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Volume II

LEVEL II

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TANKER AVIONICS/AIRCREW COMPLEMENT EVALUATION (TAACE)

PHASE I - SIMULATION EVALUATION

Volume II: Crew System Design

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FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
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This technical report has been reviewed and is approved for publication.

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Horizontal Situation Display	Crew Complement	Aerial Refueling
Multi-Purpose Display	Navigator	Boom Operator's Station
		Control/Display Criteria

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report documents a cockpit simulation study conducted to validate the pilot useability of a 3-man (pilot, copilot, boom operator), KC-135 crew system concept. Earlier analysis and mockup evaluation studies had established preliminary design criteria and control display arrangements. The effort reported herein draws upon this earlier work, and through full mission simulation, validates display formats, cockpit hardware arrangements and crew procedures. In addition, a "KC-135 Crew System Criteria" document (AFWAL-TR-81-3010) was written deriving from mission statements and control display research, design

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criteria for operating the tanker with a reduced crew. The report consists of 2 volumes; Volume I: RESULTS, and Volume II: CREW SYSTEM DESIGN.

FOREWORD

This report documents the second phase of a two-phase effort called the Tanker Avionics/Aircrew Complement Evaluation (TAACE) Program. The results obtained from a full mission simulation of an updated avionics configuration for the KC-135 tanker are reported herein. These results concern the development of the crew station avionics criteria to be met for a 3-man crew complement (pilot, copilot, boom operator) completing all KC-135 mission requirements without compromise to either mission performance or aircraft operational safety.

The program was conducted in support of the Aeronautical Systems Division, KC-135 Avionics Modernization Program (ASD/AFW) managed by Mr. Tom Biggs, by the Air Force Wright Aeronautical Laboratory's Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio. The Program Manager was Mr. Richard Moss, (AFWAL/FIGR). Lts Donald Seyler and Dan Basehore, both of the Crew Systems Development Branch (AFWAL/FIGR), were also involved with the Program.

The report was prepared in part by the Bunker Ramo Corporation, Electronic Systems Division, and Human Factors Group located at Dayton, Ohio, under USAF Contract No. F33615-78C-3614, Project No. 23915200. Mr. Robert A. Bondurant, III (AFWAL/FIGR) is the contract monitor.

The authors wish to acknowledge the assistance from Mr. George Sexton, the Lockheed Corporation, Marietta, Georgia, (formerly with Bunker Ramo Corporation), for his critical contributions in virtually every aspect of this program. Recognition is also given to the following members of the Control Synthesis Branch (FIGD): Ms. K. Adams for simulation software/hardware design, integration and program management; Lt J. Tizard for critical software/hardware design and interface; Mr. T. Christensen and Lt D. Hawthorne for essential software/hardware design interface; and Mr. D. Lair for his consultation and expertise in software/hardware design and interface problem solving. Further recognition is extended to the on-site Lear Siegler (LSI) group, headed by Mr. R. Hitchcock with Mr. A. LeDonne managing the engineering simulation hardware fabrication/integration. Radar landmass engineering buildup and integration headed by Mr. J. Vesco also of LSI. Recognition is also given to the Electronic Associates Inc. (EAI) on-site support group headed by Mr. D. Cafferty, for their computer systems support. Mr. John Kozina (Bunker Ramo) and Mr. Fritz Baker (Lear Siegler) are recognized for engineering assistance in experimental equipment integration; and Cindy Gier and Sandy Dickey (Bunker Ramo) for untiring administrative support.

This research effort was performed between June 1979 and June 1980.

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LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

A/A	Air to Air
AC	Alternating Current
ADF	Automatic Direction Finding
ADI	Attitude Director Indicator
AFB	Air Force Base
AFTO	Air Force Tech Order
AFWAL	Air Force Wright Aeronautical Laboratory
AHRS	Attitude Heading Reference System
AIC 10	Interphone Unit
AIC 18	Interphone Unit
AOA	Angle of Attack
A/P	Autopilot
APP	Approach
APN 59	Search Radar
APN 69	Beacon Radar
APU	Auxiliary Power Unit
AR	Air Refueling
ARA	Airborne Radar Approach
ARCP	Air Refueling Control Point
ARCT	Air Refueling Control Time
ARIP	Air Refueling Initial Point
ATC	Air Traffic Control
BAR	Begin Air Refueling
BDHI	Bearing Distance Heading Indicator
BO	Boom Operator
BRG	Bearing
BRT	Bright
CADC	Central Air Data Computer
CAS	Calibrated Airspeed
CCW	Counter Clockwise
C/D	Control/Display
CDI	Course Deviation Indicator
CDU	Control/Display Unit
CLR	Clear
CG	Center of Gravity
CLTR	Clutter
CMPTR	Computer
COMM	Communication
CON	Contrast
CONUS	Continental United States
CP	Copilot
CRS	Course
CRT	Cathode Ray Tube
CTR	Contour
CURS	Cursor
C/W	Caution/Warning
DC	Direct Current
DF	Direction Finder
DFT	Drift
DIR	Direct

LIST OF ABBREVIATIONS
(Continued)

DIST	Distance
DME	Distance Measuring Equipment
DOT	Operations/Training Office
DR	Dead Reckoning
E	East
EAR	End of Aerial Refueling
EGT	Exhaust Gas Temperature
EMP	Electromagnetic Pulse
EPR	Engine Pressure Ratio
EWO	Emergency War Order
FAF	Final Approach Fix
FD 109	Flight Director
FDL	Flight Dynamics Laboratory
F/F	Fuel Flow
FIGD	Control Synthesis Branch
FIGR	Crew Systems Development Branch
FL	Flight Level
FLT	Flight
FM	Frequency Modulation
FZ	Freeze
GA	Go Around
GCI	Ground Controlled Intercept
GMT	Greenwich Mean Time
GS	Groundspeed
HF	High Frequency
HSD	Horizontal Situation Display
HSI	Horizontal Situation Indicator
IAF	Initial Approach Fix
IAS	Indicated Airspeed
IC	Intercom
ID	Identification
IFF	Identification, Friend or Foe
IFF/SIF	Identification, Friend or Foe/Selective Identification Feature
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INB	Inbound
INS	Inertial Navigation System
IP	Instructor Pilot/Initial Point
JN	Jet Navigation
LOC	Localizer
MACH	Percent of Speed of Sound
MLD	Mildenhall
MGT	Management
MHz	MegaHertz
MPD	Multipurpose Display
MRT	Military Rated Thrust
N	North
NATO	North Atlantic Treaty Organization
NAV	Navigation/Navigator

LIST OF ABBREVIATIONS
(Concluded)

NM	Nautical Miles
OAT	Outside Air Temperature
OP	Operator
P	Pilot
PMD	Program Management Directive
PPSN	Present Position
RADAR	Radio detecting and ranging
RAF	Royal Air Force
RDAFB	Royal Danish Air Force Base
RDR	Radar
REC	Receiver
RGA	Rotate and Go Around
RMI	Radio Magnetic Indicator
RNAFB	Royal Norweigan Air Force Base
RNG	Range
ROC	Required Operational Capability
RPM	Revolutions Per Minute
RPT	Repeat
R/T	Receiver/Transmitter
RZ	Rendezvous
RZIP	Rendezvous Initial Point
S	South
SAC	Strategic Air Command
SELCAL	Selective Call
SKE	Station Keeping Equipment
SSB	Single Side Band
SXV	Saxa Vord
TAACE	Tanker Avionics/Aircrew Complement Evaluation
TAC	TACAN
TACAN	Tactical Air navigation
TAS	True Airspeed
TK	Track
TOLD	Take-Off and Landing Data
TRT	Take-Off Rated Thrust
U-1	UHF #1
U-2	UHF #2
UHF	Ultra High Frequency
UK	United Kingdom
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
V NAV	VHF Navigation
VOR	VHF Omnidirectional Range
VVI	Vertical Velocity Indicator
W	West
WPT	Waypoint
WX	Weather
XPH	Plans Office

SUMMARY

The USAF is considering an avionics modernization program for the KC-135 fleet and is also considering the feasibility of operating the KC-135 without a navigator (SAC ROC 5-74 w/amendments). In response to a request from the Aeronautical Systems Division, the Flight Dynamics Laboratory has recently completed a full mission simulation in which operationally qualified SAC tanker crews validated a KC-135 cockpit configuration designed to permit operating the tanker without a navigator throughout its broad spectrum of mission tasks. Critical to the success of this effort is the fact that prior to full mission simulation, three candidate crew system concepts were developed and evaluated by nine SAC aircrews during preliminary mockup studies in which the crew useability/acceptability of the three original designs was assessed. While all three designs remained responsive to the mission and manning requirements, they differed considerably in control and display sophistication and therefore, total system cost. This development of alternative designs permitted early exploration of trade-offs between cockpit/crew system capability, mission capability, and cost information necessary for resolving the feasibility issue. The assessment process carried out in a full-scale three dimensional mockup of the tanker flight deck, determined that there were desirable and undesirable characteristics of all three designs. These mockup results were used to develop a fourth "composite" configuration, attempting to specify an optimum system; the most capability for the best price. The composite configuration was evaluated in a full mission simulation lasting three months. Each crew participated for a total of 60 hours, spent in ground school training learning the new systems and procedures, practicing flying the simulator, and data collection. Data collection sessions required that the crews fly the airplane, rendezvous with various types of receivers and offload fuel during representative mission profiles, perform mission communications (ATC, receivers, etc.) and accomplish cockpit procedures and checklists. The simulation work validated the acceptability of the composite design. A consensus was reached among the participating crew members that it was feasible for the reduced crew complement to complete all tasks and perform the SAC KC-135 tanker mission if the capabilities represented in the composite design were provided.

SECTION I

INTRODUCTION

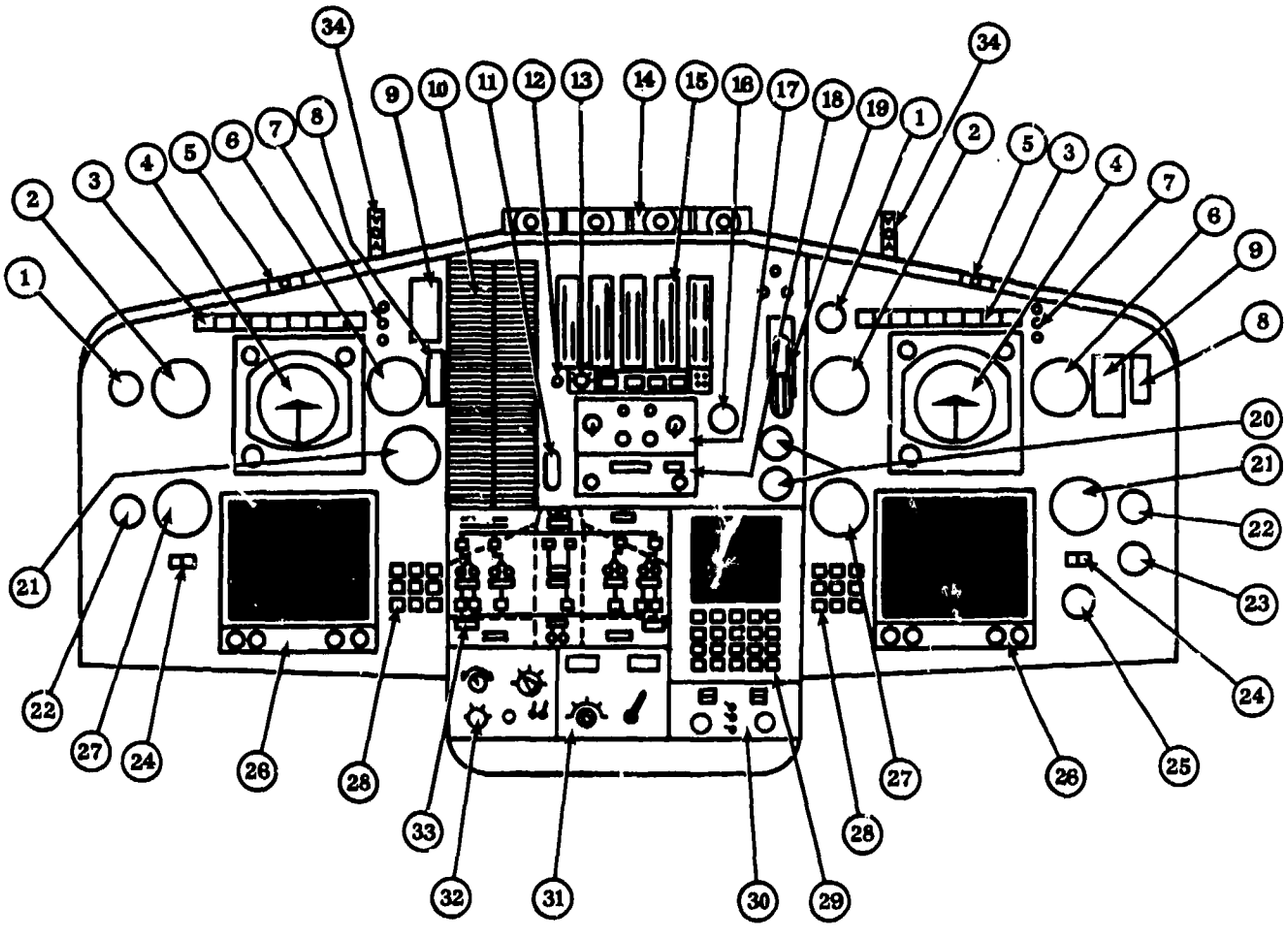
The contents of this volume describe new or modified aircrew systems for the KC-135. These systems possess the capabilities needed to fly the KC-135 missions with a crew complement of two pilots and a boom operator. These capability requirements were initially identified by SAC aircrews during a mockup study and then validated during simulated aerial refueling missions by additional SAC KC-135 aircrews. The design guidance resulting from the simulation evaluation flights is incorporated in the systems described herein. It should be noted that these descriptions represent only one of many avionics suites that could satisfy the capability requirements and crew system criteria documented in AFWAL TR-81-3010 "KC-135 Crew System Criteria", also prepared as part of this Program. Furthermore, these equipment descriptions are not formal specifications for controls or displays for a KC-135.

The actual hardware/software flown during evaluation was not required to meet military specifications for aircraft systems. The equipment was either fabricated in-house or procured so that the capabilities and concepts (not the hardware) could be demonstrated to the user aircrews for evaluation. However, these capability concepts have been reviewed by Aeronautical Systems Division engineers who have indicated that the concepts are attainable.

This volume is divided into three sections. Section I - Introduction; Section II - providing sketches of the crew system design layout; and Section III providing operational systems descriptions of the Navigation Management System and the Horizontal Situation Display are extensive and therefore are presented separately in Appendixes A and B.

SECTION II

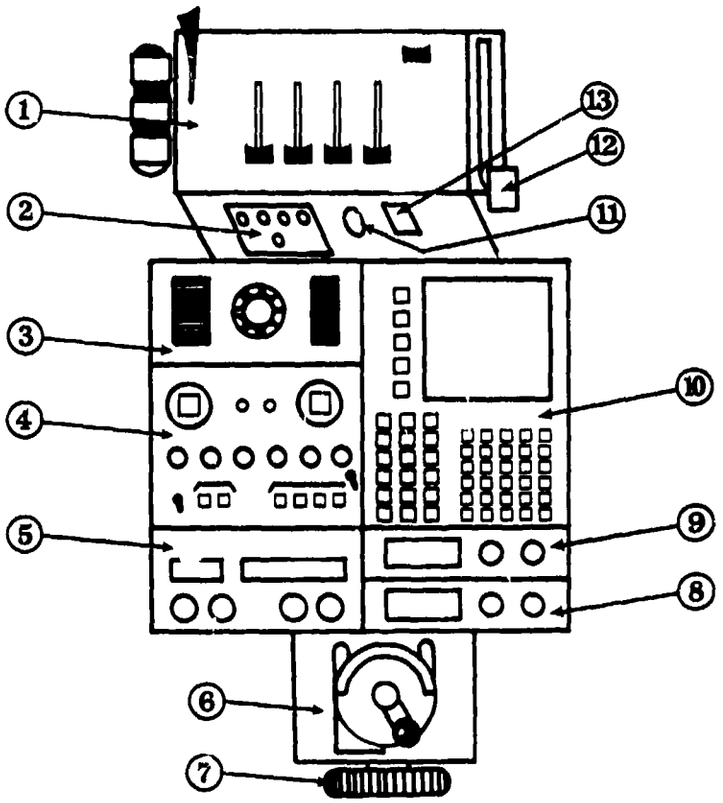
CREW SYSTEMS DESIGN LAYOUT



* 1) Angle of attack indicator (copilot's location unchanged)
\# 2) Mach/airspeed indicator
3) FD-109 annunciator lights
4) Attitude director indicator
\+ 5) Master caution light
6) Altimeter
\+ 7) Marker beacon lights
\+ 8) Altitude alert lights
\+ 9) Radio altimeter
\+ 10) Caution/warning panel
* 11) Cabin pressure emergency release
\+ 12) Thrust mgt system control
\+ 13) Engine instrument digital readouts and selector
14) Engine fire switches
\# 15) Engine instruments
* 16) Hydraulic quantity indicator
\+ 17) Altitude alert control panel
* 18) Water injection panel
19) Landing Gear Lever
20) Flap position indicators
21) Vertical velocity indicator
* 22) Clock (also added for copilot)
23) Outside air temperature gauge
\+ 24) INS/AHRS select switch
25) Cabin pressure indicator
\# 26) HSD/MPD
\+ 27) BDHI
\+ 28) HSD mode selector switches
\+ 29) Nav mgt control/display unit #1
\+ 30) INS mode control panel
\+ 31) Radar cursor and doppler controls
\+ 32) AHRS
\# 33) Fuel control panel
\+ 34) AOA Indexer

\+ New hardware, new location
\# New hardware, current tanker location
* Current tanker hardware, new location

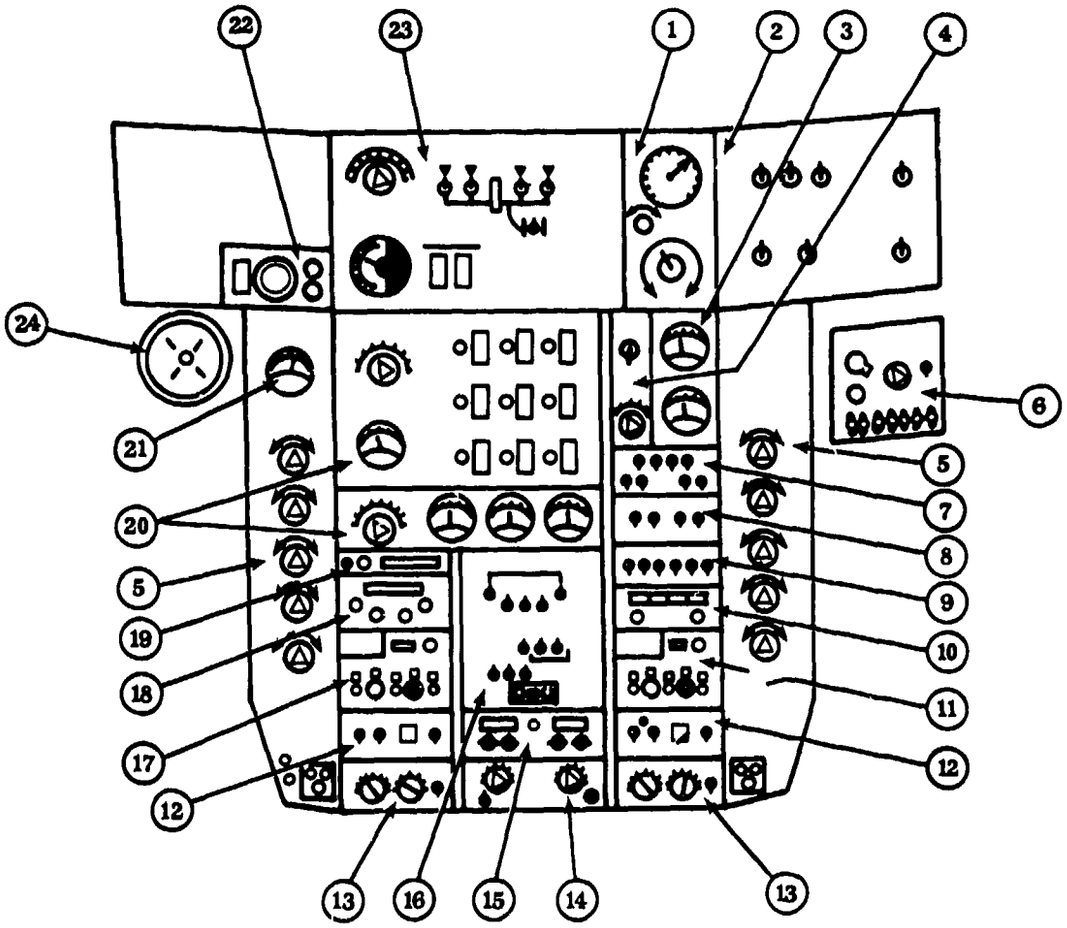
Figure 1. Front And Forward Center Instrument Panels



1) Throttle quadrant
* 2) Engine start switches
* 3) Autopilot controller
* 4) IFF/SIF control panel
\+ 5) ADF control panel
* 6) Rudder trim
* 7) Aileron trim
\+ 8) TACAN #1 control panel
\+ 9) TACAN #2 control panel
\+ 10) Nav mgt control/display unit #2
* 11) Gear horn cutout switch
* 12) Wing flap control
* 13) Rudder power cutout switch

\+ New hardware, new location
* Current tanker hardware, new location

Figure 2. Aft Center Console

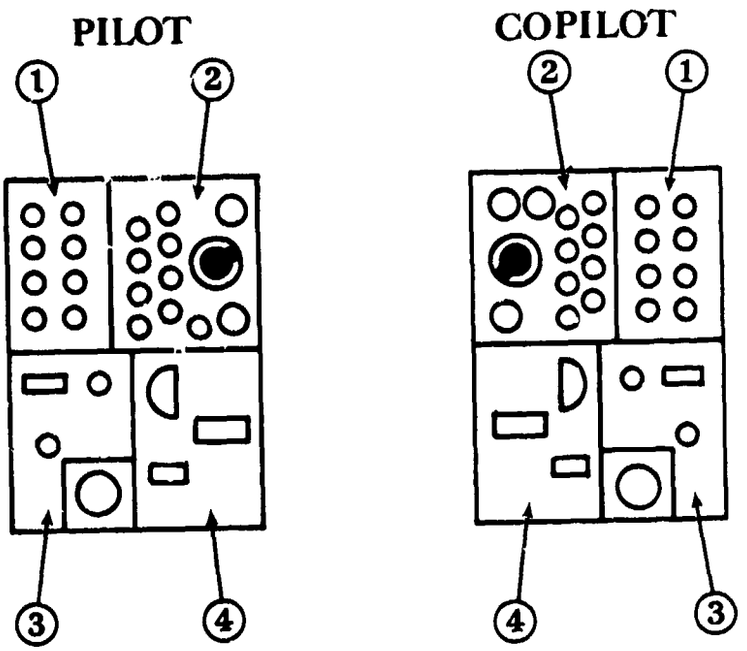


1) Cabin pressure controllers
2) Light control panel (exterior)
* 3) Volts and cycles indicators
* 4) External power control
5) Light control panel (interior)
* 6) APN-69 beacon control panel
\+ 7) Hydraulic control panel
\+ 8) Instrument power control panel
\+ 9) Anti-ice control panel
\+ 10) VHF comm control panel
11) UHF #2 comm control panel
12) Rotation go-around control panel
13) Flight director control panel
\+ 14) Radar control panel
* 15) VHF nav #1 & #2 control panel
16) Autopilot control panel
17) UHF #1 comm control panel
* 18) HF comm control panel
\+ 19) Warning bell, loudspeaker, and TACAN antenna control panel
20) Electrical control panel
21) Battery charging ammeter
* 22) Radar pressurization control panel
23) Air-conditioning control panel
24) Speaker

\+ New hardware, new location
* Current tanker hardware, new location

NOTE: Nacelle illumination switch added to 2).

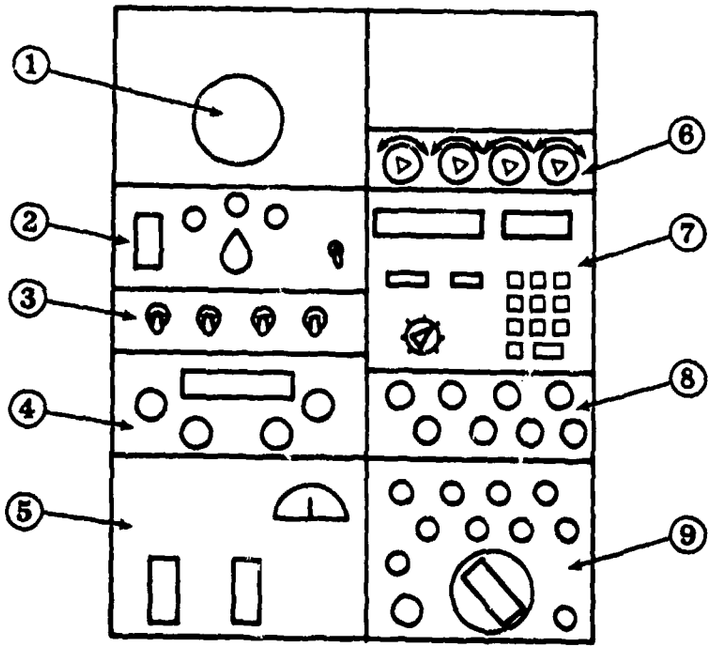
Figure 3. Overhead Panel



1) Nav monitor panel
2) AIC-18
3) Oxygen hose, dimmer, oxygen quantity, lamp receptacle
4) Oxygen regulator

New hardware, current tanker location

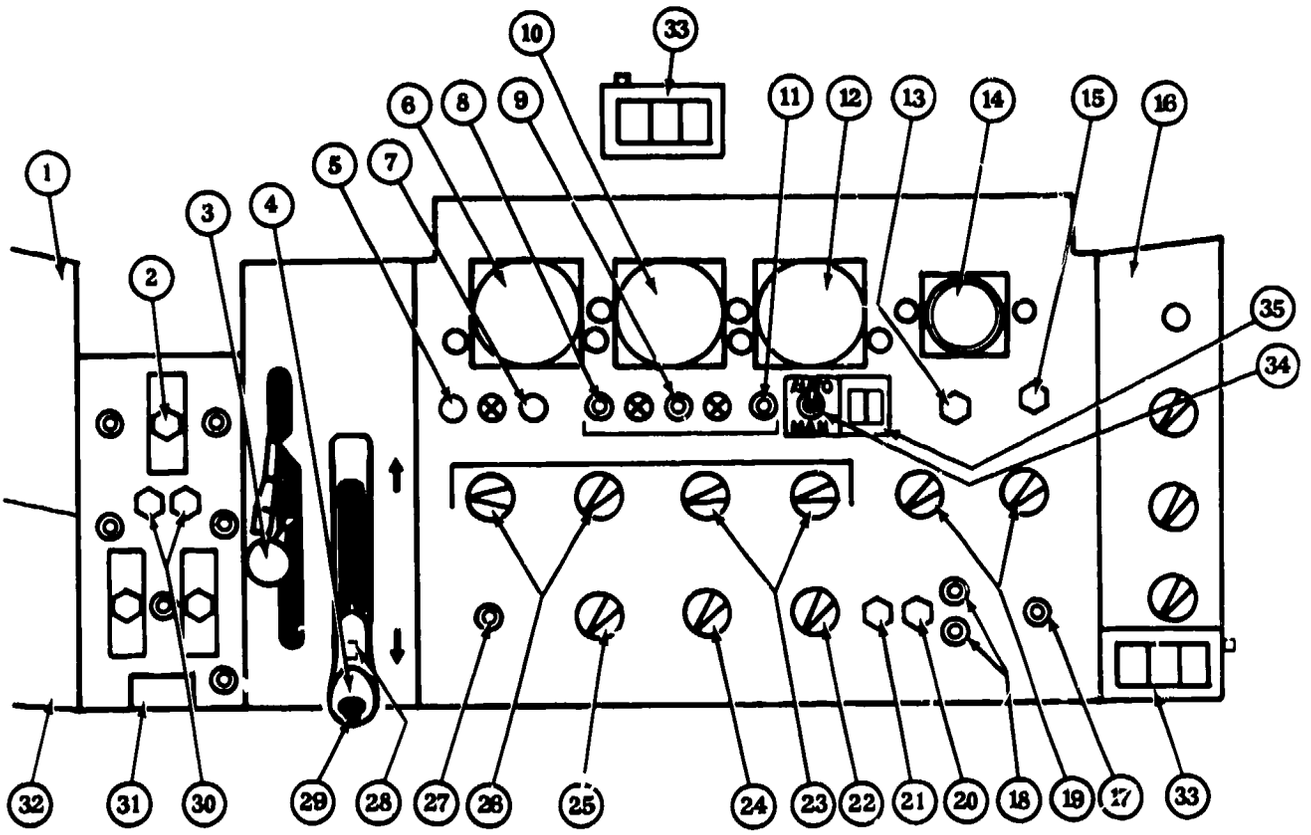
Figure 4. Side Panels



* 1) Accelerometer
* 2) Ciphony control panel
\+ 3) HF transfer and INS selector switches
* 4) HF comm control panel
\+ 5) Oxygen control panel
\+ 6) Light controls
\+ 7) INS control/display unit
\+ 8) Nav monitor panel
\+ 9) AIC-18

\+ New hardware, new location
* Current tanker hardware, new location

Figure 5. Boom Operator's Forward Station



1 OXYGEN REGULATOR PANEL (REF)
2 EMERGENCY OVERRIDE SWITCH
3 BOOM HOIST LEVER
4 BOOM TELESCOPE LEVER W/START/STOP SWITCH
5 SIGNAL AMPLIFIER TEST SWITCH
6 BOOM AZIMUTH INDICATOR
7 A/R SYSTEM RESET SWITCH
8 READY CONTACT SIGNAL LIGHT
9 MADE CONTACT SIGNAL LIGHT
10 BOOM TELESCOPING INDICATOR
11 DISCONNECT CONTACT SIGNAL LIGHT
12 BOOM ELEVATION INDICATOR
13 BOOM SIGNAL COIL TEST SWITCH
14 BOOM SIGNAL COIL TEST VOLTMETER
15 A/R MASTER SWITCH
16 BOOM OPERATOR's CIRCUIT BREAKER PANEL (REF)
17 RECEIVER PILOT DIRECTOR LIGHT
18 RESTART INDICATOR LIGHTS
19 NACELLE ILLUMINATION CONTROLS
20 BOOM MARKER LIGHT START SWITCH
21 BOOM MARKER LIGHT CONTROL SWITCH
22 BOOM NOZZLE ILLUMINATION RHEOSTAT
23 RECEIVER PILOT DIRECTOR POSITION LIGHT CONTROLS
24 UNDERBODY ILLUMINATION RHEOSTAT
25 UNDERWING ILLUMINATION RHEOSTAT
26 RECEIVER PILOT DIRECTOR BACKGROUND LIGHT CONTROLS
27 TELESCOPE-AT-DISCONNECT SWITCH
28 EMERGENCY CONTACT MADE SWITCH
29 EMERGENCY BREAKAWAY SIGNAL SWITCH
30 RECEIVER PILOT DIRECTOR LIGHT SWITCHES
31 LIMIT CUTOUT SWITCHES
32 INTERPHONE PANEL (REF)
+ 33 FUEL OFFLOAD INDICATOR WITH RESET SWITCH
+ 34 AUTO/MANUAL FUEL SELECT SWITCH
+ 35 OFFLOAD QUANTITY SELECTOR

+ New hardware, new location
# New hardware, current tanker location

Figure 6. Boom Operator's Aft Station

SECTION III

OPERATIONAL DESCRIPTIONS OF THE CREW SYSTEMS

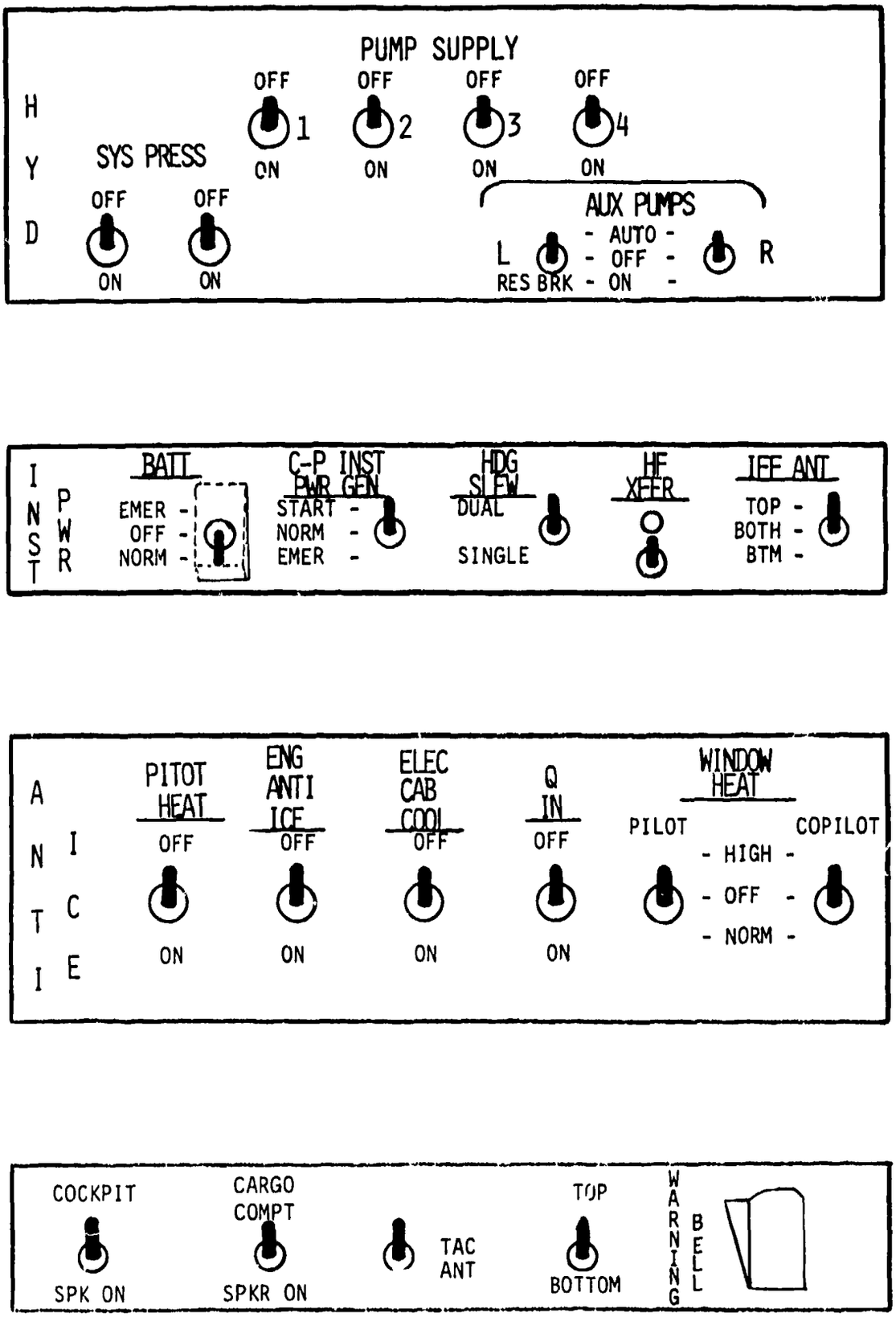


Figure 7. Switch Controls on Overhead Panel

HYDRAULIC CONTROL PANEL

This switching panel contains eight mini toggle switches which group together most of the hydraulic switching controls previously scattered throughout the cockpit and consolidates them on a single panel located in the overhead switching panel.

