Flight Manual

GKS B-52H MSFS2020 / 2024

FOREWORD

Thank you for choosing the B-52H Stratofortress for Microsoft Flight Simulator.

This aircraft is the latest project by **Golden Key Studio**, a development team with over **12 years of experience** in high-fidelity flight simulation. Our previous releases include the **MiG-21bis**, **MiG-25PD Foxbat**, and **F-111 Aardvark**, each focused on accuracy, depth, and authentic aircraft behaviour.

The B-52H is a uniquely complex aircraft, and recreating it within MSFS required a careful balance between realism and usability. The systems and procedures included in this add-on are based on real-world documentation and operational logic, while taking into account the technical limitations of the simulator. Further refinements and enhancements may be introduced in future updates.

Special attention was given to the visual fidelity of both the cockpit and exterior, aiming to capture the distinctive character of this iconic aircraft.

Golden Key Studio is proudly based in **Ukraine**. We hope this B-52H will provide you with many hours of immersive and rewarding flights in Microsoft Flight Simulator.

Versions

DOCUMENT version 0.1.0 (DRAFT)

This manual applies to PRODUCT VERSION 1.3.3 for MSFS2020 / 24

Copyright Information

Credits and Acknowledgements

I would like to gratefully acknowledge the development team for their superb work and dedication to this project. Many of you wondered if we would ever get it done, so the day has come.

Features

- Legendary long-range strategic bomber **B-52H Stratofortress (BUFF)** — an icon of American air power, designed for global reach and unmatched payload capability.

- Fly intercontinental missions with a combat radius of over 4,000 nautical miles and service ceiling above 50,000 feet.

- Experience the power of eight Pratt & Whitney TF33 engines with realistic engine management, fuel balancing, and monitoring systems.

- Highly detailed native MSFS 2024 build with advanced materials, modern shader technology, and optimized avionics performance.

- Custom flight model based on real-world aerodynamic data, including weight, payload configuration, fuel distribution, and high-altitude cruise characteristics.

- Fully functional cockpit systems, MFD avionics suite, and immersive operational workflow from cold & dark to cruise and landing.

Cockpit Systems and Gauges are made with ultimate realism according to the original B-52H Pilot's Manual and real cockpits

1. Fuel Supply System
2. Electrical Power Supply System
3. Landing Gears, Air Brakes, Intake's system
4. The full functional Autopilot with more than 8 different modes of flight.
5. Warning, Caution and Indicator Lamps
6. Lighting System.
7. Communication Equipment
8. CRAB system

Very detailed model of Exterior and Virtual Cockpit with full 3D gauges and many animated parts:

1. Wing Flex animation taking into account loading
2. Different variants of payloads
3. End many more…

Custom FX for the ultimate in realism is taken far beyond what is available by default:

1. Engine smoke and dust
2. Engine cartridge start
3. High angle of attack and stall vortex effects
4. And much more…

Custom Sound to improve immersion we have added custom sound effects:

1. Cockpit sounds
2. Environment sounds
3. Engine's cartridge start sounds

Future plans

1. Weapons module
2. Virtual crew
3. Homing system

CUSTOM KEY MAPPINGS

AUTOPILOT

"AUTOPILOT MASTER ON/OFF" toggles autopilot non steering mode.
"AUTOPILOT ALTITUDE HOLD" toggles autopilot altitude hold mode.

Note, modes of autopilot are specific and can be set only by switches in Virtual Cockpit.

AIRBRAKE

"SPOILERS TOGGLE" toggles airbrake to 100%

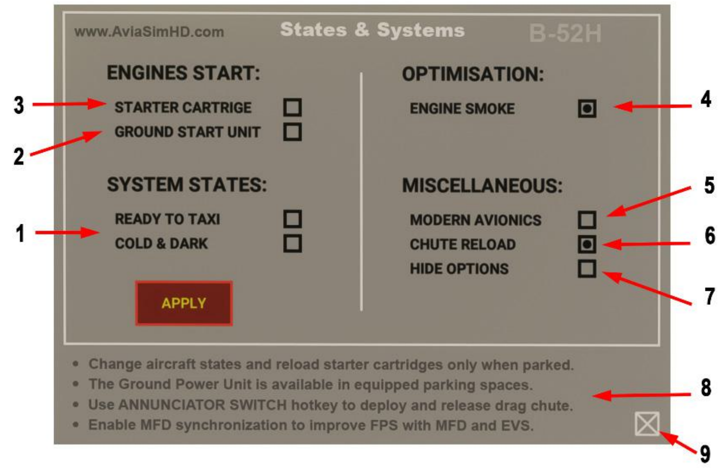
Drag Chute Deployment / Jettison

"ANNUNCIATOR ON/OFF" toggles drag chute deploy/jettison

Options Menu

Option menu button is located on the front of the glareshield

Options menu



1 SIM STATES SWITCHER
2 GROUND AIR START UNIT CONNECTION
3 STARTER CARTRIDGE LOAD
4 TOGGLE SMOKE FX
5 TOGGLE MODERN RADIO STACK
6 CHUTE RELOAD (ON THE GROUND)
7 TOGGLE OPTION MENU ICON

Figure 0-1

Important Flying Tips

Aircraft weight

Total internal fuel capacity: ~**312,000 lb**
Typical operating weights:

- Taxi / Takeoff (heavy fuel) – 390,000–400,000 lb
- In-flight cruise – 300,000–420,000 lb
- Landing (recommended) – below 330,000 lb

⚠ Heavy weight significantly increases takeoff roll and reduces climb rate.

Speed Reference

Takeoff Full Flaps

- V1 – ~145–155 KIAS
- VR – ~150–160 KIAS
- V2 – ~165–172 KIAS

Cruise

- High altitude cruise – Mach 0.78–0.84
- Typical cruise speed – 450–480 KTAS

Landing - Full Flaps, Speed Brake 4

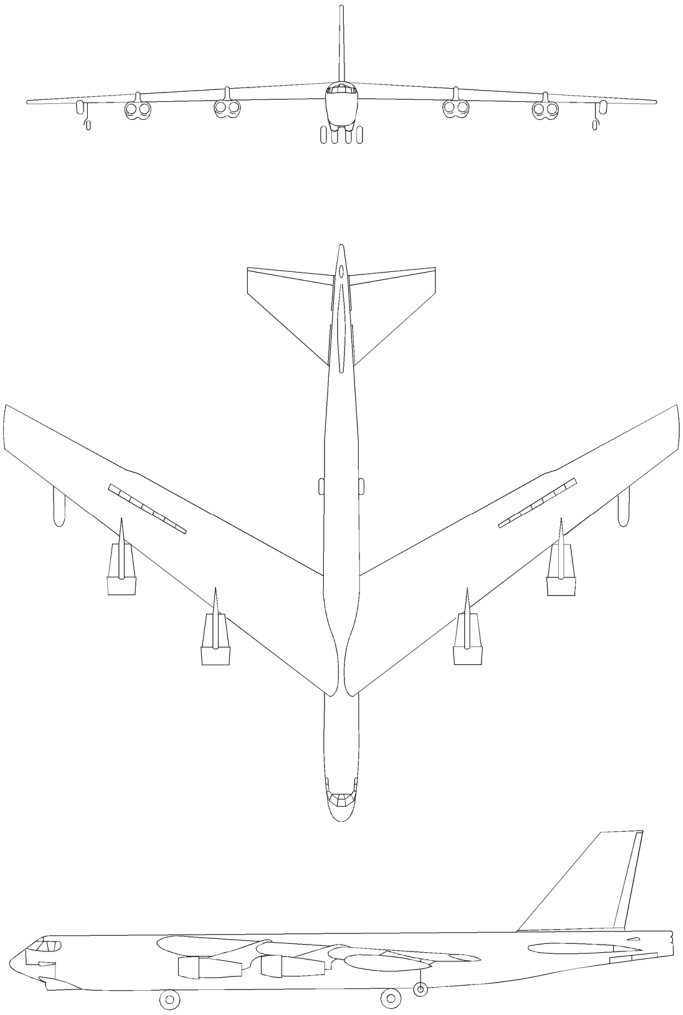
- Approach – 165–175 KIAS (depending on weight)
- Touchdown – ~155–165 KIAS

Operational Notes

- The aircraft responds slowly to control inputs — anticipate pitch and roll corrections.
  Plan descent early — B-52 does not lose altitude quickly at high weight.

- Avoid aggressive banking at low speed (large wingspan = significant inertia).
- Use gentle throttle movements — 8 engines spool up slowly.
- Monitor fuel balance for stable cruise performance.

The B-52H Stratofortress



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THE AIRCRAFT

DESCRIPTION

Boeing B-52 “Stratofortress” aircraft is of the land based heavy bombardment class designed for long range flight at high speed and altitude. The tactical mission is the destruction of surface objectives by bombs and missiles. The aircraft has provisions for ten crewmembers: a basic crew of five, three instructors and two additional crewmembers. The basic crew consists of pilot, copilot, radar navigator, navigator and electronic warfare officer. The instructor crew includes an instructor pilot, instructor navigator and instructor electronic warfare officer. Finally, the gunner and tenth man positions are also available for additional seating. A highly variable weapons load may be carried on external pylons in combination with internal cluster rack or CSRL mounted weapons loads. Up to 12 cruise missiles may be carried externally.

The aircraft can suspend a variety of gravity weapons internally on cluster rack assemblies (three cluster rack assemblies, up to 27 weapons total). Externally, the B-52 can suspend weapons using an AGM-28 pylon under each wing with standard rack adapter beams attached to each pylon and two sets of multiple ejector racks (MER) giving a total external carriage capability of 24 weapons. The heavy stores adapter beam (HSAB) can be attached to a stub pylon and up to nine MAU-12 bomb racks can be attached to each HSAB for a total external carriage capability on the HSAB of up to 18 weapons.

SPECIAL FEATURES

The aircraft is characterized by swept wings and empennage, four underslung nacelles housing eight turbofan engines, a quadricycle main landing gear, and a tip gear near each outboard engine nacelle. Engine bleed air provides the air supply for air conditioning and anti-icing. Cartridge starters are installed to provide for engine starts without assistance from an auxiliary air cart or auxiliary electrical power cart. Primary electrical power is 205-volt ac and is provided by four engine-driven generators. Hydraulic pressure is supplied by six engine-driven hydraulic pumps and two electric motor-driven hydraulic pumps. Primary pitch and yaw control is maintained by hydraulically actuated rudder and elevators. Lateral control is maintained by operation of hydraulically actuated spoilers. By varying the method of control, these same spoilers serve as airbrakes. The entire horizontal stabilizer is moved by a hydraulic mechanism to provide pitch trim. A steering and crosswind crab system provides steering of the forward main landing gear and also properly positions both forward and rear main landing gear for crosswind landings. A hydraulically driven revolver-type launcher installation in the bomb bay provides umbilical and ejector rack connections for the weapons which may be launched/ released automatically or manually by the navigators.
An electro-optical viewing system (EVS) is installed to provide pilots and navigators with a visual presentation of the area ahead of the aircraft during both day and night missions.

A GPS Navigation System which provides position updates and emulated TACAN data to the crew and a moving map display to the pilots has been added.

DIMENSIONS

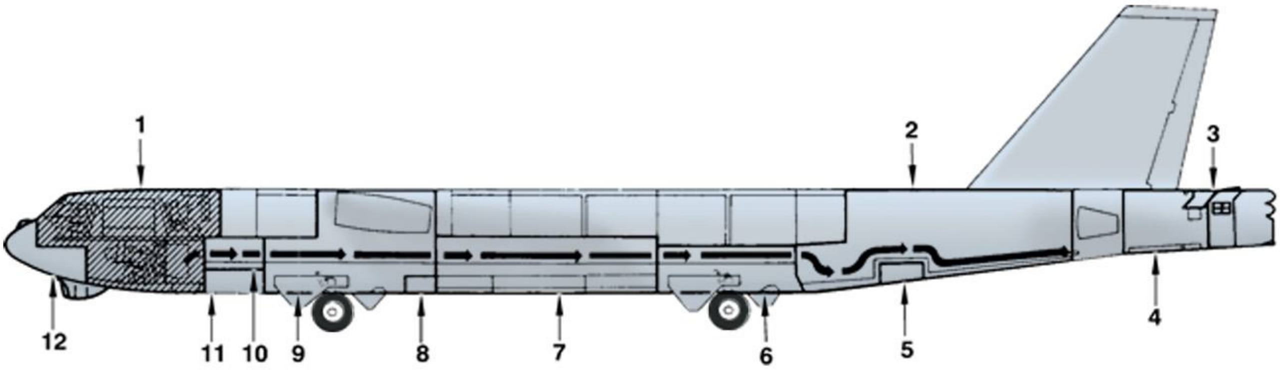
Wing Span	185 feet
Fuselage Length	159 feet 4 inches
Height	
To top of fin	40 feet 8 inches
Fin folded	21 feet 6 inches
Tread	
Centerline outboard main tires	11 feet 4 inches
Centerline tip gear to tip gear	148 feet 5 inches

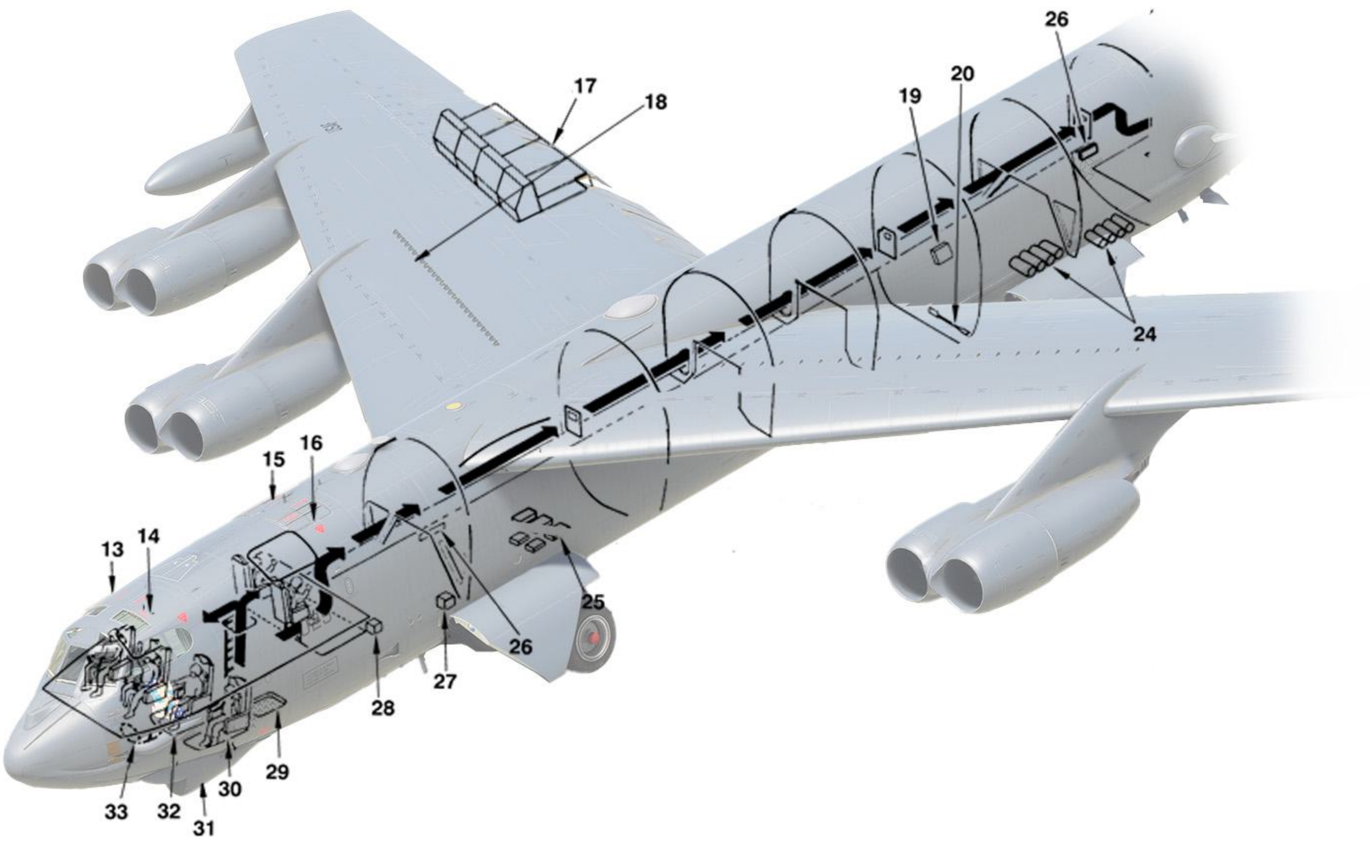
For aircraft turning radius and minimum ground clearance, see figure 2-2.

GROSS WEIGHT

The aircraft is in the 400,000 pound gross weight class. For specific weight and loading information, see WEIGHT LIMITATIONS.

General Arrangement Diagram (Typical)





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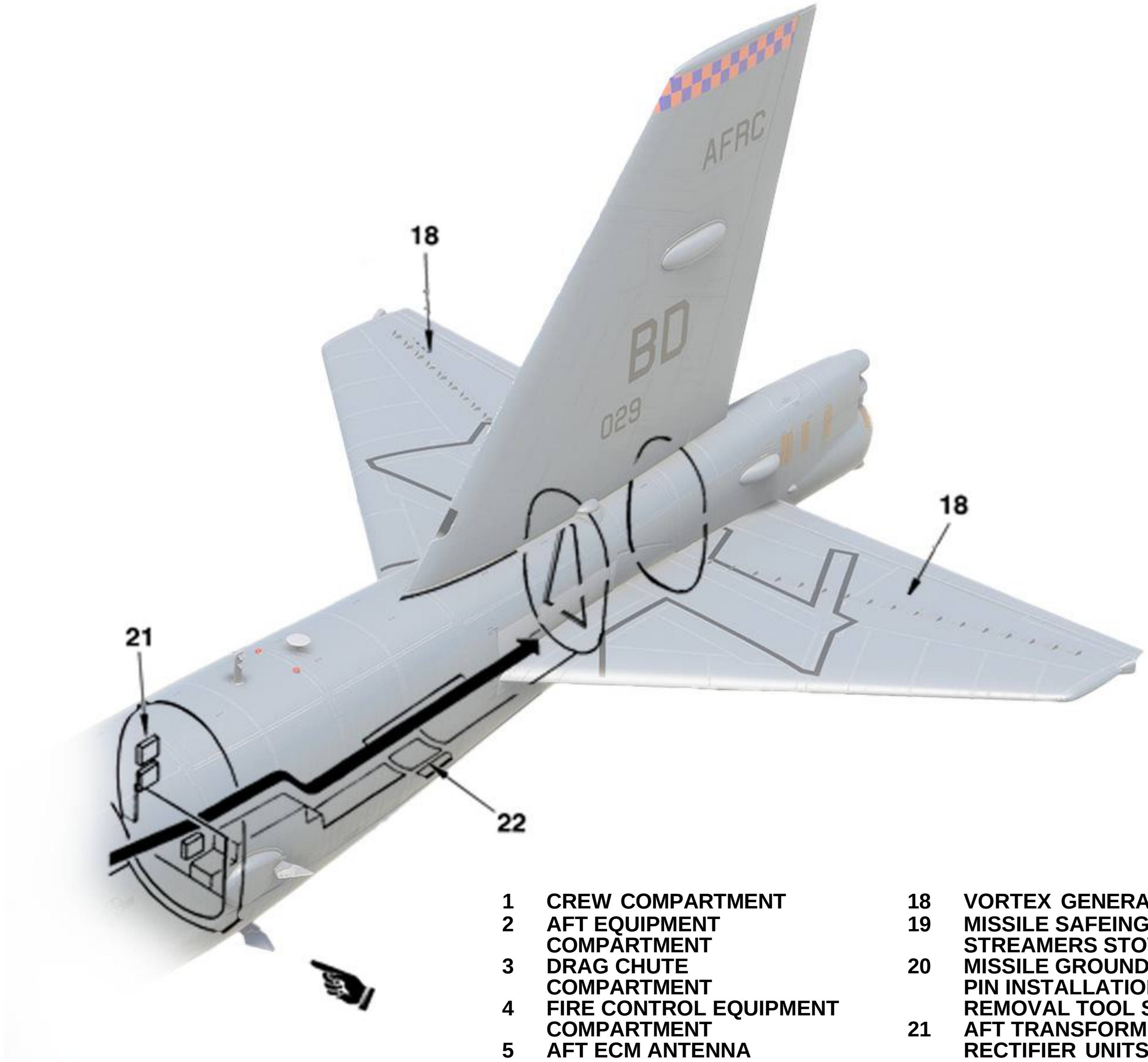


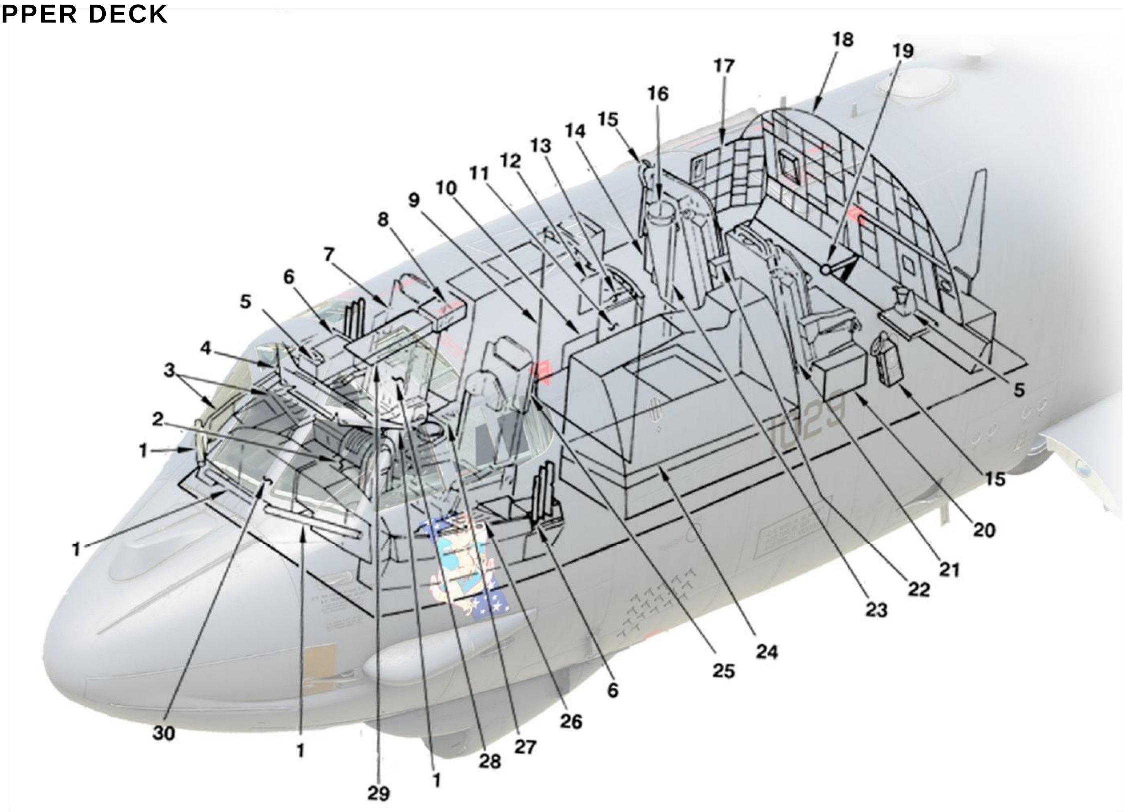
1	CREW COMPARTMENT	18	VORTEX GENERATORS
2	AFT EQUIPMENT COMPARTMENT	19	MISSILE SAFEING PINS AND STREAMERS STOWAGE
3	DRAG CHUTE COMPARTMENT	20	MISSILE GROUND SAFETY PIN INSTALLATION AND REMOVAL TOOL STOWAGE
4	FIRE CONTROL EQUIPMENT COMPARTMENT	21	AFT TRANSFORMER-RECTIFIER UNITS (3)
5	AFT ECM ANTENNA COMPARTMENT	22	AFT EQUIPMENT COMPART-MENT HATCH
6	AFT WHEEL WELL	23	DELETED
7	BOMB BAY	24	STARTER CARTRIDGE STOWAGE
8	DOPPLER ANTENNA COMPARTMENT	25	FORWARD TRANSFORMER-RECTIFIER UNITS (5)
9	FORWARD WHEEL WELL	26	EXTERNAL POWER RECEPTACLE (3)
10	EQUIPMENT DECK	27	AFT BATTERY
11	FORWARD ECM ANTENNA COMPARTMENT	28	FORWARD BATTERY
12	NOSE RADOME COMPARTMENT	29	MAIN ENTRY DOOR
13	COPILOT'S EJECTION HATCH	30	RADAR NAVIGATOR'S EJECTION HATCH
14	PILOT'S EJECTION HATCH	31	EVS STV TURRET
15	EW OFFICER'S EJECTION HATCH	32	NAVIGATOR'S EJECTION HATCH
16	GUNNERS EJECTION HATCH	33	FLIR TURRET
17	CHAFF DISPENSERS		

Figure 1-1 (Sheet 2 of 4)

General Arrangement Diagram (Typical)(Cont)

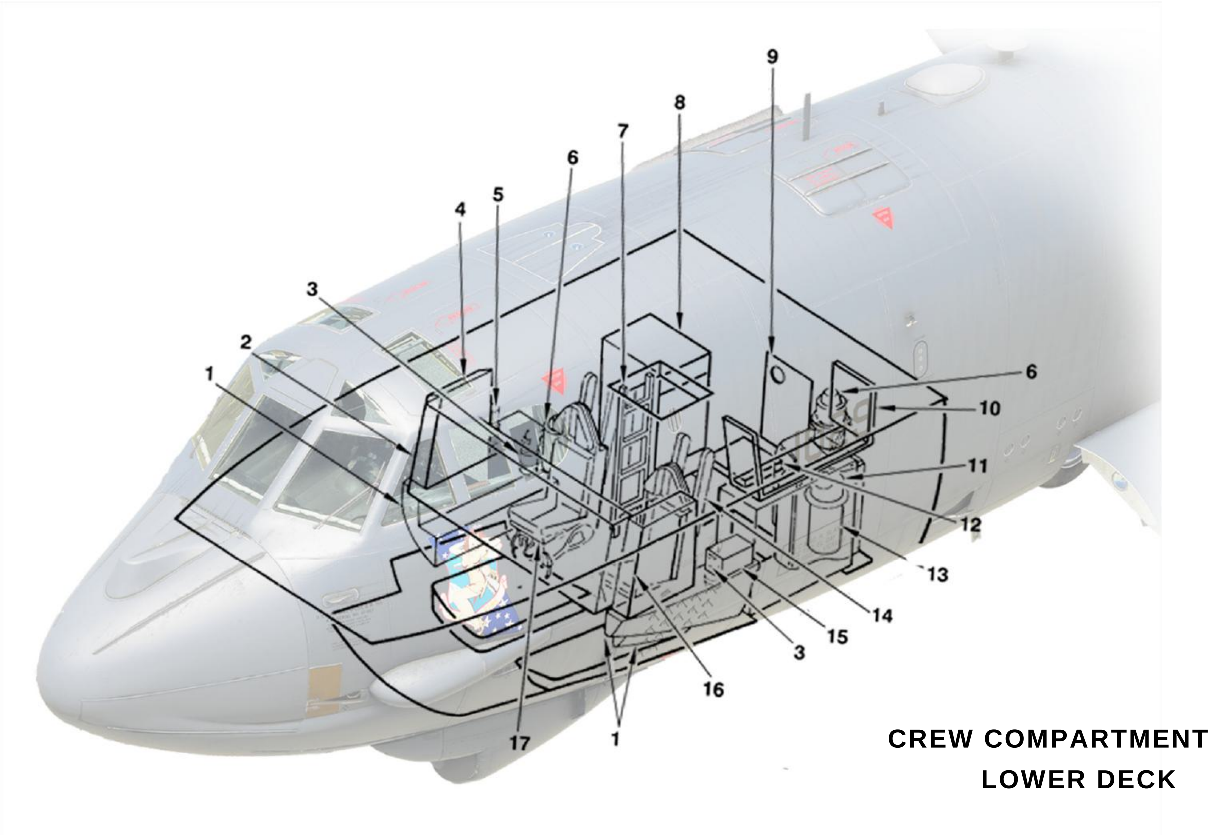
CREW COMPARTMENT

UPPER DECK



1	THERMAL CURTAIN
2	AISLE STAND
3	COPILOT’S SIDE PANEL
4	EYEBROW INSTRUMENT PANEL
5	HOT CUP
6	FOOD AND DATA BOX
7	COPILOT’S EJECTION SEAT
8	SIGNAL LIGHT
9	NIGHT FLYING CURTAIN
10	FOOD STORAGE CHEST
11	TOILET
12	FOOD WARMING OVEN
13	DEFENSE INSTRUCTOR’S SEAT
14	EW OFFICER’S FOOD STOWAGE BOXES
15	OXYGEN BOTTLE
16	PERISCOPIC SEXTANT MOUNT
17	EW OFFICER’S SIDE PANEL
18	DEFENSE STATION INSTRUMENT PANEL
19	MAIN REFUEL VALVE EMERGENCY CONTROL LEVER
20	GUNNER’S FOOD STOWAGE BOX
21	GUNNER’S EJECTION SEAT
22	EW OFFICER’S EJECTION SEAT
23	STANCHION
24	CREW BUNK
25	PILOT’S EJECTION SEAT
26	PILOT’S SIDE PANEL
27	INSTRUCTOR PILOT’S SEAT
28	PERISCOPIC SEXTANT CARRYING CASE
29	PILOTS’ OVERHEAD PANEL
30	PILOTS’ INSTRUMENT PANEL

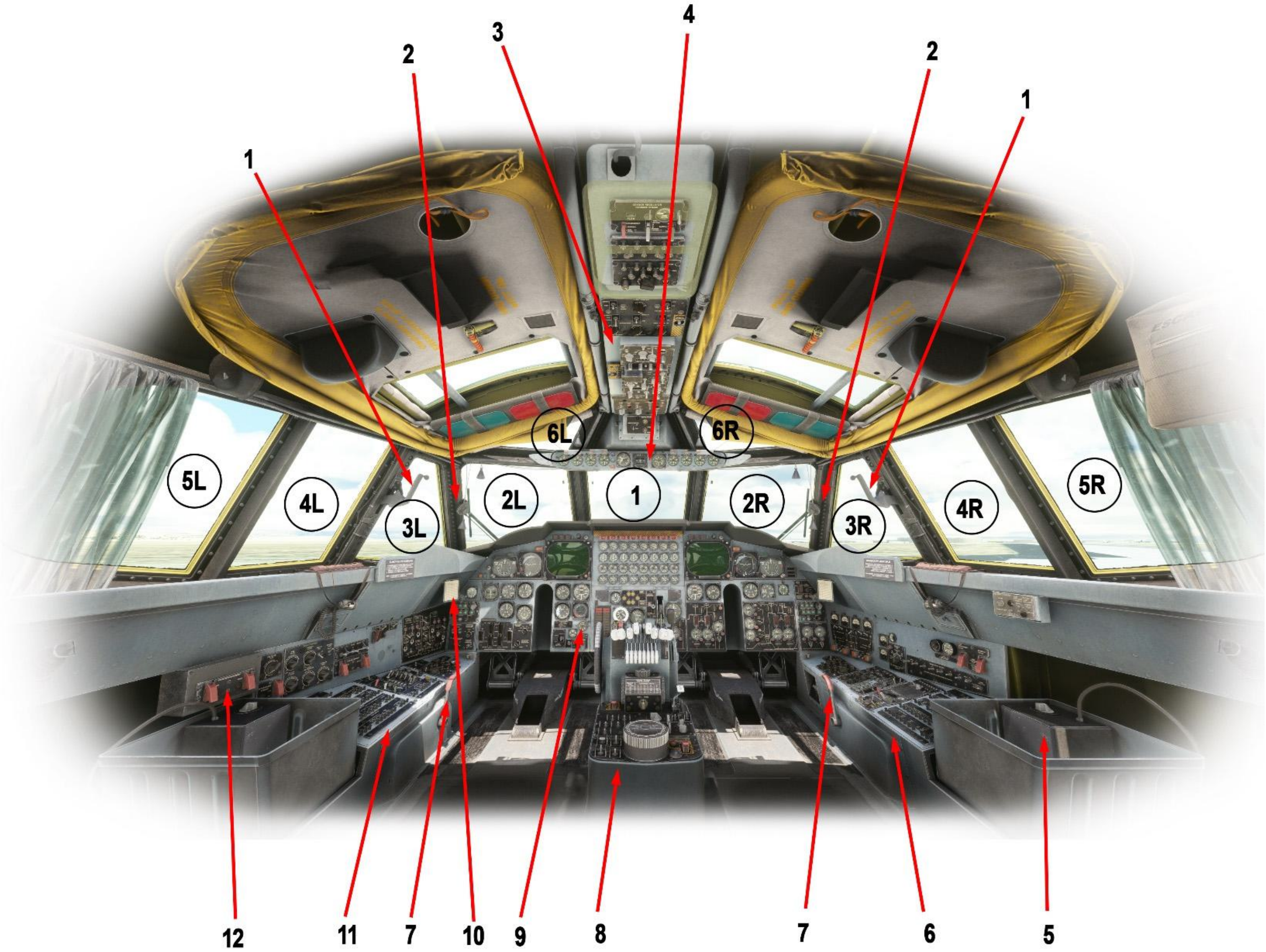
Figure 1-1 (Sheet 3 of 4)



1	MISCELLANEOUS EQUIPMENT SHELF
2	NAVIGATOR'S INSTRUMENT PANEL
3	OXYGEN BOTTLE
4	NAVIGATORS SIDE PANEL
5	HOT CUP
6	DRINKING WATER CONTAINER
7	LADDER
8	RIGHT EQUIPMENT RACK
9	PRESSURE BULKHEAD DOOR
10	LEFT EQUIPMENT RACK
11	CENTRAL URINAL
12	INSTRUCTOR NAVIGATOR'S TAKEOFF AND LANDING SEAT
13	POWER SUPPLY RACK
14	RADAR NAVIGATOR'S EJECTION SEAT
15	FOOD STOWAGE BOX
16	RADAR NAVIGATOR'S SIDE PANEL
17	NAVIGATOR'S EJECTION SEAT

Figure 1-1 (Sheet 4 of 4)

Pilots' Station



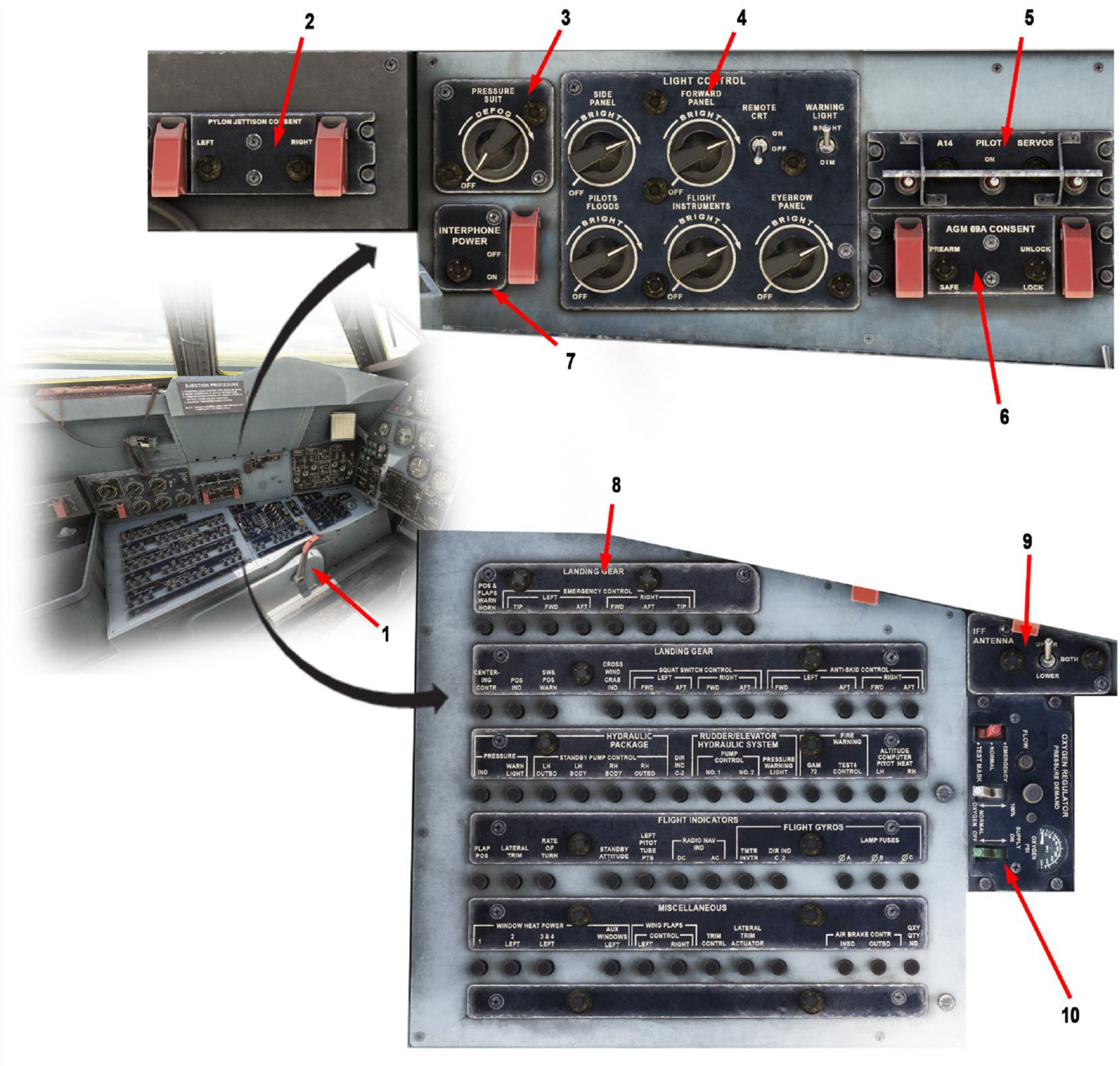
1 SLIDING WINDOW HANDLE
2 CHART HOLDER
3 OVERHEAD PANEL
4 EYEBROW INSTRUMENT PANEL
5 COPILOT'S AERP BLOWER MOUNTING BRACKET AND ELECTRICAL CONNECTOR
6 COPILOT'S SIDE PANEL
7 CONTROL COLUMN DISCONNECT LEVER
8 AISLE STAND
9 PILOTS' INSTRUMENT PANEL
10 ALTIMETER CORRECTION CARD AND HOLDER
11 PILOT'S SIDE PANEL
12 PILOT'S READINESS SWITCH ASSEMBLY

NOTE

Numbers in circles denote window numbers, windows 6L and 6R not anti-iced.

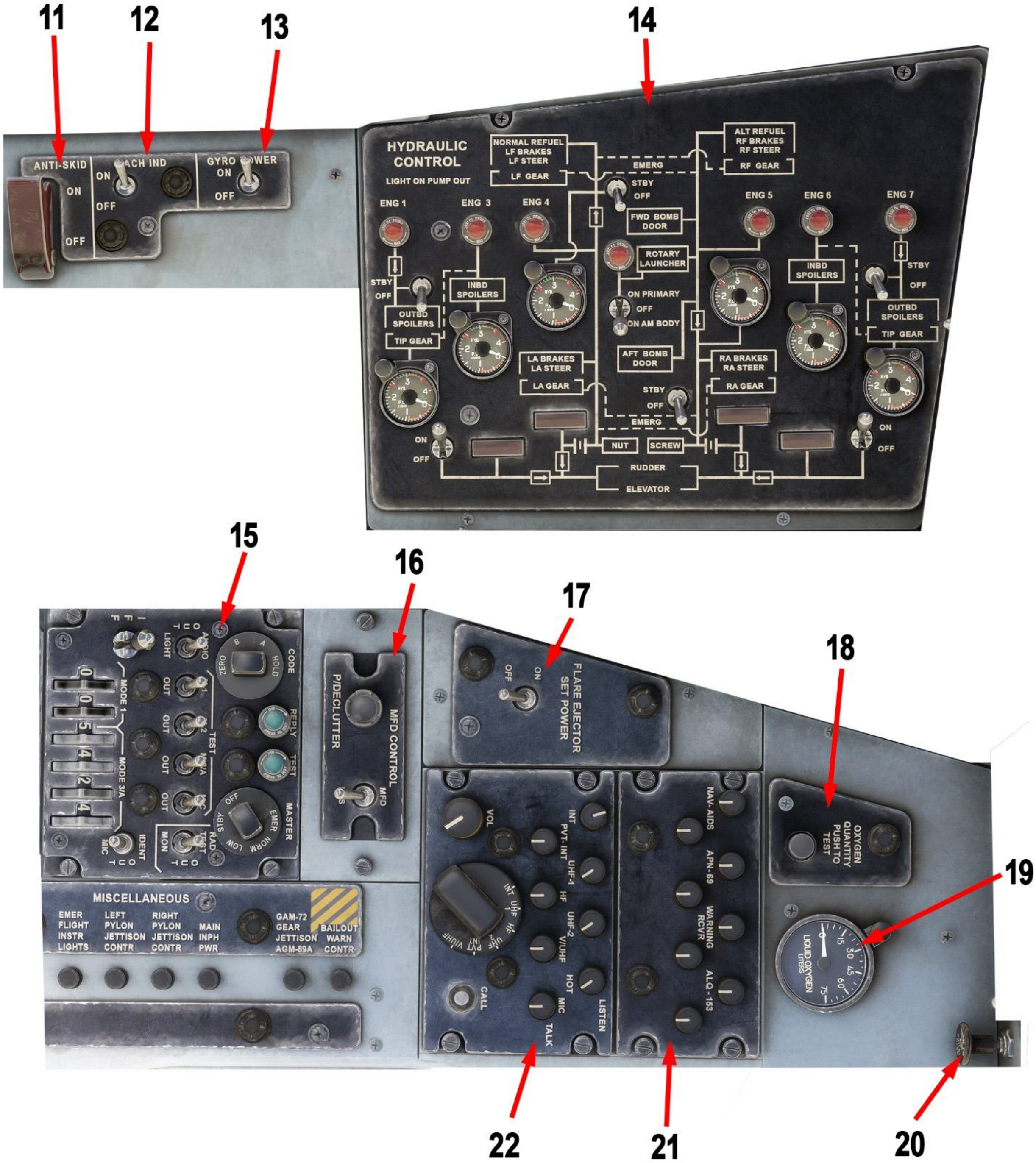
Figure 1-2

Pilot’s Side Panel (Typical)



1 CONTROL COLUMN DISCONNECT LEVER
2 PYLON JETTISON CONSENT PANEL
3 FACE PLATE DEFOG PANEL
4 PILOT’S LIGHTING PANEL
5 MUNITIONS CONSENT PANEL
6 AGM CONSENT
7 INTERPHONE POWER SWITCH
8 PILOT’S CIRCUIT BREAKER PANEL
9 IFF ANTENNA SWITCH PANEL
10 OXYGEN REGULATOR

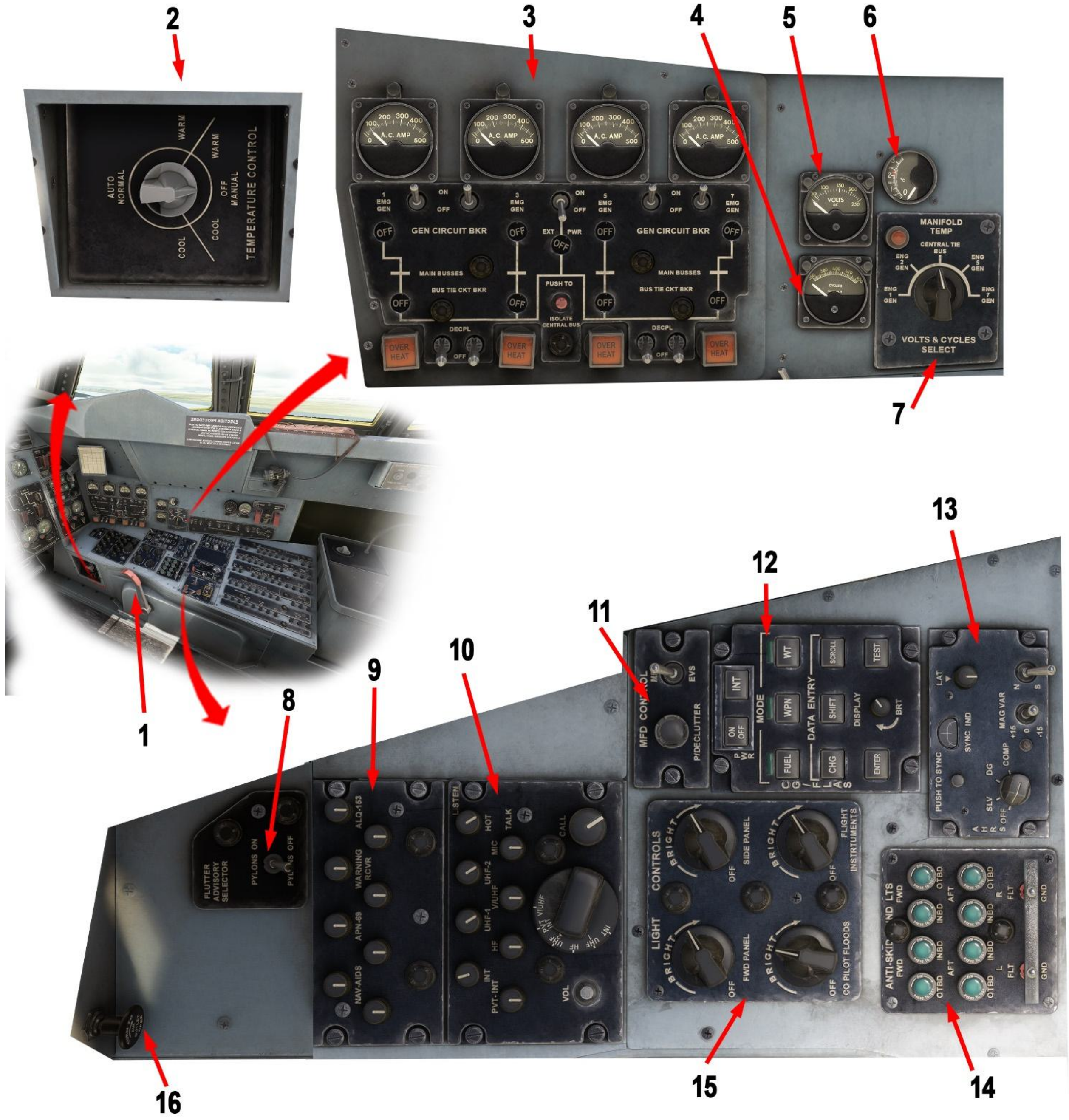
Figure 1-3 (Sheet 1 of 2)



11	**ANTISKID SWITCH**	**17**	**FLARE EJECTOR POWER**
12	**MACH INDICATOR SWITCH**	**18**	**OXYGEN QUANTITY TEST SWITCH**
13	**GYRO POWER SWITCH**	**19**	**OXYGEN QUANTITY GAGE**
14	**HYDRAULIC CONTROL PANEL**	**20**	**AIR OUTLET KNOB**
15	**IFF CONTROL PANEL**	**21**	**INTERPHONE MIXER PANEL**
16	**PILOTS MFD DISPLAY CONTROL PANEL**	**22**	**INTERPHONE CONTROL PANEL**

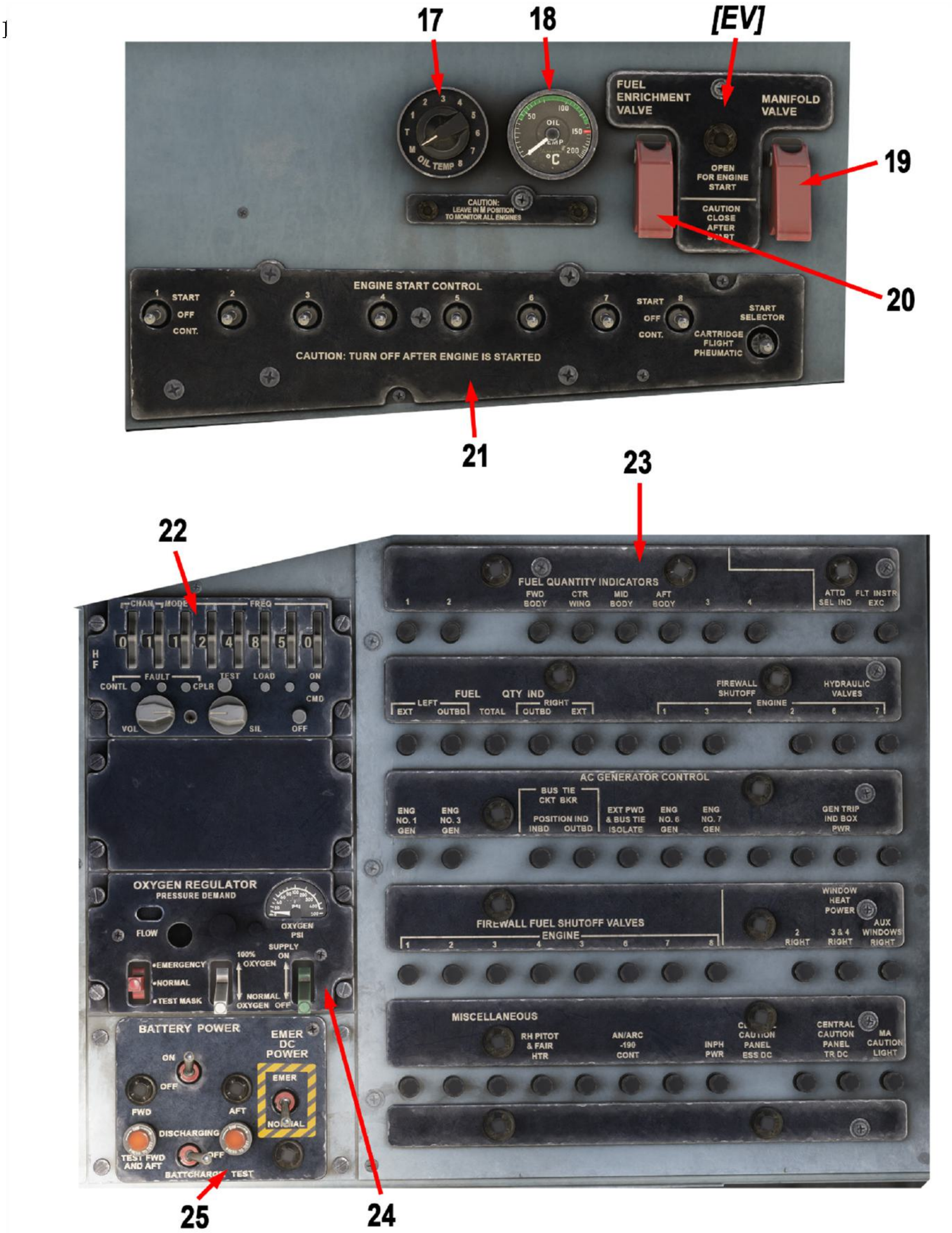
Figure 1-3 (Sheet 2 of 2)

Copilot's Side Panel (Typical)



1	CONTROL COLUMN DISCONNECT LEVER	9	INTERPHONE MIXER PANEL
2	TEMPERATURE CONTROL SWITCH	10	INTERPHONE CONTROL PANEL
3	AC CONTROL PANEL	11	COPILOTS MFD DISPLAY CONTROL PANEL
4	VOLTMETER	12	CG/FLAS CONTROL PANEL
5	FREQUENCY METER	13	AHRS CONTROL PANEL
6	MANIFOLD TEMPERATURE GAGE	14	ANTISKID CONTROL PANEL
7	FREQUENCY & VOLTMETER SELECTOR SWITCH	15	COPILOT'S LIGHTING PANEL
8	FLUTTER ADVISORY PANEL	16	AIR OUTLET KNOB

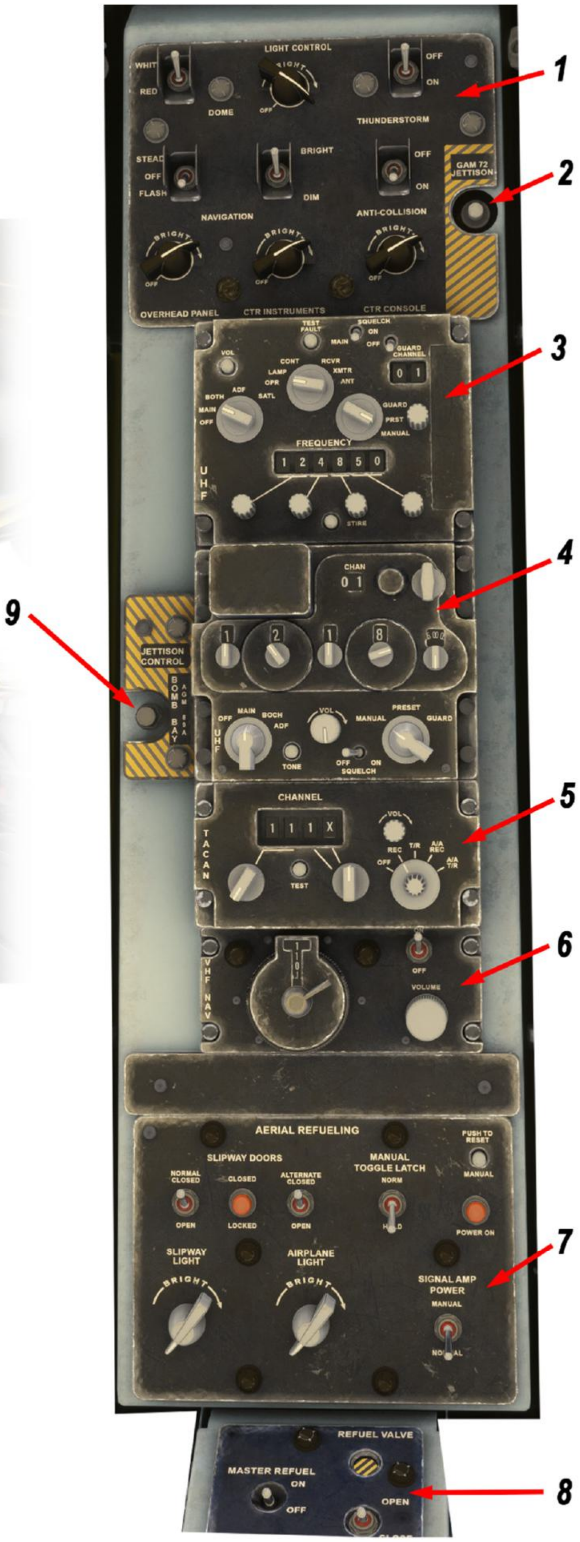
Figure 1-4 (Sheet 1 of 2)



17	**OIL TEMPERATURE SELECTOR**		
18	**ENGINE OIL TEMPERATURE GAGE**	22	**LIAISON RADIO (COM3) CONTROL PANEL**
19	**MANIFOLD VALVE SWITCH**	23	**COPILOT'S CIRCUIT BREAKER PANEL**
20	**FUEL ENRICHMENT VALVE SWITCH**	24	**OXYGEN REGULATOR**
21	**ENGINE START CONTROL PANEL**	25	**DC POWER SYSTEM CONTROL PANEL**

Figure 1-4 (Sheet 2 of 2)

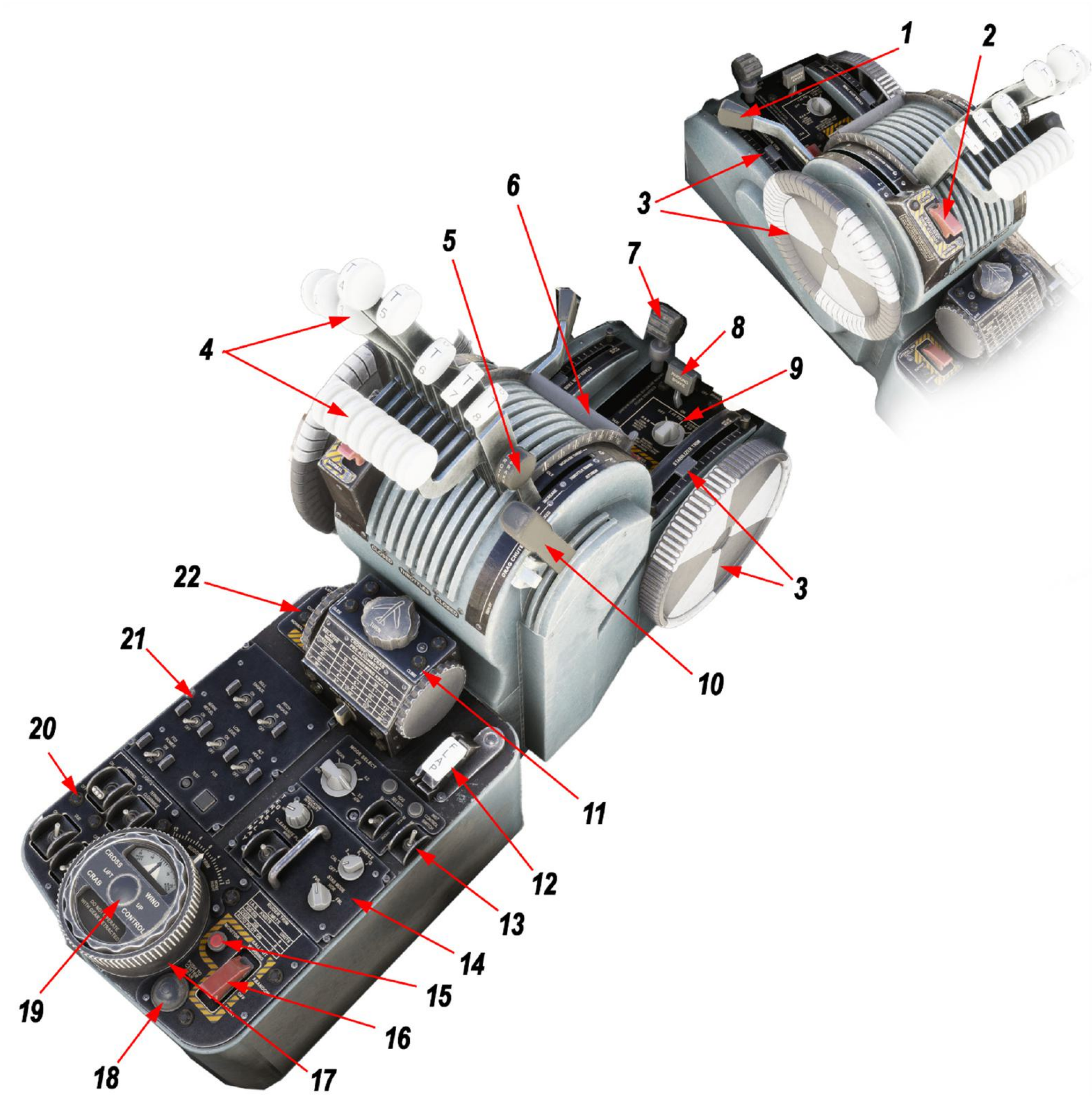
Overhead Panel (Typical)



1 OVERHEAD LIGHTING PANEL
2 GAM-72 (LAUNCH GEAR) JETTISON SWITCH
3 UHF (COM2) RADIO CONTROL PANEL
4 UHF (COM1) COMMAND RADIO CONTROL PANEL
5 TACAN RADIO (NAV1) CONTROL PANEL
6 VOR / ILS (NAV2) CONTROL PANEL
7 AIR REFUELING PANEL
8 REFUEL PANEL
9 PYLON JETTISON CONTROL PANEL

Figure 1-5

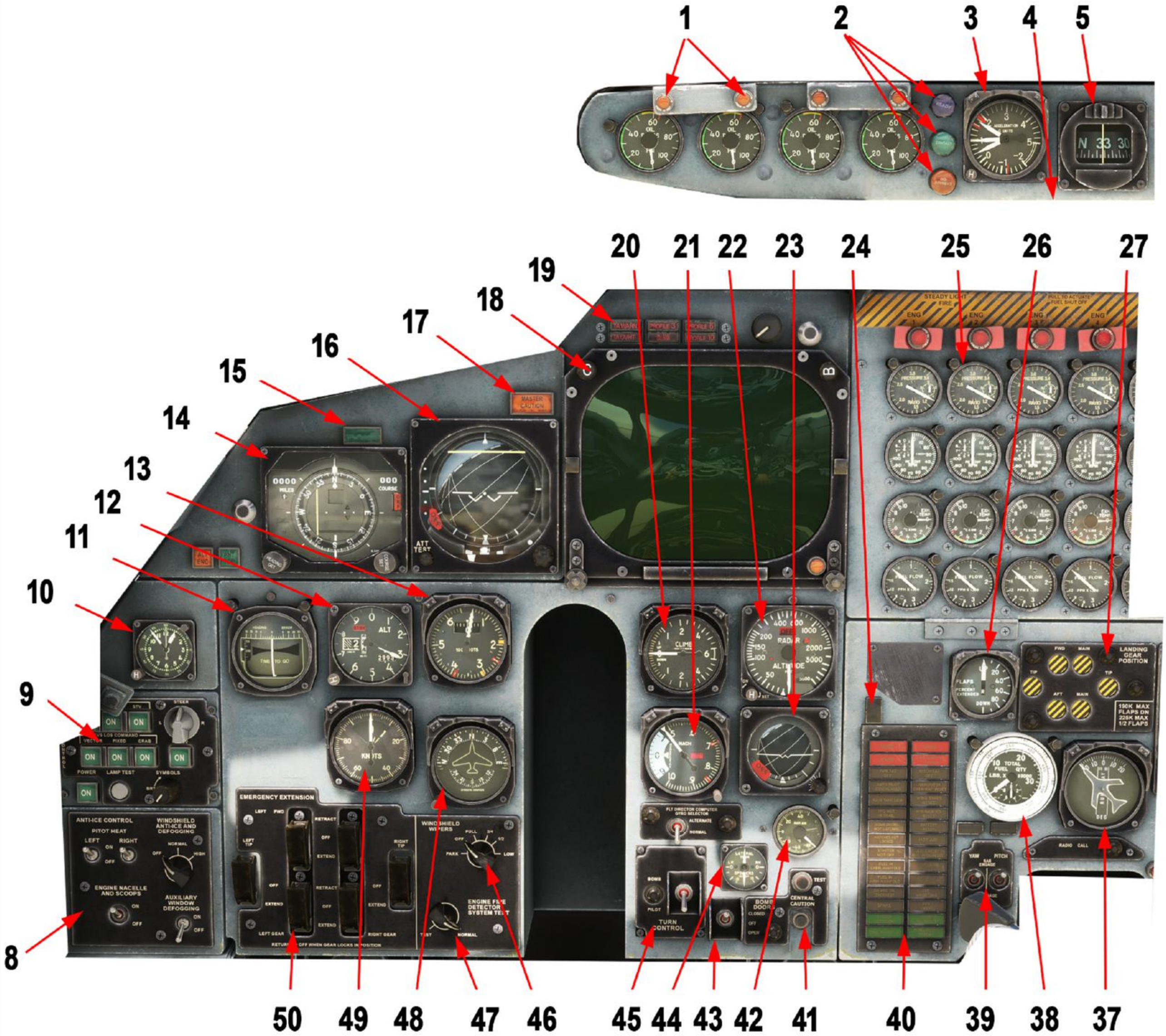
Aisle Stand



1	AIRBRAKE LEVER
2	STABILIZER TRIM CUTOUT SWITCH
3	STABILIZER TRIM WHEEL AND INDICATOR
4	THROTTLES
5	THROTTLE BRAKE LEVER
6	THRUST GATE
7	STEERING RATIO SELECTOR LEVER
8	PARKING BRAKE LEVER
9	AIR CONDITIONING PANEL
10	DRAG CHUTE LEVER
11	AUTOPILOT TURN AND PITCH CONTROLLER
12	WING FLAP LEVER
13	NAVIGATION SYSTEM SELECT PANEL
14	TERRAIN DISPLAY CONTROL PANEL
15	EMERGENCY ALARM MONITOR LIGHT
16	EMERGENCY ALARM SWITCH
17	RUDDER TRIM KNOB AND INDICATOR
18	CROSSWIND CRAB CONTROL CENTERING BUTTON
19	CROSSWIND CRAB CONTROL KNOB
20	LANDING LIGHTS PANEL
21	AUTOPILOT SWITCH PANEL
22	LATERAL TRIM CUTOUT SWITCH

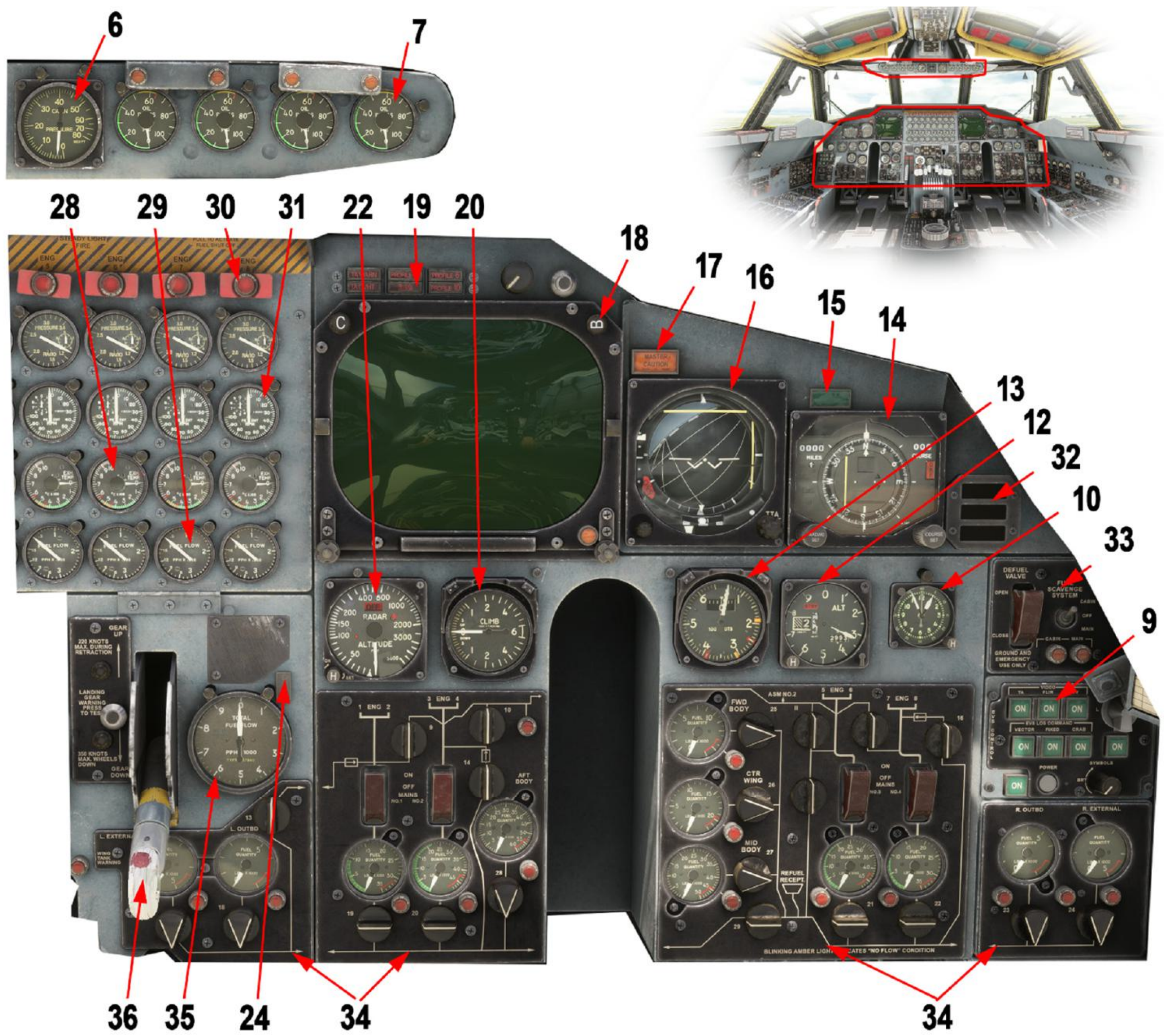
Figure 1-6

Pilots' Instrument Panel (Typical)



1 LOW OIL PRESSURE WARNING LIGHTS
2 AIR REFUELING LIGHTS
3 ACCELEROMETER
4 MAGNETIC STANDBY COMPASS CORRECTION CARD
5 MAGNETIC STANDBY COMPASS
6 CABIN ALTIMETER
7 OIL PRESSURE GAGES
8 ANTI-ICE CONTROL PANEL
9 EVS CONTROL PANEL
10 CLOCK
11 FLIGHT COMMAND INDICATOR
12 ALTIMETER
13 INDICATED AIRSPEED INDICATOR
14 HORIZONTAL SITUATION INDICATOR
15 MARKER BEACON LIGHT
16 ATTITUDE-DIRECTOR INDICATOR
17 MASTER CAUTION LIGHT
18 MFD / EVS MONITOR
19 EVS INDICATORS
20 VERTICAL VELOCITY INDICATOR
21 MACH INDICATOR
22 RADAR ALTIMETER
23 STANDBY ATTITUDE INDICATOR
24 RADAR ALTIMETER CAUTION LIGHT
25 ENGINE PRESSURE RATIO (EPR) GAGES

Figure 1-7 (Sheet 1 of 2)



26 WING FLAP POSITION INDICATOR
27 LANDING GEAR POSITION INDICATORS PANEL
28 EXHAUST GAS TEMPERATURE (EGT) GAGES
29 FUEL FLOWMETERS
30 ENGINE FIRE SHUTOFF SWITCHES
31 TACHOMETERS
32 CENTER OF GRAVITY/FUEL LEVEL ADVISORY SYSTEM (CG/FLAS) DISPLAY UNIT
33 FUEL SCAVENGE SYSTEM PANEL
34 FUEL SYSTEM MANAGEMENT PANEL
35 TOTAL FUEL FLOW INDICATOR
36 LANDING GEAR LEVER
37 CROSSWIND CRAB POSITION INDICATOR
38 TOTAL FUEL QUANTITY INDICATOR
39 SAS CONTROL PANEL
40 CENTRAL CAUTION PANEL
41 CENTRAL CAUTION PANEL RESET BUTTON
42 OUTSIDE AIR TEMPERATURE
43 BOMB DOORS SWITCH
44 LATERAL TRIM INDICATOR
45 AUTOPILOT TURN CONTROL SELECTOR SWITCH
46 WINDSHIELD WIPER SWITCH
47 ENGINE FIRE DETECTION SYSTEM TEST SWITCH
48 HEADING INDICATOR (GYRO)
49 TRUE AIRSPEED INDICATOR
50 LANDING GEAR CONTROL PANEL

Figure 1-7 (Sheet 2 of 2)

ENGINES

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ENGINE FUEL CONTROL SYSTEM 23
ENGINE IGNITION AND STARTING SYSTEM 25
NORMAL OPERATION 33

DESCRIPTION

Eight Pratt & Whitney Model TF33-P-3 turbofan engines (figure 1-30) are installed on the aircraft. The low pressure compressor on these engines consists of a compressor and fan assembly. The first and second stage rotor blades are longer than those of the remaining stages of the compressor and comprise the fan portion of the turbofan engine.

