

SECTION 16

NAVIGATION

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SECTION 16NAVIGATION

1. GENERAL

There are two types of airborne navigation systems, the independent positioning determining systems (IPDS), and the dependent positioning determining systems (DPDS). The IPDS consists of three systems, weather radar, a radio altimeter, and a gyro compass. The DPDS consists of four systems, VHF navigation, automatic direction finding (ADF), distance measuring equipment (DME), and an ATC transponder. Miscellaneous instruments are described in this Section.

2. INDEPENDENT POSITION DETERMINING SYSTEMS

A. Weather Radar (Figures 1 and 2)

The weather radar is used for weather detection and analysis. A ground mapping mode is provided as a modified display. It has a three-colour presentation on a black background. Each colour represents a different level. A three-coloured bar legend display defines the meaning of each colour.

WEATHER

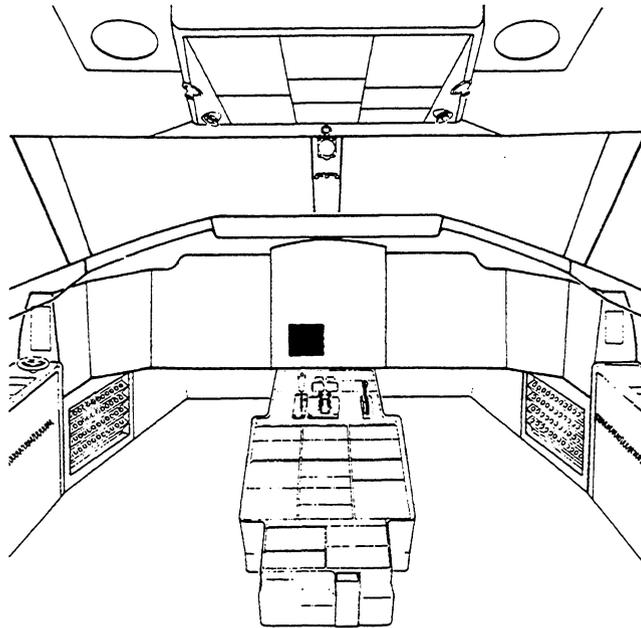
Level 3	Red	Heaviest rainfall
Level 2	Yellow	Next heaviest rainfall
Level 1	Green	Least rainfall
	Black	No reflective target

GROUND MAPPING

Level 3	Magenta	Most reflective target
Level 2	Yellow	Next level of reflective target
Level 1	Cyan	Least level of reflective target

The system consists of three line replaceable units, a receiver-transmitter, a digital indicator and an antenna pedestal with flat-plate radiator. All the system controls are on the front of the indicator (Figure 1).

The system operates in the cyclic, weather and mapping modes. In the cyclic mode, high-level signals flash. In the weather mode, azimuth strobe lines, mode and range alphanumeric are displayed to assist in evaluating weather data. In the ground mapping mode, the display is available as a secondary source of navigational information.



TARGET ALERT SWITCH/LIGHT

When pressed enables target alert in WX mode only. Amber light comes on and T is displayed if there are no targets in the target alert sector. If there are targets TGT is displayed and flashes at 0.5 second intervals.

AZIMUTH REFERENCE POINTS

Provides azimuth reference points, in 30 degree increments, to assist display analysis.

SECTOR SCANNING SWITCH

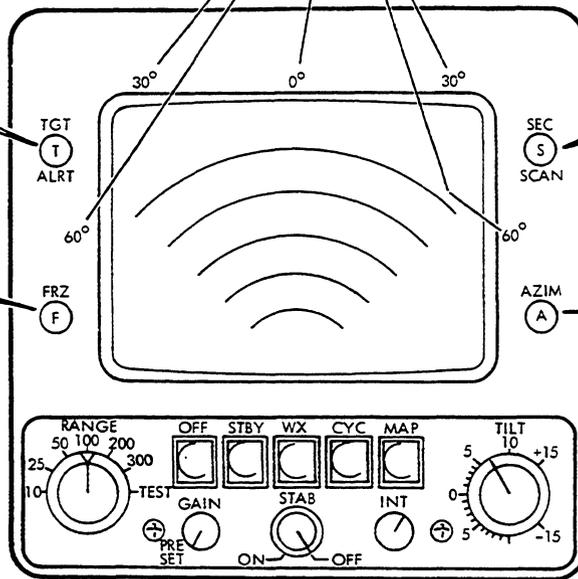
In normal position 120 degrees scanning selected. When pressed 60 degree scanning selected.

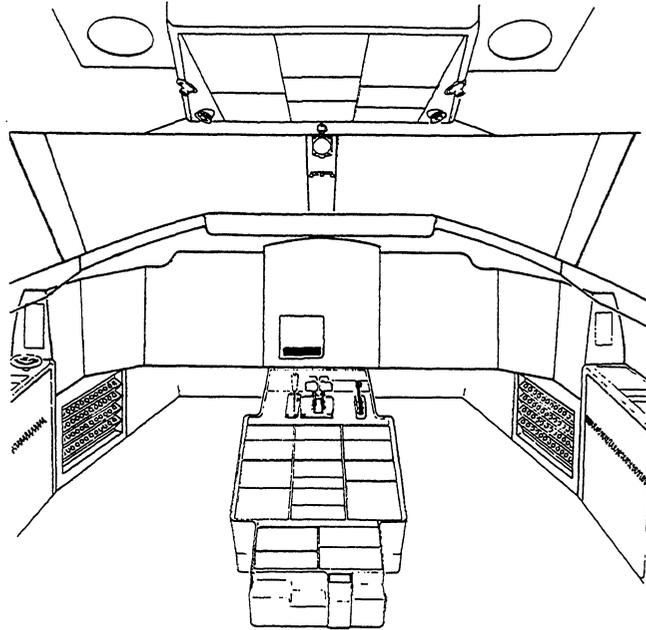
FREEZE SWITCH

When pressed, freezes the display and prevents updating. FRZ is displayed in the auxiliary field and flashes at 0.5 second intervals.

AZIMUTH STROBE SWITCH

When pressed azimuth strobe lines appear on the display.





WX (Weather mode)

When pressed radar is in weather mode and WX is displayed.

CYCLIC MODE

When pressed in WX or MAP mode high level targets flash at 0.5 second intervals. CYC is displayed and AGC is automatically selected.

STANDBY MODE SWITCH

Enables radar to be on without transmitting. During warmup period of 70 seconds WAIT is displayed, after which STBY is displayed.

MAP MODE

When pressed radar is in ground mapping mode and MAP is displayed.

RANGE/TEST SWITCH

Provides six range positions from 10 to 300 nautical miles. In TEST position displays a test pattern.

TILT CONTROL

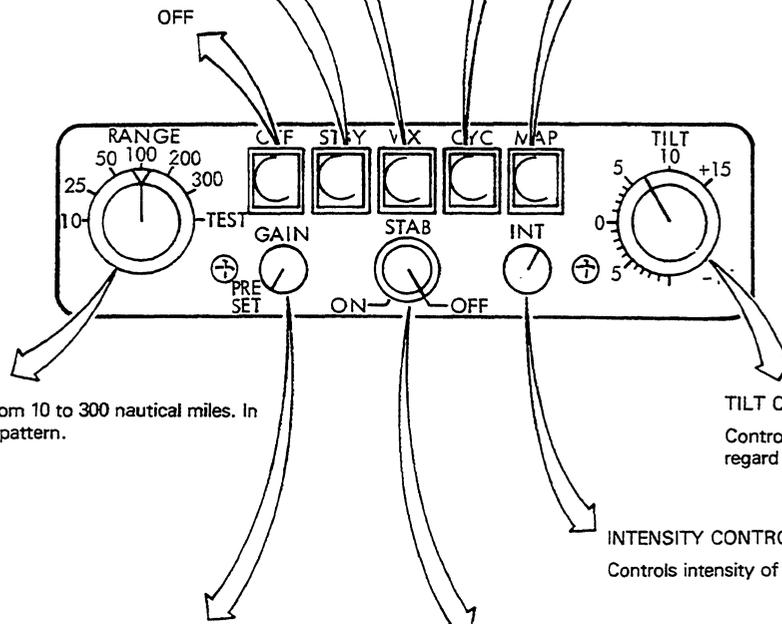
Controls angle of antenna beam tilt with regard to earth plane.

GAIN CONTROL

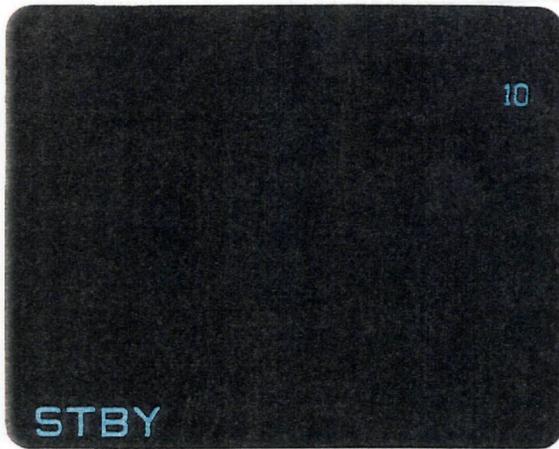
In PRESET automatic gain control is applied to the receiver. Out of PRESET manual gain is available.

STABILISATION

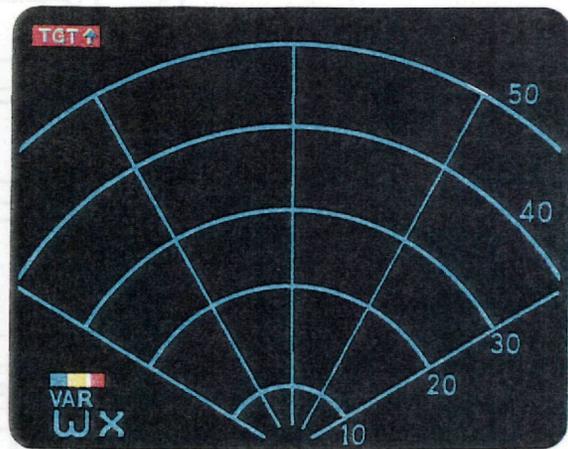
ON/OFF control of antenna stabilisation.



