4

AUXILIARY EQUIPMENT

TABLE OF CONTENTS

	Page
Communications and Associated Electronic Equipment	4-1
Birdwatcher Equipment	4-21
Lighting Equipment	4-25
Flight Recorder	4-25
Dictet Tape Recorder	4-27
Autopilot System	4-27
Navigation Equipment	4-32
Inertial Navigation System	4-36
Periscope	4-51
Destruct System	4-56

COMMUNICATION AND ASSOCIATED ELECTRONIC EQUIPMENT

The communication, electronic navigation and instrument approach equipment includes the following:

AN/ARC-50 UHF Communication, direction finding and ranging equipment.

DF 203 ADF Receiver

AN/ARN-52 TACAN Equipment

ILS Equipment

HF (618T) Radio Equipment with Sel-Call Decoder
Birdwatcher Equipment

IFF Equipment

AN/AIC-18 Interphone Equipment

AN/ARC-50 UHF RADIO NAVIGATION SYSTEM

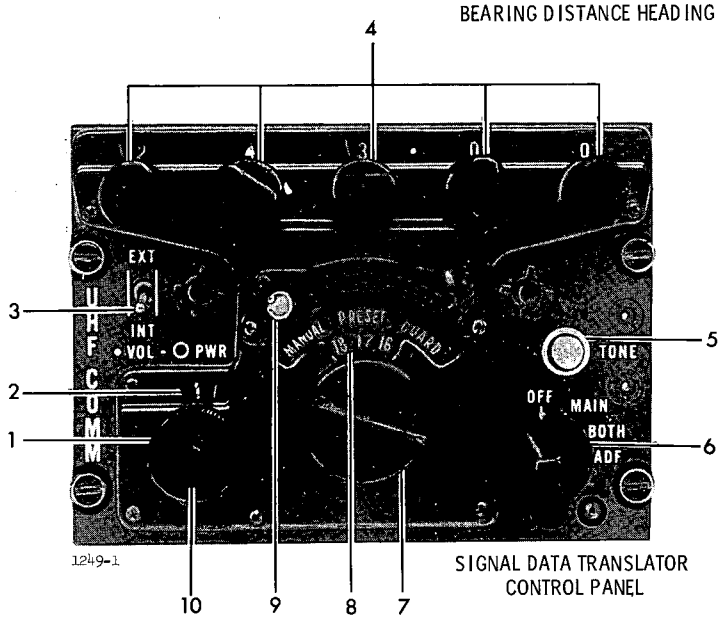
AN/ARC-50 equipment is capable of transmitting and receiving on any of 3500 channels in the frequency range of 225.00 to 399.95 MC. The equipment can be operated in either of two basic modes; an internal (narrow band) mode in which its operation is compatible with any conventional UHF radio communication set, and an external (wide band) mode in which it has high resistance to jamming and low detectability. In this mode it incorporates message privacy and range measurement functions. When used in conjunction with the UHF DF system and AN/ARA-50 set it provides direction finding capability in either mode.

In the internal mode power output is a nominal 30 watts minimum while in the enternal mode the power output is approximately 50 watts. The power output in either mode may be reduced in 10 steps of 9 db increments to a fraction of a watt.

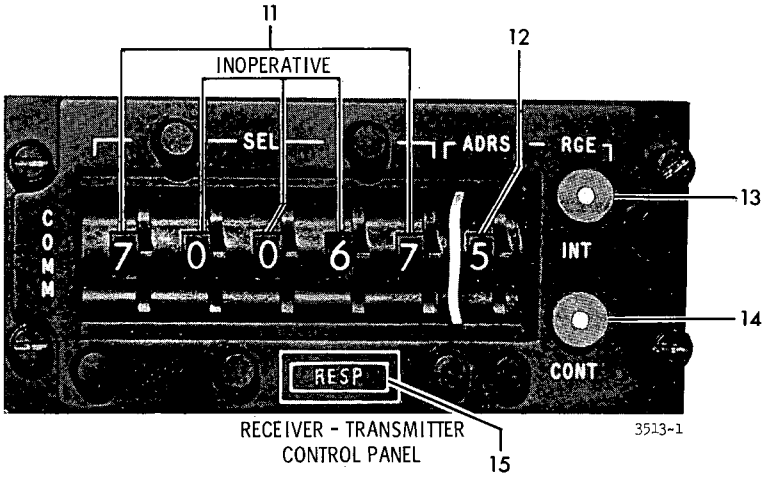
UHF RADIO PANELS AND INDICATORS

RANGE INDICATOR

BEARING DISTANCE HEADING INDICATOR (BDHI)