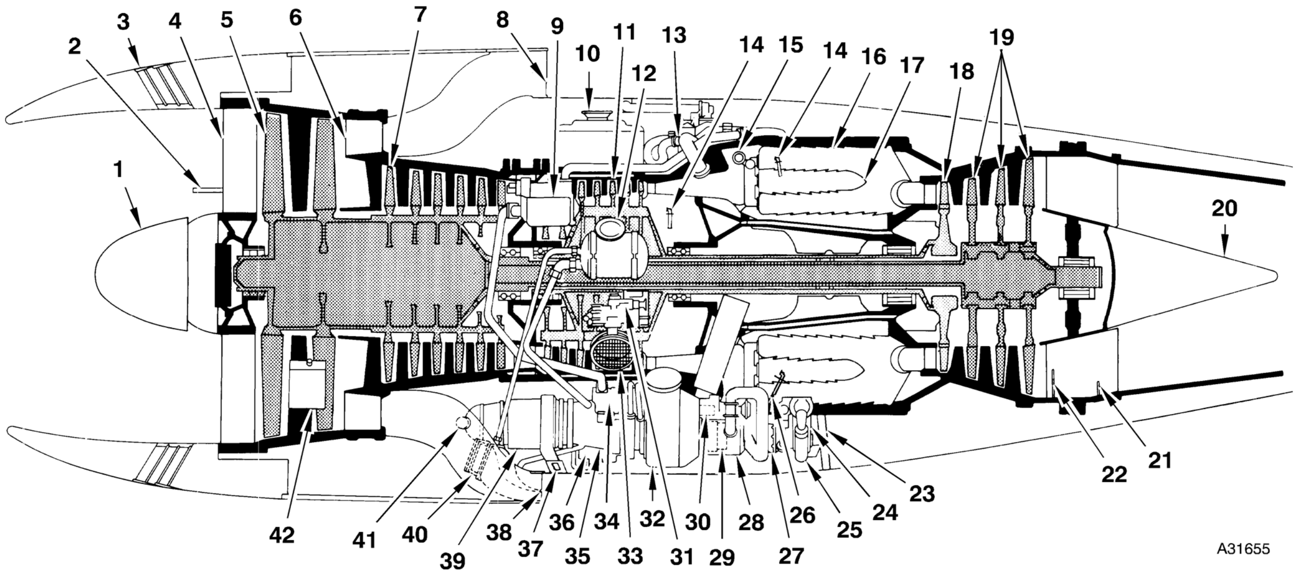
The engines are trimmed per “flat rated” engine trim procedures. Takeoff rated thrust is obtained by adjusting the throttles to a predetermined value of engine pressure ration (EPR) as determined from a takeoff rated thrust EPR curve for the prevailing conditions of field barometric pressure and runway temperature. At ambient temperatures below 100°F, takeoff rated thrust will be obtained at throttle settings below the full forward position.

The engines are mounted in pairs in four nacelles suspended below the wings and are numbered in the conventional manner from left to right 1 thru 8. The nacelles are also numbered in this manner with engines 1 and 2 in No. 1 nacelle, engines 3 and 4 in No. 2 nacelle, engines 5 and 6 in No. 3 nacelle, and engines 7 and 8 in No. 4 nacelle. In each nacelle pod, diametrically shaped fin exhaust air ducts are located outboard around each engine and inboard between engines below the strut structure from which the engines are suspended. The nacelle pod cowling is attached to engine and strut structure and to mating cowling by a series of hooks, pins, and quick-release latches to provide easy access to the engines. Cowling for each nacelle pod consists of a nose cowl for each engine, a left and right upper and lower wrap cowl, and a left and right upper and lower afterbody cowl. The wrap cowling covers the fan case and a portion of the turbofan exit ducts. The afterbody cowling covers the engine accessories and the remainder of the engine from the fan bypass duct exit to the aft end of the tailpipe. Airflow from the engine fan exit ducts is discharged axially over the afterbody cowling. Openings are provided in the cowling for servicing and to facilitate maintenance. The nose cowl, together with the nose dome, forms the engine air inlet. Eight auxiliary air inlet doors are provided in the cowl to allow a sufficient volume of air to enter the engine during ground operation and takeoff. The doors, which are spring-loaded to the closed position, are opened by differential pressure. Mach number, engine thrust setting, and aircraft angle- of-attack determine the differential pressure felt by each door. During ground operation, the doors open because of the pressure across them and assist in producing a more uniform pressure at the engine inlet. For usual flight operation, the doors close during the initial portion of climb and remain closed until landing pattern maneuvers.

The engines are identical with exception of the installation of engine-mounted accessories. The accessories are driven from an engine accessories gearbox by means of a shaft which is mechanically geared directly to the main shaft connecting the first stage turbine to the high pressure compressor. A 120 KVA generator is installed in a lower center position of engines 1, 3, 5, and 7. Generator rpm is maintained by use of a constant speed hydraulic drive installed on the same engines. A constant speed drive air-oil cooler is located aft of the generator in the area of the turbofan exit duct where engine fan air used for cooling is exhausted overboard. Fan air is diverted into special ducts for cooling of 120 KVA generators and is exhausted overboard from under the afterbody cowl. An engine-driven variable delivery hydraulic pump is installed on the lower right side of engines 1, 3, 4, 5, 6, and 7. An electrically controlled air-drive starter is installed on the lower side of each engine. All engines have cartridge start capability. The accessory drive gearbox is also utilized for mounting the accessories necessary for engine control such as the engine fuel pump, hydromechanical fuel control unit, tachometer generator, and oil pressure transmitter. For engine thrust rating information, see figure 1-30.

Engine circuit protection and the location of the applicable circuit breakers is contained in figure 1-34.

The Engine



TYPE TF33-P-3

1 NOSE DOME
2 EPR PROBE (INLET PRESSURE
3 AUXILIARY AIR INLET DOORS
4 INLET GUIDE VANES
5 LOW PRESSURE COMPRESSOR, FAN STAGES
6 FAN AIR EXIT VANES
7 LOW PRESSURE COMPRESSOR, BLADE STAGES
8 FAN AIR DUCT EXIT
9 FUEL STRAINER
10 OIL TANK, ENGINE
11 HIGH PRESSURE COMPRESSOR
12 OIL TANK, CONSTANT SPEED DRIVE
13 BLEED AIR DUCT
14 FIRE DETECTORS (ON ENGINE FIREWALL)
15 FUEL MANIFOLD (DUAL)
16 COMBUSTION CHAMBER
17 COMBUSTION CHAMBER CENTER TUBE
18 FIRST STAGE TURBINE
19 2ND, 3RD, AND 4TH STAGE TURBINES
20 EXHAUST CONE
21 EGT PROBE
22 EPR PROBE(EXHAUST PRESSURE)
23 FIRE SEAL
24 FUEL OIL COOLER
25 FUEL FLOWMETER
26 ENGINE IGNITER
27 PRESSURIZING AND DUMP VALVE
28 STARTER
29 HYDRAULIC PUMP
30 TACHOMETER GENERATOR
31 SURGE BLEED VALVE ACTUATOR AND GOVERNOR
32 ACCESSORY DRIVE CASE
33 SURGE BLEED VALVE PORT
34 FUEL PUMP
35 CONSTANT SPEED DRIVE
36 FUEL CONTROL UNIT
37 GENERATOR COOLING AIR OUTLET
38 CSD OIL COOLER AIR OUTLET
39 AC GENERATOR
40 CSD OIL COOLER
41 GENERATOR COOL AIR INLET
42 IGNITION UNIT

ENGINE DRIVEN ACCESSORIES

ENGINE NUMBER	1	2	3	4	5	6	7	8
HYDRAULIC PUMP	X		X	X	X	X	X	
AC GENERATOR & CONSTANT SPEED DRIVE	X		X		X		X	

ENGINES	THRUST IN POUNDS AT SEA LEVEL ICAO STANDARD DAY			MATERIAL
	TAKEOFF RATED THRUST	MILITARY RATED THRUST	NORMAL RATED THRUST	
TF33-P3	17,000	16,500	14,500	TITANIUM

Figure 1-30

ENGINE AIR BLEED

Pneumatic power is provided for engine starting, control cabin air conditioning, anti-icing of the left wing air conditioning ram airscoop, and pressurization of the hydraulic systems reservoirs. For further information on the above uses of engine bleed air, see PNEUMATICS, this section. In addition to the above uses of high-pressure compressor bleed air which is taken directly from the main manifold of the pneumatic system, 16th stage engine bleed air is also used for pressurization of the constant speed generator drives and the oil tank for each drive. Operation of the engine bleed valve actuators allows bleeding of the 9th stage low compressor pressure (for prevention of hung starts and engine stall), and for anti-icing of engine nacelle cowls, inlet guide vanes, nose domes, and inlet pitot tubes for the engine pressure ratio (EPR) transducers. In addition to the utilization of engine bleed air, turbofan discharge air is used for generator cooling and constant speed drive oil cooling. Bleed air obtained from the body manifold is regulated for pressurization of the missile environmental system air ducts. Right body manifold bleed air is used for anti-icing of the missile ram airscoop located in the leading edge of the right wing.

ENGINE FUEL CONTROL SYSTEM

An engine fuel control system on each engine automatically provides optimum engine performance for any throttle setting. This system makes it unnecessary to make throttle adjustments to compensate for variations in inlet temperature, altitude, or airspeed. Fuel from the tanks is routed through the fuel supply system to fuel control units which meter fuel to each engine. The throttle provides basic engine thrust control and operates through the fuel control unit to position a throttle valve. Engine fuel from the fuel supply system is also controlled by an electrically operated firewall fuel shutoff valve. Power to open this valve is supplied by the fire shutoff switch when the throttles are moved from CLOSED. This allows fuel under boost pump pressure to reach a two-stage engine-driven fuel pump. A bypass valve is provided to allow fuel to bypass the first pump stage in the event of failure. Output from the pump is delivered to the fuel control unit.

Throttles

Eight throttles (12, figure 1-33) on the aisle stand control the firewall fuel shutoff valves and the throttle valves. The throttle quadrant is marked CLOSED- -IDLE- -OPEN. In CLOSED position, essential dc power is supplied to close the firewall fuel shutoff valves. Advancing the throttles out of CLOSED position provides power to open the firewall fuel shutoff valves provided the fire shutoff switches have not been pulled (figure 1-32). At the same time, provided the engine starter switch is in START position, essential dc power is supplied to the engine ignition circuit. (When in flight with the starter switch in CONT position, 115 volt ac power will be supplied.) See START-

ER SWITCH, this section. With the throttles advanced approximately 18° from CLOSED position, the fuel control sequencing valves are positioned to provide fuel pressure for closing the fuel dump valves; metered fuel under pressure is then supplied to the primary manifold of each engine. Advancing the inboard nacelle engine throttles 3 and 5 or 4 and 6 to approximately 75% rpm (approximately 45° throttle) completes the flaps up warning circuit which sounds the warning horn if the aircraft is on the ground and the flaps are not fully extended. Retarding a throttle near the IDLE position when the landing gear is not down and locked completes a circuit providing TR power to the landing gear warning horn. Except for the two center throttles, each throttle has a different height from the adjacent throttle and is separated from the others by being slightly bent outboard for selectivity and ease of operation of individual engines. This facilitates ground handling of the aircraft and thrust settings at the pilot's discretion. A mechanical stop is provided on the throttles which prevents their being retarded to CLOSED unless each throttle knob is raised approximately 1/4 inch. An individual smaller throttle lever and knob is integrally connected to each large throttle to serve as a one-hand multiple grip for operation of the eight engines simultaneously. These are located aft of the large throttles and are spaced close together for convenience of use by the pilots.

Engine Fuel Enrichment System

The fuel enrichment system is used for ground starting of cold soaked engines at low temperatures (when the outside air temperature is at or below zero degrees Celsius) and air starting engines above 15,000 feet when using JP-5, JP-8, or JET A/A1 fuels. The FEV may also be used for starts when the temperature is 32° to 40°F. This system is not required with JP-4 fuel.

The system is made up of two major components, a fuel enrichment valve (FEV) and an auxiliary throttle valve (ATV). When the fuel enrichment valve switch on the copilot's side panel (19, figure 1-33) is set to OPEN, the system energizes the FEV. The FEV then supplies fuel under pressure to the ATV. The ATV is mechanically connected to the throttle valve. When the throttle opens during engine start the mechanical connection opens the ATV for additional fuel flow. As the engine RPM increases, the mechanical connection closes the ATV. The additional fuel from the ATV is completely shut off when the engine fuel flow reaches 1500 pph.

Throttle Positions Chart

THROTTLES POSITION	PERCENT RPM	FIREWALL FUEL SHUTOFF VALVE POSITION	IGNITION	FUEL PRESSURIZING AND DUMP VALVE	WARNING HORN
CLOSED	0%	CLOSED	Not Available	Open	
Advanced		Open unless engine fire shutoff switch is pulled	Available when throttle is advanced from CLOSED with engine starter switch in START.		
18° approx	(Starting)			Closed. Metered fuel under pressure is supplied to primary manifold.	
IDLE					Energized if throttle is retarded when landing gear is not down and locked.
45° approx.	75% approx.				Energized if aircraft is on the ground and the flaps are not fully extended.
Cruise	84 to 94%				
OPEN	106.7% max.				

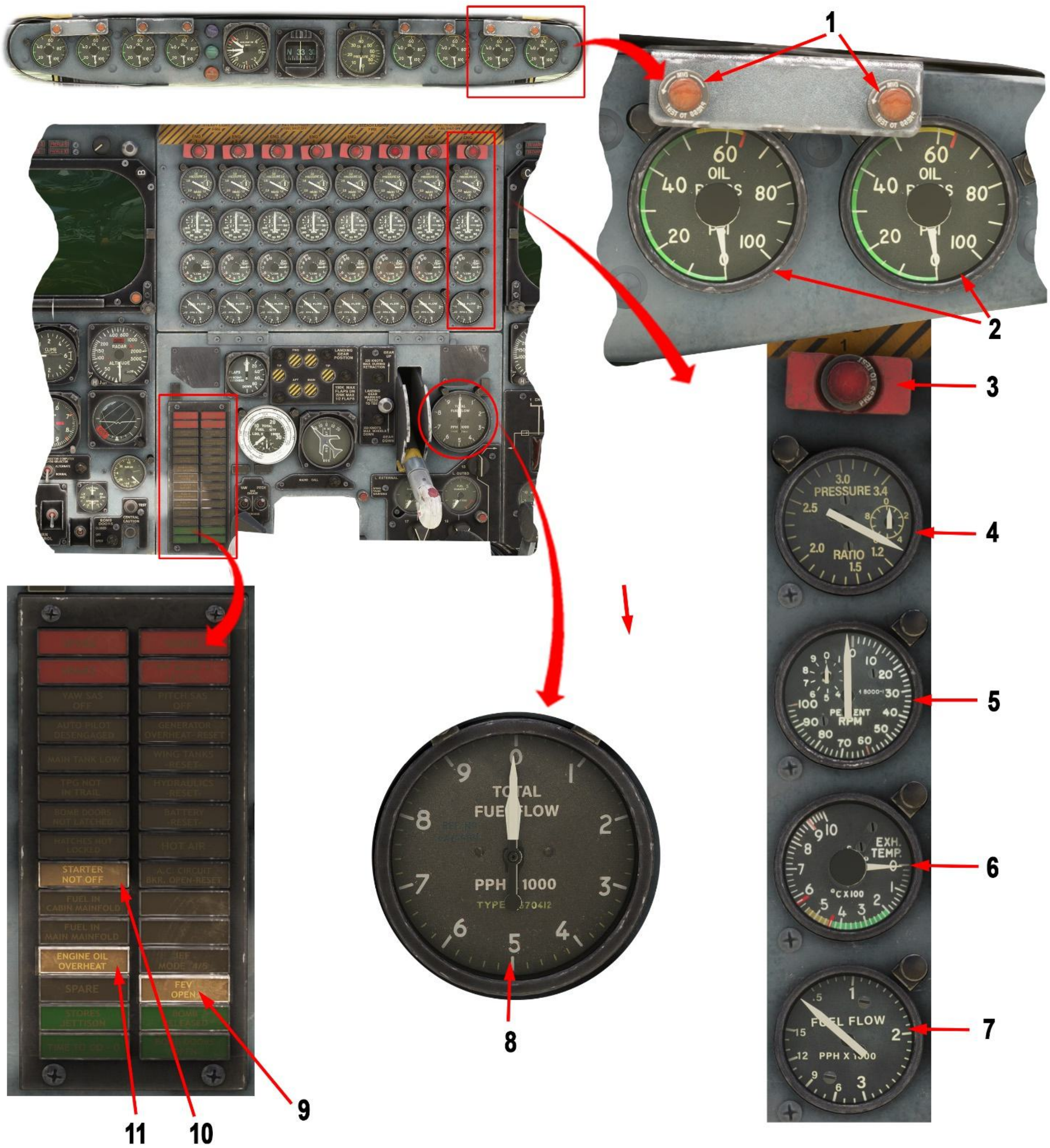
Figure 1-32

ENGINE IGNITION AND STARTING SYSTEM

A turbine-driven starter is provided on each engine. The starter turbine may utilize either low pressure bleed air obtained from a ground source or from an operating engine through the air bleed system or may utilize high pressure gas generated by burning a solid propellant cartridge. Starter operation is basically the same for pneumatic or cartridge operation with the major difference being the temperature and pressure of the two gases. The bleed air enters the starter turbine at a temperature of 500°F or less, while the cartridge-produced gas enters at a temperature in excess of 2100°F. Each starter unit consists of a turbine, gear train, and an overrunning clutch. In addition, the cartridge starter has a breech chamber with breech cap and locking handle, a pressure modulating valve, and the necessary electrical components for cartridge ignition and starter control. The cartridge cannot be ignited unless the breech is properly installed and the lock handle is in the proper position. The pressure modulating valve maintains proper operating pressure and, in case of malfunction, relieves pressure to safe limits. As engine rpm exceeds starter rpm, the overrunning clutch releases to prevent the starter turbine from being driven to an overspeed condition. When starting with compressed air, a centrifugal switch monitors rpm at the starter mounting pad and, as a specified rpm is reached, breaks the circuit to the starter control valve solenoid, allowing the valve to close and shut off the starter air supply. Each starter is geared to the high pressure compressor of the engine on which it is installed. Since the primary purpose of the cartridge-pneumatic starter is to provide for operation without need for auxiliary air and electrical power supply, provision (24, sheet 2 of figure 1-1) has been made to carry eight spare cartridges in the aircraft. Since all eight engines have cartridge-pneumatic starters, provisions are made in the electrical supply system for cartridge starting all engines simultaneously to accomplish a "quick start." These provisions also include the capability to start all engines from a single battery in the event of failure of one. The switching of the start functions to the good battery is automatic and cannot be controlled by the pilot.

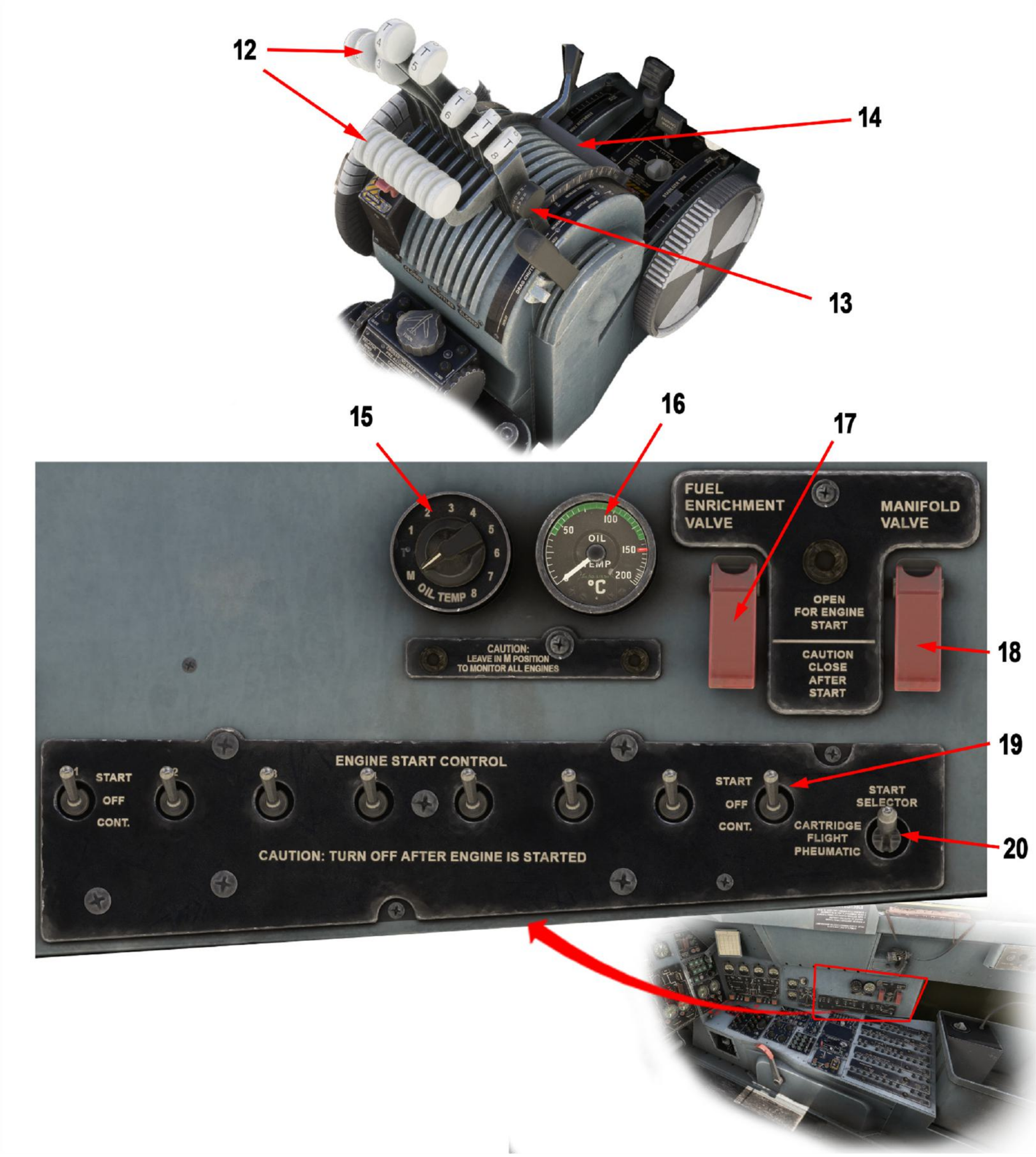
A dual ignition system is installed, having an intermittent duty dc system for starting and a continuous duty ac system for prevention of flameout. Engine ignition is accomplished by spark ignitors located in the combustion chambers of each engine. Ignition is under control of eight starter switches, a start selector switch, and the throttles. These controls may be used to obtain starts on the ground in any combination of engines from single to all, either pneumatic or cartridge. In flight, these controls are used for all combinations of air starts. Power for starting ignition is essential dc power. Outboard engine ignition systems are supplied power from the left essential dc start bus. Inboard engine ignition systems are supplied power from the right essential dc start bus. Under battery only operation, these start buses will be automatically connected to the good battery if one were to fail. AC power is used for continuous ignition.

Engine Controls and Indicators



1 LOW OIL PRESSURE WARNING LIGHT (8)
2 OIL PRESSURE GAGE (8)
3 ENGINE FIRE SHUTOFF SWITCH (8)
4 EPR GAGE (8)
5 TACHOMETER (8)
6 EXHAUST GAS TEMPERATURE GAGE (8)
7 FUEL FLOW METER (8)
8 TOTAL FUEL FLOW METER
9 FEV OPEN CAUTION LIGHT
10 STARTER NOT OFF CAUTION LIGHT
11 ENGINE OIL OVERHEAT CAUTION LIGHT

Figure 1-33 (Sheet 1 of 7)



12 **THROTTLES (8)**
13 **THROTTLE BRAKE LEVER**
14 **THRUST GATE**
15 **OIL TEMPERATURE SELECTOR SWITCH**
16 **OIL TEMPERATURE GAGE**
17 **FUEL ENRICHMENT VALVE SWITCH**
18 **MANIFOLD VALVE SWITCH**
19 **ENGINE START SWITCH (8)**
20 **ENGINE START SELECTOR SWITCH**

Figure 1-33 (Sheet 2 of 7)

NO.	CONTROL-INDICATOR	FUNCTION
		NOTE To more readily identify a malfunctioning engine, a yellow vertical stripe is painted between the left-hand and right-hand bank of engine instruments (between engines 4 and 5).
1	Low Oil Pressure Warning Lights (8)	Low engine oil pressure is indicated by eight amber low oil pressure warning lights located over each oil pressure gage on the eyebrow instrument panel. A pressure switch is installed on each engine that will cause the light to come on when a decreasing oil pressure reaches 37 (±2) psi and turn the light off when an increasing oil pressure reaches 37 (±2) psi. These lights will complement the oil pressure indicating system to provide a cross-check to establish if a malfunction is occurring in the oil pressure indicating system or in the engine. All lights have a press-to-test feature and have provisions for manually dimming or shading. The low oil pressure warning lights operate on TR power.
2	Oil Pressure Gages (8)	Indicates engine oil pressure in increments of 5 psi. **NOTE** ● If the oil pressure circuit breaker has popped out, oil pressure indicators are inoperative. ● Oil pressure will have a tendency to follow the throttle due to the type of oil pressure relief valve installed. This condition is normal provided the oil pressure stabilizes between the minimum and maximum limits.
3	Engine Fire Shutoff Switches (8)	A fire shutoff switch is provided for shutoff of fuel to each engine. Each switch closes a corresponding engine firewall fuel shutoff valve when pulled out to the FIRE SHUTOFF position, regardless of throttle position. A red fire warning light is an integral part of each switch. For other switch functions, see ENGINE FIRE SHUTOFF SWITCHES, described under EMERGENCY EQUIPMENT, this section.
4	Engine Pressure Ratio (EPR) Gages (8)	An engine pressure ratio (EPR) gage for each engine is located on the pilots' instrument panel. These gages indicate the ratio of engine inlet to exhaust pressures which is used as a measure of engine thrust. The engine inlet and exhaust indications are compared by a computer-transmitter which electrically transmits an indication to the engine pressure ratio gage.
5	Tachometers (8)	Speed of the high pressure compressor rotor in percent rpm is indicated by eight tachometers on the pilots' instrument panel. Engine driven tachometer generators supply power to operate the indicators which are independent of the aircraft electrical system. Each instrument has two pointers. The larger pointer indication is read on a dial calibrated from 0% to 100% rpm. The small pointer indication is read on a dial calibrated from 0% to 10% rpm.

Figure 1-33 (Sheet 3 of 7)

NO.	CONTROL-INDICATOR	FUNCTION
6	Exhaust Gas Temperature Gages (8)	Exhaust gas temperature of each engine is indicated by eight gages on the pilots' instrument panel. These gages are calibrated in degrees centigrade and indicate the temperature of the exhaust gases of each engine. Engine thermocouples supply power to operate the gages which are independent of the aircraft electrical power system.
7	Fuel Flowmeters (8)	Fuel flow to the engine is shown by eight fuel flowmeters on the pilot's instrument panel. These indicators read in pounds per hour and operate on TR power.
8	Total Fuel Flow Indicator	A total fuel flow indicator is located on the pilots' instrument panel. This instrument uses 115 volt ac power to electrically add the flow rates indicated on the eight individual fuel flowmeters. The totalizer indication is accurate within ±3% when all engines are operating.
9	FEV OPEN Caution Light	The amber fuel enrichment valve (FEV) open caution light comes on any time the FEV switch is in the OPEN position. It is a reminder to place the FEV switch to CLOSE after engine start. This will prevent possible damage to the valve solenoid resulting from continuous operation. It should be noted that the auxiliary throttle valve will close automatically when the total fuel flow reaches 1500 pph, however, the fuel enrichment valve will remain energized and open and the light will remain on until the FEV switch is placed to the CLOSE position.
10	STARTER NOT OFF Caution Light	An amber starter-not-off caution light on the central caution panel is marked STARTER NOT OFF. The light is illuminated by right essential bus power when a starter switch is left in START position and, even though the starter may be disengaged due to engine acceleration, the light will indicate that power for ignition is available until shut off by the starter switch.
11	ENGINE OIL OVERHEAT Caution Light	An amber engine oil overheat light on the central caution panel illuminates to read ENGINE OIL OVERHEAT when an oil temperature of 135° to 142°C or higher occurs on any engine. The engine oil overheat light may illuminate at temperatures of –10°C and below if the oil temperature selector switch (No. 16) is positioned in M or any of the eight engine positions; however, the light will immediately be extinguished when the engines are started. Due to extremely cold temperatures, an actuating cam within the gage, as well as the pointer, may rotate counterclockwise until the overheat light switch within the gage is contacted, causing the light to illuminate. Placing the temperature selector switch in T position will cause the actuating cam to move clockwise and extinguish the light as the pointer moves beyond the comparative point of contact of the actuating cam. If the light is out for all temperatures in the –10° to +135°C range, operation is satisfactory.
12	Engine Stall Prevention (ESP) Switch	An engine stall prevention (ESP) switch is located on each of the pilot's control wheels and is used to prevent engine stall due to crosswind during engine ground operation. These pushbuttons are also used as the autopilot and air refueling boom release switches. When either engine stall prevention switch is depressed, TR power is supplied to energize solenoid-operated valves which cause the compressor surge bleed valves to open on all operating engines while on the ground. When the switch is released, the surge bleed valves return to normal scheduled operation. For additional functions of this switch, see AUTOPILOT and AIR REFUELING, this section.

Figure 1-33 (Sheet 4 of 7)

NO.	CONTROL- INDICATOR	FUNCTION
13	Throttles (8)	Eight throttles on the aisle stand control engine ignition. Advancing a throttle out of CLOSED position will supply essential dc power for starting ignition to that engine if the starter switch is in START or will supply ac power for continuous ignition if the starter switch is in CONT. Returning the throttle to closed cuts off ignition power. **NOTE** Because of forward throttle creep when the throttles are positioned above IDLE setting, a potential flight safety hazard exists at any time a constant throttle setting is desired with the throttle brake lever OFF. The condition exists because of induced torque from the fuel control unit and results in making precise thrust adjustments difficult as well as creating high throttle retarding forces.
14	Throttle Brake Lever	A throttle brake lever on the aisle stand to the right of the throttles is used to adjust the amount of force necessary to move the throttles. When in OFF (aft) position, the throttle brake is released. Moving the throttle brake lever in the INCREASE (forward) direction increases throttle friction.
15	Thrust Gate	An adjustable thrust gate spans the throttle quadrant forward of the throttles to provide a means of restricting forward travel of throttles during operation requiring a limited amount of thrust. The gate, which is a roller-mounted carriage, travels between guide rails located above the quadrant surface at each side of the aisle stand. The gate carriage acts as an impediment when the throttles are advanced and it may be adjusted as necessary to provide the desired thrust limit. A scissor-type lever located on the copilot's side of the thrust gate carriage provides for adjustment of the thrust gate within a 70° arc at the forward end of the quadrant. The aft edge of the carriage, which is painted white, is used as a positioning indicator for both pilot and copilot. Lighting is provided on the copilot's side to facilitate adjustment and, on some aircraft, an index pointer is also provided on the copilot's side. The outboard side of each guide rail is marked by a metalcal in 5° increments and numbered at 10° increments from 40° thru 110°. Adjustment of the thrust gate is usually accomplished by the copilot; however, the adjustment lever is accessible to the pilot. Detents are spaced 5° apart along the left guide rail for positioning of the thrust gate which may be moved by squeezing the scissor-type lever to release a roller-tipped spring-loaded plunger. The spring-loaded plunger supplies the force to restrain the carriage in the selected detent position. It is possible to overpower this force by applying approximately twice the force required to normally operate all eight throttles simultaneously. For operation not requiring use of the thrust gate, the carriage may be stowed forward of full open throttle position.

Figure 1-33 (Sheet 5 of 7)

NO.	CONTROL-INDICATOR	FUNCTION
16	Oil Temperature Gage	A single engine oil temperature gage is located on the copilot's side panel and provides oil temperature readings for individual engine systems or maximum temperature of all engine oil supply systems as selected by the temperature selector switch. The temperature is indicated by a pointer which rotates around a temperature scale on the indicating dial calibrated from 0° to 180° C.
17	Oil Temperature Selector Switch	An oil temperature selector switch has 10 positions; one each for the eight engine oil temperature probes (as designated by engine number), a T (test) position, and an M (monitor) position. When the M position is selected, the indicating gage displays the temperature of the hottest of the eight oil temperature probes but does not show which particular engine has the high oil temperature. Due to a temperature tolerance of +5°/–0°C, a higher temperature may be indicated in M position of the selector switch than at any other separate selection (1 thru 8 positions) of engine oil systems. Due to quick response to changes in temperature of the indicating system, identification of an engine with excessively high oil temperature is readily accomplished by selecting the engines separately. When the selector switch is placed in T position, the pointer moves to the extreme maximum temperature scale stop. This position of the selector provides a method of testing for proper operation of the temperature gage and overheat light. An edge lighted panel installed below the selector and the temperature gage displays the following caution: LEAVE IN M POSITION TO MONITOR ALL ENGINES. The oil temperature selector switch, which has integral lighting, operates on 24 volt dc power on the same circuit with the engine oil overheat caution light on the central caution panel.
18	MANIFOLD VALVE Switch	The OPEN- -CLOSE manifold valve switch, guarded to the CLOSE position, is located on the copilot's side panel. OPEN position, used primarily for engine starting, provides for airflow from any engine to any other engine by supplying 118-volt single-phase ac to open the motor-driven body crossover manifold and No. 3 strut bleed valves, and TR power to open the normally closed solenoid-operated No. 1 and 4 strut bleed valves. In OPEN position, air conditioning system control of the body crossover manifold and No. 3 strut bleed valves is discontinued. This results in hot bleed air being interconnected between all engines through the body crossover manifold. The guarded CLOSE position restores 118-volt single-phase ac to the air conditioning system controls for management of bleed air source selection, and removes TR power from the solenoid-operated No. 1 and 4 strut bleed valves which resume their normally closed positions.

Figure 1-33 (Sheet 6 of 7)

NO.	CONTROL-INDICATOR	FUNCTION
19	FUEL ENRICHMENT VALVE Switch	The OPEN- -CLOSE fuel enrichment valve switch, guarded to the CLOSE position, is located on the copilot's side panel. When set to OPEN, the switch opens the fuel enrichment valves to allow increased fuel flow for engine starting in cold weather or high altitude with any alternate grade fuel. When set to CLOSE, the fuel enrichment valves are closed. **NOTE** The auxiliary throttle valve is mechanically closed when the fuel flow exceeds 1500 pph, however, the fuel enrichment valve will remain open and energized until the fuel enrichment valve switch is set to the CLOSE position.
20	START SELECTOR Switch	A start selector switch having CARTRIDGE- -FLIGHT- -PNEUMATIC positions is located on the copilot's side panel. The switch is locked in center FLIGHT position and must be pulled out before moving to either CARTRIDGE or PNEUMATIC positions. The position of this switch determines whether ignition only or both starter and ignition are provided when the starter switch is operated. In momentary CARTRIDGE position, the circuits are completed for firing of starter cartridges on engines selected by the individual engine starter switches. If a starter switch is in START position, positioning of this selector switch to CARTRIDGE position will fire the cartridge for that selected engine. In FLIGHT position, only power for engine starting ignition will be provided to the engine(s) for which the starter switch is in START. The starters will be inoperable. In PNEUMATIC position, power is supplied to open the starter air valve on the engine having the starter switch in START. Starting ignition power is also directed to that engine.
21	Engine Start Switches (8)	Eight START- -OFF- -CONT starter switches are provided on the copilot's side panel. These switches select the engine(s) for which a starting or ignition function is desired. The desired functions are determined by use of the start selector switch in accordance with the starting mode desired: pneumatic, cartridge, or inflight. When the starter switch is in START, for pneumatic starting, the starter air valve is opened and ignition power is directed to that engine. For cartridge starting, power is available to fire the cartridge for that engine. For inflight starting, only ignition power is directed to that engine. When the starter switch is in CONT, which represents "continuous ignition," 115 volt ac ignition will be provided when throttles are out of CLOSED position.

Figure 1-33 (Sheet 7 of 7)

ENGINE NORMAL OPERATION

ENGINE IGNITION AND STARTING SYSTEM OPERATION

When the engine accelerates above starter cutout speed, the starter relay becomes deenergized. This prevents the starter from reengaging if the engine speed drops below starter cutout speeds, even though the starter switch remains in START position. If the starter switch is returned to OFF position, however, and the engine speed drops below starter cutout speed, the starter relay will become energized. Then if the starter switch is placed in START position while the engine is still rotating, starter coupling shaft failure may result. The starter will not engage when the starter switch is in CONT position. CONT position of the starter switch provides continuous duty ignition for prevention of flameout during flight.

ACCELERATED ENGINE START PROCEDURE

In order to use the accelerated engine start procedure, starter cartridges must be installed prior to engine start. Installation of the starter cartridges is accomplished via the Options Menu located on the glareshield panel. (3, figure 0-1) The accelerated start function will not be available unless the cartridges are properly installed.

MONITORING EGT DURING TAKEOFF

The EGT of a normally operating engine will usually peak considerably sooner than the 2-minute engine acceleration time limit. It therefore is important that the pilot not physically making the take- off monitor EGT during the takeoff roll and as soon after unstick as possible. Throttles should be retarded to maintain the appropriate EGT limits. Normally, a very small reduction in throttle setting will return an EGT to within limits.

FUEL SUPPLY SYSTEM

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FUEL TANK VENTING 34
FUEL CHECKOUT SYSTEM 35
FUEL SYSTEM CONTROLS AND INDICATORS 35
OPERATION 44

DESCRIPTION

The fuel supply system is designed so that the engines receive fuel from the nearest of four main tanks or by pressure override from a main manifold. The main manifold can be pressurized by any auxiliary tank or tanks. The main tanks are integral wing tanks ("wet wing"); each tank has four boost pumps and normally supplies two engines. No. 1 main tank furnishes fuel for engines 1 and 2, No. 2 main for engines 3 and 4, No. 3 main for engines 5 and 6, and No. 4 main for engines 7 and 8. The auxiliary tanks include two out- board wing tanks which are integral wing tanks, an integral center wing tank, three body tanks, and two non-jettisonable external tanks. Normally, the main manifold is used for directing auxiliary tank fuel to the engines. The main manifold is separated from the refuel manifold by the main refuel valve. During a refueling operation, the main manifold is used to direct fuel to the desired tanks. See RE- FUELING SYSTEM, this section. The main manifold may also be used to transfer fuel from auxiliary tanks to main tanks. A crossfeed manifold is pro- vided which makes it possible to interconnect the fuel feed systems of each nacelle. Auxiliary fuel should be fed directly to the engines. While auxiliary fuel is being used, main tank boost pump switches are ON. The boost pumps in the auxiliary tanks are of higher capacity than the boost pumps in the main tanks thus allowing a pressure override condition to exist. When an auxiliary tank runs dry, the main tank boost pumps take over fuel supply to the engines with no interruption in fuel flow. The fuel system panel (figure 1-38) is used to control fuel flow for engine feed and air refueling operations. This panel indicates the flow of fuel obtained by selecting different positions on the controls. The majority of the fuel system controls are numbered to simplify their identification (figure 1-38). The control numbers that appear on the fuel system panel correspond to the control identification numbers that appear in this manual. The main manifold is scavenged by utilizing a float switch, a solenoid-operated valve, and a scavenge pump which directs scavenged fuel from the main manifold to No. 3 main tank.

A schematic of the fuel system showing the detailed mechanical configuration and function of the various fuel lines is given in figure 1-36. The fuel tank quantities are listed in figure 1-37.

Fuel system circuit protection and the location of the applicable circuit breakers is contained in figure 1-51.

FUEL TANK VENTING

Body fuel tanks are vented through three manifolds to a surge tank aft of the aft body tank. The surge tank opens to the atmosphere through a port located aft of the rear wheel well on the underside of the fuselage and also routes fuel discharged through the vents to the aft body tank. Body tank cavities are vented through a manifold which opens to the atmosphere through a port located aft of the rear wheel well on the underside of the fuselage. Internal tanks in each wing are vented with a single vent line for each tank. The three lines in each wing drain to a wing surge tank located in each wing tip. The surge tanks route fuel discharged through the vents to No. 1 and No. 4 main tanks.

Each external tank is vented through a single line which opens to the atmosphere through a port located on the aft outboard side of the tank strut. The vent system is designed for JP-4 fuel only.

Fuel Quantity Data

TANKS	NO.	TANK CAPACITIES: USABLE FUEL (EACH) POUNDS	USABLE FUEL (EACH) GALLONS	FULLY SERVICED (EACH) POUNDS	FULLY SERVICED (EACH) GALLONS
NO. 1 AND 4 MAIN	2	31,843	4899	31,883	4905
NO. 2 AND 3 MAIN	2	44,259	6809	44,421	6834
MID BODY	1	46,410	7140	46,501	7154
FORWARD BODY	1	13,319	2049	13,345	2053
AFT BODY	1	55,192	8491	55,237	8498
OUTBOARD WING	2	7495	1153	7540	1160
CENTER WING	1	20,982	3228	21,060	3240
EXTERNAL	2	4550	700	4583	705

USABLE FUEL TOTALS

TANKS	POUNDS	GALLONS
NO. 1, 2, 3, AND 4 MAIN	152,204	23,416
MAINS AND MID BODY	198,614	30,556
MAINS, MID BODY, FORWARD BODY, AND AFT BODY	267,125	41,096
MAINS, ALL BODY, OUTBOARD WING, AND CENTER WING	303,097	46,630
ALL TANKS	312,197	48,030

NOTES

- Fully serviced quantities include both trapped and drainable fuel.
- The tanks will have the quantities shown under conditions of ICAO standard day with fuel density of 6.5 pounds per gallon.
- See data supplied in Section V, OPERATING LIMITATIONS to determine fuel loading.

Figure 1-37

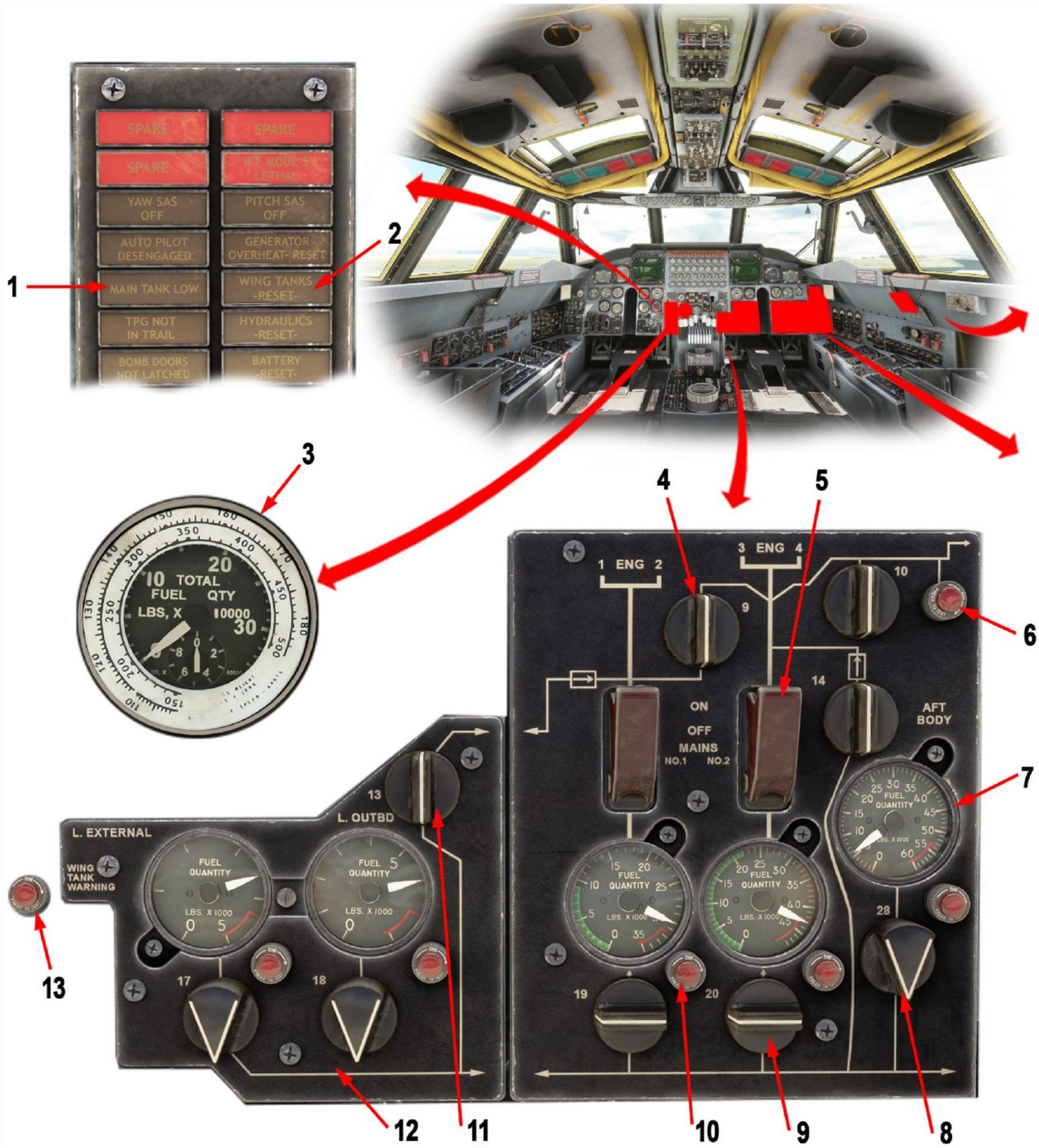
FUEL CHECKOUT SYSTEM

Fuel pressure gages and warning lights are not provided for each tank. To save weight, a fuel checkout system is provided in the fuel system. This system allows ground pressure checking of each boost pump and each valve in the fuel system. To use the fuel checkout system, fuel under pressure is routed to a pressure switch by positioning various valves. This switch is located in a fuel line between the crossfeed manifold and the No. 2 main tank. The pressure switches will close and supply power to il- luminate a pressure checkout light, indicating prop- er system operation.

FUEL SYSTEM CONTROLS AND INDICATORS

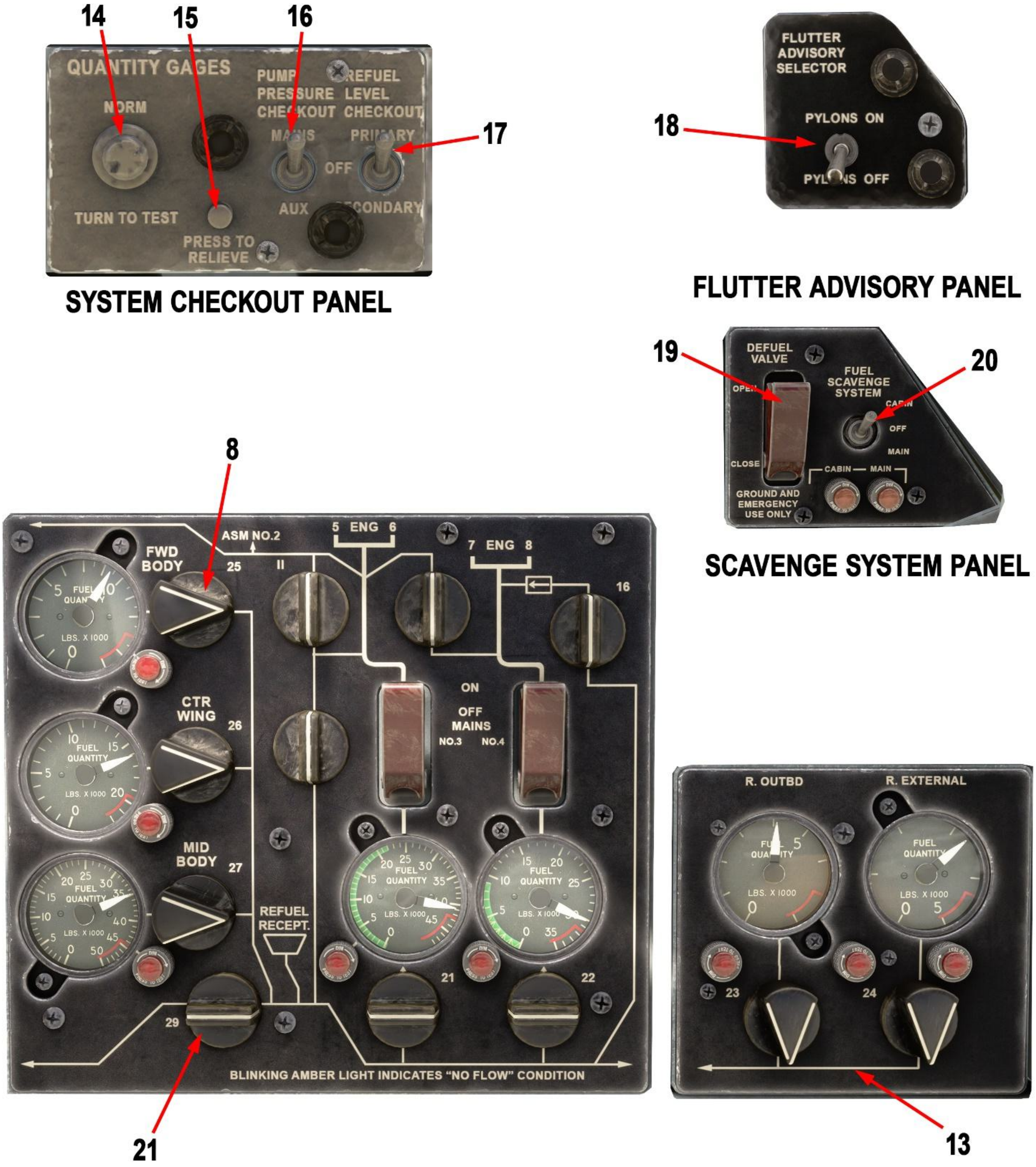
Fuel system controls and indicators located on the copilot’s side of the main instrument panel are the main fuel control panel, the flutter advisory selector, the scavenge system panel, and the system checkout panel. The total fuel quantity gage, and two caution lights on the central caution panel, are located on the forward instrument panel below the No. 1, 2, and 3 engine instruments. Figure 1-38 discusses the fuel system controls and indicators.

Fuel System Controls and Indicators



1 MAIN TANK LOW CAUTION LIGHT
2 WING TANKS RESET CAUTION LIGHT
3 TOTAL FUEL QUANTITY GAGE
4 ENGINE CROSSFEED MANIFOLD VALVE SWITCHES (SWITCHES 9 THRU 12)
5 MAIN TANK BOOST PUMP SWITCHES (SWITCHES 1 THRU 4)
6 PUMP PRESSURE CHECKOUT LIGHT
7 FUEL QUANTITY GAGES (12 PLACES)
8 AUXILIARY TANK FUEL FLOW CONTROL SWITCHES (SWITCHES 17, 18, 23 THRU 28)
9 MAIN TANK FUEL LEVEL CONTROL SWITCHES (SWITCHES 19 THRU 22)
10 FUEL FLOW INDICATOR LIGHTS (12 PLACES)

Figure 1-38 (Sheet 1 of 8)



11 AUXILIARY TANK ENGINE FEED CONTROL VALVE SWITCHES (SWITCHES 13 THRU 16)
12 FUEL FLOW CONTROL SWITCH LOCKS
13 WING TANK WARNING LIGHTS (2 PLACES)
14 QUANTITY GAGES PRESS-TO-TEST BUTTON
15 PUMP PRESSURE CHECKOUT PRESS-TO-RELIEVE BUTTON
16 PUMP PRESSURE CHECKOUT SWITCH
17 REFUEL LEVEL CHECKOUT SWITCH
18 FLUTTER ADVISORY SELECTOR SWITCH
19 DEFUEL VALVE SWITCH
20 SCAVENGE SYSTEM SWITCH
21 MAIN MANIFOLD INTERCONNECT VALVE SWITCH (SWITCH 29)

Figure 1-38 (Sheet 2 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
1	Main Tank Low Warning Light (amber)	An amber main tank low warning light is located on the central caution panel . A 4000 pound or less indication of any main tank fuel quantity gage completes a contact allowing right TR power to cause the main tank low warning light to glow, indicating that the fuel quantity in one or more main fuel tanks is below the 4000 pound level. A signal through the same circuit is also sent to the pilots' master caution lights and they will come on simultaneously with the main tank low warning light. The main tank low warning light and the master caution lights will come on in the manner described above except that a 10-second delay timer has been incorporated to prevent flashing of these lights due to fuel slosh and subsequent oscillation of the main tank fuel quantity gages.
2	Wing Tanks Caution Light (amber)	A wing tanks caution light marked WING TANKS RESET located on the central caution panel lights to warn the crew of improper fuel usage or fuel configurations for which airspeed limitations may be required to avoid flutter. The pilots' master caution lights will not come on when the WING TANKS RESET light comes on. The wing tanks caution light comes on simultaneously with the wing tank warning lights on the fuel system panel and serves to warn the crew to check either or both wing tank fuel systems for improper usage. The wing tanks caution light will go out when the reset button beside the central caution panel is pushed. This allows the WINGS TANKS RESET light to monitor the remaining circuits in its particular system for any improper usage that may occur.
3	Total Fuel Quantity Gage	The total fuel quantity gage receives its indication by electronic addition of indications of the individual fuel gages. A best flare speed indicator dial is installed outside of total fuel quantity gage to allow determination of gross weight and best flare speed directly from the quantity indication. See Wing Flap System under FLIGHT CONTROL SYSTEM, this section, for additional information on the best flare speed indicator. **NOTE** • If an individual fuel quantity gage malfunctions, the total fuel quantity gage will be in error by the amount that the individual quantity gage is in error. If the circuit breaker for the malfunctioning gage is pulled, the totalizer contribution from that gage will be zero. • There is an allowable tolerance of 3400 pounds between the total fuel quantity gage and the sum of all individual gage fuel quantity gage readings.
4	Engine Crossfeed Manifold Valve Switches (Switches 9 thru 12)	Four engine crossfeed manifold valve switches on the fuel system panel have unmarked OPEN- -CLOSED positions. These rotary switches are numbered 9, 10, 11, and 12 and control operation of the engine crossfeed manifold valves of corresponding numbers allowing interconnection of the fuel systems of each nacelle. When the white stripe on a switch is aligned with the flow line on the panel, the switch is OPEN and left essential dc power for valves 9 and 12 or right essential dc power for valves 10 and 11 is supplied to open the corresponding valves. CLOSED position supplies power to close the valve. Engine crossfeed manifold valve switches are numbered for ease of identification.

Figure 1-38 (Sheet 3 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
5	Main Tank Boost Pump Switches (Switches 1 thru 4)	Four main tank boost pump switches on the fuel system panel have ON- -OFF positions and are guarded in the ON position. The switches are numbered from 1 to 4 and each switch electrically controls the four boost pumps in the corresponding main tank. Placing a switch in ON position directs 205 volt three-phase ac power to the four boost pumps in the respective main tank. OFF position of a main tank boost pump switch deenergizes all the boost pumps in the respective main tank. Main tank boost pumps are numbered for ease of identification. **CAUTION** Closure of the main tank switch guard may not actuate the boost pump switch to the ON position. Apply firm pressure to the toggle switch when placing it to the ON position and absolutely ensure it is fully and completely ON before closing the guard.
6	Pump Pressure Checkout Light	When fuel pressure for the tanks selected by the pump pressure checkout switch (No. 16) reaches 10 psi for MAIN or 24 psi for AUX, the green pump pressure checkout light illuminates.
7	Fuel Quantity Gages (12 Places)	The quantity of available (usable) fuel in each tank is indicated in pounds by 12 fuel quantity gages on the fuel system panel. Fuel probes in each tank sense the quantity of usable fuel. The fuel probe signals are relayed to amplifiers in the gages. The fuel quantity gaging system may be in error by as much as $\pm$1.5% of gage indication due to variation in fuel dielectric constants. A full (by weight) indication of the fuel quantity gage breaks circuits causing the corresponding fuel level control valve to close if the master refuel switch is ON. The main tanks, external tank, and outboard wing tank fuel quantity gages for each wing have internal safe-level switches which complete circuits to supply TR power to the MAIN TANK LOW warning light (No. 1) or WING TANKS caution light (No. 2). See figure 5-1 for gage markings. **NOTE** For fuel densities greater than 6.5 lb/gal, the 6.5 LB/GAL fuel loading charts in T.O. 1B-52H-5 are applicable and should be used.
8	Auxiliary Tank Fuel Flow Control Switches (Switches 17, 18, 23 thru 28)	Eight auxiliary tank fuel flow control switches on the fuel system panel have unmarked REFUEL- -OFF- -ENGINE FEED positions. These rotary switches are numbered 17, 18, 23, 24, 25, 26, 27, and 28 and control of the flow of fuel to and from the auxiliary tanks. A white arrowhead is painted on top of each switch and the direction the arrow is pointing determines the position of the switch. For ENGINE FEED position, the arrow is pointed away from the tank, for REFUEL position, the arrow is pointed toward the tank, and for OFF position, the arrow is perpendicular to the flow line between tank and main manifold. ENGINE FEED position directs 205-volt three-phase ac power to the boost pumps in the respective tank. REFUEL position causes TR power to energize the fuel level control valves in the respective tank provided the master refuel switch is ON. See REFUEL SYSTEM, this section. OFF position deenergizes the boost pumps and the fuel level control valves in the respective tank. The switches for the external and outboard tanks (switches 17, 18, 23, and 24 respectively) are equipped with fuel flow control switch locks (No.12). Each lock is a pivoting bar with a detent that mates with an extension on the corresponding switch. Auxiliary tank fuel flow control valves are numbered for ease of identification.

Figure 1-38 (Sheet 4 of 8)

NO.	CONTROL- INDICATOR	FUNCTION
9	Main Tank Fuel Level Control Valves (Switches 19 thru 22)	Four main tank fuel level control valve switches on the fuel system panel have unmarked REFUEL- -OFF positions. These rotary switches are numbered 19, 20, 21, and 22 and control the flow of fuel to the main tanks. When the white stripe on a switch is aligned with the flow line on the panel, the switch is in REFUEL position and left and right TR power is supplied to energize the fuel level control valves in the respective tank provided the master refuel switch is ON. OFF position of a main tank fuel level control valve switch deenergizes the fuel level control valves in the respective tank causing them to close. Fuel level control valves are numbered for ease of identification.
10	Fuel Flow Indicator Lights (12 Places)	Twelve amber fuel flow indicator lights are located on the fuel system panel adjacent to the fuel quantity gages. Those indicator lights adjacent to auxiliary tank gages perform a dual function: 1) indicating no fuel flow from the corresponding tank during fuel feed operations, and 2) indicating no fuel flow into the tank during refuel operations. Those indicator lights adjacent to the main tank gages perform only a single function, that of indicating no fuel flow into the tank during refuel operations. With an auxiliary tank fuel flow control switch in ENGINE FEED position, the boost pumps in the corresponding auxiliary tank supply fuel to the main manifold. As soon as the auxiliary tank runs dry, a flow switch in the line completes contacts allowing right TR power to cause the respective fuel flow indicator light to flash, indicating no fuel flow from the tank. See REFUEL SYSTEM, this section, for description of refuel function of the lights. **NOTE** • A fuel flow indicator light may flash intermittently when fuel in an auxiliary tank is at a low level and the aircraft is being maneuvered. • A fuel flow indicator light may not illuminate when an auxiliary tank fuel flow control switch is in the ENGINE FEED position and the auxiliary tank is empty. See FUEL SYSTEM MANAGEMENT, this section.

Figure 1-38 (Sheet 5 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
11	Auxiliary Tank Engine Feed Control Valve Switches (Switches 13 thru 16)	Four auxiliary tank engine feed control valve switches on the fuel system panel have unmarked OPEN- -CLOSED positions. These rotary switches are numbered 13, 14, 15, and 16 and control operation of valves of corresponding numbers to direct auxiliary tank fuel to the engines. When the white stripe on a switch is aligned with the flow line on the panel, the switch is OPEN and left essential dc power for valves 14 and 15 and right essential dc power for valves 13 and 16 is supplied to open the corresponding valves. CLOSED position closes the respective valve.
12	Fuel Flow Control Switch Locks	The switches for the left external, left outboard, right outboard, and right external tanks (switches 17, 18, 23, and 24 respectively) are equipped with fuel flow control switch locks. Each lock is a pivoting bar with a detent that mates with an extension on the corresponding switch. The lock must be pivoted away from the switch before the switch can be moved from OFF position.
13	Wing Tank Warning Lights (2 Places)	Two amber wing tank warning lights on the fuel system panel are provided to warn the crew of improper fuel usage or fuel tank configurations for which airspeed limitations may be imposed to avoid flutter. The main, external, and outboard wing tank fuel quantity gages for each wing have internal safe level switches. If the fuel quantity indication of either main tank in a wing is above the green band marking on the dial and the fuel quantity indication of either the external or outboard wing tank for the same wing is below safe level, the light will come on and remain on until the fuel quantity indications of both main tanks have reached the green band marking area on the dial. The light will also come on if the fuel quantity indication of either main tank in a wing is above the green band marking on the dial and the respective outboard or external tank fuel flow control switch is in the ENGINE FEED position. If the flutter advisory selector switch is in the PYLONS ON position, the wing tank warning light will come on any time an external tank is below safe level or the fuel flow control switch for external tank is in the ENGINE FEED position.
14	Quantity Gages Press-to-Test Button	The quantity gages press-to-test button on the fuel system panel is used to test the circuit continuity. Pressing the button will cause clockwise rotation of all fuel quantity gage pointers and totalizer gage pointer up to 98% ($\pm$2%) scale. When the switch is released, all fuel quantity gage pointers and totalizer gage pointer will return to their original position if the circuits are functioning correctly.
15	Pump Pressure Checkout Press-to-Relieve Button	The pump pressure checkout press-to-relieve button on the fuel system panel is utilized to relieve the fuel pressure built up by use of the pump pressure checkout switch. Pushing this button causes left TR power to energize and open a solenoid-operated valve to allow fuel pressure to bleed off into No. 2 main tank.