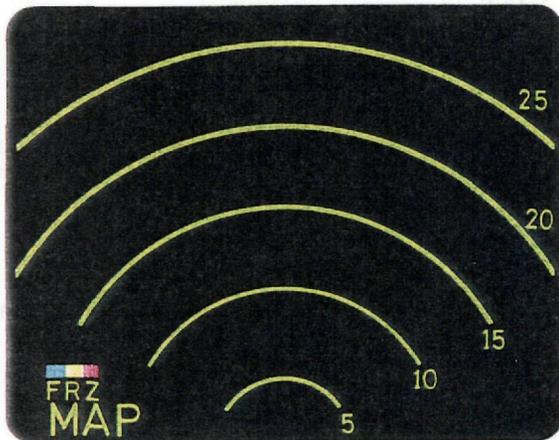
Indicator Controls
Figure 1 (Sheet 2)



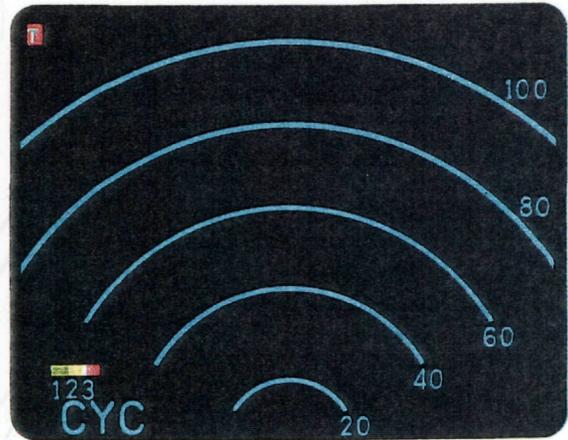
STANDBY MODE



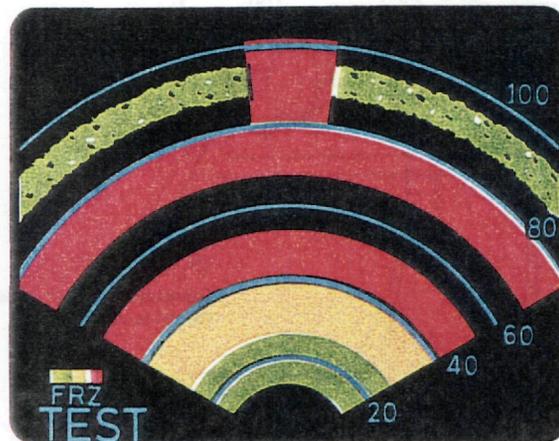
WX MODE WITH TARGET ALERT DISPLAYED



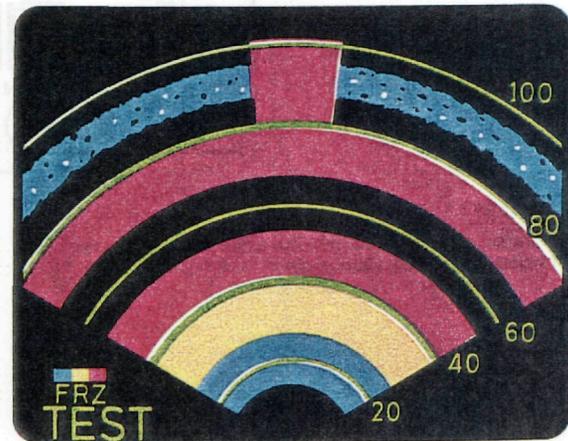
MAP MODE



CYCLIC MODE



TEST PATTERN IN WX MODE



TEST PATTERN IN MAP MODE

The antenna is stabilized in line of sight and controlled by a vertical gyro in pitch and roll. A tilt control enables any desired antenna beam angle between +15 degrees. This includes any elevation correction made by the stabilizing circuits. When the 60-degree SEL SCAN is selected the antenna scans at 28 scans per minute, and at 14 scans per minute in the 120-degree SEL SCAN.

B. Radio Altimeter Display (Figure 3)

The radio altimeter consists of a receiver-transmitter, a radio altimeter indicator, a transmit antenna and a receive antenna. The radio altimeter display is shown in Figure 3 (Sheet 1).

For aircraft 1021 and subs,
the radio altimeter display is shown in Figure 3 (Sheet 2).

The receiver-transmitter transmits a frequency modulated continuous wave (FM/CW) signal. The receiver receives a ground reflected signal and produces a signal with a frequency proportional to aircraft altitude.

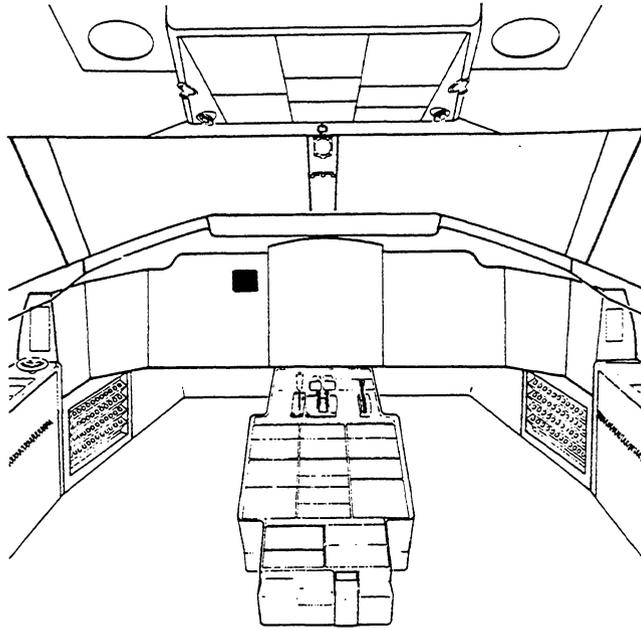
If the signal is strong enough to provide accurate data, it is translated into a dc analogue voltage which is fed to the RAD ALT indicator to drive the pointer display. The indicator sends a validity signal to the flight director computer. The dc analogue voltage is also fed to altitude trip circuits in the receiver-transmitter to provide gain programming to the autopilot during ILS approach (refer to SECTION 4, AUTOMATIC FLIGHT CONTROL SYSTEM).

If the strength of the signal is not sufficient to provide accurate altitude data, a bias voltage is sent to the RAD ALT indicator to drive the pointer off scale, and send a warning signal to the flight director computer.

A decision height knob, DH, allows the pilot to set a desired altitude. When the aircraft descends to this height, DH annunciators on the RAD ALT indicator and both attitude director indicators come on. The system, excluding the antenna, may be tested with the self-test switch on the indicator. A simulated 50-foot signal checks the accuracy of the system. If the DH index is set below 50 feet the DH annunciators come on.

On aircraft 1021 and subs,
the radio altimeter display is included as part of the attitude director indicator (ADI). The receiver-transmitter and the antennas are the same as in the basic aircraft.

The four-digit, incandescent display on the ADI indicates the aircraft radio altitude from -20 to 2500 feet. Resolution above 200 feet of altitude is 10 feet and below 200 feet resolution is 5 feet. For altitudes above 2500 feet, the display is blanked. When the radio altitude data is invalid, the display indicates a dash in each digit.

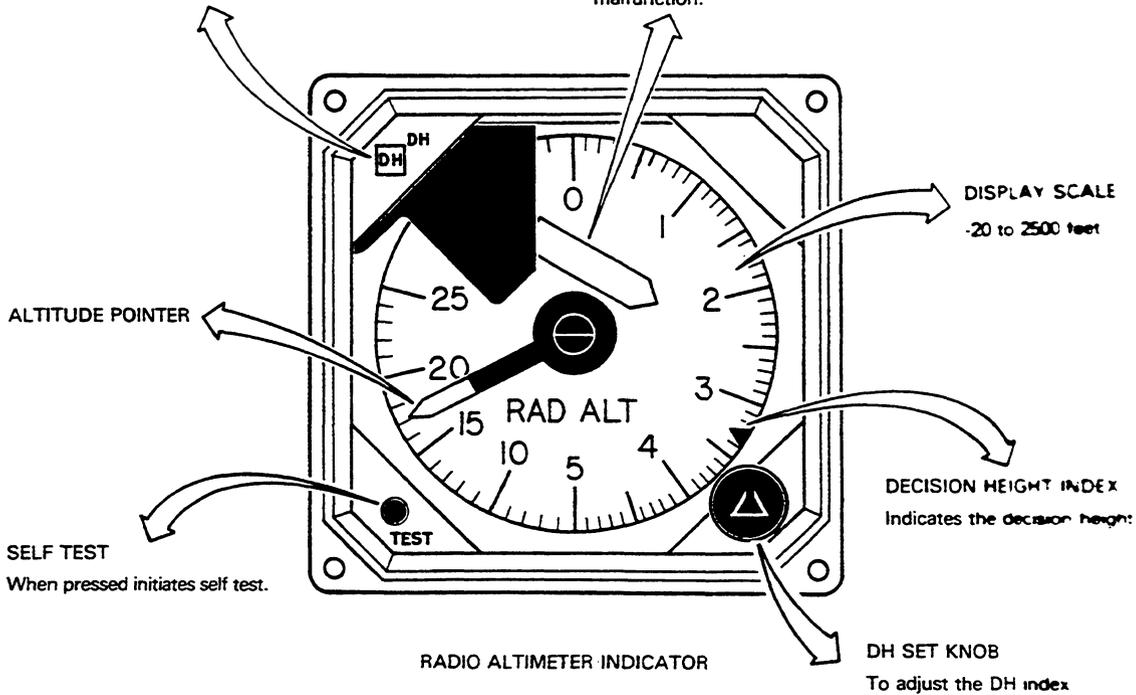


DH ANNUNCIATOR

Comes on when aircraft reaches the decision height.