1. Four Hydraulic Pump Supply Switches. Controls the hydraulic supply shutoff valve for the corresponding engine pumps. When closed, it cuts off the hydraulic fluid supply and isolates the pump.

2. Left System and Right System Hydraulic Pressure Switches. Allows pressure from the engine driven pumps or auxiliary pumps to build up in the respective system.

3. Left System Auxiliary Pump Switch. Controls a three way valve and an electric hydraulic pump. The three positions are AUTO, OFF, and RESERVE BRAKE; with OFF being the normal inflight position.

4. Right System Auxiliary Pump Switch. Allows right system auxiliary hydraulic pump to pressurize the right hydraulic system. Positions of the switch are AUTO, OFF and ON; with OFF being the normal inflight position.

INSTRUMENT POWER PANEL

This panel is made up of five mini toggle switches which consolidates electrical, instrument and other type switching functions from various places in the cockpit onto the overhead panel.

1. Battery Power. This three position guarded switch (NORMAL (guarded), OFF, and EMERGENCY) connects battery power to the DC bus.

2. Copilot's Instrument Power Generator Switch. This three position switch (EMER, NORM, START) connects the copilot's instrument power supply system to an engine driven hydraulic pump.

3. Heading Slew. This two position switch is used to select control of the heading bug on the HSD HSI format. When in "single" each pilot, through his yoke slew switch, can control the heading bug only on his HSD. In "dual" either pilot can control the heading bug on both HSDs.

4. HF Transfer Switch and Light. This two position switch, spring loaded to the down position, is used to transfer control of the HF comm radio to or from the HF radio control panel located in the overhead. The light illumi nates when control is at that location. A second HF radio control panel and HF transfer switch and light are located at the forward boom operator's station.

5. IFF Antenna Selector. This three position switch (TOP, BOTH, and BOTTOM) controls the reception for the IFF/SIF transponder.

ANTI-ICING PANEL

This panel consists of six mini toggle switches which consolidates anti-icing and similar controls from various places in the cockpit onto one switching panel on the overhead panel.

1. Pitot Heat. This OFF/ON switch provides power to the pitot tubes.

2. Engine Anti-Ice Switch. This OFF/ON switch provides hot bleed air to the nose dome, inlet guide vanes, nose cowl and EPR probe.

3. Electronic Cabinet Cooling Switch. This OFF/ON switch provides cooling air to the equipment in the equipment rack.

4. Q-Inlet Switch. Provides heat to the Q-inlet for the powered rudder system.

5. Pilot and Copilot Window Heat Switches. Two three position switches (HIGH, OFF, and NORMAL) which provide electrical power for heating the pilot's and copilot's front, side and eyebrow windows.

SPEAKER PANEL

This panel consists of five mini toggle switches which consolidate speaker control with TACAN antenna selector and warning bell.

1. Cockpit Speaker. This off/on switch controls power to the cockpit speaker switches.

2. Cargo Compartment Speaker. This off/on switch controls power to the cargo compartment speaker switches.

3. TACAN Antenna Selector Switches. These two switches allow the pilots to select the top or bottom antenna for either TACAN T/R unit.

4. Warning Bell. This guarded off/on switch controls power to the warning bell.

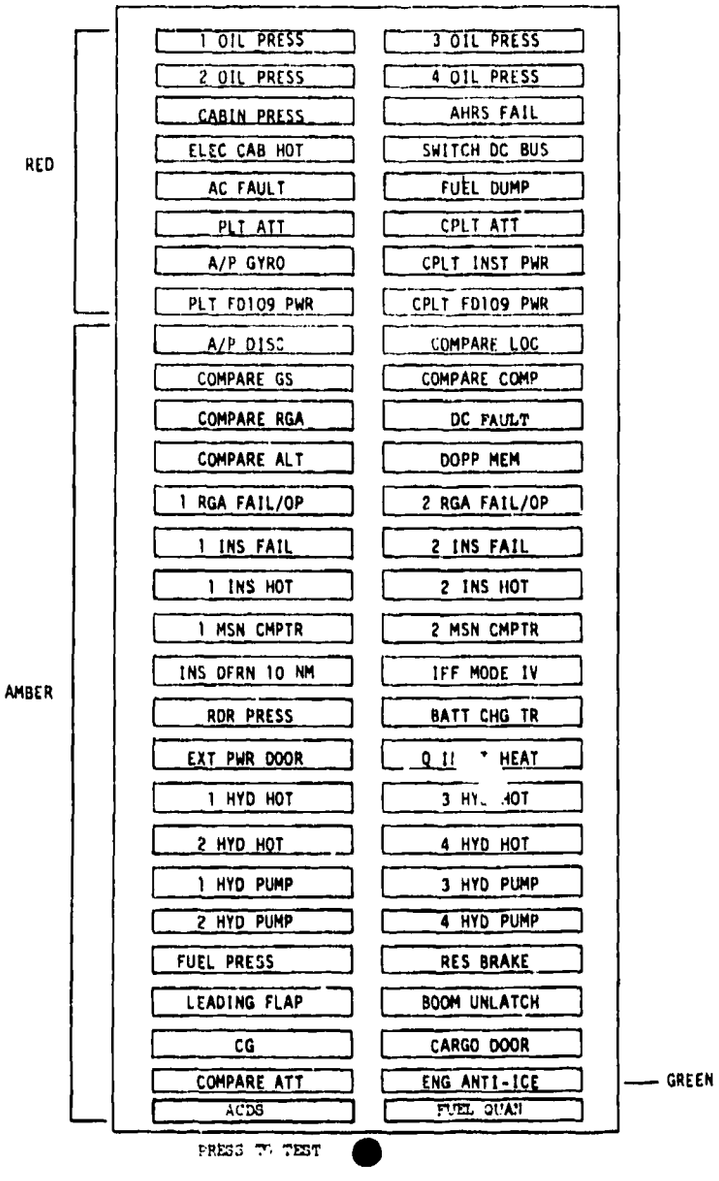


Figure 8. Caution/Warning Annunciator Panel

CAUTION AND WARNING ANNUNCIATION PANEL

A system is provided to alert the pilots of any malfunction of aircraft systems or hardware. It consists of two master caution lights, one located in the glare shield in front of each pilot, and a central caution and warning light panel consisting of 54 individual lights, located on the center instrument panel. Sensors or testing devices within the hardware automatically cause both master caution lights and the appropriate dedicated caution or warning light to illuminate when that equipment malfunctions. This alerts the pilot to take necessary corrective action.

1. Master Caution Light. A light within an alternate action switch which illuminates when a malfunction is detected by the system. Correcting the malfunction or pressing the Master Caution Light Switch causes the light to go out and arms it for annunciation of another failure, if necessary.

2. Central Caution and Warning Panel. Lights dedicated to various aircraft systems which illuminate automatically when a system failure is detected. Each time that an individual caution or warning light illuminates both master caution lights also illuminate. While pressing the master caution lighted switch causes that light to go out, only corrective action by the crew to eliminate the detected malfunction will cause the caution or warning light to go out. Nomenclature indicating the name of the system or malfunction is part of the light and can be read when the light illuminates. Warning lights for critical systems are color coded red. Caution lights for less critical systems are color coded amber.

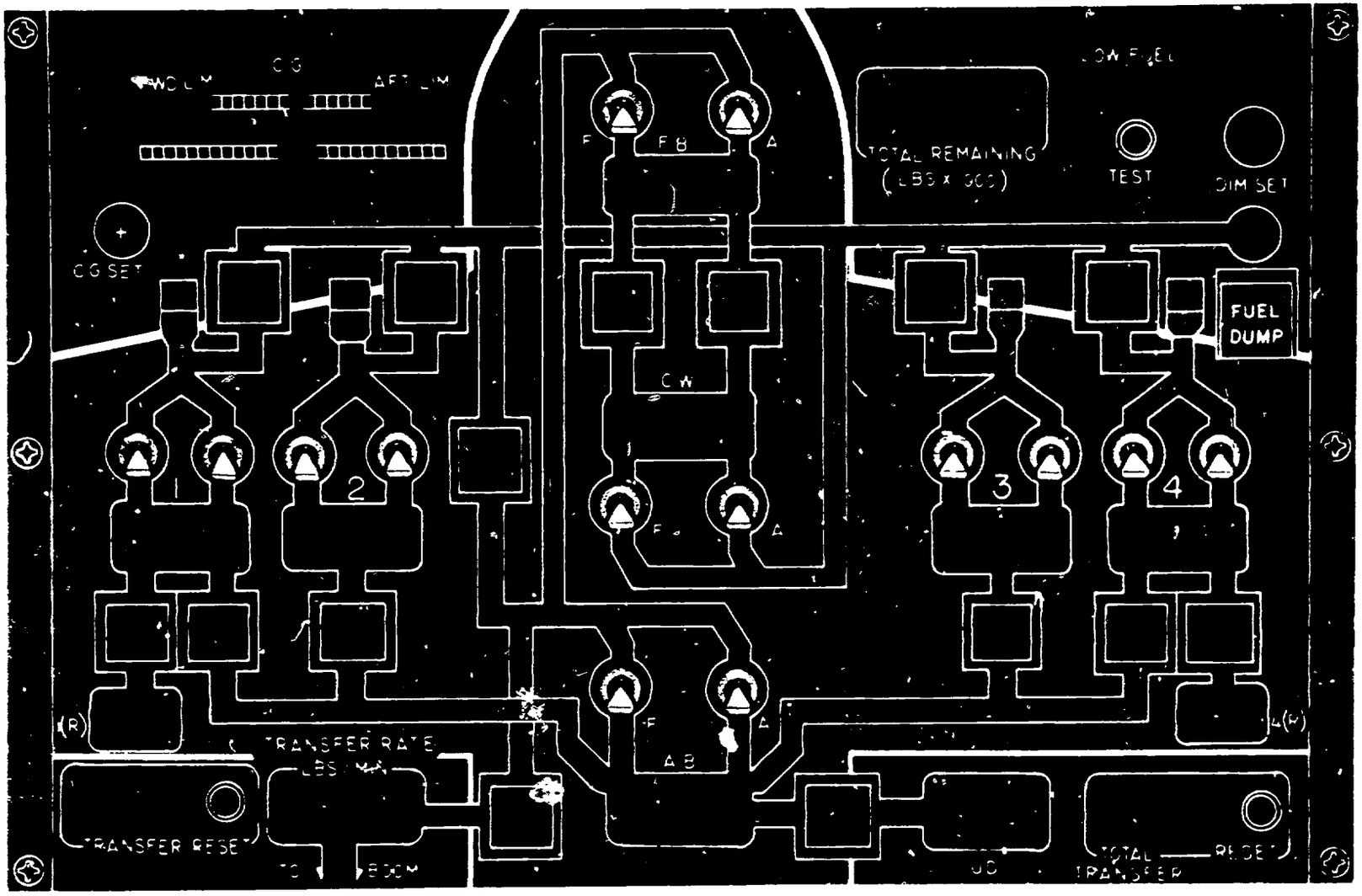


Figure 9. Fuel System Control

FUEL SYSTEM CONTROL PANEL

Aircraft fuel for engines and transfer is controlled through the fuel system control panel located on the forward center console. This panel contains pump and valve controls and quantity and transfer rate displays to provide the same functions as those on the present KC-135 fuel panel. Additionally, it has a total fuel transferred display, a lighted schematic of the fuel system, the boom engaged light, the aircraft center of gravity display, and several additional caution and warning lights. The function of each component is described below.

1. Boost Pump Switches. Eight fuel boost pump toggle switches control the forward and aft boost pumps in each of the four main tanks.

2. Override Pump Switches. Two override pump toggle switches control the forward and aft centrifugal pumps in the center wing tank. They provide higher pressure to override the main wing tank boost pump pressure when operating in the center wing tank to engines configuration.

3. Air Refueling Pump Switches. Four air refueling pump toggle switches control the flow of hydraulic fluid to the hydraulic motor driven centrifugal air refueling pumps. A forward and an aft pump are located in both the forward and aft body tanks.

4. Fuel Dump Switch. When this guarded push-to-actuate switch is activated to the fuel dump position, the A/R refueling bypass control valve is energized open, if the boom is extended; the A/R pumps are energized if the A/R pump switches are ON; and the boom hydraulic auto retract valve is energized open. When the boom is fully retracted, the A/R fuel bypass valve is closed and the fuel dump valve is activated, depressing the nozzle check valve.

5. Tank to Engine Manifold Valve. Four push-to-activate valve switches, which illuminate when the valves are in the open position, connect the fuel tanks to the engine manifold.

6. Reserve Tank Valve Switches. Two push-to-activate valve switches, which illuminate when the valves are in the open position, allows gravity flow of fuel from the #1 reserve tank to the #1 main tank and the #4 reserve tank to the #4 main tank.

7. Wing to AFT Body Tank Valve Switches. Four push-to-activate valve switches, which illuminate when the valves are in the open position, allow fuel to gravity feed from the main wing tanks to the aft body tank.

8. Upper Deck to Aft Body Tank Valve Switch. This push-to-activate valve switch, which illuminates when the valve is open, controls the gravity flow of fuel from the upper deck tank to aft body tank.

9. Air Refueling Manifold to Engine Manifold Valve Switch. This push-to-activate valve switch, which illuminates when the valve is open, controls the flow of fuel under pressure from the A/R pumps in the forward and aft body tanks to the engines. This switch is interconnected with the A/R valve switch, so that whenever fuel feed from the body tanks to the engine is in progress, the A/R line valve will automatically be closed. When the Body Tank to Engine Manifold Valve is closed the A/R line valve will return to the position originally selected. This interconnect is necessary to prevent loss of pressure through the air refueling valve/manifold or other components of the boom system.

10. Air Refueling Line Valve Switch. This push-to-activate valve switch, which illuminates when the valve is open, provides positive shutoff of fuel to the boom. It is interconnected with the body tanks to Engine Manifold Valve Switch as described above. It can be used as a positive control to preclude inadvertent pumping of fuel through the boom.

11. Center Wing to Forward Body Tank Valve Switches (LH Valves and RH Valves). Two push-to-activate valve switches, which illuminate when the valves are open, allows gravity flow from center wing tanks to forward body tank. Fuel may be transferred through either or both valves simultaneously.

12. Tank Quantity Indicators. The fuel quantity remaining in each tank (10) and the total fuel in all tanks is displayed as a digital readout in pounds times 1000.

13. Transfer Quantity and Rate Indicators. The fuel quantity transferred through the air refueling boom is displayed on two digital readouts, one for individual receivers and one for total fuel transferred. Each quantity indicator can be reset to zero independently of the other by pressing a reset switch adjacent to the display. The transfer rate in pounds per minute is displayed digitally.

14. Fuel Low Pressure Warning Lights. A red warning light indicates low fuel pressure (6.5 psi) at the engine manifold. The master caution light and low fuel pressure light on the caution and warning panel also illuminate under this condition. Four amber lights indicate low fuel pressure (6.5 psi) at each of the A/R pumps, if the pump is on and the pressure is low.

15. Main Tank Low Quantity Warning Lights. Four amber warning lights are provided, one in each engine depiction. If any main fuel tank has less than 9000 pounds of fuel, and the landing gear is down, the affected main tank low quantity warning light will illuminate unless: (a) all Tank to Engine Manifold Valves are OPEN and (b) all main tank boost pumps are ON. Four red warning lights are provided, one in each engine depiction. Whenever any main fuel tank level falls below 20% capacity, the affected red warning light will illuminate unless all engines are being fed from the tank to engine manifold configuration (Ref. KC-135-1, Pages 7-17, 7-18).

16 Center Wing Tank Low Quantity Warning. When operating engines from the center wing tank, the digital readout of fuel quantity in the center wing tank blinks continuously whenever the amount of fuel in the tank is less than 20% capacity unless both overrides pumps and at least one boost pump per main tank are ON (Ref. KC-135-1, Page 7-18).

17. Total Fuel Low Quantity Warning Light. A low quantity warning light is located in the upper right corner of the fuel panel. This amber light will illuminate wheneever the total fuel onboard is less than the total fuel required (as displayed on the nav management CDU "Fuel Plan" page) to complete the mission to landing destination (or alternate if required) plus one hour of fuel consumption at the programmed fuel burn rate. The master caution lights and the "FUEL QUAN" warning light on the central caution/warning panel will also illuminate when the total fuel low quantity warning light illuminates.

18. Fuel Flow Diagram. A dynamic representation of the fuel flow diagram is displayed through the use of lighted line segments. Segments of the fuel line in which fuel is flowing are illuminated to show direction and routing of the fuel. The display changes as changes in fuel routing are selected. Fuel lines carrying fuel for engine use are color coded yellow. Transfer fuel lines are color coded amber.

19. Center of Gravity Display. The actual center of gravity is displayed in relation to desired center of gravity and center of gravity limitations of the aircraft. The display consists of two lighted line segments, the top line showing desired CG, which is adjustable with a CG set knob, and forward/aft limitations; the bottom line showing the actual CG. The cautionary zones are color coded yellow. The limits are red. As the aircraft center of gravity (bottom scale) reaches a yellow or red area, the (top line) lighted segments blink continuously, the master caution will illuminate and the "CG" caution/warning light will illuminate.

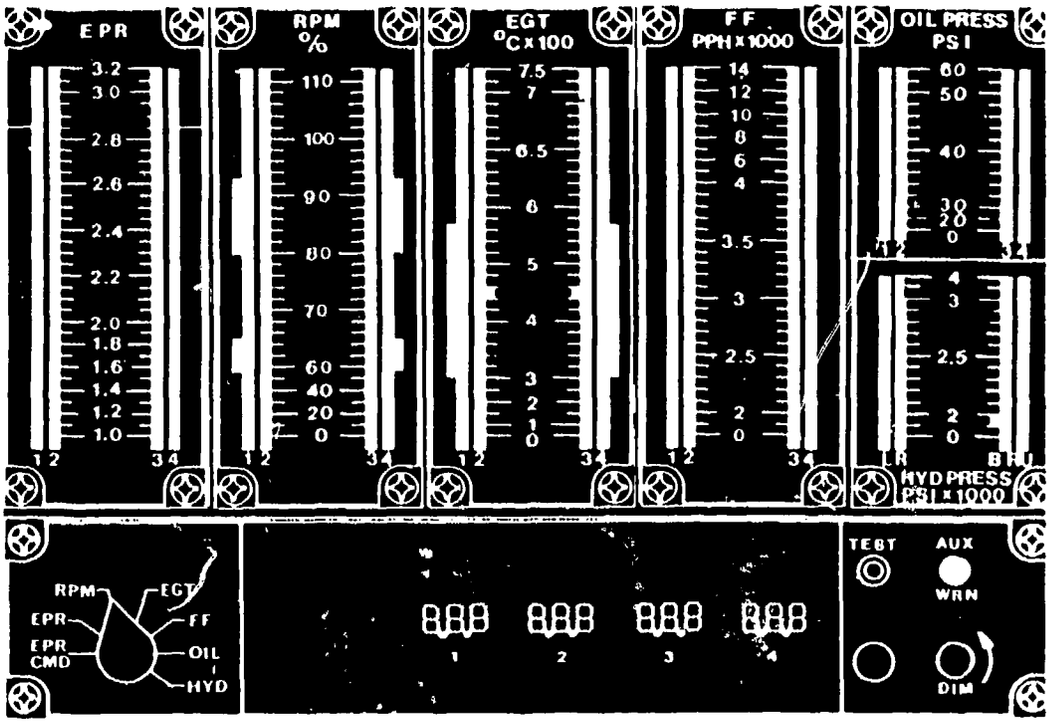


Figure 10. Engine Instrument Panel

ENGINE INSTRUMENTS

Engine and hydraulic system performance are displayed on vertical scale, segmented light type instruments. EPR, RPM, EGT, Fuel Flow, Oil Pressure and Hydraulic Pressure are displayed. The vertical lines are color coded to show normal, cautionary and out of limit conditions. Additionally, a digital readout showing each parameter for all four engines is selectable. For instance, when RPM is selected on the digital readout selector switch, the RPM for each engine is displayed digitally. The switch has a selection for each displayed parameter plus an EPR CMD position. When EPR CMD position is selected, the best EPR for engine performance for phase of flight (selected on the thrust management switch) is displayed on the digital readouts. The EPR command is displayed continuously on the vertical scale EPR lines by one segment of the line being illuminated to indicate the commanded setting. As the EPR reaches the commanded setting, the segment light goes out. If the EPR increases above the commanded EPR, the commanded segment light remains out, leaving a blank space in the line.

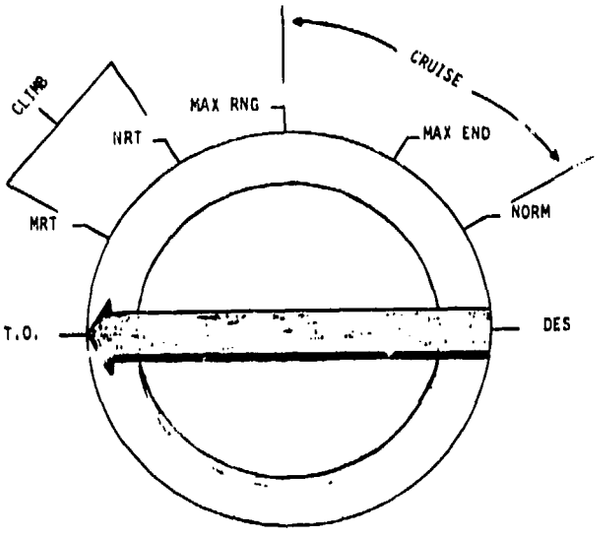


Figure 11. Thrust Management/EPR Command Controller

THRUST MANAGEMENT/EPR COMMAND SYSTEM

A six position rotary switch located on the center instrument panel is used to select the flight condition which in turn provides an EPR command on the EPR vertical scale instrument. The switch positions are T/O (takeoff), CLIMB (MRT/NRT), MAX RNG (maximum range in cruise), MAX END (maximum endurance in cruise), NORM (target EPR for best cruise performance) and DES (descent). The EPR command provides the best power for the selected flight condition considering pressure altitude, temperature, aircraft weight airspeed/mach.

The EPR command controller (see atch) located adjacent to the engine instruments, will drive the EPR command bug as follows:

Takeoff (T/O). Design capabilities provide an EPR command for a static setting. The command will automatically compensate for takeoff with or without water. The command will also be altitude and temperature compensated, automatically during the initial climb in the "T/O" setting. At "end of water", command will be compensated to provide an EPR command for acceleration to climb speed.

Climb (MRT). After climb speed has been attained, the "MRT" position will provide the proper EPR command for a military rated thrust climb. When MRT climb is selected, the EPR command is automatically compensated for altitude temperature and established climb airspeed (250, 280, 310, etc.).

Climb (NRT). After climb speed has been attained, EPR commands for normal rated thrust may be selected. NRT is also automatically compensated for altitude, temperature and climb airspeed (250, 280, 310, etc.).

Max Range (MAX RNG). The design capability of MAX RNG selection provides an EPR command compensated for instantaneous gross weight and present altitude. For max range at optimum altitude, EPR command will provide a valid signal only after the crew climbs to the optimum altitude, and thereafter, using the max range index on the AOA display for speed control. A display of time, distance, optimum altitude and optimum airspeed is selectively displayed on the nav management CDU.

Max Endurance (MAX END). The max endurance EPR command will vary with instantaneous gross weight. A display of optimum altitude, airspeed and time is displayed in nav management CDU. The max endurance index on the AOA display may be used for speed control after the desired or optimum altitude has been attained and the EPR command thrust is set.

Normal Cruise (NORM). The EPR command for normal cruise is a target thrust setting to maintain the true airspeed entered by the crew on the Nav Management System "Preflight Page". The EPR command is based on altitude, temperature and weight.

Descent (DES). The EPR command for descent will vary with altitude and will provide sufficient thrust for air conditioning and pressurization. It is assumed that the two outboard engines are at idle and airspeed is held at 280 KIAS (.78 mach to 32,500).

NOTE: The nav management CDU format for displaying "Max Range" and "Max Endurance" optimum altitudes, airspeeds, times and distances, have not been developed and are not included in the present document nav management description.

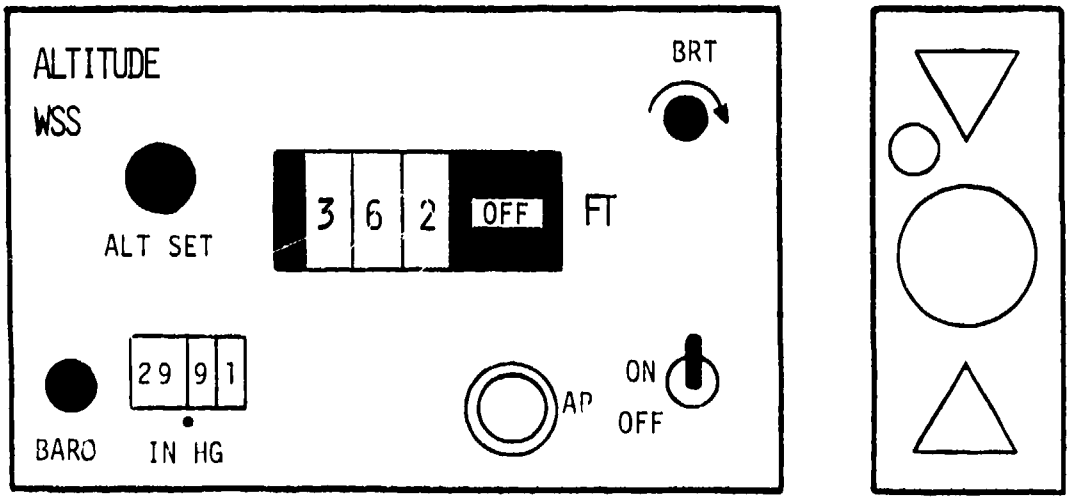


Figure 12. Altitude Warning Signal System (AWSS)

ALTITUDE WARNING SIGNAL SYSTEM (AWSS)

The AWSS consists of a control and a display unit. The control unit is located below the engine instruments. The display unit is located to the right of each altimeter display.

The controller has a power on/off switch, dimmer control for display units, approach mode push button switch, command altitude and baro set knobs and a command altitude and a barometric digital display. When power is turned on, the off flag will disappear unless there is an invalid signal in the system.

To set a desired or command altitude, the pilot first sets the baro display with the baro set knob to the same barometric pressure that is displayed on his altimeter. The pilot sets the command altitude with the altitude set knob. Altitude may be set in terms of 10,000, 1,000 and 100 foot increments. Two fixed zeros represent less than 100 feet. The altitude set knob has a "feel" detent every 500 feet.

The display unit has three indicator lights, vertically aligned and a fourth light offset to the left between the top two lights. The bottom light is a yellow triangle which points up. When lighted it commands the pilot to climb. The top light is just the opposite and when lighted, points down, commanding the pilot to descend. The center light is a round green disk shaped light. When illuminated, the green light advises the pilot that he is on his desired altitude. The fourth light is a small blue light indicating that the system is operating in the approach mode.

After the system has been turned on, the baro set in and a command altitude is selected (for example; 30,000) the following alerting will occur (see attached Profile #1):

a. The lower triangle is illuminated from ground level to 29,500 feet (reset WSS baro to 2992 when altimeter is changed).

b. Climbing through 29,500, the center green light illuminates.

c. Climbing through 29,800, the bottom light goes out.

d. Climbing through 30,200, the top light illuminates and a warning tone is sounded and is repeated every 20 seconds until climbing through 30,500.

e. Climbing through 30,500, the center green light goes out and stays out with no further tone warnings until descending through 30,500.

f. Descending through 30,500, the center green light illuminates and the warning tone is sounded, which is repeated every 20 seconds until reaching 30,200.

g. Descending through 30,200, the tone stops and the top light goes out.

h. Descending through 29,800, the bottom light illuminates and the tone is sounded every 20 seconds as long as 29,500 is not exceeded.

i. Climbing through 29,800, the tone stops and the bottom light goes out, leaving the center green light on.

j. After remaining between 29,800 and 30,200 for more than 20 seconds, the green light goes out.

k. Descending through 29,800, both the bottom yellow and the center green lights illuminate as the warning tone is sounded every 20 seconds until reaching 29,500.

l. Descending through 29,500, the middle green light goes out and the tone warnings cease.

When the pilot is cleared to descend to his approach altitude, he will set the proper baro on the WSS panel, set the approach altitude cleared to and depress the "AP" (approach) button. This will cause the AP button to illuminate (blue) and the small blue light on the WSS display to illuminate. As the aircraft descends toward the assigned approach altitude (example; 3000), the following will occur (see attached Profile #2):

a. Descending through 3200, the top and bottom lights illuminate.

b. Descending through 3000, a warning tone is sounded and all display lights extinguish.

c. No further tones or lights will be triggered unless 3200 is exceeded. If this occurs, the small blue lamp on the display will illuminate and will alert the pilot as described in a and b above.