Figure 1-38 (Sheet 6 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
16	Pump Pressure Checkout Switch	The pump pressure checkout switch on the fuel system panel is used for ground checking of fuel pressure. The switch has MAINS--OFF--AUX positions. MAINS position supplies left TR power to the low pressure side of a pressure switch. When fuel pressure reaches 10 psi, the green pump pressure checkout light (No. 6) on the fuel system panel glows. In AUX position, left TR power is supplied to the high pressure switch. When fuel pressure reaches 24 psi, the same pump pressure checkout light illuminates. OFF position completely deenergizes the pump pressure checkout circuits.
17	Refuel Level Checkout Switch	The refuel level checkout switch on the fuel system checkout panel on the copilot's side panel has PRIMARY- -OFF- -SECONDARY positions. This switch is used to check the operation of the primary and secondary float valves in the fuel level control valves. In order to check the valves in a tank, an auxiliary tank fuel flow control switch or a main tank fuel level control switch must be placed in REFUEL position, the manifold to the tank pressurized, and the master refuel switch on. PRIMARY position of the refuel level checkout switch deenergizes the primary side of the fuel level control valves (or valve) in the tank. This action permits fuel from the main manifold to flood the primary float chamber in each fuel level control valve in the tank, actuating the float valve to simulate a full-by-volume condition. This causes the fuel level control valves to close. When the fuel level control valves (or valve) in a tank close, the fuel flow indicator light adjacent to the appropriate fuel quantity gage glows steady. Moving the switch to OFF position allows each primary float chamber to drain which allows the fuel level control valves to open and the light to go out. SECONDARY position performs the same function in the secondary float chamber. The primary and secondary float chambers are the same level in any one valve. **NOTE** The refuel level checkout switch can be used during air refueling to check operation of the fuel level control valves if absolutely necessary. However, their use in flight is not recommended. Use of these switches at such a time might cause a pressure disconnect or might, as a remote possibility, result in a fuel level control valve failing closed. It is recommended, therefore, that fuel level control valve operation be checked before flight while fueling through the single point ground refueling receptacle.
18	Flutter Advisory Selector Switch	The flutter advisory selector switch, a two position toggle switch, marked PYLONS ON- -PYLONS OFF is located on the pilots' instrument panel and controls the wing tank warning light circuits. The PYLONS ON position will be used any time external pylons are installed and PYLONS OFF will be used for a clean configuration.

Figure 1-38 (Sheet 7 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
19	Defuel Valve Switch	The defuel valve switch on the fuel scavenge system panel on the right side of the pilots' instrument panel in front of the copilot has OPEN- -CLOSE positions and is guarded in CLOSE. This switch controls the defuel valve which separates the engine crossfeed manifold from the main manifold. OPEN position supplies right TR power to the valve causing it to open. CLOSE position causes the valve to close. This switch is normally used on the ground for defueling but may be used in flight. Care must be exercised during inflight use because of high fuel flow rates.
20	Scavenge System Switch	The scavenge system switch on the fuel system panel has CAB-IN- -OFF- -MAIN positions, MAIN position directs right TR power to a float switch in the scavenge line between the main manifold and No. 3 main tank. If there is fuel in the manifold, the float switch makes a contact which causes the TR power to illuminate the fuel-in-main-manifold light, open a solenoid shutoff valve, and energize a relay which directs 118-volt single-phase ac power to the main manifold scavenge pump. The fuel in the manifold is pumped into No. 3 main tank. As soon as the manifold is scavenged, the float switch breaks contact causing the scavenge pump to stop, the solenoid shutoff valve to close, and the fuel-in-main-manifold light to go out. CABIN position actuates the scavenge operation in the refuel manifold. See AIR REFUELING SYSTEM, this section. OFF position completely deenergizes the scavenge circuits in the main and refuel manifolds.
21	Main Manifold Interconnect Valves Switch (Switch 29)	A main manifold interconnect valves switch on the fuel system panel has unmarked OPEN- -CLOSED positions. This rotary switch is numbered 29 and controls the operation of main manifold interconnect valves 29 and 29A. When the white stripe on the switch is aligned with the flow line on the panel, the switch is OPEN and left TR power is supplied to open valve 29 and right TR power is supplied to open valve 29A. Opening these valves interconnects the right and left sides of the main manifold. CLOSED position closes the two valves.

Figure 1-38 (Sheet 8 of 8)

Fuel System Operation with No Pylons

NOTE

OPERATING WEIGHT (BASIC WEIGHT PLUS CREW AND OIL) CG FROM 18.0% TO 27.0% MAC.

STEP	FUEL USAGE	REMARKS
1 (TAKEOFF)	AFT BODY TO 1 AND 2 MAIN 2 TO 3 AND 4 MAIN 3 TO 5 AND 6 CENTER WING TO 7 AND 8	FOR TAKEOFF WITH MAINS 1 AND 4 ABOVE GREEN BAND AND CENTER WING AND AFT BODY CONTAIN 2000 POUNDS OR MORE EACH
	OR	
	MAINS TO ALL ENGINES (CROSSFEED VALVES OPEN)	FOR TAKEOFF WITH EITHER CENTER WING OR AFT BODY CONTAINING LESS THAN 2000 POUNDS, OPEN ALL CROSSFEED VALVES (9, 10, 11 AND 12)

CAUTION

CLOSURE OF THE MAIN TANK SWITCH GUARD MAY NOT ACTUATE THE BOOST PUMP SWITCH TO THE ON POSITION. APPLY FIRM PRESSURE TO THE TOGGLE SWITCH WHEN PLACING IT TO THE ON POSITION AND ABSOLUTELY ENSURE IT IS FULLY AND COMPLETELY ON BEFORE CLOSING THE GUARD.

2	AFT BODY TO 1, 2, 3 AND 4 CENTER WING TO 5, 6, 7 AND 8	CENTER WING TO EMPTY
3	AFT BODY TO 1, 2, 3 AND 4 FWD BODY TO 5, 6, 7 AND 8	FWD BODY TO EMPTY
4	MID BODY TO ALL ENGINES	MID BODY TO EMPTY
5	MAINS TO ALL ENGINES	MAINS 1 AND 4 TO 20,000 POUNDS EACH
6	AFT BODY TO ALL ENGINES	AFT BODY TO EMPTY
7	MAINS TO ALL ENGINES	MAINS 1 AND 4 TO GREEN BANDS

NOTE

OBSERVE WING FLUTTER LIMITATIONS.

8	LEFT OUTBOARD TO 1 AND 2 NO. 2 MAIN TO 3 AND 4 NO. 3 MAIN TO 5 AND 6 RIGHT OUTBOARD TO 7 AND 8	OUTBOARDS TO EMPTY

Figure 1-40 (Sheet 1 of 2)

STEP	FUEL USAGE	REMARKS
9	LEFT EXTERNAL TO 1 AND 2 NO. 2 MAIN TO 3 AND 4 NO. 3 MAIN TO 5 AND 6 RIGHT EXTERNAL TO 7 AND 8	EXTERNALS TO EMPTY
10	MAINS TO ALL ENGINES (CROSSFEED VALVES OPEN)	OPEN ALL CROSSFEED VALVES (9, 10, 11 AND 12)
	ALL LANDING, TRANSITION, AND LOW APPROACHES	
	MAINS TO ALL ENGINES (CROSSFEED VALVES OPEN)	OPEN ALL CROSSFEED VALVES (9, 10, 11, AND 12) WITH ANY MAIN DOWN TO 5000 POUNDS, OPEN ALL CROSSFEED VALVES (9,10,11 AND 12)

NOTE

- FOR LANDINGS, TRANSITION AND LOW APPROACHES, OPEN CROSSFEED VALVES 9,10,11 AND 12 REGARDLESS OF THE GREEN BAND.
- IF AUXILIARY FUEL USAGE IS DESIRED, IT WILL BE TRANSFERRED DIRECTLY INTO MAIN TANKS THROUGH THE MAIN MANIFOLD. SEE WING FLUTTER AIRSPEED LIMITATIONS, SECTION V, FOR SPEED RESTRICTIONS ASSOCIATED WITH USE OF AUXILIARY FUEL IN VARIOUS AIRCRAFT/MISSILE CONFIGURATIONS. AUXILIARY FUEL WILL BE IN ORDER OF OMITTED STEPS.
- DURING PRACTICE LOW APPROACHES AND LANDINGS, AUXILIARY FUEL MAY BE USED AS REQUIRED TO KEEP FUEL IN MAIN TANKS 1 AND 4 JUST BELOW TOPS OF GREEN BANDS AND BALANCE WITH MAIN TANKS 2 AND 3.

Figure 1-40 (Sheet 2 of 2)

CENTER OF GRAVITY/FUEL LEVEL ADVISORY SYSTEM

DESCRIPTION

The center of gravity fuel level advisory system (CG/FLAS) automatically provides a continuous cg indication during flight. It also indicates when the cg approaches either forward or aft limit for normal gross weights and heavy weight extension (BIG-WIP) configuration, an asymmetrical fuel loading condition, and when a fuel tank approaches a selected quantity. Weapons, flares, and chaff are manually input and fuel quantity is automatically input by the FQIS or can be manually input. The CG/FLAS controls and indicators (figure 1-53) consists of a control panel located on the copilot's side panel and a display unit located on the pilot's instrument panel. CG/FLAS abbreviations are listed in figure 1-52.

CONTROLS AND INDICATORS

Control Panel

The CG/FLAS control panel consists of the power switch, mode keys, and data entry keys. The display unit will display cg, fuel quantity, operating weight and weapon load.

See figure 1-53 for control and functional information on the CG/FLAS control panel.

Display Unit

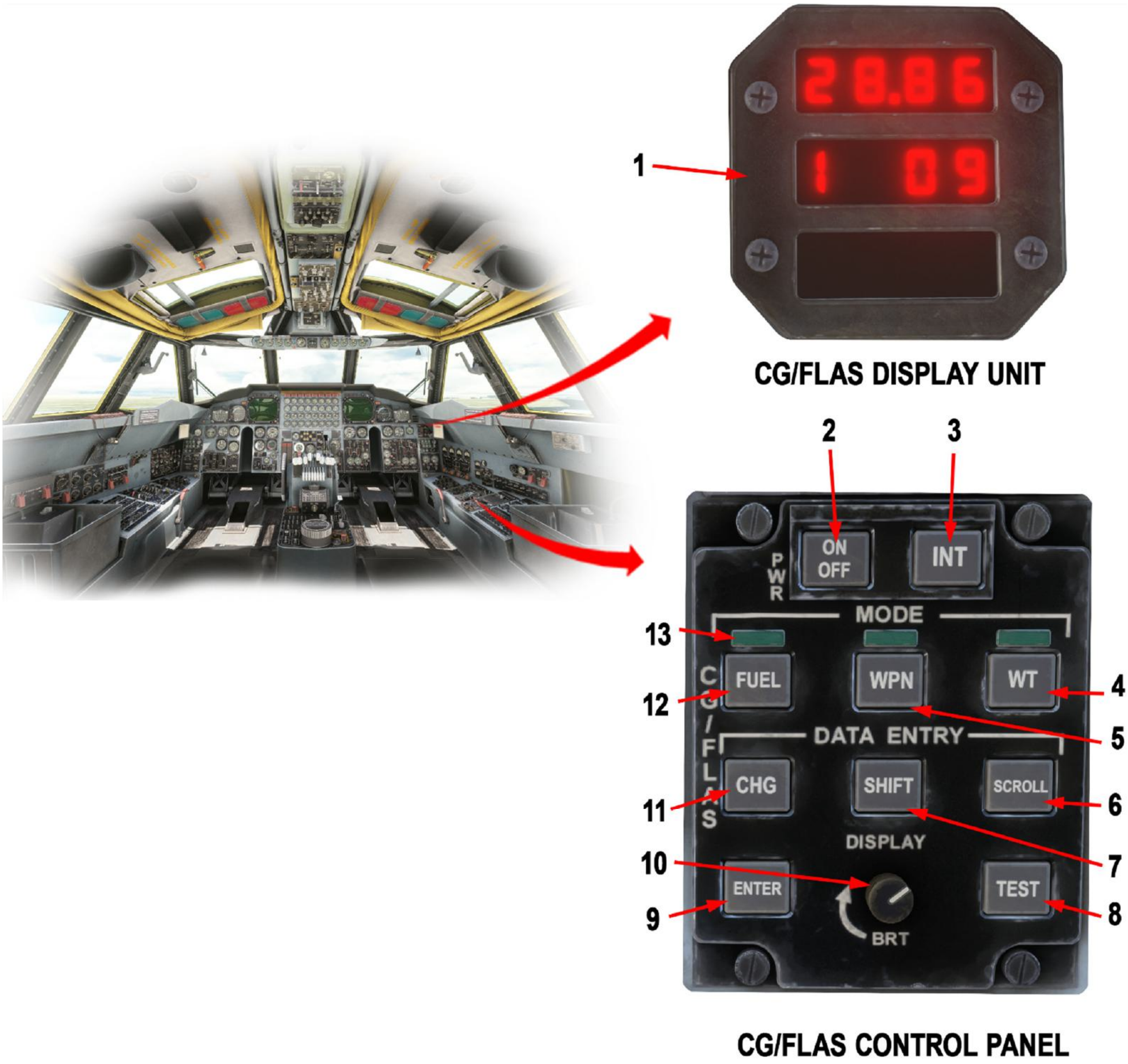
See figure 1-53 for indicator and display arrangement.

CG/FLAS ABBREVIATIONS

BS – Body Station
BS-A – Body Station Aft
BS-F – Body Station Forward
BSLA – Body Station Left Aft
BSLF – Body Station Left Forward
BSRA – Body Station Right Aft
BSRF – Body Station Right Forward
CHAF – Chaff
CHKN – Check No
CHKY – Check Yes
CONV – Conventional
ERAS – Erase
EXT – External
FLAR – Flares
GF – Gage Fail
HARP – Harpoon
INIT – Initialization
INTR – Interrupt
LT – Left
NUC – Nuclear
OPER – Operational
OW – Operating Weight
OWCG – Operating Weight Center of Gravity
PWR – Power
PYLN – Pylon
RT – Right
STRT – Start
WB-A, WBA – Weapons Bay Aft
WB-C, WBC – Weapons Bay Center
WB-F, WBF – Weapons Bay Forward
WPN – Weapon
WT – Weight
WTLA – Weight Left Aft
WTLF – Weight Left Forward
WTRA – Weight Right Aft
WTRF – Weight Right Forward

Figure 1-52

CG/FLAS Controls and Indicators



1	CG/FLAS DISPLAY UNIT	8	TEST KEY
2	POWER SWITCH	9	ENTER KEY
3	INITIALIZATION KEY	10	DISPLAY BRIGHTNESS KNOB
4	WEIGHT KEY	11	CHANGE KEY
5	WEAPON KEY	12	FUEL KEY
6	SCROLL KEY	13	MODE LIGHTS (3 PLACES)
7	SHIFT KEY		

Figure 1-53 (Sheet 1 of 6)

NO.	CONTROL-INDICATOR	FUNCTION
		CG/FLAS DISPLAY UNIT
1	CG/FLAS Display Unit	See Sheets 3 thru 6 for CG/FLAS Displays.
		CG/FLAS CONTROL PANEL
2	PWR (Power) Switch	A lighted rocker switch which alternately selects ON - - OFF. ON applies power and starts self-test.
3	INT (Initialization) Key	Enters initialization when pressed. Allows entry of operating weight, operating weight CG, and weapons load in sequence. The three mode keys (No. 4, 5, and 12) are inactive when initialization mode is active.
4	WT (Weight Status Mode) Key	Pressing the WT key activates the weight status mode and displays fuel quantity, fuel gage failure, tank designations, cg, and burn-down-to-levels. The WT mode light comes on when the WT mode is active.
5	WPN (Weapon Status Mode) Key	Pressing the WPN key activates the weapon status mode and allows operator to monitor weapon status and to decrement weapons when a release or launch occur. The WPN mode light is on when the WPN status mode is active.
6	SCROLL Key	The SCROLL key will allow the operator to sequence through the displays and select the actual aircraft loading configuration. When the CHG key is pressed, the SCROLL key will sequence thru the data available for the change function.
7	SHIFT Key	When pressed, sequences to the next digit on the display unit that data can be manually input for the selected change function. When displaying a sequence of displays (i.e., any weapon selection list or fuel and weight modes) pressing SHIFT key allows reverse scroll capability.
8	TEST Key	Initiates self-test of the system.
9	ENTER Key	Enters displayed data into the CG/FLAS.
10	DISPLAY BRT Knob	Controls brightness of the display unit. Rotating the knob clockwise increases brightness and rotating the knob counterclockwise decreases brightness.
11	CHG Key	Allows operator to change the selected data. Flashes the displayed data to be changed.
12	FUEL (Fuel Status Mode) Key	The fuel level advisory mode is active and the FUEL mode light comes on when the FUEL key is pressed. Burn-down-to-levels for selected tanks, asymmetrical fuel loadings, and external missiles that can be released are displayed.
13	MODE Lights (3)	Come on when respective status modes are active.

Figure 1-53 (Sheet 2 of 6)

In all modes, after WPN, CHKN entered, displays the aircraft cg in % MAC.

NOTE

Display will flash when within 1% MAC of either forward or aft CG limit.

- Displays operating weight (pounds), CSRL capabilities, and cg in % MAC.
- Weapons Load

- Internal Weapons Count – First window displays the forward bay, the second window the center bay and the third window the aft bay. The fourth window displays flares and/or chaff loading.
- Weapons Check – Weapons correction or check needed.
  CHKY – Check Yes
  CHKN – Check No

- Displays operation being loaded:

B-52	Aircraft
OW	Operating weight
OWCG	Operating Weight Center of Gravity

- Airplane configuration – Weapons location
  EXT – External weapons
  WB – Weapons Bay
  F – Forward
  C – Center
  A – Aft
- Body stations and weights for new weapons.
- External Weapons Count – First two windows show left pylon forward and aft positions. The next two windows show
- the right pylon forward and aft positions.

  Weapons Check – WPN will be displayed.

- Fuel Level Advisory Mode – First two display windows show the number of external missiles that can be launched without exceeding the aft cg. The 3rd window shows asymmetric fuel load and tank designation where the difference occurred. The 4th window displays pounds from selected burn down in thousands of pounds.
- Weight Status Mode – Displays selected tank(s) and fuel weight in hundreds of pounds. With gage failure, tank designation and last accurate tank reading displayed.

- Fuel Level Advisory Mode – Displays tank designation and burn-down-to level.
- Weight Status Mode – Displays the FQIS or operator input. Displays GF on gage failure, and pounds from selected burn down in thousands of pounds.

DISPLAY UNIT

Figure 1-53 (Sheet 3 of 6)

TANK SELECTION

SCROLL 14 – Main Tanks 1 and 4
MB – Mid Body Tank
23 – Main Tanks 2 and 3
MN – Main Tanks 1, 2, 3, and 4
FB – Forward Body Tank
AB – Aft Body Tank
OW – Outboard Wing Tanks, Left and Right
EX – External Tanks, Left and Right
CW – Center Wing Tank
1 – No. 1 Main Tank
4 – No. 4 Main Tank
2 – No. 2 Main Tank
3 – No. 3 Main Tank
LO – Left Outboard Tank
RO – Right Outboard Tank
LE – Left External Tank
RE – Right External Tank

SHIFT

Next scroll returns to tank selection 14

Current Aircraft CG % MAC

Number of External Weapons That Can Be Released Without Exceeding Aft CG Limit – With an ALCM/ACM pylon selected during initialization, a P is displayed if all external missiles are released and both pylons can be jettisoned without exceeding the aft cg limit.

Quantity (4, 3, 2, 1, *) From Burn-Down-To Level (LB x 1000) – Flashing * indicates tank level less than selected burn-down-to level.

NOTE

The numbers are displayed on right half of LED and letters are displayed on full LED.

ASYMMETRICAL FUEL LOADING CONDITION

E = Between External Tanks (> 1000 pounds)
0 = Between Outboard Wing Tanks (> 1000 pounds)
1 = Between Main Tanks 1 and 4, No. 1 Main is Low Tank (> 2000 pounds)
4 = Between Main Tanks 1 and 4, No. 4 Main is Low Tank (> 2000 pounds)
2 = Between Main Tanks 2 and 3, No. 2 Main is Low Tank (> 2000 pounds)
3 = Between Main Tanks 2 and 3, No. 3 Main is Low Tank (> 2000 pounds)

FUEL LEVEL ADVISORY MODE

Figure 1-53 (Sheet 4 of 6)

WEAPON STATUS MODE (NOT IMPLEMENTED)

! Will be available when the weapon module is installed.

External Load

Left Pylon – Number of weapons FWD and AFT. Example one weapon forward and three aft.

Right Pylon – Number of weapons FWD and AFT. Example two weapons forward and one aft.

P – Displayed in AFT locations to indicate an empty pylon when all ALCMs/ACMs on the applicable pylon are expended.

Internal Load

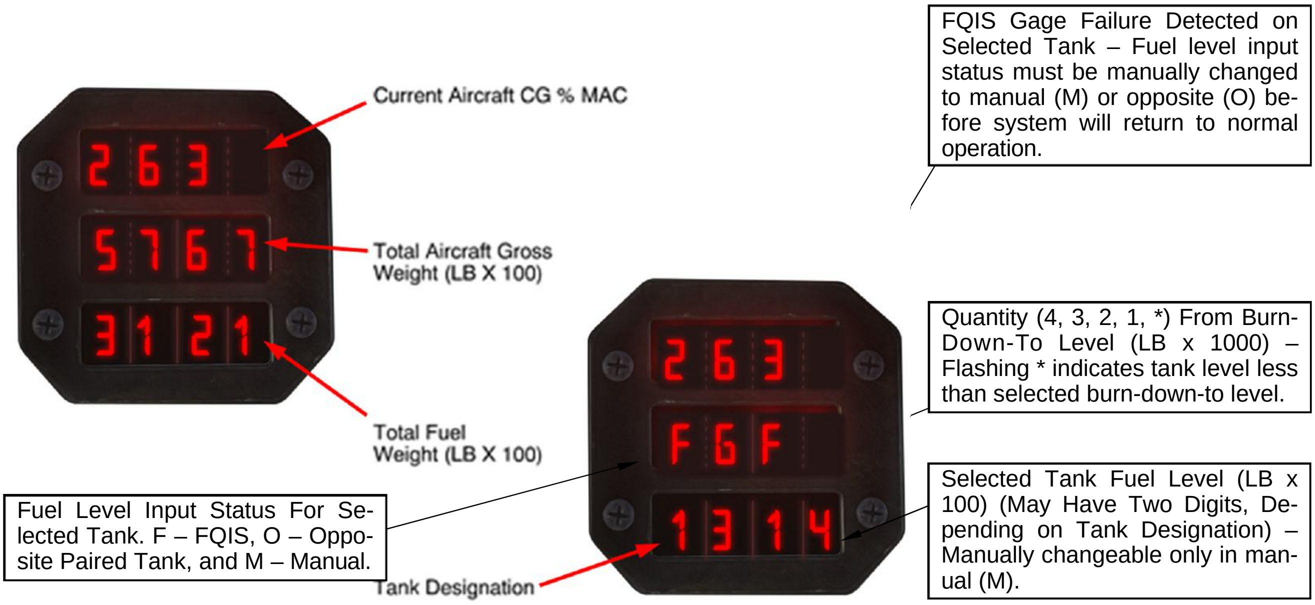
Number of weapons in FWD, CTR, and AFT bomb bay locations. CSRL weapons indicated in CTR and AFT locations only.

FLARES – CHAFF

F – Flares Remaining
C – Chaff Remaining
B – Both Remaining
Blank – Neither Remaining

WEAPON STATUS MODE (! NOT IMPLEMENTED)

Figure 1-53 (Sheet 5 of 6)



TANK SELECTION

SCROLL ▼

- 1 – No. 1 Main Tank
- 4 – No. 4 Main Tank
- 2 – No. 2 Main Tank
- 3 – No. 3 Main Tank
- F – Forward Body
- M – Mid Body
- A – Aft Body
- C – Center Wing
- LO – Left Outboard
- RO – Right Outboard
- LE – Left External
- RE – Right External

SHIFT ▲

Next scroll returns to tank selection 1

NOTE

Scroll sequence is altered if a gage failure (GF) occurs or if the fuel input status is manually changed from F. Order of preference is GF (if not corrected), M, O, and F for SCROLL key and F, O, M, and GF for SHIFT key.

WEIGHT STATUS MODE

Figure 1-53 (Sheet 6 of 6)

NORMAL OPERATION

The CG/FLAS has a self-test function, initialization process, fuel level advisory, weapon status, and weight status modes. The self-test function automatically checks the internal circuitry of the CG/FLAS. The initialization process allows the operator to enter the operating weight, operating weight cg, and weapon, flare, and chaff data. The fuel level mode allows fuel management monitoring, shows an asymmetrical fuel loading, and the number of external weapons that can be released and remain forward of the aft cg. The weapon status mode allows the operator manually to update weapon status as weapons are released, and in the weight status mode, fuel quantity can be displayed or manually changed for each tank and failed gage information is displayed.

SELF-TEST

Self-test can be accomplished any time except during initialization and the change process by pressing the TEST key and is automatically entered when power is initially applied to the CG/FLAS. All lights on the keyboard and the decimal point on the top row of the display come on at initial power application. As self-test begins, the display unit goes blank. The internal circuitry is checked, and when complete, the three mode lights come on. All the elements of the display segments on the display unit will come on one row at a time, starting on the top row, then the middle and the bottom row.

INITIALIZATION

When PWR INTR is displayed, press ENTER to display the aircraft OW. The system is programmed to initially indicate 1770 operating weight on the display unit. Obtain the OW from the aircraft DD Form 365-4 (Form F) and input the OW in hundreds of pounds. Input the OW by pressing the CHG key. The first digit of the display to be input will flash. Use the SCROLL key to increment the numbers from 0 to 9. When the appropriate number is displayed, press the SHIFT key. The second digit to be input will flash. Use the same procedure to in- put the second number. Repeat the procedure until the OW input is complete. Press ENTER to display the operating weight cg (OWCG). The system will initially display 16.0 (OWCG). Input the OWCG in percent MAC using the same procedure as for OW.

NOTE

- Use the SCROLL key to obtain the next display. Use the SHIFT key to obtain the previous display. The previous display cannot be obtained if the ENTER key is pressed.
- Use the CHG/SCROLL/SHIFT keys to input all numerical data. The keys are used as previously discussed.
- A “C” may be displayed under the digits on some displays. This indicates that the value can be modified with the CHG process.

Press ENTER to display STRT, INIT. If initialization data is stored in memory, the OPER MODE and DATA ERAS displays are selected by using the SCROLL/SHIFT key. If initialization data is not stored in memory, pressing the SCROLL/SHIFT keys do not change the display from STRT INIT as the OPER MODE, DATA ERAS, and ERAS DONE displays are not applicable.

FUEL LEVEL ADVISORY MODE

The fuel level advisory mode will be displayed when the FUEL key is pressed and the FUEL level advisory mode light will come on and remain on while the fuel level mode is active. When the fuel level advisory mode is active, aircraft cg is displayed on the top line, selected tank and burn-down-to level on the second line, and number of external missiles that can be released and asymmetrical fuel load condition on the third line. The first two digits on the third line indicate the number of external missiles that may be launched without exceeding the aft cg limit. With an ALCM/ACM pylon selected during initialization, a P is displayed if all external missiles are released and both pylons can be jettisoned without exceeding the aft cg limit. The last digit on the third line displays the burn-down-to level difference. The cue that the actual fuel level is approaching the selected burn-down-to level appears when the level is within 4000 pounds. The display at this location is blank until the 4 appears. It continues down 3000 pounds, 2000 pounds, 1000 pounds. When the actual fuel level equals the selected fuel level or less, an asterisk * will appear and begin flashing.

Fuel Input

The fuel level advisory mode is used to monitor fuel management. In the fuel level advisory mode, only the burn-down-to quantity can be manually input. Press the SCROLL or SHIFT key until the desired tank to be monitored is displayed in the first two windows of the second row. Then press CHG and the third digit in the second row will flash. Use the SCROLL key until the desired number is displayed. Press the SHIFT key and the next digit will flash and the preceding digit goes steady. Use the SCROLL key to display the desired value. Now, the desired burn-down-to level is displayed in thousands of pounds. Press ENTER to load system.

Asymmetrical Fuel Load

If an asymmetrical fuel load condition develops, the CG/FLAS will alert the crew by indicating which pair of tanks are involved, and which is the low one. If a main tank differential becomes greater than 2000 pounds relative to its opposite tank, the low tank number will be displayed. If a differential of 1000 pounds develops in the external tanks, an E will appear. If the same differential of 1000 pounds appears in the outboard tanks, an O will be displayed.

WEAPON STATUS MODE (NOT IMPLEMENTED)

WEIGHT STATUS MODE

The weight status mode is used to monitor fuel quantity and update status, if required. The weight status mode data will be displayed when the WT key is pressed. The weight status mode light comes on and remains on while the weight status mode is active. The correct aircraft cg is displayed on the top row, gross weight (in 100s of pounds) on the second row, and total fuel weight (in 100s of pounds) on the third row. Pressing the SCROLL or SHIFT key will cause the second row to display tank input status in the first digit, and burn-down-to-level difference in the last digit, and the third row to dis- play selected tank and weight. The burn-down to level can be cancelled by selecting 99. The weight status mode uses FQIS inputs normally, but a fuel weight can be manually input. Also, the opposite tank weight can be used if an opposite tank exists, such as MAIN 1 and MAIN 4. To change from one input selection to another, use the SCROLL or SHIFT key to access the desired tank(s), then the CHG, SCROLL process and then ENTER. The selections are F (FQIS), M (manual), and O displays opposite paired tank weight. When M is selected, the operator uses CHG, SCROLL, SHIFT, SCROLL until the desired weight is displayed, then ENTER. The aircraft cg calculations will be based on the manual fuel weight inputs. When the CHG key is pressed, the first digit on the center row will flash and will move from left to right and then across the bottom row as the SHIFT key is pressed. The O in- put can be used when a gage failure occurs, and an approximate reading can be monitored from the op- posite paired tank.

REFUELING SYSTEMS

AIR REFUELING SYSTEM ______________________________ 55
AIR REFUELING SYSTEM CONTROLS AND INDICATORS _ 56

AIR REFUELING SYSTEM

An air refueling system makes it possible to refuel the aircraft in flight from a boom-type tanker air- craft. An air refueling slipway and receptacle, which can be covered by hydraulically operated slipway doors when not in use, is located on top of the fuselage slightly aft of the pilots' stations. A re- fuel system (figure 1-55) makes it possible to fill all the aircraft fuel tanks from the air refueling receptacle or a single point ground refueling receptacle. The refuel system is an extension of the fuel supply system using the same panel to control flow of fuel through the same manifold. A separate refuel panel (figure 1-56) is installed on the overhead panel ad- jacent to the air refueling panel and contains the master refuel switch, the refuel valve switch, and refuel valve position indicator. See FUEL SUPPLY SYSTEM, this section. A main refuel valve down- stream from the air refuel receptacle and the single point ground refuel receptacle connects the refuel manifold to the main manifold. The main manifold distributes fuel to each tank through the fuel level control valves which are controlled from the fuel system panel (figure 1-38) located in front of the co-pilot on the pilots' instrument panel. An air refueling panel (figure 1-56) located on the pilots' over- head panel contains the controls necessary to operate the air refueling hydraulic system and to control a signal amplifier system. The signal amplifier serves to control the refueling sequence and to indicate the sequence conditions of the amplifier to the pilot and copilot.

Air refueling system circuit protection and the location of the applicable circuit breakers is contained in figure 1-60.

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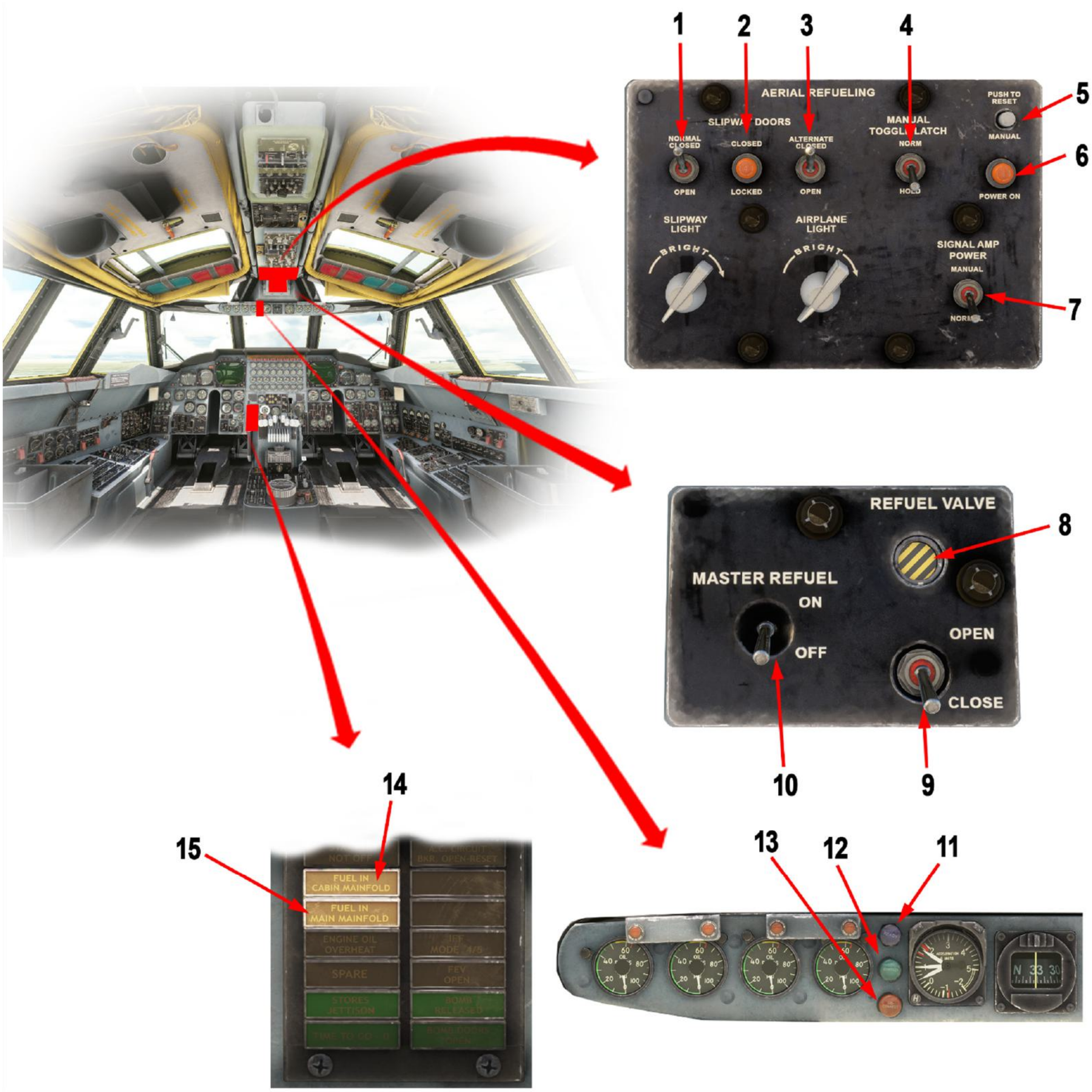
REFUELING SYSTEM CONTROLS AND INDICATORS

A description of the refueling system controls and indicators is contained in figure 1-56.

Air Refueling System Controls and Indicators



1	NORMAL SLIPWAY DOOR SWITCH	10	MASTER REFUEL SWITCH
2	SLIPWAY DOOR CLOSED AND LOCKED LIGHT	11	READY FOR CONTACT LIGHT (BLUE)
3	ALTERNATE SLIPWAY DOOR SWITCH	12	CONTACT-MADE LIGHT (GREEN)
4	MANUAL TOGGLE LATCH SWITCH	13	DISCONNECT LIGHT (AMBER)
5	SIGNAL AMPLIFIER RESET BUTTON	14	FUEL IN CABIN MANIFOLD LIGHT
6	MANUAL POWER LIGHT	15	FUEL IN MAIN MANIFOLD LIGHT
7	SIGNAL AMPLIFIER POWER SWITCH		
8	REFUEL VALVE POSITION INDICATOR		
9	REFUEL VALVE SWITCH		

Figure 1-56 (Sheet 1 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
1	NORMAL SLIPWAY DOORS Switch	Normal slipway door switch with OPEN and CLOSED positions are provided on the air refueling panel. Power is supplied to this switch when the master refuel switch is in ON position. When the normal slipway door switch is in OPEN position, right TR power is supplied to the normal slipway door control valve which allows hydraulic pressure from the left body hydraulic system to open the doors. OPEN position also directs right TR power to the signal amplifier power switch. When the normal slipway door switch is placed in CLOSED position, power is supplied to the normal slipway door control valve to close the doors.
2	SLIPWAY DOOR CLOSED & LOCKED Light (amber)	An amber slipway door closed-and-locked light is located on the air refueling panel. This light is supplied right TR power when the slipway doors are closed and locked, provided the master refuel switch is ON and the light is off when either door is not closed and locked.
3	ALTERNATE SLIPWAY DOORS Switch	The alternate slipway door switch functions similarly except that the right body hydraulic system and the alternate slipway door control valve are utilized. **NOTE** The alternate slipway door switch must be in CLOSED position for the normal slipway door switch to operate the doors properly.
4	MANUAL TOGGLE LATCH Switch	A manual toggle latch switch located on the air refueling panel has RELEASE- -HOLD positions. This switch is supplied with right TR power only when the signal amplifier power switch is in the MANUAL position, and controls the latching toggles (normally controlled by the signal amplifier). In the HOLD position, power is supplied to the manual toggle latching valve allowing the latching toggles to hold the boom in the air refueling receptacle. HOLD position also supplies power to slipway door limit switches, induction coil, and to the disconnect light. In RELEASE position, the toggles are released and allow the air refueling boom nozzle to be withdrawn from the receptacle. The latching toggles may also be released by pressing the air refueling release button on the pilot's control wheel or copilot's control wheel, by high fuel pressure, or by brute force pullouts.

Figure 1-56 (Sheet 3 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
5	Signal Amplifier Reset Button	A push-to-reset signal amplifier reset button is located on the air refueling panel. When pressed after a disconnect has been accomplished, this button resets the automatic control circuit of the signal amplifier. After resetting, the air refueling system is ready for another contact. **NOTE** Upon occasion, the signal amplifier reset button will either fall out of or be pushed inside the air refueling panel when attempting to reset after a disconnect has occurred. Placing the master refuel switch to OFF, then back to ON will accomplish the same thing as pressing the reset button and the signal power amplifier will be in the ''ready for contact'' position.
6	MANUAL/POWER ON Light (amber)	A right TR powered manual power light is on the air refueling panel. This light is illuminated when the signal amplifier power switch is in MANUAL position provided the air refueling system master switch is ON. The manual power light is out when the signal amplifier power switch is in NORMAL.
7	SIGNAL AMP POWER Switch	A signal amplifier power switch located on the air refueling panel has MANUAL- - NORMAL positions. MANUAL position directs right TR power to the manual toggle latch switch, the manual power light, and the plunger limit switch. NORMAL position directs right TR power to the plunger limit switch, the slipway door limit switches, and the signal amplifier.
8	REFUEL VALVE Position Indicator	A tab-window type refuel valve position indicator on the refuel panel has three markings to register position of the main refuel valve and switch. When the refuel valve switch is placed in OPEN position, right TR power is supplied to open the valve. When the valve is open, a limit switch stops the motor and energizes the refuel valve position indicator to show the OPEN marking. When the refuel valve switch is moved to CLOSE position, the position indicator is deenergized, showing the slanting stripes marking. The indicator remains deenergized until the valve closes and a limit switch stops the motor and energizes the indicator to show the CLOSED marking.
9	REFUEL VALVE Switch	A refuel valve switch on the refuel panel has OPEN- -CLOSE positions. This switch controls the main refuel valve located downstream from the air refuel receptacle and the single point refuel receptacle. The valve separates the refuel manifold from the main manifold. In CLOSE position, right TR power is supplied to close the main refuel valve and energize the refuel valve position indicator. In OPEN position, power is supplied to open the main refuel valve and energize the refuel valve position indicator.

Figure 1-56 (Sheet 4 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
10	MASTER REFUEL Switch	A master refuel switch on the refuel panel has ON- -OFF positions. ON position supplies right TR power to the normal and alternate slipway door control switches. In OFF position, no power is supplied to these units. The master refuel switch also supplies power to the fuel level control valve circuits. OFF position of the master refuel switch removes power from the fuel level control valve circuits; the valves will close and refueling through the valves is impossible. WARNING During low level or traffic pattern fuel panel operations, the master refuel switch will not be used by itself to control auxiliary tank fuel transfer operations. Whenever engine feed is selected with the auxiliary tank fuel flow control switch and the master refuel switch is off, the auxiliary tank boost pumps will continue to run with a no flow condition. Therefore, both the master refuel switch and all auxiliary fuel control switches will be turned off whenever fuel transfer is to be stopped. This is necessary since below 25,000 feet MSL, an explosive condition exists due to the auto-ignition temperature of fuel vapors and the potential ignition source from a malfunctioning auxiliary boost pump.
11	Ready-for-Contact Light (blue)	A blue ready-for-contact light is the upper light of the three air refueling lights on the eyebrow instrument panel. The word READY can be read on the light. The light receives right TR power through the fully open positions of the slipway door limit switches.
12	Contact-Made Light (green)	A green contact-made light is the center light of the three air refueling lights on the eyebrow instrument panel. The word CONTACT can be read on the light. The light receives right TR power through the plunger limit switch in the air refuel receptacle.
13	Disconnect Light (amber)	An amber disconnect light is the lower light of the three air refueling lights on the eyebrow instrument panel. The word DISCONNECT can be read on the light. The light receives right TR power from the signal amplifier or from the HOLD position of the manual toggle latch switch.
14	FUEL IN CABIN MANIFOLD Light	The fuel-in-manifold light marked FUEL IN CABIN MANIFOLD is located on the central caution panel and indicates when fuel is in the refuel manifolds. The FUEL IN CABIN MANIFOLD light will glow if fuel is in the refuel manifold and the master-refuel switch is placed to OFF or when the scavenge system switch (No. 18) is placed in CABIN position. The light will go out as soon as the manifold is scavenged.

Figure 1-56 (Sheet 5 of 8)

NO.	CONTROL-INDICATOR	FUNCTION
15	FUEL IN MAIN MANIFOLD Light (amber)	The fuel-in-manifold light marked FUEL IN MAIN MANIFOLD is located on the central caution panel and indicates when fuel is in the main manifold. When the scavenge system switch (No. 18) is placed in MAIN position, the FUEL IN MAIN MANIFOLD light will glow if fuel is in the main manifold. The light will go out as soon as the manifold is scavenged or the scavenge system switch is turned OFF.

Figure 1-56 (Sheet 6 of 8)

ELECTRICAL POWER SUPPLY SYSTEMS

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AC POWER SYSTEM 61
DIRECT CURRENT SYSTEM 67
NORMAL OPERATION 71
DC SYSTEM 67
EXTERNAL POWER 71
GENERATOR OPERATION 72

DESCRIPTION

Primary and secondary distribution buses supply power to the aircraft. Primary power is supplied by four engine-driven generators. This 205/118-volt three-phase ac power is used for most heavy loads such as fuel boost pumps, and wing flap motors. Single-phase 118-volt ac power is generally used for small motors, actuators, and is used for some electronic equipment. Transformers reduce single-phase ac power to 28 volts for most lighting. Secondary power is 28-volt nominal unregulated dc supplied by transformer-rectifier (TR) units fed from the 205-volt three-phase ac power of the primary system. This TR power is used for control circuits, instruments, small motors, and electronic equipment. Two nickel-cadmium batteries provide an auxiliary source of 24-volt dc power which is supplied to essential equipment in case the ac or TR system fails to function. The batteries also pro- vide power directly to emergency equipment through the forward and aft battery buses. Both ac and dc power are distributed throughout the air- craft by buses located in junction boxes and panels. Circuit breakers and fuses are installed to protect aircraft wiring. AC and dc power may be obtained for ground operation through external power receptacles. Missile ac power requirements are provided from the aircraft through circuit breakers in the engine No. 1, 3, 5, and 7 generator power boxes.

The ac input power is redistributed within the missile system through circuit breakers located in a missile power distribution box installed in the forward wheel well. Missile dc control power and other miscellaneous requirements are supplied from the aircraft non-interruptible dc (NDC) bus. The dcpower requirements for missiles are provided from one TR unit to provide dc power for the rotary launcher hydraulic pump and three paralleled NDC power supplies to provide power to missile electronics and EED power, with circuit breaker protection in the power distribution box

AC POWER SYSTEM

The ac power system consists of four engine-driven generators, a flight gyro emergency power inverter, power distribution boxes, a central bus tie, bus tie and generator circuit breakers, power load boxes, and circuit breaker panels. An ac control panel (figure 1-64) at the copilot's station provides all the controls and indicators for operation of the system. The gyro power switch on the pilot's side panel controls the flight gyro emergency power inverter.

Generators

The primary ac power supply is provided through four engine-driven 120 kva generators located underneath the engines on the accessory pads of engines 1, 3, 5, and 7. Each generator is capable of carrying 120 kva at a reasonable power factor.

GENERATOR DRIVES

Since certain electronic equipment requires constant frequency, a drive is needed to drive the generator at a constant speed throughout the range of various engine speeds. The drive used consists of a hydraulic transmission controlled by an electro- mechanical governor. The transmission receives its input drive power directly from the engine. By use of the basic governor through the wobble pump, the drive adds to or subtracts from the variable input speed of the engine and provides a constant ac out- put from the generator of 400 (±1) Hz. The frequency reference unit provides a constant ac output from the generator at 400 (+0.1) Hz. The generators are driven at a constant speed of 8000 rpm. The minimum generator cut-in speed is approximately 5670 engine rpm. Movement of the governor flyweights controls the action by directing oil pressure to vary the pitch of the wobble plate. The frequency is controlled automatically by the frequency and load controller through the magnetic trim head of the basic speed governor if the generator field is energized. If the generator field is not energized, the basic governor controls the frequency. See ELECTRICAL SYSTEM OPERATION, this section, for additional information on generator frequencies.
An electro-mechanical decoupling device is contained in the drive and provides a means of manually decoupling the drive input shaft from the engine shaft. The drive shaft and engine shaft cannot be recoupled during flight. When the temperature of a drive reaches 250° (±10°) F, the drive overheat light, master caution lights, and central caution light will come on and the drive should be decoupled.

If the drive fails to disconnect, the lights will again come on when the drive temperature reaches 350c (150) F.

GENERATOR DRIVE OIL SYSTEM

Each generator drive is provided a separate oil system which includes an oil tank having a usable capacity of 6.75 quarts and a total capacity of 9 quarts. Oil is routed through the generator drive, through an oil cooler, and returned to the tank. Cooling air for the oil cooler is provided by engine fan air. Oil temperature is controlled by a thermostatic valve which allows bypassing of the cooler. No manual controls are provided for this system.

Generator Overheat Protection

When a generator reaches a temperature of 240□C or above, its respective bus tie circuit breaker will automatically trip open and will remain open until it is closed by actuation of the generator switch.

CIRCUIT BREAKERS

Standard circuit breakers, ranging in size from 2.5 to 50 amperes, are used to provide protection for aircraft wiring. Although applied specifically for wire protection, they provide some protection for components. These circuit breakers are of the trip-free pushbutton type. Wiring to three-phase loads is protected by three individual circuit breakers, one for each phase. Special circuit breakers are used in conjunction with the offensive avionics system to provide both wire and component protection. These circuit breakers are toggle type and are used in fractional ampere ratings. Three-phase circuit breakers of this type are used for some OAS components requiring three-phase power. The three-phase breakers will open all three power circuits simultaneously in the event that a short occurs in any one circuit.

AC Power System Controls and Indicators

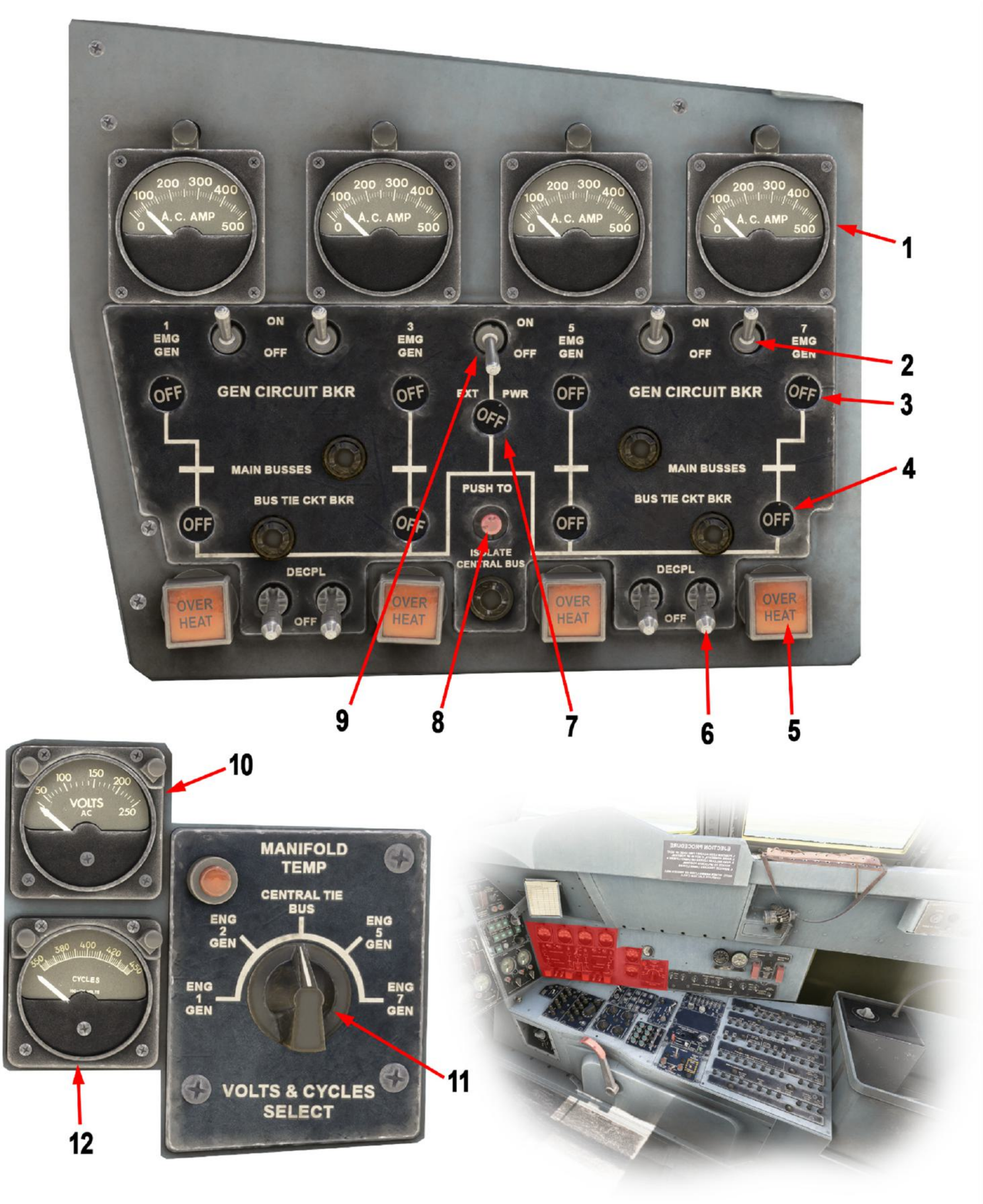
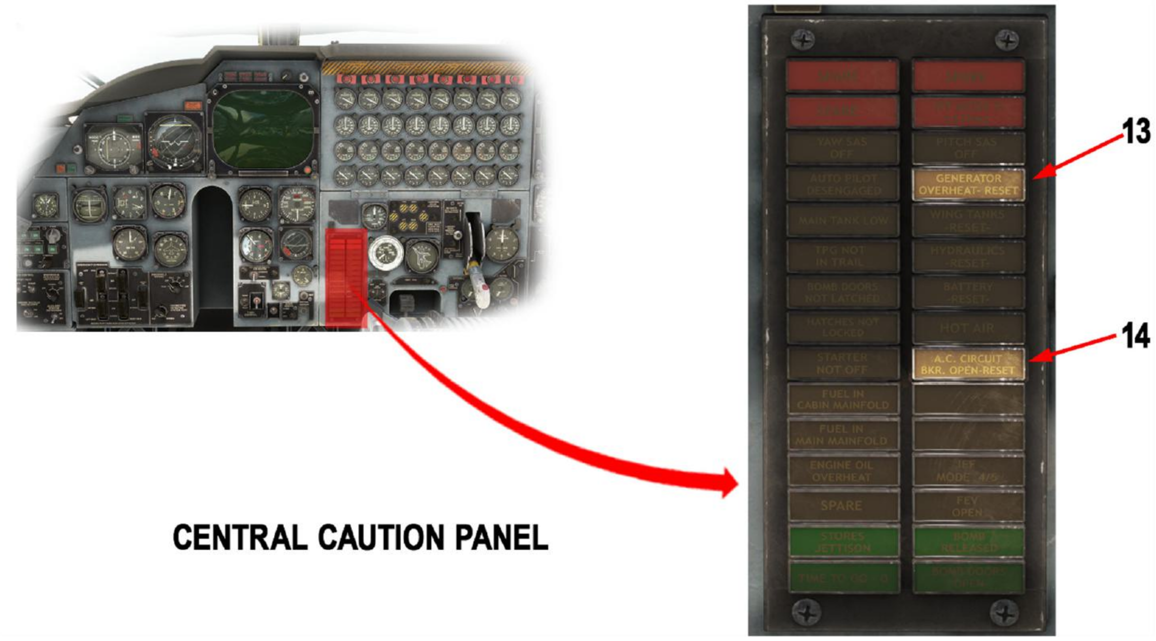


Figure 1-64 (Sheet 1 of 4)



1 AC AMMETERS (4 PLACES)
2 GENERATOR SWITCHES (4 PLACES)
3 GENERATOR CIRCUIT BREAKER POSITION INDICATORS (4 PLACES)
4 BUS TIE CIRCUIT BREAKER POSITION INDICATORS (4 PLACES)
5 GENERATOR DRIVE OVERHEAT LIGHTS (4 PLACES)
6 GENERATOR DRIVE DECOUPLER SWITCHES
7 EXTERNAL POWER CIRCUIT BREAKER POSITION INDICATOR
8 MASTER ISOLATE SWITCH
9 MAIN EXTERNAL POWER SWITCH
10 FREQUENCY METER
11 VOLTMETER AND FREQUENCY SELECTOR SWITCH
12 VOLTMETER
13 GENERATOR DRIVE OVERHEAT CAUTION LIGHT
14 AC CIRCUIT BREAKER CAUTION LIGHT

NO.	CONTROL-INDICATOR	FUNCTION
1	AC Ammeters (4 places)	Four ac ammeters provide an indication of output in amperes supplied by each individual generator. The ammeters indicate in the range from 0 to 500 amperes. See figure 5-1 for ammeter markings.
2	Generator Switches (4 places)	Four three-position generator switches are marked ON and OFF at the extreme positions respectively and are spring-loaded to the unmarked neutral position. When the switch is held momentarily in ON position, 24 volt nominal dc essential power closes the generator control relay and the generator circuit breaker and energizes the generator field. When the switch is held in OFF position, the same power trips both the generator control relay and the generator circuit breaker and closes the bus tie circuit breaker.

Figure 1-64 (Sheet 2 of 4)

AC Power System Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
3	Generator Circuit Breaker Position Indicators (4 places)	Four three-position tab indicators, one for each generator circuit breaker provide a means of indicating the position of the respective circuit breakers. Two positions of the tab indicator are bars and the other is OFF. The bars are white and run vertically and horizontally through the center of the black indicator. OFF position is black and has OFF marked in white across the center of the indicator. When the bar is aligned with the reference line on the ac control panel, the circuit breaker is closed. When the bar is at a right angle to the reference line, the circuit breaker is open. OFF position indicates the tab indicator is not receiving control power.
4	Bus Tie Circuit Breaker Position Indicators (4 places)	Four three-position tab indicators, one for each bus tie circuit breaker provide a means of indicating the position of the respective circuit breakers. The bus tie circuit breaker position indicators function in the same manner as the generator circuit breaker position indicators (No. 3).
5	Generator Drive OVERHEAT Lights (4 places)	Four amber generator drive overheat lights, one for each generator are marked OVERHEAT. The lights will illuminate when a generator drive temperature exceeds 250° (±10°) F, provided the decoupler switch is in NORM position. The lights will also illuminate when the drive temperature reaches 350° (±15°) F regardless of decoupler switch position.
6	Generator Drive Decoupler Switches (4 places)	Four generator drive decoupler switches, one for each generator are on the ac control panel. The switches are marked NORM and DECPL at the extreme positions and MON at the center position. The switch latches in NORM position and is spring-loaded to MON position after being placed in DECPL position. **NOTE** If a generator drive is decoupled during flight, it can only be recoupled while the aircraft is on the ground with the generator drive removed.
7	External Power Circuit Breaker Position Indicator	A single three-position tab indicators provides a means of indicating the position of the main external power circuit breaker relay. See External Power system Controls and Indicators this section.
8	Master Isolate Switch	A master isolate switch on the copilot's control panel is marked PUSH TO ISOLATE CENTRAL TIE BUS. Pressing the switch energizes the master isolate relay, which in turn trips the bus tie circuit breakers, isolating all generators from the central bus tie. Holding the generator switches in ON position until the bus tie circuit breakers close will repower the central bus tie.
9	Main External Power Switch	A three-position switch controls application of main external power. See External Power system Controls and Indicators this section.
10	Frequency Meter	A frequency meter adjacent to the ac control panel provides a means of reading individual frequencies of the generators and central bus tie. Some frequency meters are calibrated from 350 to 450 Hz and some from 380 to 420 Hz. For typical frequency meter instrument markings, see figure 5-1.

Figure 1-64 (Sheet 3 of 4)

NO.	CONTROL- INDICATOR	FUNCTION
11	Voltmeter and Frequency Selector Switch	A five-position frequency and voltage selector switch located adjacent to the ac control panel has ENG 1 GEN- -ENG 3 GEN- -CENTRAL TIE BUS- -ENG 5 GEN- -ENG 7 GEN positions. The switch provides a means of selecting and reading frequency and voltage of the central bus tie and of each generator. In ENG 1 GEN position, the frequency and voltage of the No. 1 generator may be read on the frequency meter and voltmeter provided the generators are isolated. The remaining positions will perform the previous operation for their respective generators as marked. When the generators are in parallel, all generator switch positions will be read the same as the CENTRAL TIE BUS position.
12	Voltmeter	A voltmeter adjacent to the ac control panel provides a means of reading individual voltages of the generators and central bus tie. The voltmeter is calibrated from 0 to 250 volts. For voltmeter markings, see figure 5-1.
13	Generator Drive Overheat Caution Light (Amber)	A generator drive overheat caution light marked GENERATOR OVERHEAT – RESET on the central caution lights panel indicates that one or more of the generator drives are in an overheat condition and the drive should be decoupled by the copilot. The copilot must monitor the generator drive overheat lights on the ac control panel in order to determine which generator drive has the overheat condition. The generator drive overheat light signal is also received by the master caution lights causing them to light simultaneously. In event the generator drive overheat caution light comes on, it should be reset by pressing the reset switch adjacent to the central caution panel so the remaining generator drives may be monitored.
14	AC CIRCUIT BKR Caution Light (Amber)	The light, when illuminated, shows amber letters AC CIRCUIT BKR OPEN, RESET on a black background. The ac circuit breaker light serves to caution that one of the generator or bus tie circuit breakers has tripped open. The light will come on at the same time any of the generator or bus tie circuit breakers open and will remain on as long as the circuit breaker is open unless it is reset. The light may be reset by pressing the reset switch adjacent to the central caution panel, at which time, it will go out and be ready for additional indication of any circuit breaker which may open. The indication given on the ac circuit breaker light is also indicated on the master caution lights located on the pilots' instrument panel. **NOTE** **60-001 thru 60-062** Faults on the left essential bus or the associated circuit breaker being open may cause the generator drive overheat light and generator drive overheat caution light to come on dimly. This is caused by a feedback voltage from the right essential bus. With a system malfunction, the lights will illuminate with normal brilliance.

Figure 1-64 (Sheet 4 of 4)

DIRECT CURRENT SYSTEM

Direct current (dc) power is normally provided through transformer-rectifier (TR) units which are supplied ac power by the generators. Two 24-volt 35 ampere-hour maintenance-free batteries are used as an auxiliary source of dc power. DC power is supplied to the various equipment from one of the following buses:

- Aft Battery Bus and Forward Battery Bus
- Emergency Battery Power Bus and Emergency Instrument Power Bus
- Right Essential Bus and Left Essential Bus
- Right TR Bus, Left TR Bus, and Aft TR Bus

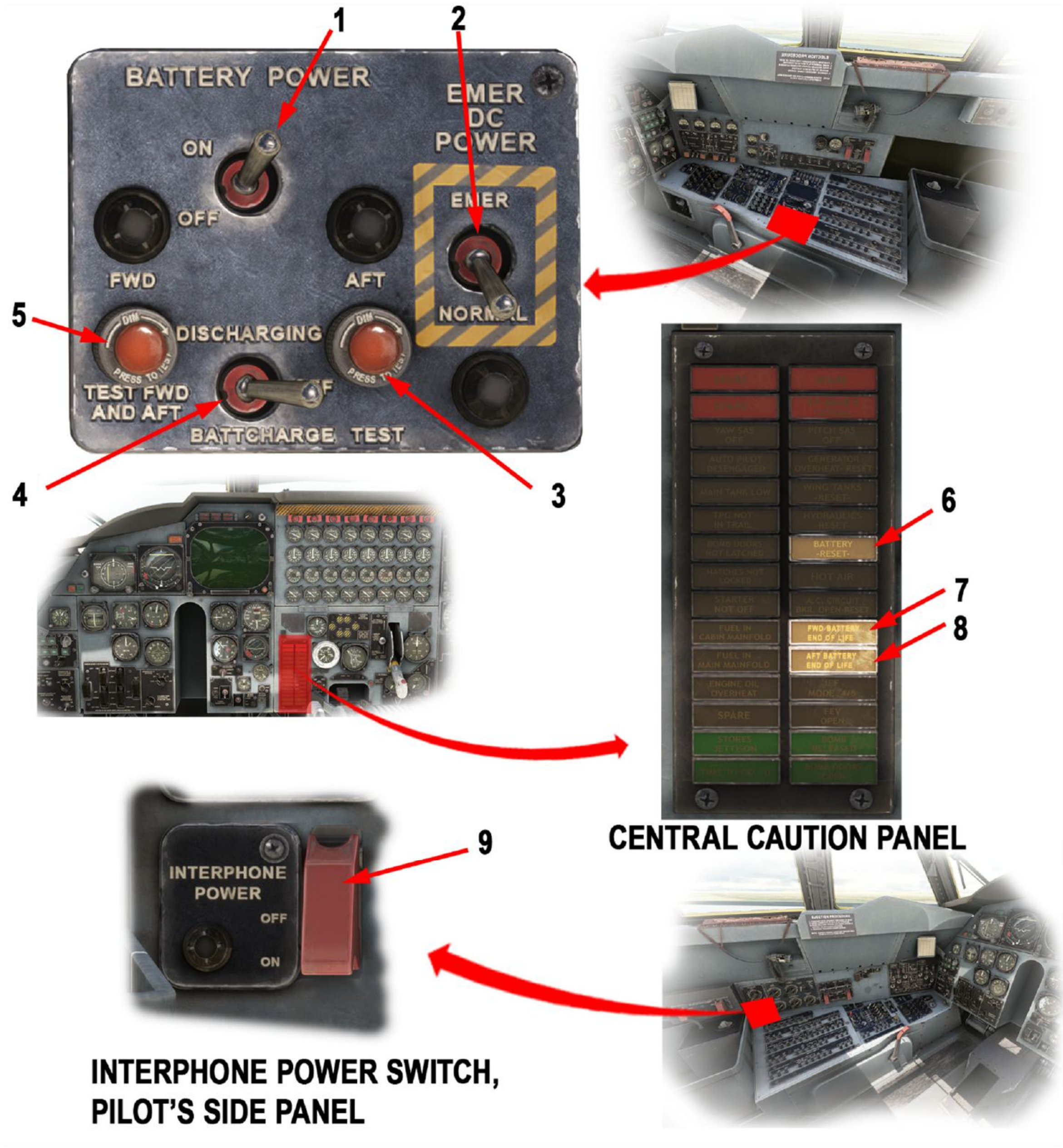
The equipment will receive power from one of the buses according to the importance of the equipment (figure 1-65). The two forward TR buses are inter- connected and will supply dc power as long as ac power is available. In the event of an ac power failure, dc power would not be supplied to the TR buses. The left essential and right essential buses normally receive TR power but in the event of an ac system failure, these buses automatically transfer to battery power provided the battery switch is ON. These buses supply battery power to essential dc operated equipment which normally receive TR dc power. The aft battery bus and forward battery bus can supply direct battery power to emergency equipment.

Batteries

An auxiliary source of dc power is provided by two 24-volt 35 ampere-hour maintenance-free batteries (27 and 28, sheet 1 of figure 1-1) designated as the aft and forward batteries located in the forward wheel well. The batteries have heaters and are capable of satisfactory operation at –40°F (–40°C). The aft battery supplies power directly through fuses and circuit breakers to battery buses located in the aft battery power box, left load central fuse installation, left load central circuit breaker panel, pilot’s circuit breaker panel, and right forward BNS over- head circuit breaker panel. The forward battery supplies power directly through fuses and circuit breakers to battery buses located in the right for- ward dc power box, right load central fuse installation, right load central circuit breaker panel, pilot’s circuit breaker panel, and aft BNS overhead panel. Essential battery buses are supplied battery power through the left and right essential dc battery re- lays when the battery switch is ON and TR power is not available. When TR power is available, the right and left dc TR relays are energized. Should the ac or TR power fail, essential battery bus loads are assured a source of power from the batteries for short periods. Loads such as emergency landing gear control, entry light, and jettison power are connected directly to the battery buses. Loads such as bailout warning and airbrake control are connected so that they may receive power from either the for- ward or aft battery, depending on position of emergency dc power switch (figure 3-21). The batteries are charged from individual static transformer-rectifiers. The transformer-rectifier unit for the for- ward battery receives ac power from engine No. 3 generator bus and that for the aft battery receives ac power from engine No. 5 generator bus. The TR units will supply charging power for their batteries as long as ac power is on the respective generator buses.

Battery power duration is dependent on the load conditions. Fully charged batteries are capable of performing a simultaneous eight engine cartridge start with no ground support equipment, and with only the minimum flight essential equipment powered can supply enough power to fly the aircraft for up to four hours in an emergency situation.