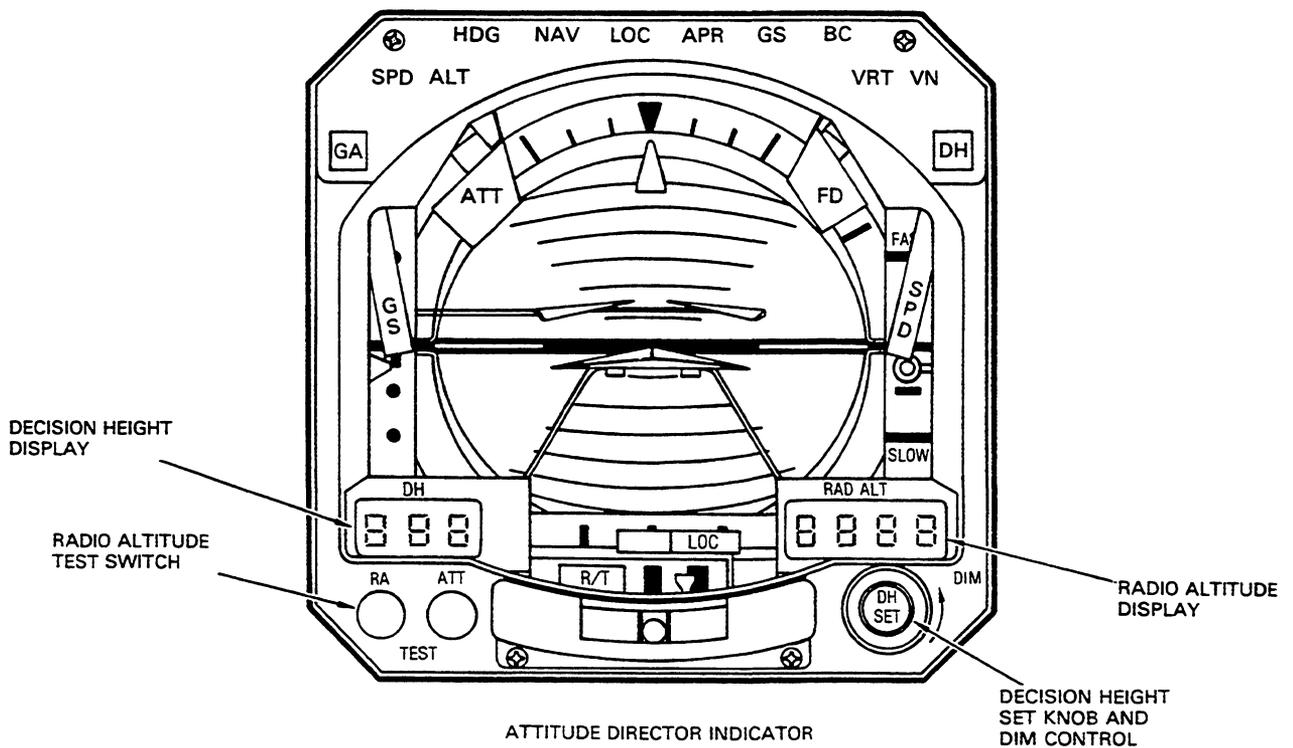
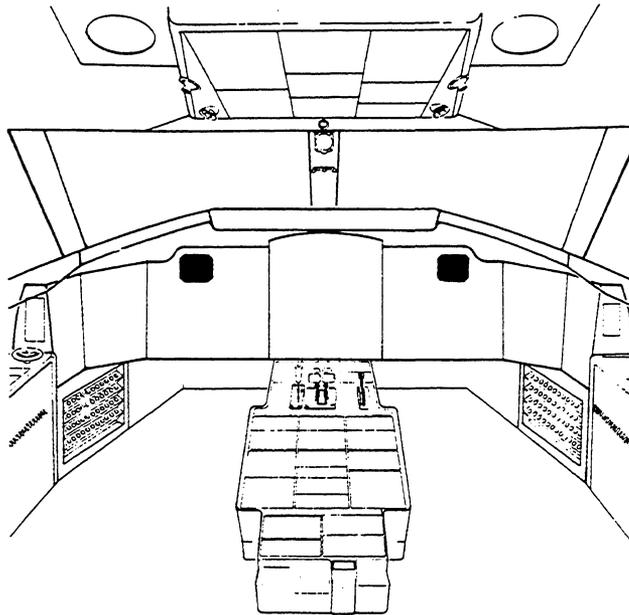
FLAG

When in view indicates system malfunction.



EFFECTIVITY: A/C 1004 TO 1020

Radio Altimeter Display
Figure 3 (Sheet 1)



EFFECTIVITY: A/C 1021 & SUBS

Radio Altimeter Display
Figure 3 (Sheet 2)

A composite control knob on the ADI provides for setting decision height and adjusting display brightness. The inner knob, DH SET, is used to set an altitude between 0 and 990 feet on the decision height (DH) display. The outer knob, DIM, controls the brightness of the RAD ALT and DH displays.

Decision height on the ADI is indicated on a three-digit incandescent display and indicates the preselected radio altitude between 0 and 990 feet that is set by the DH knob. Display resolution is 10 feet. When the aircraft is at or below the decision height, the DH annunciator comes on to warn the pilot.

A radio altitude (RA) test switch is used to initiate a test sequence. When the RA test switch on the ADI is pressed, the test sequence on the ADI RAD ALT and DH displays is initiated.

The RAD ALT display, during the test, initially shows four-eights, then changes to four-dashes and finally changes to the test altitude. The test altitude remains on the RAD ALT display until the test switch is released, then the actual altitude is displayed.

The DH display, during the test, initially shows three-eights and then reverts to the current set DH value for the remainder of the test.

The test sequence is inhibited after the ADI GS mode annunciator comes on (APR CAP engage).

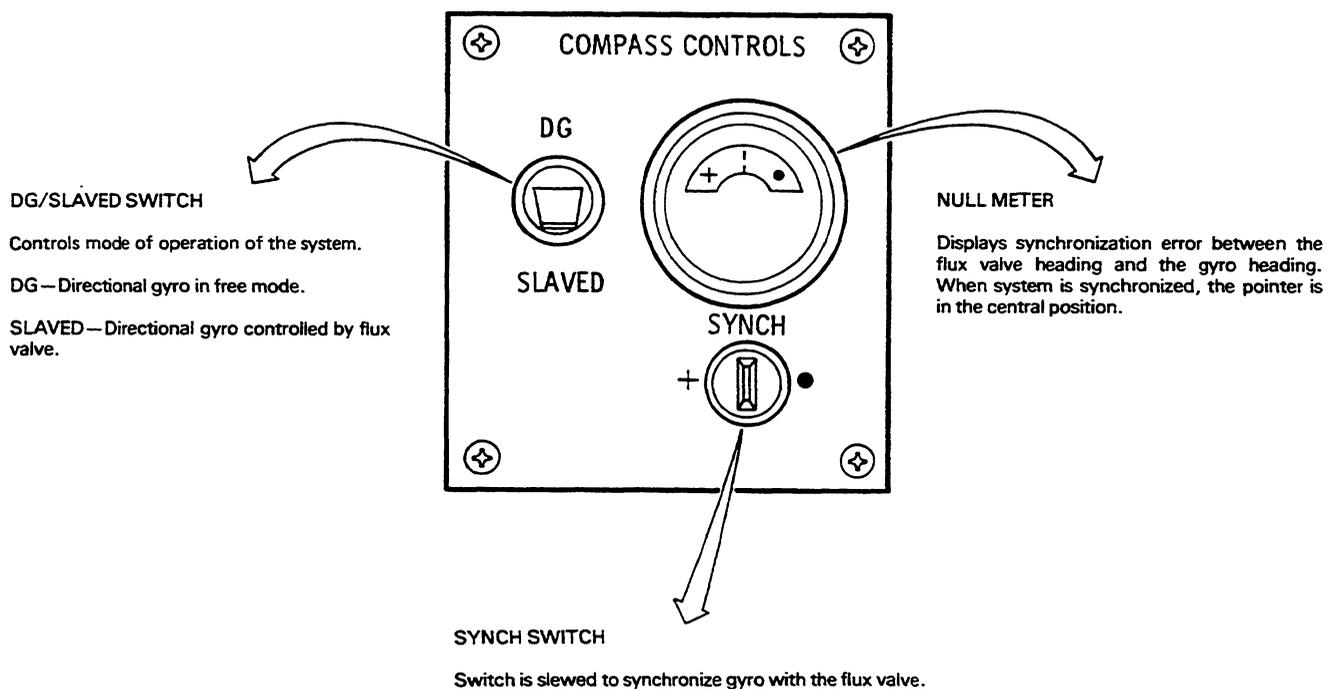
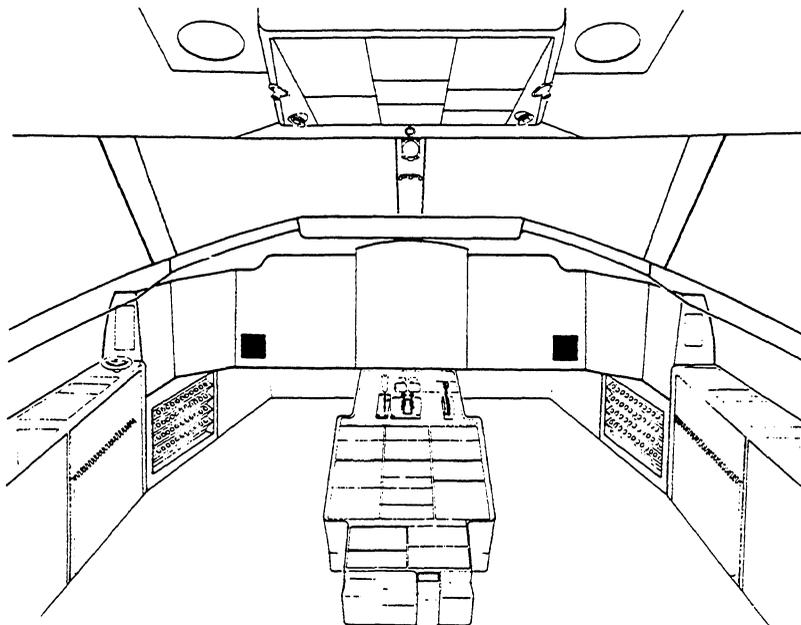
C. Gyro Compass

The compass system provides a continuous magnetic heading reference for aircraft navigation. It is a dual system consisting of two flux valves, a dual compensator, two directional gyros, two control panels and two synchronizer assemblies.