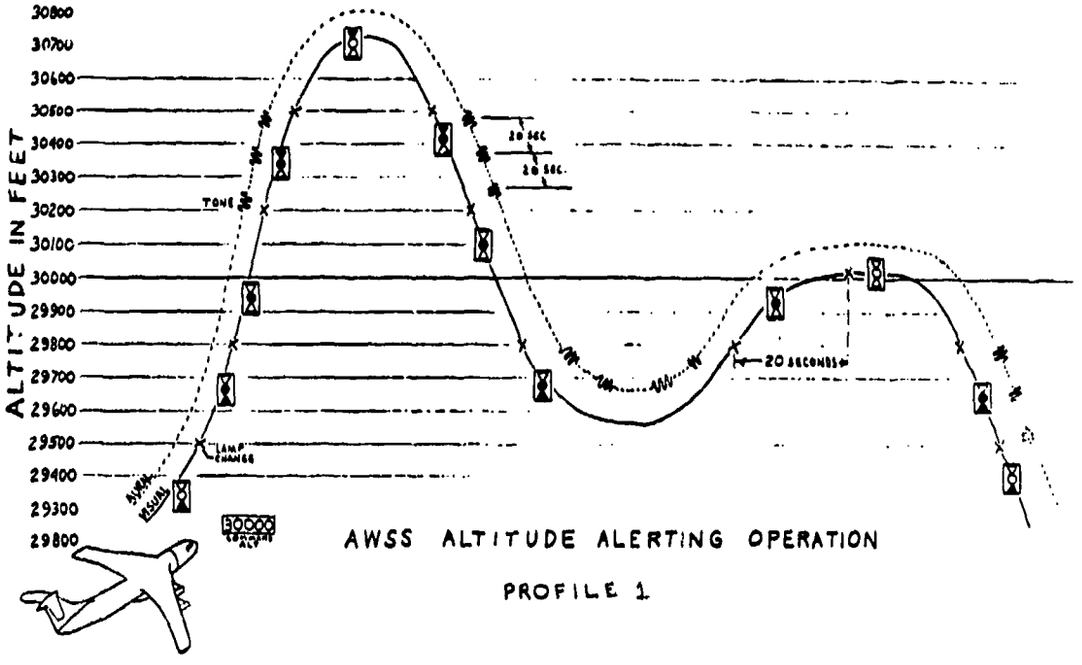
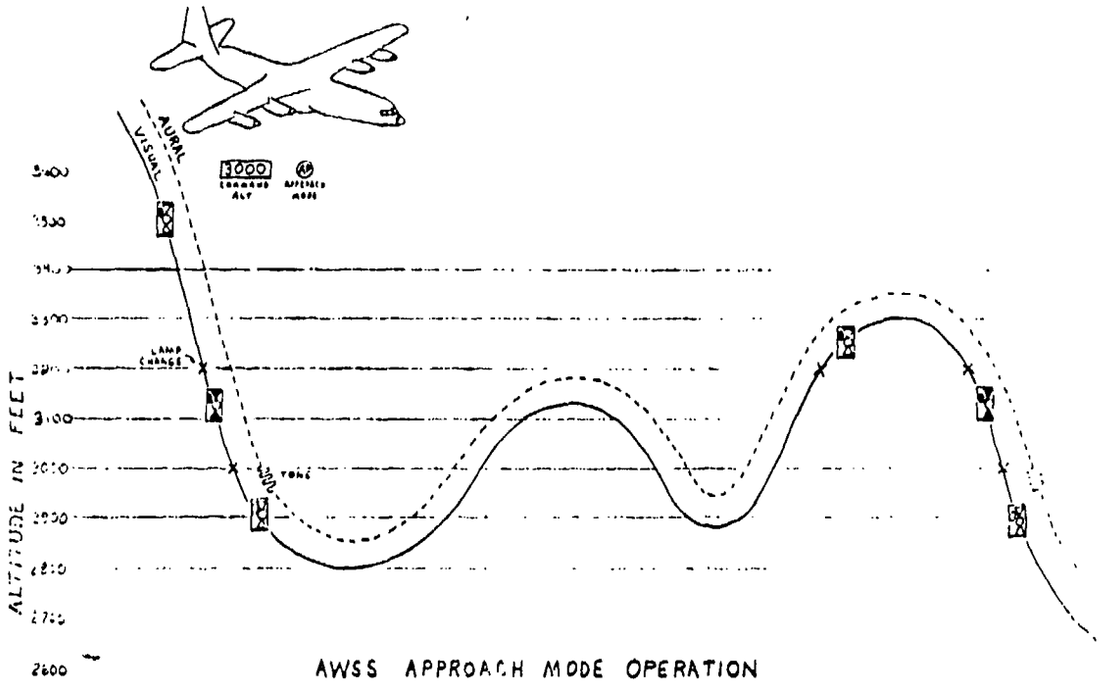


Figure 13. AWSS Profile (Enroute)



AWSS APPROACH MODE OPERATION

PROFILE 2

Figure 14. AWSS Profile (Approach)

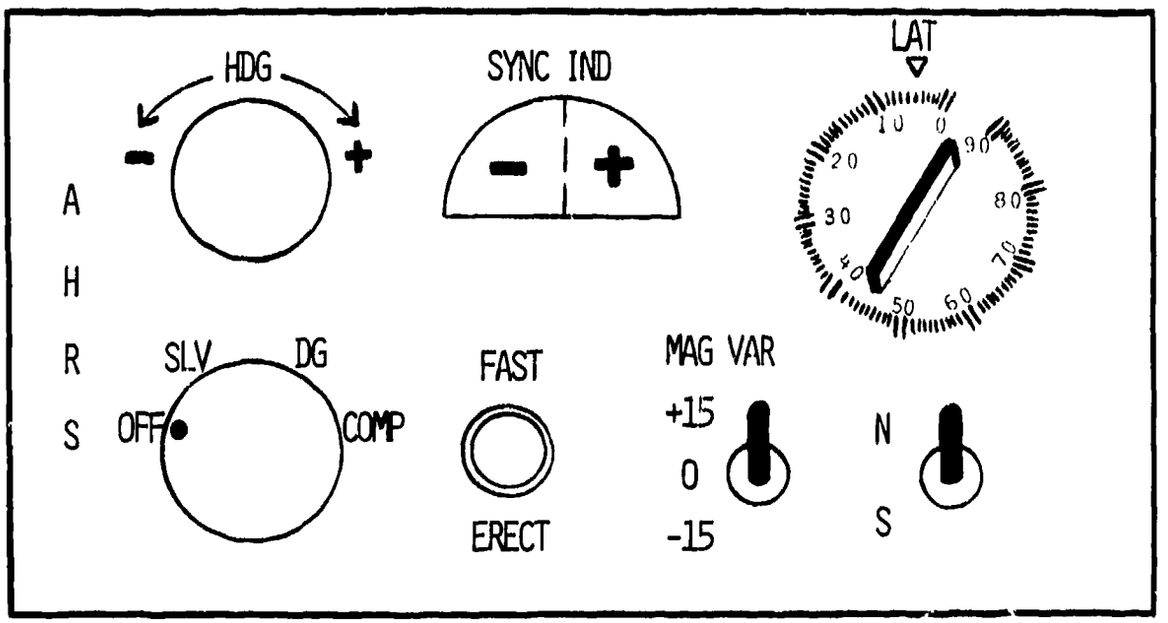


Figure 15. Attitude Heading Reference System

ATTITUDE AND HEADING REFERENCE SYSTEM (AHRS)

The Lear Siegler AHRS presently being used in the A-10 and being installed in the B-52 will be installed in the KC-135. It provides gyro stabilized information for lateral, pitch and roll axes of the aircraft. Heading inputs go to all heading indicators in the cockpit on a selective basis (described later, this section) with the exception of the standby magnetic compass. Pitch and roll inputs go to the ADI/flight director, also on a selective basis. One control/display unit is located on the forward center console. The functions on the control display unit are described below:

1. Mode Selector Switch. Controls the heading mode used by the aircraft. It is a rotary switch with the following positions: (A) OFF - All power is removed from the unit. (B) SLV (Slaved) - Normal inflight position. When this position is selected, the heading slaves at 6° per second to align with the proper magnetic heading. (C) DG (Directional Gyro) - Unslaves the compass system for use in high latitude areas or as a backup mode after an indication that the slaved mode has malfunctioned. (D) COMP (Compass) -- Provides an unstable heading reference from the magnetic azimuth detector (MAD) similar to that provided by the standby magnetic compass. This mode is used only for redundancy in case of failure of the electronic amplifier or directional gyro.

The mode selector is normally placed in the OFF position during the Engine Shutdown checklist and turned to the SLV position during the Before Taxi checklist. The system is left off during ground operations by maintenance personnel to reduce power-on time to the system and reduce MTBF.

2. HDG SYNC Control. When the mode selector switch is in the SLV position, this rotary knob is used as a backup control to fast slave the heading system to agree with the magnetic compass in the event that the normal fast slave feature has malfunctioned. When the mode selector is in the DG position, the HDG SYNC control is used to manually align the compasses with the magnetic standby compass.

3. SYNC IND (Synchronization Indicator). This pendulum type indicator continually oscillates left or right of the center position indicating correct operation of the synchronization gyro. If it remains stationary either in the center or at one limit, a malfunction of the system is indicated, in which case, the HDG SYNC control knob can be used to align the system or the mode selector can be changed to the DG position for manual type navigation.

4. N-S Hemisphere Switch. Either the northern or southern hemisphere of operations is selected on this switch.

5. LAT (Latitude Set Control). This rotary control knob, scaled 0-90°, must be maintained to within 2° of the operational latitude of the aircraft in order for the compass system to remain properly aligned. Proper adjustment of this switch has little effect during straight and level flight. However, whenever turns or repeated turns such as the refueling orbit are made, the compass system precesses proportionately to the difference between the operational latitude and the setting on this control. Automatic latitude adjustment is provided through the INS.

6. Fast Erect Switch. Pushing this switch provides a 24°/min erection cycle for the pitch and roll axes on the ADI. The normal inflight erection cycle is 1°/min. This feature is most useful in acrobatic aircraft such as the A-10 and would be rarely required in the KC-135.

7. MAG VAR (Magnetic Variation). This three position switch (+15, 0, -15) must be adjusted to the closest magnetic variation for the aircraft operational area in order to give proper erection in the pitch and roll axes. Use of this switch does not affect the heading function. The position of this switch has little effect during straight and level flight, however, it must be used for highly maneuverable aircraft in order to properly erect the pitch and roll gyros.

Pilot

HDG SELECT		ATT SELECT	
INS 1	AHRS	INS 1	AHRS

Copilot

HDG SELECT		ATT SELECT	
INS 2	AHRS	INS 2	AHRS

Figure 16. Heading and Attitude Selectors

HEADING AND ATTITUDE SELECTORS

The source of heading and attitude information provided to the flight directors, ADIs, HSDs and BDHIs is selectable by the pilots. Two lighted push type switches are located on each pilots' instrument panel. The pilot can select heading and/or attitude information from the number one INS or the AHRS. The copilot can select heading and/or attitude information from the number two INS or the AHRS. This provides redundancy for both normal and degraded mode operation.

When INS is being used for navigation, the heading information provided to the navigation/mission management system is selected through a switch on the INS mode control panel labeled INS #1 or INS #2. Additionally, whether the heading indicators are displaying magnetic or true headings is dependent upon the TRUE/MAG switch on the INS mode control panel. (Operation of both switches is explained in the section on INS.)

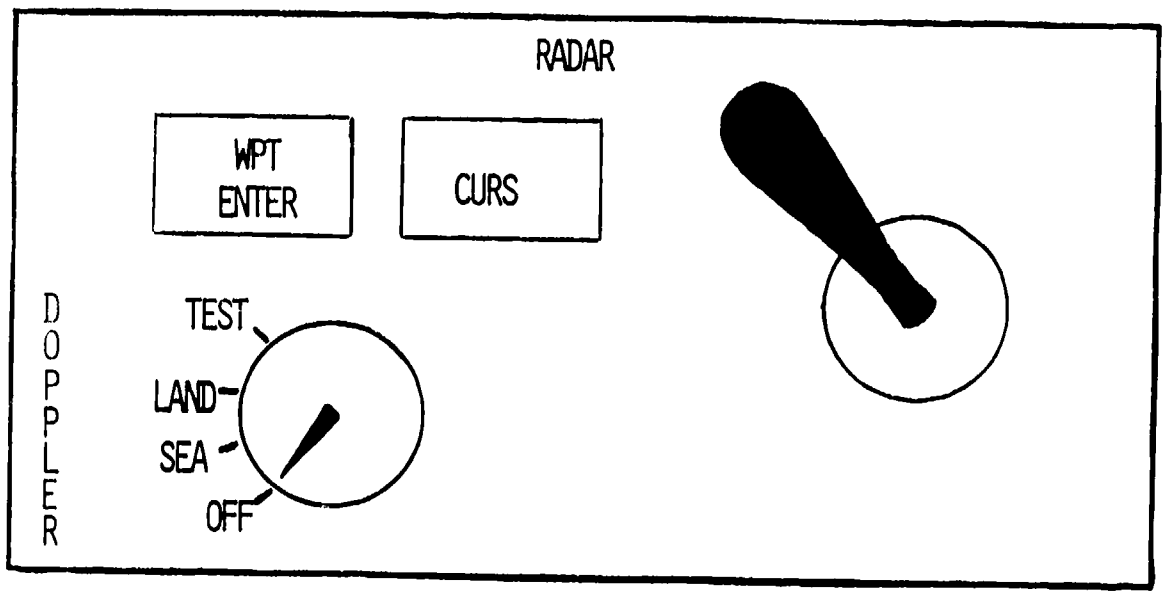


Figure 17. Doppler/Radar Cursor Control

DOPPLER/RADAR CURSOR CONTROL

The Teledyne-Ryan Common Strategic Doppler is compatible for alignment of the INS. The doppler provides groundspeed and drift angle information to the nav management system. The doppler control panel is combined with the radar cursor control panel and mounted on the forward center console. Its function is integrated within the nav management system, with the resulting information displayed on the nav management CDUs.

1. The doppler control panel has a mode switch with an OFF, LAND, and SEA mode. (A) OFF - Power is disconnected from the unit. (B) LAND - The mode used when navigation is being performed over landmass. (C) SEA - The mode used when navigating over large water areas.

2. A memory malfunction light (MEM MAL) warns the pilot of a malfunction of the doppler system. This light is displayed on the caution/warning panel and also connected to the master caution light.

3. After the control is turned to the LAND or SEA position, the doppler is programmed through the nav management CDU by the same procedure and at the same time that the INS was programmed. Present position page is selected. The latitude and longitude of the aircraft's present position is inserted and the doppler system begins navigating from that point. No warm-up is required. Groundspeed and drift angle are displayed on the nav management CDU.

RADAR CURSOR CONTROL

A radar cursor control is located on the forward center console. When cursor is selected, a cross hair appears on the display. The cross hair or cursor can be moved about the display with a joy stick cursor control and positioned at a desired location. The position of the cursor can be inserted into the Nav Management System through the cursor insert control. For example, when a radar ground target is selected, the location of that target is identified through the nav management CDU. The "CURS" switch is activated which causes a cross hair to appear on the ground radar display at the selected target location, including INS drift error. The pilot may then move the location of the cross hair with the joy stick, correcting the location of the cross hair for nav system drift. The insert function can then be activated by pressing the insert switch, which feeds the cross hair location information to the mission computer. The computer then calculates the difference between the initial cross hair location and the drift corrected location in terms of latitude and longitude. This difference is then fed into the mission computer to update the aircraft lat/long position. Further description of position update, accomplished automatically or manually by the pilot to update the navigation system is described in the "Operational Description of the Navigation Management System and Page Formats", Appendix A, this volume.

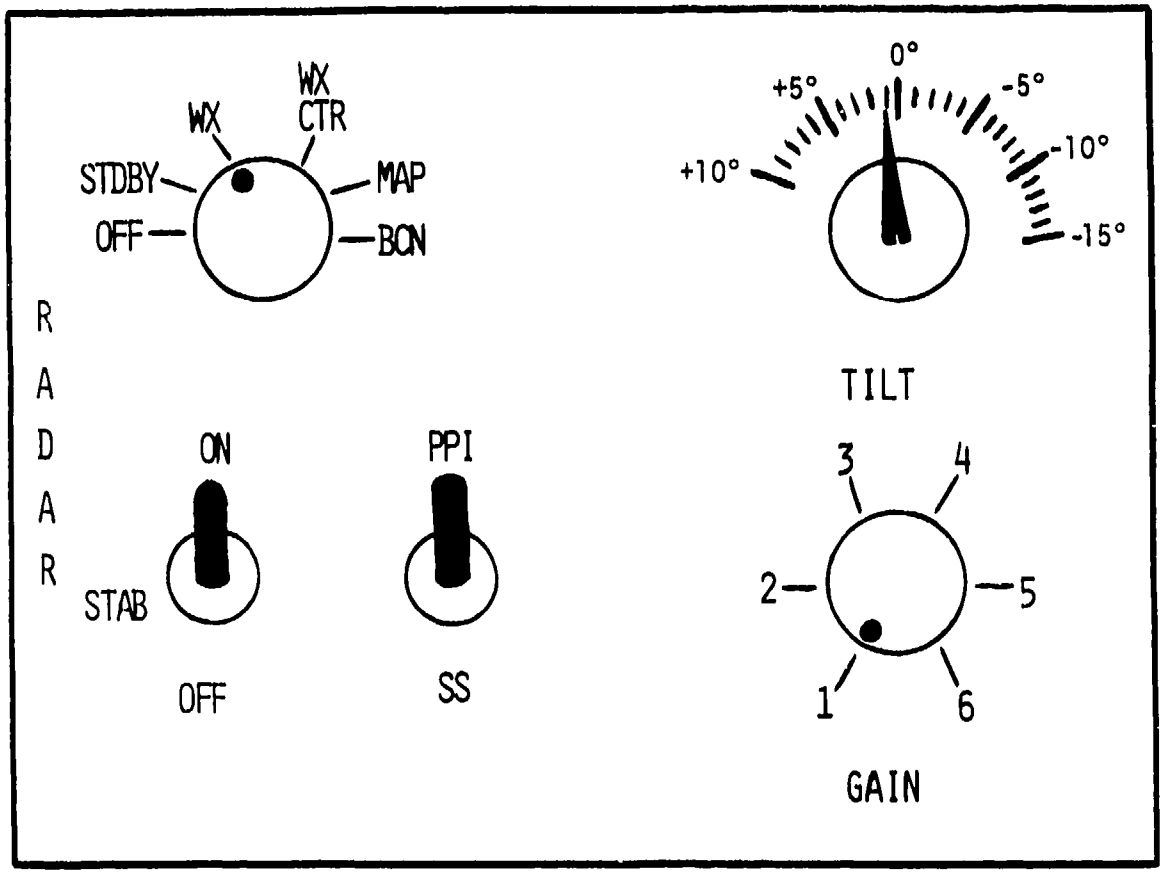


Figure 18. Radar Control Panel

Radar will be displayed on the pilot's and copilot's HSDs. Display of the information will be selectable to either or both sides of the cockpit. As described in the section on operation of the HSD, the display selectors are located on the switching matrix adjacent to the HSDs. The radar mode control panel is located on the overhead console within easy operating reach of both pilots. The radar may be used to depict ground mapping returns, weather returns, aircraft beacon returns, or aircraft skin paint returns. The unit is capable of only one of those modes at any one time. They are selectable by a mode selector switch on the mode control panel. Components of the radar unit must be pressurized. A pressure gage, pressure control, and pressure bleed system is located on the pilot's side of the overhead panel. A pressure warning indicator is integrated with the central caution and warning annunciation panel.

1. Mode selection is accomplished with a rotary switch containing the following functions: (A) OFF - Where all power is removed from the set. (B) STANDBY - The warm-up position. (C) WX - Provides a continuous scan for weather returns. Scan area depends upon the antenna tilt and range selected. (D) WX CTR - This weather contour position displays the intensity of the weather cells by depicting sharp outlines of the cell where moisture and turbulence are prevalent. (E) MAP - Provides a continuous scan for ground returns. Scan area depends upon the antenna tilt and the range selected. (F) BEACON - The search radar transmits pulses which cause operation of the radar beacon in other airplanes or at ground stations. Those beacons are then received on the aircraft display as a group of bars spaced according to the code identification of the responding radar beacons. They are displayed at the range and azimuth of the beacon location.

2. Range control of the system is accomplished through a toggle action switch located on each HSD mode selector switch panel. Range selections between 4 and 240 miles are available as described later in the HSD section.

3. Antenna tilt control is accomplished through a rotary knob, scaled to show the vertical tilt above and below the center line of the aircraft. Tilt of the antenna determines whether ground targets or weather are being painted by the radar.

4. A gain control allows intensity of the display to be adjusted.

5. Antenna Stabilization in the vertical axis is provided by an ON-OFF "Stab" switch. When "ON" the radar antenna is aligned horizontally in reference to the earth. When "OFF" the antenna is aligned to the longitudinal axis of the aircraft.

6. The radar system contains an automatic feature which displays a warning symbol on the HSD of nearby weather cells if the radar is on the WX or WX CTR position even though a radar overlay is not being displayed on the HSD. This allows the pilot to select RADAR on the HSD to determine the exact location.

7. The radar scanning pattern displayed on the HSD is controlled through the "PPI/SS" (Plan Position Indicator/Sector Scan) switch. In PPI, the radar scan will be 360° with the following scan rates: a) with the range selection switch in either the 4, 12, or 40 mile position, the scan rate is 45 RPM; b) with the range selection switch in either the 80, 160, or 240 mile position, the scan rate is 12 RPM. In PPI, the host aircraft is in the center of the display.

In SS, the sector display will cover 90 degrees (45° + 5° on either side of the centerline) and will have a scan rate of 12 RPM. In SS, the host aircraft wi' be at the apex of the pie-shaped sector. The apex is shifted to a positio.. near the edge of the HSD to provide as much viewing area as possible.

NOTE: When Radar is selected for display, "Track-up" orientation will be automatically presented.

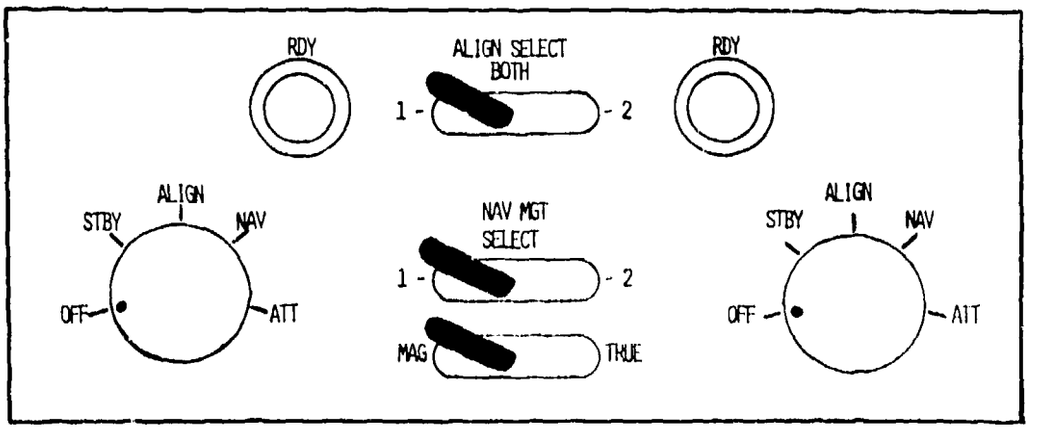


Figure 19. INS Mode Selector

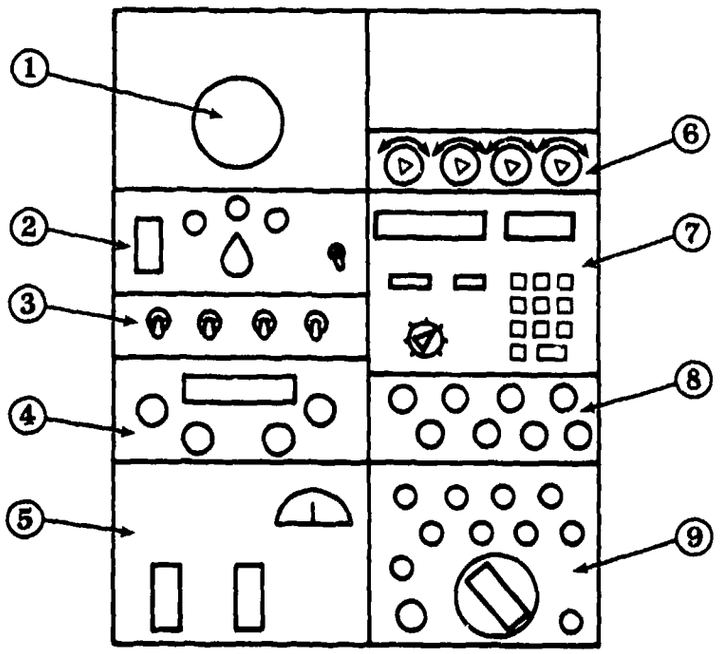
The Inertial Navigation System (INS) is made up of two Carousel IV-E black box units which are interfaced with the pilots through the nav management CDUs. One Carousel IV dedicated control head is installed in the forward boom operator's station for redundancy. OFF/ON, mode selection, and selector control for #1 or #2 INS is controlled through an INS control panel located on the forward center console. The Align Select switch on that panel allows the pilot to align either or both INS black box units simultaneously. The Nav Mgt Select switch on that panel allows either INS black box #1 or INS black box #2 to provide information to both nav management CDUs. A similar switch on the forward boom station allows selection of INS #1 or 2 to the dedicated control head at that station. Typically both inertial systems would be ON and aligned simultaneously through the control panel and the nav management CDUs. Only the selected unit, however, would provide navigation for the aircraft. The other unit is redundant and would be selected only if information from the selected unit was suspect. The MAG-TRUE switch allows the pilot to select magnetic or true heading reference from the INS. This heading indication is provided to all aircraft heading systems (regardless of INS or AHRS selection) and navigation systems. If either pilot has selected AHRS heading reference when the INS Mag-True switch is in the "true" position, the INS computer will signal the AHRS heading reference to correct for magnetic variation.

1. The mode control on the INS panel has an OFF, STBY, ALIGN, and NAV position for each of the two inertial systems, as well as the selector switch to determine which unit is connected to the nav management system. (A) OFF -Power is disconnected from the system. (B) STBY - Power is connected to the system (except the gyros) and present position may be entered. (C) ALIGN -gyros come up to speed requiring approximately 20 minutes before unit can be moved. (D) NAV - The operating position where taxi and flight operations can begin while the INS calculates the position of the aircraft. Both INSs can be aligned and programmed simultaneously by selecting "Both" on the Align Select switch and both will continue to compute position of the aircraft. That information can be displayed on either or both nav management CDUs from whichever INS is selected by the selector switch.

2. The INS is programmed through either nav management CDU by selecting the present position page and determining that the aircraft location in latitude and longitude is entered into the appropriate position on that page.

3. The flight plan page is selected and desired flight plan waypoints are identified and inserted into the system. Further description of the operation of the nav management system is contained in the section by that title.

4. The inertial nav systems are connected to the central caution and warning system. The master caution light and the appropriate caution light illuminates when #1 or #2 INS fails, #1 or #2 INS overheats, or when there is a 10 NM or more difference in aircraft position indicated between the two inertial systems.



* 1) Accelerometer
* 2) Ciphony control panel
\+ 3) HF transfer and INS selector switches
* 4) HF comm control panel
\+ 5) Oxygen control panel
\+ 6) Light controls
\+ 7) INS control/display unit
\+ 8) Nav monitor panel
\+ 9) AIC-18

\+ New hardware, new location
* Current tanker hardware, new location

Figure 20. Boom Operator's Forward Station

BOOM OPERATOR'S FORWARD STATION

The forward boom operator's station is located aft of the copilot's position, formerly the navigator station. The seat is on tracks which allows the boom operator to move from his panel to a position directly behind and between the pilots' seats. The forward boom operator's panel includes:

1. Light Controls. Rheostats to control panel lighting and a map reading light.

2. AIC-18 Communications Control and Nav Monitor. These two standard control panels allow the boom operator to monitor all communications and navigation radios and to transmit on any communications radio. Individual volume control is provided.

3. Oxygen Control. A standard oxygen regulator for the boom operator is installed in his panel.

4. HF Radio Control. A control unit for the ARC-190 high frequency communications radio is installed in this panel. The radio may be tuned from this control head after control has been taken by activating the HF control switch located above the control head. A second HF control unit and control switch is located on the pilot's overhead panel. Operation of the spring loaded HF control toggle switch takes or gives up control of the tuning functions, alternately. A green light adjacent to the switch illuminates when tuning control is at that location.

5. Ciphony Control. The ciphony control is used to provide secure UHF voice capability on UHF #1 or UHF #2 by selecting the "C/RAD 1" or "C/RAD 2" position on the mode selector. The "Plain" position on the mode selector is the normal position for unsecure transmissions. A green light adjacent to each position illuminates to indicate the position of the switch. Power to the control is selected through the "Power" switch. The signals can be zeroized by activating the guarded "Zeroize" switch.

6. Accelerometer. Since the g-meter is used only for historical purposes in the KC-135, it is located on the boom operator's panel. It can be referred to by the boom operator, pilot or maintenance personnel.

7. INS CDU. This standard, dedicated control unit for the Delco Carousel IV-E Inertial Navigation System is provided for redundancy only. It is located on the flight deck where it can be used by the boom operator or other crew members under the pilots' supervision in the event that both nav management CDUs become inoperative. The CDU may be used to operate either one of the INS black boxes through the INS mode control unit located on the forward center console (described in the section on INS). Control of the INS can be switched from the nav mgt CDUs to the forward boom operator's station through an INS transfer switch located on that panel.

The functions of the Carousel IV control unit and the operational procedures are described in pilots guide (Ref. 5).

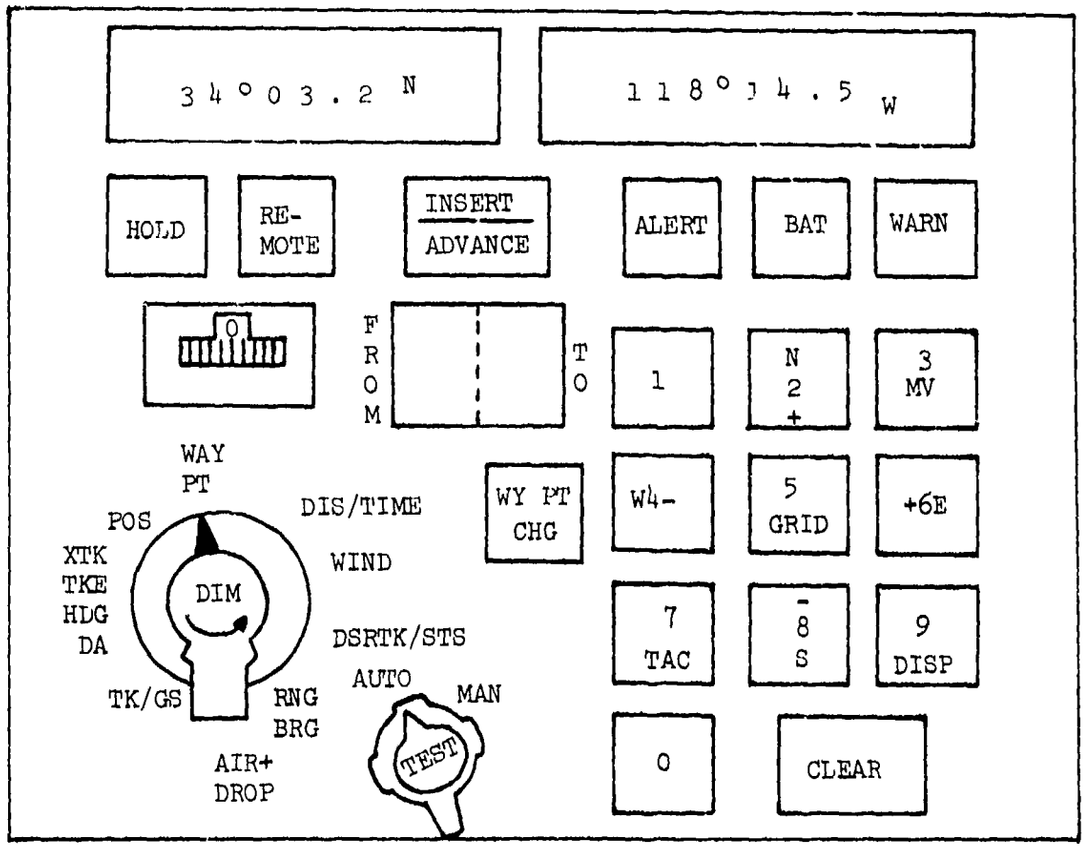
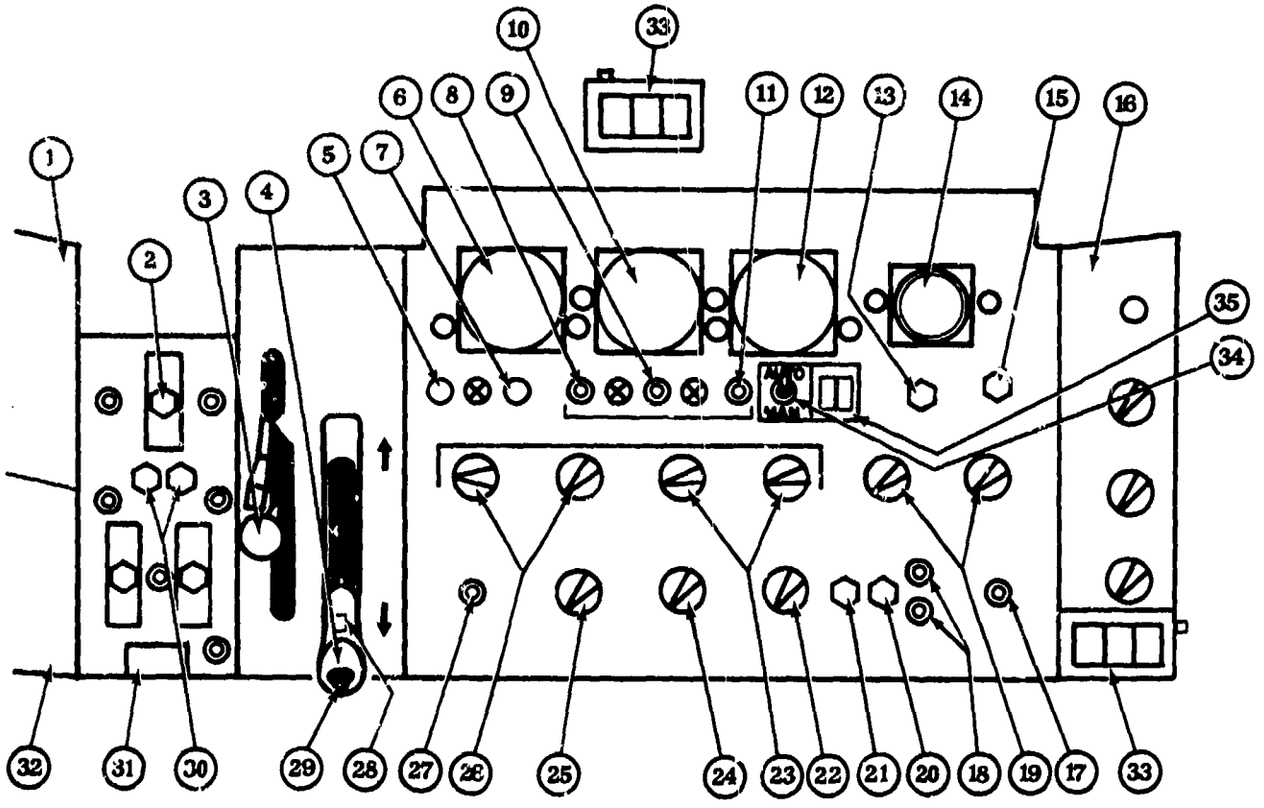


Figure 21. Carousel IV Inertial Navigation System Control Unit



1 OXYGEN REGULATOR PANEL (REF)
2 EMERGENCY OVERRIDE SWITCH
3 BOOM HOIST LEVER
4 BOOM TELESCOPE LEVER W/START/STOP SWITCH
5 SIGNAL AMPLIFIER TEST SWITCH
6 BOOM AZIMUTH INDICATOR
7 A/R SYSTEM RESET SWITCH
8 READY CONTACT SIGNAL LIGHT
9 MADE CONTACT SIGNAL LIGHT
10 BOOM TELESCOPING INDICATOR
11 DISCONNECT CONTACT SIGNAL LIGHT
12 BOOM ELEVATION INDICATOR
13 BOOM SIGNAL COIL TEST SWITCH
14 BOOM SIGNAL COIL TEST VOLTMETER
15 A/R MASTER SWITCH
16 BOOM OPERATOR's CIRCUIT BREAKER PANEL (REF)
17 RECEIVER PILOT DIRECTOR LIGHT
18 RESTART INDICATOR LIGHTS
19 NACELLE ILLUMINATION CONTROLS
20 BOOM MARKER LIGHT START SWITCH
21 BOOM MARKER LIGHT CONTROL SWITCH
22 BOOM NOZZLE ILLUMINATION RHEOSTAT
23 RECEIVER PILOT DIRECTOR POSITION LIGHT CONTROLS
24 UNDERBODY ILLUMINATION RHEOSTAT
25 UNDERWING ILLUMINATION RHEOSTAT
26 RECEIVER PILOT DIRECTOR BACKGROUND LIGHT CONTROLS
27 TELESCOPE-AT-DISCONNECT SWITCH
28 EMERGENCY CONTACT MADE SWITCH
29 EMERGENCY BREAKAWAY SIGNAL SWITCH
30 RECEIVER PILOT DIRECTOR LIGHT SWITCHES
31 LIMIT CUTOUT SWITCHES
32 INTERPHONE PANEL (REF)
+ 33 FUEL OFFLOAD INDICATOR WITH RESET SWITCH
+ 34 AUTO/MANUAL FUEL SELECT SWITCH
+ 35 OFFLOAD QUANTITY SELECTOR

\+ New hardware, new location
\# New hardware, current tanker location

Figure 22. Boom Operator's Aft Station

BOOM OPERATOR'S AFT STATION

The KC-135 boom operator's station design capabilities have been updated to reduce overall crew workload and to increase the boom operator's utility and responsibilities.