DC Power System Controls and Indicators



1 BATTERY SWITCH
2 EMERGENCY DC POWER SWITCH
3 AFT BATTERY DISCHARGING LIGHT
4 BATTERY CHARGE TEST SWITCH
5 FORWARD BATTERY DISCHARGING LIGHT
6 BATTERY CAUTION LIGHT
7 FORWARD BATTERY END OF LIFE LIGHT
8 AFT BATTERY END OF LIFE LIGHT
9 INTERPHONE POWER SWITCH

Figure 1-67 (Sheet 1 of 3)

DC Power System Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
1	Battery Switch	An ON- -OFF battery switch routes battery power to the essential battery buses. When the battery switch is placed in ON position, battery power is directed to the essential buses through the essential dc battery relays and, when TR power is available, relays are energized to transfer essential buses to TR power. In the copilot's circuit breaker panel only, the right and left essential dc buses are normally powered from their respective battery any time the battery switch is ON. If the battery switch is OFF and TR power is available, they will be powered from the TR buses. When the battery switch is in OFF position, no battery power is available to the essential battery buses. Battery power is supplied directly from each battery to individual (direct) battery buses at all times, regardless of the position of the battery switch.
2	Emergency DC Power Switch	An emergency dc power switch marked NORMAL- -EMER located on the copilot's side panel controls which source of power is connected to the emergency battery power bus and the emergency instrument power bus. When the switch is in NORMAL position, aft battery power is supplied to the emergency battery power bus, and left essential power is supplied to the emergency instrument power bus. When the switch is placed in EMER position, forward battery power is supplied to both buses. For detail loads in each switch position, see figure 3-21.
3	Aft Battery Discharging Light (amber)	Two amber lights, one for each battery, provide visual indication that the battery is discharging. With the BATT CHARGE TEST switch in TEST FWD AND AFT and the batteries greater than 85% of full charge, the battery DISCHARGING lights will flash on and off indicating the pulsing action of the charger, provided battery bus loads between 0.25 to 1.0 and 5 amps exist. At loads above 5 amps, charging action will be steady and the battery DISCHARGING lights will not come on. A battery discharging rate of 0.25 to 1.0 amp with no charging TR power present is indicated by steady lights. A press-to-test feature of the battery DISCHARGING lights allows the copilot to check the light bulbs and ground circuits. A warning light on the central caution panel marked BATTERY RESET indicates when battery charging power is not present. Reference to the two DISCHARGING lights on the copilot side panel will indicate which charger is not operating. For proper operation of the press-to-test feature, the INTERPHONE POWER switch must be ON. However, the forward battery DISCHARGING light may come on while the INTERPHONE POWER switch is OFF and no TR power is available. This condition exists due to feedback through the battery detection circuit and main TR bus loads to ground if the press-to-test feature is operated.
4	Battery Charge Test Switch	The BATT CHARGE TEST switch may be used to test the state of charge of both the forward and aft batteries. A DISCHARGING light No. 3) for each battery is located next to the test switch. With the switch in TEST FWD AND AFT, flashing of the light indicates the battery is greater than 85% charged.A battery bus load of at least 1.0 amp shall exist to assure operation of battery DISCHARGING light during battery testing with the BATT CHARGE TEST switch. No light will be present if the battery is below 85% of full charge.

Figure 1-67 (Sheet 2 of 3)

NO.	CONTROL- INDICATOR	FUNCTION
5	Forward Battery Discharging Light (amber)	The forward battery discharging light functions in the same manner as the aft battery discharging light (No. 3). The forward battery discharging light will press to test with the interphone switch OFF if a feedback voltage exists through the battery detector system.
6	Battery Caution Light (amber)	An battery caution light marked BATTERY-RESET indicates that one or both of the battery charging TR units are not supplying charging power to their respective battery buses. The copilot must monitor the battery discharging lights on his side panel in order to determine which battery is not receiving charging power; however, the battery discharging lights will not be on unless sufficient loads are on the buses. The battery caution light signal is also received by the master caution lights causing them to light simultaneously. The light may be reset by pressing the reset switch adjacent to the central caution panel. In the event the battery caution light comes on, the light should be reset so the remaining battery may be monitored
7	FWD BATTERY END OF LIFE Light (amber)	The forward battery end of life light indicates the approach to and the end of useful battery output. When battery voltage decreases to 22.2 (±0.1) volts, the respective light will flash at a rate of 45 (+20/-15) cycles per minute (a cycle being one complete on and off operation). The light will continue to flash until voltage decreases to 18 (+0.5) volts at which time the lights will remain on. At this time, the battery is discharged beyond a usable condition. The lights will remain off when voltage is 22.3 or above. With a maximum emergency load of 15 amperes on the battery buses, there is a minimum time of 6 minutes and a maximum of 14 minutes from the time the end of life lights flash on and off until they have a steady illumination.
8	AFT BATTERY END OF LIFE Light (amber)	The aft battery end of life light functions in the same manner as the forward battery end of life light (No. 7).
9	INTERPHONE POWER SWITCH	An ON- -OFF interphone power switch on the pilot's side panel, in addition to its normal functions (see INTERPHONE SYSTEM, this section), controls operation of both battery detectors. ON position energizes both battery detectors and allows the battery discharging lights to function. OFF position deenergizes the battery detectors and battery discharging light circuits.

Figure 1-67 (Sheet 3 of 3)

ELECTRICAL SYSTEM NORMAL OPERATION

CONTROL CIRCUITS

A complete understanding of the dc relays which control the primary electrical system is a valuable aid in the efficient operation of the electrical systems. All controls that affect the starting and routing of electrical power use 24-volt dc essential battery power. This use of essential battery power assures that with the battery switch in the ON position, there will always be power available to start, control, and route power throughout the aircraft. Control power for the main external power relays is also furnished by essential power while control power for the BNS and FCS external power relays is furnished by the respective power cart.

INSTRUMENT INDICATIONS

Information which can be obtained from the electrical system instruments can be correctly interpreted only if the significance of the readings is understood. A brief explanation of the meaning of the instrument readings is given in the following paragraphs.

Voltage

Voltage is the electrical potential supplied by the batteries, TR units, or generators. It is the force which pushes current through the lines. The ac voltmeter measures the effective voltage rather than the instantaneous voltage at the peak of the cycle. The only indication of battery voltage is through the battery end of life lights which flash on and off when voltage decreases to 22.2 (+0.1) volts or below. There are no means of measurement for TR voltage.

Frequency

The ac frequency meter indicates the number of voltage (and current) cycles that occur in each second. One complete cycle is considered 360 electrical degrees and each phase reaches a voltage and a current peak in both directions once during each cycle. Since this is a balanced three-phase system, the voltage peaks of the three phases are separated by one-third of a cycle or 120°.

Load

Four ac ammeters (figure 1-64) located on the ac control panel are provided to measure B phase ac current and to enable the copilot to compare the four indicated load values. Current in amperes is the rate of flow of electricity.

EXTERNAL POWER

To connect external power, several preliminary steps will first be accomplished. The battery switch should be turned ON and a check made of the battery discharging lights. These lights should illuminate since TR power for battery charging is not available. The generator circuit breakers should be open since the control circuit for external power is routed through the open side of these circuit breakers. A check of the four circuit breaker position indicators would be sufficient to determine the correct position of the generator circuit breakers since these indicators use essential battery power. If the indicators show the circuit breakers are closed, actuate the generator switches to OFF position and circuit breakers will open. When external power is plugged into the external receptacle and the external power switch is placed in ON position, essential dc power will close the external power circuit breaker sending power to the central bus tie. It is necessary that the bus tie circuit breakers be closed manually, if open, by placing generator switches to OFF in order to power all units on the aircraft. Placing any operating generator switch to ON, placing the external power switch to OFF, placing the power cart switch to OFF, or removing the external cord plug will remove external power from the aircraft system.

NOTE

- The external power unit is available only at specially equipped parking stands.

GENERATOR OPERATION

Starting

Each generator can be energized and placed on its main bus after its engine is started. Normally, it is best to actuate the generator switch after all engines are started. The latter procedure allows external power to carry the entire electrical load until all engines are operating and the flightcrew is ready to operate on aircraft power and for ground crew to disconnect external power. In addition, less copilot attention is required during engine starting. It is not necessary to trip the generator switch to OFF prior to engine starting as the generator control relay is tripped automatically on engine shutdown and bus tie circuit breakers are closed. Holding of the generator switch to ON is required only during paralleling through the bus tie circuit breaker. Paralleling through the generator circuit breaker requires momentary actuation only of the generator switch to ON. The latter is by far the more common occurrence. Joggling of the engine speed is required if the generators do not parallel. After the generators are on their respective bus, loss of aircraft dc voltage does not affect the ac generation system except that the copilot has no generator switch control. However, the ac system protects itself if faults or abnormal operation are experienced.

Shutdown

The generator may be completely shut down by use of the constant speed drive (CSD) decoupler switch without shutting down the engine. Re-coupling of the drive can only be accomplished when the aircraft is on the ground with engines shut down and the CSD removed. During normal shutdown, the under-over speed switch will trip the generator circuit breaker and de-excite the field.

ELECTRICAL LOADS

The generators are designed to carry 120 kva at a reasonable power factor. All generators have an overload capacity that allows them to operate at 240 kva for 5 seconds or at 180 kva for 5 minutes. Load indication is only shown on the ammeters. Under normal operating conditions, the load should never exceed the limitation on the ammeters.

Parallel Operation

During parallel operation, all electrical loads are divided among the four generators. Should any generator or drive fail, the load would be automatically redistributed among the remaining three generators. Two or more generators operating in parallel will have the same frequency (speed) and voltage.

Frequency Control

One frequency and load controller for each generator automatically controls the frequency through the magnetic trim head of the basic speed governor. The frequency and load controller has two basic circuits; a frequency circuit for controlling the genera- tor frequency and a load division circuit for maintaining real load balance between paralleled generators. Power for frequency and load controller sensing is supplied from the generator output. One frequency reference unit is provided in the electrical system and operates in conjunction with the four frequency and load controllers. The unit is supplied 400 Hz power from the central tie and in turn supplies 115-volt ac at 400 (±0.1) Hz to each frequency and load controller. The unit will not operate unless power is on the central tie.

Isolated Operation

For information on generator isolation, see MASTER ISOLATE SWITCH, this section.

LIGHTING EQUIPMENT

DESCRIPTION 73
EXTERIOR LIGHTING 74
INTERIOR LIGHTING 76

DESCRIPTION

EXTERIOR LIGHTING

Exterior lighting consists of landing lights, navigation lights, terrain clearance light, taxi lights, air refueling lights, crosswind landing light, anticollision lights, and a signal light. The lights utilize 28 volt ac power reduced from 118 volts ac by autotransformers. Exterior lighting controls are described in figure 1-72.

Landing Lights

A fixed landing light is installed in each forward landing gear door for use during approach and landing. The landing lights will not illuminate after the landing gear has been retracted.

Navigational Lights

The navigational lights consist of a red light on the left wingtip, a green light on the right wingtip, two white lights on each tip of the horizontal stabilizer, and three white lights, one on top of the fuselage and one on each side above the bomb bay doors .

Anticollision Lights

Three rotating anticollision lights, two on top of the fuselage and one on the bottom just forward of the empennage, are used to safeguard against midair collision.

Crosswind Landing Light

A crosswind landing light is in- stalled on the right forward landing gear to provide lighting on the landing area during crosswind landings. It will not illuminate unless the landing gear lever is in DOWN position.

Terrain Clearance Light

A retractable terrain clearance light installed on the forward bottom fuselage will provide illumination during a night crash landing. In addition, the light may also be used for night takeoff and landings.

Taxi Lights

Three taxi lights and the crosswind landing light provide lighting for taxi operation. One light is installed on the leading edge of each wing just outboard of the outboard pods. A crosswind taxi light is installed on the right forward landing gear.

Air Refueling Lights

Air refueling lights consist of five white lights, one installed in the receptacle and two in each slipway door. The lights illuminate the receptacle, slipway, and wing areas during night air refueling operations. In addition, the lights aid the tanker boom operator in checking the receiver aircraft. The lights in the slipway doors may be used for scanning the wing leading edges, nacelles, struts, and spoilers.

Signal Light

A 28 volt ac powered signal light (8, sheet 3 of fig- ure 1-1) stowed aft of the copilot may be used as a means of communication between aircraft in flight or an aid in identification. A power receptacle is located adjacent to the light for plugging in the power cord leading from the light.

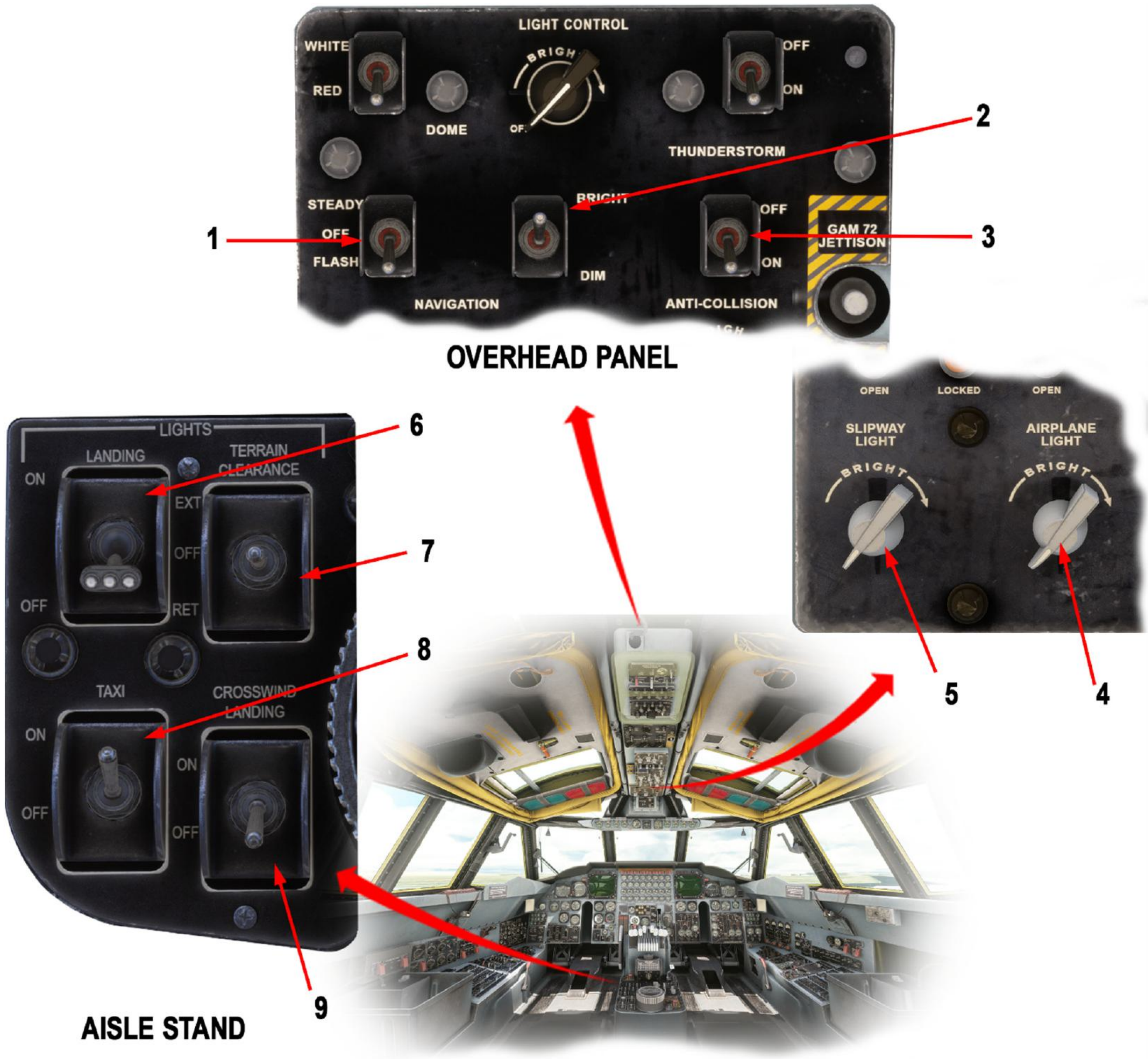
INTERIOR LIGHTING

Interior lighting is provided by red and white lights. Red lights are used during night flights since red color does not adversely affect night vision. White lights are used for daytime flights during dull light conditions and during thunderstorms to lessen the blinding effect of lightning flashes. All lights utilize 28 volt ac power reduced from 118 volts ac by autotransformers except the entry lights and, in an emergency, the essential instrument lights which use 24 volt dc battery power. Interior lighting is described in figure 1-73. Entry and walk- way lights are described in figure 1-74.

Spotlights

Spotlights are located at the pilots', EW officer's, gunner's, radar navigator's, and navigator's stations. The lights are controlled by a rheostat switch on the individual light.

Exterior Light Controls and Indicators



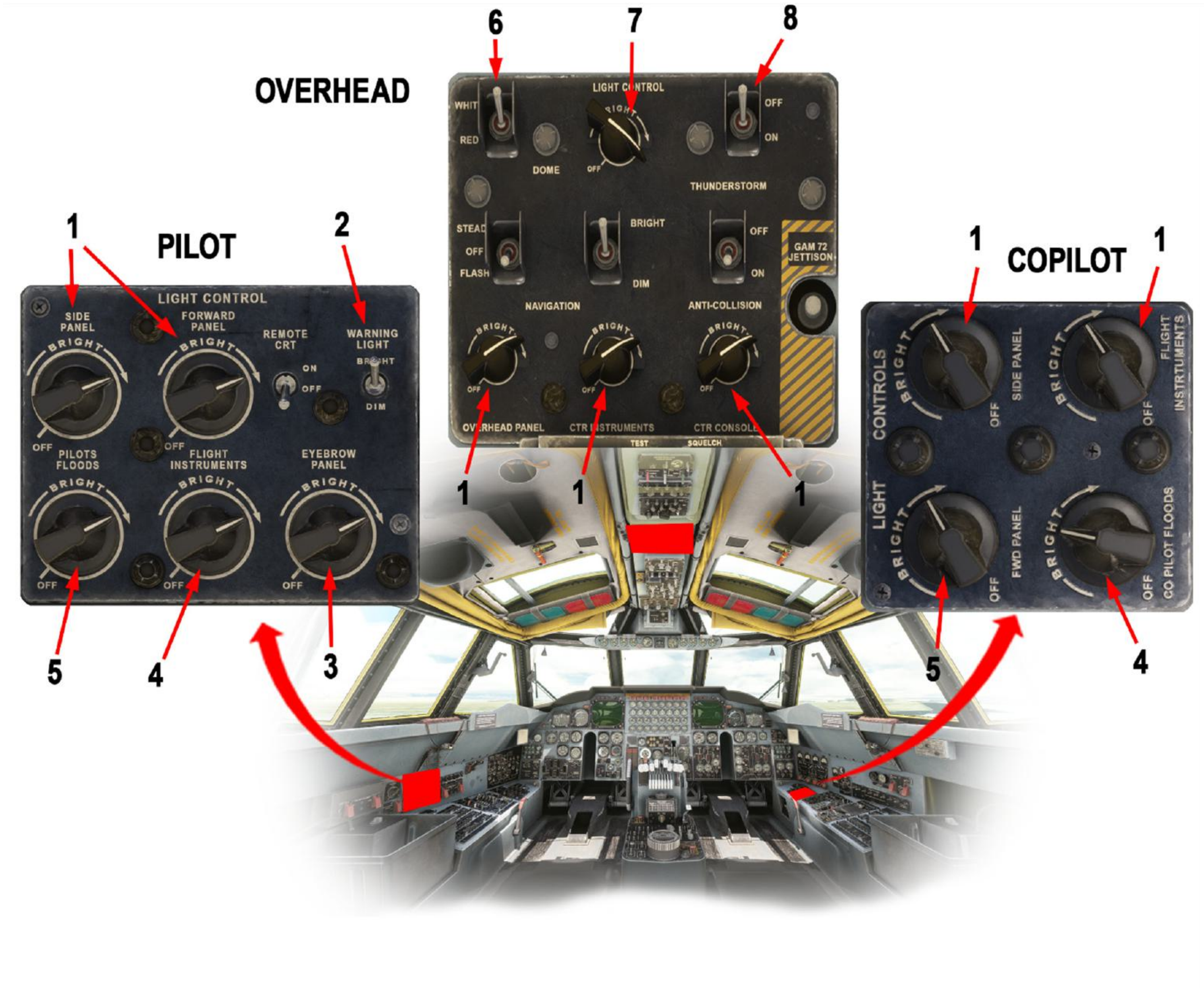
1 NAVIGATION LIGHT STEADY-OFF-FLASH SWITCH
2 NAVIGATION LIGHT BRIGHT-DIM SWITCH
3 ANTI-COLLISION LIGHTS SWITCH
4 AIR REFUELING AIRPLANE LIGHTS SWITCH
5 AIR REFUELING SLIPWAY LIGHTS SWITCH
6 LANDING LIGHT SWITCH
7 TERRAIN CLEARANCE LIGHT SWITCH
8 TAXI LIGHTS SWITCH
9 CROSSWIND LANDING LIGHTS SWITCH

Figure 1-72 (Sheet 1 of 2)

NO.	CONTROL-INDICATOR	FUNCTION
1	Navigation Light STEADY-OFF-FLASH Switch	The toggle switch on the pilots' overhead panel controls the navigation lights. The STEADY position selects steady illumination of all lights. FLASH position selects a flashing of the wing and tail lights with steady illumination of the fuselage lights, while OFF position turns the lights out.
2	Navigation Light BRIGHT-DIM Switch	The intensity of the lights are controlled by a toggle switch on the pilots' overhead panel. The BRIGHT- -DIM switch selects bright or dim illumination of all navigational lights.
3	ANTI-COLLISION Lights Switch	The lights are controlled by an ON- -OFF switch on the pilots' overhead panel.
4	Air Refueling AIRPLANE LIGHTS Switch	The left and right wing illuminating lights are controlled by a rotary switch. The air refueling lights will not illuminate unless the master refuel switch is ON and either the slipway door normal or alternate switch is in OPEN position.
5	Air Refueling SLIPWAY LIGHTS Switch	The receptacle light and slipway lights are controlled by a rotary switch. The air refueling lights will not illuminate unless the master refuel switch is ON and either the slipway door normal or alternate switch is in OPEN position.
6	LANDING Lights Switch	The landing lights are controlled by an ON- -OFF switch on the aisle stand and will not illuminate when the landing gear is up and locked.
7	TERRAIN CLEARANCE Lights Switch	The light is controlled by an open guarded three-position switch on the aisle stand. The switch has EXT- -OFF- -RET positions. In EXT position, 118 volts ac power is supplied to a motor which extends the light out of the fuselage. OFF position stops the motor and allows the light to remain at any degree of travel during extension or retraction. RET position supplies power to the motor to retract the light into the fuselage. Limit switches automatically stop the motor at either extreme of travel. Light illumination is independent of the switch and is controlled by position of the light. The light will be illuminated at any time the light is extended more than 10°.
8	TAXI Lights Switch	The lights are controlled by an ON- -OFF switch on the aisle stand.
9	CROSSWIND LANDING Lights Switch	The light is controlled by an ON- -OFF switch marked CROSSWIND LANDING on the aisle stand. Also, the light may be controlled by a switch marked TAXI on the aisle stand. The crosswind landing light will not illuminate unless the landing gear lever is in DOWN position.

Figure 1-72 (Sheet 2 of 2)

Interior Light Controls and Indicators



1	PANEL LIGHT SWITCH (7 PLACES)	6	DOME LIGHT RED/WHITE SWITCH
2	WARNING LIGHT DIMMING CONTROL	7	DOME LIGHT INTENSITY CONTROL SWITCH
3	EYEBROW PANEL LIGHT SWITCH	8	THUNDERSTORM LIGHTS
4	FLIGHT INSTRUMENT LIGHT SWITCH (2 PLACES)		
5	FLOOD LIGHT SWITCH (2 PLACES)		

Figure 1-73 (Sheet 1 of 6)

NO.	CONTROL-INDICATOR	FUNCTION
		PILOTS' STATION LIGHTING
1	PANEL Lights (Pilot's SIDE PANEL and FORWARD PANEL, OVERHEAD PANEL, CTR INSTRUMENTS CTR CONSOLE, and Copilot's FWD PANEL and SIDE PANEL)	Lights within edge-lighted panels, which illuminate indirectly from the underside, are red. The lights are the primary source of instrument lighting and are controlled by OFF- -BRIGHT rotary switches on the pilot's side panel, copilot's side panel, and pilots' overhead panel.
2	WARNING LIGHT Dimming Control Switch	A warning light dimming switch on the pilot's side panel controls the brightness of all indicator and warning lights at the pilot's and copilot's station with the exception of the fire warning lights and the landing gear lights. The switch has DIM- -BRIGHT at the extreme positions respectively and is spring-loaded to the NEUTRAL position. When the switch is placed to BRIGHT position, all indicator lights are at their brightest illumination. Momentarily moving the switch to DIM position will energize the dimming control relay to dim all lights with the exception of the fire warning, landing gear lights. The rotary flight instruments switch on the pilot's side panel provides for additional dimming control. The rotary control switch is mechanically linked to the dimming circuit, and the warning lights are automatically reset to bright whenever flight instruments lights have been turned to OFF position. The thunderstorm light control switch cuts out the dimming control circuit when positioned ON. Energizing the thunderstorm lights resets all indicator and warning lights to bright.
3	EYEBROW PANEL Lights	The eyebrow panel lights and the standby compass light are controlled by an OFF- -BRIGHT rotary switch on the pilot's side panel.
4	FLIGHT INSTRUMENTS Lights (Pilot and Copilot)	Red lights in the instrument hoods provide illumination for individual instruments. The lights are controlled by OFF- -BRIGHT rotary switches on the pilot's side panel and copilot's side panel.
5	PILOT'S and COPILOT'S FLOODS (Floodlights)	Floodlights are a secondary source of instrument lighting and are mounted in a manner so as to provide illumination on a group of instruments located in the same area. The pilots' station floodlights are controlled by OFF- -BRIGHT rotary switches on the pilot's side panel and copilot's side panel.
6	DOME LIGHT WHITE/RED Switch	One red and one white domelight are located by the pilot's and copilot's escape hatches. The light color is selected by a RED- -WHITE toggle switch.
7	DOME Light Intensity Control Switch	The intensity of the domelights is controlled by an OFF- -BRIGHT rotary switch.
8	THUNDERSTORM Lights	Two white thunderstorm lights in the pilots' compartment provide illumination during thunderstorms to lessen the blinding effect of lightning flashes. The lights are controlled by an ON - - OFF switch.
9	Bunk Compartment Domelights	One white and one red domelight located at the crew comfort station are controlled by a RED- -OFF- -WHITE switch adjacent to the oxygen regulator and interphone panel.
9A	NVIS Light Switch	The three position switch controls the light intensity of the AN/ARC-210 (V) Switch panel.

Figure 1-73 (Sheet 2)

HYDRAULIC POWER SUPPLY SYSTEMS

DESCRIPTION 78
ENGINE-DRIVEN HYDRAULIC SYSTEMS 79
RUDDER/ELEVATOR HYDRAULIC SYSTEMS 80
ROTARY LAUNCHER HYDRAULIC SYSTEMS 80
HYDRAULIC SYSTEM CONTROLS AND INDICATORS 81

DESCRIPTION

NOTE

Reference to engine-driven pumps/left or right body hydraulic systems providing standby pressure to the rudder/elevator hydraulic systems should not be misunderstood. Hydraulic pressure provided by the body systems provides a source of power for the auxiliary hydraulic pumps; however, the hydraulic fluid in the body systems is completely separated from that in the rudder/ elevator systems. Therefore, if a complete loss of hydraulic fluid occurs in the rudder/ elevator systems resulting in the illumination of all four indicator lights, normal body systems pressure will not provide any pressure within the rudder/elevator system and these flight control systems will be inoperative.

The hydraulic systems of this aircraft differ from a conventional system in decentralization. Instead of the usual single main system, there are six independent engine-driven systems consisting of inboard and outboard, right and left wing hydraulic systems, and right and left body hydraulic systems. In addition, there are two electric motor-driven primary hydraulic systems consisting of main No. 1 and 2 rudder/elevator hydraulic systems.

Engine-driven pumps, which supply normal pressure to the wing and body systems, are mounted on the right side of engines 1, 3, 4, 5, 6, and 7. Electric motor-driven pumps, which supply normal pressure systems except the inboard wing systems, are installed at the left and right wing trailing edge locations and left and right body locations.

The right body system standby pump supplies standby pressure to the No. 2 rudder/elevator hydraulic system. Engine-driven pumps 1 and 7 sup- ply normal pressure to the outboard spoilers and tip protection gear. The outboard left and right wing location electric motor-to the No. 1 and 2 main rudder/elevator hydraulic systems, are mounted on the right aft side of the fuselage in the 47 section of the aircraft. Electric motor-driven standby pumps, available for use in alldriven pumps supply stand- by pressure to the outboard spoilers and tip protection gear.

The engine-driven pumps on engines 3 and 6 supply normal pressure to the inboard spoilers and provide emergency pressure for extension of the tip protection gear. The engine-driven pumps installed on engines 4 and 5 supply normal pressure to the body systems and standby pressure to the rudder/ elevator systems. The left and right body electric motor-driven pumps provide standby pressure for the essential body systems normally serviced by engines 4 and 5, respectively.

The left body system supplies normal pressure to the air refueling system, left forward landing gear, brakes, steering and crosswind crab, left aft landing gear, brakes, and the stabilizer nut. It also supplies emergency pressure to the right forward landing gear, forward bomb door, and right aft landing gear; and it supplies standby pressure to the rudder and elevator. The right body system supplies normal pressure to the right forward landing gear, brakes, steering and crosswind crab, forward and aft bomb doors, right aft landing gear, brakes, and the stabilizer screw. It also supplies emergency pressure to the air refuel- ing system, left forward, and left aft landing gear; and it supplies standby pressure to the rudder and elevator. Due to a one-way check valve in each body system, the left body standby pump is able to sup- ply standby pressure only to the air refueling sys- tem, left forward landing gear, brakes, steering and crosswind crab, and right forward landing gear. The right body standby pump, in a similar manner, is able to supply standby pressure only to the right aft landing gear, brakes, crosswind crab, stabilizer screw, and left aft landing gear.

Pressure can be furnished from either of two engine-driven pumps or a standby pump for operation of the stabilizer, brakes, landing gear, air refueling toggle actuator, and air refueling doors. Pressure can be furnished from either No. 4 or 5 engine-driven pumps for operation of the rudder and elevator in event of failure of the No. 1 and 2 main rudder/elevator system pumps. No standby pump pressure is available to the bomb doors.

Reliability of the aircraft hydraulic systems is assured by alternate sources of pressure, providing increased life to vital equipment during either com- bat or routine missions. Launcher rotational drive is accomplished through the use of two similar but independent launcher hydraulic systems.

ENGINE-DRIVEN HYDRAULIC SYSTEMS

A variable delivery engine-driven pump supplies normal pressure to each wing and body hydraulic system and supplies standby pressure to the rudder/elevator hydraulic systems. Each pump has a rated flow of 12 gallons per minute at an output pressure of 2800 psi, with cut- out pressure of 3000 (±50) psi and provides both variable flow and pressure. At cutout pressure, the pumps continue to operate but discontinue delivery; the fluid is bypassed to return. With exception of the inboard spoilers and the aft bomb door actuator, each separate hydraulic power supply system (brakes, steering, landing gear, etc) has either or both emergency and standby alternate sources of pressure.

Each electric motor-driven standby pump has a rated flow of 3 gallons per minute at 1300 psi output pressure. The variable delivery standby pumps, which discontinue delivery at a cutout pressure of 3000 (±50) psi, are controlled by individual switches on the pilot's side panel. According to system demand, a standby pump may run continuously for several hours under emergency conditions. Due to accumulative tolerance buildup in pressure transmitters and pressure gages, engine-driven and standby pump cutout pressures will indicate 3000 (±250) psi on the hydraulic system pressure gages. A pressure switch is incorporated in each system to control the respective pressure low warning light for that system

The lights which indicate main pump pressure only are located on the pilot's side panel. A pressure transmitter in each system, located downstream of the system one-way check valve, registers system pressure at the hydraulic pressure gage on the pi- lot's side panel.
Oil-air type accumulators which have attached air gages are incorporated to provide air preload pressure for accelerating the operation of outboard wing system components and certain body system components. In the brake pressure lines, restrictor valves are located downstream from the accumulators to pre- vent a
momentary drop in pressure. Direct application of pressure is provided to the stabilizer hydraulic motors and the bomb door, landing gear, and air refueling toggle actuators. Where the restrictor valves are located downstream from the accumulator in the brake pressure lines, a thermal relief valve with an opening pressure of 3750 (±100) psi is located at each accumulator to relieve excess pressure caused from continuous use of the brakes.

Hydraulic Shutoff Valve

A motor-operated hydraulic shutoff valve is installed in the supply line of each system for control of fluid from the reservoir to the engine-driven pump. The shutoff valves are open and provide a continuous flow of hydraulic fluid when the engine fire shutoff switches on the pilot's instrument panel are pushed in to the normal position.

Hydraulic Pump (Engine-Driven)

Each engine-driven hydraulic pump is a complete packaged unit with engine mounting provisions. The pumps are of variable delivery design and are driven by the engines at a ratio speed of 0.342 of engine rpm. The pumps operate continuously with engine operation, are self-regulating, and react to either continuous or intermittent demands of pow- er, supplying variable flow and pressure accordingly. Each pump has a rated flow of 12 gallons per minute with an output pressure of 2800 psi with pump rpm at 3100. Pump cutout pressure is 3000 (±50) psi. Due to being controlled by operation of the engines, there are no manual-type controls for energizing the engine-driven hydraulic pumps. Cavitation of the pump is prevented by keeping a head of fluid available to the pump by air pressurization of the supply portion of the system. The pumps utilize hydraulic fluid from the supply for cooling and lubrication. Shutoff of the supply will result in damage to the pump while the engine is windmilling.

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Standby Pump

The standby pump in each of four hydraulic systems (body and outboard wing) supplies sufficient pressure to operate the system should the engine-driven hydraulic pump fail. The standby pump consists of a 205-volt 400 Hz ac constant speed continuous duty electric motor coupled with a variable delivery hydraulic pump which has a rated flow of 3 gallons per minute at 1300 psi, decreasing to 1.2 gallons per minute at 2800 psi. The pump and motor are packaged as a complete assembly which is self-cooled and electrically controlled. Cutout pressure of each standby pump is 3000 (±50) psi. Each standby pump is controlled by a manually operated switch and, when energized, will regulate from zero flow to full flow within 0.05 second, decreasing to zero flow at 3000 psi. The circuit breakers for the standby pumps are in the standby pump switch circuits which are controlled by TR power.

RUDDER/ELEVATOR HYDRAULIC SYSTEMS

The rudder and elevator flight controls are powered by two independent hydraulic systems (figure 1-78). Each hydraulic system has its own fluid power generation, fluid transmission, supply components, and actuation subsystem. The systems are redundant, in that either is adequate for mission accomplish- ment in event of failure of the other. Normal hydraulic power is generated by variable displace- ment hydraulic pumps driven by ac electric motors. An auxiliary hydraulic pump (hydraulic transform- er) is installed in each of the hydraulic systems to provide standby power capable of supplying adequate hydraulic pressure for system operation in the event of electric motor-driven supply failure. The auxiliary hydraulic pumps are prevented from continuous operation by a shutoff valves that are controlled by hydraulic pressure from the primary system. The left and right body hydraulic systems each supply power to one transformer.

Main Hydraulic Pump (AC Motor-Driven)

A hydraulic power supply is incorporated in each rudder/elevator system as the main (primary) source of hydraulic power. Each main hydraulic power supply consists of an electric motor-driven pump, an airless self-pressurizing reservoir, and a manifold. The motor pump assembly consists of a variable delivery, axial piston, 4 gpm hydraulic pump, and a three-phase 118/205-volt ac induction motor. The assembly is rated for continuous duty at 2 gallons per minute to an altitude of 55,000 feet. Rated pump speed is 5625 rpm. Return fluid from each system is routed through an air/oil cooler in each system.

Rudder/Elevator Auxiliary Hydraulic Pumps

An auxiliary hydraulic pump is incorporated in each rudder/elevator hydraulic system to provide a standby source of hydraulic power for rudder and elevator actuation. The auxiliary rudder/elevator pump is a transformer type unit consisting of a fixed displacement hydraulic motor with a flow reg- ulator in the inlet port and a fixed displacement hydraulic pump (driven by the hydraulic motor) with a check valve in the outlet port. The auxiliary rudder/elevator hydraulic pumps utilize power from the aircraft left and right body hydraulic systems, but maintain fluid isolation between the body hydraulic systems and the rudder/elevator hydraulic system. Each auxiliary rudder/elevator hydraulic pump has a normal output of 2 gallons per minute at a discharge pressure of 2200 (±50) psi. Each auxiliary pump delivers zero flow at pump differential pressures above 2800 psi and delivers flow at pressure differentials below 2600 (+50/–130) psi. A flow regulator is installed in the pressure port of the auxiliary hydraulic pump to limit flow to 3 (+0/–0.3) gpm.

ROTARY LAUNCHER HYDRAULIC SYSTEMS

The rotary launcher hydraulic pressure supply system provides hydraulic power for operation of the rotary launcher when the launcher is installed in the bomb bay. The system consists of two similar but independent hydraulic systems. An electric motor-driven hydraulic pump connected to the left body system provides primary hydraulic pressure for normal launcher rotation. Secondary hydraulic pressure for emergency rotation is provided by the engine No. 5 hydraulic pump through a control valve connected to the right body system

Launcher Power Pump

The rotary launcher power pump is the primary source of hydraulic pressure to rotate the launcher and is mounted on the left lower longeron midway in the bomb bay. The launcher power pump receives its fluid supply from the left body hydraulic system return line. The pump is controlled by activating the rotary launcher switch located on the pilot's hydraulic control panel. Placing the switch in the ON PRIMARY position supplies 28 volt dc power from the left TR BUS to energize the hydraulic pump control relay. When energized, this relay closes the three-phase ac circuit from the engine No. 1 generator power box to drive the launcher power pump. The ac circuit breakers for the launcher power pump are not accessible in flight.

Secondary Hydraulic Power Supply

A secondary source of hydraulic power to rotate the launcher is provided by a solenoid operated, three-way hydraulic control valve which routes pressure from the right body hydraulic system pressure line to the launcher manifold. Selecting ON RH BODY on the launcher switch located on the pilot's hydraulic control panel supplies 28 volt dc power from the left TR BUS to operate the hydraulic control valve. Secondary pressure will be interrupted during operation of either the stabilizer trim system or the bomb door system. During secondary system operation, the ENG 5 (right body) hydraulic pressure gage will indicate available supply pressure.

HYDRAULIC SYSTEM CONTROLS AND INDICATORS

The hydraulic system controls are arranged on the hydraulic control panel (figure 1-79) which is located on the forward vertical part of the pilot's side panel. The six individual hydraulic systems are represented on the control panel by six pressure gages and six pump-out indicating lights which are grouped by location according to the aircraft systems arrangement. Four standby pump control switches are located on the control panel according to positions which correspond with the arrangement of the aircraft hydraulic systems. Two switches and four lights are also located on the low- er part of the panel to control and monitor the rudder/elevator hydraulic systems. The edge-lighted control panel has an outline of the hydraulic systems shown with designated power supply components of each system.

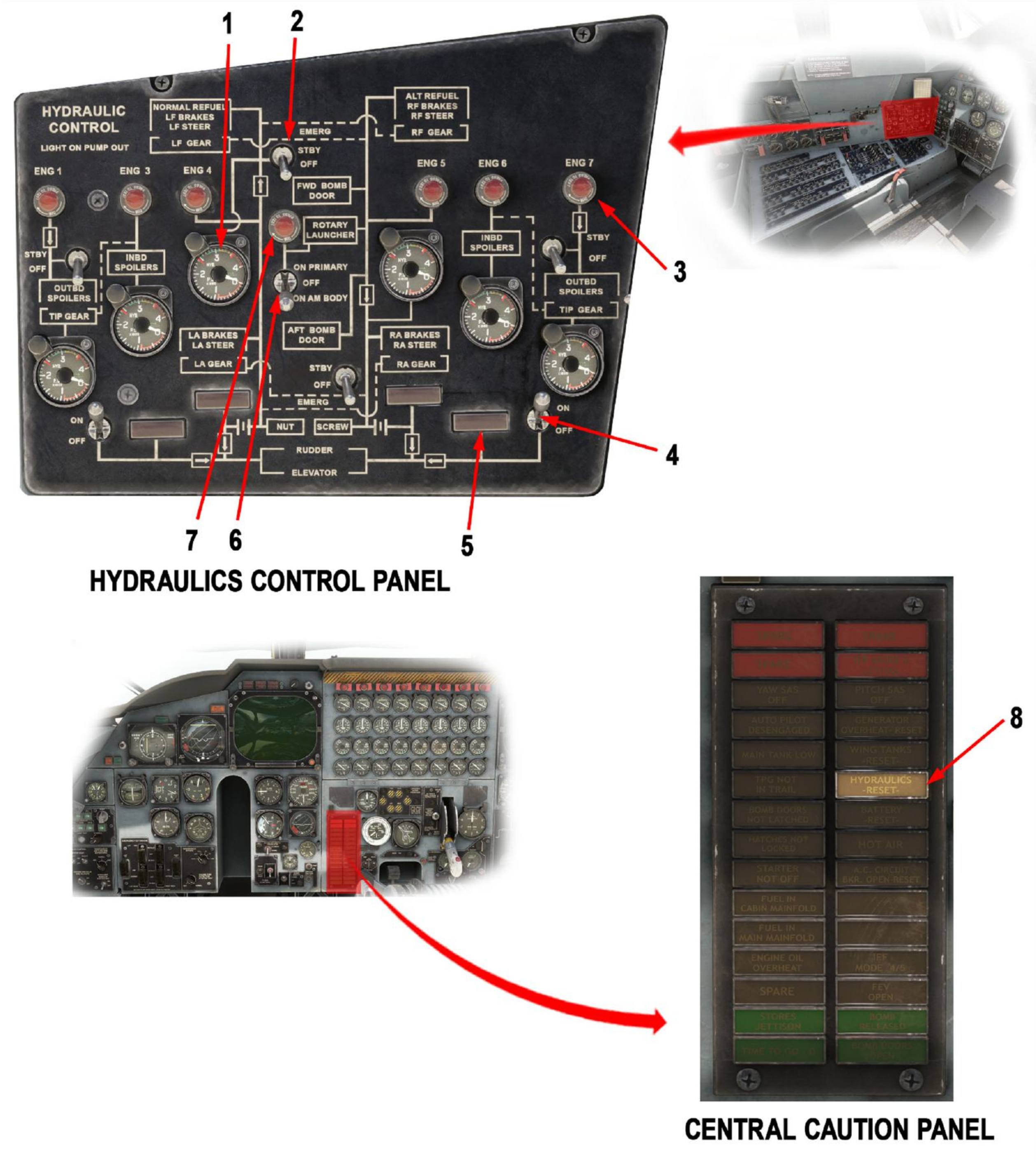
Power Drive Unit Control (PDUC) Power Switch

The PDUC power switch, a two-position switch marked ON- -OFF, located on the RH equipment rack in the lower compartment, provides power to the rotary launcher PDU. The PDUC circuit breaker is also on the switch panel.

Engine Fire Shutoff Switches

Eight pull-type engine fire shutoff switches (figure 1-33), each corresponding to a respective engine, are installed horizontally across the upper edge of the pilots' instrument panel for inflight emergency use. In addition to providing shutoff control of other systems, six of the switches will shut off the hydraulic fluid supply to engines 1, 3, 4, 5, 6, and 7 on which the hydraulic pumps are installed. Each of the six switches, corresponding to the above engines, will close the motor-operated engine firewall hydraulic shutoff valve which controls the flow of fluid from the system reservoir to the engine-driven pump. Each hydraulic shutoff valve unit consists of a dc motor and a gate-type valve which will open or close within 1 second regardless of temperature. See EMERGENCY EQUIPMENT, this section, for additional information on engine fire shutoff switches.

Hydraulic System Controls and Indicators



1 HYDRAULIC PRESSURE GAGES (6 PLACES)
2 STANDBY PUMP SWITCHES (4 PLACES)
3 ENGINE-DRIVEN HYDRAULIC PUMP OUT LIGHTS (6 PLACES)
4 RUDDER/ELEVATOR HYDRAULIC SYSTEM SWITCHES (2 PLACES)
5 RUDDER/ELEVATOR HYDRAULIC SYSTEM INDICATOR LIGHTS (4 PLACES)
6 ROTARY LAUNCHER HYDRAULIC SELECTOR SWITCH
7 ROTARY LAUNCHER POWER PUMP LOW PRESSURE LIGHT
8 HYDRAULICS RESET CAUTION LIGHT

Figure 1-79 (Sheet 1 of 4)

NO.	CONTROL-INDICATOR	FUNCTION
		HYDRAULICS CONTROL PANEL
1	Hydraulic Pressure Gages (6 places)	Six gages indicate pressure of the hydraulic systems. The gages are calibrated from 0 to 4000 psi. The location of each gage on the control panel corresponds to the respective hydraulic system which it serves and which is shown by outline on the control panel. Due to accumulative tolerance buildup in pressure transmitters and pressure gages, engine-driven and standby pump cutout pressures will indicate 3000 (±250) psi on the hydraulic system pressure gages. In the event an engine-driven pump fails on the left or right body system, the pressure gage will then indicate only pressure trapped in that portion of the system downstream of the one-way check valve. This pressure should dissipate either through normal internal leakage or by operation of a system component located downstream of this one-way check valve. When the standby pump is energized, the gage will then indicate only the pressure supplied to this isolated portion of the system. See figure 5-1 for gage markings.
2	Standby Pump Switches (4 places)	Four two position (OFF - STBY) hydraulic standby pump switches control the starting and stopping of individual system pumps. When placed in STBY position, the separate switches energize respective standby pumps to provide hydraulic system pressure.
3	Engine-Driven Hydraulic Pump-Out Lights (amber) (6 places)	Each of the six individual hydraulic systems has an amber pump-out indicating light. Since the lights indicate engine-driven pump pressure only, a light will remain on after failure of a main pump even though (for those systems which have a standby pump) system pressure is restored to normal by the standby pump. Only a return of the affected main pump to proper operation will extinguish the light. Each light is illuminated when system pressure drops to 350 (±150) psi and goes out when system pressure increases to 700 psi maximum as controlled by pressure switches in the systems. Whenever a pressure switch senses low pressure, a signal is sent simultaneously to a pump-out light on the hydraulic control panel, to the hydraulics caution light (No. 8) on the central caution light panel, and to the master caution lights on the pilots' forward instrument panel, illuminating the lights. **NOTE** During ground operation, the pump-out lights may illuminate momentarily when a demand is placed on a hydraulic system and the engine driving the pump for that system is at or near idle.

Figure 1-79 (Sheet 2 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
4	Rudder/Elevator Main 1 and 2 System Switches	Two rudder/elevator hydraulic system switches have ON- -OFF positions and in the ON position they energize ac motor-driven pumps located in the 47 section that operate the rudder/elevator main No. 1 and 2 hydraulic systems. ON position of either hydraulic system switch 1 or 2 also activates the ground cooling blower. In the OFF position, power is removed from the hydraulic pumps. The switches are spring-loaded toggle-type switches and are held in both the ON, OFF positions by detents. Moving the switches from one position to another requires pulling them out of one detent and placing them in the other detent.
5	Rudder/Elevator Main Hydraulic System Indicator Lights	Four amber push-to-test indicator lights are available for monitoring the main and auxiliary rudder/elevator hydraulic systems. The lights are marked RUD/ELEV MAIN 1 (or 2) and RUD/ELEV AUX 1 (or 2) for main rudder/elevator hydraulic systems 1 and 2 and auxiliary rudder/elevator hydraulic systems 1 and 2 respectively. When main hydraulic system switches 1 and 2 are on and the hydraulic system pumps are operating normally, the rud/elev main 1 and 2 lights and the rud/elev aux 1 and 2 lights will be out. If main rudder/elevator hydraulic system pumps 1 and/or 2 fail, their respective lights will illuminate. The aux rudder/ elevator lights 1 and/or 2 will remain out indicating that hydraulic pressure is being supplied to systems 1 and/or 2 from the right and/or left body hydraulic systems. If one or the other aux rudder/elevator lights illuminate, that specific pump has failed. Whenever a pressure switch senses low pressure, a signal is sent to the light on the hydraulic control panel and, for main hydraulic systems 1 and 2, simultaneously to the master caution light on the pilots' forward instrument panel, illuminating the lights. **NOTE** The RUD/ELEV AUX 1 and 2 lights receive signals from the same pressure switches as the RUD/ELEV MAIN 1 and 2 lights. When the main pump switches are placed ON and pumps are operating normally, all four lights will go out. When main pump switches are OFF, or pumps have failed, the RUD/ELEV AUX lights receive signals from the auxiliary hydraulic system for proper RUD/ELEV AUX light indications. Should a main pump fail, the corresponding aux light may come on momentarily, then go out indicating auxiliary system pressure is available.

Figure 1-79 (Sheet 3 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
6	Launcher Hydraulic Selector Switch	A single toggle switch provides for selection of the launcher power pump or right-hand body hydraulic system pressure to power the rotary launcher. The switch has positions marked ON PRIMARY- -OFF- -ON RH BODY. With the switch positioned to ON PRIMARY, the rotary launcher power pump is powered, and the launcher is operated by this pump. With the switch positioned to ON RH BODY, the power pump is turned off and the launcher operates from the aircraft right-hand body hydraulic system. To preclude interruption of the stabilizer trim system or bomb door operation while operating the launcher on the right-hand body system, the secondary launcher control valve is automatically turned off whenever the electrical stabilizer trim buttons are used or an electrical signal is introduced to operate the bomb doors. **CAUTION** Do not place the launcher hydraulic control switch to ON PRIMARY unless a rotary launcher is installed and will be rotated, as damage may result to the rotary launcher hydraulic pump.
7	Launcher Power Pump Low Pressure Light (Amber)	An amber launcher low pressure light indicates that a low pressure condition exists in the launcher primary hydraulic system and that hydraulic pressure is not adequate for launcher rotation. This light and the master caution light will come on when the launcher power pump output pressure drops below 1300 (±100) psi. The light will come on for a low pressure condition in the primary system only when the launcher hydraulic control switch is in the ON PRIMARY position. The light will go out when pressure increases to 1500 (±50) psi or when ON RH BODY or OFF position is selected.
	CENTRAL CAUTION PANEL	
8	Hydraulics Caution Light	An amber caution light marked HYDRAULICS – RESET and the master caution lights illuminate whenever a pressure low signal is sent from any one of the six engine-driven hydraulic pumps and the two main rudder/elevator system hydraulic pumps. The hydraulic control panel must be monitored to determine which particular hydraulic pump has a pump-out light illuminated. The hydraulics caution light circuit may be reset for use as an indicator of other malfunctions by pressing the central caution reset button which extinguishes both the central and master caution lights.

Figure 1-79 (Sheet 4 of 5)

LANDING GEAR SYSTEM

DESCRIPTION

The landing gear system is a composite of the main landing gear system and the tip gear system. All landing gear are hydraulically actuated through electrically operated valves.

The dual wheel main landing gear are in a quadricycle arrangement with two side by side forward and two side by side rear. The left forward and left rear gear retract forward into fuselage wheel wells while the right forward and right rear gear retract aft into fuselage wheel wells. The main landing gear doors are mechanically linked to the main landing gear and follow the cycle of operation selected by the normal landing gear lever or the land- ing gear emergency switches.

The tip gear are located between the outboard engine strut and the external tank strut and retract inboard and slightly forward into each wing. The function of the tip gear is to prevent damage to the wingtips during abnormal ground maneuvers and/ or high gross weight conditions. Normally, the tip gear tires contact the ground only under maximum weight conditions. The tip gear doors are in two sections. The strut section is connected to the tip gear and follows the cycle of operation for the gear. The wheel well section is hydraulically actuated and is controlled for proper sequence operation by mechanical linkage in the tip gear system.

Retraction and extension of each landing gear is accomplished by its hydraulic actuator with pressure supplied from the right and left body hydraulic systems. The landing gear is fully retracted in 10 to 15 seconds or extended in 15 to 20 seconds. A single mechanical lock on the main landing gear drag strut locks the main landing gear in either the ex- tended or the retracted position. Oleo safety switches prevent inadvertent gear retraction on the ground. There are no provisions for overriding these switches in an emergency.

For information on landing gear brakes, see WHEEL BRAKE SYSTEM, this section. For information on landing gear steering and crosswind crab operation, see STEERING AND CROSSWIND CRAB SYSTEM, this section.

LANDING GEAR GROUND LOCKS

Three pairs of landing gear ground locks prevent retraction of the landing gear on the ground. Each ground lock is a pin-type lock with a red warning streamer attached. The tip gear locks are the smallest of the two types. The front main gear locks have the ground lockpin on one end of the streamer and a two-pin steering valve bypass key on the other end. Most rear main gear also have bypass key facilities for use by maintenance when towing from the rear is required. The ground lockpins are inserted in each main landing gear drag strut and each tip gear side brace. The locks are stowed in containers which are located beneath the left equipment rack in the aft end of the navigators' compartment.

MAIN LANDING GEAR SYSTEM

The main landing gear system utilizes power for operation from the left and right body hydraulic systems which receive main pump pressure from the engine-driven pumps installed on engine No. 4 and No. 5 respectively. Pressure for actuation of front and aft landing gear which are located on one side of the aircraft is normally supplied from the body system on that same side of the aircraft.

Normal extension or retraction of the main landing gear is accomplished by positioning of the landing gear control lever. An emergency source of pressure is provided which allows separate control of the landing gear by individual switches.

Emergency pressure is provided by connecting the pressure sources of the body systems to solenoid-operated control valves which are installed on the opposite side of the aircraft.

Each main landing gear may be actuated by either of two solenoid-operated control valves, one of which is supplied with normal system pressure and the other with emergency system pressure. Al- though separate switches are used for emergency actuation, the emergency system pressure sources of the left front and aft landing gear are the same as the normal system pressure sources of the right front and aft landing gear. Similarly, the emergency system pressure sources of the right front and aft landing gear are the same as the normal system pressure sources of the left front and aft landing gear.

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Each of the body systems is equipped with an electric standby pump which is energized by a separate standby pump switch. Standby pump pressure may be supplied as an alternate source of normal system pressure when the engine-driven pumps are not operating or not providing sufficient normal pressure. Standby pump pressure may be used for actuating the front or aft pair of landing gears separately from the other pair when the engine-driven pumps are not operating. Due to the location of a check valve, pressure from the left body system standby pump is not supplied to the aft landing gear. Similarly, pressure is not supplied to the forward gear from the right body system standby pump. When the landing gear control lever is positioned, pressure from the left body system standby pump will actuate the forward landing gear through the left normal pressure control valve and the right emergency pressure control valve; pressure from the right body system standby pump will actuate the rear landing gear through the right normal pressure control valve and the left emergency pressure control valve.

The normal gear up circuit supplies power to the crosswind crab centering motor through centering switches to ensure centering of the main landing gear prior to retraction. This circuit also includes oleo safety switches which prevent inadvertent retraction when either the left front or right rear main landing gear is on the ground and the oleo strut is compressed more than 0.75 inch. A gear up lock switch de-energizes the circuits when the gear is up and locked. After being unlocked by hydraulic pressure, the landing gear will free fall almost to the down and locked position; therefore, a position switch is included in the circuit. This switch keeps the circuit energized until the landing gear reaches the full down and locked position.

The emergency gear up circuits include oleo safety switches to prevent retraction when either the right front or left rear main landing gear are on the ground. Actuation of the emergency landing gear switches does not automatically center the landing gear. Each landing gear emergency retract or extend circuit remains energized until the individual emergency switches are placed in OFF position.

LANDING GEAR OLEO SAFETY SWITCHES

When the aircraft is on the ground, the landing gear struts are compressed actuating the oleo safety switches. The oleo safety switches are also actuated in flight when the gear is extended and crabbed to an angle equal to or exceeding 14° through any combination of crosswind crab setting and rudder pedal movement. The following systems are affected by actuation of the landing gear oleo safety switches:

- The anti-ice airscoop heater for the rudder and elevator Q-spring inlet and the air conditioning scoop lip anti-ice shutoff valve will not be energized, causing ice to form on the lip under icing conditions.
- The AN/ALE-20 flare ejection circuit will become de-armed, preventing flares from being ejected.
- The rudder/elevator hydraulic system ground cooling blower will operate.
- The OAS ground cooling system blowers will operate.
- The OAS overheat system automatic shutdown thermal switch will become armed.
- Cabin pressure will dump.
- The engine stall prevention system becomes armed.
- The flap warning horn will sound and the master caution light will illuminate if the throttles are at or beyond approximately 45° of travel and the flaps are not fully extended.
- The ground interphone panels become operative.
- The landing gear cannot be retracted by either the normal or emergency controls.
- The strike camera heater control system becomes inoperative.
- The EVS FLIR window anti-icing system becomes inoperative.
- The ECM heater system becomes inoperative.
- The antiskid valves will be deenergized and application of brakes prior to landing will result in locked brakes. Normal braking may be applied during the landing roll.
- The flight loads data recorder will not record.

NOTE

> When the landing gear oleos are extended after takeoff, the operation of the above systems will be reversed.

- If the safety switches have been cycled by a takeoff and landing, Mode 4 codes will zeroize if the Mode 4 code switch is not placed in HOLD position prior to turning the IFF off.

TIP GEAR SYSTEM

The tip gear system for each gear re- ceives normal hydraulic pressure from the outboard wing hydraulic system. Normal system pressure to the left and right outboard wing hydraulic systems is supplied by engine-driven pumps installed on engine No. 1 and No. 7, respectively. Each outboard wing hydraulic system includes an electric standby pump which provides an alternate source of normal system pressure when energized by an individual switch. Emergency pressure for tip gear extension is provided by the inboard wing hydraulic systems which receive pressure from engine-driven pumps installed on engine No. 3 and No. 6. Emergency tip gear extension is accomplished by actuating individual switches which are grouped with the emergency switches for the main landing gear. There are no provisions for emergency retraction. The tip gear system operates in an indirect manner. In gear down operation, the normal landing gear lever actuates switches which energize the down circuit. When the solenoid in the normal control valve is energized, hydraulic pressure is directed to the wheel well door actuator and to the normal sequence valve. When the wheel well door opens, mechanical linkage opens the normal sequence valve permitting hydraulic pressure to enter the tip gear actuator thus extending the tip gear. A reverse sequence ensures proper door and gear timing during the retraction cycle. The tip gear circuits pass through the main landing gear oleo safety switches to prevent inadvertent retraction on the ground.

LANDING GEAR SYSTEM CONTROLS

Landing Gear Controls and Indicators are shown in figure 1-84.

CAUTION

- During retraction or extension of the landing gear by either the normal or emergency system, do not change the position of the control handle or the emergency switch while the gear is in motion since this procedure may rupture a hydraulic line.
- During retraction or extension of the landing gear by one system, do not actuate the other system while the gear is in motion since this procedure may rupture a hydraulic line.

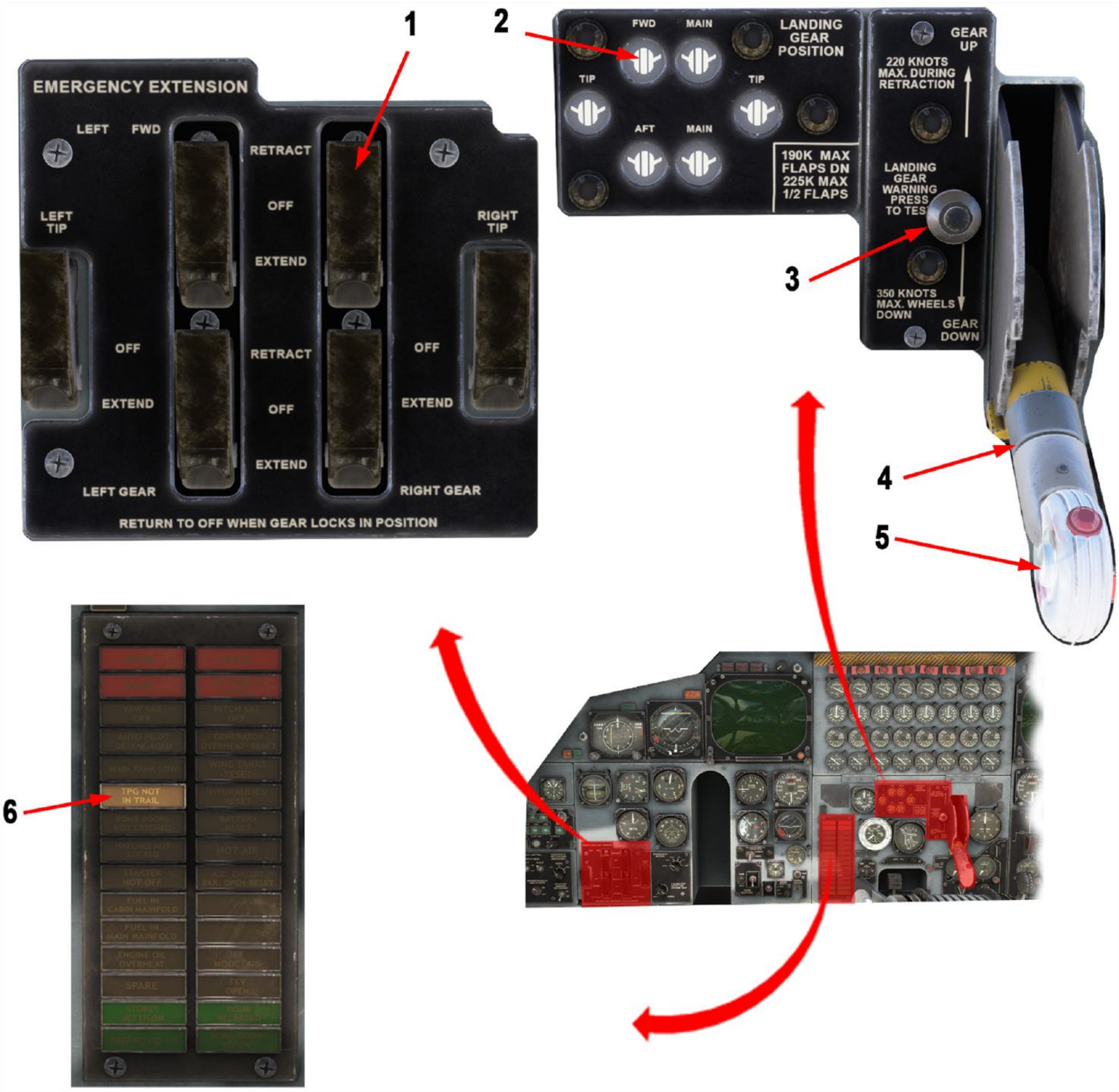
Landing Gear Warning Horn and Shutoff Button

The landing gear warning horn is flush-mounted on the upper aisle domelight mounting plate. The horn sounds a warning when any throttle is retarded below a position 2.25° to 7.5° above IDLE position while any one landing gear is not down and locked. A warning horn shutoff button (11, figure 1-6), which is used to silence the horn, is located on the copilot's side of the aisle stand. Provided a gear has not locked, the horn, which operates on TR power, will sound again when another throttle is retarded.

NOTE

When all throttles have been retarded and the shutoff button has been used to silence the warning horn, a throttle must be advanced to reactivate the warning horn system. This is necessary to ensure proper warning horn operation for an unsafe gear condition.

Landing Gear Controls and Indicators



1 LANDING GEAR EMERGENCY SWITCHES (6 PLACES)
2 LANDING GEAR POSITION INDICATORS (6 PLACES)
3 LANDING GEAR WARNING LIGHT TEST BUTTON
4 LANDING GEAR LEVER
5 LANDING GEAR WARNING LIGHT
6 TIP PROTECTION GEAR NOT IN TRAIL CAUTION LIGHT

Figure 1-84 (Sheet 1 of 4)

NO.	CONTROL-INDICATOR	FUNCTION
1	Landing Gear Emergency Switches (6 places)	Guarded switches used for emergency actuation of the landing gear. Four switches, one for each main landing gear, have EXTEND- -OFF- -RETRACT positions. The other two switches, one for each tip gear, have only EXTEND- -OFF positions since there are no emergency retraction provisions for the tip gear. The switch guards are spring-loaded and are designed to return the switches from other positions to the OFF position when the guards are closed. The emergency switches control forward direct battery power for the left forward and right aft main landing gear and aft direct battery power for the right forward and left aft main landing gear. Each switch operates an emergency control valve to direct pressure from an alternate hydraulic system for gear actuation. Each separate landing gear may be actuated independently of the others by use of the individual emergency switches. Operation of the main landing gear control lever does not affect the position of the landing gear when the emergency switches are placed in either RETRACT or EXTEND position. The electrical emergency extend (all gear) and retract (main gear only) circuits are independent of the normal circuits. However, the normal main gear circuits are interrupted by the emergency main gear circuits. When the emergency circuit is energized, the normal control valve is deenergized allowing the normal control valve to position itself so that trapped hydraulic fluid is returned to the reservoir. With normal pressure relieved, the emergency pressure will reposition the shuttle valve allowing emergency pressure to actuate the main gears. Actuation of the emergency landing gear switches does not automatically center the landing gear. The tip gear emergency extend system will override the normal system hydraulically, provided a normal system retract signal is not present. The normal landing gear retract and extend circuits are deenergized by a lock switch when the landing gears are actuated to either extreme position. Emergency retract and extend circuits are energized until the emergency switches are returned to OFF position. Due to actuation of the main landing gear oleo strut switches by the weight of the aircraft, either the normal or the emergency retract circuits cannot be energized for retraction when the aircraft is on the ground. Landing gear actuation is provided by individual emergency switches when certain gear have failed to actuate after placing the main landing gear control lever in the desired position.