SIGNAL DATA TRANSLATOR CONTROL PANEL



RECEIVER - TRANSMITTER CONTROL PANEL

1 POWER SELECTOR SWITCH
2 POWER SELECTOR INDICATOR
3 INTERNAL - EXTERNAL SWITCH
4 MANUAL FREQUENCY SELECTOR SWITCHES AND INDICATORS
5 TONE BUTTON
6 FUNCTION SELECTOR SWITCH
7 PRESET CHANNEL SELECTOR SWITCH
8 PRESET CHANNEL INDICATOR
9 MANUAL - PRESET - GUARD SELECTOR AND INDICATOR
10 VOLUME CONTROL KNOB
11 CODE SELECTOR SWITCHES
12 RANGE ADDRESS SWITCH
13 RANGE INTERROGATE SWITCH
14 CONTINUOUS RANGE SWITCH
15 RESPONSE LIGHT

F200-29(e)

Figure 4-1

Most of the AN/ARC-50 equipment is mounted in the pressurized and cooled nose compartment and includes the blower cooled translator group, the receiver-transmitter group and a separate inverter. AN/ARA-50 direction finding equipment and the flush antenna are also mounted in the nose compartment.

The AN/ARC-50 control panels are mounted on the pilot's left console. A range indicator is mounted on the instrument panel. The direction finding equipment is also connected to the No. 1 needle of the BDHI when the equipment is operating. The communication antenna is mounted in the lower right chine. Power for the equipment is provided by the essential dc bus. The left generator bus supplies blower and heater power.

SIGNAL DATA TRANSLATOR CONTROL PANEL

The translator control panel labeled UHF COMM is located on the left console. It incorporates provisions for control of frequency and power output, mode of operation and receiver volume. It provides the pilot with 20 preset frequency channels, provision for manually selecting any of 3500 frequencies and controls for operation of the separate fixed tuned guard channel receiver.

Function Selector Switch

This four position rotary switch is labeled OFF, MAIN, BOTH and ADF. In the OFF position the equipment is not energized. In the MAIN position the translator group equipment is energized with only the transmitter and main receiver operative. In the BOTH position the equipment is energized with the transmitter and both main and guard receivers are operative. In the ADF position the AN/ARA-50 equipment is energized and the main receiver and the transmitter are operative. The No. 1 needle of the BDHI is also disconnected from the DF 203 ADF receiver or TACAN receiver and receives directional signals from the ARA-50 equipment.

Manual-Preset-Guard Selector Lever and Indicator

This selector lever controls the manner of frequency selection. In the MANUAL (left) position the manual frequency selector switches are activated and the frequency selected is visible in the cutouts above each switch. In the PRESET (center) position the preset channel selector switch is activated and the channel selected is displayed in the window below the Preset indicator. In the GUARD (right) position the guard channel frequency is set on the main receiver and transmitter, and GUARD is indicated in the window below the selector lever knob.

Preset Channel Selector Switch

This switch, located in the center of the panel, selects one of twenty preset frequencies when the manual preset guard selector knob is positioned to PRESET and indicates the frequency channel selected in the window beneath the Preset indicator. The channel numbers are blanked out when MANUAL or GUARD is selected.

Frequency Selector Switches and Indicators

Five rotary switches across the top of the panel permit manual selection of any one of 3500 frequencies in the 225.00 to 399.95 mc range. These switches are activated when the manual-preset-guard selector knob is positioned to MANUAL. Each switch is used to select the digit displayed in the cutout above.

INT-EXT Mode Switch

This two position switch is labeled INT-EXT. In the INT position the translator transmits and receives narrow band AM signals independent of the receiver-transmitter equipment. This position is used for conventional UHF transmitting and receiving. In the EXT position the signal translator and receiver-transmitter are used together to receive and transmit the wind band pseudo-noise encoded signals. The EXT position is also used for direction finding and/or ranging functions. The power selector switch may be used to regulate the transmission power in either position.