The boom operator's station geometry remains unchanged, including the panel layout and the two boom controls (telescope lever and ruddervator control). The following boom station design capability changes reflect the results of the crew station evaluation during mission simulation.

1. Left Side Panel. The AIC-10 is updated to an AIC-18.

2. Center Panel. The center panel modifications are relatively minor and should not require a new panel.

a. A total fuel quantity transfer indicator with a "push to reset" function is located below the panel light controls and to the right side of the center panel. This display provides information regarding the total amount of fuel offloaded during a mission. The quantity should be reset to zero at the end of each mission.

b. A fuel offload selector and a fuel offload function switch are located just below the boom elevation indicator. These controls provide the capability to offload a desired amount of fuel either manually or automatically. To control the amount of fuel offloaded manually, the two-position offload function switch is placed in "manual" position. To offload fuel automatically, the offload function switch is placed in the "auto" position and the desired amount of fuel to be offloaded is selected (through the use of thumbwheels or toggle switches) on the fuel offload quantity selector.

c. A fuel quantity transfer indicator ("per receiver") with a "push to reset" function is located at the top center of the center panel. This indicator displays the amount of fuel offloaded for each aircraft. The "push to reset" function zeros out the quantity offloaded after each receiver completes his onload.

3. Boom Telesccpe Lever. The boom telescope lever is modified to include a "start/"stop" switch which allows the boom operator to initiate fuel offload except for fuel dump. The "start" selection on the telescope lever will allow fuel to flow to receiver if: A/R pumps have been selected for a tank with available fuel; and A/R line valve is open; and contact has been made with a receiver. Offload fuel flow will stop if: fuel is exhausted from selected tank; or fuel offload has reached a predetermined setting on the fuel offload quantity selector; or a disconnect occurs; or A/R pumps are turned off; or the pilot closes the A/R line valve; or the "stop" switch is selected on the telescope lever.

4. Fuel Offload Procedures. In order to offload fuel with the updated boom station capabilities, the procedures are modified as follows:

a. Fuel is transferred into forward body, center wing and aft body tanks as desired through the controls on the pilots' fuel control panel (no change to present procedures).

b. The desired A/R pump switches for the desired A/R tanks are selected on the pilots' fuel control panel as required for the scheduled receiver (no change to present procedures).

c. The "per receiver" fuel quantity transferred indicator is set at zero by the boom operator.

d. For auto offload, the offload function switch is placed in "auto".

e. The offfload quantity selector digits are selected to reflect the exact amount of fuel to be offloaded to the first receiver (0-99 thousand pounds).

f. The receiver is cleared to make contact (no change in procedure).

g. After contact, the boom operator initiates offload fuel flow to the receivers by selecting the "start" switch on the boom telescope lever.

NOTE: The A/R line valve (controlled by a switch on the pilots' fuel control panel) must be open prior to any aerial refueling.

h. If the auto offload functions have been selected, fuel offload will stop when the predetermined amount of fuel has been delivered to the receiver, regardless of the number of disconnects. If "manual" is selected on fuel offload function, the boom operator may select "stop" on the boom telescope lever to stop fuel offload or the copilot may stop fuel flow by turning off A/R pumps (no change in copilot procedure).

i. Receiver is cleared to disconnect (no change in procedure).

j. To prepare for auto offload for the next receiver, the boom operator: (1) "resets" the "per receiver" fuel transferred indicator to "zero", (2) cycles the offload function selector from "Auto" to "Manual" and back to "Auto" (to signal zero to offload computer), and (3) resets (if necessary) the desired offload in the offload quantity selector.

APPENDIX A

OPERATIONAL DESCRIPTION OF THE NAVIGATION MANAGEMENT SYSTEM AND PAGE FORMATS

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TABLES OF FIGURES

A. General

The navigation management system (sometimes referred to as area nav or RNAV) provides precise navigation information worldwide, with and without external navigation aids. Additionally, it provides the capability for airway navigation, nonprecision approaches, precision approaches, and aerial rendezvous between aircraft. The basis for the system is an inertial navigation system (INS) which is updated by doppler and installed navigation sensors (i.e., TACAN) through a Kalman filter. Unreasonable or erroneous information is automatically filtered out and only the most accurate information is used for updating. The system may also be updated with ground radar. If desired, navigation information may be obtained directly from individual sensors (i.e. ILS, VOR, TACAN, ADF, UHF/DF).

The system also provides the capability for computing pre-flight information for flight planning purposes, fuel remaining and fuel required, takeoff and landing aircraft performance data and aircraft center of gravity computations.

Components of the system include: 1) the navigation management computer, through which all information is fed, 2) a memory system which stores prerecorded and currently entered information (nav aids identifiers and locations, air field locations, etc.), 3) the Kalman filter described above and 4) the control/display unit (CDU) which interfaces the pilot with the nav system.

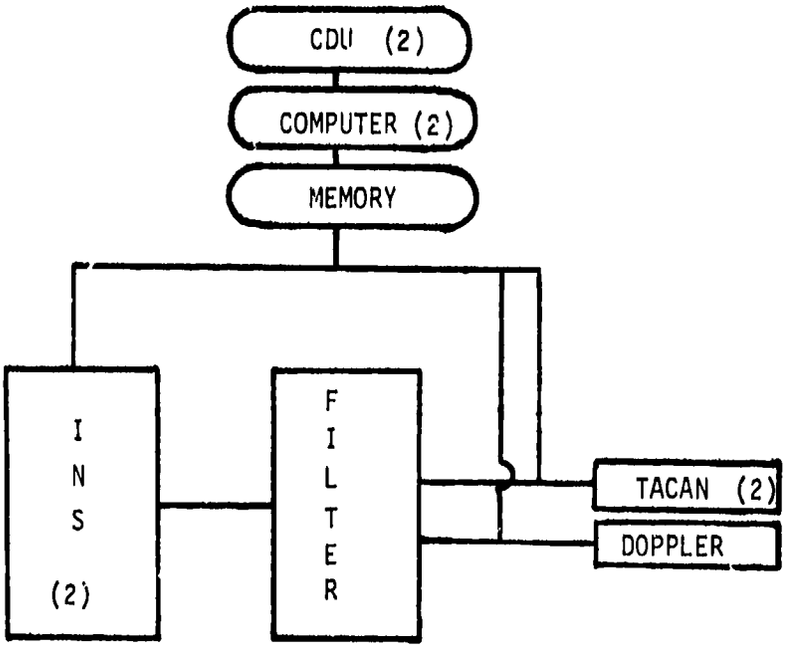


Figure A-1 Nav Management System Components

B. Control Display Unit (CDU)

The aircraft-aircrew interface consists of two cathode ray tubes (CRT) and two keyboard control/display units (Figure 2). The CRT has a 3 1/2" x 4 1/4" viewing area upon which 15 lines of information can be displayed; a title line, two lines adjacent to each of six line keys along the left side and a two line scratch pad for typing information. The CDU also has forward and aft page slew (scroll) keys, four page/special function keys along the right side of the CRT and a 48 key alphanumeric/page/special function keyboard.

C. Operation of the CDU

1. CDU Pages (Figure 3)

One of several different informational formats (pages) can be displayed by pressing the specific function keys on the keyboard; i.e., Flight Plan, Preflight, Fuel Plan, Present Position, Hold/Rendezvous, Takeoff and Landing Data, Center of Gravity and Navigation Aids. The Waypoint Data Page and Nav Aids Data Page may be displayed by first displaying "Flight Plan" or "Nav Aids" then pressing the line key adjacent to the desired waypoint. The flight plan page may also be displayed by pressing the "Direct To" key. Each page has a specific function which is discussed in greater detail later. The purpose of the pages are:

a. Flight Plan Page (FLT PLAN). Displays the sequential list of lateral and vertical waypoints that define the aircraft route.

b. Waypoint Data Page. Displays waypoint data relevant to a selected waypoint.

c. Preflight Page (PREFLT). Used to insert flight planning information (wind and TAS) so that estimated time enroute, fuel required and fuel remaining can be calculated.

d. Fuel Plan Page. Displays estimated time enroute between waypoints, estimated fuel required and estimated fuel remaining based upon information inserted on the Preflight Page.

e. Present Position Page (PPSN). Displays current aircraft lateral performance data.

f. Takeoff and Landing Data Page (TOLD). Used to insert conditions and display aircraft performance data.

g. Center of Gravity Page (CG). Displays aircraft weight and balance and percent mean effective chord (% MAC) information.

h. Navigation Aids Page (NAV AIDS). Displays identifiers for all prestored navigation aids, airway intersections and airfields, arranged alphabetically.

i. Navigation Aids Data Page. Displays all prestored information concerning selected navigation aids, airway intersections and airfields.

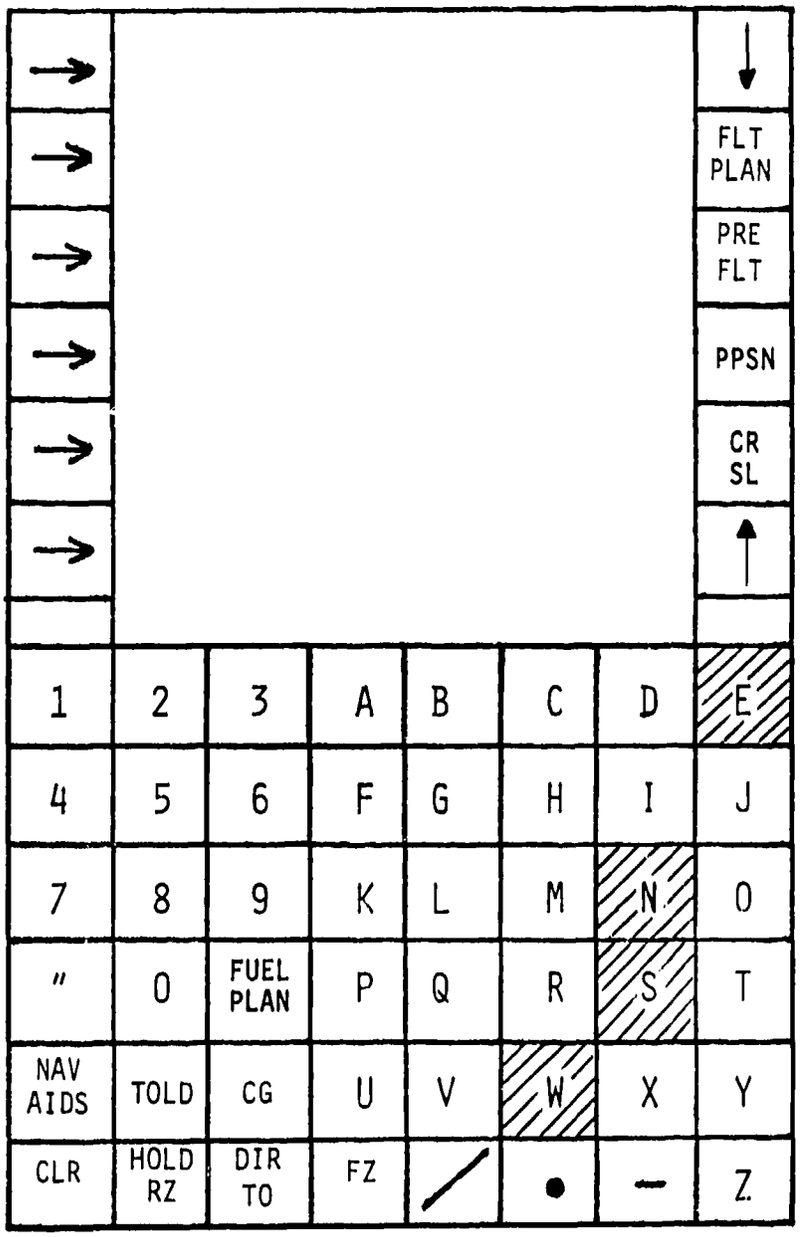


Figure A-2 Nav Management Control/Display Unit

j. Holding/Rendezvous Page (HOLD/RZ). Displays information on a designated holding pattern or refueling rendezvous track.

2. Special Functions

a. Direct to Function (DIR TO). Displays the Flight Plan Page with the capability to navigate from the present position directly to a newly defined waypoint or to any flight plan waypoint.

b. Flight Plan Freeze (FZ). Displays the words ///Flt Plan Freeze/// in the title line of the Flight Plan Page and prevents automatic update of the flight plan at waypoint passage. It also displays the words ///Present Position Freeze/// on the Present Position Page and freezes all information displayed on that page, i.e., the display is not continuously updated even though the nav system continues to navigate.

c. Display Slew (↑). Scrolls the display forward or back one or six lines per press as appropriate.

d. Clear (CLR). Used to clear scratch pad entries; first press clears last digit typed, second press clears up to last slant (/), and third press clears the scratch pad.

e. Cursor Slew (CURS SLEW). The cursor always appears where the next entry will be typed on the scratch pad. It may be moved to a new position with the cursor slew switch.

f. Numbers, letters and symbols. Appear on the scratch pad as the keys are pressed.

g. Entry keys. Provides capability to enter information from scratch pad to any display line as indicated by an asterisk.

3. Typing the Data

Entering or changing information in the system or on a page is accomplished by 1) selecting the appropriate page, 2) typing the information on the keyboard (message is displayed on the scratch pad) and 3) inserting the information by pressing the line key adjacent to the line on the CDU where the desired information is required. This action clears the scratch pad and inserts the information in the necessary position. The scratch pad may also be cleared by pressing the "clear" key. Pressing the "clear" key once removes the last letter or digit. Pressing it a second time clears everything back to the first slant symbol (/) and pressing it a third time clears the entire scratch pad.

4. Defining the Waypoint (Format)

Waypoints may be defined in several ways. They must be typed in the proper format in order for the nav management system to accept them.

* FLT PLAN

FROM			
	EDAF		0368
280	LL1	97	4000
037	BD1 HOLD	102	FL070
062	BD2	36	FL070
351	HAM	12	FL190
275	LL2	49	FL390

WAYPOINT DATA

* WPT BERRY	N531140 E0103220 FFO 307/124
* GMT 1410:10	
FLT PLAN	ETA 1429:45 TTW 19:35 DTW 163.9
GS 245	
PSN FR BERRY	179/163.9

* PREFLIGHT

FROM	WIND	TAS	FFx1000
EDAF	270/35	240	1.4
LL1	290/85	440	1.2
BERR	360/105	440	1.2
HAM	360/105	440	1.2
BD1	360/105	450	1.0
EDAF	050/25	180	8

* FUEL PLAN

FROM	ETE TM RMN	FUEL RQ LEG TOT	FUEL RMN
EDAF	0 2+06	0 129	170
LL1	32 1+34	5 124	165
BERRY	1+09 25	14 110	151
OFFLD		105 5	46
HAM	10 15	2 3	44
EDAF	15 0	3 0	41

FigureA-3 Nav Management Page Formats

PRESENT POSITION

* N422810 W1290736

* GMT 1219:00

WIND 228/106 DFT L10
TAS 355 GS 265

TAC 1 BRG/DIST
MLD 020/43

TAC 2 BRG/DIST
BZN 150/127

* IDENT RAD/DIST FROM
MINAS 357/128

* TOLD

TAKEOFF DATA

RCR	23
FLAP SET	20
GROSS WT	221300
RWY TEMP	47
PRES ALT	830
SFC WIND	270/20

* CENTER OF GRAVITY

BASIC WT		105741
OIL		169
DROGUE		
CARGO/PAX		
B 1250	C	
E	F	00
H 2000	I	J 1000

NAV AIDS

AA	AB	AC
AD	AE	AF
AG	AH	AI
AJ	AK	AL
AM	AN	AO
AP	AQ	AR

NAV 3 DATA

EDBB TF EHOF

* PSN N 23114 E0103412

CHAN 89

FREQ	114.20	321	382
	415	DF	GCA
	ILS		

* HOLD/RZ

INB CRS/TYPE	270/H
INB LEG/TURNS	5/R
REC TAS/DFT CR	440/-5
REC IP	N403520 E0321630
TURN RNG/OFFSET	21/10

← PUSH TO INSERT

Figure A-3 (Continued)

a. Latitude/Longitude. Identified as LL1, LL2, etc. Format -- N402210/E0072509/8000. Minutes and seconds must be typed as four characters. Typing leading zeros is optional, however, at least one zero must be typed to represent degrees; all zeros will appear in the display. Trailing zeros must be typed. Note: 8000 signifies flight planned altitude and is a required entry since waypoints are three-dimensional points. Four or five digit numbers are automatically designated by the Nav Management System as altitudes (8000, 0085, 16000). A three digit number is automatically designated as a flight level (FL290, FL090).

b. Bearing/Distance From a Prestored Nav Aid or Previously Identified Point. Identified as BD1, BD2, etc. Format -- FF0/110/30.2/5000 or LL1/265/19.8/FL290.

c. Prestored Nav Aids. Prestored in memory as a Lat/Long and identified as a two or three-letter symbol; e.g., FFO, IND, FM. Format -- FFO/2200.

d. Route Intersection. Placed in memory as a Lat/Long (LL3), or Bearing/Distance (BD4), or prestored in memory and identified as a combination of three alphanumerics (5EG, N3E) or up to a five-letter name or identification (BERRY, NILES). Format -- NILES/6000.

e. Airfield. Prestored in memory as a four letter identifier (KFFO, EDAF). Format -- EDAF/0368.

NOTE: The computer automatically labels/identifies waypoints typed and entered as latitude/longitude (LL1, LL2, etc.) and as bearing/distance (BD1, BD2, etc.). Any waypoint may be further identified by the pilot by typing a slant (/) followed by the desired label/identifier immediately after the altitude entry during the original typing procedure. This additional identifier will appear directly below the LL or BD identifier on the Flight Plan, Preflight, and Fuel Plan pages. It can be deleted by typing a minus (-) and pressing the line key adjacent to the waypoint. It cannot be re-entered, however, once eliminated without re-identifying the original LL or BD waypoint.

If holding or rendezvous is to be accomplished at a waypoint which has a two line identifier, the second line will be replaced with the appropriate word ("HOLD", Rz, etc.) when the Hold/Rz Page has been completed and information inserted as described later during the discussion on that page.

NOTE: When the map format is displayed on the HSDs, the LL or BD identifier will be displayed; the additional identifier will not.

5. Items Identified by an Asterisk Symbol (*)

An asterisk symbol designates an item which may be changed through the keyboard scratch pad. An asterisk next to a page title indicates that all or most items on that page may be changed through the keyboard.

D. Description of Pages

1. Flight Plan Page

*FLT PLAN			
FROM	BERRY		4000
072	3EG	27	17000
336	FRED HOLD	60	FL200
086	MT	34	FL200
005	KBOS	112	0830

FigureA-4 Flight Plan Page

a. Entering the Flight Plan. When the "Flight Plan" key is pressed on keyboard, the above page (format) appears. The page actually may show only the title line and the "FROM" line if the Flight Plan page has no waypoint entries, or it may be full or partially full from previously stored data. The course (column 1) and distance (column 3) are not typed in but are automatically determined and entered by the computer. For example: the course from BERRY to 3EG is 072°; the distance from BERRY to 3EG is 27 NM. The top line on the Flight Plan Page, when the page is slewed or scrolled (slewing is discussed in a later section) all the way down, is the "From" waypoint. The from waypoint will be identified by the word "From" in the first space on the top line. If the flight plan is slewed up so that the "From" waypoint is not displayed, the word "From" also disappears. The 2nd line, when "From" is displayed, is the "To" waypoint. The first waypoint identified as a latitude/longitude position (N43°12'10"/E010°15'39") is designated by the computer as LL1, the second LL2, etc. The flight plan information is non-volatile, that is it will not change or erase when power is turned off. In order to erase flight plan memory, type "F/P erase" on the scratch pad and enter it on the "From" line. This provides a clean flight plan page and allows the assignment of LL1 to the first lat/long waypoint identified from the scratch pad. After the flight plan has been built, if an additional Lat/Long waypoint is injected between two others, the new waypoint is designated according to when it was typed and entered, not according to where it is placed in the flight plan. For example: A flight plan which contains 9 Lat/Long waypoints, LL1 through LL9, is entered on the flight plan page. An additional Lat/Long waypoint is required between LL2 and LL3. Its coordinates and altitude (N_ _ _ E _ _ _ / 8000) are typed on the scratch pad. When the line key adjacent to LL3 is pressed: 1) LL3 moves down one space, 2) the new waypoint (designated as LL10) is inserted between LL2 and LL3, 3) the message disappears from the scratch pad. The flight plan then reads LL1, LL2, LL10, LL3, etc.

The flight plan altitude must be entered. Since waypoints are three dimensional, to make a complete entry on the flight plan page it is necessary to type N431210/E101539/8000 on the scratch pad and insert it by pressing the appropriate line key. When the altitude or flight level remains the same as for the previous waypoint, it may be entered using ditto marks. For example, a scratch pad entry might be IND/" indicating that the flight planned altitude over IND is the same as for the previous waypoint. The altitude in the flight plan for IND would be displayed the same as the altitude above it.

b. Changing scratch pad or flight plan entries. To erase any part of scratch pad entry, press the "Clear" key once, twice or three times as necessary and retype. To change any individual letter or digit scratch pad entry, the "cursor slew key" should be pressed until the cursor is directly below the character to be changed. Typing a new character will then change the entry and the cursor slew will return to its previous position. (Operation of the cursor slew is discussed later in this section.) To change any part of a flight plan after it has been entered 1) type minus (-) on the scratch pad, 2) press the line key adjacent to incorrect entry (entry will be erased), 3) type new information on scratch pad and 4) press adjacent line key to enter in the appropriate position. The altitude of any waypoint may be changed by typing the desired altitude on the scratch pad (i.e., 5000) and entering through the line key adjacent to desired altitude change.

NOTE: If the operator types non-logical data in the scratch pad, an attempt to enter it in the flight plan will result in the incorrect scratch pad message blinking alternately with the word "error".

NOTE: As aircraft approaches to within 5 NM of "to" waypoint, the waypoint identifier begins blinking at 1 cycle per second and continues blinking until that waypoint becomes the "from" waypoint.

Based on TAS and degrees of course change, a turn lead point is automatically computed (5 NM max) and the navigation management system automatically changes to the succeeding waypoint. At that time, if the Nav Mode is selected in the flight director, the flight director commands a turn to intercept the new course and, if the lateral nav mode has been selected on the autopilot, the aircraft starts to turn on course.

2. Waypoint Data Page

To display information held in memory by the nav management system for any waypoint:

a. Display the Flight Plan Page by pressing the "Flight Plan" key or the "Dir To" key.

b. Press the line key adjacent to the waypoint for which the information is desired. This brings up the Waypoint Data Page and displays all information contained in the system for that waypoint. An example is shown below.

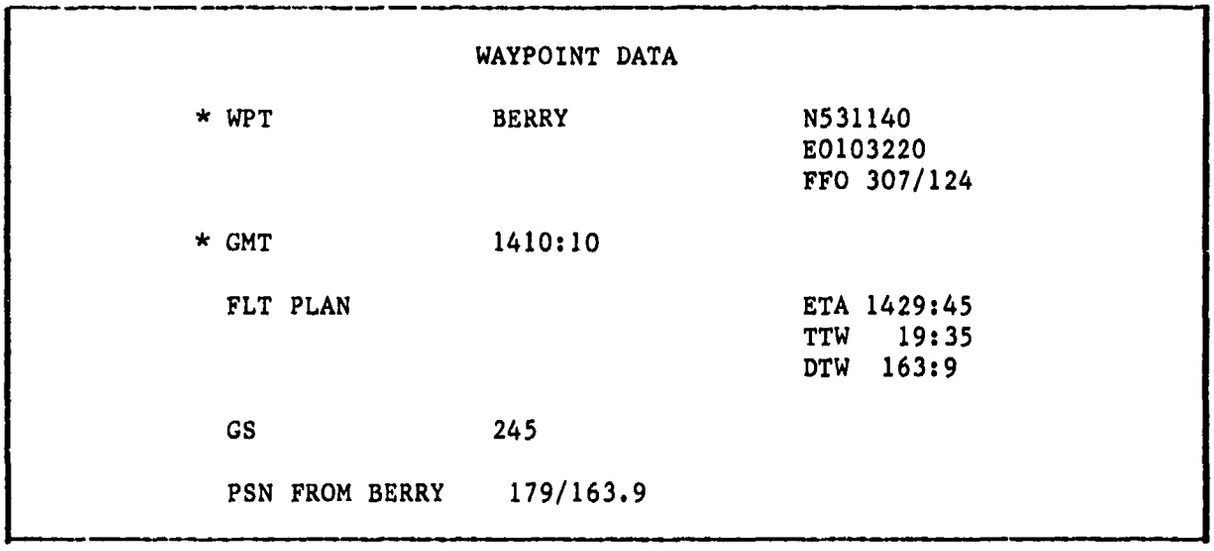


Figure A-5 Waypoint Data Page

1st line -- Waypoint identifier and the data that defines selected waypoint. When the selected waypoint is a bearing/distance (BD) or an airway intersection, both its bearing/distance info and its Lat/Long are displayed.

2nd line -- Greenwich Mean Time (GMT). Time must be entered with four digits -- two for hours and two for minutes (0200, etc.).

3rd line -- Estimated Time of Arrival (ETA), Time To Waypoint (TTW), and Distance To Waypoint (DTW), computed along the flight plan route if the waypoint is in the flight plan, or direct if not.

4th line -- Ground speed in knots.

5th line -- Radial and distance from the selected waypoint.

c. When the symbol of a previously identified waypoint (i.e. LL1 or BD2, etc.) is typed on the scratch pad and entered opposite the top adjacent line key, all information on the waypoint data page is changed to reflect that waypoint. A waypoint which is not already identified and in memory may be defined on this page by typing a latitude/longitude or bearing/distance on the scratch pad and entering it on the top line key. A coded "LL" or "BD" will not appear as a waypoint identifier, in this case.

3. Preflight Page

The Preflight Page is used to program planning information (wind and TAS) so that estimated time enroute (ETE), fuel required (by leg and total), and fuel remaining, can be calculated by the navigation computer and displayed on the Fuel Plan Page. Fuel flow is automatically computed from the performance data stored in the mission computer memory and is displayed in the right hand column of the preflight page.

NOTE: Weight and balance page (discussed later in this section) must be completed in order to display accurate fuel information on the Preflight and Fuel Plan pages.

Flight plan waypoints which appear on the Flight Plan Page are repeated on the Preflight Page (only the first 4 characters of any 5 character identifiers appear due to limited spaces on the CRT). The information pertinent to each waypoint is typed on the scratch pad and entered by pressing the line key opposite the waypoint. Information can be typed in the following formats:

Wind and TAS	= 360/105/425
Dittos may be used if information does not change.	
No change of wind or TAS	= " / " / "
Only wind direction and wind speed changes	= 360/105/ "
Only TAS changes	= " / " /440

Information entered on the preflight page automatically updates the Fuel Plan Page whenever it is inserted.

NOTE: In order to more accurately display fuel information requirements, an alternate airport (if required) must be included on the Flight Plan Page and programmed on the Preflight Page.

* PREFLIGHT

FROM	WIND	TAS	FFx1000
EDAF	270/35	240	14
LL1	290/85	440	12
BERR	360/105	440	12
HAM	360/105	440	12
BD1	360/105	450	10
EDAF	050/25	180	8

FigureA-6 Preflight Page

4. Fuel Plan Page

The Fuel Plan Page displays estimated time enroute (ETE) between waypoints (in hours and minutes), fuel required for the leg between each successive waypoint (in pounds x 1000), total fuel required for the remainder of

the flight plan from each waypoint (in pounds x 1000) and estimated total fuel remaining aboard the aircraft at each waypoint (in pounds x 1000). NOTE: The value will appear as a decimal if less than 1000 pounds, e.g., .3, .9, etc.

Flight plan waypoints which appear on the Flight Plan Page are repeated on the Fuel Plan Page. As wind and TAS are inserted on the Preflight Page, the information on the Fuel Plan page is updated. This includes the estimated time enroute (ETE) between waypoints and the total flight plan time remaining (TM RMN) at each waypoint.

The total remaining fuel (FUEL RMN) information is automatically displayed on the FUEL RMN column, except for fuel offload. Aerial refueling offload is entered on this page opposite the waypoint where the offload is to begin. It is entered by typing "OFFLD" followed by the amount of projected fuel to be offloaded/transferred (in pounds times 1000) and pressing the line key immediately below the waypoint where the refueling is to begin. For example: "OFFLD/105" inserted at the appropriate place in the flight plan would be displayed in the "From" and "Fuel Req" columns. When it is entered, the total fuel required (FUEL RQ) column and the estimated total fuel remaining (FUEL/RMN) column will be automatically updated.

* FUEL PLAN (lbs. x 1000)

FROM	ETE TM RMN	FUEL RQ LEG/TOT	FUEL RMN
EDAF	0 2+06	0 129	17C
LL1	32 1+34	5 124	165
BERRY	1+09 25	14 110	151
OFFLD		105 5	46
HAM	10 15	2 3	44
EDAF	15 0	3 0	41

Figure A-7 Fuel Plan Page

5. Present Position Page

When the "present position" key is pressed on the keyboard, the following page appears. It displays present lat/long coordinates, GMT, wind

direction and velocity, drift angle (difference between ground track and heading), true airspeed (TAS), ground speed (GS), and the TACAN station identifiers, bearings and distances to the auto or manually tuned TACAN stations. The present position relative to any position with a two, three, four, or five letter identifier held in memory (displayed on the Nav Aids Page or identified on the Flt Plan Page as an LL or BD) may be obtained by typing the identifier on the scratch pad and pressing the line key adjacent to "IDENT". The identifier and magnetic radial and distance from that point will then be displayed.

PRESENT POSITION

* N422810	W1290736
* GMT	1219:00
WIND 228/106	DFT L10
TAS 355	GS 265
TAC 1	BRG/DIST
MLD	020/43
TAC 2	BRG/DIST
BZN	150/127
* IDENT	RAD/DIST FROM
MINAS	357/128

Figure A-8 Present Position Page

NOTE: Since the TACAN information is displayed on this page, a short description of their automatic tuning capability is included. TACANs will have auto-tune as well as manual tune capability with station, bearing and distance information displayed on the Present Position Page. They will be auto-tuned whenever the CMPTR Nav Mode is selected on the HSD switching matrix and an "Auto Tune" message will be displayed on the appropriate HSD as described in this report (Volume II, Appendix B). The mission computer will determine which stations along the way will provide the best navigation update information and will automatically tune the TACAN receivers to either TACAN or DME Only stations. The three letter identifier of the tuned nav aid will be displayed on the Present Position Page. When auto tuned, the strongest signal is always in TACAN #1. The computer determines best information for INS position update through triangulation and prioritizes the information as distance/distance, distance/bearing, bearing/bearing. When in computer mode, the TACAN stations can be retuned through the keyboard by typing a minus (-), pressing a line key adjacent to the station, typing the identifier of the desired nav aid, and inserting it by pressing the same adjacent line key. The computer will match the identifier with the TACAN channel, tune the nav receiver and display the identifier and nav receiver tuned on the Present

Position Page. The "Auto Tune" message on the HSD will be deleted. The station tuned in this manner (manually tuned) will remain tuned. (To return to TACAN auto tune capability, delete the keyboard tuned TACAN station by using the minus (-) key as described above. When out of range, dash marks will replace the bearing and/or distance display and, if auto tuned, the "Auto Tune" message will disappear from the HSD. The TACANs may be tuned through the conventional control heads on the aft center console and display TACAN bearing and distance information on the BDHIs and on Present Position Page. The information is also displayed on the HSD/HSI as described in Volume II, Appendix B, this report.

6. Center of Gravity Page (CG)

The Center of Gravity (CG) Page is used to display aircraft weight and balance and percent mean effective chord (% MAC) information. One set of representative data is displayed to demonstrate the concept. Mechanization requires programming of aircraft structural and loading information similar to that used to compute DD Form 365, Weight and Balance Clearance Form F. "Conditional" data is inserted by the crew and center of gravity information is computed and displayed.