Figure 1-84 (Sheet 2 of 4)

NO.	CONTROL-INDICATOR	FUNCTION
2	Landing Gear Position Indicators (6 places)	Tab-window type landing gear position indicators display landing gear position. Each tab indicator has three visual indicators to register landing gear position. When the landing gear is up and locked, the word UP appears in the tab window. A gear in an intermediate position or when there is no dc power on the aircraft is indicated by slanting alternate black and ivory stripes. The appearance of a wheel symbol indicates a gear down and locked.
3	Landing Gear Warning Light Test Button	When pressed, causes landing gear warning light (No. 5) to illuminate.
4	Landing Gear Lever	The lever handle is in the shape of a miniature landing gear wheel to facilitate recognition. Positions of the lever are GEAR UP- -GEAR DOWN. The landing gear lever is held by a spring-loaded pawl and a detent on the inside end of the lever making it necessary to pull out on the handle approximately 1/4 inch to move the lever from one position to the other. In changing positions of the landing gear lever, the pawl travels the lever quadrant surface which has detents at each end for engaging the pawl in the GEAR UP or GEAR DOWN position. The quadrant has a safety stop at a midpoint position between the detents. The safety stop provides a positive GEAR DOWN latched position if the pawl on the landing gear control lever fails to remain in the GEAR DOWN position detent. The lever quadrant with visible detents at each end is located on the face of the instrument panel and in addition, the landing gear control lever, which must be pulled out approximately 1/2 inch in changing positions, is held in GEAR UP and GEAR DOWN positions by an overcenter spring. Landing gear lever movement actuates a group of switches which control the solenoids of the control valves and the first motion of the landing gear hydraulic actuator will unlock the locks for gear actuation in either the up or down position. The landing gear lever is mechanically linked to a steering ratio selector unit which prevents movement to GEAR UP until the steering ratio selector lever is in TAKEOFF LAND position. This mechanical linkage also adjusts the steering ratio selector unit to zero ratio, when the landing gear lever is moved to GEAR UP. The GEAR DOWN position of the landing gear lever energizes the landing light and crosswind landing light circuits. The landing gear lever controls TR power for all warning and indicator systems and essential power for normal landing gear control including the tip gears. **NOTE** The effort required to operate the landing gear lever is increased if the rudder pedals are not in neutral. This increase in operating effort is caused by the requirement to displace the steering system.

Figure 1-84 (Sheet 3 of 4)

NO.	CONTROL-INDICATOR	FUNCTION
5	Landing Gear Warning Light (Red)	A red landing gear warning light in the end of the landing gear lever warns of incorrect landing gear position. When gear actuation is taking place and the landing gear position does not agree with the landing gear lever position or the landing gear warning horn is blowing, or when the landing gear lever is not in the detent, the red light in the landing gear lever illuminates. As soon as the landing gear is locked in the selected position, the red light goes out provided the warning horn is not blowing. The warning light circuit is deenergized to allow the warning light to go out when the landing gear lever pawl, which is retracted by a control lever spring, is fully seated in the lever quadrant detents. **NOTE** Flight at high indicated airspeeds and Mach numbers may produce enough wing twist to cause the tip protection gear doors to gap open. This will cause the landing gear warning light to go on and cause an intermediate tip gear signal to appear. Reduction of airspeed will correct this situation. However, flight may be continued under these conditions without affecting normal operation of the aircraft.
6	Tip Protection Gear Not In Trail Caution Light (Amber)	Light is marked TPG NOT IN TRAIL and illuminates when a reversal of the tip protection gear is detected. This light and the master caution lights illuminate if a tip gear casters more than 120° either side of trail. While the master caution lights may be extinguished by pushing to reset, the central caution panel light will remain on until the tip gear casters to a trail aft position. **CAUTION** When the tip gear is reversed, the strut resides on the inboard side of the wheel and may cause damage if retraction is attempted.

Figure 1-84 (Sheet 4 of 4)

STEERING AND CROSSWIND CRAB SYSTEMS

DESCRIPTION

A means of steering the aircraft on the ground and of presetting the crab angle of the landing gear during crosswind landings and takeoffs is furnished by two separate yet integrated systems known as the steering and the crosswind crab system. The steering system and crosswind crab system are integrated through mechanical and cable linkage to a differential coordinating unit. Cable and mechanical linkage from this unit operate steering metering valves on both forward and rear main gear. The steering metering valves meter hydraulic pressure to the actuating cylinders which position each forward gear for steering or all four gear for crosswind crab.

NOTE

> Actuation of the crosswind crab system sets up a new neutral position for steering which does not affect the turning angle available with the takeoff and landing steering ratio but limits the turning angle available with the taxi steering ratio. With crosswind crab set and the steering ratio se- lector in TAXI, the available turning angle of the forward gear relative to the new neu- tral is 55° in the direction of the crab setting and 55° minus the crab setting in the direction opposite the crab setting. See figure 1-87.

STEERING SYSTEM

The forward main landing gear are steered by hydraulic pressure controlled by movement of the rudder pedals. The left forward gear uses pressure from the left body hydraulic system and the right forward gear uses pressure from the right body hydraulic system. Emergency source of hydraulic pressure is not available for steering; however, un- der certain conditions, standby pressure can be used. In the event of steering failure on one front gear, it will trail the other front gear which has steering avail able. Steering is accomplished when the rudder pedals move mechanical and cable linkage through a ratio selector unit and a differential coordinating unit to the metering valves which hydraulically position the forward main gear. The steering ratio selector unit mechanically limits steering angles for two conditions. A taxi ratio allows the forward gear to be turned to a maximum angle of 55° right or left of a center position with full rudder pedal travel. The second ratio is used for takeoff and landing and restricts the turning angle to approximately 12° right or left of center.

The differential coordinating unit has three main components, a forward drum, a jackscrew, and a rear drum. All three are interconnected. Rudder pedal movement for steering mechanically moves the forward drum in an amount determined by the ratio selector. Movement of the forward drum moves the rear drum through linkage to mechanically operate the steering metering valves on each of the forward main gear. These valves meter hydraulic pressure to the actuating cylinders to position the gear as desired. During forward towing operations, a valve between the steering actuating cylinders on each forward gear must be opened by a steering bypass key to bleed pressure. This is to prevent damage caused by hydraulic locking of the pistons in the actuating cylinders. This valve was also incorporated on the rear gear so that towing from the rear could be accomplished. The bypass keys for the forward gears are attached to the ground lock streamers. When the key is inserted into the steering metering valve receptacle, one pin secures the key in place and the other moves the bypass valve to bleed pressure. Centering springs are provided near each steering valve which only assist in returning the gear and rudder pedals to neutral whenever pressure on the rudder pedals is removed.

NOTE

> For maximum steering and rudder control, no rudder trim should be used. The maxi- mum steering angle is reduced when rudder trim in the opposite direction is used. For example, steering to the left is reduced when nose right trim is introduced. The steering angle is reduced proportionally to the amount of trim used to displace the rudder pedals.

Turning Angles Available With Maximum Crosswind Crab Setting

REMARKS:

Crab setting refers to direction of the nose of the aircraft relative to desired heading.

CONDITIONS:

- Aircraft taxiing with 20° nose left crosswind crab setting.
- Steering ratio lever in TAXI.

(1) Turning angle available in direction of crab setting is 55° from new neutral position.

(2) Turning angle available in direction opposite crab setting is 35°(55° minus 20°) from new neutral position.

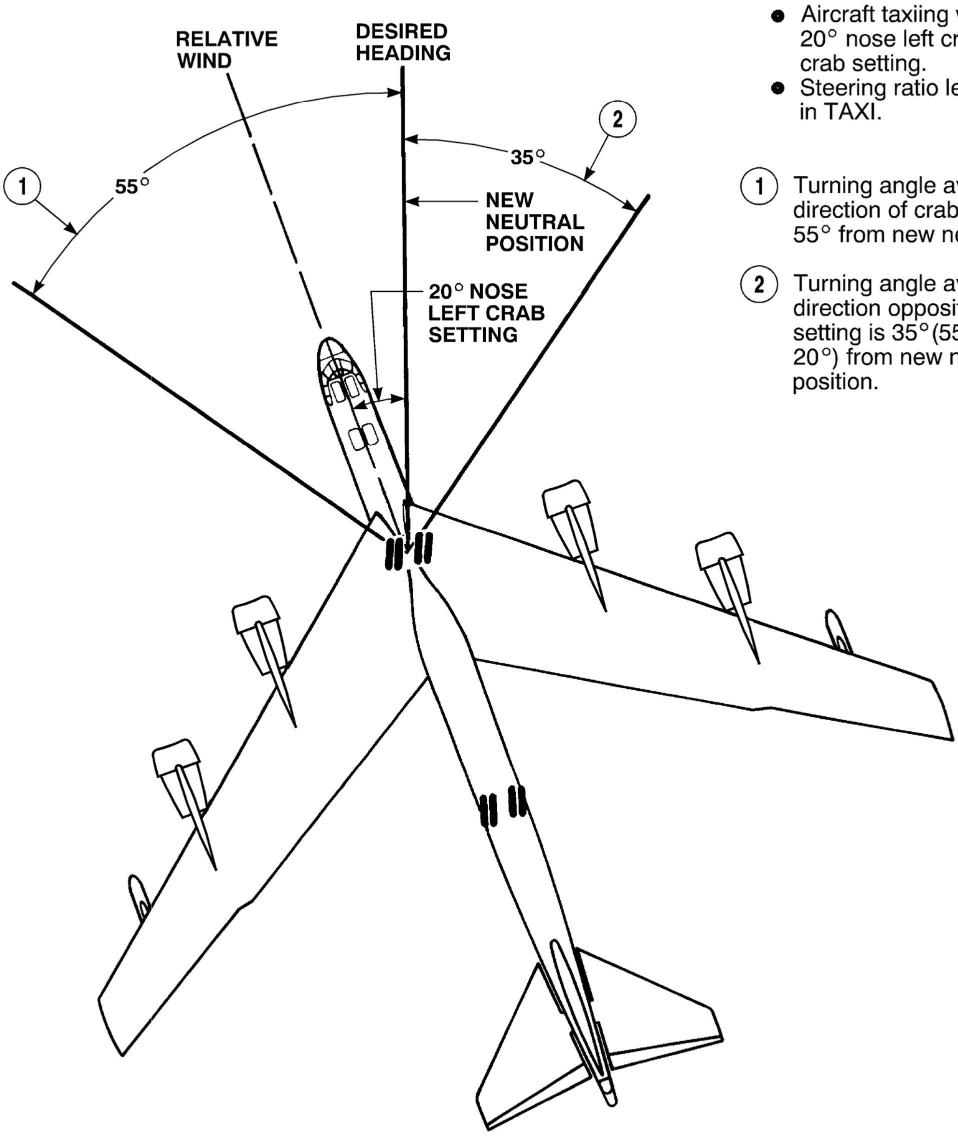


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Figure 1-87

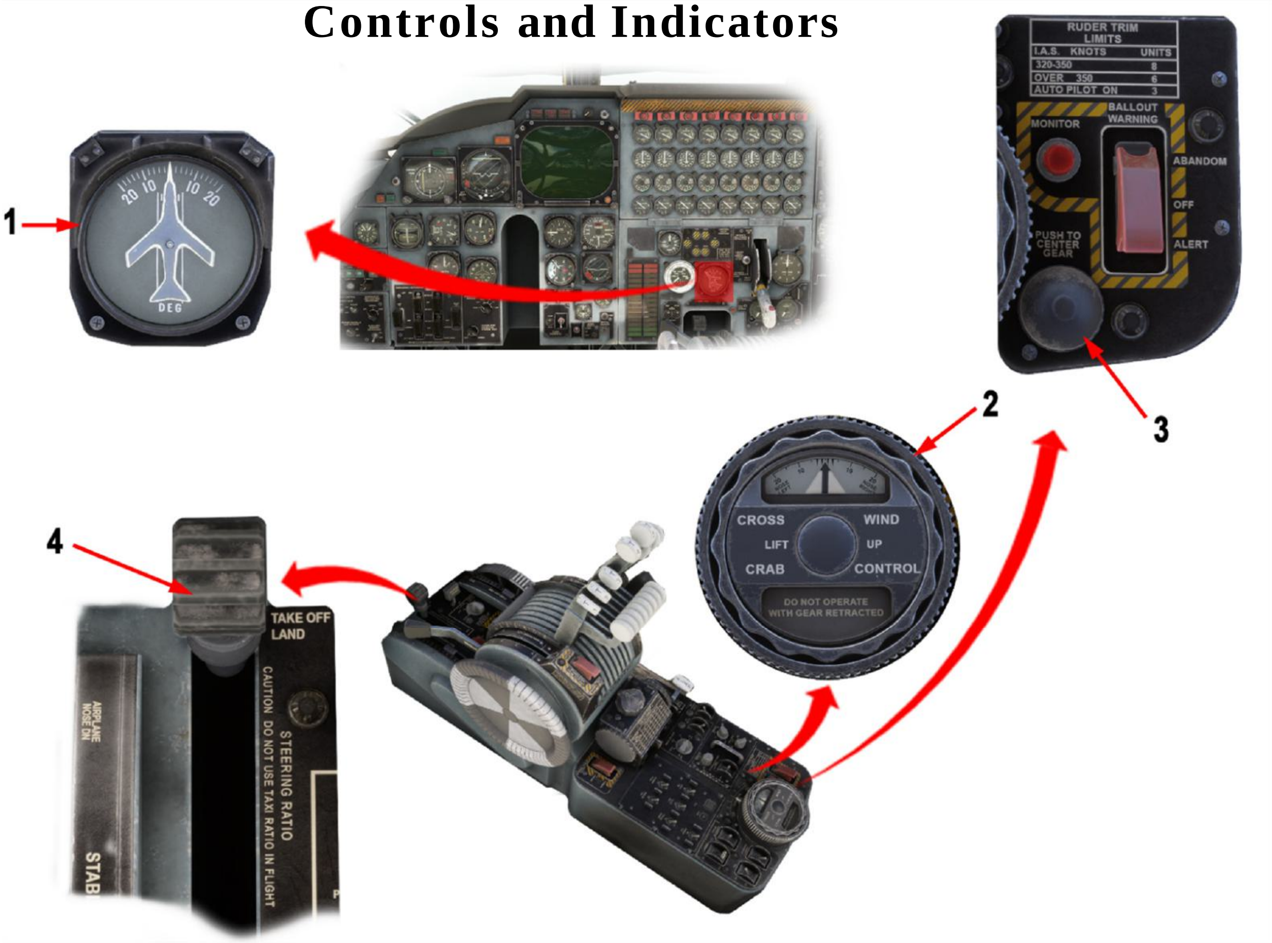
CROSSWIND CRAB SYSTEM

A crosswind crab system is provided on this aircraft to facilitate making crosswind takeoffs and landings and to reduce the hazards of crosswind conditions. The crosswind crab system provides a means of turning all four main gear to align with the runway while the aircraft is flown in a wings-level attitude compensating for drift. This system utilizes the steering actuators on the front main gear and a similar set on the rear main gear. The landing gear can be preset and turned up to 20° left or right of center during the approach. The maximum of 20° crab will accommodate landings in crosswinds up to and including 43 knots blowing 90° to the runway at a landing weight of 270,000 pounds. The direction of the landing gear is preset by a crosswind crab control knob which mechanically operates the steering metering valves on each main gear. These valves meter hydraulic pressure to the actuating cylinders to position the gear as desired. The crosswind crab system is automatically centered when the landing gear lever is moved to the GEAR UP position. On the ground after landing, the gear is quickly centered by a pilot-operated centering button or by turning the crosswind crab control knob to center. Crab position of the aft gear is fed to the EVS for positioning the STV and FLIR sensors.

STEERING AND CROSSWIND CRAB SYSTEM CONTROLS AND INDICATORS

A discussion of steering and crosswind crab system controls and indicators is contained in figure 1-88.

Steering and Crosswind Crab Controls and Indicators



1 CROSSWIND CRAB POSITION INDICATOR
2 CROSSWIND CRAB CONTROL KNOB AND INDICATOR
3 CROSSWIND CRAB CONTROL CENTERING BUTTON
4 STEERING RATIO SELECTOR LEVER

Figure 1-88 (Sheet 1 of 3)

NO.	CONTROL-INDICATOR	FUNCTION
1	Crosswind Crab Position Indicator	The crosswind crab position indicator shows in a relative plan view presentation the amount in degrees that the landing gear is turned to compensate for aircraft crab during crosswind conditions. The indicator is an electrically operated instrument and receives power from the TR bus which is carried through two position transmitters, one on the left forward gear and one on the left rear gear. The indicator has a diagram marked with a miniature runway and a scale calibrated from 0° to 20° both right and left. Two movable pointers, mounted one above the other, indicate the degree of turn. The lower pointer, a simple needle, indicates the forward gear, and the upper pointer, in the form of a miniature aircraft, indicates the rear gear. Since the gear position is in the opposite direction from that indicated by the pointers, it is always considered that the aircraft is being turned into the wind at an angle to the runway. When the aircraft is steered, the lower pointer will move in a direction opposite that of the turn and the upper pointer will remain in the position of the crab angle. **NOTE** • After crosswind crab has been set, both pointers of the crosswind crab indicator should match crab angle within 2°. • The control knob can be turned while the aircraft is on the ground with responding control knob indicator movement without hydraulic pressure or electrical power. Therefore, if an unobserved crab setting exists, upon aircraft taxiing, the gear will immediately actuate to a left or right crab position resulting in the aircraft rapidly departing centerline.
2	Crosswind Crab Control Knob	The crosswind crab control knob and indicator is recessed in the rudder trim control knob on the aft end of the aisle stand. The control has an indicator in the form of a miniature aircraft which points to a degree scale to indicate the amount of nose left or right crab selected. To move the control, it is necessary to lift up before turning. When the crosswind crab control knob is turned for crab, cable linkage moves the jackscrew at the differential coordinating unit. The jackscrew positions the rear drum of the coordinating unit to move cable and mechanical linkage to operate the forward gear steering metering valves. The jackscrew also moves cable and mechanical linkage to operate the rear gear steering metering valves. It is to be noted that the rear main gear can be steered only through movement of the jackscrew of the coordinating unit while the forward main gear are steered by movement of the rear drum of the coordinating unit. The rear drum can be moved both by the jackscrew for crosswind crab and by the forward drum of the coordinating unit for steering by the rudder pedals. This action allows steering of the forward gear even when the forward gear are preset for crosswind crab. **NOTE** When the main landing gear are extended and crabbed in flight to an angle equal to or exceeding 14° through any combination of crosswind crab setting and rudder pedal movement, the landing gear safety switch will be actuated causing certain aircraft systems to start operating or to shut down. For further information, see LANDING GEAR OLEO SAFETY SWITCHES, this section.

Figure 1-88 (Sheet 2 of 3)

Steering and Crosswind Crab Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
3	Crosswind Crab Control Centering Button	Used to center all four main landing gear from a turned position to neutral. The crosswind crab centering button controls an electric motor which turns the jackscrew in the coordinating unit in the desired direction to center all four gear. When the left rear gear is centered, power to the motor is interrupted causing all centering action to stop. The centering button, a push-type switch that is spring-loaded to OFF position, is supplied TR power. It is covered with a moisture and dust-proof rubber cap which must be pressed to actuate the centering button. The direction of the motor is governed by two cam-actuated centering switches on the left rear main landing gear. When either of these switches are actuated by the cam and the centering button is pushed, the circuit is energized to operate the centering motor.
4	Steering Ratio Selector Lever	Used to select one of two steering ratios. The two ratios are TAXI- -TAKEOFF LAND which allow steering of up to 55° and approximately 12° respectively. To move the lever from either one of these positions, a knob on the lever must be pulled up to free the lever from a detent position. When the lever is moved from one position to the other, it mechanically adjusts the steering ratio selector unit to limit the angle of turn available. The ratio selector lever is mechanically linked to the landing gear lever. This is done to prevent moving the landing gear lever up unless the ratio selector lever is in TAKEOFF LAND and to prevent moving the ratio selector lever while the landing gear are retracted. When the landing gear lever is moved to GEAR UP, the linkage will adjust the steering ratio selector unit to a zero steering ratio. This prevents any actuation of the steering metering valves by rudder pedal movement and returns the steering control system to center. Since normally the landing gear lever will be positioned before using the emergency landing gear switches, the ratio selector will usually be adjusted accordingly. Centering cams in each gear maintain the gear at centered position as soon as oleos are fully extended. A trunnion swivel shutoff valve is on each main gear and shuts off hydraulic pressure to the steering valves when the landing gear have retracted 38° to 60°. This prevents steering action before the gear has cleared the wheel well during landing gear extension. **NOTE** With the steering ratio selector lever in either the TAXI or TAKEOFF LAND position, the landing gear will follow the rudder pedal displacement by a predetermined amount. Moving the selector lever from one to the other position will be met by increasing resistance as the rudder displacement is increased from the neutral position. This is the result of attempting to steer the landing gear to the new position as required by the steering ratio selector unit through use of the selector lever. This condition can be avoided by placing the rudder pedals in the neutral position before moving the steering ratio selector lever.

Figure 1-88 (Sheet 3 of 3)

WHEEL BRAKE SYSTEM

DESCRIPTION

Each wheel of the main landing gear has hydraulic brakes. The brakes are of the segmented rotor multiple-disc type utilizing cerametallic brake linings. Braking is accomplished by toe pressure on any or all of the rudder pedals. No differential braking is provided. An antiskid system to automatically detect and correct a skid condition is on each wheel of the main landing gear. Parking brakes are also provided.

Wheel brake system circuit protection and the location of the applicable circuit breakers is contained in figure 1-92.

WHEEL BRAKE HYDRAULIC SYSTEM

Each main landing gear has an individual brake system as shown in figure 1-90. Brake pressure for the front and rear gear on the right side is supplied by the right body system and pressure for the front and rear gear on the left side is supplied by the left body system. There is an accumulator for each main gear brake system, one located in each wheel well. There is a pressure gage on each accumulator which gives brake system pressure or air preload if the brake system is bled down. The two forward main gear brakes are actuated simultaneously and the two rear main gear brakes are slaved to the for- ward brake systems. This provides equal braking pressure on all four main gear. Brake application pressure is supplied to each aft main landing gear by individual slave pressure-operated metering valves. Both aft brake slave metering valves are normally supplied with slave pressure from the left body hydraulic system; however, an alternate source of slave pressure is supplied to both valves from the right body hydraulic system. Slave pressure from either body system will open the slave metering valves of both aft gear to permit brake application from pressure supplied by the body system which corresponds with the side on which the gear is located. Toe pressure on the rudder pedals is transmitted to two main metering valves through mechanical linkages and a spring system of feel and return springs. The feel springs absorb linkage travel and hold spring tension on the metering valves. The return springs return and hold the metering valves in the off position. A retraction lockout cylinder is connected to each spring cartridge assembly, which contains a retraction lockout spring and a return spring, to limit the amount of brake pressure that can be applied to stop wheel rotation during gear retraction. This reduced braking pressure, which amounts to approximately one-fourth normal braking pressure, is for the purpose of preventing undue stresses on the retraction mechanism by a sudden braking of the wheels. Hydraulic pressure from the main metering valves is used for two purposes; one is brake actuation on each wheel of the forward main gear and the other is hydraulic actuation of the two slave metering valves, one for each rear main gear. Pressure is supplied to the two slave metering valves through the normal slave line or the alternate slave line. Differential pressure in the normal slave line holds a control valve in the alternate slave line closed. The alternate slave line control valve will open if the pressure in the normal slave line becomes appreciably less than the pressure in the alternate slave line. Either slave line pressure can enter the two slave metering valves through a shuttle valve on each metering valve. The shuttle valve positions according to pressure differential. Hydraulic pressure to the brakes is further controlled by an anti- skid system. An antiskid indicator panel is installed on the copilot's side panel for testing antiskid electrical circuits.

Wheel Brake System Controls and Indicators

1	PARKING BRAKE LEVER	3	ANTISKID INDICATOR LIGHTS
2	ANTISKID SWITCH	4	ANTISKID TEST SWITCH

Figure 1-91 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
1	Parking Brake Lever	Moving the parking brake lever aft while depressing the brake pedals sets the parking brakes. A mechanical linkage from the parking brake lever locks the brake pedals in a brakes-applied position. As long as hydraulic pressure is available, the brakes will remain on. The parking brake may be released by merely depressing the brake pedals until the parking brake lever releases; then release the brake pedals.
2	Antiskid Switch	Switch has two positions, ON- -OFF, and is guarded to the ON position. When the switch is ON, the antiskid system is in operation.
3	Antiskid Indicator Lights (green) One for each of the 8 main wheel brakes	When illuminated with antiskid test switch in GND position, indicates the antiskid shields have power; when illuminated with antiskid test switch in FLT position, indicates the individual brake has released.
4	Antiskid TEST Switch FLT OFF GND	Is used to test the antiskid system before taxiing and before landing. The switch has FLT- -OFF- -GND positions and is spring-loaded to OFF. With the aircraft on the ground and the antiskid test switch in the GND position, all eight indicator lights should illuminate. Illumination indicates that the antiskid shield for the corresponding wheel brake is receiving power. With the aircraft in flight and the antiskid test switch in FLT position, all eight lights should be illuminated. Illumination indicates that the antiskid system has released for that particular wheel brake.

Figure 1-91 (Sheet 2 of 2)

Rudder Pedals

Toe pressure on any one of the four rudder pedals will actuate the wheel brakes.

ANTISKID SYSTEM

The antiskid system consists of a skid detector on each main gear wheel, a dual antiskid valve for each gear, a relay unit for each main gear, and an antiskid switch. The antiskid system is supplied with essential dc power from each main gear anti-skid shield. The dual antiskid valve is electrically actuated through relays from a skid detector unit on each wheel. This valve is spring-loaded to the open position to allow pressure to reach the brakes. When any wheel is in a skid condition, a signal is transmitted by the skid detector unit through the relay unit to actuate the valve. The dual antiskid valve is then positioned to shut off pressure to the brake and opens a port to the return line releasing the brake pressure on that wheel. At the end of the skid signal, following a very short time delay, brake pressure is again restored to the wheel. If the skid continues until wheel rotation stops, a locked wheel signal is transmitted through an additional relay to release brake pressure from that wheel. Upon brake pressure release, the wheel is free to rotate and again starts to accelerate. After a short time delay to permit the wheel to reach nonskid speed, the brake pressure is again restored to the wheel.

NOTE

A skid or locked wheel condition on any one wheel does not affect braking on any other wheel.

ANTISKID INDICATOR PANEL

The antiskid indicator panel (figure 1-91), located on the copilot's side panel, is used to perform a cross check of the antiskid system. The antiskid in- dicator is supplied with essential dc power from each main gear antiskid shield.

DRAG CHUTE SYSTEM

DESCRIPTION

A 44-foot ribbon-type drag chute is provided for deceleration during the landing roll. The parachute is installed in a compartment (3, sheet 1 of figure 1-1) aft of the rudder in the top of the tail section of the fuselage. When the compartment door is opened, the drag chute is deployed. The opening door pulls the ripcord and releases the spring-loaded pilot chute into the slipstream. The pilot chute then pulls out the main drag chute. The risers of the main chute are attached to the aircraft through a terminal held by the jettison mechanism.

NOTE

> The drag chute can only be reloaded on the ground while the aircraft is fully stopped. The reload function is available in the Options Menu (4, figure 0-1).

DRAG CHUTE LEVER

A drag chute lever (10, figure 1-6) is located on the copilot's side of the aisle stand. Positions of the lever are DEPLOY- -LOCKED- -JETTISON. This lever manually operates the drag chute release and jettison mechanisms through a cable system. Normally, the lever must be moved to DEPLOY before it can be moved to JETTISON position. A hinged stop prevents movement of the control lever from LOCKED to DEPLOY position without lifting the stop in order to prevent inadvertent deployment. LOCKED position holds the spring-loaded drag chute compartment door securely closed. JETTISON position causes release of the jettison mechanism and allows the chute to pull free of the aircraft.

NOTE

> Drag chute deployment is assigned to the **ANNUNCIATOR ON/OFF** hotkey. Turning the annunciator **ON** deploys the chute. Turning it **OFF** jettisons the chute.

FLIGHT CONTROL SYSTEMS

DESCRIPTION 103
POWERED RUDDER/ELEVATOR SYSTEM 103
STABILIZER TRIM SYSTEM 104
LATERAL CONTROL SYSTEM 105
LATERAL TRIM SYSTEM 105
WING FLAP SYSTEM 106
FLIGHT CONTROL SYSTEM CONTROLS AND INDICATORS 107

DESCRIPTION

Primary flight control of the aircraft is accomplished by three basic systems: the elevator, rudder, and lateral control systems. The elevators and rudder are moved by hydraulically powered systems. See POWERED RUDDER/ELEVATOR SYSTEM, this section. Lateral control is accomplished by spoilers which are part of a spoiler and airbrake control system. Ailerons are not installed on the aircraft.

POWERED RUDDER/ELEVATOR SYSTEM

A hydraulically powered rudder/elevator system (figure 1-96) is installed in the aircraft in conjunction with a yaw and pitch stability augmentation system (SAS) which provides dutch roll damping, reduced structural loads, and controllability in turbulence. For further information on the SAS, see Stability Augmentation System (SAS), in AUTO- MATIC FLIGHT CONTROL SYSTEMS, this section. SAS commands applied to the rudder hydraulic actuator are applied in series with pilot inputs (i.e., the rudder pedals do not reflect rudder movement due to SAS inputs). The maximum rudder deflection is limited to ±19° for mechanical control inputs and ±10° for SAS inputs. Two elevator actuators are incorporated in the pitch axis control system to provide an irreversible actuation system. The elevator actuators position the elevators in response to mechanical control inputs transmitted to each actuator from the control column or autopilot pitch axis and by electrical signals transmitted to each actuator from the SAS. Autopilot commands are applied to the actuators in parallel with pilot inputs (i.e., the control column is displaced when the elevators are displaced). SAS commands are ap- plied to the actuators in series with pilot inputs (i.e., the control column does not reflect elevator movement due to SAS inputs). The maximum elevator deflection is ±19° for mechanical control in- puts and approximately ±5° for SAS inputs.

RUDDER AND ELEVATOR ACTUATORS

The rudder is powered by a single actuator while the elevator is powered by two actuators, one each for the right and left surfaces, operating independently of one another. The rudder and elevator actuators are dual tandem type units with each of the two cylinders utilizing power from one of the two rudder/elevator hydraulic systems. The actuators position the rudder and elevators in response to pilot and/or electrical input commands. Each actuator package consists of two shutoff valves, four filters, and two position transducers. Each rudder and elevator actuator also employs two electrohydraulic control valves. These electro- hydraulic flow control valves are controlled by electrical inputs. Each unit meters hydraulic fluid flow to an auxiliary servo actuator in response to an electrical signal.

RUDDER PEDALS

The rudder pedals are conventional and are adjustable fore and aft by levers on the inboard side of each pedal. A vertical hinge incorporated into each pedal allows the pedals to be individually folded aft to provide additional leg room.

RUDDER TRIM

A ball bearing screw actuator, which is extended or retracted by a cable system attached to the rudder trim knob, moves the rudder torque tube to a new position relative to the Q-spring lever and provides rudder trim. The Q-spring tends to maintain the torque tube in the neutral position as set by adjustment of the trim knob. Movement of the rudder pedals in flight rotates the torque tube causing displacement of the Q-spring lever; however, when use of rudder is discontinued, Q-spring force returns the trim will displace the entire rudder control sys- tem including the rudder pedals. This displacement moves the rudder by mechanical command input to the rudder actuator.

Rudder Trim Knob and Indicator

The rudder trim knob and indicator on the aisle stand is the only control provided for rudder trim. Rotation of the knob actuates the trim screw and repositions the rudder torque tube to a new neutral trim which is maintained by the Q-spring.

CONTROL COLUMNS

The control columns transmit control movements through separate control column disconnect mechanisms to the respective right and left forward control cable quadrant, where a pair of cables joins them into a single system. A force switch assembly is contained in each of the control rods located between the control column transverse shaft bellcranks and the forward elevator control quadrants. These switches, although having no effect on the elevator system, provide the pilots with a means of quickly terminating any unscheduled stabilizer trim movements that may result from stabilizer or autopilot system malfunction (except stabilizer trim reversal). For further information on force switch operation, see FORCE SWITCHES under STABILIZER TRIM SYSTEM, this section. Either or both control columns may be manually disconnected from the cable system and stowed forward against the instrument panel. A connection is provided between the disconnect linkage and the seat ejection system so that the column will be automatically disconnected and stowed during the seat ejection cycle.

STABILIZER TRIM SYSTEM

Pitch trim of the aircraft is provided by the stabilizer trim system (figure 1-97). The leading edge of the stabilizer is raised and lowered by a jackscrew driven by two hydraulic motors. One of the motors drives the screw and the other drives the nut. The motor driving the screw is supplied with pressure from the right body hydraulic system while the left body hydraulic system supplies the motor driving the nut.

The hydraulic pressure to the motors is metered by valves which are controlled by the cable system or a parallel electric trim control system through a followup system. The mechanical followup system automatically returns the metering valves to the closed position when the stabilizer reaches the position called for by the cable system, the electric trim control system, or the autopilot. When engaged, the autopilot provides stabilizer trim through the followup system. An alternate source of hydraulic pressure for the upper hydraulic motor (which drives the screw) is furnished by the right body standby pump. No standby pump is pro- vided for the lower hydraulic motor (which drives the nut). Stabilizer speed is approximately four units every 10 seconds with both left and right body hydraulic systems operating and engines at idle and six units every 10 seconds with engines operating at 82% rpm and above. When operated only on standby pressure, this speed is reduced to approximately one unit every 10 seconds. Trim position creeping, due to airloads on the stabilizer when the hydraulic system is unpressurized, is prevented by a hydraulically released brake on each hydraulic motor drive. This brake is completely released when hydraulic pressure is above 1000 psi. The electrical input into the followup system is equivalent to approximately seven units every 10 seconds of stabilizer travel. Pitch trim is not automatically adjusted when the wing flaps are raised and lowered. An automatically operated heating element is installed in each followup screw to prevent icing of the screw threads. Missile rotary launcher operation in the secondary mode places a high demand on the right body hydraulics system. To ensure a continuous hydraulic supply for bomb door operation and/or for stabilizer trim screw operation, trim change electrical inputs in both the noseup and nosedown directions are paralleled to rotary launcher hydraulic interrupt relays. Operation of either interrupt relay will result in interruption of the launcher hydraulic drive for the duration of the trim change and/or bomb door operation.

Stabilizer Trim Wheels and Indicators

Manual control of the stabilizer trim metering valve is provided by rotation of the stabilizer trim wheels on the aisle stand. The pilot's trim wheel is attached to the throttle shaft and operates through a chain sprocket linkage to move a trim indicator located forward and inboard of the wheel. The copi- lot's trim wheel and trim indicator are located oppo- site to the pilot's trim indicator. The indicators are calibrated in units of stabilizer leading edge move- ment from nine units AIRPLANE NOSE DN to four units AIRPLANE NOSE UP, with one unit equal- ling 1° of stabilizer travel. Any trim accomplished using the electric trim control system will feed back through the cable system rotating the manual trim wheels and indicators. The manual trim wheels can be used to override the electric trim control system or autopilot trim system. The trim wheel face and periphery is painted in alternate black and white segments as a visual aid and reminder when the electric trim control system is being used.

Stabilizer Trim Cutout Switch

A guarded stabilizer trim cutout switch on the aisle stand is provided to disconnect the dc control cir- cuits between the trim buttons and the stabilizer trim control relay coil. Manual control of stabilizer trim is not affected by the cutout switch.

LATERAL CONTROL SYSTEM

Lateral control and airbrake action are provided by a spoiler and airbrake system. Each wing is provided with seven spoilers which perform a dual function. Rotation of the control wheels actuates hydraulically operated spoilers located on the upper surface of each wing just aft of the rear spar. Rising the spoilers interrupts the flow of air over the wing, causing a reduction in lift and an increase in drag.

When the control wheel is rotated, the spoilers are actuated to provide lateral control. In addition, when the airbrake lever is actuated, the spoilers are raised symmetrically to act as airbrakes. Each of the 14 spoilers has a separate hydraulic actuator. On each wing, the four outboard spoilers are mechanically linked to operate as a unit and are called group A. The three inboard spoilers are also mechanically linked to operate as a unit and are called group B. Group A spoilers are powered by the outboard wing hydraulic system (hydraulic pumps on engines 1 and 7); group B spoilers are powered by the inboard wing hydraulic system (hydraulic pumps on engines 3 and 6). Hydraulic pressure is metered by four metering valves, one for each group of spoilers. The four metering valves are controlled through four differential mechanisms, one for each valve, which allow the metering valves to be operated by either air- brake control, lateral control (including lateral trim), or both simultaneously. When lateral control and airbrake control mechanisms are used simultaneously, the differential mechanisms in one wing will be moved the total amount called for by both control systems and the spoilers will respond to the total control signal. At the same time, the differential mechanisms in the opposite wing will receive control movements in the opposite direction. The net result is that the output movement of the differentials is the difference between opposing input signals; the spoilers respond to the difference in the two. This will result in cancellation of airbrake action in cases where the spoiler signal equals or is greater than the airbrake signal, permitting the lateral control system to override the airbrake system. Spoiler action for lateral control is initiated by con- trol wheel rotation which mechanically opens hydraulic metering valves to supply pressure to the spoiler actuators. A mechanical followup system au- tomatically returns the metering valves to the closed position when the spoilers reach the position called for by the control wheels or by the autopilot, if engaged. The spoilers are full up (60°) at approximately 80° of wheel rotation. Rotation of the control wheels will cause both metering valves in both wings to be displaced. All spoilers will rise on the wing toward which the control wheel is turned and, at the same time, the metering valves in the opposite wing will be displaced in the opposite direction to lower spoilers. This will have no effect on the spoilers on this wing if they are already in the down position. The metering valves permit this control movement without bottoming. Two overtravel spring cartridges located in each wing allow continued operation of the remainder of the system should a metering valve, followup system, differential mechanism, or trim mechanism be jammed.

NOTE

At airspeeds above 250 knots, the spoiler actuators do not have sufficient force to raise the spoilers full up. Adequate roll control is still available under these conditions. Because of this force limitation, the roll re- sponse with wheel position is not the same with airbrakes up as with zero airbrakes.

CONTROL WHEELS

Dual control wheels (2, figure 1-101) are provided for the pilots. Each wheel has, on its outboard handgrip, a stabilizer and lateral trim button, an autopilot and air refueling (IFR) boom release but- ton, and an interphone-mike trigger switch. Each wheel has, on its inboard handgrip, an EVS NFOV (narrow field of view) select switch.

LATERAL TRIM SYSTEM

An electrically controlled lateral trim system (fig- ure 1-99) provides a means of obtaining lateral trim (lateral control neutral position). Lateral trim but- tons on the control wheels control a single centrally located electrical trim actuator which is cable-con- nected to an actuator drum on the spoiler centering mechanism in each wing. Rotation of the actuator drum relocates the neutral position for each center- ing mechanism which in turn tends to hold the en- tire lateral control system in a new position. Maxi- mum displacement of the neutral position is equiv- alent to approximately 20° of rotation to left and right of the zero-control wheel position. Limit switches are incorporated within the electrical trim actuator to prevent the actuator from exceeding its maximum allowable travel. The effect of lateral trim will be modified as airbrakes are applied, making readjustment of lateral trim necessary.

Lateral Trim Cutout Switch

The 118-volt single-phase ac circuit for the lateral trim actuator can be disconnected by actuating the lateral trim cutout switch (9, figure 1-101).

Lateral Trim Indicator

A single lateral trim indicator (6, figure 1-101) provides an indication of trim input which is comparative with spoiler position. Spoiler position does not necessarily correspond to indicated trim which is electrically positioned by the lateral trim actuator shaft. As much as 3° of trim indication may be necessary to compensate for tolerances in the lateral control system. The indicator is calibrated in degrees of spoiler position from 0° to 15° spoiler up with a separate scale for left and right spoilers. The indicator pointer is a single needle pointed at both ends and will indicate on either scale. The pointer is electrically connected to a position transmitter of the lateral trim actuator shaft.

AIRBRAKE ACTUATION

Use of the spoilers as airbrakes is controlled by an airbrake lever which electrically controls solenoid valves in airbrake control actuators at each spoiler differential unit. The airbrake control actuators reset the spoiler differential units to open the spoiler metering valves. The metering valves are opened in pairs so that the outboard spoilers move as a unit and the inboard spoilers move as a unit, providing symmetrical airbrake action.

Airbrake Lever

The airbrake lever (12, figure 1-101) has an OFF position and six positions. Detents are provided at OFF position, positions 1, 2, 4, and 6. Position 1, marked AR, used primarily for air refueling, gives increased roll rate authority. When the airbrake lever is progressively moved through its full range (with the control wheel in neutral), the outboard spoiler and the inboard spoilers operate alternately as described in figure 1-101, sheet 4, item 12.

WING FLAP SYSTEM

The wing flap system includes four separate wing flap sections. The flaps are of the Fowler type with high lift-drag ratio resulting in shortened takeoffs and reduced landing speeds. All four flap sections are simultaneously driven by a single power unit located in the fuselage aft of the center section gear spar. The power unit consists of two 205-volt three-phase ac motors joined by differential gearing. Each motor is provided with an electrically released brake which will be released only when the motor is energized and putting out torque. A flap torque tube driven by the power unit extends out each wing on the aft side of the rear spar. This torque tube drives two jackscrews in each flap section to extend or retract flaps. During the first 37 1/2% of extension, the flaps rotate downward 35° with little rearward movement. For the remainder of the extension, the flaps move rearward only. Most of the drag increase occurs during the first 20% of the flap motion. This initial 20% rotates the flaps down 29° in approximately 12 seconds, leaving only 6° of rotation in the remaining 80% of flap extension. The flaps are electronically controlled by a single flap lever. No emergency control system is provided for the flaps; however, should one of the two motors in the power unit be rendered inoperative, the remaining motor will extend or retract the flaps in approximately 120 seconds. An overspeed brake mechanism located at the outboard end of each flap torque tube functions automatically to modulate rate of flap movement in case of excessive rpm of the flap drive. Such excessive rpm would be induced by the slipstream acting to “drive” a flap section or sections which had been rendered “free” because of a broken torque tube. The overspeed brake limits the movement to a rate that will not cause damage to the free section or sections.

WING FLAP LEVER

Control of the wing flaps is accomplished by moving a lever with an airfoil-type knob (7, figure 1-101) on a detent quadrant located on the right side of the aisle stand.

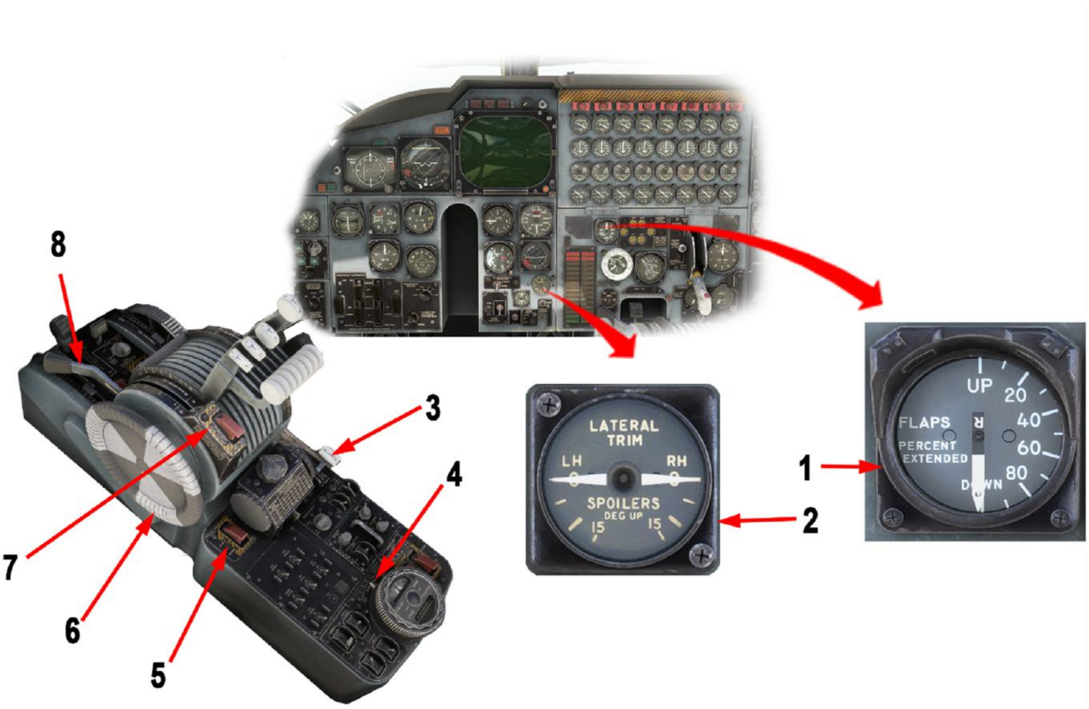
WING FLAP POSITION INDICATOR

A dual wing flap position indicator (5, figure 1-101) reads from 0% to 100% of wing flap travel. The indicator transmitters, which are controlled by TR power, are located in the overspeed brakes on the outboard ends of each torque tube. The dual indicating system is provided to show any difference in position of the left- and right-wing flap sections such as would result from a broken flap torque tube. The top needle in the indicator, has a hole in it, is marked R and indicates the position of the right-wing flaps. The bottom needle is marked L and indicates the position of the left flaps.

WING FLAPS UP WARNING SIGNAL

The wing flaps up warning signal is sounded by the landing gear warning horn. The signal will sound only when the aircraft is on the ground, throttles for engines 3 and 5 or 4 and 6 are beyond approximately 45° of travel (as indicated on the thrust gate guide rail) and flaps are not fully extended.
The horn is activated by a series circuit energized by TR power through the horn, throttles for engines 3 and 5 or 4 and 6, a landing gear squat switch, and through the flap warning horn switch. Engines 1, 2, 7, and 8 are not included in this circuit. When the flaps warning horn is energized, a signal is also sent to the master caution light to cause it to illuminate.

Flight Control System Controls and Indicators



1 WING FLAP POSITION INDICATOR
2 LATERAL TRIM INDICATOR
3 WING FLAP LEVER
4 RUDDER TRIM KNOB AND INDICATOR
5 LATERAL TRIM CUTOUT SWITCH
6 STABILIZER TRIM WHEELS AND INDICATORS
7 STABILIZER TRIM CUTOUT SWITCH
8 AIRBRAKE LEVER

Figure 1-101 (Sheet 1 of 4)

NO.	CONTROL-INDICATOR	FUNCTION
1	Wing Flap Position Indicator	A dual wing flap position indicator is provided which reads from 0% to 100% of wing flap travel. The dual indicating system is provided to show any difference in position of the left and right wing flap sections such as would result from a broken flap torque tube. The top needle in the indicator, has a hole in it, is marked R and indicates the position of the right wing flaps. The bottom needle is marked L and indicates the position of the left flaps.
2	Lateral Trim Indicator	A single lateral trim indicator provides an indication of trim input which is comparative with spoiler position. Spoiler position does not necessarily correspond to indicated trim which is electrically positioned by the lateral trim actuator shaft. As much as 3° of trim indication may be necessary to compensate for tolerances in the lateral control system. The indicator is calibrated in degrees of spoiler position from 0° to 15° spoiler up with a separate scale for left and right spoilers. The indicator pointer is a single needle pointed at both ends and will indicate on either scale.
3	Wing Flap Lever	The wing flap lever provides UP- -OFF- -DN positions with detents at UP and DN positions. This lever must be pulled up out of the detent before it can be moved from either the UP or DN position. An OFF position is located on either side of a spring-loaded latch-type stop which is in the middle of the detent quadrant. Depressing the latch toward the flap lever allows the flap lever to be moved from OFF position on either side of the latch to the opposite detent. When the lever is placed in the UP or DN position, a circuit is closed to supply TR power to left and right flap extend or retract relays. Limit switches provide protection for both extension and retraction operations. When the lever is in OFF position, the circuits are deenergized and the wing flaps are held in their last position.
4	Rudder Trim Knob and Indicator	The rudder trim knob and indicator is the only control provided for rudder trim. Rotation of the knob actuates the trim screw and repositions the rudder torque tube to a new neutral trim which is maintained by the Q-spring. The indicator is a mechanical indicator calibrated in units of trim up to a maximum of 12 units nose left and 12 nose right.
5	Lateral Trim Cutout Switch	The 118-volt single-phase ac circuit for the lateral trim actuator can be disconnected by actuating a CUTOUT- -NORMAL guarded switch on the left side of the aisle stand. When the switch is in CUTOUT (guard up) position, the circuit is broken and lateral trim is inoperative. This switch must be in NORMAL (guard down) position before lateral trim can be accomplished.
6	Stabilizer Trim Wheels and Indicators	Manual control of the stabilizer trim metering valve is provided by rotation of the stabilizer trim wheels on the aisle stand. The pilot's trim wheel is attached to the throttle shaft and operates through a chain sprocket linkage to move a trim indicator located forward and inboard of the wheel. The copilot's trim wheel and trim indicator are located opposite to the pilot's trim indicator. The indicators are calibrated in units of stabilizer leading edge movement from nine units AIRPLANE NOSE DN to four units AIRPLANE NOSE UP, with one unit equalling 1° of stabilizer travel. Any trim accomplished using the electric trim control system will feed back through the cable system rotating the manual trim wheels and indicators. The manual trim wheels can be used to override the electric trim control system or autopilot trim system. The trim wheel face and periphery is painted in alternate black and white segments as a visual aid and reminder when the electric trim control system is being used.

Figure 1-101 (Sheet 1 of 2)

NO.	CONTROL-INDICATOR	FUNCTION
7	Stabilizer Trim Cutout Switch	A guarded CUTOUT- -NORMAL stabilizer trim cutout switch is used to disconnect the dc control circuits between the trim buttons and the stabilizer trim control relay coil. When this switch is in CUTOUT (guard up) position, the circuits are broken and the stabilizer trim cannot be operated electrically. For normal electrical control of stabilizer trim, this switch must be in NORMAL (guard down) position. Manual control of stabilizer trim is not affected by the cutout switch in either CUTOUT or NORMAL position.
8	Airbrake Lever	The airbrake lever operates six contacts in the airbrake switch box supplying emergency battery power to the solenoid valves at the hydraulic control units. These units mechanically open the metering valves which direct hydraulic pressure to actuate the spoilers. The lever has an OFF position and six operating positions marked 1- -2- -3- -4- -5- -6. Detents are provided at OFF positions 1, 2, 4, and 6. Position 1, marked AR, is used primarily for air refueling and gives increased roll rate authority. OFF position of the airbrake lever deenergizes the airbrake control circuits and permits the spoilers to provide lateral control only. When the airbrake lever is progressively moved through its full range (with the control wheel in neutral), the outboard spoiler and the inboard spoilers will be operated alternately as follows:

LEVER POSITION	OUTBOARD SPOILERS	INBOARD SPOILERS
OFF	0°	0°
1	10°	0°
2	10°	20°
3	40°	20°
4	40°	40°
5	50°	40°
6	50°	60°

NOTE

The spoilers move rapidly from one position to another as new positions are selected by the airbrake lever. Gradually moving the airbrake lever from one position to another will not result in a reduced rate of spoiler movement nor can they be stopped in any intermediate position.

Figure 1-101 (Sheet 2 of 2)

AUTOMATIC FLIGHT CONTROL SYSTEMS

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AUTOPILOT

AUTOMATIC FLIGHT CONTROL SYSTEM

The word "autopilot," as used in this manual, consists of the entire digital automatic Flight Control System (FCS). The autopilot provides automatic flight control with nonsteering and pitch and roll steering modes. The bomb mode, another autopilot auxiliary control mode, allows the autopilot to be integrated with the EFB navigation tablet (Flight plan and GPS mode). A synchronization mode, also called a followup system, is provided with the autopilot and operates anytime the autopilot is on but disengaged. The followup system of the autopilot, allows the roll servo and pitch servo to align (i.e., synchronize) to existing flight attitude and heading of the aircraft for smooth engagement of autopilot control modes. An interlock system is provided as protection against improper operation of the autopilot and to ensure the pilot of primary flight control at all times. The autopilot operates on TR power and 118 volt single-phase ac power.

WARNING

The autopilot will be used with caution during any critical phase of flight (i.e., low level, air refueling, or combat breakaway maneuvers). The trim condition of the aircraft should be closely monitored at all times when using the autopilot, but particularly so during the critical flight phases mentioned above. In the event of automatic trim system failure, large amounts of stabilizer trim can be compensated for by the autopilot. This can result in severe pitch down/up when either a change in attitude or power setting causes an automatic dis- connect or when a manual disconnect is accomplished. To minimize the effect of an automatic trim system failure, the fore and aft position of the control column should be monitored closely.

If several units of nose- down stabilizer trim and aft position of the control column are detected while flying with autopilot altitude hold engaged, be aware that autopilot disengagement by any means will cause abrupt pitchdown unless proper preventive steps are taken. Disen- gaging the autopilot, retrimming, and reen- gaging at frequent intervals, is recom- mended.

NOTE

If dc or ac power to the AHRS is lost, the autopilot will disengage immediately.

AUTOPILOT NONSTEERING MODES

Autopilot stabilization and altitude hold are referred to as autopilot nonsteering modes because control column inputs are not used to command pitch and roll to the autopilot. Autopilot stabilization is provided anytime ROLL ENGAGE and/or PITCH ENGAGE switches on the control panel are set to the ON position. The autopilot can be operated with only roll stabilization or only pitch stabilization if desired. The autopilot stabilization mode is used to hold the aircraft in straight and level flight on a constant heading using pitch, roll, and heading signals provided by the AHRS. Aircraft attitudes and heading changes are made by a crewmember using the autopilot flight controller or by the OAS. The autopilot stabilization mode is al- ways selected first before other autopilot control modes can be engaged. The altitude hold mode is used to maintain the aircraft at a constant barometric pressure altitude. Altitude hold cannot be engaged unless the pitch flight stabilization mode is engaged. Pressure signals from the Air Data Sensor Unit are processed by the FCS Processor to control elevator and stabilizer trim as required to maintain the aircraft at the pressure altitude existing at the time of selection.

AUTOPILOT PITCH AND ROLL STEERING MODES

Aerial refuel and low level modes of the autopilot are referred to as steering modes and are designed to substantially reduce the loads imposed during aerial refueling and to reduce pilot fatigue during low level mode of flight. When using the aerial re- fuel and low level modes, the pilot flies the aircraft through the autopilot by control column inputs in the same manner that he flies without the autopilot except that control column forces are considerably reduced. Inputs by the pilot through the column generate electrical signals proportional to the force applied through force transducers in and below the control columns. These signals to the autopilot are used to command the aircraft in pitch and roll in lieu of signals from the autopilot pitch, turn, and roll knobs. Turn, roll trim, and pitch trim knobs are disabled in the steering modes. The maximum bank angle in aerial refuel mode is 40 degrees and 45 degrees in low level mode. Lateral control force stiffens when angle limits are approached.

Attempts to increase the bank angle beyond these limits will result in an autopilot disconnect. Aerial refuel and low level modes differ in that during aerial refuel mode, the autopilot will maintain a constant attitude and will resist attempts to change that attitude. The autopilot will return the aircraft to its original attitude unless the pilot holds a particular change to pitch or bank angle for a sufficient period of time to allow the autopilot to adjust. Once the autopilot adjusts, it will aid the pilot in maintaining the new attitude. The pilot will feel very little resistance in the lateral controls for bank angles up to 8 degrees. Any bank angle between 8 degrees and 45 degrees established by the pilot will be held by the autopilot regardless of changes to power or airspeed. Changes in pitch attitude will also be maintained by the autopilot in low level mode regardless of changes in thrust or airspeed. A reduction of manual rudder requirements is realized through use of the yaw axis of the stability augmentation system and the hydraulically powered rudder system. The pilot trims the aircraft laterally but need not apply any stabilizer trim. The autopilot will automatically trim the aircraft to assist the pilot in maintaining a pitch attitude and will trim to compensate for any gross weight or cg change.

AUTOPILOT SAFETY FEATURES

Force Override

The autopilot can be disconnected with manual force applied to the pilot or copilot control column or wheel. A column or wheel force exceeding approximately 30 pounds in flight stabilization mode or 40 pounds in steering modes will disengage the autopilot.

Pitch Protection

The autopilot monitors for excessive pitch attitude, pitch rate, and control column forces. The autopilot limits the pitch rate command to 6.5 degrees per second for all modes. An accelerometer located in the digital amplifier unit detects changes in G- forces relative to autopilot pitch commands to provide g limiting in autopilot steering modes.

NOTE

> When the PITCH ENGAGE switch is ON, the stabilizer trim portion of the stabilizer and lateral trim button will be inoperative.

Roll Protection

The autopilot monitors and limits roll attitude, roll rate, and control column roll forces in nonsteering and steering modes. Additional roll protection will disengage the autopilot if either pilot exerts a wheel force exceeding 30 pounds in flight stabilization or 40 pounds in steering modes. The flight controller turn knob, when rotated to the first detent, will limit bank angle to approximately 39 degrees for nonsteering modes; roll rate command is limited to 10 degrees per second. Further rotation of the turn knob to the full mechanical stop will command approximately 40 degrees of bank to facilitate a breakaway.

NOTE

> When the ROLL ENGAGE switch is ON, the stabilizer and lateral trim button will continue to operate normally for trim of the spoilers and the stabilizer.

In aerial refuel and low level modes, turns commanded with the control wheel are limited in bank angle to 40 and 45 degrees, respectively. In the autopilot bomb mode, turn control is transferred to the OAS. With BOMB position of OAS selected, turns are limited in bank angle to 38 degrees by the autopilot. Roll rate com- mand is limited to 10 degrees per second with the autopilot bomb mode engaged. The flight controller roll trim knob is effective only in the autopilot bomb mode and provides approximately 20 degrees maxi- mum roll command to correct FCI standoff error.

G Limiter

Autopilot steering modes will reduce control column force requirements considerably with the additional assistance provided by the elevator servo. Consequently, it would be possible for the pilot to inadvertently exceed the load limits of the aircraft in a pull-up, pushover, rapid turn, or combination of pull-up and turn. To prevent exceeding the physical limits of the aircraft, a G limiter function has been incorporated in the autopilot. The G limiter function is set to limit acceleration from a minimum of 0.2 g to a maximum of 1.8 g. As the pilot maneuvers the aircraft through any longitudinal attitude change, the autopilot accelerometer will sense the amount of acceleration and reduce the autopilot elevator command. As a result of less elevator command, the pilot will observe more force is required on the control column to command the aircraft in pitch. Any attempt by the pilot or copilot to increase applied control column force beyond 40 pounds will disengage the autopilot.

PITCH AND ROLL STEERING FLIGHT CHARACTERISTICS

Aerial Refuel Mode

The aerial refuel mode of the autopilot was designed primarily to substantially reduce the loads imposed on the aircraft during air refueling and will be utilized for all air refueling operations with tanker aircraft, when the equipment is operative, unless specific directives dictate otherwise.

NOTE

> The aerial refuel mode is not recommended for formation flying other than that required for air refueling operations.

The pilot will find that using the aerial refuel mode will improve manual proficiency. This mode provides stability in pitch and roll which will resist attitude changes due to tanker downwash or turbulence. The aircraft responses in the aerial refuel mode differ from the low level mode in that more rapid aircraft responses are obtained when wheel or column force is applied. This characteristic allows smoother control inputs to maneuver the aircraft in the small envelope behind the tanker and also allows use of more of the envelope, thus reducing air craft loads. When the pilot relaxes wheel or column force following momentary corrections, the autopilot will restore the aircraft to the attitude existing prior to the correction.-

NOTE

> The characteristics of the following pitch and roll maneuvers while in aerial refuel mode may be observed by the pilot without the aid of a tanker.

PITCH MANEUVERS

The attitude hold and pitch attitude reference change features of the autopilot while in aerial refuel mode may be demonstrated by the following maneuvers. Momentarily pitch the aircraft up or down approximately 2 degrees and immediately relax force on the control column. When force is relaxed, the aircraft will return to the original flight attitude. A change to the pitch attitude reference may be accomplished by maintaining column force for some period of time. As an example, with the PITCH ENGAGE and ROLL ENGAGE switches ON, establish an approximate 2 degree noseup pitch attitude by rotating the pitch knob. Place AERIAL REFUEL switch ON and push the control column forward until the aircraft rotates to level flight. Relax column force and observe that the air- craft starts recovery to the original 2 degrees nose- up attitude. Maintain level fight and observe that the restraining force necessary to maintain level flight gradually decreases until column force is zero. When column force reaches zero, the aircraft attitude reference will have changed from 2 degrees noseup to level flight. Thus, a change in pitch attitude reference is accomplished automatically by the autopilot when column force is maintained for a specific period of time. The amount of reference change is dependent on the length of time column force is maintained. Automatic stabilizer trimming occurs during autopilot aerial refueling operation whenever a continuous column force is applied.

ROLL MANEUVERS

The attitude hold and roll attitude reference change features of the autopilot when in aerial refuel mode may be demonstrated by the following maneuvers. Momentarily roll the aircraft left or right, establishing a shallow bank angle and immediately relax force on the control wheel. When force is relaxed, the aircraft will return to the original flight attitude. Reestablish the bank angle, restrain the wheel, and note that the wheel force will gradually decrease until the aircraft roll attitude is maintained at the new reference with zero wheel force.

Turns are accomplished by changing the roll attitude reference but the roll characteristics of the aerial refuel mode require a special technique. The change in roll reference from wings level to a 30 degree bank angle, for example, may require maintaining a wheel force as long as 30 seconds. However, the time required to change the roll reference may be shortened by slight overcontrolling. That is, after the desired bank angle is established, a slight increase in wheel force (through the use of cross control) will increase the roll reference rate of change. Returning to wings level after turning requires a similar procedure.

RECEIVER-TANKER CONTACT TECHNIQUES

The aerial refuel mode of the autopilot is designed to be compatible with refueling altitude, airspeed, and downwash characteristics of the tanker air- craft. Generally, each pilot must perform several contacts with the tanker before the optimum air refueling technique is developed and full confidence in this mode of the autopilot is realized.

NOTE

The pilot should be prepared to initiate a switch or force disconnect prior to engaging the AERIAL REFUEL switch since some autopilot failures may result in a hardover pitch and/or roll servo action. Force disconnects during this condition are easily initiated by resisting column or wheel movement until applied force exceeds the disconnect value.

Low Level Mode

The low level mode of the autopilot was designed to aid the pilot in flying the aircraft at low altitudes and to reduce pilot fatigue during this type of flying.

NOTE

- The low level mode is not recommended for penetrations, takeoffs, formation flying, holding patterns, instrument approach procedures, landing, or flight at any altitude other than that required for low level or low level missions.
- The pilot should be prepared to initiate a force disconnect prior to engaging the LOW LEVEL switch since some autopilot failures may result in a hard-over pitch and/or roll servo action. Force disconnects during this condition are easily initiated by resisting the column or wheel until applied force exceeds the disconnect value.

PITCH MANEUVERS

After engaging the low level mode, pitch maneuvers are commanded through the autopilot by applying force to the control column. Pitch characteristics may be observed by gradually increasing control column force. As force is increased, the column starts to move with a corresponding change in air- craft pitch attitude. Allow the aircraft attitude to change a few degrees by applying column force. The column will return approximately to neutral as stabilizer trim occurs and the aircraft will be maintained in the new attitude. This attitude will be maintained by the autopilot. Automatic trimming may be observed during changes in aircraft speed due to climbing or descending flight or by advancing or retarding the throttles. Apply a column force and observe that trimming occurs.

ROLL MANEUVERS

Bank the aircraft left or right to a bank angle of 8 degrees or less. When wheel force is relaxed, the autopilot will return the aircraft to wings level. Bank the aircraft left or right to a bank angle greater than 8 degrees. When wheel force is re- laxed, the autopilot will maintain the aircraft in the new bank angle. Continue the bank angle to ap- proximately 30 degrees and note that wheel force must be increased in order to keep the wheel dis- placed at this bank angle. The increase in wheel force is called wheel stiffening and autopilot disconnect will occur at approximately 45 degrees of bank angle or when approximately 40 pounds of wheel force is reached. This roll force disconnect feature is available in all modes.

OUT-OF-TRIM EFFECTS

Effects of an out-of-trim aircraft may be noted by disengaging the autopilot, slightly reducing power on engines 7 and 8, and reengaging the autopilot low level mode. The same observation can be made with the autopilot stabilization mode engaged. This exaggerated out-of-trim condition illustrates the necessity of trimming the aircraft before engaging the autopilot. Wheel displacement may be decreased by advancing throttles for engines 7 and 8. Note the aircraft heading is maintained constant. Heading hold in autopilot stabilization is accomplished by the lateral control servo operating the spoiler sur- faces. If heading is drifting after autopilot stabilization is selected, the autopilot roll axis will compensate for drift and command the lateral control servo to displace and rotate the wheel.

OAS (TACAN; NAV1&2 ILS; GPS) TIE-IN

The OAS tie-in (second station) mode may be se- lected while in autopilot stabilization, altitude hold, or low level modes by positioning the autopilot TURN CONTROL selector switch to BOMB. The pilot retains autopilot pitch and manual rudder control but autopilot roll and heading control is transferred to the OAS. The autopilot limits bank angle to 15 degrees (±3 degrees) below 18,000 feet and to 38 degrees (±4 degrees) at or above 18,000 feet in NAV mode of the OAS. In BOMB mode of OAS with autopilot stabilization or altitude hold modes selected, bank angle is limited to 38 degrees (±4 degrees). However, if the BOMB mode of OAS and low level are selected, bank angle is limited to 15 degrees (±3 degrees). With the low level mode engaged, pilot initiated pitch steering through the control column simultaneously with OAS second station roll steering may appear awkward at first, requiring coordination between the pilot and radar navigator. The autopilot will disconnect if the pilot restrains wheel movement that accompanies second station roll steering commands. Manual control of the aircraft can be regained by overpowering the autopilot aircraft in pitch or roll with sufficient column/wheel force or by pressing the autopilot re- lease button. Second station control can also be dis- engaged, with roll steering return to the pilot, by rotating the flight controller turn knob out of detent or setting the autopilot TURN CONTROL selector switch to PILOT.

STABILITY AUGMENTATION SYSTEM (SAS)

A Stability Augmentation System (SAS) has been installed in the aircraft to substantially reduce structural fatigue damage rates and peak loads, to provide improved dutch roll damping, and to im- prove controllability of the aircraft under turbulent flight conditions. The SAS is an electrohydraulic two-axis (pitch and yaw) system. The system utilizes three hydraulic actuators; one for the rudder and two for the elevators. Each actuator responds to mechanical and electrical input commands. The mechanical commands come from the pilot or autopilot. Electrical input signals come from the SAS electronic control units. Each actuator has dual electrohydraulic flow control valves. The elec- trohydraulic flow control valve is the point where electrical signals become proportional hydraulic sig- nals. Each servo unit provides its related control valve. The flow control valve is an electrohydraulic unit which receives SAS generated electrical sig- nals. Electrical commands from the SAS trans- mitted to the electromechanical flow control valve are in series with the mechanical commands. For this reason, electrically commanded surface dis- placement of the rudder and elevators is not re- flected by movement of the rudder pedals or control column. Mechanical inputs to the rudder and eleva- tors is limited to 19°. Electrical commands are limited 10° authority in yaw and 5° authority in pitch.