The flux valves are magnetic azimuth detectors that sense the direction of the horizontal component of the earth's magnetic field relative to the longitudinal axis of the aircraft.

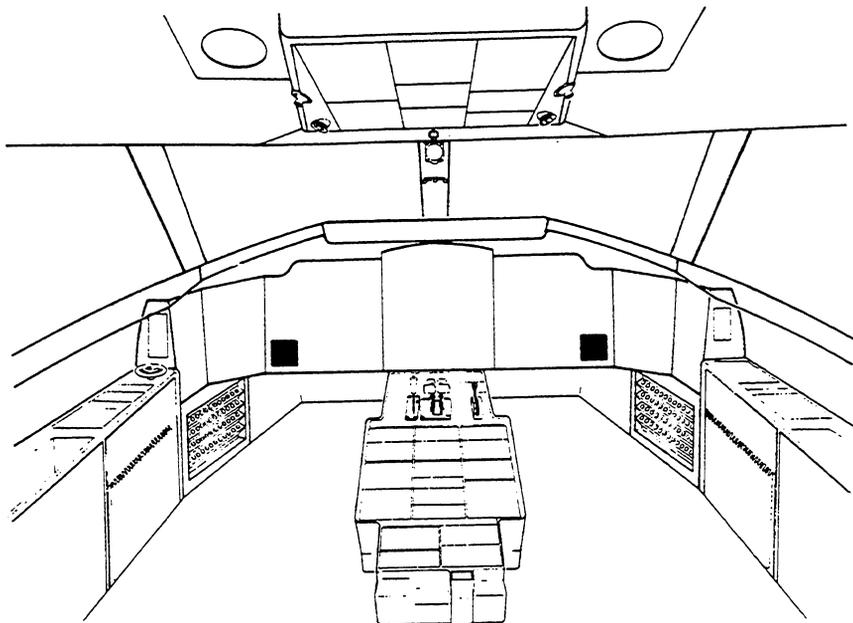
The dual compensator electrically compensates for single-cycle error. The two gyros and amplifier assemblies provide gyro stabilized heading references for the horizontal situation indicators (HSI), the radio magnetic indicators (RMI), navigation receivers and the autopilot.

Both control panels contain a mode switch, a slew switch and a null meter. Operation of the compass controls is described in Figure 4.



EFFECTIVITY: A/C 1004 TO 1020

Compass Control Panel
Figure 4 (Sheet 1)

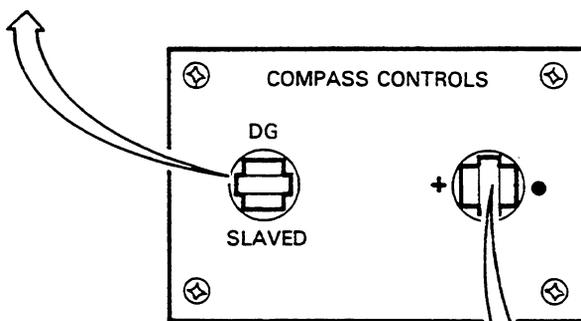


MODE SWITCH

Controls mode of operation of the system.

DG - Directional gyro in free mode.

SLAVED - Directional gyro controlled by flux valve.



SYNCH SWITCH

Switch is slewed to synchronize gyro with the flux valve.

EFFECTIVITY : A/C 1021 & SUBS

3. DEPENDENT POSITION DETERMINING SYSTEMS

A. VHF Navigation (Figures 5, 6, 7 and 8)

The VHF navigation system is a dual receiving system (NAV-1 and NAV-2) and operates in two modes, VHF omnirange (VOR) for enroute navigational guidance, and instrument landing system (ILS) for terminal guidance. The ILS consists of a localiser (LOC) receiver and a glidescope (GS) receiver. A marker beacon receiver is provided for distance-to-runway threshold information.

The VOR mode is operational when a VOR frequency is set on the navigation control unit and ILS is operational when a LOC frequency is set on the navigation control unit. The GS frequency is paired to the LOC frequency and is automatically tuned. The marker beacon receiver is operational in both modes.

(1) VOR Mode

NOTE: The following description applies to both systems. Only NAV-1 is described.

When the navigation receiver is tuned to a VOR frequency, the received signal is processed to produce an aural signal to identify the station received, a deviation signal and a bearing signal. The aural signal is fed to the intercom system and the bearing signal is fed to the pilots' HSI and RMI to drive the bearing pointer. A deviation signal is fed to the HSI and the flight director computer, and a TO/FROM signal to the HSI. A flag circuit monitors the output of the receiver and provides a validity signal.

(2) ILS Mode

The ILS mode provides terminal guidance using ground station localiser and glideslope transmitters. The received LOC deviation signal is fed to the course deviation bar on the pilot's HSI and the received GS deviation signal is fed to the vertical deviation pointer on the ADI. The receiver also provides LOC validity and GS validity signals which are fed to the flight director computer and to the HSI and ADI warning flags.

(3) Marker Beacon Receiver (Figure 9)

The marker beacon receiver provides visual and aural indication of the position of the aircraft when flying over the marker beacon radio

stations. As the aircraft passes the markers, an aural tone and an indicator light signal are produced as follows:

<u>MARKER</u>	<u>LIGHT</u>	<u>TONE</u>
Outer	OUTER (blue)	400 Hz
Middle	MIDDLE (amber)	1300 Hz
Inner	AIRWAY (white)	3000 Hz

A HIGH/LOW switch adjacent to the lights controls the sensitivity of the marker beacon receiver.

(4) VOR Test Mode

NOTE: The receiver is set to a VOR frequency and the course selector to approximately five degrees prior to testing.

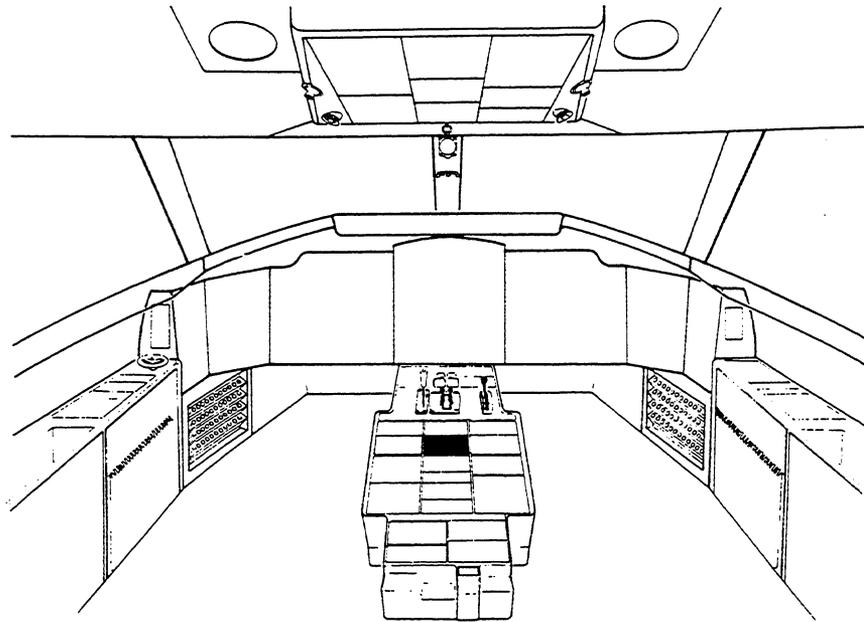
When the TEST switch on the NAV control unit is held in the NAV position and a VOR signal is present the following occurs: the HSI NAV mode flag remains out of view, the TO/FROM flag indicates TO and the course deviation bar centres. The RMI pointer indicates between 0 and 5 degrees magnetic bearing. The three marker lights flash and an aural tone is heard through the headphones/speaker.

When the TEST switch is released, the HSI NAV mode flag comes into view within one second and goes out of view within 5 seconds. The marker lights stop flashing and the system returns to the pretest condition.

If there is no VOR signal present when the test switch is set to NAV, the HSI NAV mode flag goes out of view after three seconds and the TO/FROM flag indicates TO. The RMI indicates between 0 and 5 degrees magnetic bearing. The marker lights flash and an aural tone is heard through the headphones/speaker. When the TEST switch is released, the HSI NAV mode flag comes into view, the RMI pointer parks and the marker lights go out within one second.

(5) ILS Test Mode

When the TEST switch is in the NAV position with a LOC signal present the following occurs; the HSI NAV mode flag stays out of view, the lateral deviation bar deflects one dot to the right and the GS deviation bar moves down one dot. The ADI GS deviation pointer moves down one dot and the expanded localizer pointer moves out of view to the right. The three marker lights flash and an aural tone is heard through the headphones/speaker.



NAV-1 FREQUENCY DISPLAY

Displays frequency chosen for the NAV-1 system. The DME-1 operates on the same frequency unless DME HOLD has been set prior to altering the NAV-1 frequency.

DME-1 HOLD PUSH SWITCH

When set to HOLD, the amber light comes on and the DME-1 frequency holds to enable the NAV-1 frequency to be altered without affecting the DME frequency.

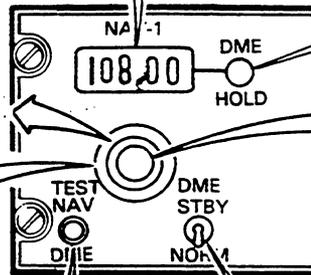
**NAV-1 DME-1
FREQUENCY SELECTOR**

Controls NAV-1 and DME-1 operating frequency.
Selector for tenths and hundredths of MHz.

