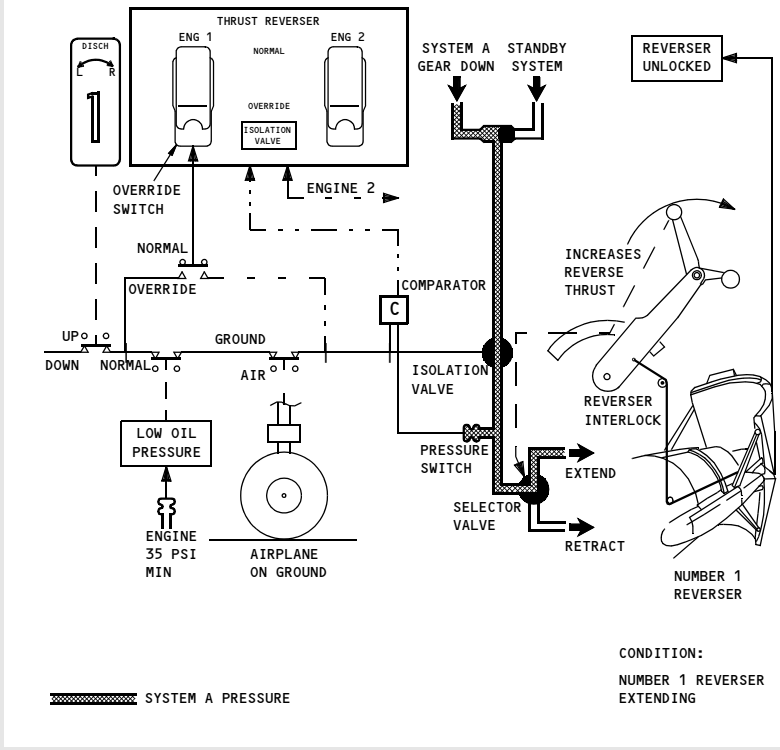
With the engine fire warning switch down and the engine low oil pressure switch sensing pressure, an electrical circuit including the nose gear, or main gear air/ground safety sensors, allows the thrust reversers to deploy. When all three electrical conditions are satisfied, the isolation valve will be solenoid-held to the open position. Loss of any electrical condition will cause the isolation valve to spring closed. The selector valve is controlled by the reverse thrust lever and directs hydraulic pressure to unlock, extend, retract or lock the doors.

The amber ISOLATION VALVE light will illuminate whenever a comparator senses a disagreement between the electrical condition to either isolation valve and the hydraulic pressure condition (the isolation valve open in flight, or closed on the ground). Positioning the guarded switch to the OVERRIDE position bypasses the oil pressure switch and the air/ground safety sensor and opens the isolation valve (if the fire switch is down). The override switches should not be used by flight crews for normal operations in flight or on the ground.

An engine control/reverser interlock system is provided. This interlock limits the thrust increase command if the reverser remains stowed when the reverse thrust lever is moved to a reverse position. The interlock is withdrawn during reverser translation from the stowed position to the deployed position. If the reverser remains deployed when the reverse thrust lever is moved to the forward thrust position, thrust increase commanded by the forward thrust lever is limited. The interlock is withdrawn during reverser translation from the deployed position to the stowed (flight) position. Freedom of motion of the forward thrust levers is not an absolute indication that the thrust reverser is fully deployed or stowed and locked, since the interlocks are withdrawn during reverser motion.

WARNING: Actuation of the thrust reversers on the ground without suitable precautions is dangerous to ground personnel.

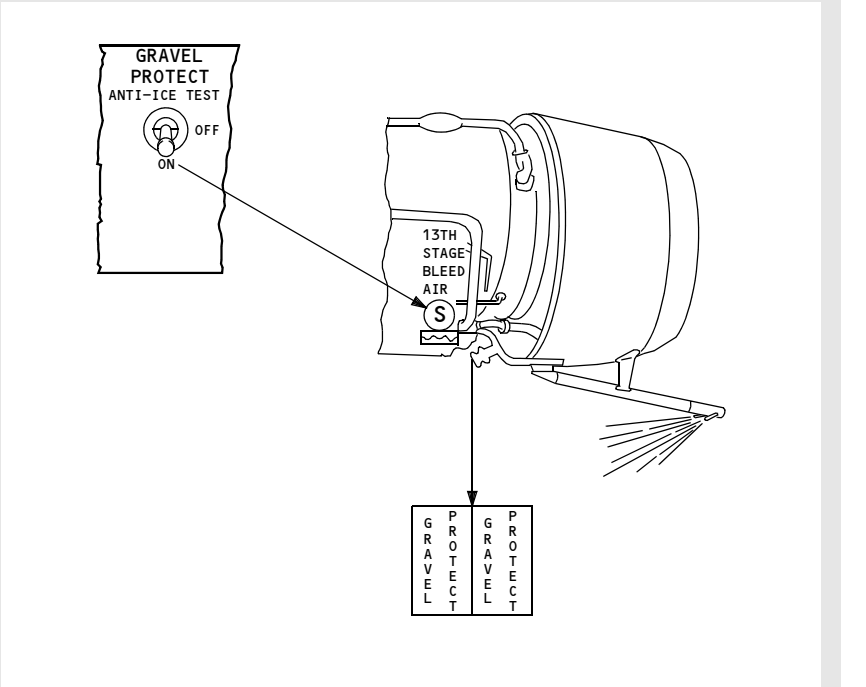
Thrust Reverser Schematic



Gravel Protection (As Installed)

Airplanes with gravel protection have a vortex dissipator boom installed below and forward of each engine nose cowl. High pressure air is discharged toward the ground through nozzles at the boom end.

This prevents dirt, gravel and other debris which lie below the engine from being picked up by vortices and entering the engine.



PDCS System Description

General

The performance data computer system (PDCS) provides the crew with flight guidance data to assist in achieving the most efficient and economical operation of the airplane. The data is presented in the form of digital displays on the CDU and bug displays on the EPR indicator(s).

The PDCS is controlled by the crew and consists of a computer, a control display unit (CDU) and mode annunciator.

The primary function of the PDCS is to compute and display target airspeed and EPR settings for each phase of flight: takeoff, climb, cruise, descent, holding, and go-around. For each of these phases of flight (flight modes) the PDCS computes and displays optimum EPR and airspeed values on the CDU and drives the EPR bug(s) to the computed values.