NORMAL OPERATION OF SAS

Pilot operation of the electronic portion of the SAS consists essentially of engaging or disengaging the yaw and pitch SAS switches. The yaw and pitch SAS switches should not be engaged when transitioning from ground power to aircraft power. This is necessary to avoid giving erroneous information to the maintenance crew since the power changeover with the switches engaged trips the maintenance warning indicators on the electronic units in the 47 section. If the yaw channel fail light comes on during flight, the operation of the system is not im- paired, but the failure of one rate channel is indicated. If it is a nuisance failure, it is often possible to return the questionable channel to operation by disengaging the yaw SAS switch and then returning it to the ENGAGE position.

AUTOMATIC FLIGHT CONTROLS AND INDICATORS

AUTO PILOT

Autopilot Flight Controller

The autopilot flight controller (figure 1-103) is located on the aisle stand. When the autopilot is engaged, the flight controller provides a means for maneuvering the aircraft from the pilot's or copilot's position through the TURN, PITCH, and ROLL TRIM knobs.

Control Panel

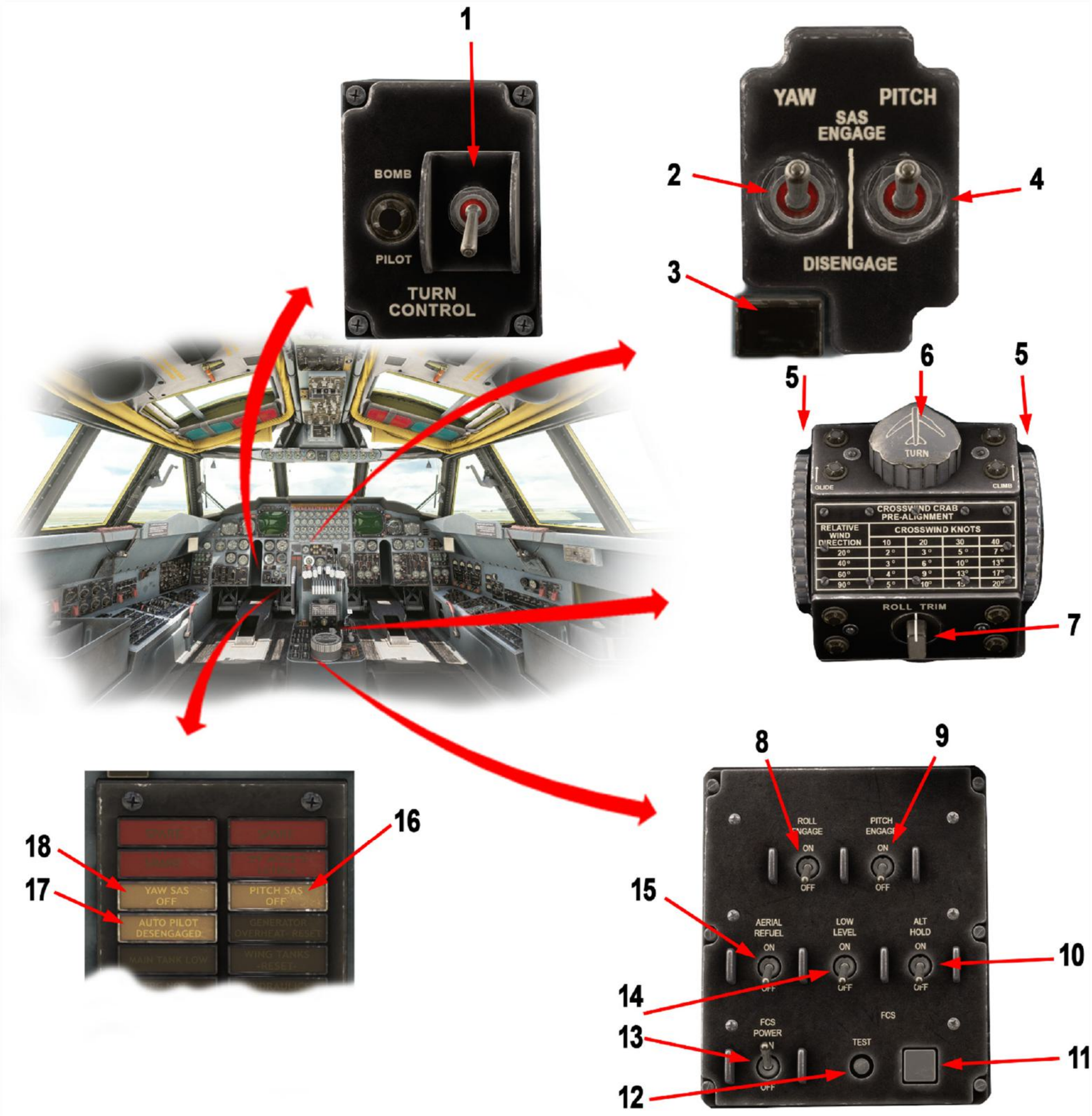
The autopilot control panel is located on the aisle stand (figure 1-103). Switches located on the control panel are identified as POWER, ROLL ENGAGE, PITCH ENGAGE, AERIAL REFUEL, LOW LEV-EL, and ALT HOLD. A test switch (test function is N/I) is provided to initiate preflight testing of the autopilot. A reset switch, identified as VALID/INVAL, is provided to indicate valid or invalid preflight test results.

STABILITY AUGMENTATION SYSTEM

SAS Control Panel

The SAS control pane is located on the pilots' for- ward instrument panel. The panel contains two switches (figure 1-103) labeled YAW SAS and PITCH SAS respectively, and a CHANNEL FAIL light.

Automatic Flight Controls and Indicators



1 AUTOPILOT TURN CONTROL SELECTOR SWITCH
2 YAW SAS SWITCH
3 YAW CHANNEL FAIL LIGHT
4 PITCH SAS SWITCH
5 PITCH KNOBS (2)
6 TURN KNOB
7 ROLL TRIM KNOB
8 ROLL ENGAGE SWITCH
9 PITCH ENGAGE SWITCH
10 ALT HOLD SWITCH
11 VALID/INVAL RESET SWITCH/INDICATOR
12 TEST SWITCH
13 FCS POWER SWITCH
14 LOW LEVEL SWITCH
15 AERIAL REFUEL SWITCH
16 PITCH SAS OFF LIGHT
17 AUTOPILOT DISENGAGE LIGHT
18 YAW SAS OFF LIGHT

Figure 1-103 (Sheet 1 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
1	Autopilot TURN CONTROL Selector Switch	The autopilot turn control selector switch is of the solenoid locking type and has PILOT--BOMB positions for selecting either the autopilot flight controller (PILOT) or the OAS (BOMB), respectively, for turn command of the autopilot. Interlocks will return the turn control selector switch from BOMB to PILOT position without disengaging the autopilot when the pilot's turn knob is rotated out of center detent.
	SAS CONTROL PANEL	
2	YAW SAS Switch	The YAW SAS switch has two positions, ENGAGE- -DISENGAGE. The ENGAGE position of the switch supplies power to the engage valves in the hydraulic actuators and places the system in operation. It also supplies a reset pulse to the comparators when placed in the ENGAGE position. The DISENGAGE position removes power from the hydraulic actuator engage valves. The switch is a solenoid locking type switch and is held in the ENGAGE position by dual coil electromagnets. If the logic circuitry determines that the switch contacts should be broken, the electromagnets are released allowing the spring-loaded switches to return to the DISENGAGE position.
3	Yaw CHANNEL FAIL Light (Amber)	A push-to-test yaw channel fail light serves to warn the pilot that a single rate channel of the SAS yaw axis has failed.

Figure 1-103 (Sheet 2 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
4	PITCH SAS Switch	The PITCH SAS switch has two positions, ENGAGE- -DISENGAGE. The ENGAGE position of the switch supplies power to the engage valves in the hydraulic actuators and places the system in operation. It also supplies a reset pulse to the comparators when placed in the ENGAGE position. The DISENGAGE position removes power from the hydraulic actuator engage valves. The switch is a solenoid locking type switch and is held in the ENGAGE position by dual coil electromagnets. If the logic circuitry determines that the switch contacts should be broken, the electromagnets are released allowing the spring-loaded switches to return to the DISENGAGE position.
	AUTOPILOT FLIGHT CONTROLLER	
5	PITCH Knobs (2 places)	Interconnected pitch knobs labeled PITCH, are provided for adjustment of the reference pitch attitude that will be maintained by the autopilot. Adjustment of the pitch knobs will command the elevator for climb or descent for autopilot stabilization mode. The pitch knob is mechanically stiffened in the autopilot altitude hold mode; forced rotation of the pitch knobs will disengage the altitude hold mode and allow the pilot to adjust pitch as required for changing altitude. The pitch knob is disabled for autopilot steering modes. Forward rotation (GLIDE) of the pitch knobs results in aircraft descent; aft rotation (CLIMB) will command the aircraft to climb.
6	TURN Knob	The turn knob, labeled TURN, provides coordinated turns in autopilot nonsteering modes. Rotating the turn knob results in an aircraft turn in the same direction as the knob is rotated. The rate of turn is proportional to the speed of the aircraft and amount of bank commanded with the turn knob. Moving the turn knob out of center detent puts turn control back to the pilot regardless of the setting of the autopilot turn control selector switch. Additional detents are located at points in the turn knob rotation corresponding with approximately 10 degrees less than the maximum bank capability of 50 degrees. The turn knob is disabled for autopilot steering modes. **NOTE** When the turn knob is not in use, it should be in the detent at center position of total knob rotation. The autopilot will not engage with either turn or trim knobs out of detent.
7	ROLL TRIM Knob	The roll trim knob is used principally to correct FCI standoff error when the autopilot turn selector switch is in BOMB position. The roll trim knob can only operate with autopilot stabilization, altitude hold, or low level modes. The roll trim knob is disabled during aerial refuel mode of operation or whenever the turn control selector switch is set to the pilot position. Use of the roll trim knob for lateral trim will deflect a spoiler and increase drag causing the aircraft to roll. Lateral trim should normally be accomplished by fuel management.

Figure 1-103 (Sheet 3 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
		AUTOPILOT CONTROL PANEL
8	ROLL ENGAGE Switch	The ROLL ENGAGE switch has ON--OFF positions. ON position engages the lateral control servos. OFF position disengages the servos. Can be engaged by HOTKEY "**AP MASTER ON/OFF"**
9	PITCH ENGAGE Switch	The PITCH ENGAGE switch has ON--OFF positions. ON position engages the elevator and stabilizer trim servos. OFF position disengages the servos. Can be engaged by HOTKEY "**AP MASTER ON/OFF"**
10	ALT (Altitude) HOLD Switch	The ALT HOLD switch has ON--OFF positions. In the ON position, the autopilot will maintain the aircraft at a constant barometric pressure altitude. Barometric pressure signals from the air data sensor unit are processed to operate the elevator and stabilizer pitch trim servos as required to maintain the pressure altitude existing at the time that the ALT HOLD switch was set to ON. Can be engaged by HOTKEY "**ALT THOLD ON/OFF"**
11	VALID/INVAL Indicator/Reset Switch **(NOT IMPLEMENTED)**	When the TEST switch is pressed, the autopilot status will be indicated as VALID or INVAL on the indicator.
12	TEST Switch **(NOT IMPLEMENTED)**	The TEST switch actuates a built-in-test (BIT) system to determine the operational status of the autopilot. The system is wired through the aircraft squat switches and is therefore usable on the ground only.
13	FCS POWER Switch	The FCS POWER switch has ON--OFF positions. When the POWER switch is set to the ON position, electrical power is applied and the synchronization mode of the autopilot is operational. **NOTE** In the event of any indicated malfunction of autopilot disengagement, place the POWER switch to the OFF position, thus assuring positive autopilot disengagement.
14	LOW LEVEL Switch	The LOW LEVEL switch has ON--OFF positions. In the ON position, signals are supplied from the force transducers which allow the pilot to control the aircraft through the autopilot. The turn knob and pitch knobs are disabled when the low level mode is engaged. In the OFF position, power is removed from the low level portion of the autopilot. The LOW LEVEL switch will automatically return to OFF when the autopilot is disengaged for any reason.
15	AERIAL REFUEL Switch	An AERIAL REFUEL switch has ON--OFF positions. In the ON position, signals are supplied from the force transducers which allow the pilot to control the aircraft through the autopilot. Turn, pitch, and roll trim knobs are disabled when the aerial refuel mode is engaged. In the OFF position, power is removed from the aerial refuel portion of the autopilot. The AERIAL REFUEL switch will automatically return to OFF when the autopilot is disengaged for any reason.

Figure 1-103 (Sheet 4 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
		CENTRAL CAUTION PANEL
16	PITCH SAS OFF Light (Amber)	Push-to-test light marked PITCH SAS OFF warns the pilots that two associated channel failures of the pitch SAS have occurred and that the holding coils for the ENGAGE switch have been released returning the switch to the DISENGAGE position. Simultaneously with the illumination of the PITCH SAS OFF light, the master caution light on the pilots' panel will illuminate.
17	AUTO PILOT DISENGAGED Light (Amber)	Illumination of the AUTO PILOT DISENGAGED light (amber master caution lights also come on) alerts the pilot and copilot that ROLL ENGAGE or PITCH ENGAGE switches have been returned from ON to the OFF position. The warning lights operate with any autopilot mode selected. The warning lights can be turned off by resetting the ROLL ENGAGE and/or PITCH ENGAGE switches to ON, by momentarily placing the POWER switch OFF then ON, or by pressing either autopilot release button.
18	YAW SAS OFF Light (Amber)	Push-to-test light marked YAW SAS OFF warns the pilots that two associated channel failures of the yaw SAS have occurred and that the holding coils for the ENGAGE switch have been released returning the switch to the DISENGAGE position. Simultaneously with the illumination of the YAW SAS OFF light, the master caution light on the pilots' panel will illuminate.

Figure 1-103 (Sheet 5 of 5)

PILOT'S OPERATION OF THE AUTOPILOT

Pilot's inflight operation of the autopilot may be accomplished by the following procedure:

1. Check POWER switch ON.
2. Check aircraft wings level and ball centered.

    a. The aircraft should be trimmed by fuel management and thrust adjustments as much as possible since manual trim will deflect the spoilers and create drag.

    b. Use rudder trim, as required, to obtain straight and level flight. Observe RUDDER TRIM LIMITATIONS, Section V.

3. Check autopilot flight controller for:
    a. TURN knob in detent.
    b. ROLL knob in detent.
4. Place ROLL ENGAGE and PITCH ENGAGE switches ON.

WARNING

The pilot should be prepared to immediately disengage the autopilot in the event of a hardover indication following engagement.

NOTE

- Upon engagement, there should be no engage transient exceeding 1/2 degree of pitch or yaw and 1 degree of roll.
- Autopilot stabilization may be engaged in a normal climb or descent and the aircraft will continue to fly that attitude until the pilot moves his pitch knob.
- If the autopilot is engaged when the aircraft is banked for a turn, it will automatically roll the aircraft to a near wings-level attitude.
- The autopilot will not completely compensate for all lateral mistrim. If the aircraft is not properly trimmed before autopilot engagement or becomes out of trim after engagement, the aircraft may fly slightly wing low until the aircraft is retrimmed by fuel management and thrust adjustments.
- If the AHRS fails, the autopilot will disengage.
- Yaw SAS is required to provide dutch roll damping.

5. Place ALT HOLD switch to ON if constant altitude control is desired. The aircraft is now under autopilot control on the roll and pitch axes.

NOTE

The aircraft should, with no more than two overshoots, stabilize out on a "reference" altitude within the following stated tolerances from "engage" altitude during straight and level flight.

Below 30,000 feet pressure altitude	(±) 30 feet
Above 30,000 feet pressure altitude	(±) 0.1% engage reference altitude.

During turns, deviation from the engaged reference altitude should not exceed (±) 60 feet (for roll angles less than 30°). ALT HOLD will be disengaged if the flight controller pitch knob is rotated out of detent, or when AERIAL REFUEL or LOW LEVEL mode is selected.

6. Standard maneuvers may be executed with the PITCH and TURN knobs. Climbs and descents may be accomplished with the PITCH knob; turns may be made with the TURN knob. A climbing or descending turn may be made with a combination of the two knobs.
7. Steady displacement of the control wheel indicates asymmetrical fuel load or engine thrust requiring appropriate fuel management and/or thrust adjustment to center the control wheel.

NOTE

- During operation on autopilot, airbrake operation should be performed with caution to avoid excessive longitudinal out-of-trim condition and to prevent possible automatic pilot disengagement.
- During autopilot control with ALT HOLD engaged, operation of the wing flaps is permissible. While operating flaps, a large but not dangerous indicated altitude change will result due to a change in airflow across the static source. Lowering flaps results in a gain in altitude; raising flaps will result in a loss of altitude.

8. The low level mode should be engaged after stabilizing at an altitude consistent with the start of low level flight with the aircraft trimmed. The low level mode is engaged as follows:

- POWER switch – ON
- PITCH ENGAGE switch – ON
- ROLL ENGAGE switch – ON
- LOW LEVEL switch – ON
- No other autopilot mode is engaged (if ALT HOLD is on, it will drop out)
- NORMAL and ALTERNATE SLIPWAY DOOR switches are CLOSED
- ROLL TRIM and TURN knob in detent

NOTE

- The LOW LEVEL switch should be placed ON immediately after placing the PITCH ENGAGE and ROLL ENGAGE switches ON to avoid low level flight in an autopilot nonsteering mode.
- In the event of a malfunction of the slipway door system, the LOW LEVEL switch may be engaged if the MASTER REFUEL SWITCH is OFF or is cycled from ON to OFF after the slipway door switches are in the CLOSED position.
- When engaging either the LOW LEVEL or AERIAL REFUEL switches, the pilot and copilot should not be exerting any force on the control column. If either pilot is exerting a force on the controls when the LOW LEVEL or AERIAL REFUEL switch is engaged, an engage transient will occur. The action will be observed as a short pulse action on the control columns but will not drive the control limit.

9. The air refueling system must be configured for air refueling in order to engage the aerial refuel mode. The aerial refuel mode is placed in operation while approaching the precontact position (at approximately 10 knots above refueling airspeed) and will be engaged as follows:

- POWER switch – ON
- PITCH ENGAGE switch – ON
- ROLL ENGAGE switch – ON
- AERIAL REFUEL switch – ON
- No other autopilot mode engaged

NOTE

- Engaging the PITCH ENGAGE, ROLL ENGAGE, and AERIAL REFUEL switches (in this order) should be accomplished as rapidly as possible to minimize the time the autopilot is in a nonsteering mode.
- When engaging the AERIAL REFUEL switch, if the signal amplifier cycles from ready to disconnect, push the reset button and return air refueling system to ready condition.
- During aerial refueling, boom disconnects caused by excessive pressure, exceeding the boom envelope limits, or boom operator initiated disconnects, will not disengage the autopilot.

PNEUMATIC SYSTEMS

DESCRIPTION 122
AIR BLEED SYSTEM 122
MANIFOLD VALVE SWITCH 123
AIR CONDITIONING SYSTEM 123
AIR CONDITIONING SYSTEM CONTROLS AND INDICATORS 123

DESCRIPTION

The pneumatic systems include the air bleed system and the air conditioning and pressurization system.

AIR BLEED SYSTEM

The air bleed system incorporates a wing leading edge manifold and controls for collect- ing and routing high pressure hot air. This air may be obtained either from the final stage compressor of each operating engine or from an auxiliary air source applied to a ground start connection on the underside of each nacelle. The air bleed system is the power source for engine starting and the air source for heating, cooling, and pressurizing the crew compartment. The system is designed so that normal airflow is from the No. 2 nacelle through a ram air heat exchanger (precooler) in the No. 2 strut into the distribution ducting in the wing lead- ing edge and fuselage. On the ground, the landing gear squat switch functions to fully open the cooling air ejector valve at all times to allow maximum pre- cooler operation. In flight, duct temperatures not to exceed 190°C result from regulation of ram air passing through the heat exchanger in the precool- er. A bleed air overheat light comes on if the duct temperature exceeds approximately 210°C. In the event of failure of the bleed air supply from No. 2 nacelle, either through duct failure or shutdown of engines 3 and 4, emergency airflow may be obtained from No. 3 nacelle by placing the bleed selector switch (6, figure 1-110) on the aisle stand, in the EMERG RH INBD position. This air does not pass through a strut mounted precooler and therefore may directly subject the distribution ducting and the air conditioning system to bleed air tempera- tures of 232° to 399°C, depending on engine thrust settings and OAT. The distribution ducting and the routing it follows, particularly along the wing leading edge, are not designed for safe operation at temperatures above 246°C when the aircraft is below 25,000 feet.

Above 25,000 feet with low OAT conditions, adequate cabin heating may not be available with the bleed selector switch in the NORMAL LH IN BD position. This is caused by over-cooling of the bleed air by the precooler, with the result that the bleed air temperature may not be high enough to permit adequate cabin heating. In order to minimize this problem, the following instructions apply:

1. At altitudes below 25,000 feet, place the bleed selector switch in NORMAL LH INBD position.
2. At altitudes of 25,000 feet or above, place the bleed selector switch in EMERG RH INBD position.

WARNING

- When EMERG RH INBD is selected below 25,000 feet, an explosive condition may exist in the wing if fuel vapors have accumulated near the hot air ducting and the duct temperature exceeds 246°C. Therefore, the bleed air overheat light, and the manifold temperature gage will be closely monitored to prevent exceeding 246°C below 25,000 feet, since bleed air is not precooled in EMERG RH INBD. The explosive danger no longer exists above 25,000 feet, due to the high auto-ignition temperature of fuel vapor above this altitude.

MANIFOLD VALVE SWITCH

The manifold valve switch is used primarily for engine starting and provides for airflow from any engine to any other engine. For operation of the manifold valve switch see 3, figure 1-110.

AIR CONDITIONING SYSTEM

The air conditioning system provides crew compartment ventilation with filtered temperature controlled air, piped cooling to electronic equipment, pressurization, and emergency ram air ventilation. High pressure hot air from the air bleed system provides the energy to air condition and pressurize the crew compartment. The bleed air ducting contains a thermal switch which is connected to an amber press-to-test warning light on the pilot's instrument panel to warn of bleed air overheat. Additionally the master caution light will come on when the bleed air over- heat light comes on. The bleed air overheat light comes on at 210°C. In case of bleed air overheat another thermal switch is located in the air conditioning pack (ACP) compressor discharge duct which will shut the ACP down if the temperature exceeds 224°C. Bleed air, which has been partially cooled by a temperature controlled precooler in the No. 2 strut, is admitted to the system by the air conditioning system pressure regulator and shutoff valve, which is operated electrically by the cabin pressure (air conditioning) master switch on the aisle stand. From the air conditioning shutoff valve, bleed air passes through a catalytic filter then di- vides. Part of the hot air passes through a flow control valve and is cooled by the ACP. A water separator downstream of the ACP removes moisture from the cooler air. The remaining uncooled bleed air passes through a pressure regulator valve and is mixed with the cooled air and ducted to the crew station lower outlets to maintain the desired cabin temperature. The remainder of the air cooled by the ACP is ducted into the pressurized compartment where it supplies cooling to electronic equipment and crew station overhead outlets. Cabin pressurization is provided by regulating the discharge of cabin air through combination cabin pressure safe- ty and outflow valves. Ram air ventilation of the crew compartment and some cooling of electronic equipment may be obtained by positioning the air conditioning master switch in RAM to shut off conditioned air, open the emergency ram airscoop, and open the outflow valves. For ground operations, the OFF position is used when the ground cooling cart is connected to the ground cooling connection in the forward wheel well to cool electronic equipment and ventilate the compartment. Also, cooling air can be obtained by selecting 7.45 when bleed air is avail- able through an air cart connected to No. 2 nacelle or from an engine run.

WARNING

Extreme caution must be exercised by all crewmembers when stowing and securing gear aboard the aircraft. Care will be taken to ensure that gear is safely secured and is not stowed on or near heating ducts, outlets, electrical wiring, and electronic equipment. Periodically during flight, each crewmember should check ducts, outlets, electrical wiring, and electronic equipment in his immediate area to see that they are free of combustible materials.

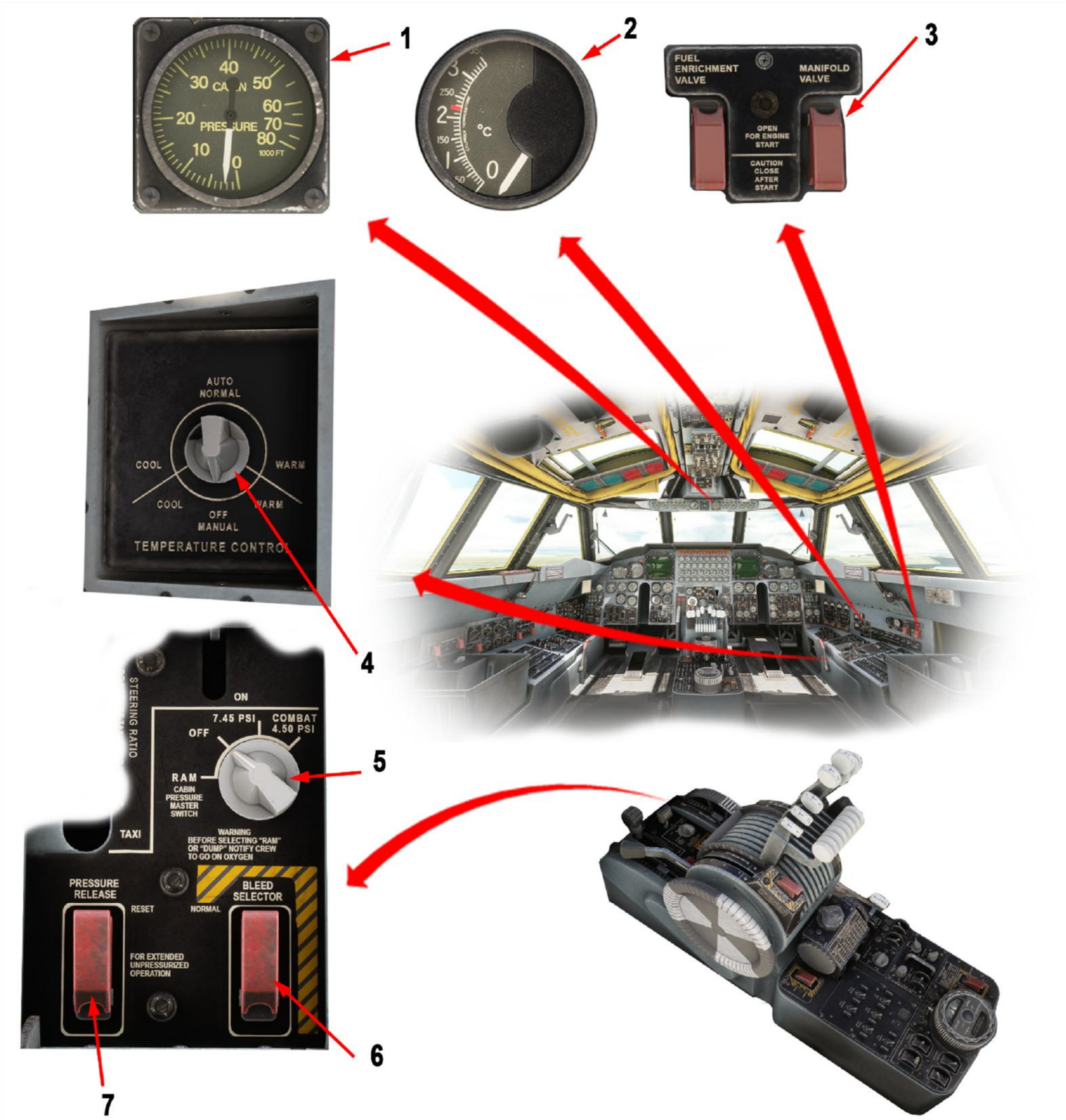
AIR CONDITIONING SYSTEM CONTROLS AND INDICATORS

System controls and indicators are described in fig- ure 1-110.

AIR OUTLET CONTROLS

Two knobs at pilots station and defense station, and three at navigators' station marked AIR OUTLET remotely control shutoff and quantity of airflow from outlets at that station and may affect the overall distribution as described under AIR DISTRIBUTION. By an arrow-indicated turn-clockwise-to-lock feature, the knobs may be set at a desired intermediate point between all the way in and out. The air outlet knob at the top of the cluster associated with the placard UPPER controls head outlets airflow at that station.

Pneumatic Systems Controls and Indicators



1 CABIN ALTIMETER
2 MANIFOLD TEMPERATURE GAGE
3 MANIFOLD VALVE SWITCH
4 TEMPERATURE CONTROL SELECTOR
5 CABIN PRESSURE (AIR CONDITIONING) MASTER SWITCH
6 BLEED SELECTOR SWITCH
7 PRESSURE RELEASE SWITCH

Figure 1-110 (Sheet 1 of 5)

NO.	CONTROL-INDICATOR	FUNCTION
1	Cabin Altimeter	The single pointer Type MA-2 cabin altimeter marked CABIN PRESSURE ALT on the eyebrow instrument panel is graduated to indicate cabin pressure altitude in 1000-foot increments to 50,000 feet, then in 5000-foot increments from 50,000 to 80,000 feet. The instrument is a self-contained unit requiring no external power source.
2	Manifold Temperature Gage	The manifold temperature gage indicates the temperature from 0° to 300°C in the air bleed manifold. The gage is electrically operated by TR power through a temperature sensor bulb in the manifold at the air conditioning duct lead-off.
3	MANIFOLD VALVE Switch	The OPEN- -CLOSE manifold valve switch is guarded to the CLOSE position. The OPEN position, used primarily for engine starting, provides for airflow from any engine to any other engine by supplying 118-volt single-phase ac to open the motor-driven body crossover manifold and No. 3 strut bleed valves, and TR power to open the normally closed solenoid-operated No. 1 and 4 strut bleed valves. In OPEN position, air conditioning system control of the body crossover manifold and No. 3 strut bleed valves is discontinued. This results in hot bleed air being interconnected between all engines through the body crossover manifold. The guarded CLOSE position restores 118-volt single-phase ac to the air conditioning system controls for management of bleed air source selection, and removes TR power from the solenoid-operated No. 1 and 4 strut bleed valves which resume their normally closed positions.
4	TEMPERATURE CONTROL Selector (2 places)	Two rotary temperature control selectors, one at the copilot's station and one at the radar navigator's station, are a combination switch-rheostat. Marking of AUTOMATIC RANGE with graduations marked COOL- -NORMAL- -WARM and MANUAL TEMPERATURE CONTROL with COOL- -OFF- -WARM positions indicate two modes of controlling cabin temperature, automatic and manual, with separate means of regulation. The temperature selector has a range marked AUTO COOL to AUTO WARM which selects temperatures from 54° to 96°F. **NOTE** • The cabin pressure (air conditioning) master switch must be in 7.45 PSI or COMBAT 4.50 PSI position for cabin temperature control circuits to be energized. • Allow 15 to 20 minutes for the cabin temperature to stabilize at the selected setting when the temperature control selector is in AUTOMATIC.

Figure 1-110 (Sheet 3 of 6)

NO.	CONTROL-INDICATOR	FUNCTION
4	TEMPERATURE CONTROL Selector (Cont)	When the knob is positioned on the AUTOMATIC RANGE, ac power is switched to the electronic automatic cabin temperature regulator for cycling the modulating valves in the respective zone, hot and cold air ducts as required, to drive the valve toward open or toward closed in maintaining the temperature selected. Rotating the knob to OFF position removes the power from the cabin temperature modulating valves which then remain stopped at the last position to which cycled, causing a constant ratio of hot to cold air to be delivered to the cabin regardless of temperature. Moving the spring-loaded knob from OFF to the WARM or COOL position allows for manual adjustment of the air temperature by setting up a new ratio of hot to cold air. Holding the knob in the WARM position further opens the cabin temperature hot air modulating valve providing a warmer air mixture, while holding the knob in the COOL position further opens the cold air modulating valve providing cooler flow. **NOTE** Care should be taken when adjusting the temperature manually to preclude going beyond the desired detent.
5	CABIN PRESSURE (Air Conditioning) MASTER SWITCH	Four-position RAM- -OFF- -7.45 PSI- -COMBAT 4.50 PSI cabin pressure (air conditioning) master switch is grouped with the pressure release and bleed selector switches, and is accessible to both pilots. Either RAM or OFF position shuts off the hot air supply to the air conditioning system by supplying 118-volt single-phase ac to close the air conditioning shutoff valve and, when the manifold valve switch is in CLOSE and the bleed selector switch is in NORMAL LH INBD position, to close the body manifold crossover valve while maintaining the No. 3 strut bleed valve closed. Also, RAM or OFF position removes TR control power and 118-volt single-phase ac from temperature control circuits preventing the 205-volt three-phase ac operating power from reaching temperature modulating valve motors. To provide adequate external air for pneumatic engine start without external power a circuit breaker marked ALT PNEU START CONT is installed to supply battery power to energize the air conditioning shutoff and flow control valves. Once energized, airflow will close the valves, provided the cabin pressure (air conditioning) master switch is in either RAM or OFF position. The emergency cabin ram airscoop is driven closed by 118-volt single-phase ac in every position of the switch except RAM position, which is used to open the ram airscoop. RAM position also dumps cabin pressure by supplying TR power to open the cabin pressure release sole- noid valve. OFF position does not dump cabin pressure which, however, will bleed down by normal leakage.

Figure 1-110 (Sheet 4 of 6)

NO.	CONTROL-INDICATOR	FUNCTION
5	CABIN PRESSURE (Air Conditioning) MASTER SWITCH (Continued)	Both 7.45 PSI and COMBAT 4.50 PSI positions close the emergency ram airscoop while at the same time opening the air conditioning shutoff valve to admit bleed air to the air conditioning system from the air bleed system according to positions of the manifold valve switch and the bleed selector switch. Also, 7.45 PSI and COMBAT 4.50 PSI positions energize the temperature control circuits for either manual or automatic operation and remove power from the cabin pressure release solenoid valve which then closes to permit cabin pressurization according to the selected schedule. COMBAT 4.50 PSI position provides a low differential pressurization schedule by connecting TR power to the 4.50 psi solenoid in the pressure regulator to shift the regulator from high (7.45 psi) to low pressure differential operation.
6	BLEED SELECTOR Switch	Guarded NORMAL LH INBD--EMERG RH INBD bleed selector switch is grouped with the cabin pressure master switch and the pressure release switch and is accessible to both pilots. **NOTE** The manifold valve switch must be in the guarded CLOSE position and the cabin pressure (air conditioning) master switch must be in either 7.45 PSI or COMBAT 4.50 PSI position for the bleed selector switch to be energized. With the bleed selector switch energized, the guarded NORMAL LH INBD position connects 118-volt single-phase ac power so as to simultaneously close the No. 3 strut bleed valve and open the body crossover manifold valve thus providing the normal precooled bleed air supply from the No. 2 strut to the air conditioning system. Lifting the guard and moving the switch to EMERG RH INBD position reverses the electrical connections thus closing the body manifold crossover valve while the No. 3 strut bleed valve opens to provide an emergency hot (not precooled) bleed air supply to the air conditioning system.
7	PRESSURE RELEASE Switch	A guarded RESET- -DUMP pressure release switch is grouped with the cabin pressure master switch and the bleed selector switch and is accessible to both pilots. During pressurized operation, the switch will be in the guarded RESET position and will be energized by TR power through the cabin pressure master switch. Raising the guard and actuating the switch to DUMP position energizes the cabin pressure release solenoid valve to the open position causing the connected outflow valves to open and dump cabin pressure.

Figure 1-110 (Sheet 5 of 5)

ANTI-ICING SYSTEMS

DESCRIPTION 128
ENGINE, NACELLE, AND SCOOPS ANTI-ICING SYSTEM 128
ENGINE, NACELLE, AND SCOOPS ANTI-ICING SYSTEM NORMAL OPERATION 131
PITOT ANTI-ICING NORMAL OPERATION 132
WINDSHIELD ANTI-ICING AND WINDOW DEFOGGING 132
WINDSHIELD ANTI-ICING AND WINDOW DEFOGGING NORMAL OPERATION 133
EVS TURRET WINDOW ANTI-ICING 133

DESCRIPTION

Anti-icing is provided for the engines, nacelles, scoops, windshield, windows, and pitot heads, with all controls, except for EVS windows, being located on the anti-ice control panel located on the left side of the pilots' instrument panel. Controls for anti-icing of EVS windows are at the radar navigator's station. An engine, nacelle, and scoops anti-icing switch provides control for the use of engine bleed air for anti-icing of the engine inlet components, nacelles, and air conditioning pack heat exchanger ram airscoop.

Two additional switches operate electrical heaters for all pitot tubes. In addition, the left pitot heat switch controls the Q-spring ram air inlet heaters. A rotary switch is provided for the selection of a normal or high rate of heat for windshield anti-icing and defogging. The engine, nacelle, and scoops anti-icing switch provides inflight relay control of power used to open a solenoid valve which connects anti-icing bleed air to the missile environmental system ram airscoop located in the right wing leading edge.

NOTE

> To prevent engine damage caused by formation of ice which enters the inboard engine inlet area of the nacelles, the nose cowl cap covers between the engines are equipped for bleed air anti-icing.

Anti-icing systems controls and indicators are described in figure 1-114.

ENGINE, NACELLE, AND SCOOPS ANTI-ICING SYSTEM

Engine, nacelle, and scoops anti-icing is accomplished thermally by hot air bled from the engine high pressure compressors except for the Q-spring ram air inlet and cabin emergency ram airscoop which are heated electrically.

Engine inlet guide vanes and nose domes receive hot compressor bleed air independently, as an individual system on each engine, by means of a duct on each side of each engine; each duct has a thermal restrictor and a TR powered relay-controlled motor-driven shutoff valve.

Nacelle anti-icing uses hot air from the air bleed system through a shutoff valve in each nacelle to prevent ice formation on the leading edges of the nose cowls. For anti-icing each engine nose cowl, hot air from the shutoff valve is directed through a modulating valve at each engine. The modulating valve provides sufficient volume at safe temperatures and pressures for anti-icing the engine nose cowl. The modulating valve incorporates two overheat controller temperature sensing elements to maintain an 85°F anti-icing temperature and two overheat thermoswitches to shut off bleed air should nacelle temperature exceed 120°F. The nacelle anti-icing shutoff valves are air actuated, fail-safe-to-closed, and solenoid-operated to open when the air bleed system is pressurized and the solenoid is energized by TR power.

The ram airscoop in the left wing, which supplies the ram air coolant to the air conditioning pack heat exchanger, and the right wing ram airscoop, receives anti-icing air from the air bleed system through a shutoff valve which is air actuated, fail- safe-to-closed, and solenoid-operated to open when the air bleed system is pressurized and the solenoid energized by TR power. The Q-spring ram air inlet is electrically anti-iced by 118-volt single-phase ac and relay controlled by TR power. The cabin emergency ram airscoop is electrically anti-iced by 118-volt single-phase ac and relay controlled by TR power.

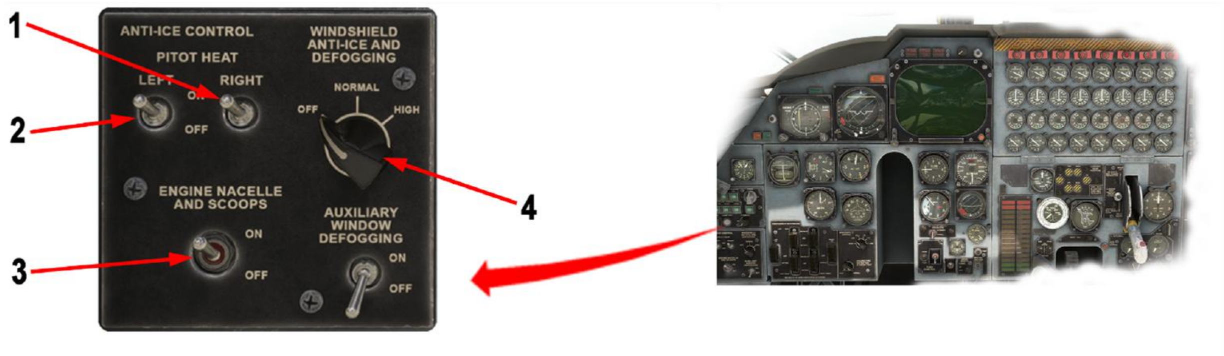
TR power to turn on both bleed air and electrical anti-icing of scoops is supplied through the landing gear squat switch relay, when aircraft weight is off the wheels, for inflight use only.

The missile airscoop anti-ice valve receives relay-controlled TR power through the control panel switch (3, figure 1-114) and the landing gear squat switch relay. The missile airscoop anti-ice valve receives relay controlled TR power from the RH AIRSCOOP ANTI-ICE circuit breaker located on the RH forward dc power panel.

No provisions are made for emergency operation of the engine, nacelle, and scoops anti-icing system.

On all aircraft the emergency ram airscoop is electrically heated and will also cycle approximately 1 minute open and 15 seconds closed to prevent ice formation when the engine, nacelle, and scoops anti-icing switch is ON and the air conditioning master switch is in RAM.

Anti-Ice System Controls and Indicators



NO.	CONTROL-INDICATOR	FUNCTION
1	RIGHT PITOT HEAT Switch	The ON position of the switch energizes the pitot tube heaters on the right side of the aircraft to prevent pitot tube stoppage by icing. OFF position removes power from the heaters.
2	LEFT PITOT & Q-SPRING HEAT Switch	The ON position of the switch energizes the pitot tube heaters on the left side of the aircraft to prevent pitot tube stoppage by icing. The left pitot heat switch also controls the Q-spring ram air inlet heater. OFF position removes power from the heaters.
3	ENGINE NACELLE AND SCOOPS Switch	The ON- -OFF engine, nacelle, and scoops anti-icing switch controls anti-icing of engine inlet components, nacelle leading edge areas, the ram airscoop lip in the left wing, and the cabin emergency ram airscoop. ON position makes the connections to supply TR power to energize the various solenoids and relays which cause the anti-icing air valves to open and turn on the electrical heater power. OFF position deenergizes the solenoids and relays, causing engine, nacelle, and scoop anti-icing to be shut off. This switch also controls the electric heaters for the cabin emergency ram airscoop.
4	WINDSHIELD ANTI-ICE AND DEFOGGING Switch	The three-position OFF- -NORMAL- -HIGH rotary selector windshield anti-ice and defogging switch electrically controls application of power to autotransformers supplying the respective window heater voltages as required. In OFF position, no power reaches the autotransformers and ac power is removed from the main windshield window electronic temperature control units so windows will not be heated. NORMAL position causes the main windshield window power transformers to be energized to produce the lower of two output voltages for anti-icing the main windows with the necessary ac power supplied to operate the electronic temperature control units. NORMAL position also causes the auxiliary window power autotransformers to be energized to heat the auxiliary windows for defogging. HIGH position switches connections to the main windshield window power transformers so they produce the higher output voltage required for anti-icing the main windows (1 thru 4L & R) under the most severe icing conditions.

Figure 1-114

ENGINE, NACELLE, AND SCOOPS ANTI-ICING SYSTEM NORMAL OPERATION

Normal operation of engine, nacelle, and scoops anti-icing consists of turning the control switch ON before entering suspected icing conditions and turning the switch OFF as soon as there is no further need for anti-icing. Proper operation of the anti-icing system is indicated when a noticeable EPR drop on all engines is noted upon actuating the anti-icing control switch to ON. Engine, nacelle, and scoops anti-icing should remain ON at all times during icing conditions. This includes static ground operation, taxiing, and takeoff. The engine and nacelle anti-icing system was designed to prevent the accumulation of ice in the inlet section of the engine, not to remove it. Thus it is essential that icing conditions be anticipated. During night flights an inadvertent encounter of icing conditions or unobserved ice buildup is more likely to occur. Therefore, whenever there is any indication or suspicion that icing conditions may exist, the engine, nacelle, and scoops anti-icing switch will be turned ON during night flights below 20,000 feet when the OAT gage reading is below 10°C. If ice should form, the engine will be operated at or above a minimum EPR that will provide adequate anti-icing. To attain proper anti-icing for the engine, nacelle, and scoops, the following minimum EPR values must be maintained:

ALTITUDE - FEET	EPR
Below 5000	1.07
5000 to 10,000	1.09
10,000 to 15,000	1.12
15,000 and above	1.18

CAUTION

- To prevent loss of thrust and possible engine damage due to ice ingestion, engine, nacelle, and scoops anti-icing will be turned ON prior to encountering ice.
- Indiscriminate or prolonged use of engine and nacelle anti-icing may cause cracking of inlet guide vanes. Anti-icing should be used only as necessary in prevention of icing and not for prolonged periods in dry air. When the possibility of encountering icing conditions no longer exists, engine, and nacelle anti-icing should be turned off.
- No EPR drop noted on one or more engines upon actuating the engine and nacelle anti-icing control switch would indicate possible malfunction of the anti-icing system and known or suspected icing conditions should be avoided.
- If ice is inadvertently allowed to build up on the engine inlet, throttle setting should be reduced (if flight conditions permit) before anti-ice is activated to prevent or reduce engine damage. Throttle settings should be consistent with minimum EPR's for use of anti-ice heat and ignition should be turned on until engine stabilizes.

NOTE

- When descending under possible inlet icing conditions, starter switches should be placed in CONT and remain in CONT until sufficient thrust for anti-ice heat has been reestablished and stable engine operation obtained. If the descent is being made for a landing and inlet icing conditions are anticipated, starter switches should be placed to CONT prior to final thrust reduction. Starter switches may be placed to CONT prior to descent for low level operations or landing and left in CONT until climb out of low level or after final landing.
- Possible icing conditions are indicated by either of the following speed, temperature, and moisture combinations:
  1. Ground operation and at speeds below 250 knots IAS if the OAT true is 47°F (8°C) or below and the dewpoint is within 4°F (2.3°C) of the OAT with or without visible moisture.
  2. Flight above 250 knots IAS if the OAT true is below 32°F (0°C) and with visible moisture present. Visible moisture is defined as rain, wet snow, or fog with visibility 1 mile or less.

Icing conditions which lead to use of the engine, nacelle, and scoops anti-icing system at altitudes above approximately 25,000 feet should, to the maximum extent possible, be avoided. Engine compressor stalls which are characterized by a recurring "bang" at the rate of about one per second may occur from 1 to 5 minutes after anti-icing is turned on. Such stalls, if experienced for only a short duration, may not produce harmful effects; however, to prevent possible engine damage, prolonged operation with the stall condition should be avoided. To avoid stall conditions or reduce the intensity, see ENGINE COMPRESSOR STALL under ENGINE MALFUNCTIONS, Section III. If anti-icing is required and compressor stall is experienced, the following procedure will be observed:

1. Increase engine thrust (not to exceed NRT) to approximately 99% RPM. Airbrakes may be required to maintain the desired speed schedule. If engine continues to stall at high thrust settings, turning the anti-icing off momentarily may eliminate the stall.

NOTE

> To reduce engine compressor stalls, anti-icing should be turned off when making engine deceleration above 15,000 feet. Anti-icing can then be turned on after the engines have stabilized at the reduced throttle settings.

2. If the stall condition is not eliminated by increasing thrust, reduce throttle setting to IDLE.
3. If due to the amount of thrust adjustment required, difficulty is experienced in maintaining proper airspeed, descend to an altitude at which the engine stall will no longer occur. Return to normal thrust settings until such time as anti-icing is no longer required. If a prolonged stall (more than 1 minute) has been encountered, the information will be recorded on Form 781 to facilitate maintenance inspection.

PITOT ANTI-ICING

Left and right pitot heat is powered by 28-volt ac power. The left and right pitot tubes provide input to the parameter scheduling unit of the stability augmentation system (SAS). Altitude computer pitot heaters are supplied 118-volt ac power. There is no emergency provision for pitot anti-icing.

PITOT ANTI-ICING NORMAL OPERATION

Pitot heat switches should be ON prior to takeoff or in flight whenever icing conditions are anticipated to prevent ice formation and loss of airspeed indication. Switches should be turned OFF after landing.

WINDSHIELD ANTI-ICING AND WINDOW DEFOGGING

The main windshield windows and all auxiliary windows except the panes at each side of the upper center window are heated for anti-icing or defogging by means of transparent electrically conductive film between the glass laminations. The main windshield windows are numbered left and right from the center, which is No. 1 thru 4L & R, and are anti-iced by having the conductive film next to the outer pane. Inner surfaces of the main windows are defogged by part of the anti-icing heat being conducted through the laminated glass.

The auxiliary windows include those numbered 5L & R, 6L & R, and the pilot's and copilot's escape hatch windows. The auxiliary windows, except 6L and R which are unheated, have the conductive film next to the inner pane with the primary purpose of defogging the inner glass surface. AC power at the necessary voltages for heating the respective conductive films to the required operating temperature for each heated window is supplied by 118-volt ac autotransformers.

Heater power to the auxiliary windows is interrupted by individual thermal snap switches on the inner surface of each window as protection from overheating. The main windshield windows may be heated at either of two heating rates while only a single heating rate is provided for the auxiliary windows, as selected by the windshield anti-ice and defogging switch. Main windshield windows 3L & R are the pilot's and copilot's sliding windows. When either sliding window is opened, a limit switch also opens removing power from the autotransformer supplying both 3L (or R) and 4L (or R) so main windshield windows 3 and 4 will not be anti-iced while the sliding window on that side is open.

WINDSHIELD ANTI-ICING AND WINDOW DEFOGGING NORMAL OPERATION

NORMAL position of the windshield anti-ice and defogging switch will give the longest main windshield service life and will provide satisfactory anti-icing and defogging under normal flight conditions. The following procedure is recommended:

1. Turn windshield anti-ice and defogging switch to NORMAL prior to takeoff. Leave the switch in this position as long as satisfactory anti-icing and defogging is obtained.

CAUTION

> To prevent damage to the heated windows, operate on NORMAL 15 minutes before turning switch to HIGH position.

2. The switch should be set to HIGH at any time the NORMAL setting does not provide satisfactory anti-icing or defogging of main windshield windows.
3. Turn the switch to OFF after landing.

EVS TURRET WINDOW ANTI-ICING

Anti-icing and defogging of the FLIR and STV turret windows is provided when the FLIR and STV turret air switches on the EVS environmental power control panel are placed on. The FLIR window is made out of germanium and contains a sensor which is connected to a temperature controller to maintain a temperature range from 86°F to 98°F. This germanium window is used as an electrical semiconductor; therefore, when the FLIR window heat system is energized, lethal voltage is present on the window surface. The temperature controller is connected through a squat switch relay to prevent inadvertent FLIR window heat operation while the aircraft is on the ground. Heating power is 118-volt ac.

The STV window is heated by means of transparent electrically conductive film between the glass laminations. This window contains a sensor which is connected to a temperature controller to maintain a temperature range from 86°F to 98°F. The STV window heat system is not connected to the squat switch and may be operated safely while the aircraft is on the ground. Heating power is 118-volt ac.

INSTRUMENTS

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ALTITUDE COMPUTER 134
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MISCELLANEOUS INSTRUMENTS 140

DESCRIPTION

The instruments in this subsection include pitot-static operated instruments, electrically operated instruments, radar altimeter, and miscellaneous instruments. The Attitude Heading Reference System (AHRS) is also included in this subsection. The Attitude-Director Indicator (ADI) and the Horizontal Situation Indicator (HSI) are covered under FLIGHT DIRECTOR SYSTEM, this section.

PITOT-STATIC SYSTEM

Four pitot tubes, two pitot-static tubes, and six static ports provide impact and static pressures to operate the pitot-static instruments. Two pitot tubes are located aft of the forward ra- dome on the lower left and lower right of the control cabin. The left forward pitot tube supplies impact pressure to the pilot's airspeed indicator, the EVS IAS transducer, and the OAS equipment. The right forward pitot tube supplies impact pressure to the copilot's airspeed indicator, autopilot equipment, the true airspeed computer, and flight loads record- er. Two pitot tubes are located just below and just aft of the pitot tubes described above. These pitot tubes supply impact pressure through a manifold valve to the parameter scheduling unit. The parameter scheduling unit provides gain signals to the yaw electronic control unit of the stability augmentation system (SAS).

Two pitot-static tubes are located forward of the wing leading edge on the upper left and upper right of the aft control cabin. The aft pitot-static tubes provide impact and static pressure to the AIMS altitude computer. The static lines from both tubes are connected together and supply static pressure to the altitude computer. The right aft tube pro- vides impact pressure to the altitude computer. The impact pressure line from the left aft tube is capped and not used. Three static ports are located on each side of the control cabin. Each port is interconnected with the corresponding port on the opposite side of the air craft. The bottom ports provide static pressure for the true airspeed computer, the autopilot equipment, and flight loads recorder. The center ports provide static pressure for the copilot's airspeed, altimeter, and vertical velocity indicators, the navigator's altimeter, the OAS equipment, and the SAS parameter scheduling unit. Static pressure for the pilot's altimeter, airspeed, vertical velocity indica- tor, and the EVS IAS transducer is supplied by the top ports.

TRUE AIRSPEED COMPUTER

The aircraft is equipped with a true airspeed com- puter which uses static pressure, pitot pressure, and temperature to compute true airspeed. True airspeed information is supplied to the true air- speed indicator on the radar navigator's front panel and on the pilots' instrument panel. Mach information is computed from pitot and static pressure and is supplied to the Mach indicator on the pilots' instrument panel.

ALTITUDE COMPUTER

The CPU altitude computer provides the same inputs to both the altimeter and the IFF. The operating mode of the altimeter (RESET or STBY) has no effect on the computer inputs to the IFF transponder. The computer measures pressure altitude referenced to standard sea level pressure of 29.92 and corrects for position error.
For altimeter functions, this corrected altitude is used to drive the altimeter display when the altimeter is in servo mode.

PITOT-STATIC INSTRUMENTS

The pitot-static instruments include:

- The pilot's and copilot's indicated airspeed indicators
- The pilot's and copilot's vertical velocity indicators
- The Mach indicator
- The pilots' and navigators' true airspeed indicators
- Navigators' altimeter
- The pilot's and copilot's AAU-19A altimeters (when in the STBY mode)

When the altimeters are in the RESET mode, they use information supplied by the altitude computer.

Indicated Airspeed Indicators

A Type L-7A indicated airspeed indicator (B, figure 1-118) is located at both the left and right sides of the pilots' instrument panel. By the use of two pointers, the pilots can observe the airspeed indication and the maximum allowable airspeed indication at the same time. The airspeed dial is graduated from 50 to 650 in 10-knot increments. A rotating drum, visible through a window in the dial, is graduated from 0 to 100 in 2-knot increments for sensitive indications. Stops limit the maximum speed pointer travel in the range from 200 to 600 knots. Mach number indications from 0.6 to 1.0 are also provided in this range as a reference for the Mach number index adjustment. A triangular index at the edge of the dial is set to the aircraft maximum allowable Mach number by an adjustment made at the rear of the instrument case. This adjustment governs the rate of change of the maximum air- speed pointer to indicate the Mach airspeed of the aircraft for any flight altitude or airspeed. In operation, the maximum airspeed pointer moves down the scale from the upper limits with lowering pressure altitude, and the indicated airspeed pointer moves up the scale with increasing airspeed. When the pointers coincide, the maximum Mach/airspeed for the existing flight condition has been reached.

Vertical Velocity Indicators

An vertical velocity indicator (C, figure 1-118) is located at both the right and left sides of the pilots' instrument panel.

Mach Indicator

A Type ME-5 Mach indicator (D, figure 1-118) located on the left side of the pilots' instrument panel indicates the ratio of aircraft speed to the speed of sound at the particular pressure altitude at any time during flight. The instrument has a range of

0.5 to 1.0 which is indicated on a stationary dial by a rotating pointer. A rotating subdial is also provided which reads in hundredths and is graduated from 1 to 10. The ME-5 is a servo-type indicator, receiving power from the true airspeed computer through a Mach indicator switch on the pilot's side panel (9, figure 1-118). Movable indices are located on the face of the instrument, one on the main dial and one on the subdial which rotates with the subdial scale. These indices can be moved by the pilot to any value of Mach number desired as a reference without affecting the reading or adjustment of the instrument. Rotating the knob in the lower right corner of the instrument while in its normal (out) position will move the index on the main dial. Depressing and rotating the knob will allow adjustment of the index on the subdial. However, if there is no power on the instrument, movement of the subdial index may cause movement of the subdial and the main dial pointer. This rotation of pointer and subdial scale will not affect indicator reading. A red power-off flag will appear when power to the Mach

indicator is off and will remain in view for approximately 40 seconds after Mach indicator switch is turned ON when power is available. When power is turned ON and the true airspeed computer is warmed up sufficiently, the needle and the subdial will indicate the appropriate Mach reading.

NOTE

> The Mach indicator ideally would give a true Mach reading; however, there are two sources of error in the system. One is the position error inherent in the pitot-static system and the other is the instrument error inherent in the mechanism of the instrument itself.

True Airspeed Indicator

A true airspeed indicator (E, figure 1-118) located on the pilot's instrument panel is a remote indicating unit. A main dial and subdial in the true airspeed indicator repeat airspeed information transmitted from the true airspeed computer. A cut- out and reference mark on the main dial permit reading of the subdial. The power to operate this indicator is supplied by the true airspeed computer.

Altimeter (Pilot and Copilot)

A Type AAU-19/A altimeter (A, figure 1-118) is on the pilot's and copilot's instrument panels. The altimeter has a counter-drum-pointer display. The counters and drum provide a direct digital readout in thousands and hundreds of feet. The single pointer repeats the 100-foot indications of the drum, serving both as a vernier for the drum and as a quick indication of the rate and direction of altitude change. The altimeter can be operated in either the servo (computer controlled) mode or the standby (static pressure) mode as selected by the RESET-STBY lever. The RESET-STBY lever is spring loaded to an unmarked neutral position be- tween RESET and STBY positions. When in the standby mode, a STBY flag will be in sight on the instrument face. A barometric pressure set knob and barometric scale are provided for adjusting the altimeter setting. A field elevation check should be made in both modes using ±75 feet as the maximum altimeter error allowable in either case. In addition, readings between the two modes should correspond within 75 feet.

SERVO MODE

Servo mode is designed to be the primary mode of operation and should be used unless failure prohibits. In the servo mode, the basic pressure altitude indication of the instrument is servo-corrected for position error by the CPU-66 altitude computer. Inflight, the allowable difference between servo mode readings of two altimeters is 75 feet at all altitudes and speeds. The altimeter is placed in servo mode by momentarily positioning the reset-stby lever to RESET. The STBY flag will disappear. A failure monitor circuit will automatically return the system to standby mode and the STBY flag will appear for any of the following malfunctions:

- Primary power failure
- Servo amplifier or motor failure
- Switch failure
- Relay failure
- Monitor failure

The CPU-computer error sensing system senses error in a servo loop that takes its input from a pneumatic sensor within the computer. All error sensing is downstream of the sensor and as a result there is no monitor function applied to the sensor itself. The AAU-19/A altimeter also has a means of monitoring internal failures which will revert the altimeter to STBY. In addition, it is designed to be capable of accepting electrical signals from the computer which differ from the uncorrected pneumatic altitude (standby mode) by as much as ±4500 feet without the altimeter monitor inadvertently switching the altimeter to the standby mode. This is to compensate for large altitude position errors in some airplanes. Since a single CPU-66 computer drives both altimeters in the servo mode, no means of comparison between AAU-19/A altimeters is available if both are in RESET. This condition can be circumvented by operating the pilot's altimeter in RESET and the copilot's altimeter in STBY. Both altimeters will then display data derived from separate sources and provide a means of comparison and independent backup.

If the altimeter reverts to standby mode automatically, attempt should be made to reset to the servo mode. If the malfunction was transient, the altimeter will reset. If the fault remains, the altimeter will not reset but will operate normally in the standby mode.

WARNING

- If the computer pneumatic sensor were to fail or become locked in a particular position, or system failures - such as pitot or static source icing, ice or water blockage in static lines, leaks, or pitot head dam- age - were to occur, the computer could de- liver erroneous data to the altimeters. The aircraft could experience a large change in altitude before the AAU-19/A error detection circuit would react and switch the system to standby. Erroneous data would also be delivered to the transponder and relayed, on interrogation, to the ground radar agency.
- If it is determined that the altitude computer (CPU-66) has failed or is delivering erroneous data, placed the mode C enabling switch to the OUT position and advise the ARTC center.

NOTE

- If the altimeter cannot be switched to STBY manually due to a switch malfunction, the STBY mode can be acquired by momentarily opening the ALT CMPTR circuit breaker (for approximately 3 seconds). The altimeter will revert to standby and operate as a pneumatic altimeter.
- The altimeter correction card is not used in the servo mode.

STANDBY MODE

In the standby mode, the altimeter operates solely from the static pressure system. A black-on-red STBY flag will be in view, indicating that the instrument is providing a normal static pressure reading and that displayed altitude is not corrected for position error. The instrument will be in standby mode when aircraft power is first applied and will remain in standby mode until the RESET- STBY lever is momentarily placed to RESET. The altimeter may be shifted from servo to standby mode by holding the RESET-STBY lever in the STBY position until the STBY flag appears. Normally 1 to 3 seconds are required for this to happen due to the time delay built into the instrument to prevent nuisance trip-offs. When the altimeter is in the standby mode, an internal vibrator will operate continuously. The vibrator minimizes mechanical friction, enabling the instrument to provide a smoother display during altitude changes. Should vibrator failure occur, the altimeter will continue to function but a less smooth movement of the instrument display will be evident with changes in altitude.

WARNING

- When the altimeter is operating in standby mode, the appropriate altimeter correction card for the current aircraft configuration will be used to fly corrected altitude for traffic separation.

- If the altimeter's internal vibrator is inoperative, the 100-foot pointer may momentarily hang up when passing through "0" or 12 o'clock position. The pointer hangup can be minimized by tapping the altimeter case. Pilots should be especially watchful for this failure when their minimum approach altitude lies within the 800 to 1000 foot part of the scale, such as 1800 to 2000 feet or 2800 to 3000 feet, and should use any appropriate altitude backup information available.

CAUTION

During normal use of the barometric setting system, momentary locking of the barocounters may be experienced. If this occurs, do not force the setting. Application of force may cause internal gear disengagement and result in excessive altitude errors in both standby (STBY) and servo (RESET) modes. If locking occurs, the required setting may sometimes be established by rotating the knob a full turn in the opposite direction and approaching the setting carefully.

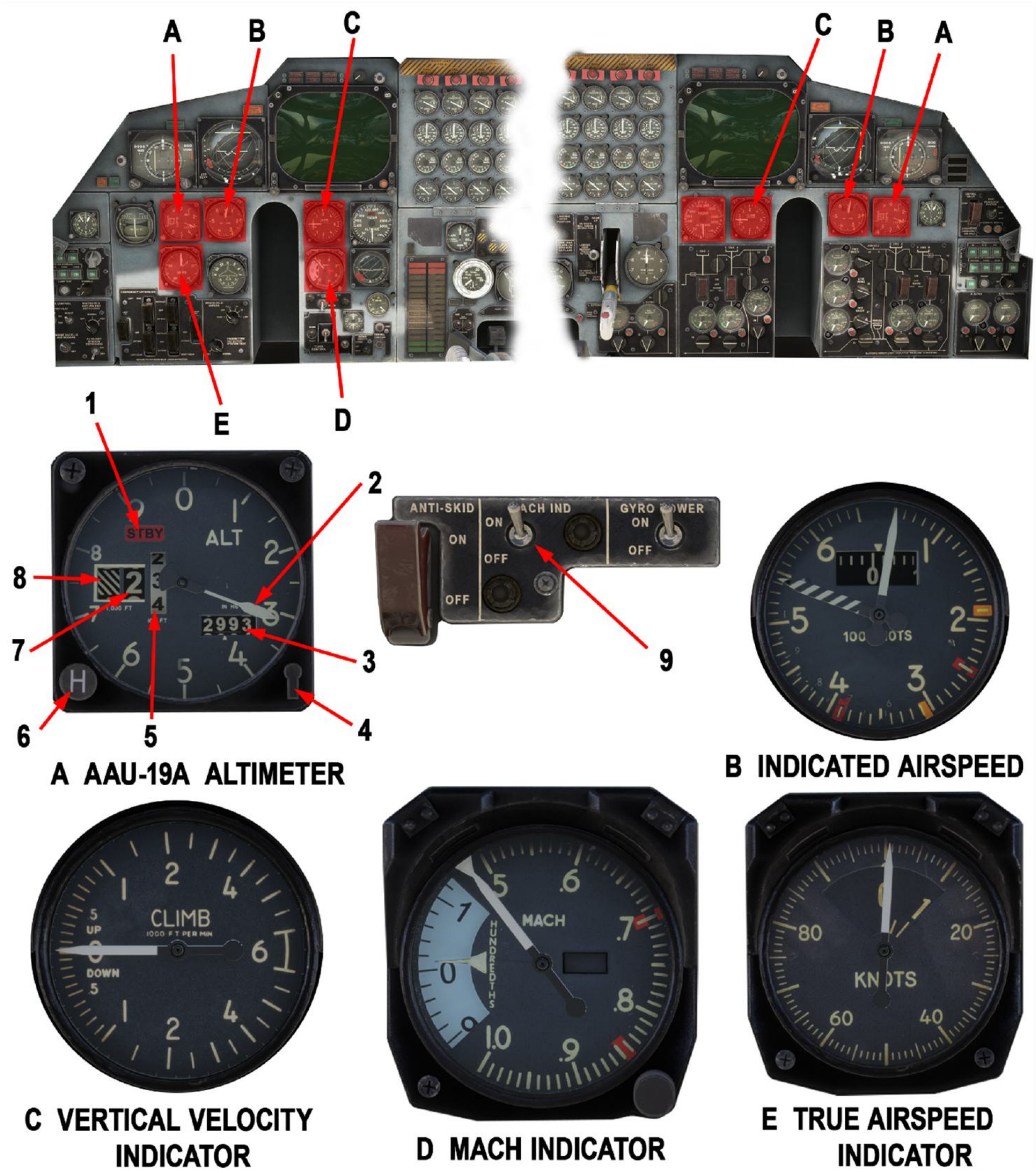
Altimeter Correction Card

An altimeter correction card and holder are located on the pilot's glare shield. The altimeter correction card is for a clean configuration and serves as a baseline correction. The card reflects position error only and is based on an average gross weight of 325,000 pounds and a standard day temperature. When configured with external weapons, altitude corrections can be computed by applying the applicable chart correction, from Part 1 of the performance manual, to the clean configuration altimeter card.

WARNING

When the altimeter is operating in standby mode, the appropriate altimeter correction card for the current aircraft configuration will be used to fly corrected altitude for traffic separation.

Pitot Static Indicators



1	STANDBY FLAG	5	100-FOOT DRUM
2	100-FOOT POINTER	6	BAROMETRIC PRESSURE SET KNOB
3	BAROMETRIC SCALE	7	1000-FOOT COUNTER
4	RESET – STBY LEVER	8	10,000-FOOT COUNTER
		9	MACH INDICATOR SWITCH

Figure 1-118 (Sheet 1 of 1)

MISCELLANEOUS ELECTRICAL INSTRUMENTS

Horizontal Situation Indicator

See FLIGHT DIRECTOR SYSTEM, this section.