Selector for tenths and units of MHz.

VOLUME CONTROL ON/OFF SWITCH

Switches NAV-1 and DME-1 on/off and controls volume of the audio signal to the headphones.



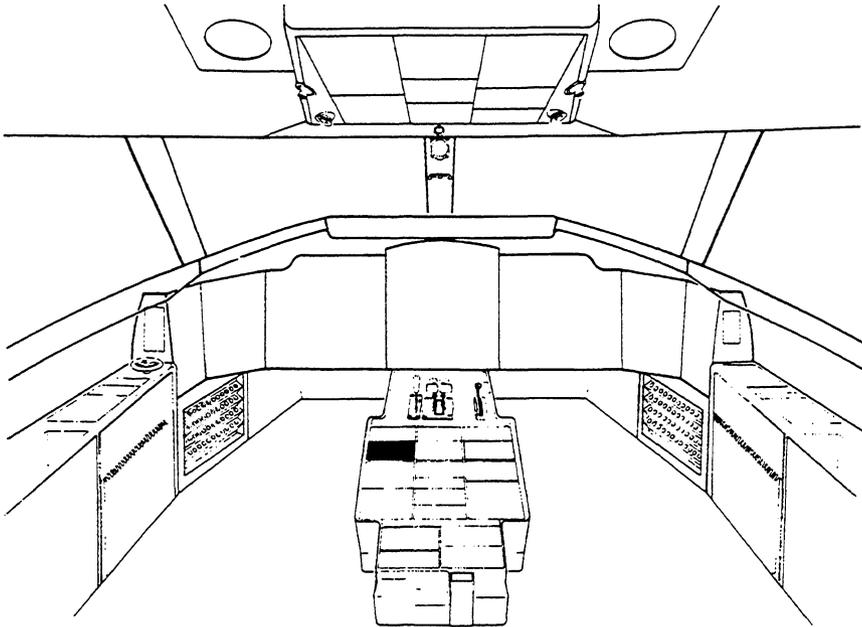
TEST SWITCH

Selects self test of NAV-1 or DME-1 system.

DME-1 STATUS SWITCH

In STBY power is applied to the DME-1 system but no transmission takes place. In the NORM position the DME-1 system is fully operational.

NAV-1 Control Panel
Figure 5



NAV-2 FREQUENCY DISPLAY

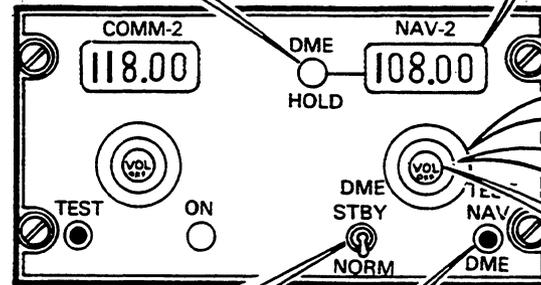
Displays frequency chosen for NAV-2 system. The DME-2 system operates on the same frequency unless DME HOLD has been set prior to altering the NAV-2 frequency.

DME-2 HOLD PUSH SWITCH

When set to HOLD the amber light comes on and the DME-2 frequency holds to enable the NAV-2 frequency to be altered without affecting the DME frequency.

NOTE

The COMM-2 controls are described in Section 6.



NAV-2 DME-2 FREQUENCY SELECTOR

Selector for tenths and units of MHz.

Selector for tenths and hundredths of MHz.

DME-2 STATUS SWITCH

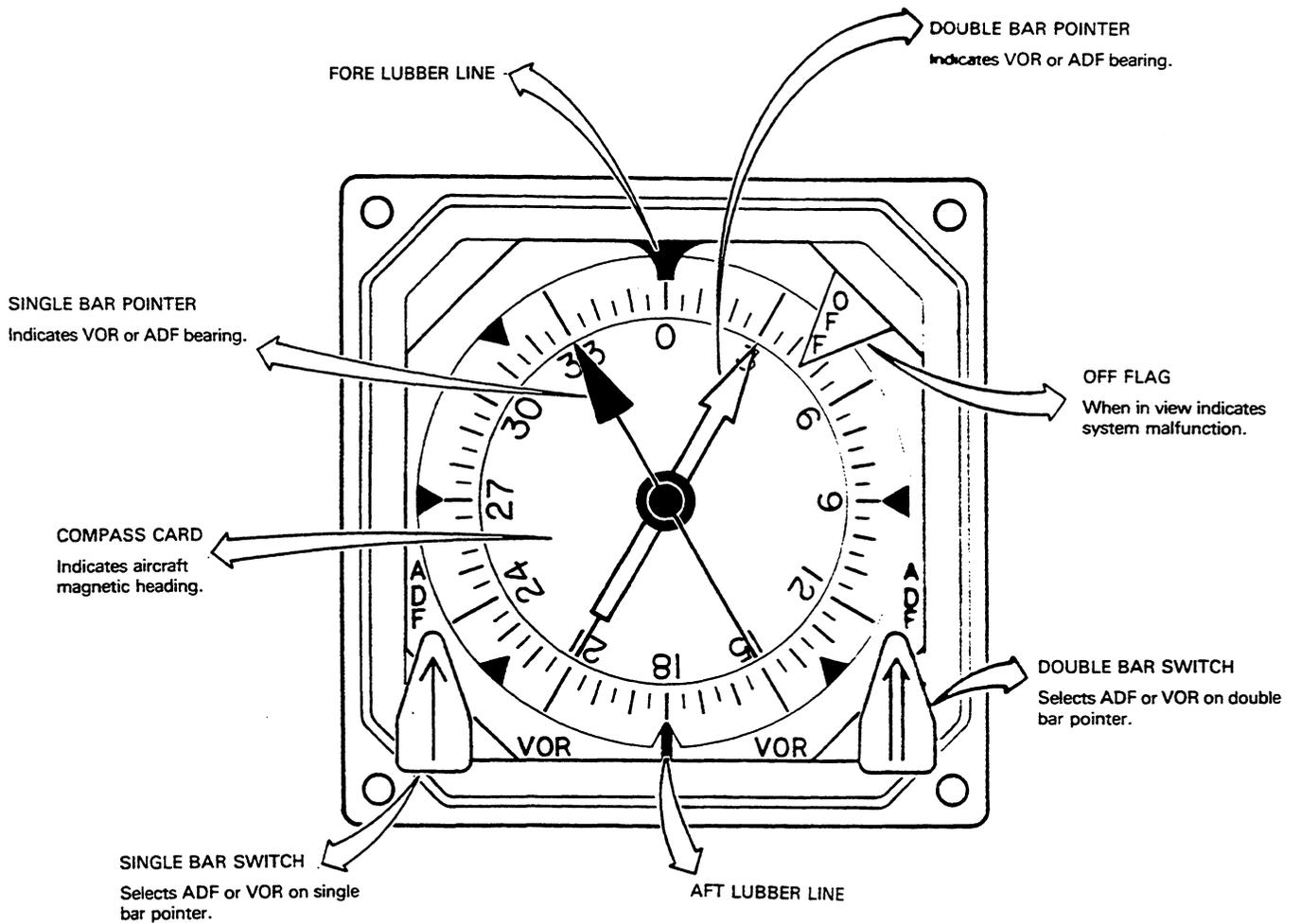
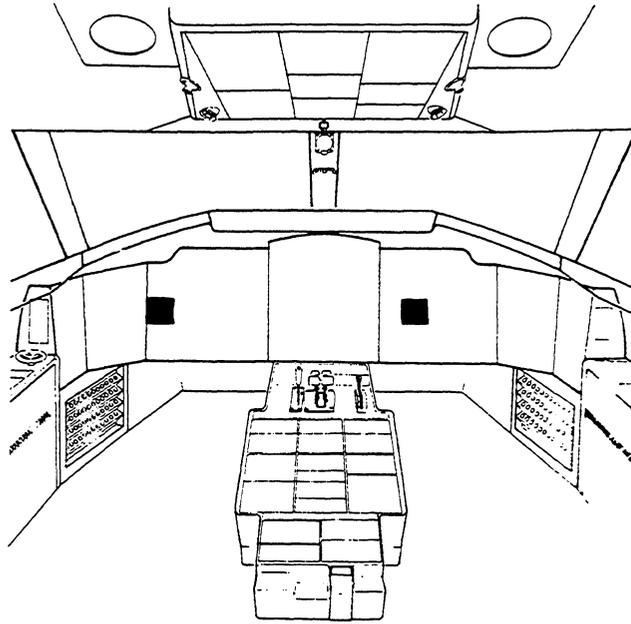
In STBY, power is applied to the DME-2 system but no transmission takes place. In the NORM position the DME-2 is fully operational.