Power Selector Switch and Indicator

The rotary switch is the larger of the two concentric knobs and controls the output of the transmissions from the translator and receiver-transmitter combination. It has ten positions labeled 1 to 10 to permit setting power output from the maximum of 30 watts (10) to a low of .3 microwatts (1) in 9 db increments in the INT or narrow band mode. In the EXT or wide band mode power is increased to a maximum of 50 watts but also may be reduced in the 9 db units to approximately 1.0 microwatt. The digit in the cutout above the knob indicates the power output selected. The A position, providing for an additional amplifier, is operative but power output is the same as the 10 position.

Volume Control

This is the smaller center knob concentric with the power selector switch and adjusts the audio level of the receivers. Clockwise rotation will increase volume.

Tone Button

This button is located on the right side of the panel. When depressed, a 1020 cycle tone is produced for audio checking or transmission on either INT or EXT mode.

RECEIVER-TRANSMITTER CONTROL PANEL

The receiver-transmitter control panel located just aft of the translator control on the left console is used when operating in the external or wide band mode only. In this mode of operation the AN/ARC-50 provides the following functions:

1. Secure voice communications.
2. Semi Automatic Direction Finding.
3. Semi Automatic Range Measurement.
4. Automatic Ranging.
5. Automatic Ranging and Direction Finding.

The panel contains rotary selector and range address switches with position indicators, pushbutton interrogation and continuous ranging switches and indicating lights and a separate response indicator light. These switches and lights are only operative when the INT-EXT mode switch is in the EXT position.

Code Selector Switches

Five rotary type digital indicating selector switches labeled SEL are provided on the panel. The digital window type indicators have positions labeled from 0 to 7. Communicating stations must have identical code selecting settings in order to establish wide band communication.

NOTE

In this installation only the 1st and 5th selector switches are operative giving 64 possible code selections. 2nd and 3rd selector switches must be on 0 and the 4th select switch must be on 6.

Range Address Switch

The inboard or 6th rotary selector switch labeled ADRS-RGE is used for selective ranging. It has eight positions which show position indications of 1 thru 5 inclusive for 5 possible range addresses. The other three positions are labeled A, O, and T. The A position allows for a range measurement on any terminal regardless of its address (ADRS-RGE) code. This is considered an emergency code. The O position is an off position which prevents another terminal from ranging although voice communication capability is retained. The T position is a test position for checking indicator lights on the translator and receiver transmitter panels.

Range Interrogate Switch and Indicator Light

This pushbutton switch containing an integral light is used to make interrogation of direction and range in the external mode. When the translator function selector switch is in the ADF position the one time bearing reading will be indicated on the No. 1 needle of the BDHI. If the translator function switch is in the MAIN or BOTH position pressing the INT button will provide a one time range measurement in nautical miles and tenths. Normal time for one time directional or range indication is 3 seconds. The button is also used to establish automatic ranging and automatic ranging and direction finding in combinations with the CONT button. The button will be momentarily depressed and the light illuminated while the ranging or direction range is being obtained. The light will be extinguished after approximately 3 seconds.

Continuous Range Switch

This pushbutton switch and integral light labeled CONT, when pressed, sets the receiver-transmitter into a continuous automatic ranging or combination ranging and DF conditions. This condition is activated by the interrogate button provided that the other station has previously activated their continuous range operation. The light is illuminated at both stations while continuous ranging or ranging and DF operation is in effect. The range indicator and No. 1 needle of the BDHI will be updated every 5 seconds. Either station pressing its CONT button or MIC button will terminate the automatic cycle. When the cycle is completely broken the range indicators will return to 000.0 miles.

Response Light

The response light, labeled RESP, will be illuminated when the AN/ARC-50 is answering a range measurement interrogation from another aircraft or station.

DISTANCE INDICATOR

The distance indicator is mounted on the upper left side of the instrument panel and displays the distance between two ranging AN/ARC-50 sets. Negative contact will result in a 000.0 reading.