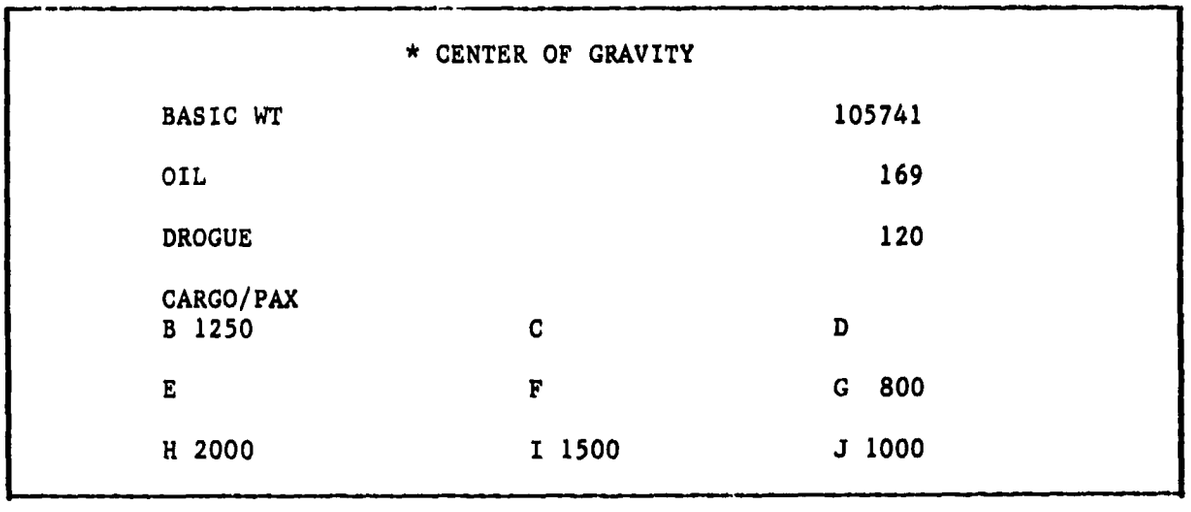


Figure A-9 Center of Gravity Page

NOTE: The following list shows the complete Center of Gravity information. The first two lines are pre-programmed. The next six lines of information (Drogue, Cargo/Pax) are entered through the scratch pad. The remaining lines are automatically computed and displayed.

* CENTER OF GRAVITY		
BASIC WT		105741
OIL		169
DROGUE		120
CARGO/PAX		
B 1250	C	D
E	F	G 800
H 2000	I 1500	J 1000
K 3140	L	M
N	O	P
OPERATING WT		115720
FUEL		
RSVR 1-4		5600
OUTBRD 1-4		26400
INBRD 2-3		29200
CTR WG		23600
AFT BDY		5000
FWD BDY		100000
UPPER DK		200
TOTAL FUEL		100000
WATER		5580
CORR T.O. GR WT		221300
T.O. PERCENT MAC		23.3
PERCENT MAC LIMITS		18.0/35.8

FigureA-9(Continued)

NOTE: Only six lines will be displayed at one time.

7. Takeoff and Landing Data Page

The Takeoff and Landing Data (TOLD) Page is used to display aircraft performance data. One set of representative data is displayed to demonstrate the concept. Mechanization requires the aircraft performance charts to be programmed so that "conditional" information could be inserted and takeoff landing data could be computed and displayed.

* TOLD	
TAKEOFF DATA	
RCR	23
FLAP SET	20
RWY TEMP	47
PRESS ALT	830
SFC WIND	270/20
GROSS WT	221300

Figure A-10 TOLD Page

NOTE: The following list shows the complete TOLD information. The first five lines of the takeoff data and the first five lines of the landing data will be entered through the scratch pad. The remaining lines will be automatically computed and displayed. The landing flap setting may be changed as desired.

* TOLD

TAKEOFF DATA	
RCR	23
FLAP SET	20
RWY TEMP	47
PRES ALT	830
SFC WIND	270/20
GROSS WT	221300
PERCENT MAC	24
STAB TRIM	2
TRT WET EPR	2.83
TRT DRY EPR	2.49
S1	114
ROT SPD	148
CMB SPD/DEV	162/3
CLN-UP ALT	1170
FLAP RTR-20	---
- 0	174
EPR WTR OUT	2.42
CRT FLD LGTH	10200
TO GND RUN	7900
EM THLD SPD	164
EGT LMT W/D	680/660

Figure A-10 TOLD Page (continued)

NOTE: Only six lines of information are displayed at one time.

* TOLD

LANDING DATA	
RWY AVAIL	10470
RWY TEMP	47
PRES ALT	375
RCR	23
RWY HDG	330
GROSS WT	140000
PERCENT MAC	24
FLAP SET	50
MIN THLD SPD	127
HOLD SPD	220
MIN CTL SPD	100
PTN SPD 20	157
30	147
40	137
APR SPD 50	132
THLD SPD	127
STOP DIST	4000
EPR GO-ARND	2.45
EPR T-GO	2.41

Figure A-10 TOLD Page (concluded)

8. Navigation Aids Page (NAV AIDS)

NAV AIDS		
ADN	ADW	BDA
BHD	BGR	BIKF
BO	BOO	BZN
CGY	CRH	CRK
CROIX	CSL	CYER
CYOX	EDDH	EFHK

Figure A-11 Nav Aids page (Step 1)

When the "Nav Aids" key on the keyboard is pressed, the above page appears. It displays an alphabetical listing of all navigation aids, airfields, and airway intersections held in memory in the navigation management system. Each of these aids has been defined with lat/long and/or bearing/distance coordinates. Any of these prestored points may be used when building a flight plan by typing the 2, 3, 4, or 5 symbol identifier on the scratch pad, along with the altitude, and inserting it in the desired position in the flight plan by pressing the appropriate adjacent line key.

9. Nav Aids Data Page

To display prestored information on any identifier listed on the Nav Aid Page, press the line key adjacent to the line with the desired identifier. The three identifiers on the selected line will then be displayed vertically adjacent to the line keys, as shown in the following example.

NAV AIDS
CYQX
EDDH
EFHK

Figure A-12 Nav Aids Page (Step 2)

Pressing the line key adjacent to the nav aid for which nav aid data are desired, causes the Nav Aids Data Page with the following information to be displayed.

	NAV AID DATA		
EFHK	HELSINKI-VANTAA		
* PSN	N602000 E0245800		
CHAN	89		
FREQ	114.20	381	322
	415	366	396
	DF	ASR	ILS

Figure A-13 Nav Aids Page (Step 3)

NOTE: Even though an * is shown adjacent to PSN, the information on that line can only be changed to insert the lat/long of radar reference points as described in Section H, this document.

10. Holding/Rendezvous Page (HOLD/RZ)

* HOLD/RZ	
INB CRS/TYPE	010/H
INB LEG/TURNS	5/R
REC TAS/DFT CR	440/-5
REC IP	N403520 E0321630
TURN RNG/OFFSET	21/10
PUSH TO INSERT	

Figure A-14 Hold/Rendezvous Page

When the "Hold/Rz" key is pressed, the above page is displayed. The titles along the left side are always displayed.

a. Holding. The inbound course (always 3 digits, i.e., 000-359) and the type of maneuver (A-Anchor, H-Hold, or R-Rendezvous) must be entered through the scratch pad.

The length of inbound leg and direction of turns are entered through the scratch pad by typing the length of the leg, e.g., 40, followed by the direction of turn, e.g., L, thus the entry would be entered as "40/L". Should it become necessary to change only the length of leg, this may be accomplished by entering either "40" or the entire line of information, "40/L". The direction of turn may be changed by entering either the entire line of information, "40/L", or just the direction of turn, "L". The top two lines contain all the information that is necessary to define and display a holding pattern.

b. Anchor. An anchor pattern, while shaped similar to a holding pattern, has a specified distance laterally between parallel inbound and outbound legs. That distance may be specified for display by typing and entering information in the "OFFSET" line, e.g., "20" inserted through the TURN RNG/ OFFSET line key. NOTE: When an "OFFSET" entry is made manually as described here, any information in the "TURN RNG" space is replaced by two dashes (--).

c. Rz. If a point parallel rendezvous is to be performed, an "R" denoting rendezvous on the first line and the required information on the third and fourth lines of information must be completed. The "inbound leg/ turns" line will automatically display a "--/L", which indicates a left turn, point parallel maneuver. However, if a right point parallel maneuver is required, the "L" may be changed to an "R" through the scratch pad. The receiver's true airspeed and drift correction (+ for right, - for left) are entered on the third line using the same typing and entry logic as the previous line. The receiver's initial point (IP) is entered on the fourth line as a lat/long, or a bearing/distance from a waypoint in memory, or as the identifier of a waypoint in memory. The computer then calculates and automatically displays the turn range and offset on the fifth line. Turn range is the distance in nautical miles that the tanker should be from the receiver when the tanker should start the 180° turn for refueling rendezvous. Offset is the perpendicular distance in nautical miles between the tanker's track and the receiver's track at the time that the tanker begins the 180° turn for refueling rendezvous.

When the required information for holding, or anchor or rendezvous has been entered, the line key adjacent to the title "Push To Insert" is pressed. This calls up (displays) the Flight Plan Page. If holding or an anchor pattern or a point parallel rendezvous is to be accomplished at a waypoint in the flight plan, press the line key adjacent to the desired waypoint. The appropriate word (Hold, Anchor, Rz) will be displayed immediately below the waypoint to be used as a holding fix. NOTE: To simplify this description, the "HOLD" symbol is discussed. Procedures are the same for displaying the other modes/symbols except as noted.

Holding Procedures. As the aircraft approaches the holding fix, that fix automatically moves to the top or "FROM" line on the display, the word "FROM" disappears and the flight plan "freezes"; i.e., it does not automatically update until the word "HOLD" is deleted. For example, if "HOLD" is entered at IND, the Flight Plan Page display will change as follows:

* FLT PLAN			
FROM	IND		FL200
090	FFO	96	5000

* FLT PLAN			
	IND HOLD		FL200
090	FFO	96	5000

Figure A-15 Flight Plan Page -- Hold Entry (Example 1)

To delete "HOLD" (or the other symbols) from the flight plan, a minus (-) is typed on the scratch pad and the line key adjacent to the "HOLD" entry is pressed. The word "HOLD" is deleted. Any waypoint including "IND", may be deleted by typing another minus (-) and pressing the adjacent line key.

To hold at the present position rather than at a waypoint in the flight plan, (1) select "FZ" and note L/L on PPSN Page, (2) type L/L from PPSN Page onto the scratch pad, (3) select "Flt Plan" Page, (4) enter L/L from the scratch pad on the second ("TO" waypoint) line key, (5) complete the first two lines on the Hold/Rz Page and press the line key adjacent to "Push To Insert" to display the Flight Plan Page, (6) press the second line key to display "HOLD" at the "TO" waypoint, (7) press the "FZ" key to deactivate the freeze function. This completes programming a holding pattern at present position. Upon re-crossing the holding pattern fix, the flight plan will update to show the holding fix with the word "HOLD" on the "FROM" line on the "Flt Plan Page and the word "FROM" disappears (see following example).

///FLT PLAN FREEZE///			
FROM	IND		FL200
090	LL 01 HOLD	26	FL200

* FLT PLAN			
	AL 01 HOLD		FL200
090	FFO	70	5000

FigureA-16 Flight Plan Page -- Hold Entry (Example 2)

When holding is no longer required, typing a minus (-) on the scratch pad and pressing the line key adjacent to "HOLD", causes the word "HOLD" to disappear.

In addition to the holding information being displayed on the Flight Plan Page, the appropriate holding pattern is also displayed on the symbol generated map on the horizontal situation display (described later in this document).

E. Special Functions

1. Direct To

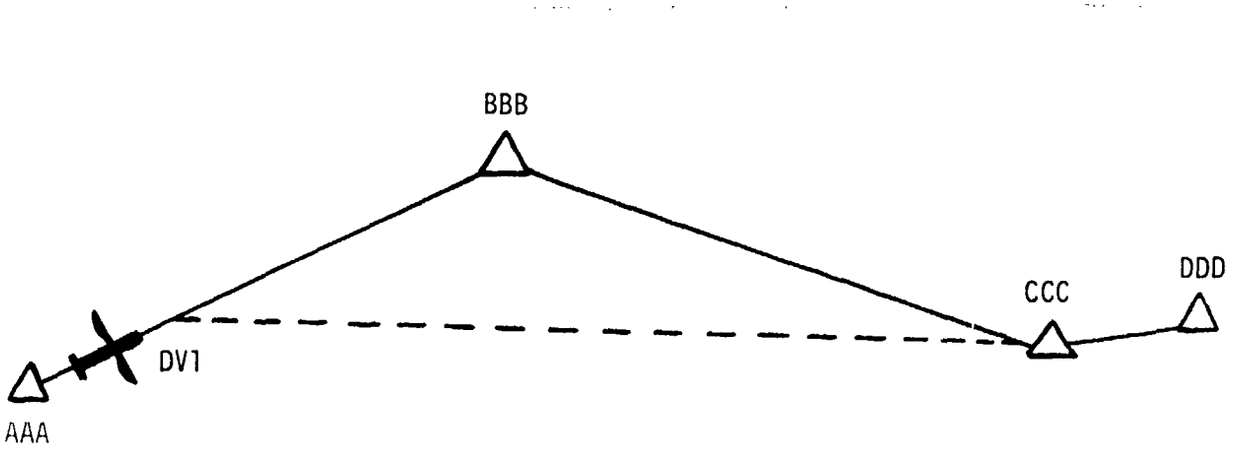
The "Direct To" feature is used to go from your present position (1) direct to any waypoint in your flight plan, or (2) direct to a waypoint entered through the scratch pad.

a. Direct to a waypoint in the flight plan:

1) Press "Dir To" key to get Flight Plan Page. Flight Plan Page will have words "Dir To (D-1)" flashing at 1/2 second intervals on the "From" waypoint line. When the "Dir To" key is activated, the computer establishes a waypoint at the present position of the aircraft (waypoint "D1" in the example below) and deletes the previous "From" waypoint (AAA is deleted in the example below).

* FLIGHT PLAN			
FROM	DIR TO (D-1)		
030	BBB	100	1000
150	CCC	75	1000
085	DDD	52	1000

FigureA-17 "Direct To" Function (Step 1)



FigureA 18 "Direct To" (Example 1)

2) Press adjacent line key to point in flight plan where you wish to go, i.e., "CCC" this: (1) erases all lines on Flight Plan Page between present position and new "To" waypoint line ("CCC"), (2) moves new "To" (CCC) waypoint line and all other lines up, (3) computes course and distance from present position "DIR TO" to "CCC" and displays that information in the appropriate places on the Flight Plan Page, and (4) stops the flashing "DIR TO (D-1)" on the "From" line.

* FLT PLAN			
FROM	DIR TO (D-1)		1000
110	CCC	118	1000
085	DDD	52	1000

Figure A-19 "Direct To" Function (Step 2)

b. Direct to a waypoint entered through the scratch pad (not part of the flight plan).

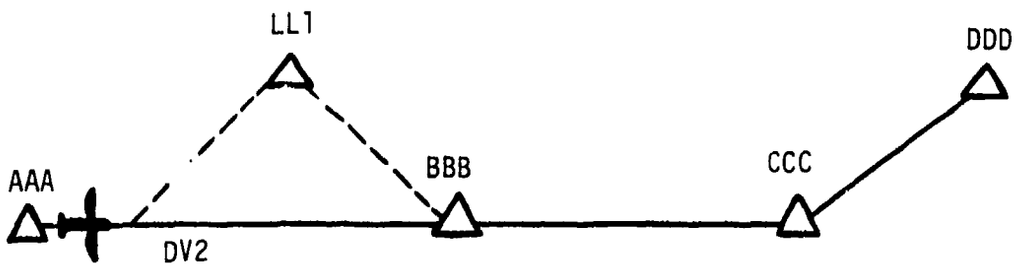


Figure A-20 "Direct To" (Example 2)

1) Press "DIR TO" key for Flight Plan Page. Information is displayed as described in a.1) above, except if this is the second "Direct To" leg on this flight plan, then the "From" line would read "From DIR TO (D2)". The number in parenthesis indicates the number of "Direct To" legs identified on this flight plan.

2) Type the definition of the new waypoint that you wish to go "Direct To" in scratch pad (2, 3, 4 or 5 letter identifier, identifier/ bearing/distance, or latitude/longitude, plus altitude).

3) Press the second line key adjacent to the "TO" waypoint. The newly identified scratch pad waypoint (LL1) will appear on the second line. The previous "TO" waypoint (BBB) and all other flight plan waypoints will move down one line to make room for the newly identified waypoint (LL1).

4) Course and distance from present position to "Direct To" waypoint (LL1) is recomputed and displayed in appropriate spaces. "DIR TO" flashing stops.

c. Direct to a waypoint from holding. If HOLD, ANCHR, or RZ is on the top line of the Flight Plan Page, indicating that the aircraft is maneuvering in one of those patterns, and it is desired to go direct to a waypoint, the "DIR TO" key should be pressed. This displays the Flight Plan Page with "DIR TO" on the top or "From" line. The previous "From" line holding waypoint will be deleted. Procedures described earlier can then be followed.

2. Freezing the Flight Plan

Occasionally it is desirable that the flight plan does not automatically update to the succeeding waypoint (e.g., if it is desired to track outbound from a waypoint or if it is desired to receive distance and time countdown information closer than the computed turn point or update point inbound to a waypoint). The flight plan can be prevented from automatically updating to the succeeding waypoint by pressing the Flight Plan Freeze key (FZ) on the keyboard. Additionally, when the "FZ" key is pressed, all information displayed on the Present Position Page is frozen or placed in a hold condition so that it can be read and recorded as necessary. The titles of both pages are changed to reflect this condition as ///FLIGHT PLAN FREEZE/// and ///PRESENT POSITION FREEZE///, respectively. The navigation system will continue to navigate on the "TO" course while the displays are in freeze. When the "FZ" key is pressed a second time, the page titles return to the original format, the flight plan will automatically update, and the information on the Present Position Page automatically displays updated present position information.

3. Slewing the Display

Six pages have more than six lines of information; therefore, require a "slew" or scroll feature: They are (1) Nav Aids, (2) Flight Plan, (3) Preflight, (4) Fuel Plan, (5) TOLD, and (6) Center of Gravity. Additionally, the Nav Aids Data Page and waypoint data page are slewable for better operation. The method in which that information is slewed is described in greater detail below.

a. Nav Aids Page. The slew switches function as momentary single action switches. Each time that one is pressed, a full page of data advances (the next six lines of navigation aids) into view. The system has a "wrap-around" feature. That is, when the slew switch is pressed after the alphabetical listing has reached the end of the alphabet, the beginning (first six lines of the opposite end) of the alphabetical listing is displayed. For example: When Figure 21 is displayed, pressing the slew up key ↑ once displays Figure 22; or pressing the slew down key ↓ displays Figure 23.

NAV AIDS		
AA	AB	AC
AD	AE	AF
AG	AH	AI
AJ	AK	AL
AM	AN	AO
AP	AQ	AR

Figure A-21 NAV Aids Slew (Example 1)

NAV AIDS		
AS	AT	AU
AV	AW	AX
AY	AZ	BA
BB	BC	BD
BE	BF	BG
BH	BI	BJ

Figure A-22 NAV Aids Slew (Example 2)

NAV AIDS		
ZI	ZJ	ZK
ZL	ZM	ZN
ZO	ZP	ZQ
ZR	ZS	ZT
ZU	ZV	ZW
ZX	ZY	ZZ

Figure A-23 Nav Aids Slew (Example 3)

NOTE: The Nav Aids Page format contains three columns of 2, 3, 4 or 5 letter identifiers so that a total of 18 identifiers may be displayed at any one time.

b. Flight Plan Page. The slew switches function as continuous action switches (rate switches). When either slew switch is pressed and held, the lines of information on the display will move up or down, respectively, at a rate of 1 line each .5 seconds. A "wrap-around" feature is not included. Therefore, whenever the display reaches the last line of information in the direction of travel, the movement of the lines of information stops and the last line of information will remain in view. The opposite slew switch must then be utilized to slew the display.

NOTE: The format of the Flight Plan Page is shown below. Any six lines may be displayed at one time.

* FLT PLAN			
FROM	FFO		0824
330	BD1	47	6000
050	3EG	138	7500
125	IND	92	14000
175	LL1	25	FL190
183	LL2	111	FL270
169	FWA	137	FL270
144	BD2	86	FL270
058	AM	214	FL270
336	OKK	77	FL240
228	ROMNI	40	17000
048	BURLI	15	5000
048	BRICE	10	2000
048	GUS	5	1012

Figure A-24 Flight Plan Page Format

c. TOLD Page and Center of Gravity Page. The slew switches for these pages function as momentary single action switches. Each time that one is pressed, a full page of data advances into view (i.e., the next six lines of information) similar to the Nav Aids Page. The "wrap-around" feature is also included on these pages.

d. Nav Aids Data Page and Waypoint Data Page. The slew switches for these pages function as momentary single action switches similar to the NAV AIDS, TOLD and CG. Slewing scrolls through the entire lists of NAV AIDS and flight plan waypoints stored in memory displaying the data on each of them. The "wrap-around" feature is also included.

e. Preflight Page and Fuel Plan Page. The slew switches for these pages function as continuous action (rate) switches similar to the Flight Plan Page. The "wrap-around" feature is not included.

4. Operation of the Cursor Slew

The cursor automatically positions itself immediately below the position where the next symbol is to be typed. Therefore, when the scratch pad is clear, the cursor is positioned at the first space on the left side of the scratch pad. As the first symbol is typed, the cursor moves one space to the right (below the next blank space), etc. When a symbol is typed in the last (22nd) space on the scratch pad, the cursor moves to the next lower line in the scratch pad at the first space on the left side.

The cursor may be positioned with the cursor slew key to any position on the scratch pad. This is most useful in correcting an error made while typing. Pressing the "cursor slew" key moves the cursor from right to left at eight spaces per second. It can be positioned below an incorrect entry, which then may be corrected by over typing. Once the cursor has been positioned with the cursor slew and a symbol has been typed, the cursor automatically repositions itself to its original position prior to activation of the cursor slew key.

When the cursor slew key is held down continuously, the cursor will move left to the first space on the scratch pad on the line on which it is located, then jumps to the last space (extreme right) on the other line in the scratch pad, and then continues moving left again.

F. Nav Management Preflight Procedure

The alignment procedure should be accomplished as soon as possible after power is applied to the aircraft to permit stabilization of the system prior to taxiing. The INS switches are placed in "standby" and in "both" until step (1) below, is completed, then INS #1 and #2 Align Modes are selected. Thereafter, when the green ready lights illuminate on the INS mode selector, the INS systems are placed in the NAV position and the navigation management system is ready to operate and the aircraft may be taxied.

1. Press PPSN -- check present position lat/long indicated on the CDU against actual aircraft present position. If not correct, type correct lat/long on scratch pad and press line key adjacent to the top line to insert.

NOTE: Wind, TAS, and drift will display dash marks when aircraft is on the ground. Groundspeed will be accurate within two knots during ground operations.

2. Type correct time at the next minute on the scratch pad. On the minute, press the line key adjacent to "GMT" to insert the correct time on the digital time line.

3. Press the "FLT Plan" key to select Flight Plan Page and slew it down until "FROM" appears on the top line.

4. Type "F/P ERASE" on the scratch pad and press the "FROM" line key. This insures an unused flight plan page.

NOTE: The following steps may be used to manually load a flight plan (on the ground or in the air). However, nav management system capability includes the use of a device that contains a pre-programmed flight plan.

The pre-programming is accomplished at a location remote from the aircraft, i.e. base operations. The device is pre-programmed by pilots or navigators on a CDU similar to the CDU in the aircraft (to aid in training and familiarization). Once the device is pre-programmed, it is carried out to the aircraft, inserted into the aircraft nav management system flight plan memory, and then flown as is or modified as desired.

5. Type the present position identification and field elevation on the scratch pad.

6. Press top line key for insertion.

7. Type the first flight plan waypoint identification and desired altitude on the scratch pad and press second line key for insertion.

8. Repeat identification and insertion until all enroute flight plan waypoints and the destination (including alternate) are inserted. This completes the basic flight plan entry.

9. Select HOLD/RZ Page and complete the line items required for the first hold or rendezvous for the mission.

10. Insert the Hold, Rz or Anchor at the appropriate place in the flight plan. Repeat as required.

11. Select the Center of Gravity Page and complete all necessary line items for this takeoff.

12. Select Preflight Page and enter planned wind and TAS for each leg.

13. Select Fuel Plan Page and enter planned fuel offload. Check the computed fuel required and fuel remaining.

14. Select the Takeoff and Landing Data Page and complete all required aircraft performance takeoff data line items and items necessary to compute landing data for landing immediately after takeoff.

This completes the normal preparation of the navigation system for the mission.

If a rapid launch is required, e INS mode selectors may be pre-set (when cocking the aircraft) or immediately set at the Nav mode when the crew enters the aircraft. When power is applied to the aircraft, the immediate selection of Nav mode automatically starts a modified alignment cycle on the INS gyros. The INS system will assume that the heading of the aircraft is the same as it was when power was last shut down on the AHRS. During this cycle, the navigation computer will not start updating present position until an adequate airspeed signal (90 kcs) is received from the CADC (Central Air Data Computer). Therefore, midpoint of the departure runway should be pre-loaded on the present position page. The flight plan may be loaded during or after departure. If the green nav ready lights are not on prior to take-off (requires approximately six minutes at standard day temp), then the aircraft should be leveled as soon as possible after take-off until the green nav ready lights come on. This procedure will result in a higher than normal INS drift rate.

G. Overfly Update Procedure

To update the nav management system by flying over a known lat/long position either of two procedures may be used.

1. Direct Insertion

a. Select the Present Position Page by pressing the "PPSN" key.

b. Type a known lat/long on the scratch pad as the aircraft approaches the known position (i.e., nav aid).

c. Insert the known lat/long position from the scratch pad by pressing the top adjacent line key as the aircraft passes directly over the identified point.

2. Insertion with PPSN Frozen

a. Select the Present Position Page.

b. Press freeze key as aircraft passes over any known lat/long fix or passes over a nav aid, airfield or over any identifiable waypoint in memory.

c. Type lat/long or waypoint identifier of the position overflown on the scratch pad.

d. Insert the known lat/long or identifier from the scratch pad by pressing the top adjacent line key. This will display the corrected lat/long of the overflown fix.

e. Press the freeze key. This will unfreeze the display and allow the present position to "catch up" and display the aircraft's updated present position.

H. Radar Update Procedure

Either of two procedures may be used.

1. When radar reference points (fixes) to be used for INS alignment or NAV MGT system update are known/determined during preflight planning for the mission, those fixes may be identified and stored in the NAV MGT system for later use. That is done as follows -- normally as part of the preflight procedures for setting up the NAV MGT system.

Preflight Procedure

a. Select Nav Aids Page and slew until the identifiers for radar reference points appear, i.e., RAD1, RAD2, etc.

b. Press the line key adjacent to RAD1 to display the Nav Aids Data Page. The first line will display the identifier (RAD1).

c. Type the latitude and longitude of the radar reference point onto the scratch pad and insert it on the second line adjacent to the title "PSN".

This will identify that typed lat/long as "RAD1" allowing it to be recalled later using only the identifier.

d. Display the Nav Aids Data Page for RAD2 and repeat the procedure to identify and store a second radar reference point. Up to ten radar reference points may be stored in this manner.

Inflight Procedure

a. Select ground mapping mode on radar control panel.

b. Select radar on HSD switching matrix.

c. Select PPSN Page on NAV MGT system.

d. Type the identifier for the radar reference point (e.g., RAD1) on scratch pad.

e. Select "cursor" on cursor panel. This will insert the cursor location from the scratch pad into the nav mgt system. The cursor will appear at the radar reference lat/long with INS drift included, i.e., the point where the Nav Mgt system believes RAD1 to be. The cursor light illuminates and information on scratch pad disappears.

f. Eyeball the cursor position vs. the actual reference point on ground map. It should be within flying hours x 2 nm. If not, (1) the INS has excessive drift (switch to #2 INS) or (2) an incorrect reference point is being used (re-enter lat/long).

g. If the cursor is within drift limits, move the cursor over the reference point on the radar ground map with the joy stick.

h. Press waypoint insert key on cursor control panel. Insert key illuminates to indicate position update and joy stick is deactivated. Present position updates to the correct lat/long based on the difference between the original cursor location and the cursor location corrected with the joy stick, i.e., the system triangulates and calculates the aircraft's actual position from the radar reference point and changes the lat/long of the aircraft present position to agree.

i. Press the cursor switch to extinguish cursor light and to extinguish the insert light and to delete the cursor from the display.

2. When the radar reference point is not known/determined until shortly before it is to be used to update the NAV MGT system, it may be desirable to update the point without first entering it on the Nav Aids Data Page. This can be done by following the same Inflight Procedure except that on Step d, type the lat/long for the radar reference point (known radar fix) on the scratch pad. When "cursor" is selected (Step e) the cursor will appear at the location which the NAV MGT system believes that lat/long to be. All other steps/procedures remain the same.

I. Operation of the Nav Management System With Dual CDUs

The pilot aircraft interface device for the nav management system consists of two alphanumeric keyboard/CRT control/displays, one unit located on the right side of the forward center console and one unit located on the forward right side of the aft center console. Information can be typed onto the scratch pad and inserted onto the appropriate information page via the adjacent line keys on either CDU. The CDUs operate independently. For example, one CDU may display the Flight Plan Page while the other CDU displays the Present Position Page. Information may be entered through either unit, with the most recently entered information being used for calculations or display. When something is typed on the scratch pad, it appears only on the CRT adjacent to where it is typed and it can be entered only through that CDU.

J. Nav Management Printout

A set of special purpose keys (to be developed) will allow the aircrew (or ground crew) to selectively activate a computer printout to include:

1) the flight plan as actually flown to include winds and fuel usage,

2) system performance parameters on a programmed frequency (i.e. oil pressure and hydraulic pressure every 10 minutes)

3) a record of system malfunctions.

APPENDIX B

HORIZONTAL SITUATION DISPLAY (HSD) SWITCHOLOGY, FORMATS AND ASSOCIATED CONTROLS

TABLE OF CONTENTS

LIST OF FIGURES

HORIZONTAL SITUATION DISPLAY (HSD) SWITCHOLOGY,

FORMATS AND ASSOCIATED CONTROLS

An HSD was located on the pilot's and copilot's instrument panels, immediately below the ADI. The device replaces the standard HSI and presents plan-view navigation information, radar information or a mixture of both. The information on the display is controlled through a switching matrix (Figure 1) located adjacent to the display. Switching functions for the two displays are independent of each other, permitting individual display selection by each pilot. The displays are used in conjunction with the flight director system, navigation computer and integrated navigation control-display unit (CDU). The switching matrix provides switches for controlling navigation mode selection, HSD format selection and function selection.

1. NAV MODE SELECTOR

The operation of each nav mode selection switch is as follows:

a. CMPTR (Computer). Depressing this legend switch causes computer generated navigation information to be made available to the HSD for display through the HSD format selectors. Computer generated navigation information is navigation data derived from the INS, Doppler, available radio aids to navigation, CADC and AHRS. Under normal operating conditions, the CMPTR mode will be the most reliable estimate of the aircraft's navigation situation. This mode is not used for TACAN, VOR or ILS approaches, (except for computer generated map ILS approaches which are described in the section on ILS).

b. ▲ SWITCHES (solid symbol indicates both bearing and CDI information available). With CMPTR NAV Mode selected these switches are disengaged and the ▲ bearing pointer and CDI on an HSI format will display course to the next flight plan waypoint. When one of these four ▲ switches are selected, course guidance information, in conjunction with a selected course, will be displayed on the HSD. These switches are mutually exclusive, i.e., only one can be activated at any one time. They are also mutually exclusive with the CMPTR switch. The switches illuminate when activated. When a switch is pressed, it illuminates and the previously activated switch is deactivated. When an illuminated switch is pressed, nothing happens (no "off" function). If a ▲ switch is selected and the ground signal is insufficient, ▲ bearing pointer will rotate CCW and the CDI will swing from side to side. If a ▲ switch is selected and R/T unit is "off", ▲ bearing pointer disappears and CDI will stow to the side of the case.

(1) TACAN #1▲, TACAN #2▲. Depressing either one of these switches automatically changes the HSD to the HSI format and permits TACAN, CDI guidance information, in conjunction with a selected course, to be displayed on the HSD. In addition, bearing to the selected NAV aid is displayed on the bearing pointer and the time/distance from the aircraft to the station are displayed.

HSD MODE SELECTOR SWITCHES

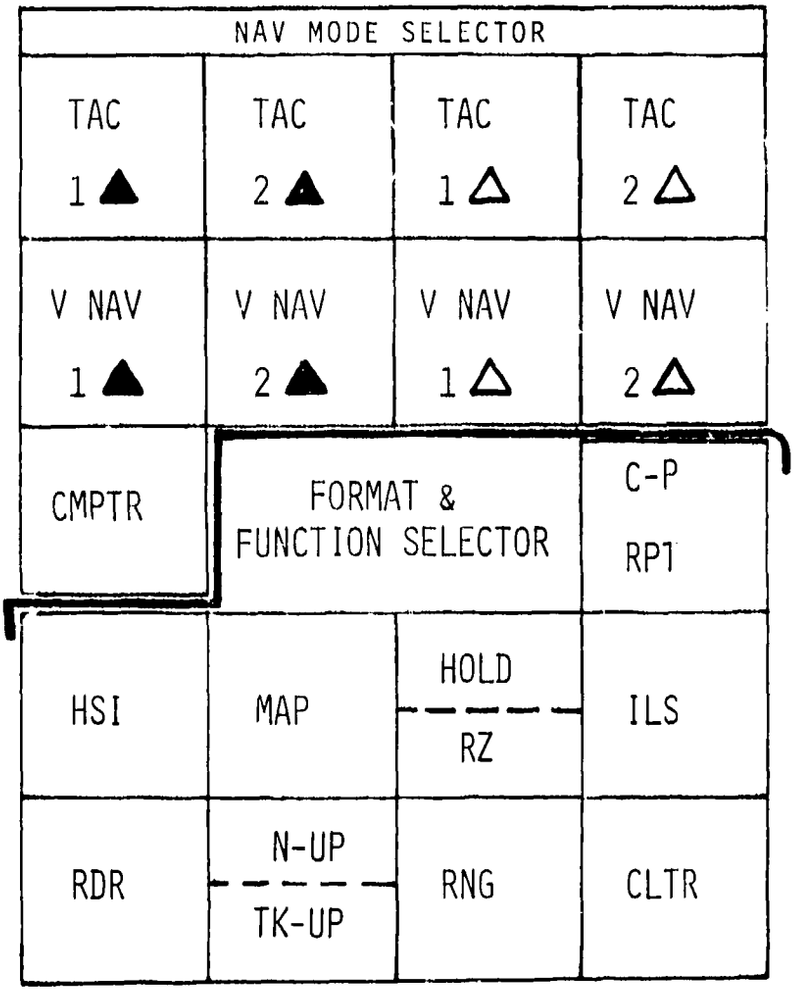


FIGURE B-1 HSD Switching Matrix

(2) VHF NAV #1▲, VHF NAV #2▲. Depressing either one of these switches automatically displays the HSI format and permits CDI guidance information, in conjunction with a selected course, as well as bearing information (on the ▲ bearing pointer), on the HSD, if a VOR frequency is tuned in the respective RT unit, or localizer course deviation and an ILS frequency is tuned in the respective RT unit. If an ILS [illegible] tuned for the selected VHF NAV #1 or #2 ▲ switch, the bearing pointer symbol (▲) will disappear from the HSD.