VOLUME CONTROL ON/OFF SWITCH

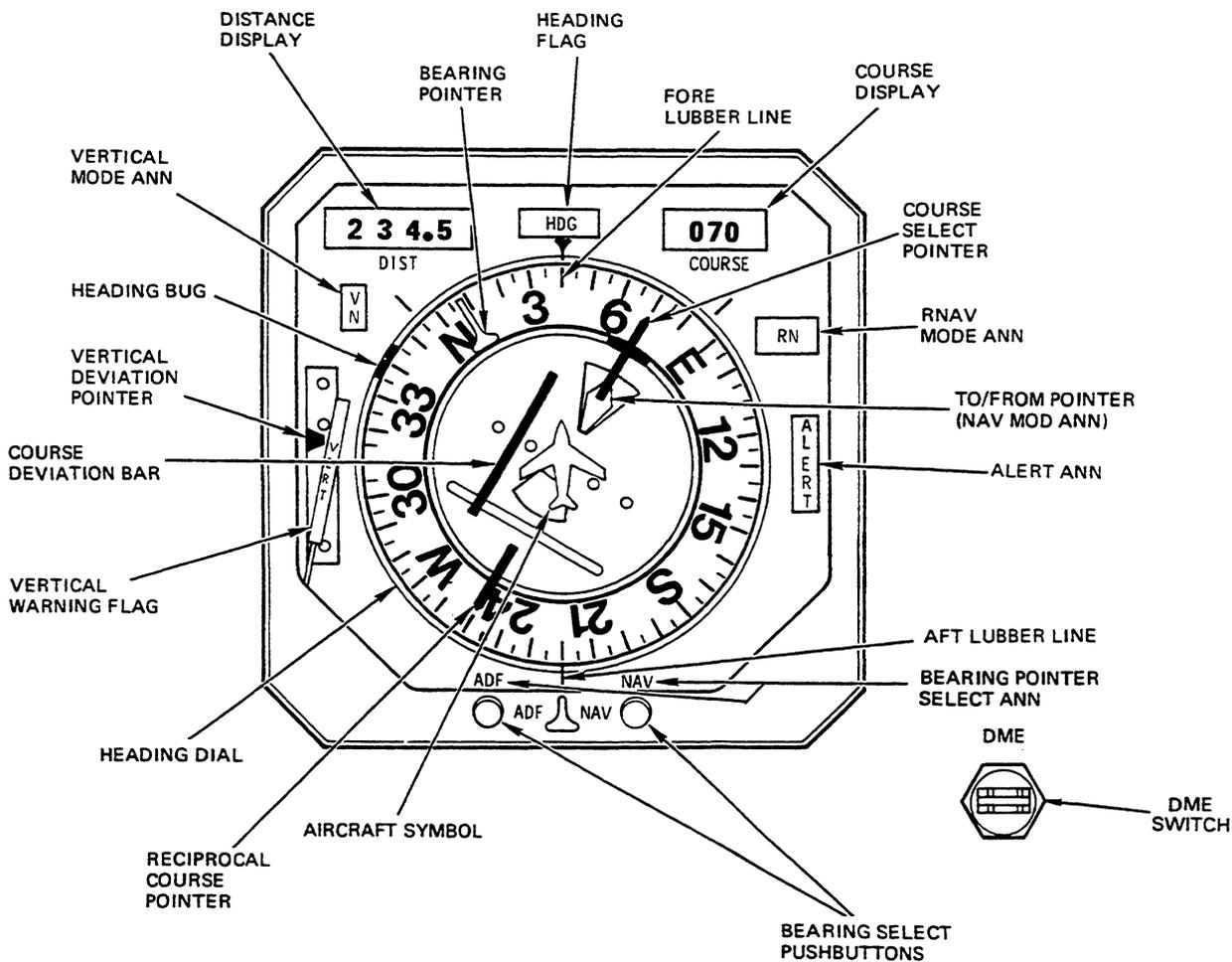
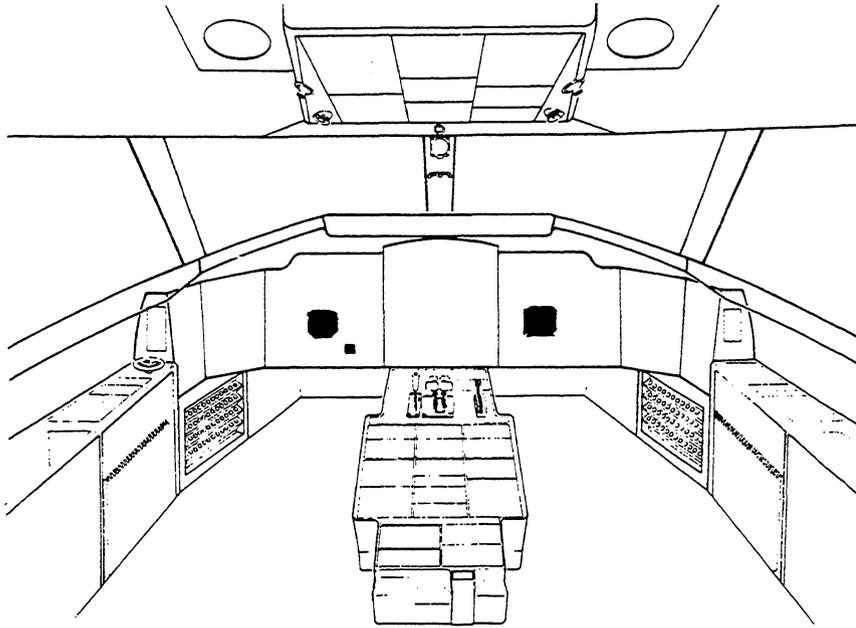
Switches NAV-2 and DME-2 on/off and controls volume of the audio signal to the headphones.

TEST SWITCH

Self test NAV-2 or DME-2 systems.

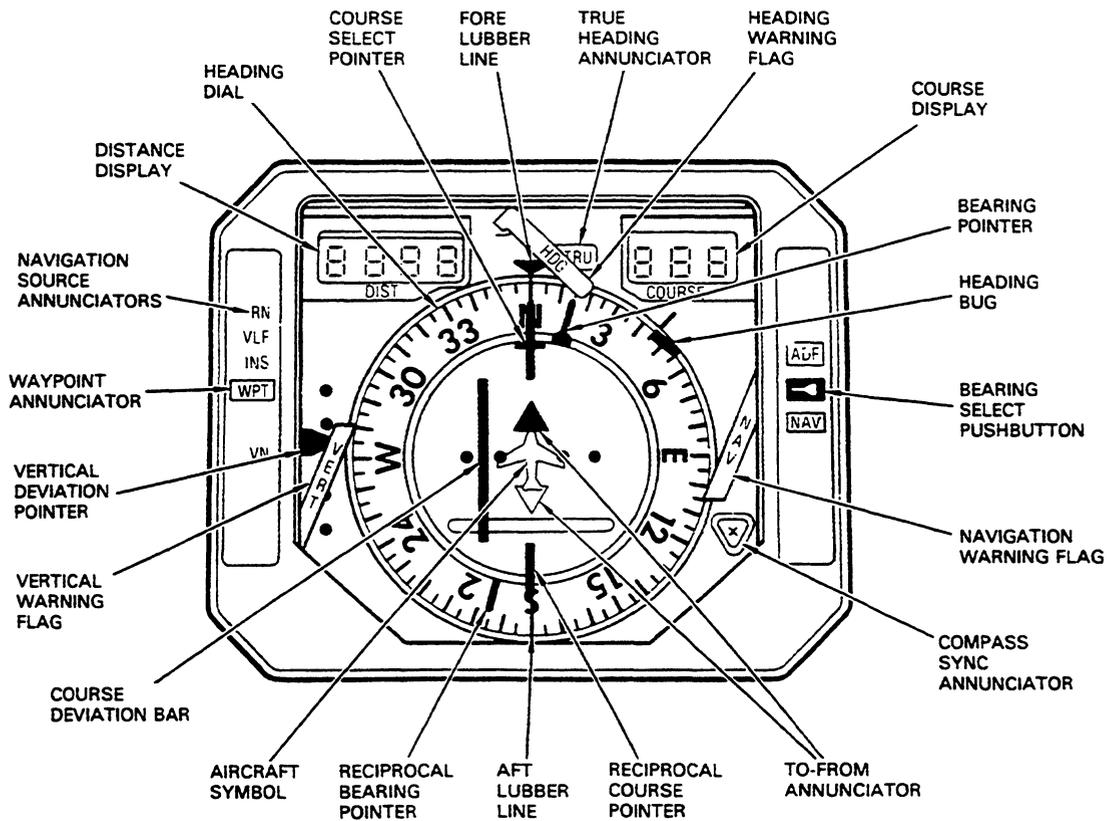
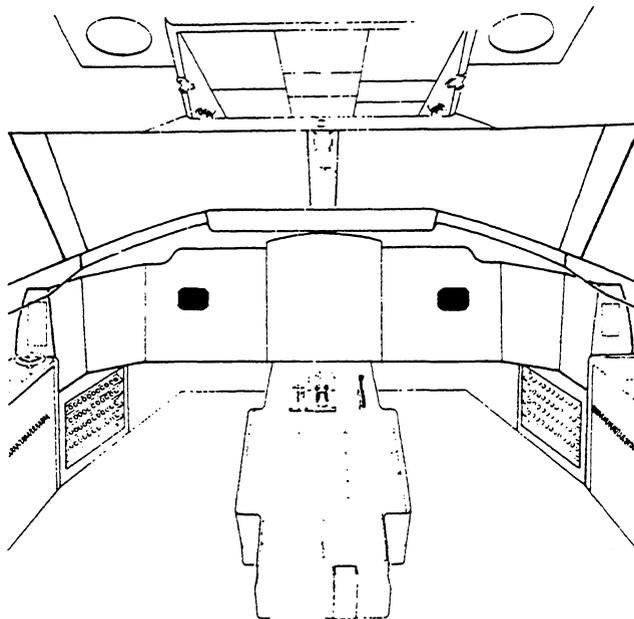


Radio Magnetic Indicator
Figure 7



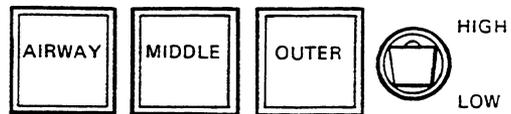
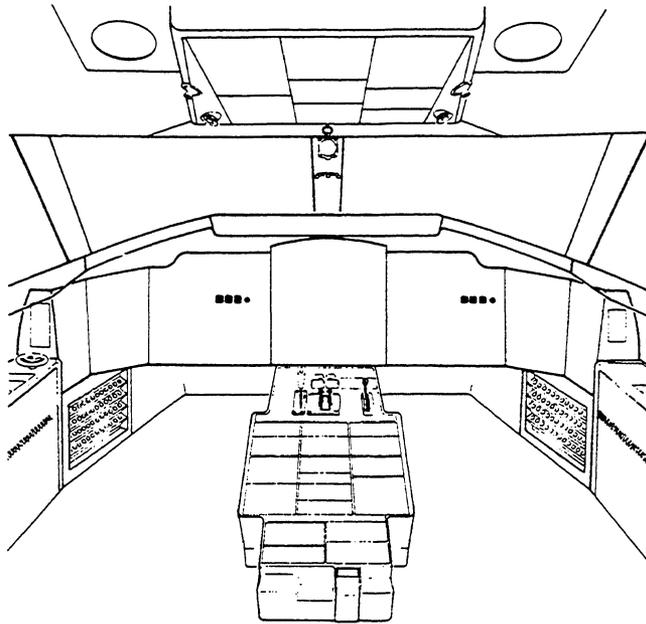
EFFECTIVITY: A/C 1004 TO 1020

Horizontal Situation Indicator
Figure 8 (Sheet 1)



EFFECTIVITY: A/C 1021 & SUBS

Horizontal Situation Indicator
Figure 8 (Sheet 2)



Marker Lights with High/Low Switch
Figure 9

When the TEST switch is released the HSI NAV mode flag comes into view within one second goes and out of view within five seconds. The marker lights go out and the system returns to the pretest condition.