C-2A Heading Indicator (Gyro)

A Type C-2A heading indicator (gyro) (A, figure 1-119) is located on the left side of the pilots' instrument panel. This instrument receives 115 volt three-phase ac power as controlled by the gyro power switch on the pilot's side panel. The heading indicator (gyro) is an unslaved-type gyro which provides auxiliary headings for navigational purposes and is also used to provide headings in the event of failure of the main compass system. A calibrated compass card (1, figure 1-119) located on the upper portion of the instrument is read against a lubber line fixed on the instrument mask. The mask has a cutout in the lower portion (2, figure 1-119) which shows reciprocal heading. A spring-loaded push-to-set type synchronizing knob (3, figure 1-119) is located on the lower left portion of the indicator and is used to realign or calibrate the dial to known references. Emergency dc power is supplied to the heading indicator clutch at all times.

NOTE

- The heading indicator (gyro) should be monitored throughout the flight for correct magnetic or grid heading and reset as necessary. The heading indicator (gyro) may be the first or only indication of a heading system malfunction.
- The allowable drift rate is ±8 degrees per hour minus the earth's rate; therefore, the instrument should be periodically reset to correct for drift beyond the capabilities of the leveling system.

Gyro Power Switch

A gyro power switch (4, figure 1-119) located on the left side of the pilot's instrument panel has ON- -OFF positions. In the ON position, power is supplied to the pilot's and copilot's attitude indicating systems, and the C-2A heading indicator (gyro). The gyro system operates on 205-volt three-phase ac aircraft power from the No. 3 generator bus routed to the flight gyro transformer. The flight gyro transformer reduces the ac power to 115-volt ac which is supplied to the pilot's and copilot's attitude indicating systems and C-2A heading indicator (gyro). In the event of ac electrical power failure on the No. 3 generator bus, an emergency flight gyro inverter will supply 115-volt three-phase ac power to the pilot's attitude indicator and C-2A heading indicator (gyro). In addition, the inverter supplies lighting power for the pilot's attitude indicator. The inverter utilizes emergency dc power and is automatically controlled by a gyro power switching relay when the gyro power switch is in ON position. When the gyro power switch is in OFF position, power is cut off to the instruments and the inverter. See Instrument Operation under COMPLETE AC POWER FAILURE, Section III, for further information concerning the emergency flight gyro inverter.

NOTE

- When one of the flight gyro power circuit breakers trip, the gyro system will continue to function. If two circuit breakers trip, the system will not function properly.
- If any of the three flight gyro circuit breakers trip and cannot be reset, do not pull the remaining circuit breakers unless the AHRS has also failed, resulting in an inflight emergency. The emergency instrument inverter is designed to function during aircraft power failures and not during a single instrument failure. The condition which caused the circuit breaker to trip could damage the emergency inverter. However, with flight gyro circuit breaker(s) tripped and AHRS failure, this is an acceptable risk.
- The ATT warning flag indicates the attitude information displayed on the pilot's and/or copilot's attitude director indicator may be erroneous and the standby attitude indicator should be checked to determine proper attitude references.

Attitude-Director Indicator

See FLIGHT DIRECTOR SYSTEM, this section.

Standby Attitude Indicator

A standby attitude indicator (D, figure 1-119), Type ARU-30/A3, located on the pilot's instrument panel, provides a continuously operating source of attitude reference in case of primary attitude indicator malfunction. The standby attitude indicator receives dc power from the emergency instrument bus. Normally, the emergency instrument bus receives power from the forward TR bus through the left essential bus. If TR power is lost, the indicator receives dc power from the forward/aft battery. See BATTERY LOADS, Section III.

An OFF flag (10, figure 1-119) appears upon loss of all power to the indicator. A pitch trim and caging knob (7, figure 1-119) permits zeroing the horizon line with reference to the miniature aircraft (6, figure 1-119) and, when pulled, cages the attitude sphere (5, figure 1-119) and causes the OFF flag to appear. The pitch trim and caging knob is spring-loaded. Do not allow the knob to spring back when released or damage to the indicator may result.

Radar Altimeter

A Type AN/APN-224 radar altimeter (B, figure 1-119) is located on each side of the pilots' forward instrument panel. The instrument provides for measuring the absolute altitude from 0 to 5000 feet. An altitude indicator needle (15, figure 1-119) indicates altitude from 0 to 400 feet in 20 foot increments, 400 to 1000 feet in 50 foot increments, and 1000 to 5000 feet in 500 foot increments. If the altitude indicator needle has disappeared behind the mask (16, figure 1-119) and the absolute altitude is less than 5000 feet, the receiver-transmitter has failed or is unreliable. The radar altimeter control knob (17, figure 1-119) is a detented, push-to-test, rotary switch used to control power to the indicator and receiver-transmitter, to set the low altitude limit index cursor (14, figure 1-119), and to test the lights and the radar altimeter system. When the control knob on either indicator is rotated clockwise, out of the detent, power is supplied to the indicator and the receiver-transmitter. The other indicator remains off unless it is turned on. The OFF flag (12, figure 1-119), when visible, indicates an off condition or system power failure.

WARNING

The radar altimeter OFF flag does not indicate all failures of this system.

During normal system operation the flag is withdrawn and a black background appears in the window. If the aircraft absolute altitude is below 5000 feet and the indicator is on, the indicator needle will point to the aircraft absolute altitude. If the aircraft absolute altitude is above 5000 feet, the indicator needle will be behind the mask and the OFF flag will be visible. An adjustable low altitude limit index cursor (14, figure 1-119) is provided on the circumference of the indicator dial. The cursor can be manually set to any altitude between 0 and 5000 feet by rotating the radar altimeter control knob. If the needle indicates an absolute altitude less than the altitude set by the cursor, the amber low altitude caution light on the indicators and the amber RDR ALT LOW lights (11, figure 1-119) on the pilots' instrument panel will come on. The caution light will be out any time the needle indicates an absolute altitude greater than the altitude set by the cursor. Momentarily pressing the control knob (17, figure 1-119) tests the low altitude caution light (13, figure 1-119), the RDR ALT LOW light (11, figure 1-119), the green system test light (18, figure 1-119), and the radar altimeter system. If the indicator does not display a reading of 1000 (±100) feet when the system test light is ON, the indicator is defective. A defective receiver-transmitter is indicated by the system test light being out during system test. The radar altimeter operates on 115 volt ac power from generator bus No. 3. The radar altimeter low caution light operates on right TR power.

RADAR ALTIMETER TIE-IN

The radar altimeter provides absolute altitude inputs to the OAS for altitude calibration and weapon delivery functions. The radar altimeter also provides absolute altitude inputs to the EVS which are displayed on the EVS monitors. For additional information, see EVS MONITOR under ELECTRO-OPTICAL VIEWING SYSTEM (EVS), this section.

RADAR ALTIMETER LOW CAUTION LIGHT

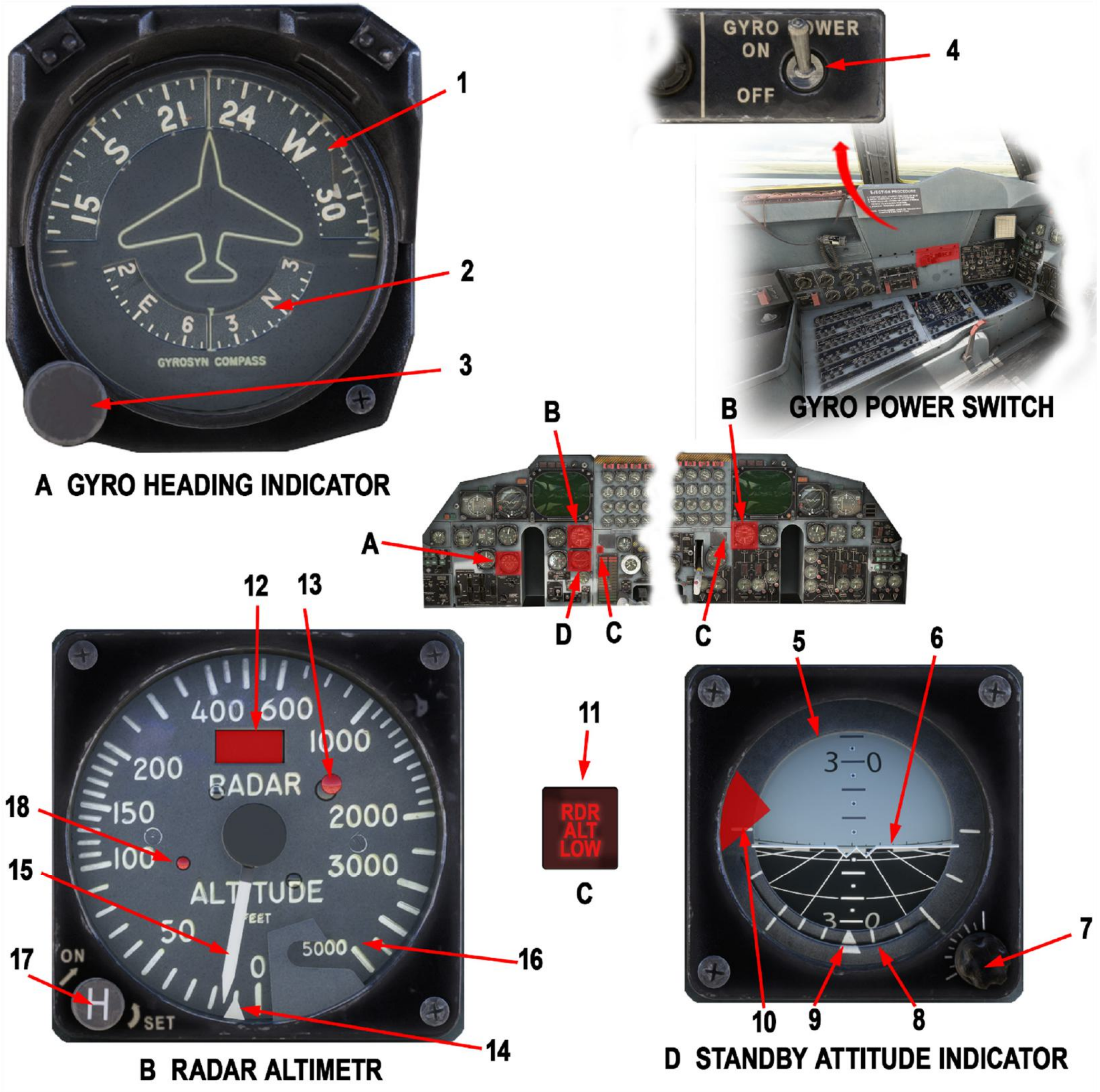
An amber press-to-test radar altimeter low caution light (11, figure 1-119) is located adjacent to each pilot's radar altimeter. Each caution light illuminates when its associated radar altimeter indicated altitude is below the altitude at which its cursor is set.

Radar Altimeter Normal Operation

The radar altimeter is to be used in conjunction with the terrain avoidance system and will be in- cluded in the pilot's normal instrument scanning pattern for a continuous cross-check with other terrain clearance information. The radar altimeter will indicate only the highest terrain detected within its 90 degree conical shaped pattern. The system will function without degrade up to 45° of pitch and roll and 2200 fps of climb or descent. Predicted error tolerance is 3 feet or 4% of indicated altitude, whichever is greater. The following procedure is used to place the radar altimeter in operation and may be accomplished in one continuous action.

1. Rotate the radar altimeter control knob clockwise out of the detent enough to move the index cursor to any indication between 0 and 5000 feet. This will turn on the system and remove the OFF flap from view.
2. After a warmup of approximately 1 minute, if the aircraft is flying at an absolute altitude less than 5000 feet, the indicator needle will appear from behind the mask and rotate in a counterclock- wise direction to indicate the aircraft absolute altitude.
3. System test is accomplished by setting the index cursor to 1500 feet and pressing the control knob. The indicator needle should point to 1000 (±100) feet, the system test light, the indicator low altitude caution light, and the RDR ALT LOW light should come on.
4. Reset the index cursor to the desired absolute altitude.
5. To turn the system off, rotate the radar altimeter control knob on both the pilot and copilot indicators counterclockwise into the detent. The OFF flap will appear and the indicator needle will rotate clockwise until it disappears behind the mask.

Miscellaneous Electrical Instrument Controls and Indicators



1	COMPASS CARD	10	OFF FLAG
2	RECIPROCAL HEADING WINDOW	11	RDR ALT LOW CAUTION LIGHT
3	SYNCHRONIZING KNOB	12	OFF FLAG
4	GYRO POWER SWITCH	13	LOW ALTITUDE CAUTION LIGHT
5	ATTITUDE SPHERE	14	LOW ALTITUDE LIMIT INDEX CURSOR
6	MINIATURE AIRCRAFT	15	ALTITUDE INDICATOR NEEDLE
7	PITCH TRIM AND CAGING KNOB	16	MASK
8	BANK SCALE	17	RADAR ALTIMETER CONTROL KNOB
9	BANK POINTER	18	SYSTEM TEST LIGHT

Figure 1-119

MISCELLANEOUS INSTRUMENTS

Accelerometer

An accelerometer (A, figure 1-120) is located on the pilots' eyebrow panel. The accelerometer is a self-contained unit requiring no external connections. The dial is calibrated in g units from –2 to +4 g's. The instrument contains three pointers, the main pointer giving continuous indications. Two auxiliary pointers indicate and maintain maximum plus and minus accelerations until they are reset, using the reset knob on the front of the instrument.

Magnetic Standby Compass

A pilot's magnetic standby compass (B, figure 1-120) is located on the eyebrow instrument panel between the oil pressure gages.

Spring-Wound Clocks

A Type A-13A clock (C, figure 1-120) is provided on the left and right sides of the pilots' instrument panel. They are spring-wound 8-day clocks and have a winding knob on the lower left corner. A sweep second hand and minute totalizer, both controlled by successive depressions of a START-STOP-RESET knob on the upper right corner, are provided.

Outside Air Temperature Gage

A Type G-10 outside air temperature gage (D, figure 1-120) is located on the left side of the pilot's instrument panel The temperature range of the gage is -70° to +50°C.

Miscellaneous Instruments

Figure 1-120

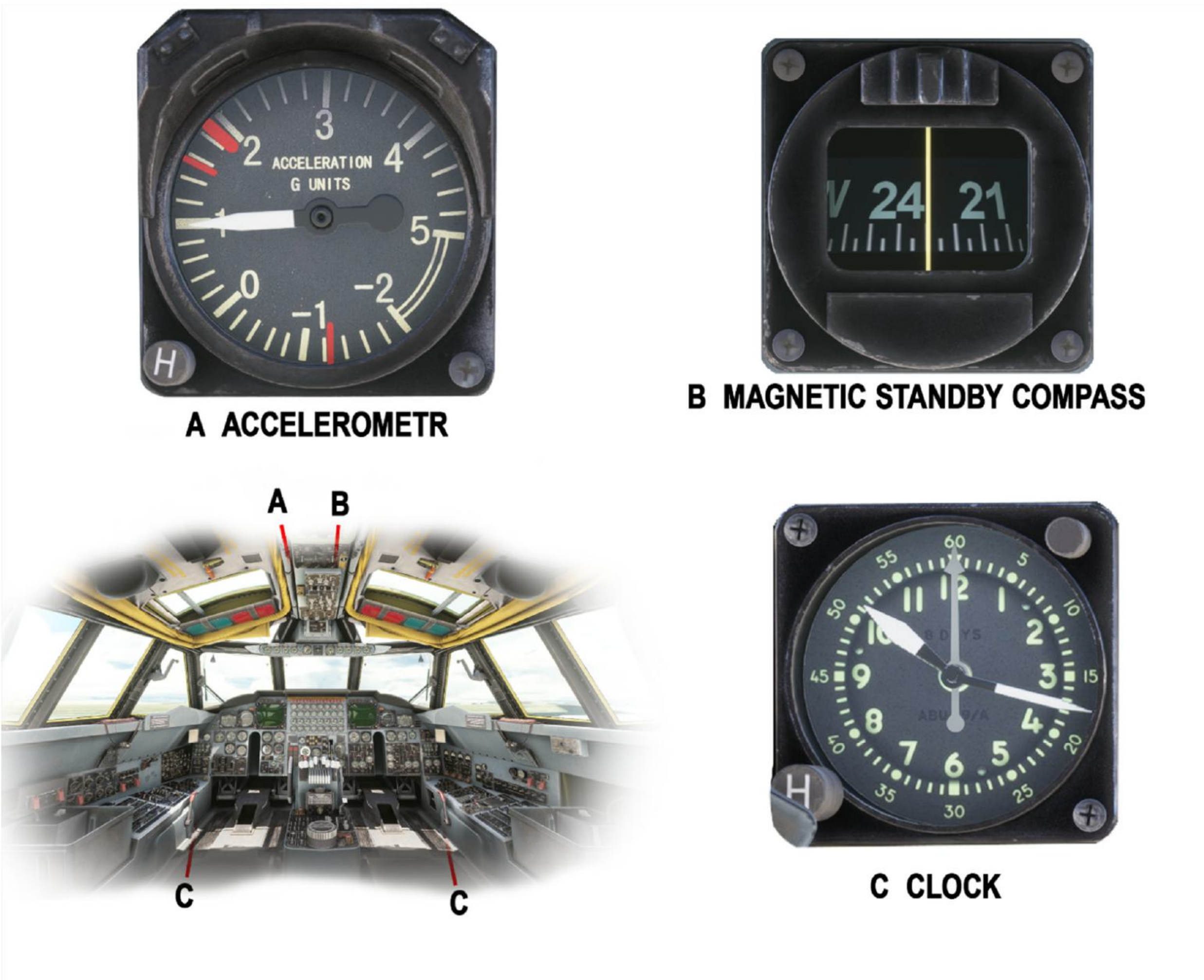


Figure 1-120

FLIGHT DIRECTOR SYSTEM

DESCRIPTION ____ 143
ATTITUDE-DIRECTOR INDICATOR (ADI) ____ 143
ATTITUDE SELECT SWITCH ____ 144
HORIZONTAL SITUATION INDICATOR (HSI) ____ 144
NAVIGATION SYSTEM SELECT PANEL ____ 144
FLIGHT DIRECTOR SYSTEM CONTROLS AND DISPLAYS ____ 146
NORMAL OPERATION ____ 154

DESCRIPTION

NOTE

Some of these instruments have red warning flags which may be difficult to see at night.

The flight director system provides the pilot and copilot with a display of airplane attitude, heading, and position. The system also provides a visual display of steering commands which the pilot follows to attain and hold any desired attitude, altitude, heading, and course in all phases of instrument flight. The flight director system consists of the following primary equipment: attitude director indicator, horizontal situation indicator, nav system select panel switches, flight director controls, CPU-4A flight director computer, and a turn rate gyro (pilot's ADI). The copilot's turn rate is supplied by the AHRS. The mode select switch on the nav system select panel selects TACAN, VOR, ILS, ILS APP or GPS for display. Inputs from systems external to the flight director system are provided from the TACAN, ILS/VOR, glide slope receiver and GPS IU systems. Pitch and roll is supplied by either the AHRS or MD-1 gyro.

ATTITUDE-DIRECTOR INDICATORS (ADI)

The ARU-49/A attitude director indicators (figure 1-124), display the aircraft pitch and roll attitude, rate of turn, and yaw coordination information. Glide slope information can be obtained from the raw data glide slope indicator or the pitch steering bar. In addition, the localizer information is presented by the bank steering bar/course deviation indicator provided the proper navigation mode is selected. If power failure occurs on the No. 3 generator bus, the pilot's attitude director indicator is powered by the flight gyro emergency inverter and automatically supplies attitude and rate of turn information. The copilot's ADI will lose all functions, including attitude, pitch, roll, and rate of turn, therefore, the dc-powered standby attitude indicator must be used by the copilot under complete ac power failure conditions. During power failure on No. 3 generator bus, the pitch and bank steering bars will be in view, but are inoperative. The pilot's and copilot's attitude director indicators are interconnected to provide an attitude comparator warning system. A description of the various components of the attitude director indicator is given below.

NOTE

An error in the pitch indication of the attitude indicators is generated during accelerations or decelerations. The error is indicated in a nose-high direction during and after a forward acceleration and in a nose-down direction during and after deceleration. The longer the duration of acceleration (or deceleration), the greater the indicated error and the longer it persists when acceleration (or deceleration) ceases. The erection system reduces the error at about the same rate it was generated. Pitch error may reach one bar width during a high gross weight takeoff.

Pitch and Roll Attitudes

Pitch and roll attitudes are displayed in the standard manner with the pitch scale located on the attitude sphere and the bank pointer and imprinted bank scale located on the lower half of the instrument. The pilot's and copilot's attitude indicators receive pitch and roll signals from the MD-1 or the AHRS gyro systems, as determined by attitude select switches. The MD-1 and AHRS both receive power from the No. 3 generator bus.

ATTITUDE SELECT SWITCH (NOT IMPLEMENTED)

The attitude select switch (35, figure 1-124) is an alternate action pushbutton switch located above the ADI at the pilot's and copilot's station. It has a green NORM light at the top of the pushbutton, and an amber ALT light at the bottom. It is used to select the pitch/roll data source for the respective station ADI, and is independent of the source selected at the other station. The NORM light at the pilot's station indicates selection of AHRS pitch/roll data for the pilot's ADI and for the pitch and roll bars on the pilots EVS monitor. The NORM light at the copilot's station indicates selection of MD-1 pitch/roll data for the copilot's ADI and EVS monitor. The ALT light at the pilot's station indicates se- lection of the MD-1 pitch/roll data for the pilot's ADI and EVS monitor. The ALT light at the copilot's station indicates selection of AHRS pitch/roll data for the copilot's ADI and EVS monitor. See figure 1-123 for data flow.

WARNING

When the pilot's or copilot's attitude select switch (but not both) is in the alternate position both ADIs are using the same attitude source. The attitude comparator warning system cannot detect a failure of a single attitude source. Under this condition, failure detection is limited to the indicators. Therefore, periodic manual comparison of the ADIs with the standby attitude indicator is required when either attitude select switch is in the alternate position.

HORIZONTAL SITUATION INDICATOR (HSI)

A Type AQU-2/A horizontal situation indicator (figure 1-124) is located on both the pilot's and copilot's instrument panel. It is an electrically operated instrument and replaces the bearing distance indicator, the radio course indicator, and the directional indicator (heading system). In the event of loss of all ac power, no information will be available from either the pilot's or copilot's HSI.

GPS IU/TACAN Emulation HSI Operation

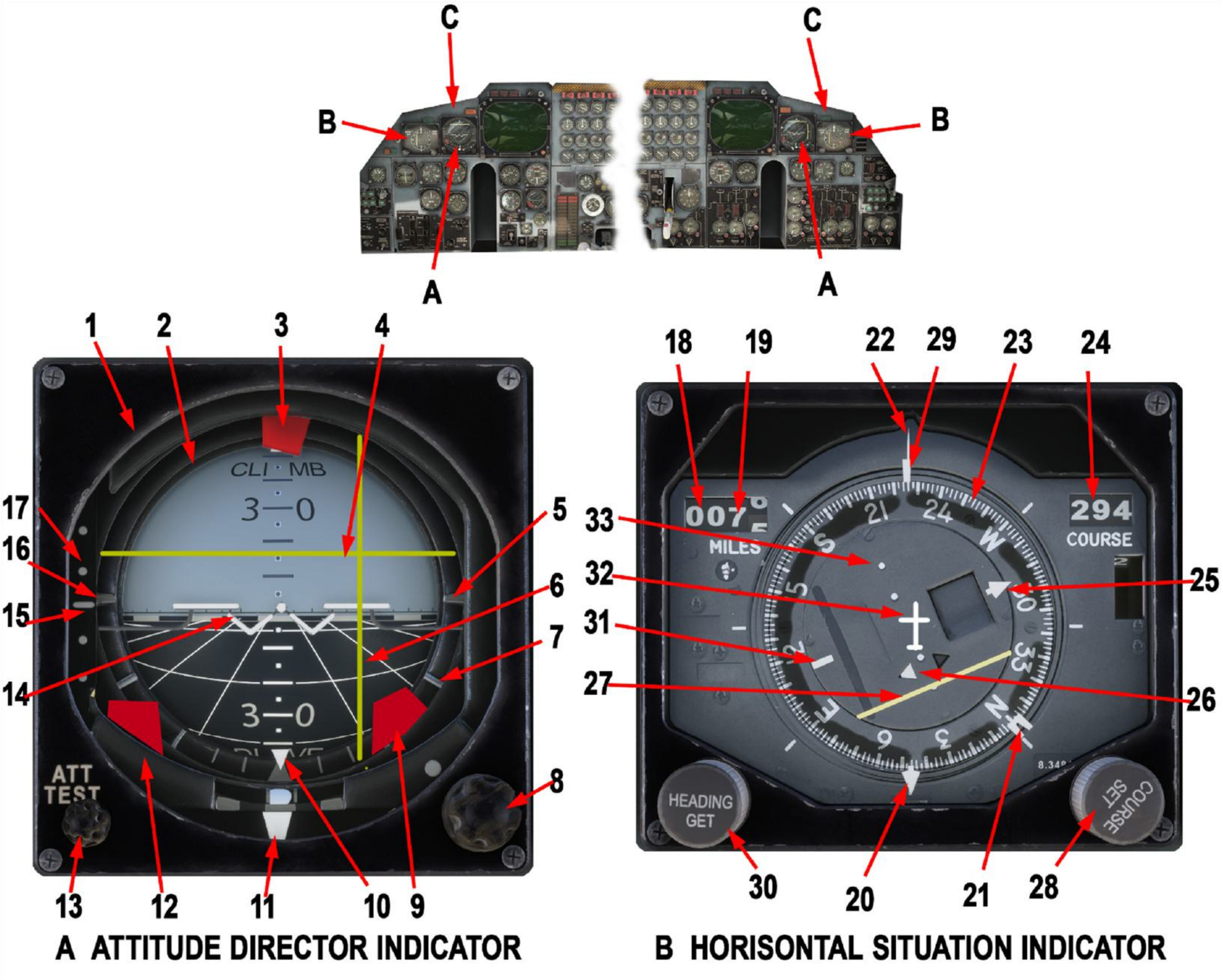
The IUS will provide the HSI with range and bearing to the selected Navaid along with steering indications when the GPS is selected on the Navigation System Select Panel MODE SE- LECT switch. When the IU is unable to determine the selected TACAN station, either the station is not within 200 nm, or the Navaid database contains more than one Navaid with the same TACAN channel within 200 nm of the aircraft current position, the Range Indicator Warning Flag will be displayed and the TACAN bearing pointer will rotate.

NOTE

During IU/TACAN emulation operation, with the MODE SELECT switch in GPS, a TACAN station identifier is not generated by the IU and therefore is not supplied to the Interphone system. The absence of the audio identifier has no effect on IU/ TACAN emulation.

NAVIGATION SYSTEM SELECT PANEL

The navigation system select panel (figure 1-124), on the aisle stand contains the navigation MODE SELECT switch, the HDG SELECT switch, and the INST CONTROL switch. The MODE SELECT allows selection of GPS, TACAN, VOR, ILS, or ILS APP for display on the flight director indicators. The HDG SELECT switch has MAN and NOR positions and controls the input source for signals to the bank steering bar on the attitude-director indicator. The INST CONTROL switch has PILOT- -COPLT positions and selects whether the pi- lot or copilot has control of the course and heading set knobs on the HSI.



1	GLIDE SLOPE INDICATOR (OUT OF VIEW)
2	ATTITUDE SPHERE
3	COURSE WARNING FLAG
4	PITCH STEERING BAR
5	BANK STEERING BAR SHIELD
6	BANK STEERING BAR/COURSE DEVIATION INDICATOR
7	BANK SCALE
8	PITCH TRIM KNOB
9	ATT WARNING FLAG
10	BANK POINTER
11	TURN AND SLIP INDICATOR
12	OFF FLAG
13	ATT TEST PUSHBUTTON
14	MINIATURE AIRCRAFT
15	GLIDE SLOPE WARNING FLAG
16	GLIDE SLOPE INDICATOR
17	GLIDE SLOPE DEVIATION SCALE
18	RANGE INDICATOR
19	RANGE INDICATOR WARNING FLAG
20	BEARING POINTER (HEAD)
21	HEADING MARKER
22	LUBBER LINE
23	COMPASS CARD
24	COURSE SELECTOR WINDOW
25	COURSE ARROW (HEAD)
26	TO-FROM INDICATOR (TO SHOWN)
27	COURSE DEVIATION INDICATOR
28	COURSE SET KNOB
29	BEARING POINTER (TAIL)
30	HEADING SET KNOB
31	COURSE ARROW (TAIL) (SOME HSIS)
32	AIRCRAFT SYMBOL
33	COURSE DEVIATION SCALE

Figure 1-124 (Sheet 1 of 9)

NAVIGATION SYSTEM SELECT PANEL

36 INSTRUMENT CONTROL SWITCH

37 HEADING SELECT SWITCH
38 NAV MODE SWITCH

NO.	CONTROL-INDICATOR	FUNCTION
	A ATTITUDE-DIRECTOR INDICATOR	
1	Glide Slope Indicator (out of view)	Location of stowed glide slope indicator.
2	Attitude Sphere	The attitude sphere is a sphere marked with the artificial horizon and the pitch reference scale, and moves to display pitch and roll.
3	Course Warning Flag	A course warning flag comes into view when any course signal selected by the pilots' nav mode select switch fails or becomes unreliable. The course warning flag will come into view in GPS IU/TACAN Emulation mode when the IU determines the TACAN emulation data is unreliable.
4	Pitch Steering Bar	A pitch steering bar indicates whether the aircraft has the proper pitch to intercept the glide slope correctly. The bar operates in ILS APP mode only. When not in operation and normal power is available, the pitch steering bar is out of view.

Figure 1-124 (Sheet 2 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
		A ATTITUDE-DIRECTOR INDICATOR (Cont)
5	Bank Steering Bar Shield	The bank steering bar shield covers the bank steering bar when normal power is available and the nav mode select switch is not in an ILS mode (ILS or ILS APP).
6	Bank Steering Bar/Course Deviation Indicator	A bank steering bar indicates whether the aircraft has the correct bank angle and rate of turn to intercept the localizer beam ‘‘on course’’ if the AN/ARN-14 is tuned to an ILS frequency. It performs the same function with respect to an omni-range beam if the AN/ARN-14 is tuned to an omni-range station and the nav mode select switch is in ILS. In addition, the bank steering bar operates when the heading select switch (located adjacent to the navigation system select panel on the pilots’ aisle stand) is in MAN position. The bar will then operate in conjunction with the heading set by the heading set knob and will indicate the correct bank angle and rate of turn to intercept the desired heading ‘‘on course.’’ When the nav mode select switch is in GPS, TACAN or VOR and normal power is available, the bank steering bar is out of view behind the bank steering bar shield (No. 5). **WARNING** If the CPU-4A computer is calibrated properly and when centering the bank steering bar, an initial bank angle of 30° (+0°/–5°) will be indicated. Cross-check the bank steering bar with the bank pointer on the attitude-director indicator to preclude the possibility of exceeding a bank angle of 30° . **NOTE** When in TACAN, VOR, ILS, or ILS APP mode of operation, the course warning flag will appear when the ARN-21 or ARN-14 fails or signals from the URN-3 beacon or the VOR or ILS stations are lost or become unreliable. Continued display of this warning flag after the heading select switch has been positioned to MAN does not indicate faulty operation of the bank steering bar.
7	Bank Scale	Used with Bank Pointer (No. 10) to indicate aircraft bank.
8	Pitch Trim Knob	Turning the pitch trim knob zeroizes the horizon line with reference to the miniature aircraft.

Figure 1-124 (Sheet 3 of 9)

NO.	CONTROL- INDICATOR	FUNCTION
9	ATT Warning Flag	An ATT warning flag comes into view, in the pilot's and copilot's attitude director indicators, under the following conditions: (1) When the power is off to one or both indicators or is lost to the comparator circuits. (2) When the attitude sphere position between the pilot's and copilot's indicators differs in roll by more than 6° (±1°) for more than 1 second, and when compensated for, pitch trim positions differ by more than 6° (±1°) in pitch for more than 1 second. (3) When the comparator and related circuits fails. (4) When the ATT TEST pushbutton (No. 13) on the pilot's or copilot's ADI is pressed and held for at least 2 seconds. **NOTE** The ATT warning flag indicates the attitude information displayed on the pilot's and/or copilot's attitude director indicator may be erroneous and the standby attitude indicator should be checked to determine proper attitude references.
10	Bank Pointer	Indicates aircraft bank (roll) on the bank scale (No. 7).
11	Turn and Slip Indicator	Indications of aircraft rate of turn and slip are provided by the needle and ball arrangement at the bottom center of the instrument. Turn rate information is provided by the rate of turn gyro for the pilot's needle and by the AHRS for the copilot's needle.
12	OFF Flag	The OFF flag appears upon interruption of power to the attitude indicating system. Interruption of any two phases of ac power to the flight gyro transformer causes the copilot's OFF flag (normal mode) to appear. When the gyro power switch is OFF, the pilot and copilot OFF flags are in view. When the gyro power switch is turned ON, both OFF flags should disappear in approximately 60 seconds. **WARNING** The OFF flag does not appear during every attitude indication failure. Therefore, it is possible that a malfunction of the attitude indicator portion of the attitude-director indicator might be determined only by cross-checking it with the turn and slip indicator and the other remaining flight instruments.

Figure 1-124 (Sheet 4 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
		ATTITUDE-DIRECTOR INDICATOR (Cont)
13	ATT TEST Pushbutton	An ATT TEST pushbutton is provided for checking the operation of the attitude comparator warning system. When the pilot's ATT TEST pushbutton is pressed, the pilot's attitude sphere rotates 10° (±1°) in both the roll and pitch axes and the pilot's and copilot's ATT warning flags appear. When the copilot's ATT TEST pushbutton is pressed, the copilot's attitude sphere rotates 10° (±1°) in both the roll and pitch axes and the pilot's and copilot's ATT warning flags appear. The pilot's and copilot's attitude sphere will always give a right roll and pitch up indication. This checkout indicates that the attitude comparator warning system is functioning properly.
14	Miniature Aircraft	The miniature aircraft is a fixed symbol representing the aircraft and is used as the attitude reference against the movable sphere (No. 2).
15	Glide Slope Warning Flag	A glide slope warning flag comes into view during ILS or ILS APP mode of operation when the glide slope equipment fails or a glide slope signal of dependable strength is not being received.
16	Glide Slope Indicator	The glide slope indicator indicates on a glide slope deviation scale (No. 17) whether the aircraft is above or below the glide slope. The indicator operates when the nav mode select switch (No. 38) is in either ILS or ILS APP position and the ARN-14 is tuned to an ILS frequency. When not in operation, the glide slope indicator is stowed out of view in the upper left corner of the indicator.
17	Glide Slope Deviation Scale	Used with glide slope indicator (No. 16) to indicate aircraft vertical position (above or below) relative to the glide slope.
HORIZONTAL SITUATION INDICATOR		
18	Range Indicator	A range indicator will give a digital display of the line-of-sight distance (up to 300 nautical miles, 200 nautical miles in GPS mode) to a URN-3 surface beacon.
19	Range Indicator Warning Flag	The range indicator display (No. 18) will be covered by the range indicator warning flag if the TACAN radio system is not tuned to a surface beacon that is within 300 nautical miles of the aircraft and will also be covered if the TACAN station is not transmitting a signal of dependable strength. In GPS IU/TACAN Emulation mode the warning flag will be visible when either the selected TACAN station is not within 200 nautical miles of the aircraft, or the Navaid database contains more than one Navaid with the same channel as the selected TACAN within 200 nautical miles of the aircraft.

Figure 1-124 (Sheet 5 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
20	Bearing Pointer (Head)	A bearing pointer (head) that indicates the bearing heading to an Emulated TACAN, a URN-3 surface beacon, or to an omni-range station. The bearing pointer indicates the bearing to a GPS emulated TACAN station when the Nav mode switch is in the GPS position and the TACAN radio system is tuned to the proper channel which must be within 200 nautical miles of the aircraft. The bearing pointer indicates bearing to a URN-3 surface beacon when the nav mode select switch (NO. 38) is in TACAN position. The TACAN radio system must be tuned to the surface beacon and the surface beacon must be within 300 nautical miles of the aircraft. The bearing pointer indicates bearing to an omni-range station when the nav mode select switch is in VOR position and then only if the omni-range radio (ARN-14) is tuned to that station. The bearing pointer is inoperative when the omni-range receiver (ARN-14) is tuned to an ILS station.
21	Heading Marker	A heading marker that indicates a desired heading. The heading marker rotates with the compass card after the desired heading is selected by the heading set knob (No. 30).
22	Lubber Line	The fixed reference line representing the nose of the aircraft used to read compass card and heading marker headings.
23	Compass Card	The rotating compass card provides an indication of aircraft heading when referenced to the lubber line (No. 22). **NOTE** Aircraft headings indicated by the compass card will be related to magnetic north or gyro north depending on whether the AHRS compass system is in slaved or gyro operation. Bearings indicated by the bearing pointer will always be magnetic.
24	Course Select Window	The course selector window gives a digital display of the desired course selected by the course set knob. **NOTE** The digital display in the course selector window should be checked and, if necessary, reset with the course set knob when changing the instrument control switch position from the pilot's or copilot's setting.
25	Course Arrow (Head)	A course arrow (head) that indicates the desired course selected by the course set knob during ILS, ILS APP, VOR, TACAN, and GPS modes. The course arrow will rotate (in step) with the compass card.
26	To-From Indicator	A TO-FROM indicator that indicates whether the selected course, if intercepted and flown, will take the aircraft to the selected facility, or vice versa. The pointer references the surface beacon if the nav mode select switch is in TACAN or GPS. For all other positions of the nav mode select switch, the pointer references the omni-range station; however, if the ARN-14 is tuned to an ILS frequency, the pointer is not visible.

Figure 1-124 (Sheet 6 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
		B HORIZONTAL SITUATION INDICATOR (Cont)
27	Course Deviation Indicator	A course deviation indicator referenced to the course arrow that indicates whether the aircraft is left or right of the desired course or localizer beam. When the course deviation indicator is aligned with the head (No. 25) and the tail (No. 31) of the course arrow, the HSI is indicating the aircraft is on course. The deviation indicator provides information relative to the localizer beam when the nav mode select switch is in ILS or ILS APP and the ARN-14 is on and tuned to an ILS frequency. In GPS mode the CDI provides information relative to the emulated TACAN station. For all other conditions, the course deviation indicator provides information relative to the desired course provided TACAN radio or ARN-14 is tuned to the respective surface beacon or omni-range station.
28	COURSE SET Knob	The course set knob used to set the course arrow and the digital display in the course selector window to the desired course. When the nav mode select switch is in VOR position and the ARN-14 tuned to an ILS frequency, the course set knob has no functional effect on the course deviation indicator; however, the course deviation indicator rotates in conjunction with the course set knob. The course set knob is also used to provide the course setting to the IU for GPS/TACAN Emulation. **NOTE** • To prevent course counter malfunctions, the course set knob should not be moved or spun in a rapid, jerky motion. • The course set knob will be quite warm to the touch when the system is operated for extended periods of time in moderately high ambient temperatures.
29	Bearing Pointer (Tail)	The tail indicates the reciprocal heading of the bearing pointer (No. 20).
30	HEADING SET Knob	A heading set knob is used to set the heading marker to the desired heading. **NOTE** The heading set knob will be quite warm to the touch when the system is operated for extended periods of time in moderately high ambient temperatures.
31	Course Arrow (Tail)	The tail, on some HSIs, indicates the reciprocal heading of the Course Arrow (No. 25).
32	Aircraft Symbol	An aircraft symbol is fixed on the face of the HSI and oriented to the nose of the aircraft.
33	Course Deviation Scale	The course deviation scale is made up of equally spaced dots that are perpendicular to the course arrow (No. 25). Each dot represents 5° of deviation from course or 1/4 of the localizer width.

Figure 1-124 (Sheet 7 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
ATTITUDE SELECT SWITCH		
34	LAMP TEST BUTTON	The lamp test button is located adjacent to the attitude select switch on both the pilot's and copilot's forward instrument panel and is used to test the bulbs in the respective attitude select switch. Pressing the button will light the respective green NORM and amber ALT lights.
35	ATTITUDE SELECT Switch	The attitude select switch is an alternate action pushbutton switch located above the ADI at the pilot's and copilot's station. It has a green NORM light at the top of the pushbutton, and an amber ALT light at the bottom. It is used to select the pitch/roll data source for the respective station ADI, and is independent of the source selected at the other station. The NORM light at the pilot's station indicates selection of AHRS pitch/roll data for the pilot's ADI and for the pitch and roll bars on the pilots EVS monitor. The NORM light at the copilot's station indicates selection of MD-1 pitch/roll data for the copilot's ADI and EVS monitor. The ALT light at the pilot's station indicates selection of the MD-1 pitch/roll data for the pilot's ADI and EVS monitor. The ALT light at the copilot's station indicates selection of AHRS pitch/roll data for the copilot's ADI and EVS monitor. See figure 1-123 for data flow. **WARNING** When the pilot's or copilot's attitude select switch (but not both) is in the alternate position both ADIs are using the same attitude source. The attitude comparator warning system cannot detect a failure of a single attitude source. Under this condition, failure detection is limited to the indicators. Therefore, periodic manual comparison of the ADIs with the standby attitude indicator is required when either attitude select switch is in the alternate position.
NAVIGATION SYSTEM SELECT PANEL		
36	INST CONTROL SWITCH	An instrument control switch located on the navigation system select panel on the aisle stand has PILOT- -COPLT positions and selects whether the pilot or copilot has control of the course and heading set knobs on the HSI. When the switch is in PILOT position and the pilot rotates his course and heading set knobs, the corresponding information will be displayed on the copilot's HSI and the copilot will not be able to change these settings. The reverse of the above condition will be true when the instrument control switch is in COPLT position. Both pilot's and copilot's horizontal situation indicators and attitude indicators are fully operative regardless of the position of the instrument control switch.

Figure 1-124 (Sheet 8 of 9)

NO.	CONTROL-INDICATOR	FUNCTION
		NAVIGATION SYSTEM SELECT PANEL (Cont)
37	HDG SELECT Switch	A heading select switch located on the navigation system select panel on the aisle stand is marked HDG SELECT. The switch has MAN- -NOR positions and controls the input source for signals to the bank steering bar on the attitude-director indicator. In NOR (normal) position, the information displayed on the flight director indicator is determined by the position of the mode select switch. In MAN (manual) position, the flight director system operates the same as when the switch is in NOR position with the exception of the bank steering bar. The bank steering bar comes into view and responds to the heading set by the heading set knob on the horizontal situation indicator. The bar indicates zero deflection when the aircraft has the correct bank angle to arrive at the selected heading. The heading can be maintained by keeping the bank steering bar at zero deflection. **NOTE** ● With any of the course navigation modes selected on the pilots' nav mode select switch, if any of the navigation receivers fails or the signal is lost or unreliable, the course warning flag (No. 3) will appear. Continued display of the course warning flag after the heading select switch has been positioned to MAN does not indicate faulty operation of the bank steering bar. ● If the heading select switch is in MAN position, the selected heading rather than the selected course is commanded by the bank steering bar. To fly a specific course rather than heading, check that the heading select switch is in NOR position.
38	Nav MODE SELECT Switch	The rotary switch has GPS- -TACAN- -VOR- -ILS- -ILS APP positions. In the GPS position the GPS emulated TACAN provides the currently selected NAVAID three letter identifier and channel, and the range and bearing from the NAVAID to the aircraft. In TACAN position, the TACAN system may be placed in operation in the normal manner as outlined under NORMAL OPERATION OF TACAN RADIO. In VOR position, the omni-range radio navigation system is selected and may be placed in operation as noted under OMNI-RANGE RADIO AN/ARN-14, this section. In ILS position, the instrument landing system mode of navigation is selected; for further information, see INSTRUMENT LANDING SYSTEM (ILS) EQUIPMENT, this section. In ILS APP position, the instrument landing system-approach mode of navigation is selected; for further information, see AUTOMATIC APPROACH EQUIPMENT, this section. The autopilot localizer and glide slope can be energized only when the nav mode select switch is in ILS or ILS APP position respectively and the omni-range radio system is on and tuned to an ILS frequency.

Figure 1-124 (Sheet 9 of 9)

FLIGHT DIRECTOR SYSTEM NORMAL OPERATION

AUTOMATIC FLIGHT CONTROL SYSTEM COUPLING

The Autopilot Turn Control Selector Switch (Ref. Figure 1-103, Item 1) provides the primary interface between the navigation system and the Automatic Flight Control System (AFCS).

PILOT Position (Normal)

With the selector in PILOT, the navigation system operates in Flight Director mode.

In this mode, steering commands generated by the selected navigation source are displayed on the flight director command bars. The command bars provide pitch and roll guidance necessary to maintain the selected course, intercept radials, track flight plan legs, or follow glideslope/localizer signals as applicable.

NOTE

> No automatic control inputs are applied to the aircraft flight controls in the PILOT position. The pilot must manually fly the aircraft, using the flight director indications as primary steering reference.

The flight director system provides computed guidance only; it does not engage servos or move control surfaces.

BOMB Position

With the selector in BOMB, the Automatic Flight Control System engages lateral steering commands from the selected navigation source.

In this mode, the aircraft will automatically track the active navigation guidance in accordance with the selected navigation mode. This includes:

- TACAN course tracking
- VOR radial interception and tracking
- GPS flight plan navigation (LNAV)
- Localizer and glideslope tracking during ILS approach

When properly configured, the system is capable of automatic approach tracking down to Decision Height (DH), provided all required signals remain valid and within system limitations.

TURNS TO AND MAINTAINING HEADING

To select and fly a particular magnetic heading using the bank steering bar or heading marker, proceed as follows:

1. Place autopilot turn control selector switch (1 of Figure 1-103) to BOMB.
2. Place heading mode select switch to MAN.
3. Rotate heading set knob to align heading marker with desired magnetic heading on compass card.
4. If autopilot turn control selector switch is in PILOT, bank aircraft to center bank steering bar. Reduce bank angle as necessary to keep bank steering bar centered. Rollout will be complete when desired heading is reached. Maintain heading by keeping bank steering bar centered.

TACAN OR VOR NAVIGATION

To fly a selected TACAN or VOR course, proceed as follows:

1. Select desired frequency on TACAN or VOR receiver.
2. Place nav mode select switch to TACAN or VOR.
3. Place autopilot turn control selector switch to BOMB.
4. Place heading select switch to NOR.
5. Set course set knob. Rotate course set knob un- til head of course arrow aligned with desired course on compass card. The course window should indicate the same course, and the CDI should show the aircraft deviation from the selected course.
6. Establish intercept heading. The intercept heading to be flown should be determined on the basis of prescribed instrument flying techniques.
7. Monitor course deviation indicator. Check movement toward aircraft symbol. As CDI approaches aircraft symbol, autopilot will turn aircraft to heading of selected course.
8. Check position of course deviation indicator. If CDI is offset, indicating overshoot or undershoot, correct course to center CDI.

NOTE

When operating in TACAN or VOR navigation modes, minor lateral deviation from the programmed ground track may occur. Such deviations are inherent to ground-based radio navigation and may result from signal geometry, magnetic reference tolerances, and wind correction dynamics.

In GPS navigation mode, lateral deviation from the programmed ground track is minimal due to continuous satellite-based position computation and ground-referenced track guidance.

GPS IU/TACAN NAVIGATION

To fly a selected GPS/TACAN emulation course, with the FLIGHT PLAN loaded, proceed as follows:

1. Place autopilot turn control selector switch (1 of Figure 1-103) to BOMB.
2. Place nav mode select switch to GPS.
3. Place heading select switch to NOR.
4. Set course set knob. Rotate course set knob until head of course arrow aligned with desired course on compass card. The course window should indicate the same course, and the CDI should show the aircraft deviation from the selected course.
5. Establish intercept heading. The intercept heading to be flown should be determined on the basis of prescribed instrument flying techniques.

NOTE

When positioned at significant lateral distance from the active flight plan leg, automatic GPS track capture may not occur. In such cases, the aircraft must be maneuvered to an appropriate intercept heading either manually or by using MANUAL HEADING mode to establish proper geometry for track interception.

6. Monitor course deviation indicator. Check movement toward aircraft symbol. As CDI approaches aircraft symbol, autopilot will turn aircraft to heading of selected course.
7. Check position of course deviation indicator. If CDI is offset, indicating overshoot or undershoot, steer aircraft toward CDI to center it.

ILS APPROACH

The following operating procedure shows the nor- mal method of using the flight director system to intercept a localizer course and glide slope in con- junction with an ILS approach. Specific instrument flight procedures, which vary from base to base, are not considered.

1. Select localizer frequency on VOR/ILS receiver and identify station.
2. Place heading select switch to NOR.
3. Place autopilot turn control selector switch to BOMB.
4. Set course set knob. Rotate the course set knob to set localizer front approach course in the course selector window. The head of the course arrow should point to the same course on the compass card.

NOTE

The published front approach course must be set in the course selector window for all ILS approaches to obtain accurate directional indications on the HSI course deviation indicator.

5. Place nav mode select switch to ILS to obtain steering information from bank steering bar.
6. Center bank steering bar. When the aircraft heading is within 90° of the published front approach course, steer aircraft as necessary to keep bank steering bar centered. The steering bar should provide an intercept angle to the localizer course of up to 45° and, when the course is approached, command a turn inbound to place the aircraft on the localizer course.

WARNING

The flight director commands up to a 45° angle of intercept to the localizer course without regard to the location of the outer marker and/or glide slope intercept point. Therefore, the pilot is responsible for properly positioning the aircraft by use of the other nav aids or radar before following the bank steering bar commands to the localizer course.

- If the published front course is not set in the course selector window, the bank steering bar is unreliable.
- In the ILS mode of operation, the flight di- rector computer does not compensate for wind which may cause localizer standoff. Therefore, it might be necessary to complete the intercept without using the bank steering bar in strong crosswinds.

7. Place nav mode select switch to ILS to obtain steering information from bank steering bar.

8. Center bank steering bar. When the aircraft heading is within 90° of the published front approach course, steer aircraft as necessary to keep bank steering bar centered. The steering bar should provide an intercept angle to the localizer course of up to 45° and, when the course is approached, command a turn inbound to place the aircraft on the localizer course.

WARNING

The flight director commands up to a 45° angle of intercept to the localizer course without regard to the location of the outer marker and/or glide slope intercept point. Therefore, the pilot is responsible for properly positioning the aircraft by use of the other nav aids or radar before following the bank steering bar commands to the localizer course.

- If the published front course is not set in the course selector window, the bank steering bar is unreliable.

- In the ILS mode of operation, the flight di-rector computer does not compensate for wind which may cause localizer standoff. Therefore, it might be necessary to complete the intercept without using the bank steering bar in strong crosswinds.

NOTE

- In ILS APP mode, wind drift corrections are accomplished automatically. Consequently, centering the bank steering bar results in an aircraft flight path along the center line of the localizer approach course.

- The pitch steering bar comes into view when switching to ILS APP. However, pitch steering corrections should not be made at this time.

9. When flying aircraft on localizer approach course, monitor glide slope indicator. When indica- tor approaches center, Place nav mode select switch to ILS APP

10. Adjust aircraft pitch attitude to center pitch steering bar.

11. Keep pitch and bank steering bars centered. The pitch and bank steering bars command attitude correction directly proportional to glide slope and localizer deviations to correct to or maintain the ILS flight path.

NOTE

The pitch and bank steering bars do not indicate direct ILS localizer nor glide slope in- formation. Cross-check as necessary the glide slope indicator and CDI to ensure the aircraft is on course and glide slope.

1.

NAVIGATION EQUIPMENT

DESCRIPTION 157
TACAN RADIO AN/ARN-118(V) 157
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OMNI-RANGE RADIO AN/ARN-14 167
INSTRUMENT LANDING SYSTEM (ILS) 167
GLIDE SLOPE EQUIPMENT AN/ARN-31 or AN/ARN-67 167
MARKER BEACON RECEIVER AN/ARN-32 167
INSTRUMENT LANDING SYSTEM INDICATORS 167
OMNI-RANGE RADIO/ILS CONTROLS AND INDICATORS 168

DESCRIPTION

The navigation equipment includes a TACAN radio, GPS IU/TACAN Emulation, omnirange radio, glide slope equipment, marker beacon receiver, radar altimeter, rendezvous radar, IFF radar, radar warning receiver, fire control radar, Doppler radar, attitude heading gyroscope set (AHRS), OAS, and EVS.

TACAN RADIO (NAV1)

The AN/ARN-118 TACAN(V) (Tactical Air Navigation) radio is provided to operate in conjunction with surface navigation beacons and suitably equipped aircraft. The TACAN radio and surface beacons form a radio navigation system which enables the aircraft to obtain continuous indications of its range and bearing to any selected surface beacon located within line-of-sight distance from the aircraft up to 300 nautical miles, depending on aircraft altitude. The B-52 TACAN installation is not designed for air-to-air operation; however, the aircraft can obtain range and bearing indications from other air-to-air equipped aircraft when they are at altitudes lower than the B-52. The ARN-118 only provides range to other aircraft when interrogated.

The receiver-transmitter of the TACAN radio initiates the interrogation process by radiating pulse signals. These signals, known as distance interrogation pulses, are detected at the particular surface beacon installation or cooperating aircraft to which the TACAN radio is tuned, causing the station to respond with its own transmitted pulses. These response pulses are received by the receiver portion of the TACAN radio and are converted into a range indication which is displayed on the range indication of the HSI. In addition, the station transmits a reference signal which can be received by the TACAN radio anytime the receiver portion is in operation. This reference signal is displayed as a bearing indication on the HSI. Bearing information may be received even though interrogation pulses are not being transmitted by the TACAN radio. Each station may be identified by a tone identification signal in International Morse Code. Placing the TACAN-ODR (VHF omnidirectional range) marker mixer switch to ON position provides the tone identification signal in the crewmember's headset.

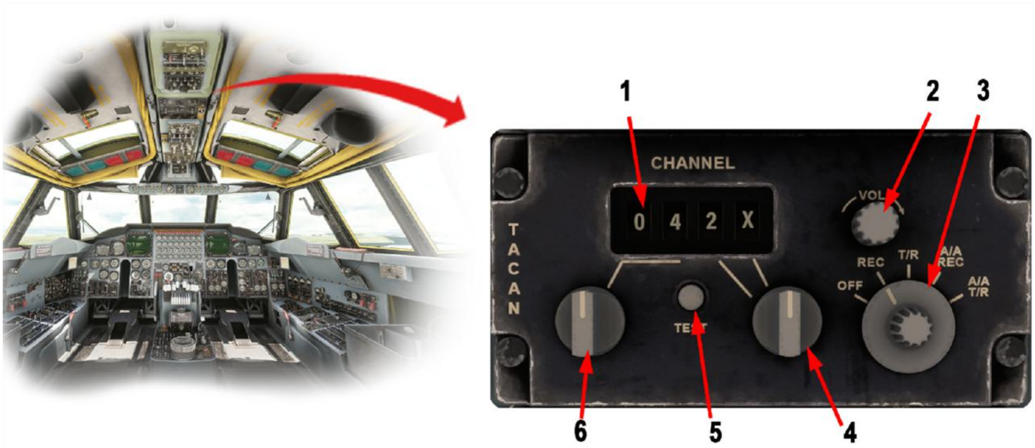
The nav mode select switch is used to select TACAN for display of the flight director system.

The TACAN control panel (figure 1-127) is located on the pilots' overhead panel. Three rotary knobs, located on the TACAN control panel, provide a means by which a desired TACAN channel may be selected. Channels are equally divided between X and Y channels and are spaced at 1 megahertz to provide a total of 252 operating channels available.

NOTE

- TACAN channels correspond to encoded frequency assignments that are also utilized by VOR ground stations. Within the simulator environment, a bidirectional conversion between VOR frequencies and TACAN channel designations is implemented. When a flight plan is loaded, associated VOR frequencies and their corresponding TACAN channels are displayed on the MFD navigation page together with the station identifier.
- The TACAN channel assignment may also be viewed in the cockpit tooltip when the cursor is positioned over the TACAN channel selector control.

TACAN Radio Controls and Indicators



1	CHANNEL INDICATOR WINDOW	4	X-Y CHANNEL SELECTOR KNOB
2	VOLUME CONTROL KNOB	5	TEST SWITCH
3	FUNCTION SELECTOR KNOB	6	TENS CHANNEL SELECTOR KNOB

NO.	CONTROL-INDICATOR	FUNCTION
1	CHANNEL Indicator Window	Displays the TACAN channel set by the tens (No. 8), units (No. 4), and (No. 5) X-Y channel selector knobs.
2	VOL Control Knob	The volume control knob is used to adjust the volume of the audio identification signal received from the beacon/aircraft through the headset.
3	Function Selector Switch	A five-position function selector switch has OFF- -REC- -T/R- -A/A REC- -A/A T/R positions. In the OFF position, the system is deenergized. In the REC position, bearing information from a selected surface beacon is received. This fundamental bearing is the angle to surface beacon referenced to magnetic north. In the T/R position, relative bearing is calculated and slant range distance to the surface beacon is measured. In the A/A REC position, and the A/A T/R position, are not implemented **NOTE** GPS IU/TACAN emulation is not possible when the TACAN function selector switch is set to OFF or to an Air-to-Air mode (A/A REC or A/A T/R).

Figure 1-127 (Sheet 1 of 2)

TACAN Radio Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
4	X-Y Channel Selector Knob	The X-Y channel selector knob is used to set the X or Y function on the channel and displays X or Y in the channel selector window (No. 1).
5	TEST Switch	Not implemented
6	Tens Channel Selector Knob	The Tens channel selector knob is used to set the first two digits (hundreds and tens) of the channel and displays the digits in the channel selector window (No 1). The channel selector knobs used on these control heads contain built-in mechanical stops to prevent rotation past the twelve (12) position on the hundredth/tenth digit channel settings. Do not attempt to override this mechanical stop. Direction of knob rotation must be reversed when the stop is reached. The selector knob is also used to select the channel for GPS IU/TACAN emulation .

Figure 1-127 (Sheet 2 of 2)

TACAN / VOR RADIO Normal Operation

The following procedure is used to place the TACAN system in operation:

1. Place NAV mode select switch to TACAN position.
2. Set channel selector knobs to desired channel.
3. Set function selector switch to desired mode of operation.
4. Pull NAV AIDS interphone mixer switch out to identify selected beacon. Adjust volume of audio signal with the volume control knob on TACAN control panel.
5. To turn the TACAN system off, place the function selector switch to OFF position.

INTEGRATED TACAN OMNI-RANGE OPERATION

1. Nav mode select switch in TACAN position: With TACAN function selector switch in T/R, bearing and range to the selected TACAN beacon is indicated on the HSI, and the course deviation indicator (CDI) on the HSI indicates deviation from the selected course to the TACAN beacon. (If the TACAN system goes into search, the CDI goes to the null or zero position and remains until TACAN once again locks onto the station.)
2. Nav mode select switch in VOR position: With function selector switch in T/R the HSI indicates omni bearing to VOR beacon and DME range. The CDI of the HSI responds to the omni station except when an ILS station is selected, then the CDI provides localizer information.

.

GPS IU/TACAN EMULATION

As part of the aircraft Global Positioning System (GPS), the GPS Interface Unit (IU) provides GPS navigation and TACAN emulation to the pilots' monitors. Flight plan data is also supplied and displayed to the pilots, along with GPS data, on two video situational displays available on the EVS monitor. GPS derived emulation of TACAN information is also available on the HSIs.

WARNING

GPS TACAN emulation requires a valid flight plan to be created in the EFB prior to flight. The flight plan must be Send To both ATC and AVIONICS before departure.

Failure to properly load the flight plan into the avionics system will prevent GPS-based TACAN guidance and may result in loss of automatic course tracking capability.

For detailed flight plan creation and loading procedures, refer to the Flight Plan subsection of this section.

Pilots' Controls and Displays

The GPS system interfaces with the pilots through two displays. These displays are available using the EVS monitors when the MFD is selected on the MFD Control Panel (figure 1-127C). The two displays are the Mission Route Screen/Moving Map Display (figure 1-127D), and the Destination Screen (figure 1-127E). The GPS position on the NAV MODE switch on the Navigation System Select Panel also provides GPS navigation and TACAN emulation to the pilots' HSIs.

TACAN CONTROL PANEL

The TACAN control panel is used with GPS IU/TACAN Emulation to select the TACAN channel for emulation. When the channel is set on the control panel, the data associated with the set channel is obtained from the Flight Plan data automatically.

MFD CONTROL PANEL

WARNING

The GPS receiver is not certified for instrument procedures. Do not accomplish a TACAN penetration and/or approach with the navigation mode selector in the GPS position.

NOTE

During IU/TACAN emulation operation, with the MODE SELECT switch in GPS, a TACAN station identifier is not generated by the IU and therefore is not supplied to the Interphone system. The absence of the audio identifier has no effect on IU/ TACAN emulation.

The MFD Control Panel's toggle switch (figure 1-127C) must be set to the MFD position before either IU/TACAN display may be viewed. The switch is used to select the video source for the EVS display. If both the pilot's and copilot's MFD Controls are set to the MFD position, then changing MFD screens on one monitor will change the display on the other monitor as well. However, setting one control to the MFD position and one to the EVS position will allow one monitor to display MFD screens and the other monitor to display screens associated with the EVS mode, respectively.

Navigation between display pages is accomplished by selecting the arrow icons located along the lower portion of the screen (Ref. Figure 1-127D, Item 18).

Mission Route Screen/Moving Map Display

The Mission Route Screen provides situational awareness to the pilots. Depending on the mode of operation, the display may include the following items when they occur within the selected range:

- All NAVAIDS contained in the Flight Plan
- All destinations
- The active destination
- Associated NAVAIDS
- Selected NAVAID
- Fly-To destination
- Bullseye 1 and 2 (NOT IMPLEMENTED)
- Range and bearing from the associated NAVAID to the Current Destination
- Range and bearing from the selected NAVAID to the aircraft when in GPS mode
- Selected number of look-ahead flight legs
- True Air Speed (TAS) in Knots
- Ground Speed (GS) in Knots
- Wind Direction and Speed
- Time-To-Go to destination in seconds when within 200 seconds of the destination, in hours, minutes, and seconds
- Magnetic Heading (HDG M)
- Heading Error
- Ground Track
- Viewing Range
- Error Messages

The map is oriented magnetic heading up as indicated by the M beside the heading. The heading is displayed in a box at the top of the compass rose. As the heading changes, the compass rose rotates in one degree increments matching the heading. The track indicator is used to display the ground track and moves along the compass rose as needed to accurately depict the ground track.

The map can be displayed in 200, 100, 50, 25, and 12.5 nautical mile ranges. A number indicating the range in nautical miles (NM) of the moving map is displayed in the upper part of the map box.

Map range adjustment is accomplished using the **Range Increase** and **Range Decrease** controls located along the lower portion of the MFD display (Ref. Figure 1-127D, Items 17 and 12).

The scale is measured from the center of the aircraft symbol (aircraft present position) to the top of the compass rose. There is also a mid–range arc drawn on the map that represents half the distance of the scale. As an example, if the map range displayed in the upper left corner of the map box is 100 NM, mid–range arc represents the 50 NM range from the center of the aircraft.

The map also displays destinations, and Navaids that are found to be within the selected map scale. Destinations in the route are connected by straight lines and are not intended to depict the actual flight path of the aircraft.

The Time-To-Go to the destination is displayed at the top or the map display. It will be displayed as h:mm:ss up to 9:59:59.

IDENTIFYING NAVAIDS ON THE MISSION ROUTE MAP

The center of each Navaid symbol represents the latitude and longitude of that Navaid. The Navaid symbol outline is filled in when that Navaid is the selected Navaid. To the left of each Navaid will be its three-letter identifier. Valid Navaids are VORTAC, VOR/DME and TACAN stations.

IDENTIFYING BULLSEYES ON THE MISSION ROUTE MAP (NOT IMPLEMENTED)

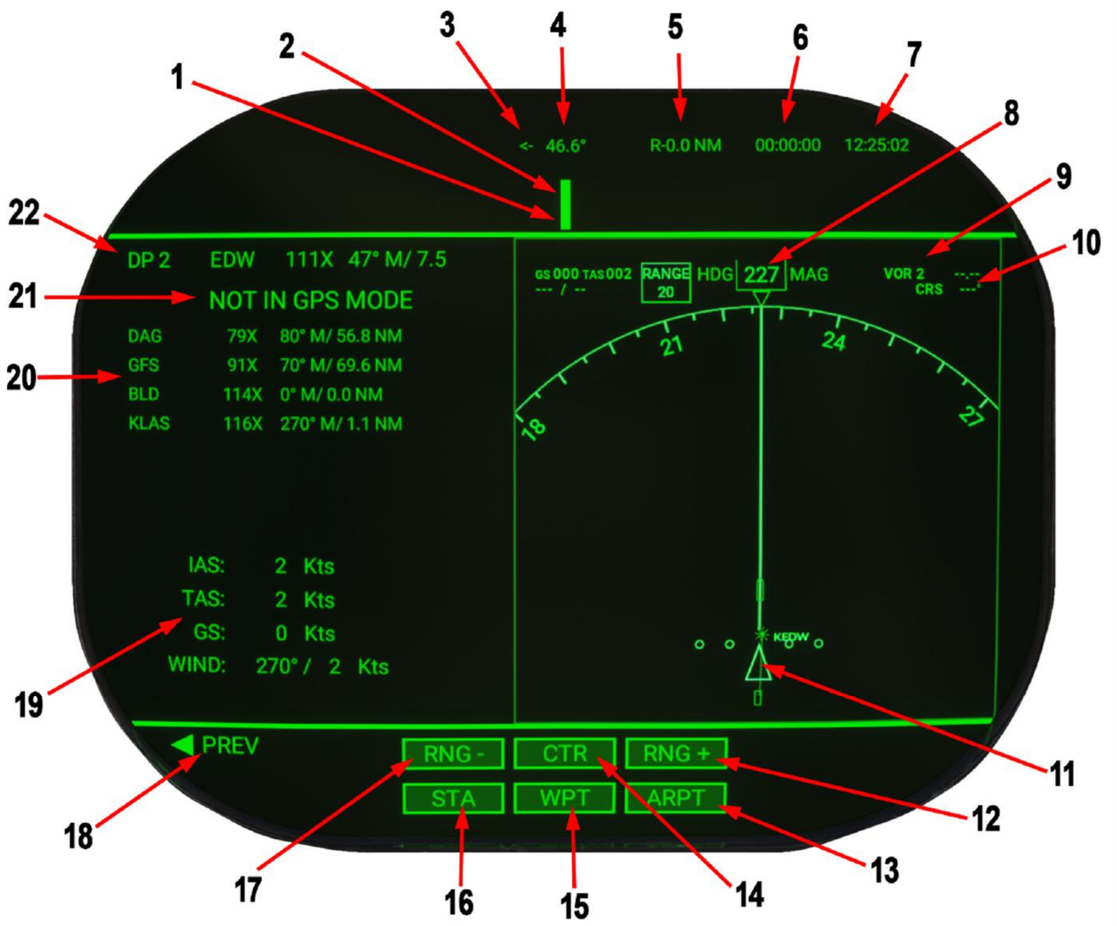
The center of the Bullseye symbol represents the point at which the latitude and longitude for that Bullseye is defined. Bullseyes are identified by a ⌖ symbol on the display.