NOTE: CDI guidance information relative to a ground-based nav aid can only be displayed if the Nav aid is selected [illegible] of the ▲ bearing selector switches.

c. △ SWITCHES. Open symbol indicates only bearing information available (no CDI). These selector switches permit bearing information to be displayed on the △ bearing pointer on the HSD, when the display is in the HSI format. These switches are mutually exclusive. △ VHF NAV switches can be used in conjunction with the CMPTR NAV Mode and HSI Format to provide VOR bearing information. △TACAN selectors are not available when in the CMPTR NAV mode because both TACANS are being auto tuned. However, TACAN bearing information is displayed on △ pointer if no △ V NAV switches are depressed and "CMTR" is selected and has auto tuned a TACAN R/T unit; △ time/distance information are displayed; △TACAN switch will not light up; TACAN △ ID will be "TAC 1" on PPSN page; △ will be auto tuned to strongest TACAN signal; and "Auto 1" and "Auto 2" will be displayed in the lower right corner of the HSI.

(1) TACAN #1△, TACAN #2△. Depressing either one of these two switches places bearing information to the respective TACAN station on the △ bearing pointer and the time/distance from the aircraft to the station are displayed. These switches are only active when the HSI Format has been selected and when CMPTR is not selected because of the TACAN autotuning feature.

(2) VHF NAV #1△, VHF NAV #2△. Depressing either one of these two switches displays bearing information to the VOR tuned in the selected RT unit on the △ bearing pointer.

NOTE: Depressing a VHF NAV △ bearing pointer switch in which an ILS is tuned will cause the displayed △ pointer to disappear from the HSD since only the ▲ bearing pointer switches can be used in conjunction with an ILS. The light in the △ switch will blink to signal an error. If an ILS frequency is tuned after a VHF NAV △ has been depressed and illuminated, the effect is the same.

NOTE: The NAV mode selector switches replace the TACAN select switch currently found in the KC-135. Thus, in addition to the effect they have on the HSD, they interface with the flight director. If CMPTR is selected (flight director mode selector switch in NAV/LOC), the command bars present command information to fly the flight plan course as defined through the navigation management control-display unit. With any of the ▲ bearing select switches depressed, the flight director command bars will provide information to fly the selected course to the Nav aid, if a TACAN or VOR facility is tuned, or the localizer and glideslope, if an ILS is tuned and the flight director mode selector is in APP MAN or APP AUTO. The △ bearing select switches do not effect the operation of the flight director.

2. FORMAT AND FUNCTION SELECTOR -- FORMAT

The description of the format and function selector switches is divided into two sections for clarity. The operation of the HSD format selection switches is as follows:

a. HSI (Horizontal Situation Indicator). Selection of this legend switch causes the HSI format to be displayed on the HSD and the HSI switch light to illuminate. HSI may be selected for any of the NAV modes with the information being displayed a function of the NAV mode selected.

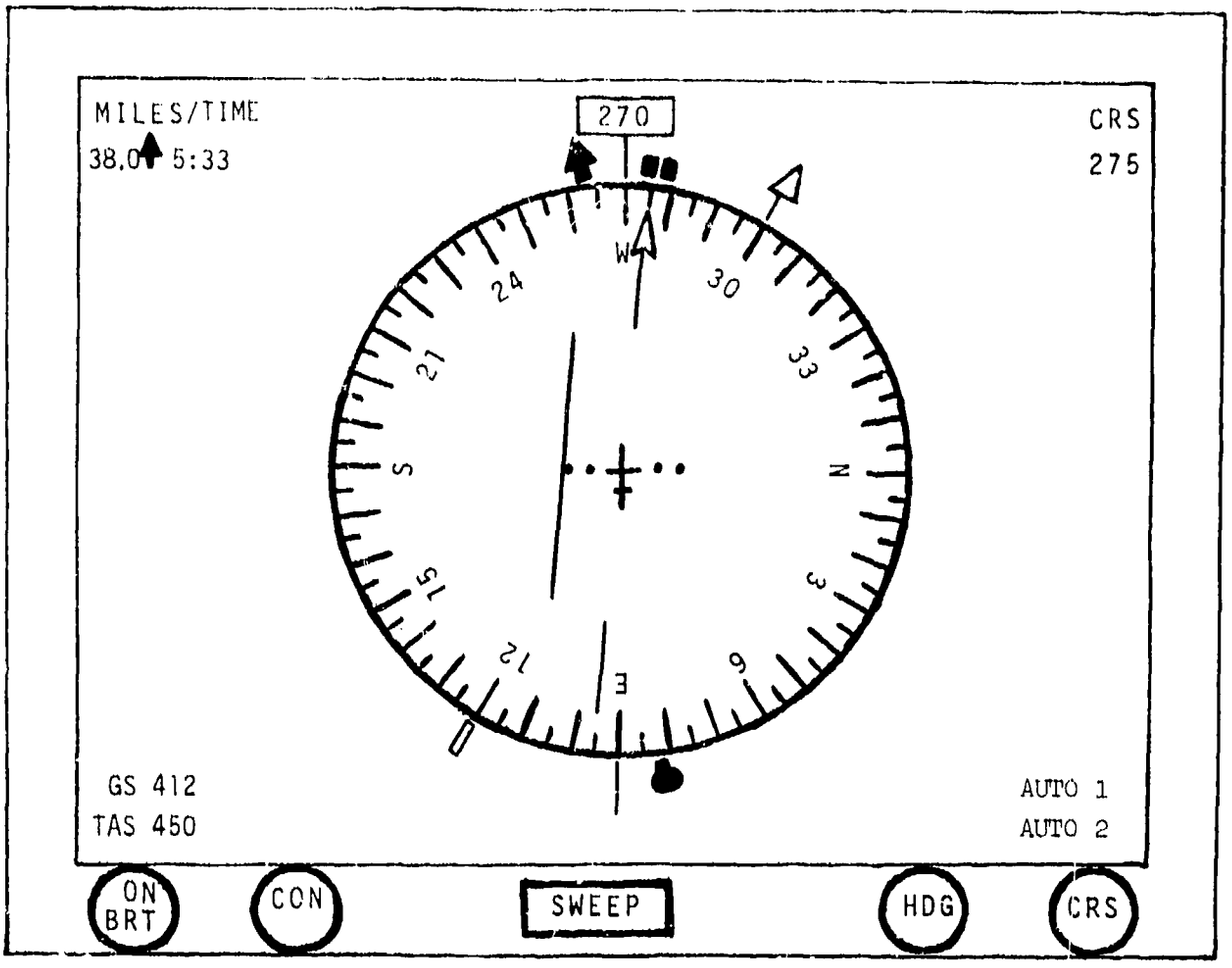
(1) If CMPTR is selected, the HSI format (▲ and CDI) provides course information relative to the computer generated flight plan course. The CRS SET (Course Set) knob is declutched and course deviation information is relative to the flight plan course. Without a flight plan, the ▲ will rotate CCW. △ bearing information is displayed as a function of the selected V NAV bearing △ switch (TAC △ switches are inactive). If no V NAV is selected, TACAN info may be displayed on △ if TACAN is auto tuned. "AUTO 1" and "AUTO 2" will be displayed in the lower right corner of HSI display when TACANs are auto tuned.

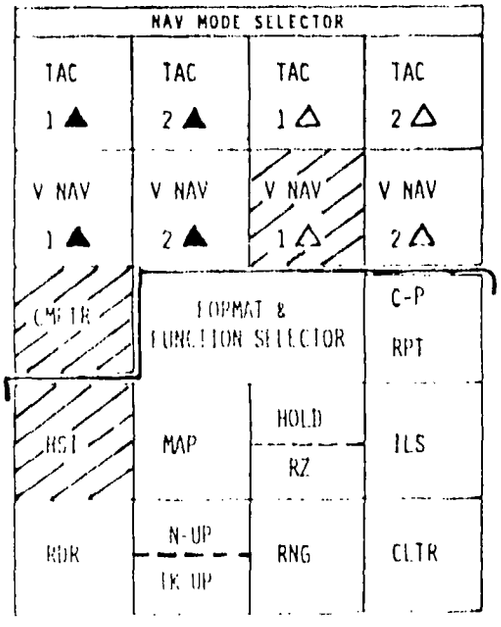
(2) If a ▲ (bearing and CDI) switch is selected, the HSI format presents digital course, course deviation and bearing information relative to the nav aid tuned in the respective RT unit, with desired course selected through the CRS SET knob. Without an adequate ground signal (R/T unit on), ▲ will rotate CCW. Selected ▲ R/T unit off, ▲ and CDI disappears.

(3) If a △ (bearing only, no CDI) switch is selected, the HSI presents bearing information relative to the nav aid station, if a TACAN or VOR frequency is tuned in the respective RT unit. If an ILS frequency is tuned in the selected RT unit, the △ bearing pointer will disappear and the △ switch will blink.

Figures 2, 3, 4 and 5 depict some of the possible HSI variations which may be displayed on the HSD. The switch selections necessary to display those specific variations are shaded.

HSI FORMAT - CMPTR NAV MODE





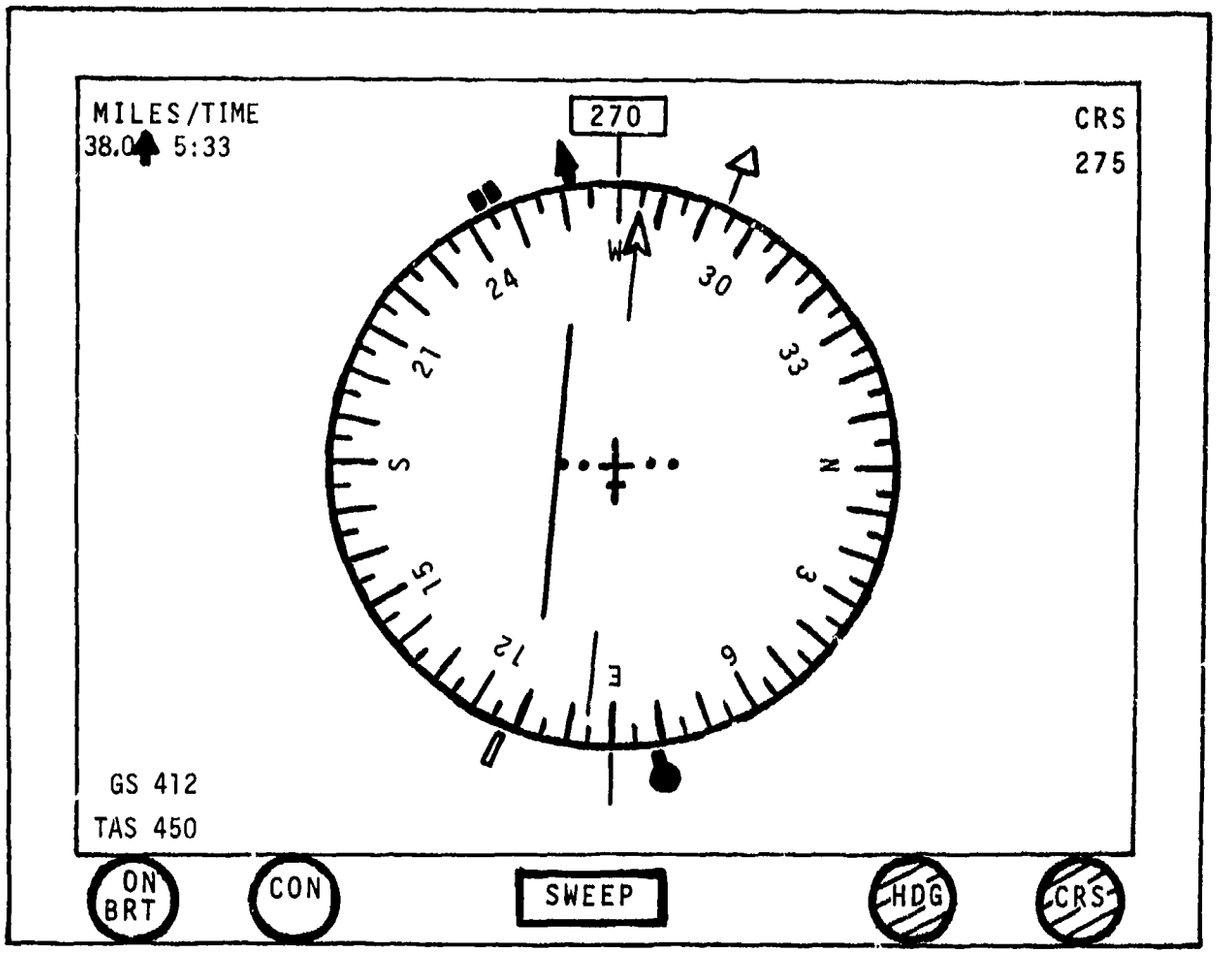
HSD MODE SELECTOR SWITCHES

NOTE:

- BRG and DIST to waypoint in nav management system. Time is displayed.
- only BRG information displayed to VOR station (No DME). Overrides auto tuned TACANS.
- TACAN 1 and TACAN 2 information will be displayed only on PPSN page of nav management system, since they are always auto tuned when in the CMPTR nav mode. When CMPTR is selected, (W/O ΔVNAV), TACAN information displayed on the HSI bearing pointer will be from the strongest nav aid signal received.

Figure B-2 Computer Nav Mode

HSI FORMAT - TAC NAV MODE



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD / RZ	ILS
RDR	N-UP / TK-UP	RNG	CLTR

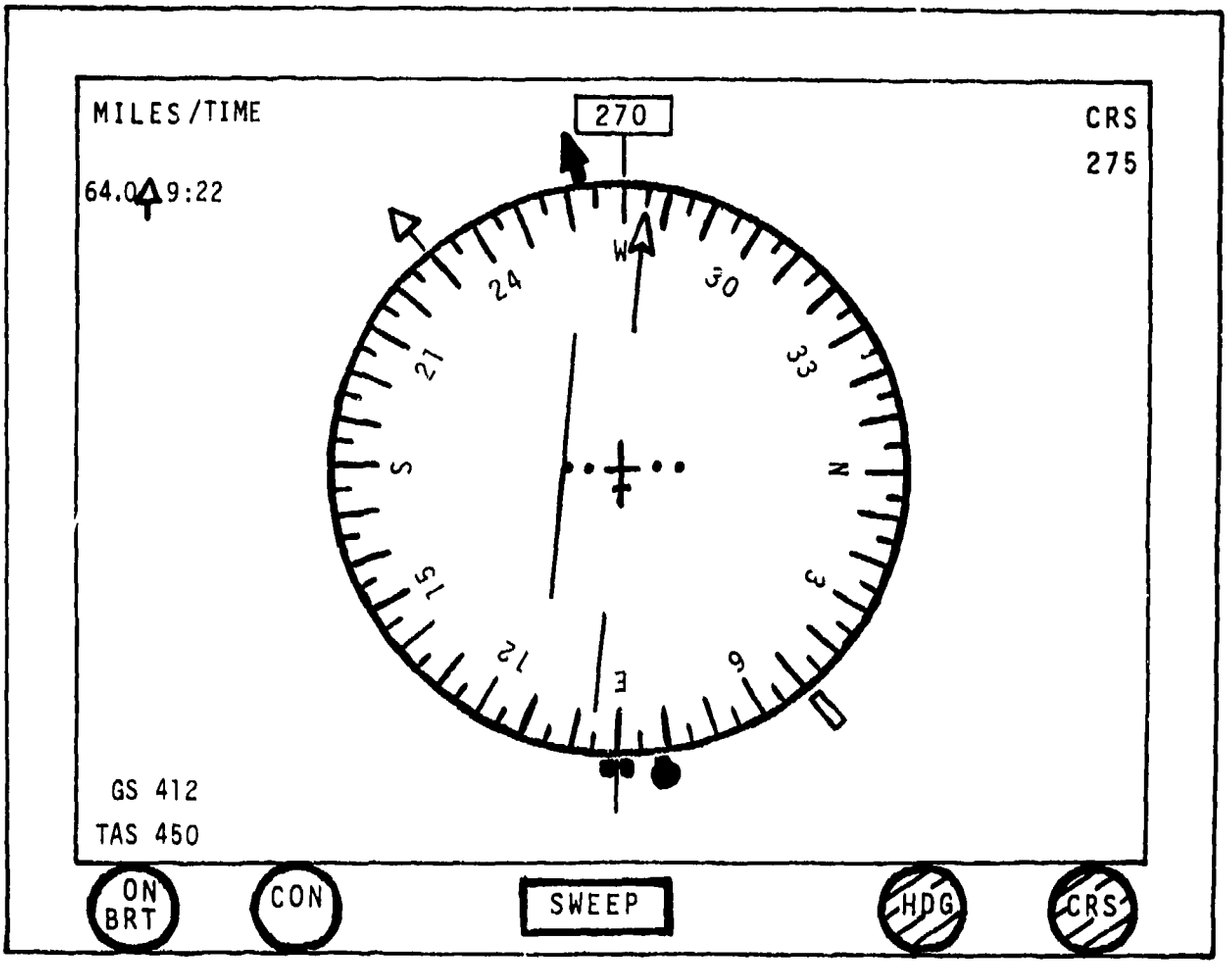
HSD MODE SELECTOR SWITCHES

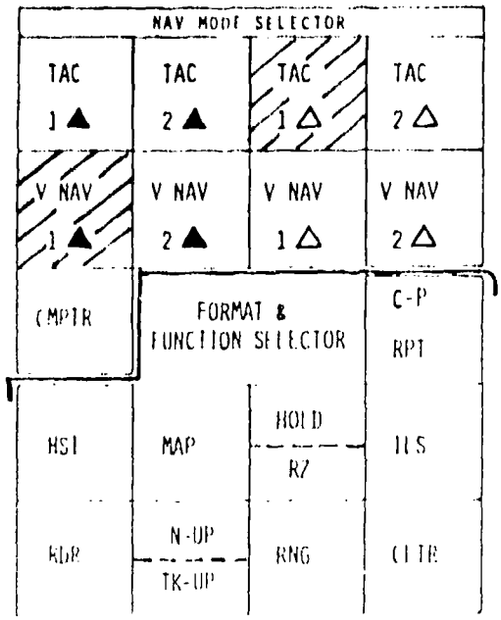
NOTE:

- HSI format automatically displayed.
- ▲ BRG and DIST to manually tuned TACAN station. Time is displayed.
- △ BRG to VOR station (No DME).
- HSI switch light illuminates automatically.

Figure B-3 TAC Nav Mode

HSI FORMAT - VOR NAV MODE





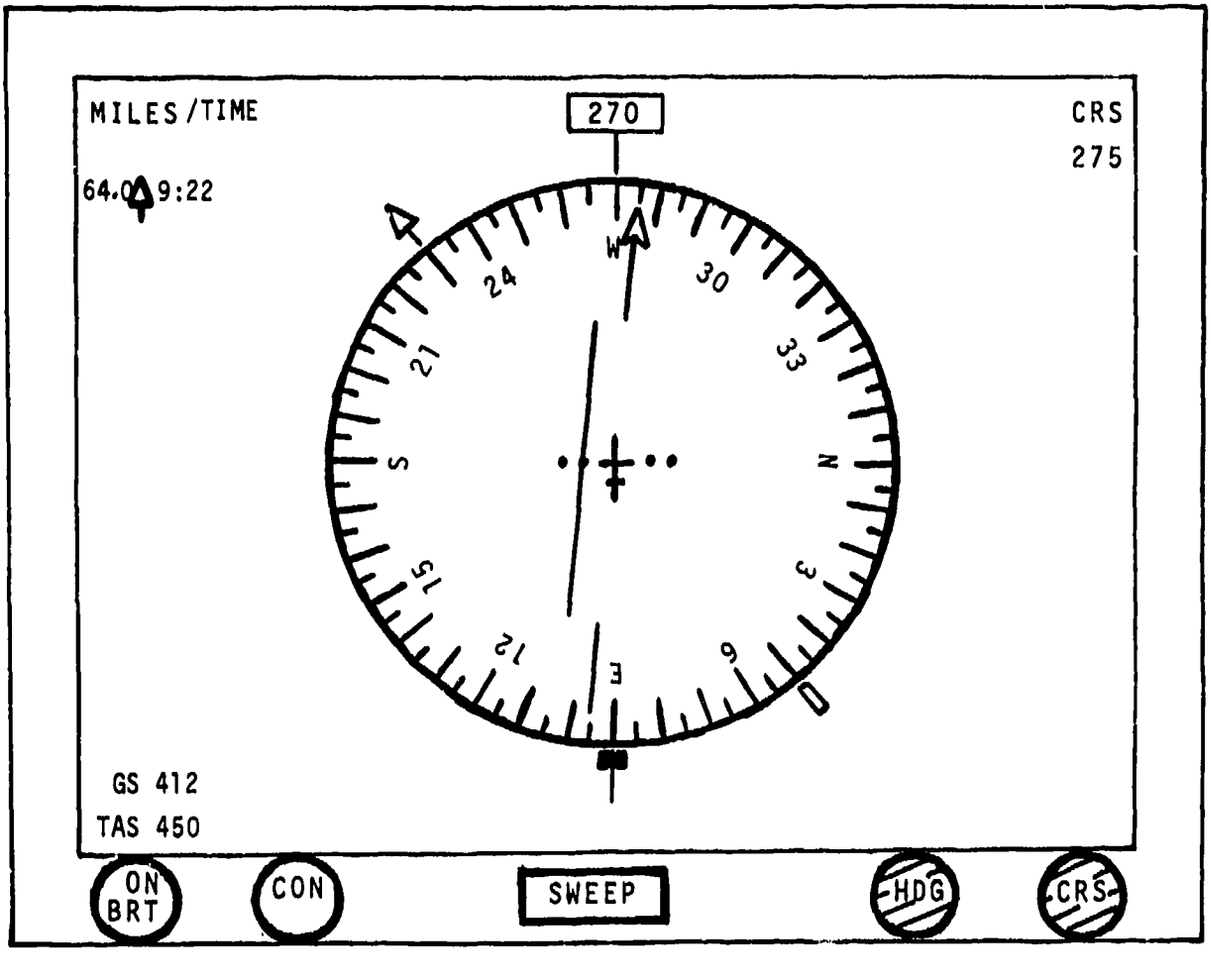
HSI MODE SELECTOR SWITCHES

NOTE:

- HSI format automatically displayed.
- ▲ BRG to VOR station (No DME).
- △ BRG and Dist to manually tuned TACAN. Time is displayed.
- HSI switch light illuminates automatically.

Figure B-4 VOR Nav Mode

HSI FORMAT - ILS NAV MODE



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD / RZ	ILS
RDR	N-UP / TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

NOTE:

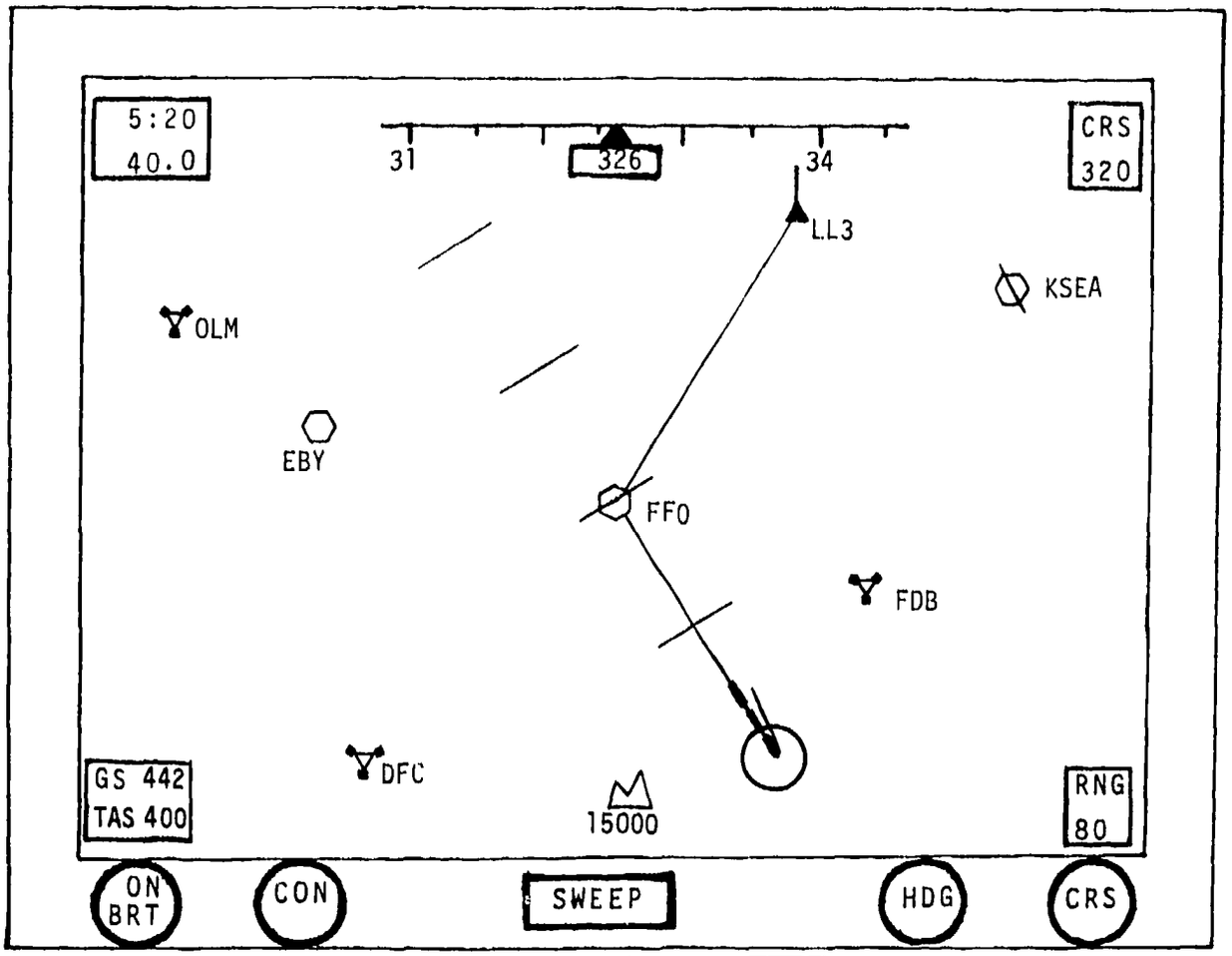
- HSI format automatically displayed.
- VHF NAV 1▲ tuned to ILS frequency so ▲ is not visible.
- △BRG and Dist to manually tuned TACAN station. Time is displayed.
- HSI switch light illuminates automatically.

Figure B-5 ILS Nav Mode

b. MAP. Selection of this mode causes the MAP format to be displayed on the HSD. The MAP format is only selectable if the CMPTR nav mode is selected. If any nav mode other than the CMPTR nav mode is selected, the MAP select switch will not activate, and the display will not change.

Figures 6, 7, 8 and 9 depict some of the possible MAP format variations which may be displayed on the HSD. The switch selections necessary to display those specific variations are shaded.

HSD MAP FORMAT - NORTH UP (CLUTTERED)



NOTE:

- Range marks always indicate the present (instantaneous) track of the aircraft over the Earth's surface.
- Predictor lines show that the desired course (320°) is being maintained.

NAV MODE SELECTOR			
TAC 1▲	TAC 2▲	TAC 1△	TAC 2△
V NAV 1▲	V NAV 2▲	V NAV 1△	V NAV 2△
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD RZ	ILS
RDR	N-UP TK-UP	RNG	CLTR

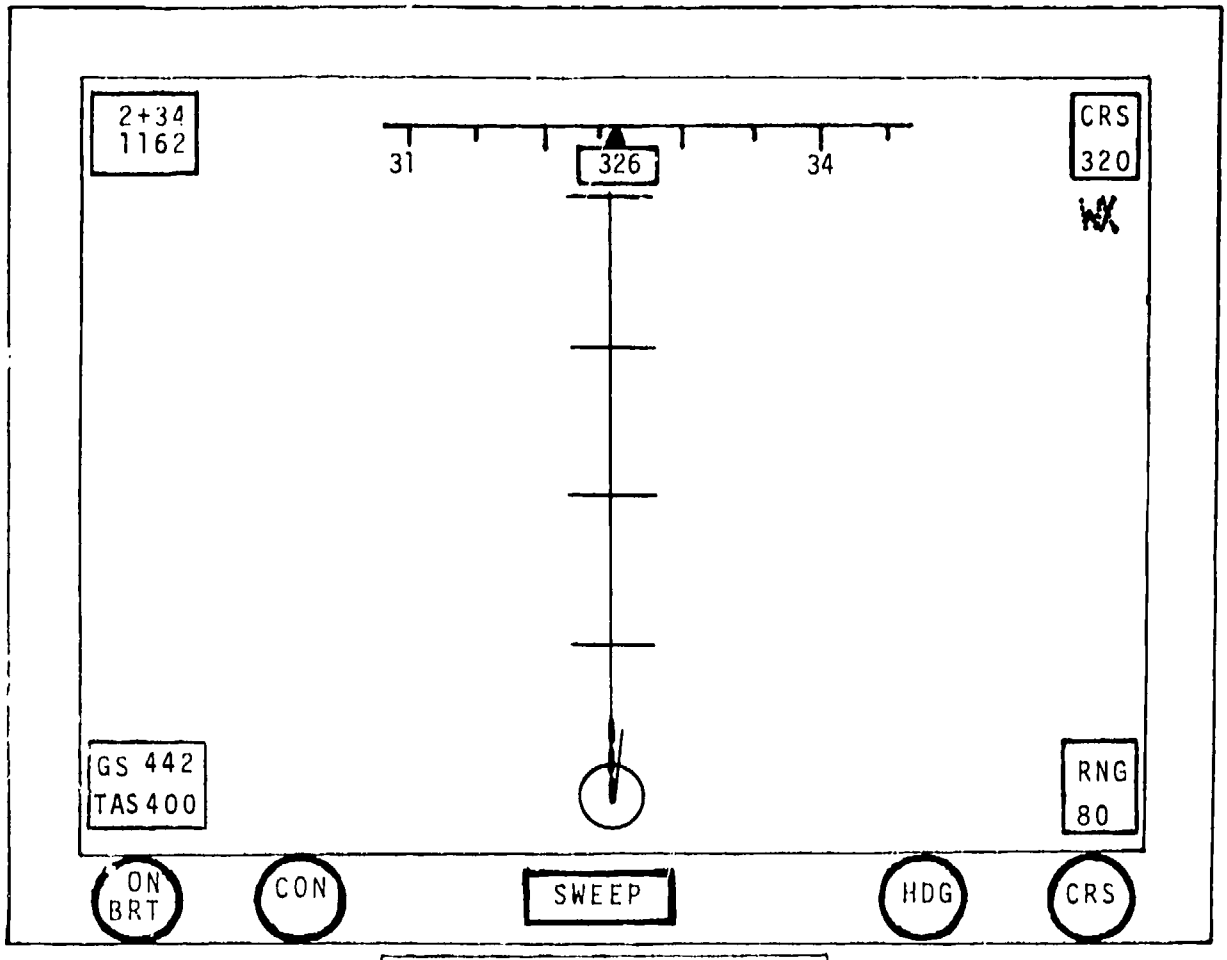
HSD MODE SELECTOR SWITCHES

NOTE:

- Clutter refers to amount of symbology displayed.
- Box in upper left hand corner indicates time in minutes and seconds and distance in miles and tenths of miles.
- Aircraft symbol shows a right drift correction of 6° (326° vs 320°).

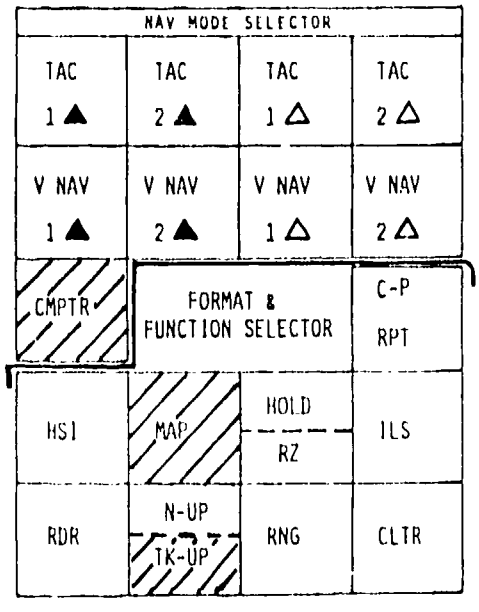
Figure B-6MAP--North Up

HSD MAP FORMAT - TRACK UP (UNCLUTTERED) W/WX WARN



NOTE:

- Aircraft symbol shows a right drift correction of 6° (326° vs 320°).
- Aircraft is on course with proper drift correction.