If there is no LOC signal present when the TEST switch is in the NAV position, the HSI NAV mode flag goes out of view after three seconds, the lateral deviation bar moves one dot and the expanded localizer pointer moves out of sight to the right. The marker lights flash and an aural tone is heard through the headphones/speaker.

When the TEST switch is released the HSI NAV mode flag comes into view within one second, the lateral bar centres, the ADI GS deviation pointer parks and the expanded localizer pointer centres. The marker lights go out.

(6) Flight Director Switching

A two position switch on the flight director switching panel labeled CAPT FLT DIR, switches the pilot's flight director navigational information from NAV 1 in the normal position, to NAV 2.

(7) Automatic Flight Control System Interface

The navigation system is interfaced with the automatic flight control system through the NAV, APR and VORAPR switch/lights on the flight director mode selector (refer to Section 4).

(8) Instrument Comparator

The instrument comparator monitors compass heading information used by NAV-1 and NAV-2 system, localiser signals and glidescope signals. Should a predetermined difference be exceeded, individual annunciators, HDG, GS and LOC come on (refer to Section 4).

B. Automatic Direction Finder (Figure 10)

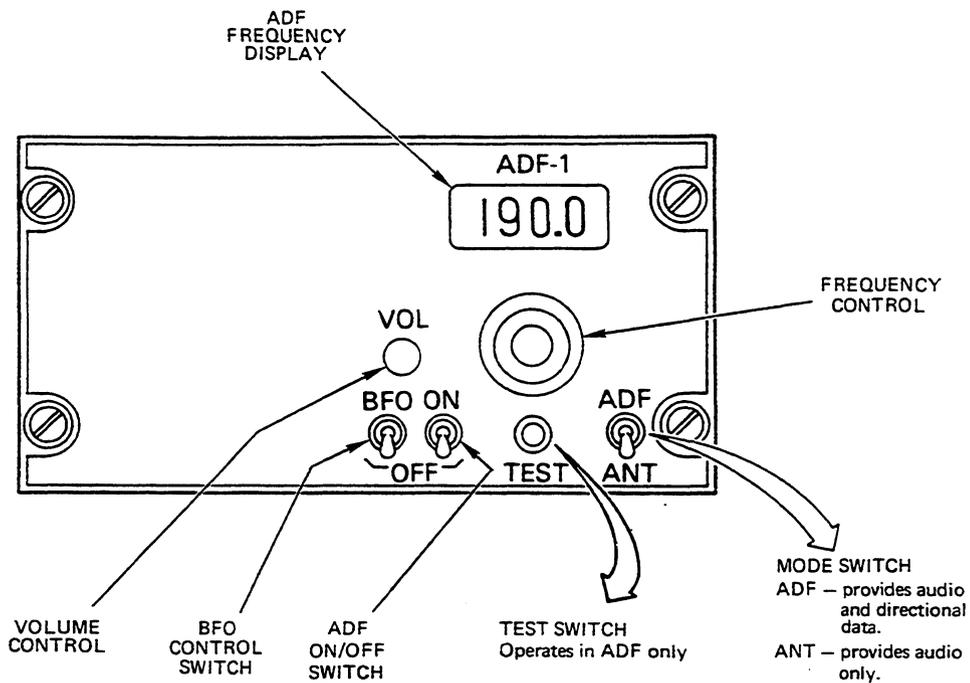
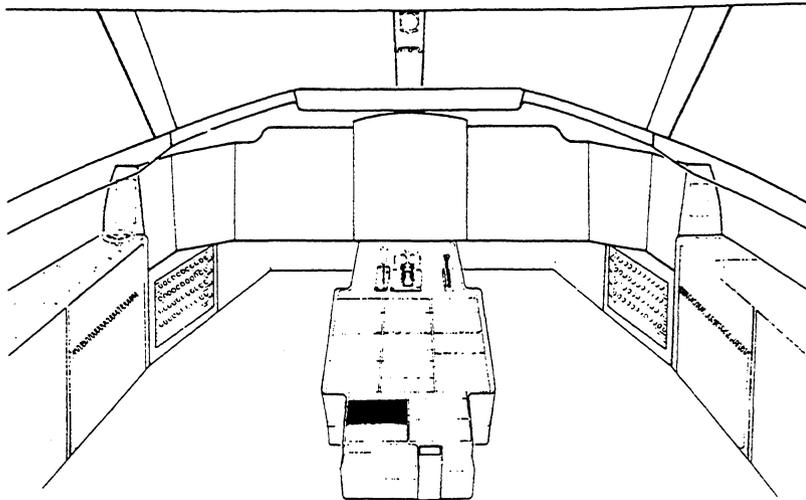
The ADF provides aural reception from selected ground stations and indicates relative bearing to that station. The station selected may be a non-directional beacon or standard AM broadcast station in the frequency range 190 to 1749.5 kHz.

The major units in the system are the combined sense and loop antenna, a receiver, and two radio magnetic indicators. There are three selectable switch positions:

ANT - Audio reception with RMI parked

ADF - Audio reception with RMI providing bearing

Tone - Beat frequency oscillator (BFO) in addition to ANT or ADF to enable CW reception.



ADF Control Unit
Figure 10

With the ADF switched on and the frequency tuned to the desired station the system functions as follows:

- In the ANT mode, the mode switch is in the ANT position to disable the loop antenna circuits and the BFO switch is set to OFF. The signal received by the sense antenna is fed to the receiver as an RF signal with no bearing information. The receiver processes the signal and passes it as an audio signal to the intercom system. As there is no bearing information the RMI pointer is parked in the horizontal position.
- In the ADF mode, the mode switch is in the ADF position and the BFO is off. Signals from the sense and loop antenna are sent to the receiver as radio frequency signals carrying bearing information. This is processed by the receiver which sends an audio output to the intercom system and bearing information to the pilot's RMI, the pilot's HSI, the copilot's RMI and the copilot's HSI.
- In the tone mode, the BFO is included in the ADF or ANT mode to receive CW signals for station identification.

The self-test facilities can only be operated in the ADF mode. When the test switch is operated the pointer rotates 90 degrees counter-clockwise from the existing position and returns when the test switch is released. A 1000-Hz tone is sent to the intercom system.

(1) VOR Interface

When the VHF NAV system is in the NAV mode the VOR sends a bearing signal to the RMIs. Two VOR/ADF switches mounted on the front of the indicator permit VOR or ADF bearing information to be displayed on the single bar and double bar pointers.

(2) Compass System Interface

When the compass system is valid, a validity signal is sent to the RMI and the heading flag is cleared. Magnetic heading is also fed to the RMI compass card which displays the aircraft heading against a fixed lubber line.

C. Distance Measuring Equipment

The DME is a dual system consisting of two DME receiver-transmitters and two antennas. When the DME is on in the NORM position, a coded interrogation signal is transmitted to the ground station, the ground station sends back a coded reply. The DME receives the signal and calculates the slant distance to the ground station from the time between the transmitted signal and the received signal. An analogue voltage

proportional to the slant distance is fed to the HSI as distance in nautical miles, to the flight director computer for gain programming and to the VNAV computer/controller for vertical navigation computations. The receiver section also uses the analogue voltage to produce a DME valid signal when the system is functioning correctly and the ground station is in range. If a valid signal is not available, dashes appear on the distance display on the HSI.

A DME-1/DME-2 switch, on the pilot's instrument panel, permits the pilot to select which system feeds the pilot's HSI, the flight director computers and the VNAV computer. The copilot does not have this facility.

A test switch, NAV/DME, on the NAV-1 and NAV-2 control units, allows the associated DME to be tested. When the test switch is set to DME, the distance display on the HSI reads either 000.0 or 000.1.

D. ATC Transponder (Figure 11)

The transponder (TRP) provides air traffic control (ATC) with coded identification and altitude data.. The system consists of two transponders, two antennas and one control unit. When the transponder is selected to operate in mode A, only the selected code identification signal is transmitted. When mode C is selected, aircraft altitude is added to the identification signal. The identification code is set on the control unit and the altitude data is fed to the transponder when the ALT/OFF switch is in the ALT position.