Pilots' MFD Control Panel Controls and Indicators

NO.	CONTROL-INDICATOR	FUNCTION
1	EVS Monitor Source Select Switch (MFD - EVS)	The switch is used to select the video source for the EVS display. MFD position selects IU/TACAN displays and the EVS position selects EVS displays. If both the pilot's and copilot's MFD Controls are set to the MFD position, then changing MFD screens on one monitor will change the display on the other monitor as well. Setting one control to the MFD position and one to the EVS position will allow one monitor to display MFD screens and the other monitor to display screens associated with the EVS mode, respectively.
2	Display Mode Control Switch (P/DECLUTTER)	The P/DECLUTTER control is used for cursor positioning and navigation within the MFD interface. In operational use, it functions as a cursor control device for menu selection and display interaction. **WARNING** In the simulator implementation, this control has been functionally replaced by direct interaction with the MFD touchscreen for improved usability.

Figure 1-127C

Mission Route Screen/Moving Map Display



1. **Heading Error Indicator**
2. **Lubber Line**
3. **Course Intercept Cue**
4. **Cross-Track Distance (XTK).**
5. **Distance to Active Waypoint (NM)**
6. **Estimated Time to Active Waypoint (ETE)**
7. **Current Time displayed as h:mm:ss.**
8. **Present Magnetic Heading**
9. **Active Navigation Mode**
10. **OBS Selected Course**
11. **Aircraft Symbol**
12. **Map Range Increase Button**
13. **Destinations Display Button**
14. **Map Mode Selection Control**
15. **Flight Plan Waypoint Display Toggle**
16. **Navigation Aids Display Toggle**
17. **Map Range Decrease Button**
18. **Display Page Selection Button**
19. **Airspeed and Wind Information**
20. **Remaining Flight Plan Waypoints List**
21. **Annunciator Message Field**
22. **Active Waypoint Indication**

Figure 1-127D (Sheet 1 of 3)

Destination Screen

The Destination Data Screen (figure 1-127E) is used to provide information regarding Flight Plan and associated Navaids. The Destination Data Screen also provides information about the current heading. The Destination Data Screen is capable of displaying the following:

- All Destinations (with any indications of active and/or modified)
- Destination Types
- Associated Navaids (includes three letter identifier, channel number, and range and bearing from the Navaid to its associated destination)
- Selected Navaid
- Range and Bearing from the Selected Navaid to the Aircraft, when in GPS mode
- True Air Speed (TAS) in Knots
- Ground Speed (GS) in Knots
- Wind Direction and Velocity
- Magnetic Heading (HDG)
- Ground Track (TRK)
- Drift
- Error Annunciators (if any)

During certain modes of operation, some of these capabilities may not be available.

Destination Screen Operation

IDENTIFYING ITEMS IN THE DESTINATION LIST

The Destination List is displayed in the middle of the Destination Data Screen. The list displays up to 7 destinations in the route at a time. Each row in the list shows the destination number, destination type, and the destination's associated Navaid.

Each destination's associated Navaid is depicted by its three letter identifier, channel, frequency, distance and bearing from the Navaid to the destination. The bearing displayed is relative to magnetic North. If the destination has not been modified, then the range and bearing displayed will be the distance and bearing filed with the flight plan. This information is read in from the Flight Plan directly and be modified via EFB FP manager .

The Current Destination is identified by an outline surrounding the destination number, type, and associated Navaid.

SCROLLING THROUGH THE DESTINATION LIST

The pilot/copilot can scroll through the list of destinations on the Destination Data Screen by pressing small triangles on the right side of the MFD (Ref. Figure 1-127E, Items 3 and 5). will appear when there are more destinations in the list. When the top of the destination list is reached, the triangle pointing up will disappear. Similarly, the triangle pointing down will disappear when the bottom of the destination list is reached.

Destination Data Screen

1. **Computed Flight Parameters**
2. **Destination Data**
3. **Destination List Scroll UP .**
4. **Active Destination**
5. **Destination List Scroll DOWN**
6. **GPS Emulated Data / Annunciator Message Field**
7. **Display Page Selection Button**
8. **Default runway.**

Figure 1-127E

GPS Emulated TACAN Display

The GPS Emulated TACAN provides the currently selected Navaid's three letter identifier and channel, and the slant range and bearing from the Navaid to the aircraft. This data is only available while the Nav MODE SELECT switch on the Navigation System Select Panel is set to GPS mode and active Flight Plan is loaded. When not in GPS navigation mode, NOT IN GPS MODE will be displayed in place of the Selected Navaid's range and bearing. 21, figure 1-127D shows GPS Emulated TACAN data on the Mission Route Screen, and 6, figure 1-127E shows GPS Emulated TACAN data on the Destination Data Screen.

The selected Navaid symbol will also be filled in on the Mission Route Map if the Navaid is within the viewable range. Some conditions prevent the selected Navaid from being displayed. When such a condition occurs, one of the following annunciator messages listed in figure 1-127F will be displayed in place of the selected Navaid data displayed on the GPS Emulated TACAN line.

Associated Navaid Range and Bearing

The associated Navaid field provides the associated Navaid's three letter identifier and TACAN channel, VOR frequency and the distance and bearing from the Navaid to the destination. The distance and bearing will reflect the data filed with the associated flight plan.

Each destination may have one associated Navaid. On the Destination Data Screen, the associated Navaid is displayed in the Destination List with the destination number and type (figure 1-127E). On the Mission Route Screen, the associated Navaid is displayed below the Mission Route Map along with the Current Destination Number (22 on figure 1-127D). On the Mission Route Map, the Current Destina- tion is connected to its associated Navaid by a solid line. This is done only for the Current Destination. Some conditions prevent the associated Navaid for the Current Destination from being displayed. When such a condition occurs, one of the annunciators messages listed in figure 1-127F will be displayed below the map on the Mission Route Screen in place of the associated Navaid data.

Computed Flight Parameters Displayed on the MFD

Computed flight parameters are displayed on both the Destination Data Screen and the Mission Route Screen. The computed flight parameters are comprised of the following items:

- True Air Speed (TAS)
- Ground Speed (GS)
- Wind Velocity and Direction relative to magnetic North
- Ground Track relative to magnetic North
- Heading relative to magnetic North
- Drift

On the Destination Data Screen (1, figure 1-127E), the computed flight parameters are displayed at the top of the screen. On the Mission Route Screen (19, figure 1-127D), the TAS, GS, and winds are displayed on the left side of the screen while the heading, ground track, and drift are displayed on the Mission Route Map. The heading is displayed in a box at the top of the compass rose while ground track is displayed using a floating track marker. The drift is determined by the difference between the heading and track bug.

Annunciators Displayed in the Annunciator Field

Se Figure 1-127F for information.

Annunciators Displayed in the Annunciator Field

Se Figure 1-127F for information.

FLIGHT PLAN REQUIREMENTS

The aircraft is equipped with avionics originally developed in the 1980s and based on the technology standards of that era.

The GPS Emulated TACAN system does not support modern AIRWAYS-based flight plan formats. Accordingly, flight plans must be constructed using ground-based radio navigation aids only.

Flight Plan Creation Procedure

To ensure proper GPS Emulated TACAN navigation system operation, a valid flight plan must be created in the Free Flight main screen (Figure 2-2D) prior to Flight Start. The completed flight plan must be SENT to both ATC and AVIONICS before selecting Start Flight. Figure 2-2C (12)

WARNING

If the flight plan is not transmitted to ATC and AVIONICS prior to flight start, the simulator will default to a modern AIRWAYS flight plan format. This format is not compatible with the aircraft MFD avionics and may result in loss of navigation guidance.

When creating a compatible flight plan in the EFB, the following parameters must be defined:

- Departure Figure 2-2A (3)
- Arrival (10)
- Flight Plan Type: NO AIRWAYS (5)

After selecting NO AIRWAYS, all route waypoints must be manually added. Permissible Waypoint Types

TACAN / VOR / VORTAC / DME / ILS

WARNING

Do not use the FIND ROUTE (6) function as well as ADD procedures DEPARTURE (4) ARRIVAL (8) and APPROACH (9)
This action will automatically convert the flight plan to the modern AIRWAYS format, which is not readable by the aircraft avionics system

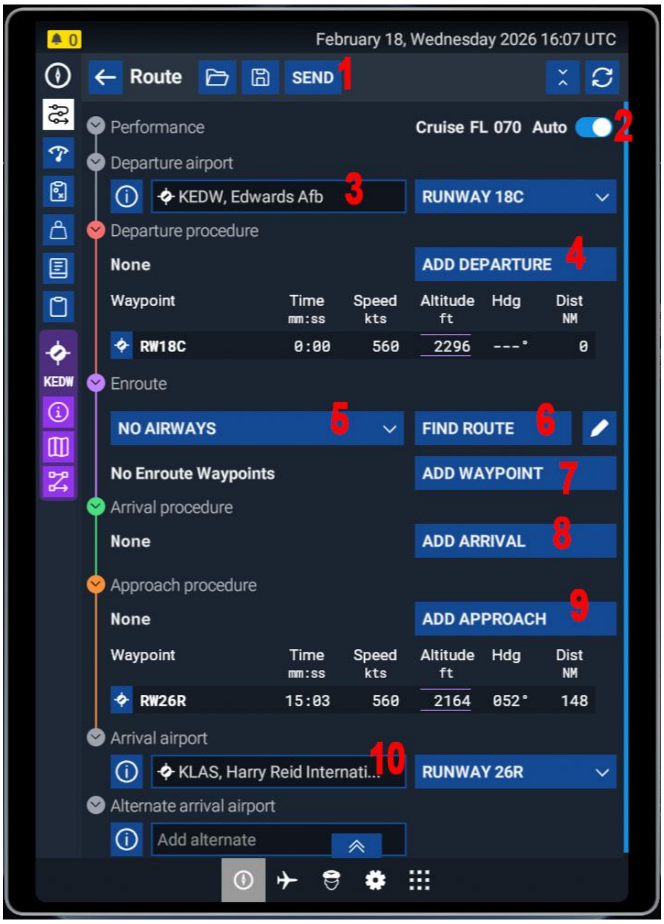


Figure 2-2A

Waypoints may be added using either of the following methods:

EFB Map Interface – Right-click the desired navigation aid and select ADD to Flight Plan.(11)

Figure 2-2B

Manual entry using the ENTER ROUTE STRING field. Figure 2-2C(13)

A valid minimum flight plan must include:

1. Departure Airport
2. Arrival Airport
3. At least two intermediate route waypoints.

For planning convenience, it is recommended to enable automatic cruise altitude determination using the Cruise FL AUTO selector located at the top of the EFB screen Figure 2-2A (2)

After completing flight plan construction, the plan must be sent to ATC & AVIONICS. Figure 2-2C(12)

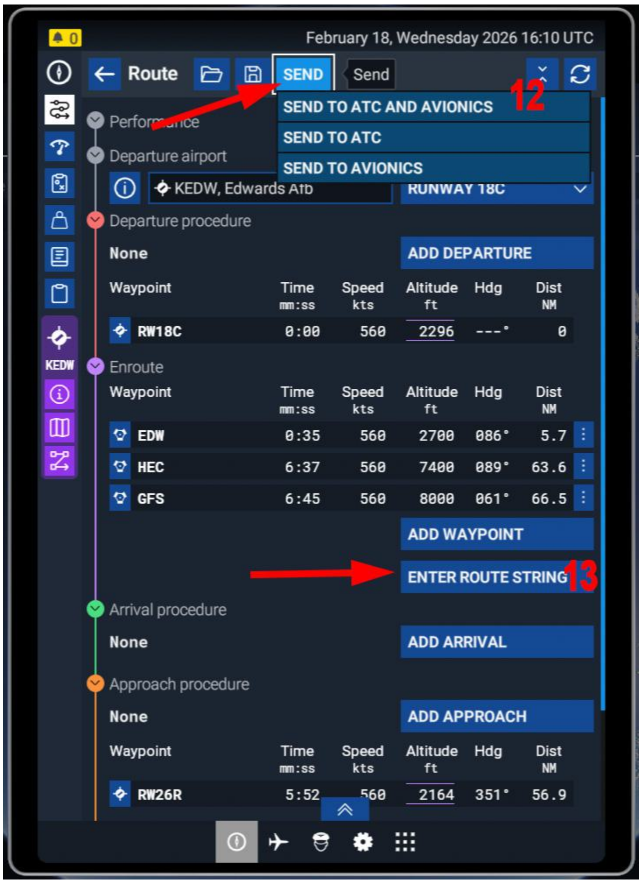


Figure 2-2C

NOTE

If the flight plan has been properly constructed and transmitted to ATC prior to flight start, flight plan adjustments may be made after loading, provided the restrictions described above are observed.

After transmitting the flight plan to ATC, the aircraft spawn location may be adjusted. Figure 2-2C(14)

For example, selecting a parking stand will result in aircraft loading in a Cold and Dark configuration.

Figure 2-2D

GPS IU/TACAN Annunciator Messages

ANNUNCIATOR MESSAGE	CAUSE
CHANNEL	GPS Emulated TACAN Display Box: The selected Navaid is either more than 200 NM away from the aircraft, or there is a communication problem with the TACAN Control Panel. Associated Navaid Message Display Box: The Current Destination has been moved more than 200 NM away from the associated Navaid.
CONFLICT	More than one Navaid with the tuned channel is within 200 NM of the current aircraft position.
NAVAID DATA	The Navaid database in invalid.
NO MISSION DATA	The Flight Plan (Mission) Data has not been: loaded from the EFB to ATC and Avionics
NO NAVAID ASSIGNED	There is currently no Navaid associated with the Current Destination.
NOT IN GPS MODE	The Nav MODE SELECT switch on the Navigation Select Panel is not in the GPS position. Or active leg of the flight plan is not captured

Figure 1-127F

OMNI-RANGE RADIO (NAV2)

The omni-range radio provides a very high frequency receiver for navigation over land and for runway localizer instrument approaches. The omni-range radio includes a receiver, a control panel on the pilots' overhead panel, and shares an HSI with the TACAN system. The horizontal situation indicators (figure 1-124) are located on the pilots' instrument panel. To start the omni-range radio, position the power switch to ON. To turn off the omni-range radio, position the switch to OFF.

INSTRUMENT LANDING SYSTEM (ILS) EQUIPMENT

The instrument landing system (ILS) provides the pilots with a straight line glide slope and a localizer or on-course guidance. The ILS system is used both as a means of navigation and as an aid to assist the pilots when landing in inclement weather. The ILS consists of the glide slope equipment omnirange radio the pilots' control panel, and the marker beacon receiver.

Glide Slope Equipment

This equipment indicates glide angle of the aircraft with relation to the runway for instrument approach. The control and indicators are common to the omni-range radio. A glide slope indicator (16, figure 1-124) on the attitude-director indicator indicates aircraft position relative to a glide slope beam. A warning flag on the left side of the indicator moves out of sight when a glide slope signal is received. To start the glide slope equipment, position the omni-range radio power switch to ON. To stop the equipment, position the power switch to OFF.

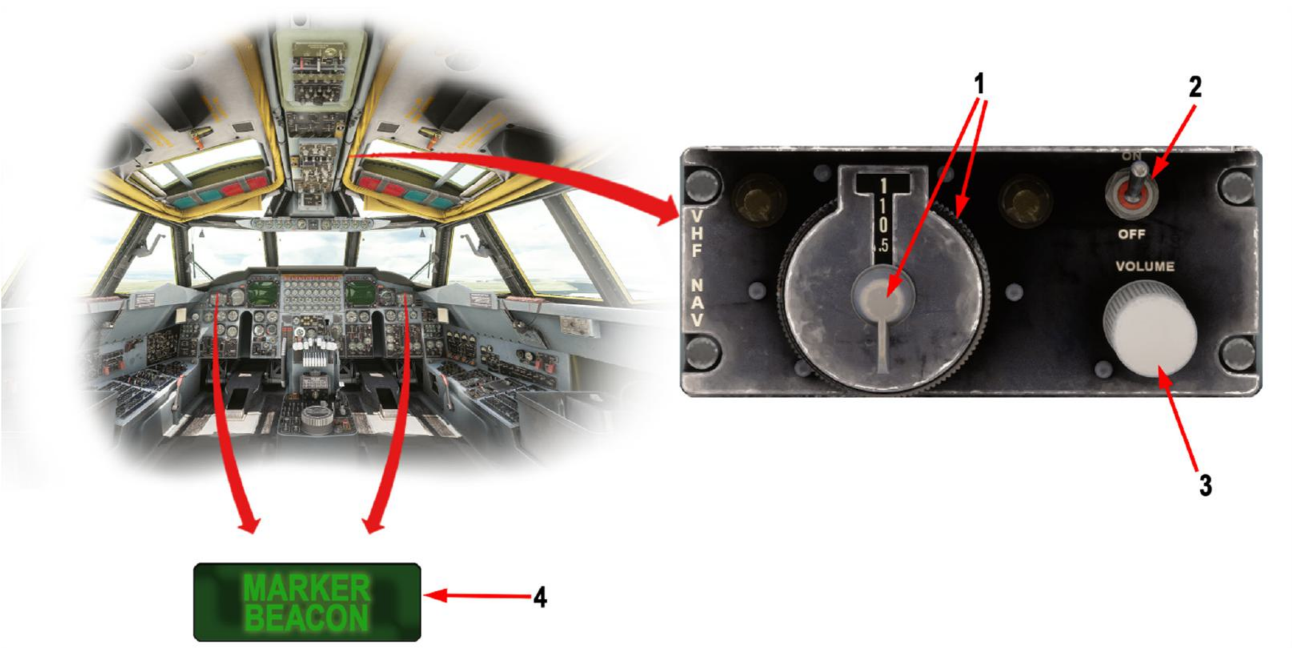
Marker Beacon Receiver

This receiver is used both as a navigational and landing aid. When flying over a beacon, a signal is heard on the interphone and observed as a light (4, figure 1-128) illumination just above each AQU-2/A.

Instrument Landing System Indicators

Course, bearing, and range indicators are integrated in the AQU-2/A horizontal situation indica- tor. See FLIGHT DIRECTOR SYSTEM, this section.

Omni-Range Radio/ILS Controls and Indicators



NO.	CONTROL-INDICATOR	FUNCTION
1	Frequency Selector Switch	The frequency selector switch is used to select the desired frequency. Tuning the receiver to the proper localizer channel automatically tunes the glide slope receiver to the proper glide slope channel frequency. The selector is calibrated from 108.0 to 135.9 MHz.
2	Power Switch	ON position provides operation of the signal comparison glide path and omni-range operation. OFF position turns off the equipment.
3	Volume Knob	The volume knob is used to adjust the receiver audio to the interphone system.
4	MARKER BEACON Indicator Light (green)	The marker beacon indicator light is used as a navigational and landing aid. The light is green with translucent-colored lettering MARKER BEACON on a black background and is located just above the respective pilot's horizontal situation indicator. These lights are tested by pushing the central caution panel test switch .

Figure 1-128

IFF TRANSPONDER SET

NOTE

The IFF transponder supports standard MSFS functionality only.

Mode 3/A is used for normal flight operations.

The transponder set AN/APX-64 (AIMS) provides for Mark X IFF with selective identification feature (SIF), automatic altitude reporting, and Mark XII (Mode 4) encrypted IFF. The transponder set is the airborne portion of a two-way link between the aircraft and ground radar installations. The ground radar station sends an interrogation signal which is received by the aircraft; the aircraft transponder (reply system) then replies with coded signals which are received on the ground and displayed on the radar scope as unique identification and altitude signals. The ground station may interrogate in more than one mode. However, the transponder only replies in those modes that are enabled. In addition to the normal replies listed above, the transponder contains provisions for a special emergency mode of operation (EMER position of the master switch), and for transmission of an “identification of position” (IDENT) signal. The transponder receives coded altitude information from the CPU-66 altitude computer (see INSTRUMENTS this Section). Modes 1, 2, 3/A, and C have a self-test capability with either internally generated test interrogations or ground station interrogations. Mode 4 operation requires that the mode 4 transponder computer be physically installed in the aircraft and, when installed, operation is continuously monitored by a caution light.

The interrogation and reply modes are as follows:

INTERROGATION	REPLY
MODE 1	Any one of 32 possible codes, as set on IFF panel
MODE 2	Any one of 4096 possible codes, as set on APX-64 transponder
MODE 3/A	Any one of 4096 possible codes, as set on IFF panel
MODE C	Standard ATC code for altitude reporting
MODE 4	As determined by mode 4 transponder computer

CODE SELECTIONS

Mode 1 code selectors are eight-position thumbwheel type selectors with integral indicators. The first digit selector is numbered from 0 thru 7, and the second digit selector is numbered from 0 thru 3. A total of 32 mode 1 code combinations is available.

Mode 2 codes are manually inserted at the transponder located under the bunk.

Mode 3/A code selectors are thumbwheel type selectors with integral indicators numbered from 0 thru 7. The mode 3/A selectors allow selection of any base eight code from 0000 to 7777, for a total of 4,096 different codes.

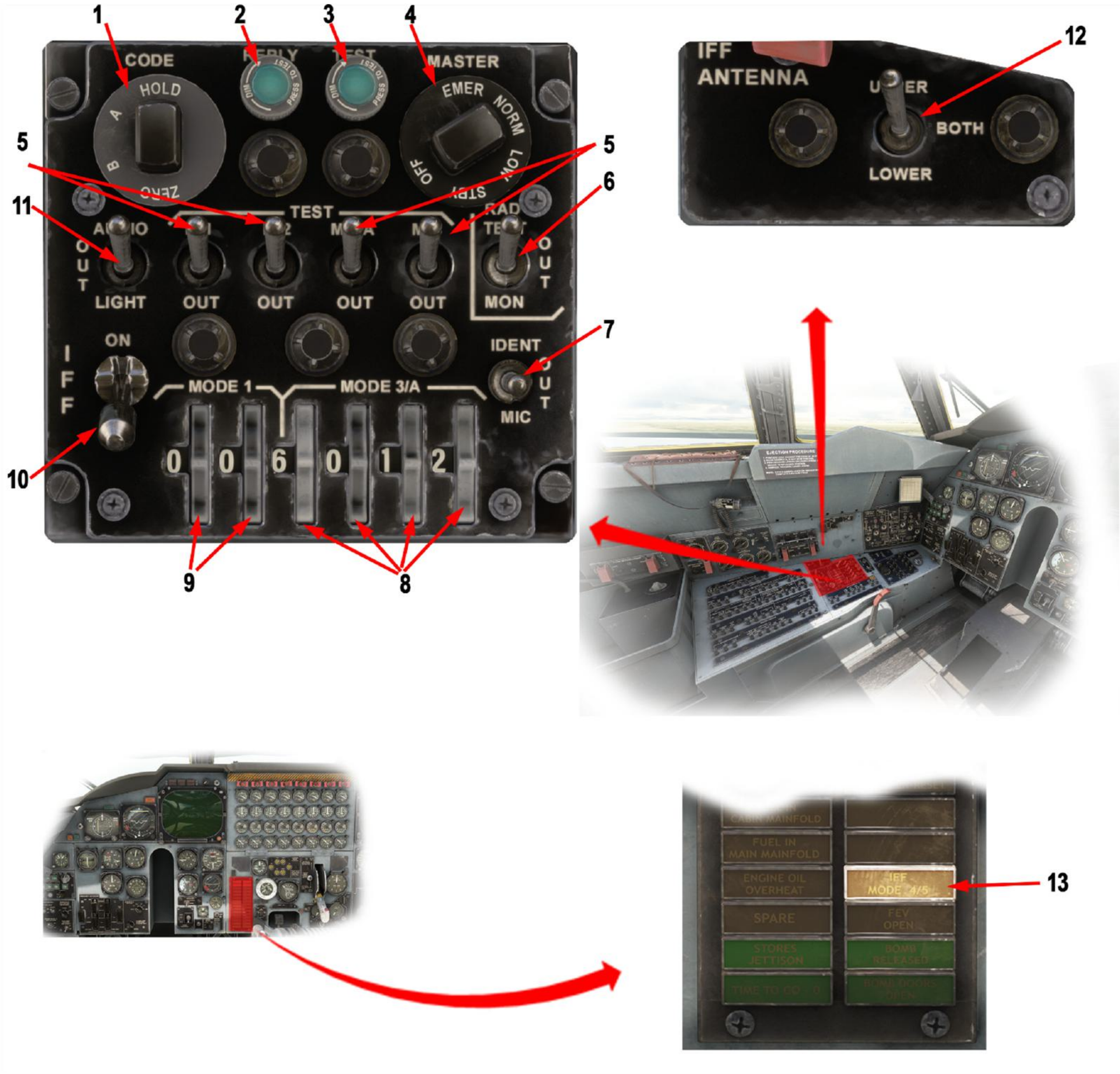
Mode 4 codes are preset using a crypto keying device.

AN/APX-64 IFF Normal Operation

Normal operation is as follows:

1. Position master switch to STBY for warmup. Warmup requires about 3 minutes.
2. Set mode mode 3/A code selectors as briefed.
3. Position IFF antenna switch to BOTH.
6. Position master switch to LOW or NORM as desired.
7. Position mode enabling switches to ON as briefed.
8. Position RAD TEST/MON switch to OUT or MON as desired.
9. Perform mode 4 operations as briefed.
10. To turn off equipment, place the master switch to OFF.

AN/APX-64 IFF Controls and Indicators



1	MODE 4 CODE SWITCH	8	MODE 3/A CODE SELECTORS
2	MODE 4 REPLY LIGHT	9	MODE 1 CODE SELECTORS
3	TEST LIGHT	10	MODE 4 ON/OUT SWITCH
4	MASTER SWITCH	11	MODE 4 AUDIO/LIGHT SWITCH
5	TEST MODE ENABLING SWITCHES (4)	12	IFF ANTENNA SWITCH
6	RAD TEST/MON SWITCH	13	IFF MODE 4 CAUTION LIGHT
7	IDENT/MIC SWITCH		

Figure 1-129 (Sheet 1 of 3)

AN/APX-64 IFF Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
1	Mode 4 CODE Switch	NOT IMPLEMENTED
2	Mode 4 REPLY Light (Green)	NOT IMPLEMENTED
3	TEST Light (Green)	Press-to-test light. Rotate lens clockwise to dim. Comes on when transponder indicates proper response to self-test of modes 1, 2, 3/A, or C or to external interrogation. Source of interrogations is controlled by the mode enabling switch (No. 5) TEST POSITIONS or RAD TEST/MON switch (No. 6).
4	MASTER Switch	Five position rotary switch, has OFF--STBY--LOW--NORM--EMER positions. When set to OFF, all power is removed from the transponder and transponder computer. When set to STBY, provides power to transponder receiver and computer for warmup. Warmup time requires approximately 3 minutes. When set to LOW, transponder operates with reduced receiver sensitivity. When set to NORM, transponder operates at normal receiver sensitivity. When set to EMER, causes automatic transmission of emergency reply signals to mode 1, 2, or 3/A, regardless of code settings. Switch must be pulled out to turn to OFF or EMER. **NOTE** The master switch must be in the NORM position for self-test with mode enabling switches.
5	TEST (Mode Enabling Switches) (4 Places)	NOT IMPLEMENTED
6	RAD TEST/MON Switch	NOT IMPLEMENTED
7	IDENT/MIC Switch	NOT IMPLEMENTED
8	MODE 3/A Code Selectors (Four Thumbwheels)	Eight position thumbwheel type selector. When set to a numbered position, selects mode 3/A codes. Thumbwheels are continuously rotatable with no stops and are numbered 0 thru 7 consecutively.
9	MODE 1 Code Selectors (Two Thumbwheels)	NOT IMPLEMENTED
10	MODE 4 ON/OUT Switch	NOT IMPLEMENTED
11	MODE 4 AUDIO/LIGHT Switch	NOT IMPLEMENTED
12	IFF ANTENNA Switch	A three-position IFF antenna switch on the pilot's side panel allows selection of UPPER, BOTH, or LOWER IFF antennas. When the IFF antenna switch is positioned to BOTH, the transponder alternates between antennas.
13	IFF MODE 4 Caution Light	NOT IMPLEMENTED

Figure 1-129 (Sheet 2 of 2)

COMMUNICATION AND ASSOCIATED ELECTRONIC EQUIPMENT

DESCRIPTION 172
INTERPHONE SYSTEM AN/AIC-18 172
UHF LINE-OF-SIGHT (LOS) RADIO AN/ARC-171(V) 174
LOS RADIO NORMAL OPERATION 174
LIAISON RADIO AN/ARC-190(V) 176
ARC-190(V) LIAISON RADIO NORMAL OPERATION 179

DESCRIPTION

The communication and associated electronic equipment (figure 1-131) includes an interphone system, UHF command radio, Line-of-Sight (LOS) radio set V/ UHF radio system

INTERPHONE SYSTEM AN/AIC-18

A transistorized interphone system provides intercommunication between the crew stations, transmission and reception on UHF command, V/UHF and liaison radio sets, and reception of audio signals from specialized receivers. Control panels (figure 1-133) vary according to station requirements. The pilot's, copilot's, instructor pilot's, radar navigator's, navigator's, instructor navigator's, gunner's, EW officer's, bunk, and defense instructor's stations each have a control panel containing a selector switch, volume control knob, hot mic talk switch, call button, and seven mixer switches. In addition, each of the previously named stations except the bunk has an auxiliary interphone panel containing eight mixer switches. Two interphone panels located in the left forward wheel well contain a call button and volume control knob and provide interphone and call functions only. This interphone system has separate microphone and headset amplifiers which provide uninterrupted communication at all times.

Interphone System Controls

INTERPHONE SELECTOR SWITCH

An interphone selector switch (10, figure 1-133) on each crewmember's interphone panel has INT- -UHF-1- - HF- -UHF-2- -PVT INT and V/UHF positions. INT position provides normal interphone communication between crewmembers.

INTERPHONE VOLUME CONTROL KNOB

An interphone volume control knob (11, figure 1-133) on each interphone panel is used in conjunction with the mixer switches to regulate the volume level received at that station.

HOT MIC TALK SWITCH
(NOT IMPLEMENTED)

A hot mic talk switch (7, figure 1-133) on each crewmember's interphone panel provides communication between two or more crewmembers without actuating microphone switches.

MIXER SWITCHES

The mixer switches (1-6, 8, and 12-15, figure 1-133) on the pilot's, copilot's, allow the crew members to monitor the channels essential to individual crew positions. In addition, an individual volume control is incorporated as an integral part of each mixer switch, providing a simple and adequate method of adjusting all signals to a level desired by the crewmember. Pulling one or more mixer switches out provides listening to the corresponding channel(s) simultaneously with transmission or reception on any other channel selected by the interphone selector switch. The mixer switches allow listening to the interphone system, command radio, liaison radio, LOS radio, hot mic, V/UHF radio, and private interphone (pilot, copilot, TACAN or omni-range radio and marker beacon), IFF mode 4 (pilot)

INTERPHONE POWER SWITCH

An ON- -OFF interphone power switch (figure 1-133) is located on the pilot's side panel. ON position provides direct battery power to the pilot's, co- pilot's interphone facilities. In addition, when positioned to ON, direct battery power is supplied to the two interphone facilities in the left forward wheel well provided the battery switch is ON. OFF position turns off power to the interphone system. In addition, the interphone power switch controls operation of the battery detector systems.

NOTE

This switch provides a direct connection of a portion of the interphone system to the batteries, independent of the battery switch. To conserve batteries, this switch should be placed in OFF position whenever ac power is lost or removed from the air- craft and the interphone system is not to be operated.

Interphone System Controls

TYPICAL INTERPHONE PANEL FOR THE PILOT, COPILOT INSTRUCTOR PILOT, RADAR NAVI-GATOR, NAVIGATOR, INSTRUCTOR NAVIGA-TOR, EW OFFICER, DEFENSE INSTRUCTOR, GUNNER, AND BUNK STATION

TYPICAL AUXILIARY MIXER SWITCHES FOR THE PILOT, COPILOT, INSTRUCTOR PILOT, RADAR NAVIGATOR, NAVIGATOR, INSTRUCTOR NAVIGATOR, EW OFFICER, DEFENSE INSTRUCTOR, AND GUNNER

1 INTERPHONE MIXER SWITCH
2 PRIVATE INTERPHONE MIXER SWITCH
3 UHF-1 MIXER SWITCH
4 HF MIXER SWITCH
5 UHF-2 MIXER SWITCH
6 HOT MIC MIXER SWITCH
7 HOT MIC TALK SWITCH
8 V/UHF MIXER SWITCH
9 CALL BUTTON
10 INTERPHONE SELECTOR SWITCH
11 INTERPHONE VOLUME CONTROL KNOB
12 NAV-AIDS MIXER SWITCH
13 APN-69 MIXER SWITCH
14 WARNING RCVR MIXER SWITCH
15 IFF MODE 4 MIXER SWITCH
16 ALQ-153 MIXER SWITCH

Figure 1-133

UHF LINE-OF-SIGHT (LOS) RADIO (COM1)

The AN/ARC (line-of-sight) radio (figure 1-137A) provides voice and modulated code communication from aircraft to aircraft and aircraft to ground. There are 760 frequencies available in steps of 0.025 MHz within the frequency range of 136.975 – 118.000 MHz. The AN/ARC-radio control panel is installed aft of the UHF command radio or UHF/VHF dual com- mand radio control panel on the pilot's overhead panel (figure 1-137A)

Line-of-Sight Radio Controls and Indicators

FUNCTION SELECTOR SWITCH

The function selector switch (11, figure 1-137A) selects the desired function and has OFF- -MAIN- -BOTH- -ADF- -SATL positions. OFF position removes power from the radio set or transfers control to the satellite terminal. MAIN position turns the main receiver-transmitter on in the receive mode. BOTH position energizes both the main and guard frequencies. SATL position transfers control to the satellite terminal at the navigator's station. ADF position is not used on this aircraft.

MANUAL-PRESET-GUARD SWITCH

(NOT IMPLEMENTED)

A MANUAL- -PRESET- -GUARD switch (7, figure 1-137A) controls the mode of frequency selection: manual frequency when in MANUAL position, preset frequency when in PRESET position, and guard frequency when in GUARD position.

MANUAL FREQUENCY SELECTOR KNOBS

The four manual frequency selector knobs (8, figure 1-137A) are used for selection of any one of 7000 frequency channels other than those already available on the preset channels. They have the capability of selecting any 0.025 MHz increment frequency from 225 thru 399.975 MHz.

MANUAL FREQUENCY INDICATORS

The manual frequency indicators (10, figure 1-137A) located on the LOS UHF radio control panel consist of a six digit display which indicates manual operating frequency set by the manual frequency selector knobs.

PRESET CHANNEL SELECTOR SWITCH

(NOT IMPLEMENTED)

A preset channel selector switch (6, figure 1-137A) is used to select any one of 20 preset channel frequencies.

PRESET CHANNEL INDICATOR

(NOT IMPLEMENTED)

A preset channel indicator (4, figure 1-137A) indicates the channel to which the preset channel selector switch is set.

SQUELCH SWITCHES

The MAIN and GUARD squelch switches (3, figure 1-137A) having ON- -OFF positions disable the main or guard receiver squelch circuits when de- sired. When the squelch switches are ON, the squelch circuits are enabled. When they are OFF, the squelch circuits are disabled.

VOLUME CONTROL KNOB

A volume control knob (1, figure 1-137A) located on the radio control panel is used to adjust the volume of both main and guard receivers.

LOS RADIO NORMAL OPERATION

1. Position function selector switch to BOTH.

The LOS PMT light on the AFSATCOM control at the navigator's station will illuminate if the mode selector is ON.

2. Test initiate selector switch to OPR.
3. Set FREQUENCY by selector knobs.
4. Adjust VOL control knob to desired level.

For turn off:

1. Position function selector switch to OFF

UHF Line-Of-Sight (LOS) Radio AN/ARC-171(V) Controls

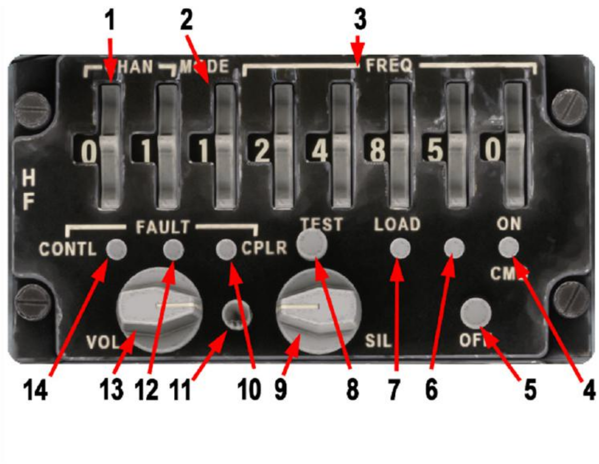
1 TONE BUTTON
2 TEST FAULT LIGHT
3 SQUELCH SWITCH
4 PRESET CHANNEL INDICATOR
5 PRESET FREQUENCY WRITE-ON CHART
6 PRESET CHANNEL SELECTOR SWITCH
7 MANUAL-PRESET-GUARD SWITCH
8 MANUAL FREQUENCY SELECTOR KNOB
9 PRESET-STORE BUTTON
10 MANUAL FREQUENCY INDICATORS
11 FUNCTION SELECTOR SWITCH
12 TEST INITIATE SELECTOR SWITCH

Figure 1-137A

LIAISON RADIO AN/ARC- (COM3)

This liaison radio provides long range voice communications in the high frequency range. The radio operates over a frequency range of 2.0000 to 29.9999 MHz in 100 Hz steps, giving 280,000 available frequencies. The radio operates in the USB, LSB, AM, and CW modes. It uses 115-volt, three-phase ac power for operation. The radio controls are located on the copilot's side panel (figure 1-138).

Liaison Radio Controls and Indicators



1	CHANNEL INDICATOR SWITCHES (2)	8	TEST SWITCH
2	MODE INDICATOR SWITCH	9	SQUELCH CONTROL
3	FREQUENCY INDICATOR SWITCHES (6)	10	COUPLER FAULT INDICATOR
4	POWER ON INDICATOR	11	SQUELCH DISABLE SWITCH
5	TAKE COMMAND-OFF SWITCH	12	RECEIVER/TRANSMITTER FAULT INDICATOR
6	TAKE COMMAND INDICATOR	13	VOLUME CONTROL
7	LOAD SWITCH	14	CONTROL FAULT INDICATOR

NO.	CONTROL-INDICATOR	FUNCTION
1	CHANNEL Indicator Switches (2)	The two thumbwheel CHAN switches select preset channels 00 thru 29. The CHAN switches are enabled only when the MODE switch (No 2) is in P position. Both frequency and mode of operation are preassigned to each preset channel.
2	MODE Indicator Switch	The MODE thumbwheel switch selects the following modes of operation: UV -Upper sideband voice LV -Lower sideband voice AM -Amplitude modulation P -Preset channel UD -Upper sideband data (not used) LD -Lower sideband data (not used) CW -Continuous wave (not used) A -Unassigned (not used)

Figure 1-138 (Sheet 1 of 3)

NO.	CONTROL-INDICATOR	FUNCTION
3	FREQ Indicator Switches (6)	The six thumbwheel FREQ switches select operating frequencies from 2.0000 to 29.9999 MHz in 100 Hz steps. A frequency higher than 29.9999 cannot be selected. If a frequency lower than 2.0000 is selected, the CONTL FAULT indicator (No. 14) will light. Any time a new frequency is selected, a receiver tune cycle is initiated. The next time the microphone switch is pressed, a transmit tune cycle is initiated.
4	Power ON Indicator	The power ON indicator lights whenever the liaison radio is energized.
5	TAKE CMD-OFF Switch	The TAKE CMD-OFF switch is a three-position, spring-return to center switch. When momentarily operated to TAKE CMD (up) position, primary power is applied to the liaison radio, the control is enabled, and the TAKE CMD (No. 6) and ON (No. 4) indicators light. When momentarily operated to OFF (down) position, primary power is removed from the liaison radio and the TAKE CMD and ON indicators go off.
6	TAKE CMD Indicator	The TAKE CMD indicator lights whenever the control has command of the liaison radio. It is intended for systems that have more than one control location. Since the installation has only one control, the TAKE CMD indicator will light whenever the ON indicator lights. Failure of the light to be lit to do indicates a malfunction.
7	LOAD Switch	The momentary action, pushbutton LOAD switch causes mode and frequency data to be stored in the receiver-transmitter preset channel memory. Data is stored in the memory location indicated by the preset CHAN switches. Mode and frequency data is obtained from MODE and FREQ switches.
8	Test Switch	The momentary action, pushbutton TEST switch initiates a receive self-test cycle. When TEST switch is pressed, all FAULT indicators light, and, when released, all FAULT indicators go out. If the receive test fails, one of the FAULT indicators lights. After pressing the TEST pushbutton, the next time the microphone switch is pressed, a transmit self-test is initiated. The transmit self-test is performed on upper sideband with 1000 Hz cw tone. If the test fails, one of the FAULT indicators will light.
9	SQL (Squelch) Control	The SQL control is a four-position switch that selects the squelch level. In the fully ccw position, the squelch is disabled.
10	CPLR (Coupler) FAULT indicator	The CPLR FAULT indicator lights when a fault occurs in the antenna coupler.

Figure 1-138 (Sheet 2 of 3)

Liaison Radio Controls and Indicators (Cont)

NO.	CONTROL-INDICATOR	FUNCTION
11	Squelch DSBL (Disable) Switch	The SQL DSBL switch is an alternate-action pushbutton switch. When out, the squelch level is selected by the SQL control. When in, the squelch is disabled.
12	R/T (Receiver/Transmitter) FAULT Indicator	The R/T FAULT indicator lights when a fault occurs in the receiver-transmitter. **NOTE** If the omni-range (AN/ARN-14) is operating at the same time as the ARC-190 liaison radio, a false R/T fault indicator may light. Cycling the ARC-190 should correct this indication.
13	VOL Control	The VOL control is an eight-position switch that adjusts the receiver audio output level.
14	CONTL (Control) FAULT Indicator	The CONTL FAULT indicator lights when a fault occurs in the radio set control, the FREQ switches are set below 2 MHz, the CHAN switches are set to an unloaded preset channel with the MODE switch set to P, or the MODE switch is set to A.

Figure 1-138 (Sheet 3 of 3)

ARC LIAISON RADIO NORMAL OPERATION

Operation Modes

POWER TURN ON

The liaison radio is energized by momentarily operating the TAKE CMD-OFF switch to TAKE CMD. The ON and TAKE CMD indicators will light. If the MODE switch is set to P and the CHAN switch is set to an unloaded channel, frequency is set below 2 MHz or the MODE switch is set to A, the CONTL FAULT indicator will light.

POWER TURN OFF

The liaison radio is deenergized by momentarily operating the TAKE CMD-OFF switch to OFF. The TAKE CMD and ON indicators will go off.

MODE AND FREQUENCY PRESETTING

The AN/ARC-190(V) liaison radio has 30 preset channels. These channels are numbered 00 thru 29. Mode and frequency information for each preset channel is stored in a nonvolatile memory located in the receiver-transmitter. Presetting is accomplished on the master control panel with the equipment turned on. Presetting is normally done before flight but may be done in flight, if necessary, and is accomplished as follows:

1. Momentarily operate TAKE CMD-OFF switch to TAKE CMD.
2. Set MODE switch to desired mode.
3. Set FREQ switches to desired frequency in the range of 2.0000 thru 29.9999 MHz. If frequency is set below 2.0000 MHz, the CONTL FAULT indicator will light.
4. Set CHAN switch to desired channel. Channels are numbered from 00 thru 29.
5. Press LOAD pushbutton. This causes the mode and frequency information to be loaded into the receiver-transmitter nonvolatile memory.
6. Repeat steps 2 thru 5 for each preset channel required.

MODE SELECTION

The AN/ARC-190(V) liaison radio can operate in the upper sideband voice (UV), lower sideband voice (LV), amplitude modulation (AM), or preset (P) modes. The UD, LD, CW, and A positions of the MODE switch are not used. When the MODE switch is set to UV, LV, or AM, the mode and fre- quency of the liaison radio is determined by the MODE and FREQ switches. When the MODE switch is set to P, the mode and frequency of the liaison radio is determined by the preset CHAN switch. If an unloaded preset channel is selected, the CONTL FAULT indicator will light.

FREQUENCY SELECTION

When the MODE switch is set to P, the frequency is selected by the CHAN switches. In all other MODE switch positions, the frequency is selected by the FREQ switches. If a frequency below 2.0000 is selected, the CONTL FAULT indicator will light.

ELECTRO-OPTICAL VIEWING SYSTEM (EVS)

DESCRIPTION 180
STEERABLE TV (STV) SYSTEM 180
FORWARD LOOKING INFRARED (FLIR) SYSTEM 180
EVS CONTROLS AND INDICATORS 181

DESCRIPTION

The EVS provides the crewmembers with a visual presentation of the area ahead of the aircraft for low level penetration during both day and night missions. To accomplish this function, the EVS utilizes a steerable low light level television camera (STV) and a steerable forward looking infrared sensor (FLIR) to supply video, which is then displayed on monitors at the pilot's and copilot's station, and on the MFD's at the navigator's and radar navigator's positions. The EVS also receives input signals from other aircraft ancillary systems, which are converted to symbology suitable for TV display and are displayed on the EVS monitors. The offensive avionics system (OAS) furnishes terrain avoidance profile (TA) video information for display on the EVS monitors. The sensors for STV and FLIR are mounted within steerable turrets on the under side of the aircraft just aft of the forward radome. The STV turret (31, figure 1-1) is on the left side of the aircraft and the FLIR turret (33, figure 1-1) is on the right.

Each turret rotates in azimuth to follow the position of its sensor when that sensor is being used, but rotates to the aft or stow position when the sensor is not in use. The turrets are provided with optical windows to protect the sensors and have window wash facilities to remove debris from the windows during flight. The EVS is composed of three major electronic/electrical subsystems: the Steerable Television Set (STV) the Forward Looking Infrared Set (FLIR) and the Data Presentation Group The components are located in three major areas of the aircraft: the forward ra dome area, the pilots' area, and the navigators' area.

STEERABLE TV (STV) SYSTEM

The STV consists of a camera assembly, camera electronics unit, and a control panel at the radar navigator's station. It provides high quality video information over a wide range of ambient light levels, from bright sunlight to starlight. The night scenes closely approximate daylight operation for target location and identification, which enables the STV to serve as a low light level sensor for the EVS.

STEERABLE TV (STV) SYSTEM

The STV consists of a camera assembly, camera electronics unit, and a control panel at the radar navigator's station. It provides high quality video information over a wide range of ambient light levels, from bright sunlight to starlight.

The STV can view selected areas within ±45° in azimuth, referenced to the centerline of the aircraft. In the elevation plane, the STV can view scenes within +15° and –45° referenced to the camera mounting surface. Either the video in the entire field of view, or in the center 1/3 of the field of view can be selected by the operator to enhance the presentation on the display.

FORWARD LOOKING INFRARED (FLIR) SYSTEM

The FLIR consists of a sensor assembly, signal data converter, and control panel at the radar navigator's station. The function of the FLIR is to convert infrared radiation that is not visible to the unaided eye into real-time information for display on the EVS monitor. The FLIR is especially useful for tar- get location and identification through thin cloud coverage and in complete darkness. The scanner assembly detects thermal radiation and converts the energy into electrical signals. The signal processor converts the IR video into video suitable for presentation on the monitors. A refrigerator system in the scanner assembly provides the extremely low temperatures required by the IR detectors and is controlled by the FLIR panel located on the radar navigator's forward panel.

EVS CONTROLS AND INDICATORS

The EVS controls and indicators are described in figure 1-174.

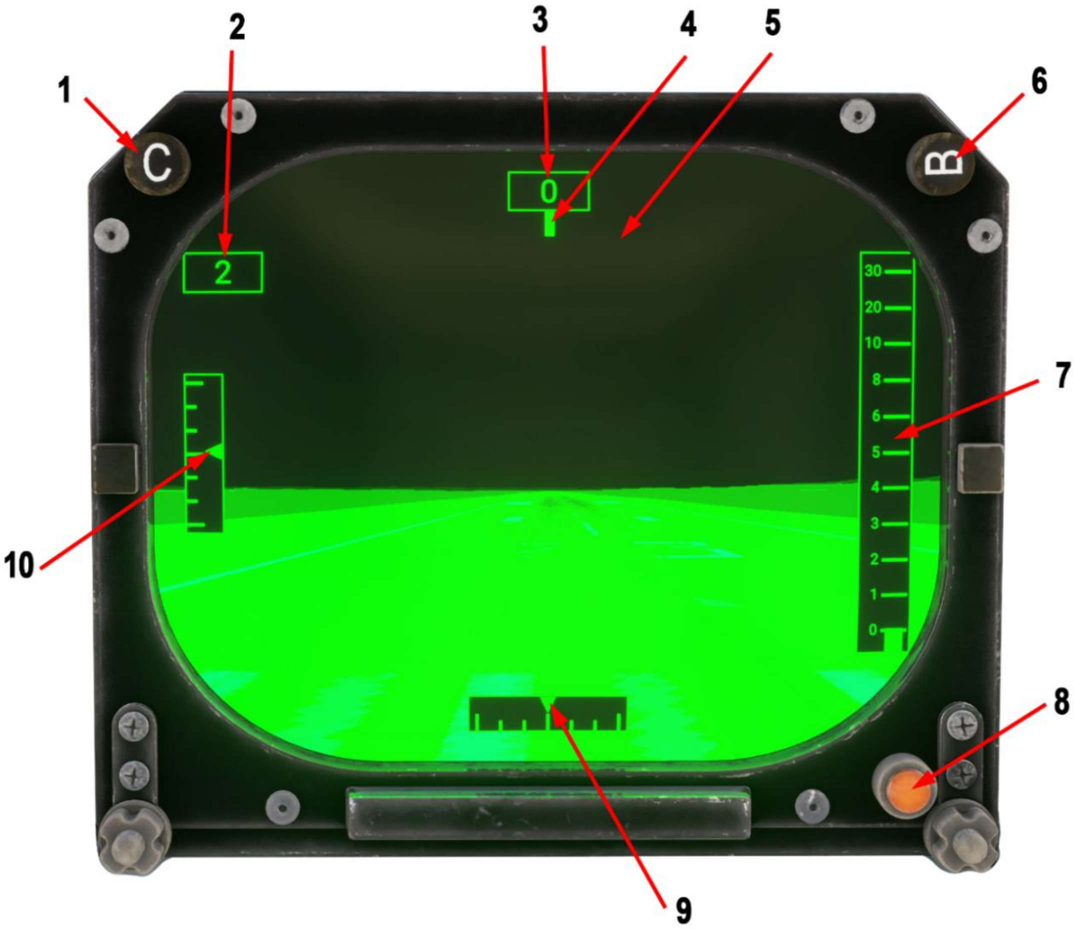
EVS Monitors

The EVS monitor with a light or green shaded face is located at both pilot stations and at both navigator stations (called MFD's). The monitor provides TV format displays of FLIR and STV sensor video. In addition, the monitors at each pilot station pro- vide profile mode display of the terrain avoidance radar system.

. PILOTS' MFD CONTROL PANELS

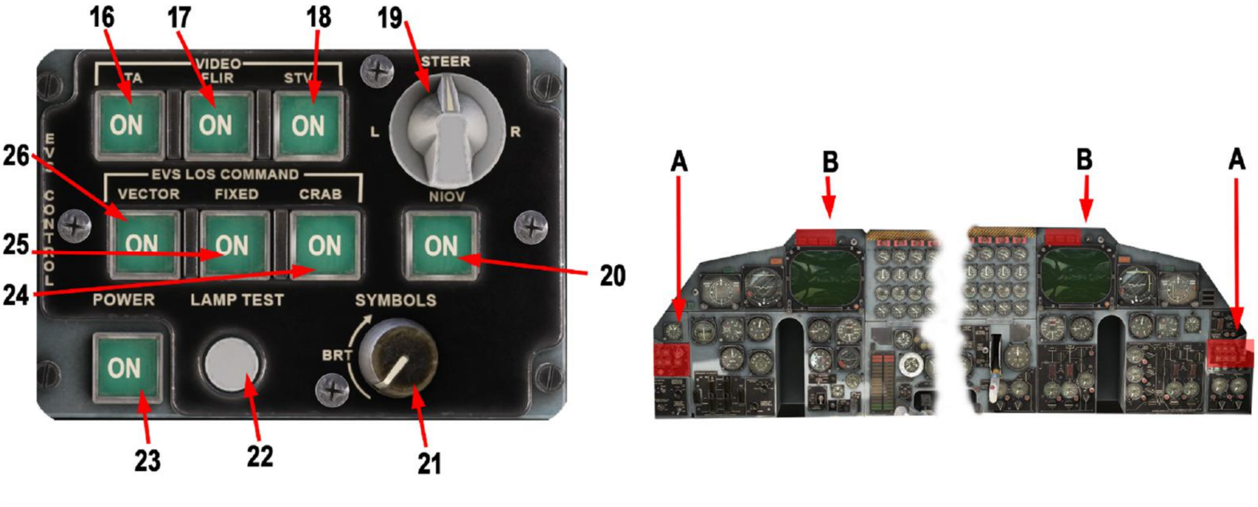
Two control panels, one on the Pilot's side panel and one on the Copilot's side panel are used to select the display source for the respective EVS monitor. A two position switch on the panel has EVS and MFD positions. Each switch operates independently of the other, allowing one monitor to display EVS while the other displays MFD data, or both monitors to display data from the same source. For de- tailed information on the control panel and MFD displays see GPS IU/TACAN EMULATION, this section

EVS Controls and Indicators



1. **CONTRAST KNOB**
2. **INDICATED AIRSPEED INDICATOR**
3. **TIME–TO–GO INDICATOR (BOMB MODE ONLY)**
4. **HEADING REFERENCE MARKER**
5. **HEADING ERROR MARKER**
6. **BRIGHTNESS KNOB**
7. **RADAR ALTITUDE INDICATOR**
8. **OVERHEAT LIGHT**
9. **EVS SENSOR AZIMUTH INDICATOR**
10. **EVS SENSOR ELEVATION INDICATOR**

Figure 1-174 (Sheet 1 of 20)



A EVS CONTROL PANEL (PILOTS' STATION 2 PLACES)

16	**TA VIDEO SWITCH**	**22**	**LAMP TEST SWITCH**
17	**FLIR VIDEO SWITCH**	**23**	**POWER SWITCH**
18	**STV VIDEO SWITCH**	**24**	**CRAB STABILIZATION SWITCH**
19	**MANUAL STEERING KNOB**	**25**	**FIXED STABILIZATION SWITCH**
20	**NARROW FIELD OF VIEW SWITCH**	**26**	**VECTOR STABILIZATION SWITCH**
21	**SYMBOLS DIMMING KNOB**		

Figure 1-174 (Sheet 2 of 20)

NO.	CONTROL-INDICATOR	FUNCTION
		EVS MONITOR (6 PLACES)
1	Contrast Knob	The contrast knob marked C is used to vary the gain of the video amplifier circuit thereby controlling the image contrast of the monitor. Clockwise rotation of the knob increases the image contrast. The contrast knob is turned clockwise, after the brightness knob has been set, until a satisfactory display is obtained.
2	Indicated Airspeed Indicator	The indicated airspeed indicator provides a numeric indication of aircraft indicated airspeed in knots. The indicator is a box with three enclosed digits that vary from 000 to 450 in 1-knot increments. The numerics are updated every 1/6-second to provide continuously corrected airspeed information.
3	Time -To-Go indicator	The time-to-go indicator provides an indication of time in seconds remaining before the OAS provides a bomb release pulse or crosses a commanded destination. The indicator is a box with three enclosed digits that vary from 000 to 200 (Format 3 or pilots' display). The time-to-go indicator is functional when OAS is in bomb or navigation mode.
4	Heading Reference Marker	The heading reference marker consists of two vertical black bars separated by a white bar, and provides a fixed zero-degree azimuth reference for the movable heading/bank steering marker. 5
5	Heading Error Marker or Bank/Steering Marker	HEADING ERROR MARKER The heading error marker indicates bomb mode heading error while in bomb mode or navigation heading error when the OAS is not in bomb mode. When time-to-go numerics are displayed, this indicator is showing OAS heading error and conversely when the time-to-go numerics are not displayed, this indicator is showing bank/steering.
6	Brightness Knob	The brightness knob marked B varies the illumination of the monitor. Clockwise rotation of the knob turns monitor ON and increases illumination. This knob is nor mally turned counterclockwise - (with the contrast knob fully counterclock wise) until the monitor illumination is not visible. This provides the proper brightness knob setting for normal ambient lighting conditions .
7	Radar Altitude Indicator	The radar altitude indicator consists of an altitude scale and a white ribbon indicator. The scale is made up of 13 fixed index lines, 11 fixed numerics, and a blanking box. Each numeric indicates a scale factor representing hundreds of feet above terrain. The white ribbon indicator moves vertically along the scale and represents radar altitude determined by the radar altimeter. The indicator is scaled from 0 to 3,000 feet (Fornat 3 and pilots' displays) or 0 to 5,000 feet (Format 4 and 5). .

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NO.	CONTROL-INDICATOR	FUNCTION
		EVS MONITOR (6 PLACES)
8	Overheat Light	The amber overheat light is connected to an overheat sensor in the monitor and will come on when the overheat sensor signals an overheat condition and will remain on until the overhead condition is corrected. This light incorporates an integral press-to-test feature for testing the light bulb. **CAUTION** If this light cannot be extinguished by providing increased cooling air within 5 minutes after initial illumination, the monitor should be turned off or equipment damage can be expected.
9	EVS Sensor Azimuth Indicator	The EVS sensor azimuth indicator is made up of an azimuth reference scale and an azimuth marker. The scale will be a ''long'' scale or a ''short'' scale depending on whether pilots' or navigators' have steering control. The ''long'' scale consists of index marks numbered in degrees, whereas the ''short'' scale consists only of index marks. Both navigators' monitors will always display ''long'' scale. Both pilots' monitors will display ''long'' scale only when navigators have steering control and will always display ''short'' scale when either pilot has steering control. The azimuth marker will move horizontally along the azimuth scale in direct proportion to azimuth angular positioning of STV and FLIR sensors.
10	EVS Sensor Elevation Indicator	The EVS sensor elevation indicator is made up of an elevation reference scale and an elevation marker. The scale will be a ''long'' scale or a ''short' scale depending on whether pilots' or navigators' have steering control. The ''long'' scale consists of index marks numbered in degrees, whereas the ''short'' scale consists only of index marks. Both navigators' monitors will always display ''long'' scale. Both pilots' monitors will display ''long'' scale only when navigators have steering control and will always display ''short'' scale when either pilot has steering control. The elevation marker will move vertically along the elevation scale in direct proportion to elevation angular positioning of STV and FLIR sensors.

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NO.	CONTROL-INDICATOR	FUNCTION
		A EVS CONTROL PANEL (2 PLACES) (PILOTS' STATION)
16	TA VIDEO Switch	The TA video switch is a momentary pushbutton switch which provides selection of the TA terrain trace on the respective pilot's EVS monitor. The TA video may be selected alone or in dual mode with FLIR or STV displays. When TA video is selected by pressing the switch, the word ON in green is illuminated on the switch face. When TA is selected with FLIR or STV, the system is automatically placed in vector steering mode. Other modes may subsequently be selected. The TA video switch must be momentarily pressed again to deactivate the TA circuits.
17	FLIR VIDEO Switch	The FLIR video switch is a momentary pushbutton switch which provides selection of the FLIR video on the respective pilot's EVS monitor. The FLIR video may be selected alone or in conjunction with TA display. When FLIR video is selected by pressing the switch, the word ON in green is illuminated on the switch face. The FLIR circuits may be deactivated by momentarily pressing the FLIR video switch or STV video switch. In either case, the ON light will go out.
18	STV VIDEO Switch	The STV video switch is a momentary pushbutton switch which provides selection of the STV video on the respective pilot's EVS monitor. The STV video may be selected alone or in conjunction with TA display. When STV video is selected by pressing the switch, the word ON in green is illuminated on the switch face. The STV circuits may be deactivated by momentarily pressing the STV video switch or FLIR video switch. In either case, the ON light will go out.
19	Manual Steering Knob	The manual steering knob has L- -OFF- -R positions and is spring-loaded to the center OFF (unmarked) position. The knob must be pressed before it can be rotated out of the center position. Provided a steering mode is selected (vector, fixed, or crab switch lights on), the selected sensor and turret may be manually steered in azimuth left (L) or right (R) by use of the steering knob. When the knob is released it will return to the center position and sensor and turret control reverts to the steering mode selected. **WARNING** This knob should only be used while the aircraft is on the ground while stopped or during a slow speed maneuver such as taxiing, etc since disorientation may result.

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NO.	CONTROL-INDICATOR	FUNCTION
	A EVS CONTROL PANEL (2 PLACES) (PILOTS' STATION) (Cont)	
20	Narrow Field-Of-View Select Switch	The NFOV select switch is a pushbutton switch permits either pilot or copilot, while he has steering command, a means of selecting NFOV of the selected sensor. Pressing the button will cause the sensor to switch to the other field-of-view.
21	SYMBOLS Dimming Knob	The symbols dimming knob is a rotary knob used to set the brightness of the symbols on the respective EVS monitor. Clockwise rotation of the knob, as marked, will brighten the symbols and counterclockwise rotation will dim the symbols.
22	LAMP TEST Switch	The lamp test switch is a pushbutton switch used to test all the indicator lights on the respective EVS control panel.
23	POWER Switch	The power switch is a push-on/push-off type switch having an ON position (pressed) (switch face flush with switch housing) and an OFF position (extended) (switch face extends approximately 1/8 inch from switch housing) which is mechanically latched in each position. The switch is used to turn on and place the respective EVS monitor in standby mode and to provide power for turret and sensor drive and other electronic circuits. When pressed in ON position, the word ON in green is illuminated on the switch face provided power is on in the aircraft. When the switch is pressed again and the switch face extends from its housing, the switch is OFF and the respective EVS monitor is deactivated and power is removed from the other circuits provided through the switch.
24	CRAB Stabilization Switch	The crab stabilization switch is a momentary pushbutton switch which provides selection of crab stabilization of the line-of-sight (LOS) of the selected sensor. When crab LOS stabilization is selected by pressing the switch, the word ON in green is illuminated on the switch face. In crab stabilization, the selected sensor and turret are driven in azimuth to a position corresponding to the crab angle position of the aft landing gears and the sensor driven to 2° above the aircraft centerline. The crab stabilization may be deactivated by pressing the crab, vector, or fixed stabilization switches.
25	FIXED Stabilization Switch	The fixed stabilization switch is a momentary pushbutton switch which provides selection of fixed stabilization of the line-of-sight (LOS) of the selected sensor. When fixed LOS stabilization is selected by pressing the switch, the word ON in green is illuminated on the switch face. In fixed stabilization, the selected sensor and turret are driven in azimuth to a position corresponding to 0° or the centerline of the aircraft and the sensor driven in elevation to 2° above the waterline of the aircraft if TA is not selected or to the waterline of the aircraft if TA is selected. The fixed stabilization may be deactivated by pressing the fixed, vector, or crab stabilization switches.

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NO.	CONTROL-INDICATOR	FUNCTION
26	VECTOR Stabilization Switch	The vector stabilization switch is a momentary pushbutton switch which provides selection of flight vector stabilization of the line-of-sight (LOS) of the selected sensor. When vector LOS stabilization is selected by pressing the switch, the word ON in green is illuminated on the switch face. In vector stabilization, the selected sensor and turret are driven in azimuth to a position corresponding to the drift angle output of the OAS and the sensor driven in elevation according to the output of the angle-of-attack computer. See figure 1-173 for additional stabilization information. The vector stabilization may be deactivated by pressing the vector, fixed, or crab stabilization switches. **NOTE** If INS drift information is erroneous when an INS is commanded as a prime NAV mode or if doppler is malfunctioning, vector stabilization should not be used since azimuth position may be unreliable.

MISCELLANEOUS EQUIPMENT

WINDSHIELD WIPERS

Electrically operated windshield wipers clear the windows in front of the pilot and copilot. A separate motor drives each of the two blades. Both wipers are controlled by a single rotary-type switch (46, figure 1-7) on the pilots' instrument panel. The switch has PARK- -OFF- -FULL- -3/4- -1/2- -LOW positions, giving a choice of wiper speeds. The switch is spring-loaded from PARK to OFF position. After use, the switch is held in PARK position until the blades move to the stowed position and stop. The switch is then placed to OFF position.

Do not operate windshield wipers on dry or dirty glass as this can scratch or damage the glass.

NOTE

If rain repellent has been applied to the windshield, hold windshield wiper opera- tion to an absolute minimum as approximately 30 minutes of wiper operation will remove the rain repellent.

BEST FLARE SPEED INDICATOR

A best flare speed indicator is installed around the outside of the case of the total fuel quantity gage (figure 1-180) adjacent to the fuel system panel. The indicator is to be used prior to landing to determine the best flare speed when using full flaps. To obtain this information initially, the gross weight must be computed after the aircraft is in a landing configura- tion based on actual load on board. Then the best flare speed indicator is adjusted so that the com- puted gross weight value on the gross weight scale is opposite the pointer on the gage. The airspeed val- ue adjacent to the computed gross weight value is the best flare speed for that weight with airbrakes in position 4 and full flaps. As fuel is consumed, the to- tal fuel quantity gage pointer will point to the air- craft gross weight and the corresponding best flare speed for airbrakes in position 4.

Best Flare Speed Indicator

CONTROL-INDICATOR	FUNCTION
Best Flare Speed Indicator	A best flare speed indicator is installed around the outside of the case of the total fuel quantity gage. The indicator is to be used prior to landing to determine the best flare speed when using full flaps and air brakes 4.

Figure 1-180

Personnel Coding

Where necessary to distinguish crewmembers, the following code letters will be used

(P) Pilot
(CP) Copilot
(N) Navigator
(G) Gunner
(RN) Radar Navigator
(EW) EW Officer

(IP) Instructor Pilot
(IN) Instructor Navigator
(DI) Defense instructor
(GC) Ground Crew
(10th) Tenth Crewmember