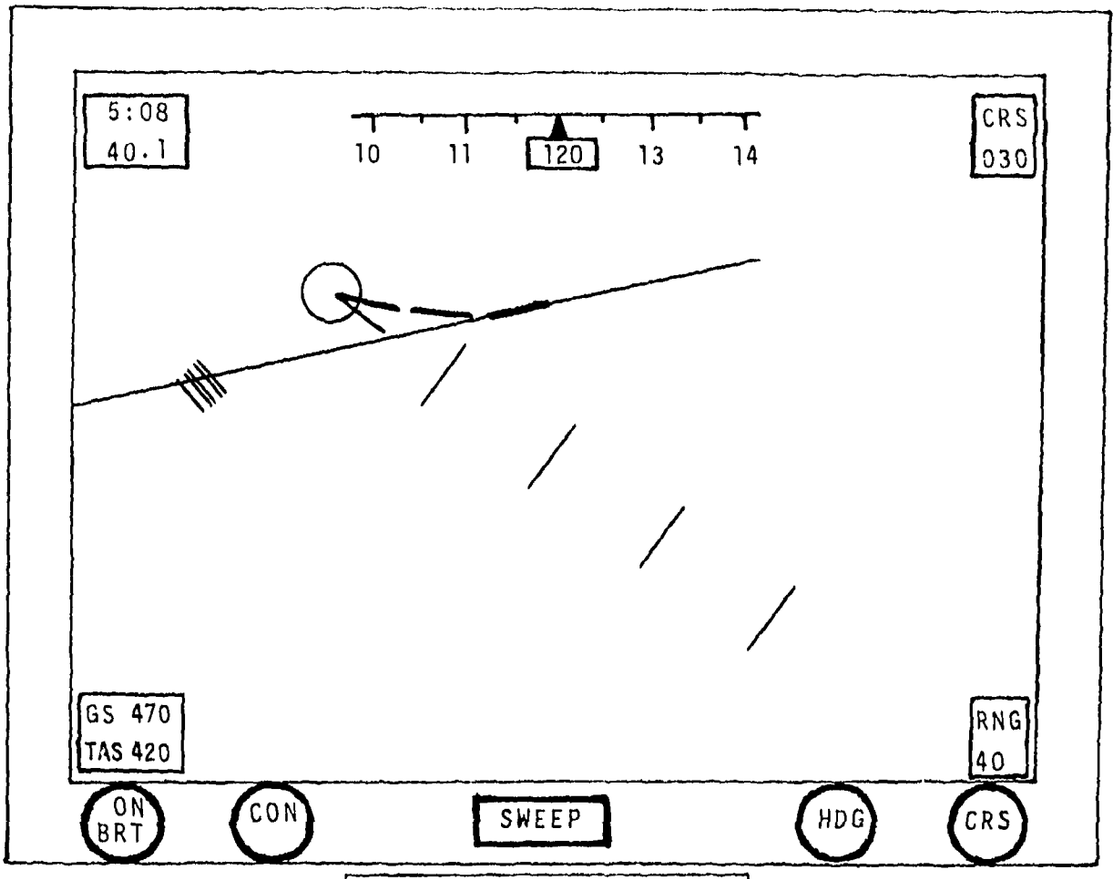
HSD MODE SELECTOR SWITCHES

NOTE:

- Radar is ON and in WX or WX CTR mode. Flashing "WX" symbol alerts pilot to display weather radar because it is painting a return.
- Box in upper left hand corner indicates time in hours and minutes when time is more than 60 minutes (: replaced by +), and distance is more than 999 (decimal deleted).

Figure B-7 Track-Up W/Wx

HSD MAP FORMAT -- NORTH UP W/BEACON



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD / RZ	ILS
RDR	N-UP / TK-UP	RNG	CLTR

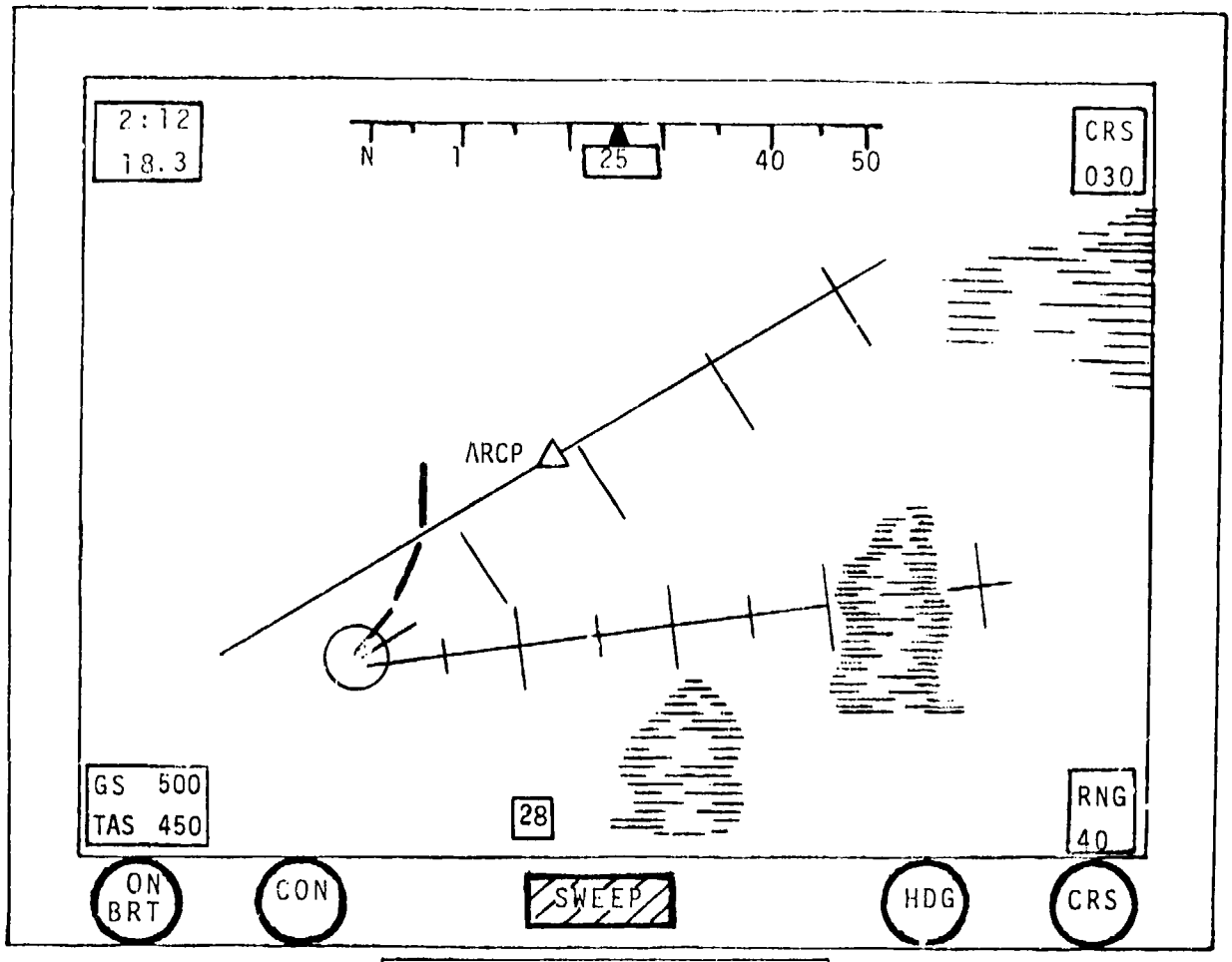
HSD MODE SELECTOR SWITCHES

NOTE:

- Radar is in Beacon mode.
- Predictive vector lines indicate aircraft's predicted location at the end of 30, 60, and 90 seconds respectively. Aircraft is in a left turn and will intercept desired course (030°) in 60 seconds.

Figure B-8North-Up W/Beacon

HSD MAP FORMAT W/RADAR WX



NOTE:

- Aircraft is off course to the right, in a left turn, and will intercept desired course in 60 seconds.

NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD / RZ	ILS
RDR	N-UP / TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

NOTE:

- Sweep line is displayed 28° right of aircraft longitudinal centerline.
- Radar is in WX or WX CTR mode.

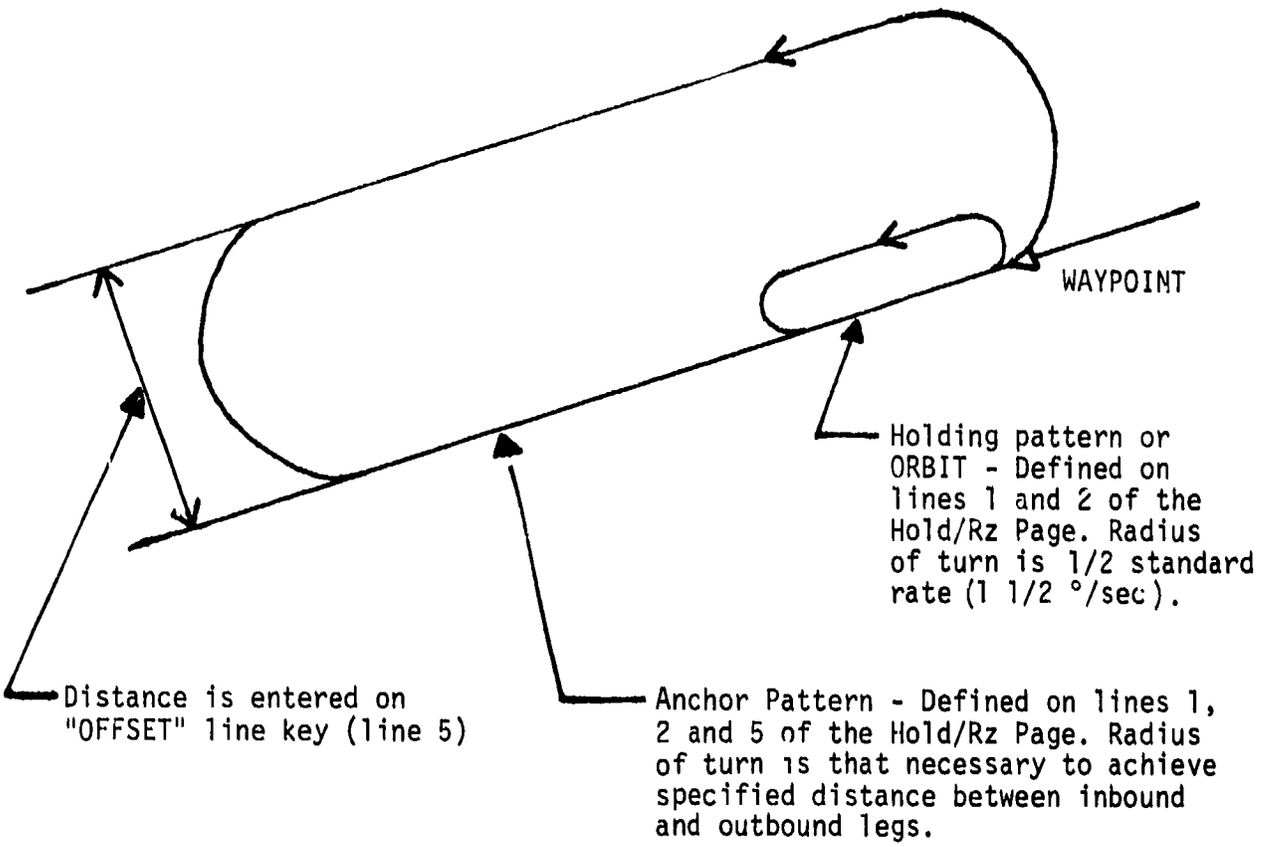
Figure B-9 Map W/Wx Radar

c. HOLD/RZ (HOLD/RENDEZVOUS). Selection of this HSD mode causes either the HOLD format or the RENDEZVOUS format to be displayed. The parameters presented on these formats are defined for the computer through the navigation management control-display unit. The HOLD/RZ switch permits sequential selection of either the HOLD or the RZ format display with successive pushes of the switch. As with the MAP format, HOLD/RZ may only be selected if the CMPTR nav mode has been selected. Even if pressed, the switch will remain inactive in an incompatible nav mode. When the RZ format is selected, the flight director is deactivated, requiring the pilot to navigate without commanded information. The flight director reactivates automatically whenever a new format other than RZ is selected.

Figure 10 depicts a holding pattern and anchor pattern.

Figure 11, 12, 13 and 14 depict some of the possible holding pattern or anchor pattern format variations which may be displayed on the HSD. The sequence shows an aircraft approaching and entering a pattern.

HOLDING/ANCHOR PATTERN

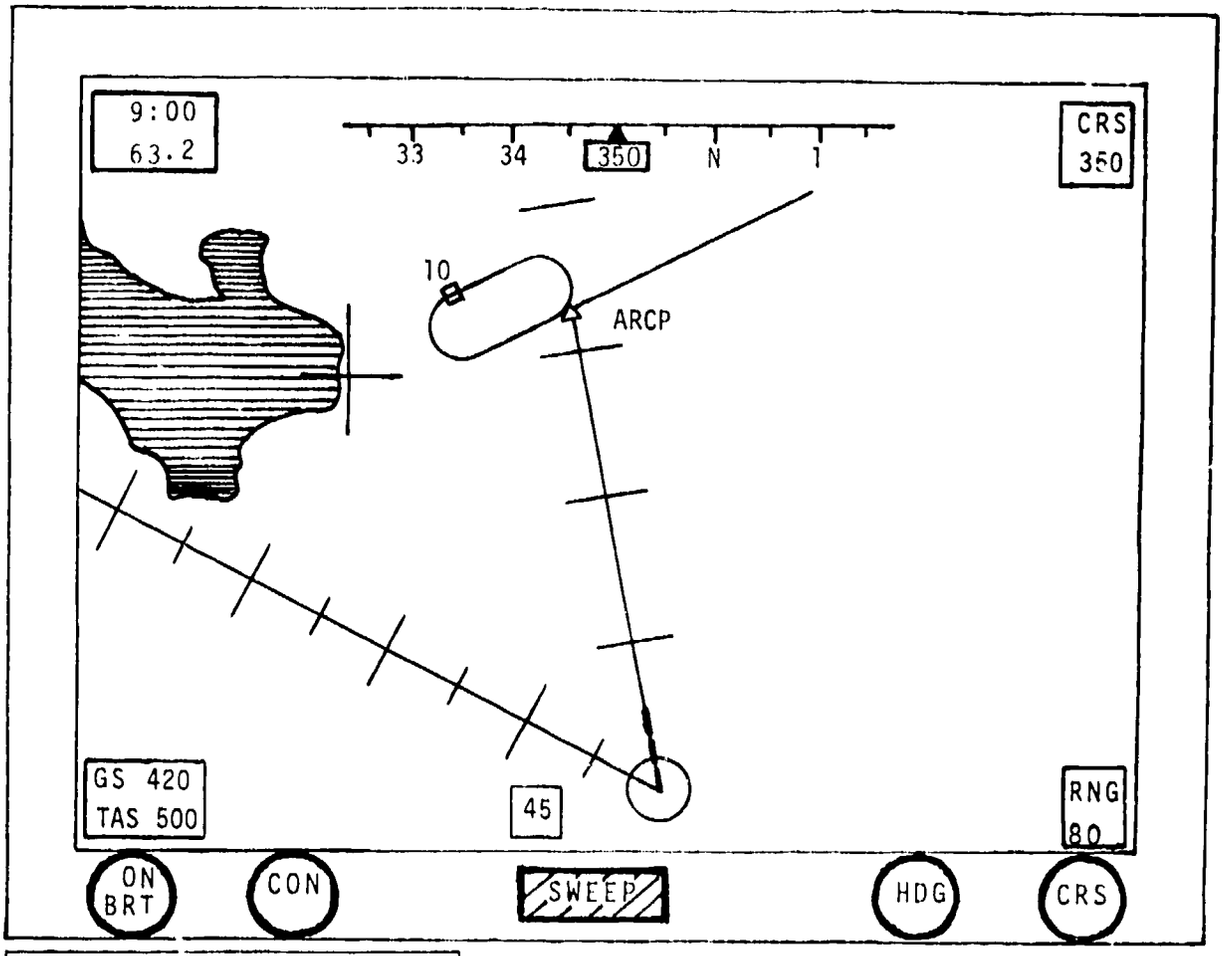


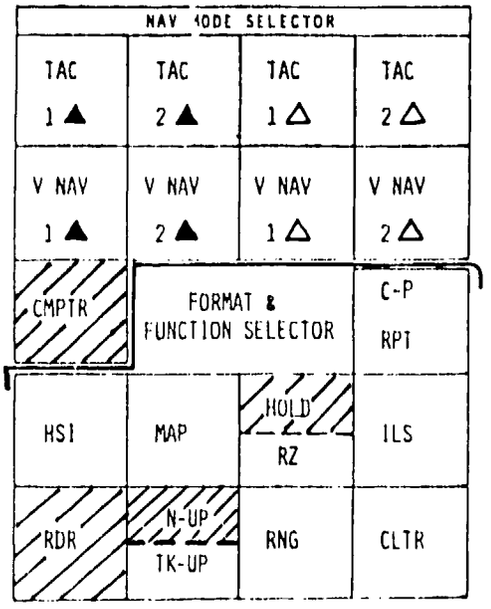
NOTE:

- This diagram is furnished to graphically depict the definition of terms and is not a format that will be displayed.

Figure B-10 Holding/Anchor

HSD HOLD FORMAT W/RADAR & CURSOR





HSD MODE SELECTOR SWITCHES

NAV MGT HOLD/RZ PAGE PROGRAMMED AS:

INB CRS	030
INB LEG/TURNS	10/L
REC TAS/DFT CR	
REC IP	
TURN RNG/OFFSET	--/10
PUSH TO INSERT	

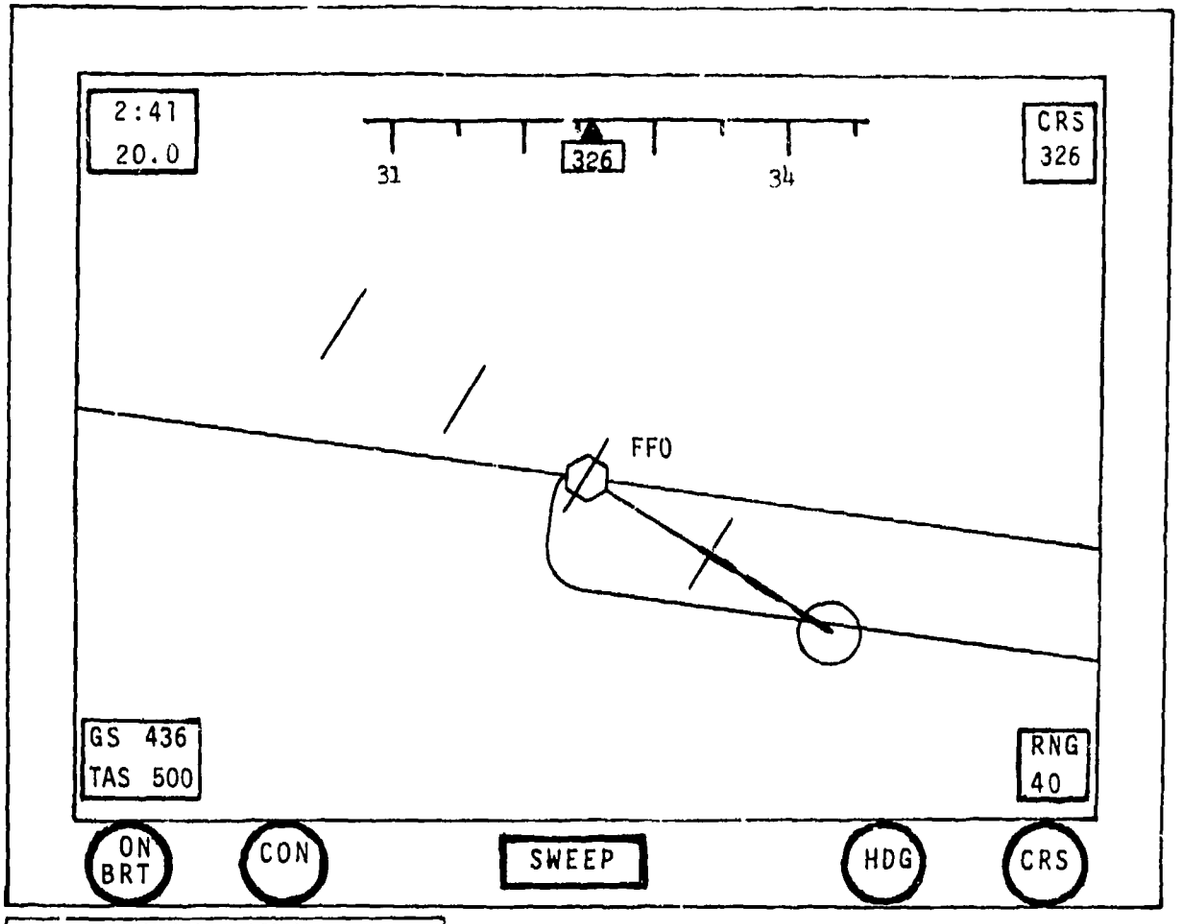
NOTE: •Holding pattern "INB CRS" is displayed (top rt.) when aircraft reaches wpt changeover (approx. 2 miles).

•Radar in GND MAP mode.

•Radar cursor switch activated.

Figure B-11 Hold W/Radar

HSD HOLD FORMAT



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD RZ	ILS
RDR	N-UP TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

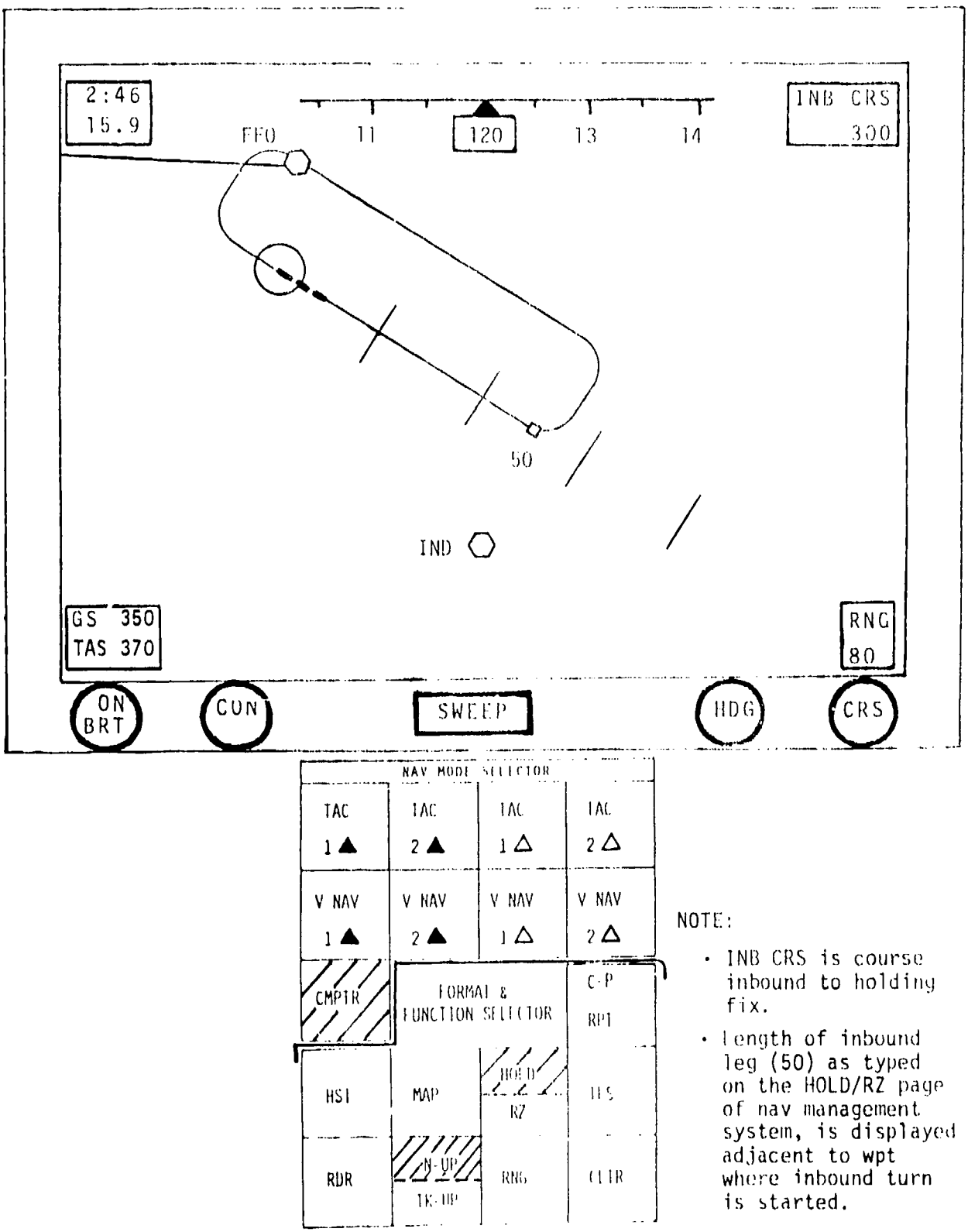
NAV MGT HOLD/RZ PAGE PROGRAMMED AS:

INB CRS/TYPE 280/A
INB LEG/TURNS 50/L
REC TAS/DFT COR
REC IP
TURN RNG/OFFSET --/20
PUSH TO INSERT

NOTE:
- Holding pattern "INB CRS" is displayed (top rt.) when aircraft reaches wpt changeover (approx. 2 miles).
- Radar in GND MAP mode.
- Radar cursor switch activated.

Figure B-12 Hold Format

HSD ANCHOR FORMAT

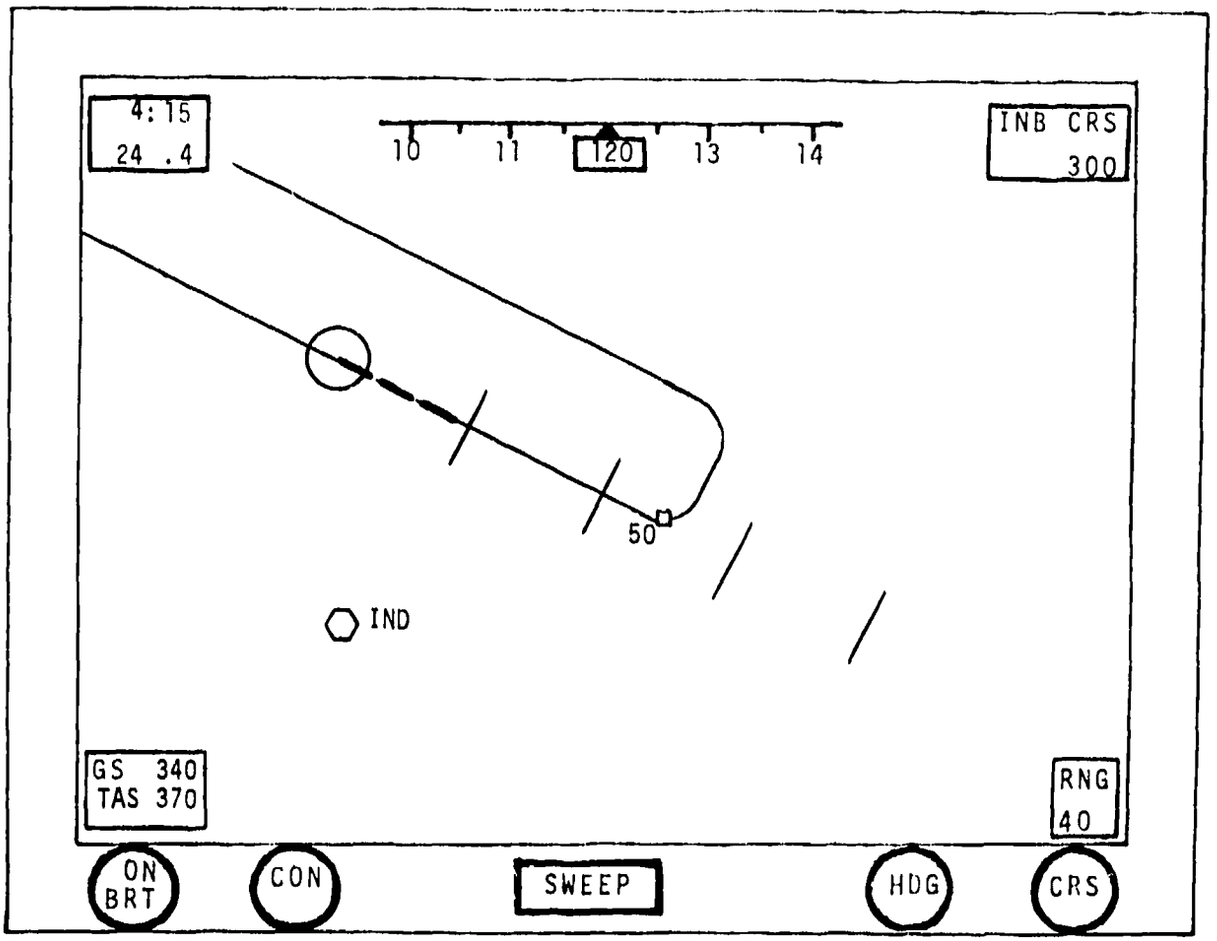


NOTE:

- INB CRS is course inbound to holding fix.
- Length of inbound leg (50) as typed on the HOLD/RZ page of nav management system, is displayed adjacent to wpt where inbound turn is started.

Figure B-13 Anchor Format HSD MODE SELECTOR SWITCHES

HSD ANCHOR FORMAT



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD RZ	ILS
RDR	N-UP TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

NOTE:

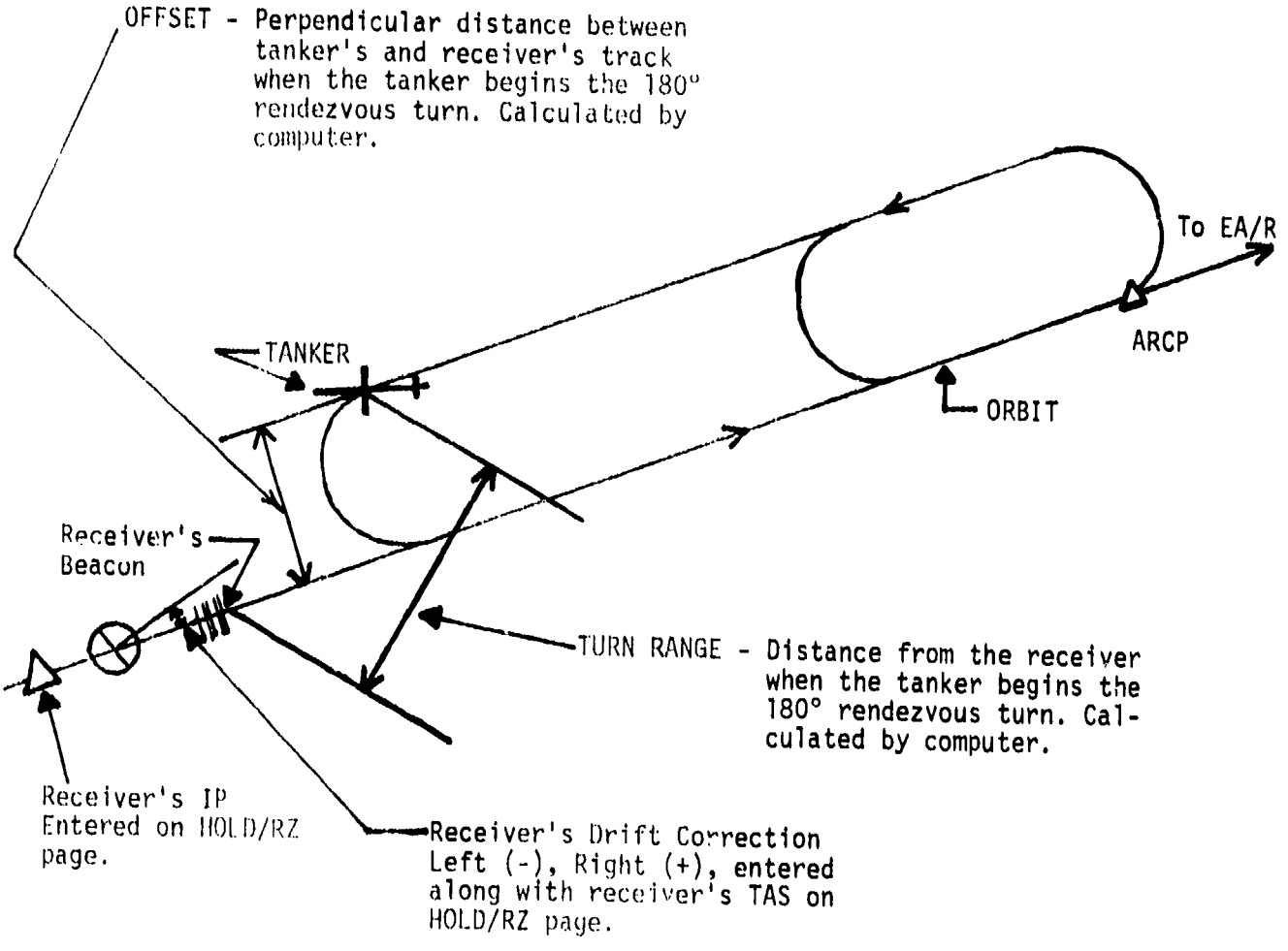
- INB CRS is the holding pattern course inbound to holding fix.
- Outbound holding fix is displayed with leg length.

Figure B-14 Anchor Format

Figure 15 depicts Point Parallel Rendezvous.

Figures 16 and 17 depict some of the possible point parallel rendezvous format variations which may be displayed on the HSD. The sequence shows the tanker as it approaches the receiver (beacon) and prepares to make its 180° turn inbound. Figure 8 could occur later in this sequence after "MAP" has been selected on the HSD format selector switches.