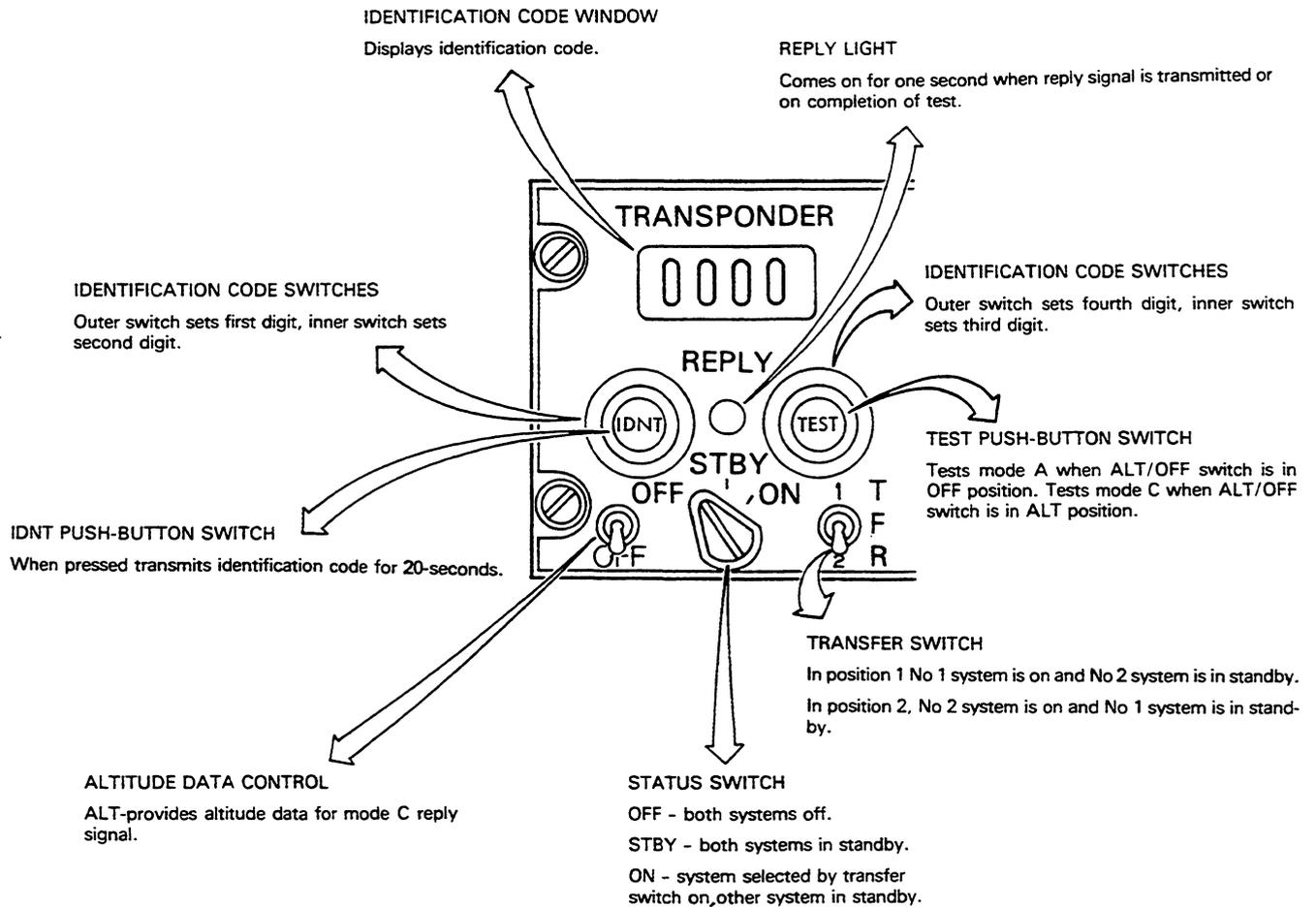
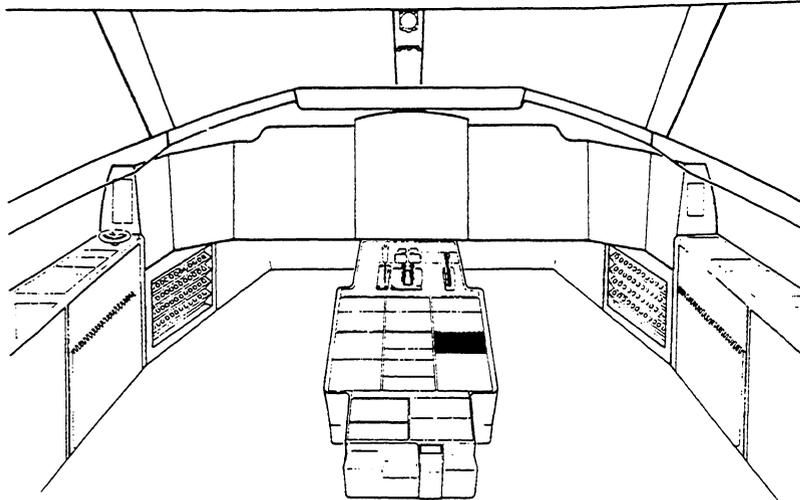
On receipt of an interrogation signal the TRP tests the validity of the received signal. If it is in mode A or mode C, it responds with the appropriate coded information. Each time the TRP replies the REPLY lamp comes on for one second. If requested by ATC the pilot can momentarily press the IDENT push switch, to extend the transmitted reply to 20 seconds.

The TEST push-button switch tests mode A if the ALT/OFF switch is in the OFF position and mode C if in the ALT position. The REPLY lamp will come on to indicate the system is functioning correctly.

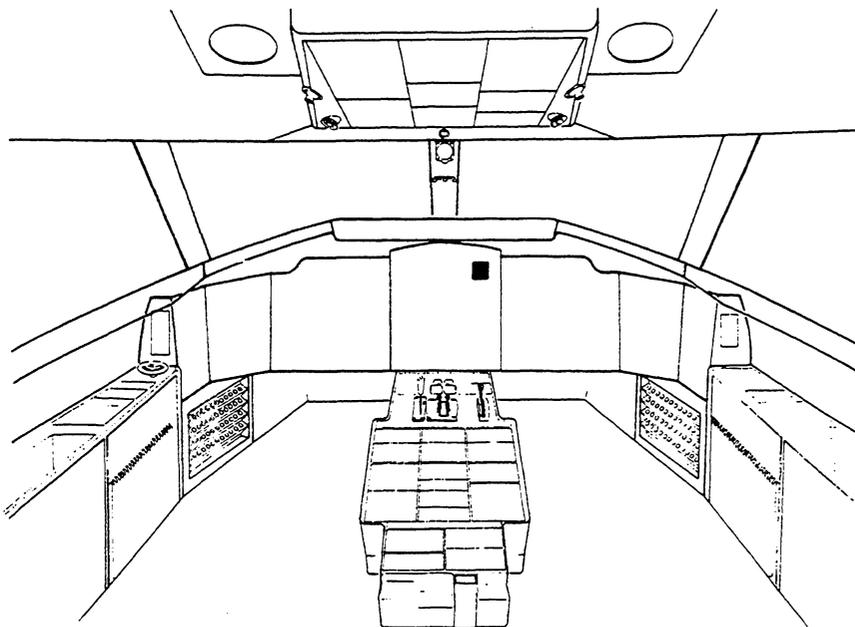
4. MISCELLANEOUS INSTRUMENTS

A. Digital Clock

The digital clock is described in Figure 12.



Transponder Control Unit
Figure 11



SET SWITCH

UP - advances clock one second for each second held.

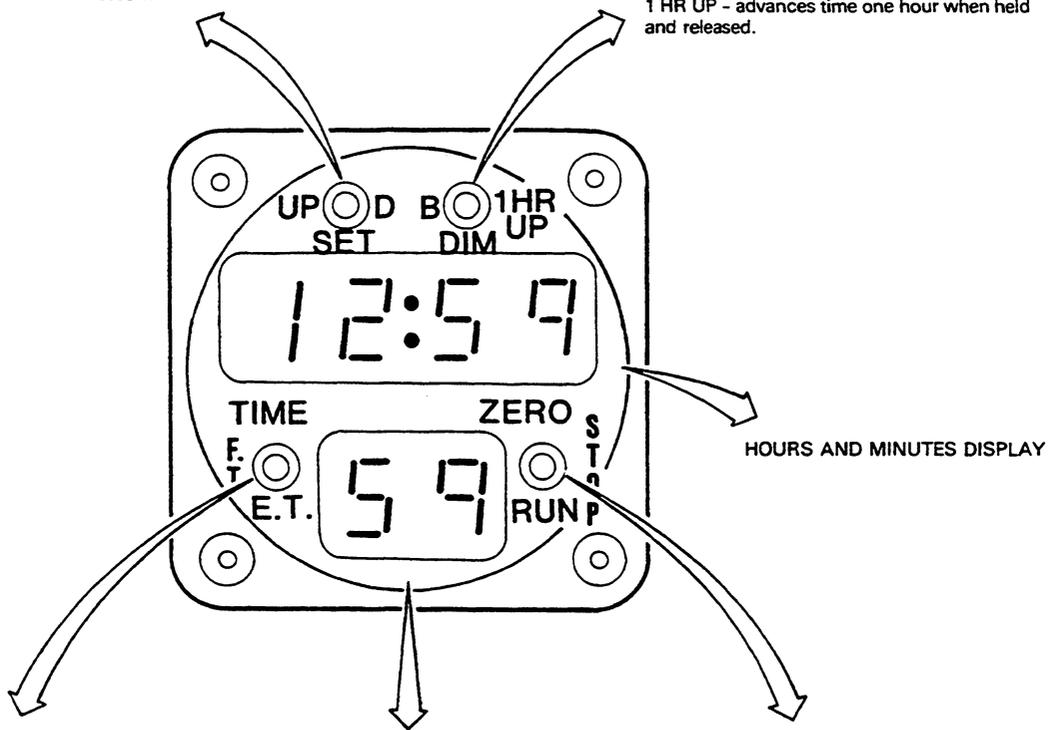
D - retards clock one second for each second held.

BRIGHT/DIM SWITCH

B - brightens display.

DIM - dims display.

1 HR UP - advances time one hour when held and released.



TIME SWITCH

TIME - displays selected standard time.

F.T. - displays flight time.

E.T. - displays elapsed time.

SECONDS DISPLAY

ELAPSED TIME SWITCH

RUN - starts elapsed time meter.

STOP - stops elapsed time meter.

ZERO - returns elapsed time meter to zero when held and released. Also returns flight time meter to zero when the aircraft is on the ground.

Digital Clock
Figure 12