POINT PARALLEL RENDEZVOUS

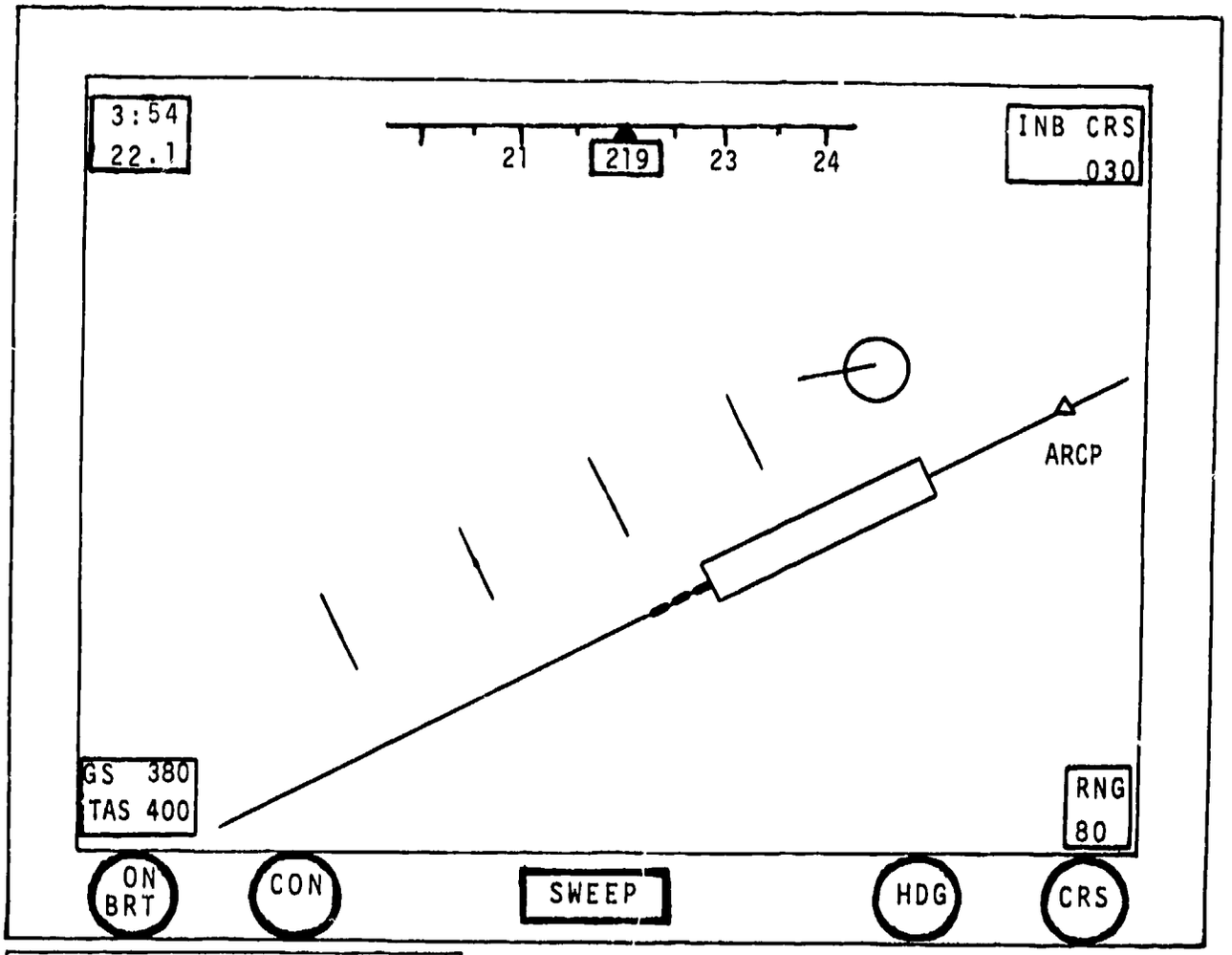


NOTE:

- This diagram is furnished to depict the definition of terms and is not a format that will be displayed.

Figure B-15 Rendezvous

HSD RZ FORMAT



NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD RZ	ILS
RDR	N-UP TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

NAV MGT SYSTEM PROGRAMMED AS:

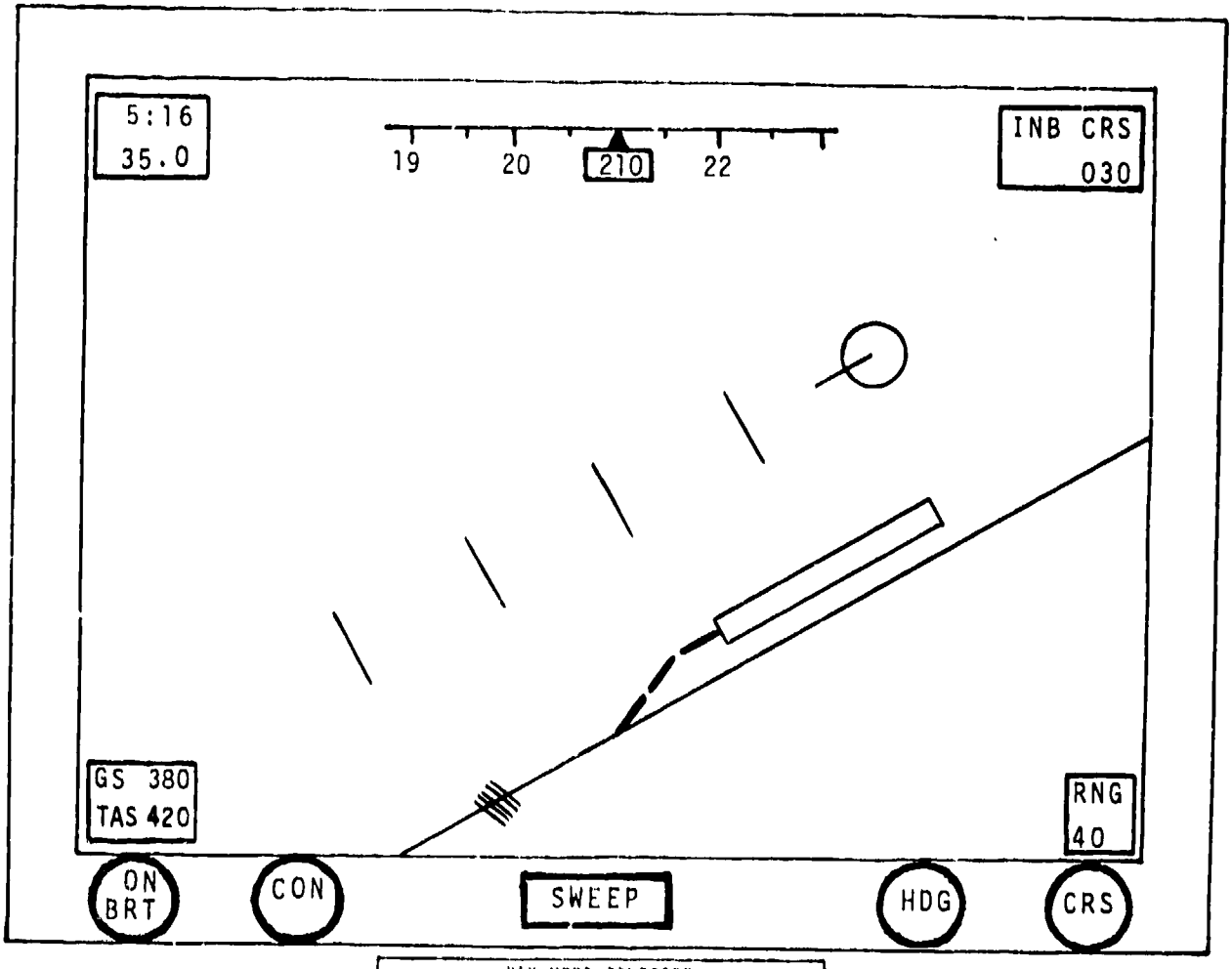
INB CRS/TYPE	030/R
INB LEG/TURNS	--/L
REC TAS/DFT CR	440/-5
REC IP	N403520 E0321630
TURN RANGE/OFFSET	21/10

◄ PUSH TO INSERT

NOTE:
- INB CRS is course inbound to ARCP.
- Predictive vector lines are now displayed at the leading edge of the TURN RANGE/OFFSET symbol paralleling ground track.

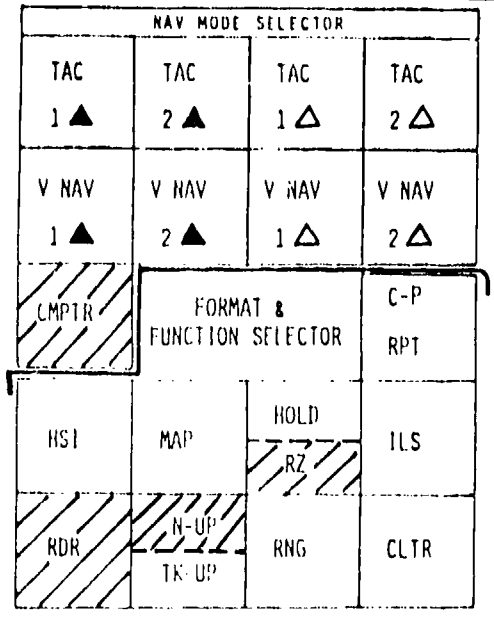
Figure B-16 Rz Format

HSD RZ FORMAT



NOTE:

- Aircraft has just started a left turn toward reciprocal (210°) of inbound course (030°).



HSD MODE SELECTOR SWITCHES

NOTE:

- INB CRS is course inbound to the ARCP.
- Predictive vector lines are now displayed at the leading edge of the TURN RANGE/ OFFSET symbol.
- Radar is in Beacon mode.

Figure B-17 Rz Format

d. ILS. ILS information can be displayed on either the conventional HSI format or a modified MAP format.

(1) Obtain the ILS HSI Format (Figure 5) as follows:

With the Nav Mode selector in CMPTR and the HSD format selector switch in HSI, MAP or HOLD/RZ, pressing the ▲ (BRG and CDI) VHF NAV or TACAN switch causes (1) the CMPTR light to go out, (2) the pressed switch to activate (illuminate), (3) permits manual tuning of TACAN RT units through the control head, (4) automatically changes the HSD format to an HSI display, and (5) illuminates the HSI format switch. TACAN, VOR or ILS can then be flown with the HSI format.

NOTE: No ▲ (BRG pointer) is displayed with the ILS format; however, (BRG/DIST-NO CDI) pointer selections may be made.

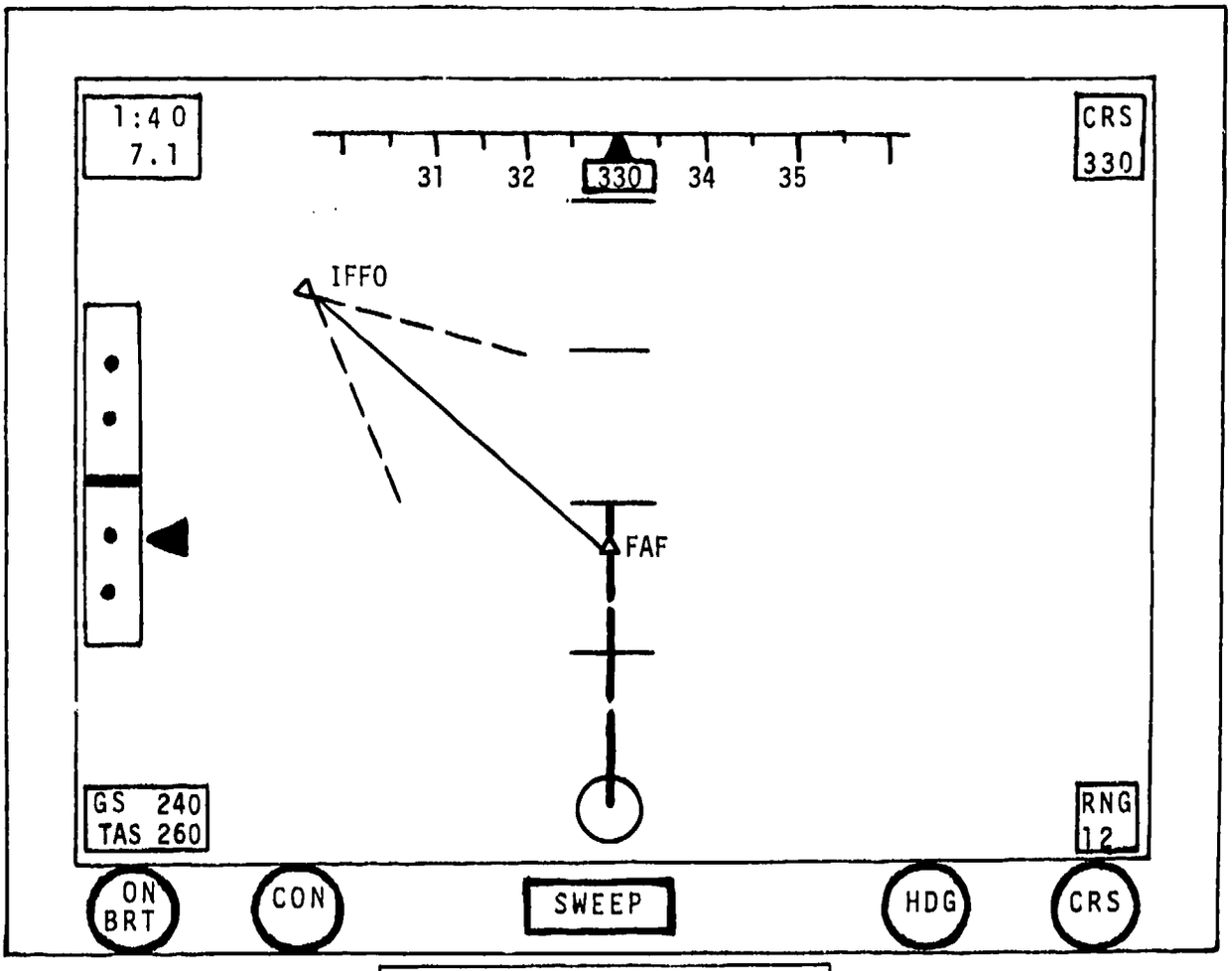
(2) The ILS MAP Format rather than the HSI format can be displayed as follows:

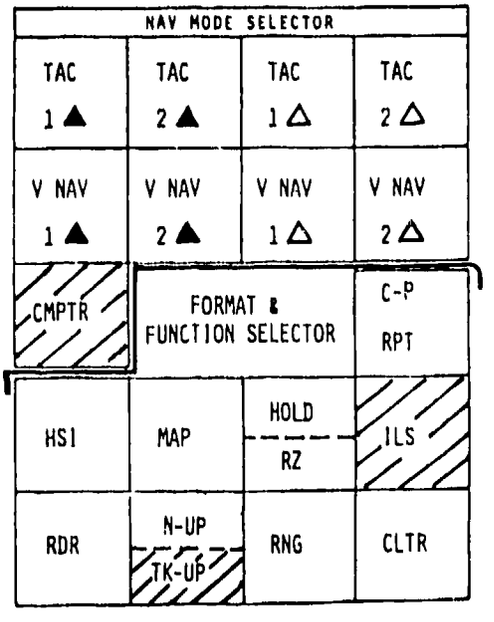
With the Nav Mode selector in CMPTR (light on), pressing the ILS HSD format switch (light on) causes the HSD to display a glideslope indicator on the left side of the HSD and a localizer fan emanating from the airfield on either side of the final approach course. The frequencies in both receivers will be scanned by the computer. The #1 VHF NAV frequency has priority over #2 VHF NAV if both are tuned to ILS frequencies. If and when an ILS frequency is tuned in either receiver, the ILS MAP format is displayed. If a VOR frequency is tuned in both receivers (even frequencies 108.0 through 111.8 and all frequencies 112.0 through 117.9 mHz) with ILS fc ıt selected, the ILS map display will remain and a fault message will appear (ſune ILS Freq").

Figures 18, 19 and 20 depict some of the possible ILS MAP format variations which may be displayed on the HSD. The sequences shows an aircraft on an ILS approaching an airfield.

For short range displays (4NM), the 30, 60, 90 second predictor lines may be de-selected through the use of a special purpose switch (not shown).

HSD ILS FORMAT





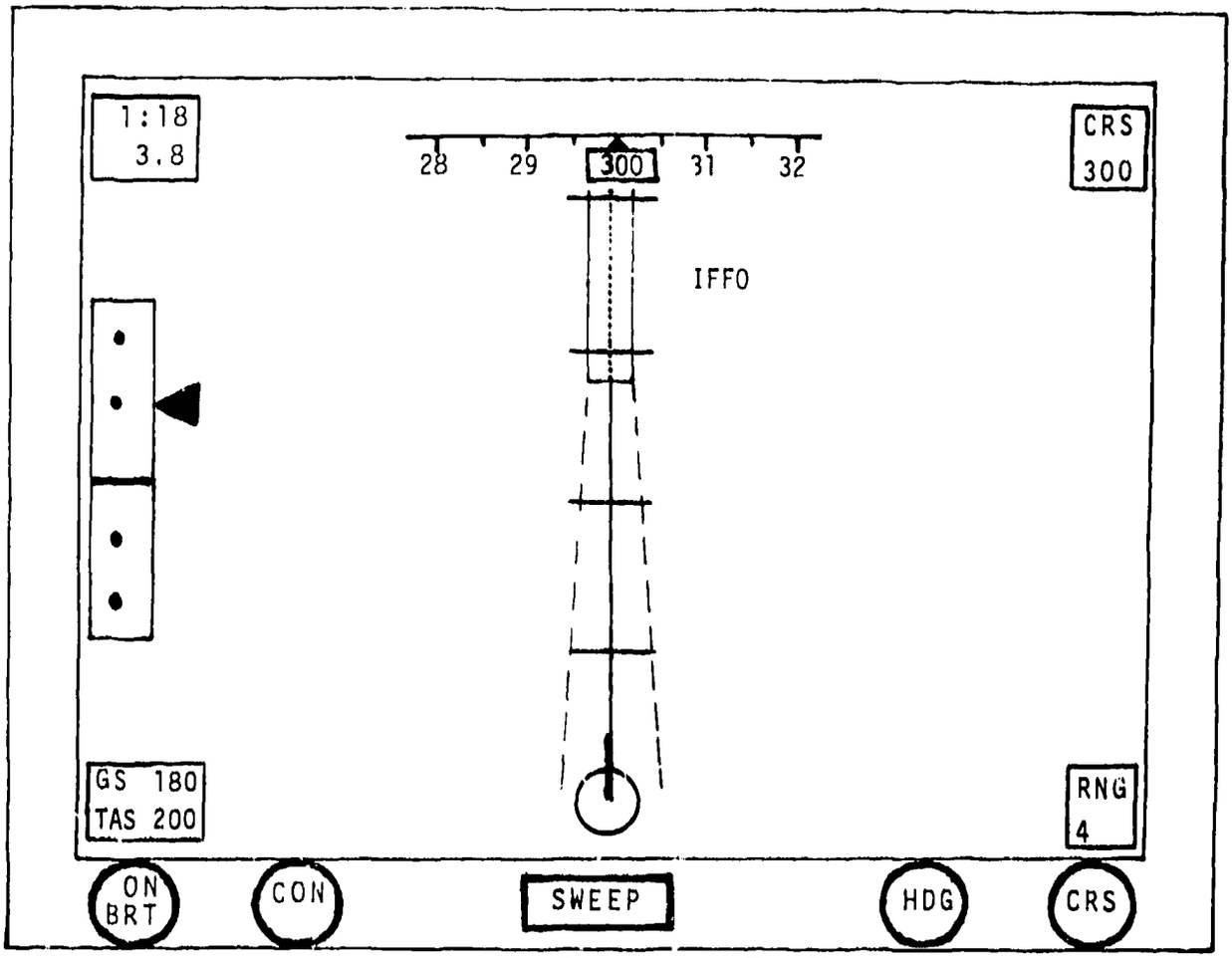
HSD MODE SELECTOR SWITCHES

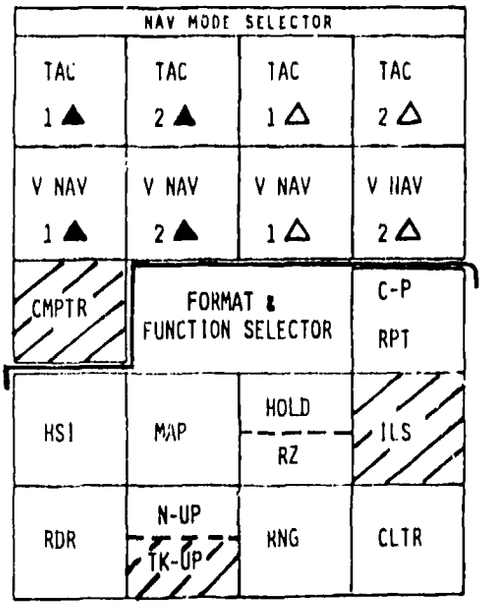
NOTE:

- ILS frequency tuned in VHF NAV 1 or 2 (ILS frequency not tuned in either R/T unit causes "Tune ILS FREQ" fault message to appear and final approach fan to disappear).

Figure B-18 ILS Format

HSD ILS FORMAT





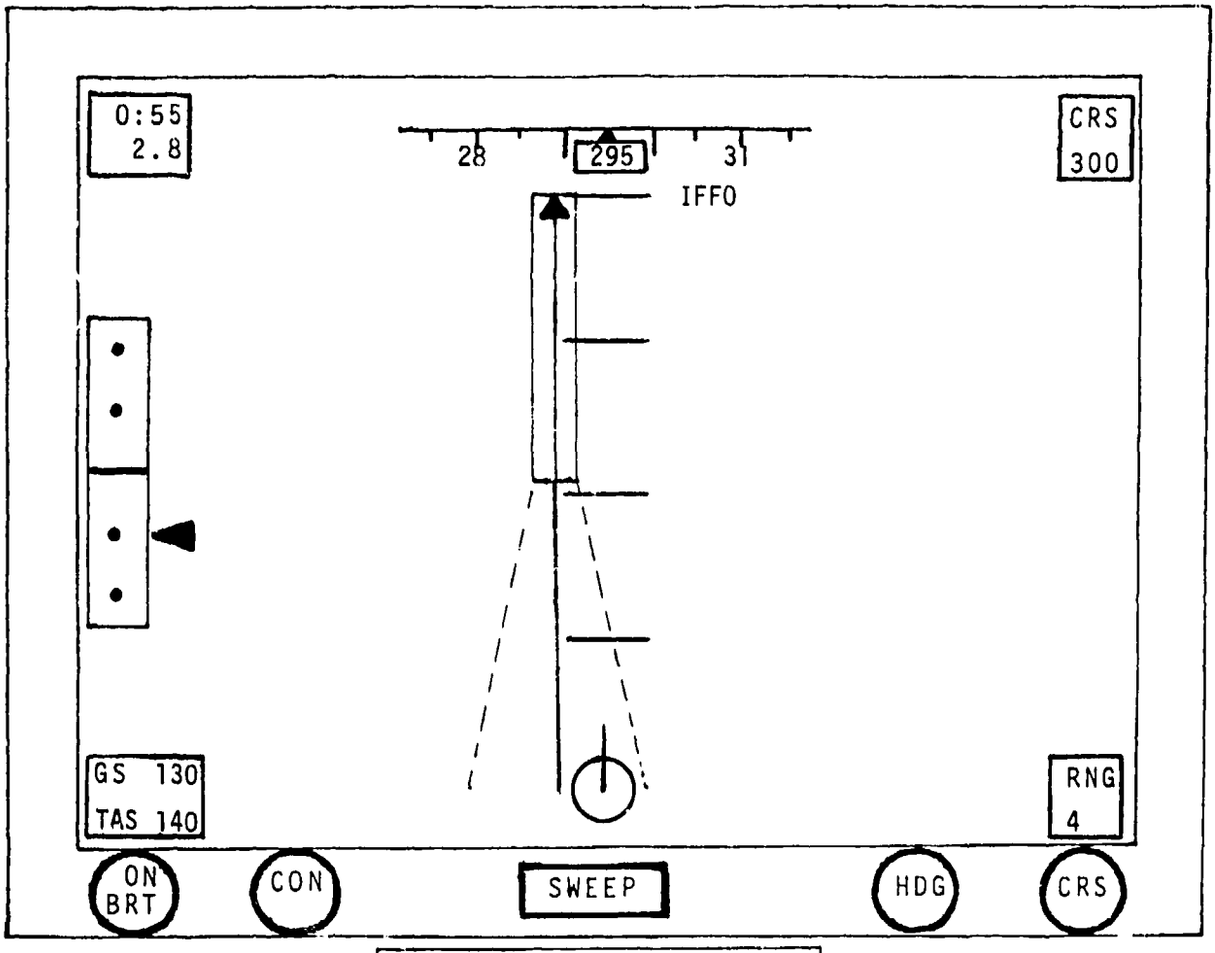
HSD MODE SELECTOR SWITCHES

NOTE:

- ILS frequency tuned in VHF NAV 1 or 2
- Predictor lines de-selected.

Figure B-19 ILS Format

HSD ILS FORMAT



NOTE:

- Aircraft is to the right of localizer.
- Aircraft is above glideslope.

NAV MODE SELECTOR			
TAC 1 ▲	TAC 2 ▲	TAC 1 △	TAC 2 △
V NAV 1 ▲	V NAV 2 ▲	V NAV 1 △	V NAV 2 △
CMPTR	FORMAT & FUNCTION SELECTOR		C-P RPT
HSI	MAP	HOLD / RZ	ILS
RDR	N-UP / TK-UP	RNG	CLTR

HSD MODE SELECTOR SWITCHES

NOTE:

- ILS frequency tuned in VHF NAV 1 or 2
- Predictor lines de-selected.

Figure B-20 ILS Format

3. FUNCTION SELECTOR SWITCHES

The operation of the function selection switches is as follows:

a. RADAR. Selection of this switch causes radar information, as determined by the position of the RADAR mode selector switch to be displayed on the HSD. Radar information (weather, ground map and beacon modes), may be overlayed on any HSD format except HSI. Radar overlay may be de-selected by a repeat selection of the RDR switch. Radar may be selected by itself (if the HSI format was previously selected) by pressing the RDR format switch, i.e., the HSI switch and the RDR switch are mutually exclusive. Radar is displayed only on the track-up presentation. When radar only is displayed, range, speed, time/distance and course information are presented in the four corners of the display, the same as with the map format. The range of the displayed information is either scaled to be compatible with the format being overlayed or selected with the RANGE/SCALE switch. The radar range may be varied between the pilot and copilot. Whenever radar is selected by both pilot and copilot the scale on both displays will go to whatever range was previously selected by each pilot. The radar cursor control and display is discussed in paragraph 4. When radar only is being displayed, pressing the MAP, HOLD/RZ or ILS format switch will overlay the radar on the respective format. Pressing the HSI or RDR switch will display the HSI format without radar.

b. N-UP/TK UP (North/Track-Up). Selection of this function reorients the displayed format to either a north or track-up presentation. Activation of the switch will cause a north-up presentation to change to track-up, or a track-up presentation to change to north-up accompanied by appropriate lighting of half of the switch. The function is only compatible with the MAP and ILS formats. The display automatically changes to track up for radar display. When the format changes, the N-UP or TK-UP remains the same until the switch is cycled.

c. RANGE. Selection of this toggle action (spring loaded to center) switch causes the range and scale of the displayed information to change. Each "up" selection increased ranged while each "down" selection decreases range. Generally, the HSD format automatically changes range to a preselected value as each different format is selected. The programmed ranges are: MAP -- 160 NM, HOLD/RZ -- 80 NM, ILS -- 12 NM. The range of the displayed information is changed by selecting the RANGE switch. Each press of the switch changes the range to the next higher or lower predetermined value. The total range and distance between range marker values (in NM) when radar is displayed are 4/1, 12/3, 20/5, 40/10, 80/20, 160/40 and 240/60.

d. CLTR (Clutter). Selection of this toggle switch either adds or delete computer generated navigation information from the MAP, HOLD/RZ or ILS dislay formats (press up add clutter; press down deletes clutter). The various stages of clutter/declutter are: 1. basic map symbology, 2. (1) plus TACANS, 3. (2) plus all other NAV AIDS, 4. (3) plus airfields and obstructions.

e. CP-RPT (HSD Repeat switch). This switch is labeled "CP-RPT" on the pilot's panel and "P-RPT" on the copilot's panel. When the "CP-RPT" switch is

pressed by the pilot, the information being displayed on the pilot's HSD will be replaced (identically) with the information being displayed on the copilot's HSD and the switch light will illuminate. The pilot's HSD mode/format selector switches remain on. If the RPT switch is reselected, the RPT switch light goes out and the previously selected mode/format reappear. Vice versa applies to the copilot's use of the HSD repeat switch.

4. HSD CONTROLS

a. CRS SET (Course Set). This knob (located below the HSD) performs the same function as the Course Set knob located on the HSI on the existing KC-135. However, it is only operable with the ▲ (bearing + CDI) nav mode selector switches selected and the HSD in the HSI mode. In all other switch combinations, the knob is declutched, with course information being generated by the computer based on the pilot programmed flight plan.

b. HDG SET (Heading Set). This knob (located below the HSD) performs the same function as the heading set knob on the existing KC-135. It controls the heading markers (which is a part of the HSI format) regardless of the NAV mode being utilized. The heading marker may also be moved with the heading slew switch on the control yokes. This slew switch moves the heading marker 1° per switch contact. If the heading slew switch is held down for more than 1/2 second, the heading marker is slewed at 18°/sec. The heading slew switches work individually (pilot's yoke switch moves pilot's heading marker, etc.) when the slew switch on the overhead panel is selected to "Single", or together (either pilot's or copilot's switches move both heading markers) when the slew switch is selected to "Dual". The heading marker provides input to the the flight director when the "Heading" mode is selected on the flight director.

c. SWEEP CONTROL. When pressed, this rocker type switch (located below the HSD) causes a cursor line to project from the nose of the aircraft symbol on the HSD. The sweep will remain visible for as long as the switch is held down plus 5 seconds. It will move at 5°/second in a fan shaped pattern, in the direction that the rocker switch is being held, 90° either side of the ground track of the aircraft. The number of degrees between the displayed sweep and the ground track is displayed digitally near the lower center edge of the HSD. It can be used to determine the amount of aircraft course change necessary to approach or avoid a specified target.

5. OTHER RELATED CONTROLS/DISPLAYS

a. RADAR CURSOR CONTROL. A radar cursor control is located on the forward center console. When cursor is selected, a cross hair appears on the display at a location identified on the nav management CDU scratch pad. The cross hair or cursor can be moved about the display with a joy stick type cursor control and positioned at the correct location (as identified on nav management CDU scratch pad). The updated position of the cursor can be inserted into the nav management system through the cursor insert control switch. For example, when a ground target is identified, its position is typed on the nav management CDU scratch pad and then the "CURS" switch is selected. The cursor appears where the INS computes the target location. If an error exists, the cursor can then be moved to a position over that target with the cursor control stick. The insert function can be activated by pressing the "wpt enter"

switch, which feeds the updated ground target information to the mission computer. The computer then calculates the relative location of the aircraft from the ground target and updates the position of the aircraft.

b. RADAR WEATHER WARNING. The radar system contains an automatic feature which displays a warning symbol (flashing "WX") on the HSD (HSI or MAP format) of nearby weather cells if the radar mode selector is on the WX or WX CTR position even though a radar overlay is not being displayed on the HSD. This allows the pilot to select RADAR on the HSD to determine the exact location.

c. BEARING DISTANCE HEADING INDICATOR. The Bearing Distance Heading Indicators (BDHI's) are described here although they are not part of the HSD. The selection of Nav aid information to be displayed on the BDHIs integrated with that displayed on the HSD provides a more complete picture. The source of each bearing and/or distance information displayed on each BDHI is selectable as shown below. Pilot and copilot BDHI control/display are identical and completely independent. The signal source selectors below the BDHI are formatted, sized and shaped to be easily read and manipulated. The bearing pointers do not obscure in any way the numbers or graduation on the compass rose or the numbers in the distance readout. The annunciators above the BDHI are electronic lighted displays that automatically display signal source to each bearing pointer. The left is always #1, the right is always #2. The annunciators are bright enough and large enough to be easily interpreted in day or night ambient light, without being distracting. The annunciators will be blank if the selected signal source control head is not turned on or is not receiving an adequate signal. An inadequate signal source (i.e. out of range or an ILS frequency tuned or no flight plan programmed into the INS) will also be indicated by a rotating bearing pointer and a flag over the distance readout (when appropriate).

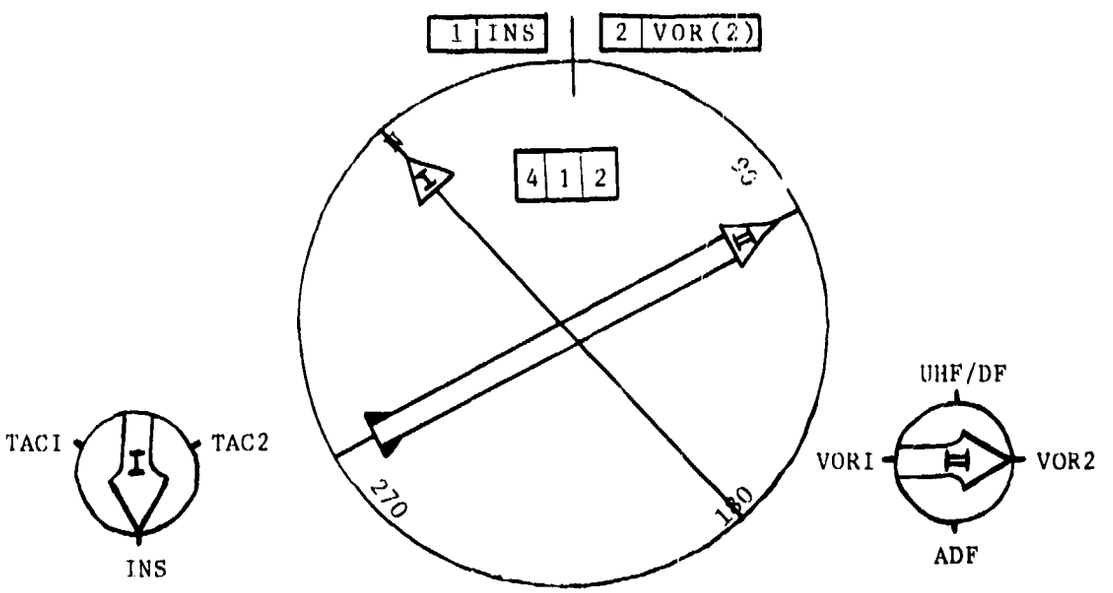


Figure B-21 BDHI

*U.S.Government Printing Office: 1982 -- 559-005/4039