UHF ANTENNAS

The UHF communication antenna is located on the lower right chine and remains ex-

tended. Provisions are available to hydraulically retract the antenna flush. The UHF-ADF antenna is mounted on the bottom of the nose compartment and is the receiving antenna at any time the function switch on the translator is in the ADF position. It is optimized for the DF function and communications and ranging will be inferior when using this antenna for other than the direction finding function.

NORMAL OPERATION

Internal Mode UHF Communications

1. Microphone selector switch - UHF.
2. Function switch - MAIN or BOTH.
3. INT-EXT switch - INT.
4. Power selector switch - Set.
5. MANUAL-PRESET-GUARD lever - As desired.

NOTE

If GUARD is selected frequency selection will be automatic.

If MANUAL:

6. Frequency selector switches - Set.

If PRESET:

7. Channel selector switch - Set.
8. Mic button - Press.
9. Volume control - As desired.

External Mode UHF Encoded Communication

NOTE

External mode is applicable only when communication is with another AN/ARC-50 station.

1. Microphone selector switch - UHF.
2. Function switch - MAIN or BOTH.
3. INT-EXT switch - EXT.
4. Power selector switch - Set.
5. MANUAL-PRESET-GUARD lever - MANUAL or PRESET as desired.

NOTE

If GUARD is selected communications will be in the narrow band conventional mode even though INT-EXT switch is in EXT.

If MANUAL:

6. Frequency selector switches - Set.

If PRESET:

7. Channel selector switch - Set.
8. Code selector switches - Set.
9. Range address switch - 0 or as desired.
10. Mic button - Press (tone will be heard for approximately 1 second).
11. Volume control - As desired.

Semi Automatic Ranging

A one time range interrogation is made as follows:

1. Select proper frequency and power.
2. Function switch - MAIN or BOTH.
3. INT-EXT switch - EXT.
4. Code Selector switch - Set.
5. ADRS-RGE selector switch - Set.
6. INT button - Press. Light will illuminate for approximately 3 seconds.

When the light extinguishes range indication may be read.

To update range reading:

7. INT- Press.

To communicate with range partner:

8. Mic button - HOLD. Wait for tone to mute.

Automatic Ranging

Automatic continuous ranging with both stations receiving continuously updated range information every 5 seconds is accomplished as follows:

1. Frequency and power - Set.
2. Function switch - MAIN or BOTH.
3. INT-EXT switch - EXT.
4. Code selector and range address switches - Set.
5. Request selected range partner to press CONT button.
6. CONT button - Press.
7. INT button - Press.
8. CONT light - Check on.
9. INT and RESP light - Check alternate illumination. Both stations will receive updated range readings every 5 seconds.

NOTE

After a continuous range is established, if a ranging interrogation cycle is not completed, the equipment will automatically re-interrogate once. The digital range indication will be held during this period for approximately 10 seconds and, if ranging is not re-established, then reset to zero.

To resume communication:

10. Mic button - Press. Tone will be heard for 0-10 seconds depending on which part of the ranging cycle is in progress.

NOTE

First transmission after muting will be to ranging partner only. Subsequent transmissions will be heard by all stations having identical code selections.

11. Volume control - Adjust.

ADF Operation

During ADF operation the AN/ARA-50 equipment and directional antenna are used for receiving, and the direction of signals from the responding UHF station will be indicated by the No. 1 needle of the BDHI.

Internal Mode Direction Finding

For DF operation in conventional narrow band mode proceed as follows:

1. Select proper frequency and power.
2. Function switch - ADF.
3. INT-EXT switch - INT.
4. Request communicating station for continuous transmission or tone.
5. Bearing to transmitting station will be indicated by the BDHI No. 1 needle.

External Mode Direction Finding

For semi automatic or one time ADF bearing proceed as follows:

1. Select proper frequency and power.
2. Function switch - ADF.
3. INT-EXT switch - EXT.
4. Code selector switch - Set.
5. Range address switch - Set.
6. INT button - Press momentarily. Light will illuminate for approximately 3 seconds. When light is extinguished, bearing will be indicated by the BDHI No. 1 needle.

To update bearing:

7. INT button - Press.

To resume communication:

8. Mic button - HOLD.

For continuous updated ranging and automatic direction bearing proceed as above except:

1. Request ranging partner to press CONT button.
2. CONT button - Press.
3. INT button - Press.

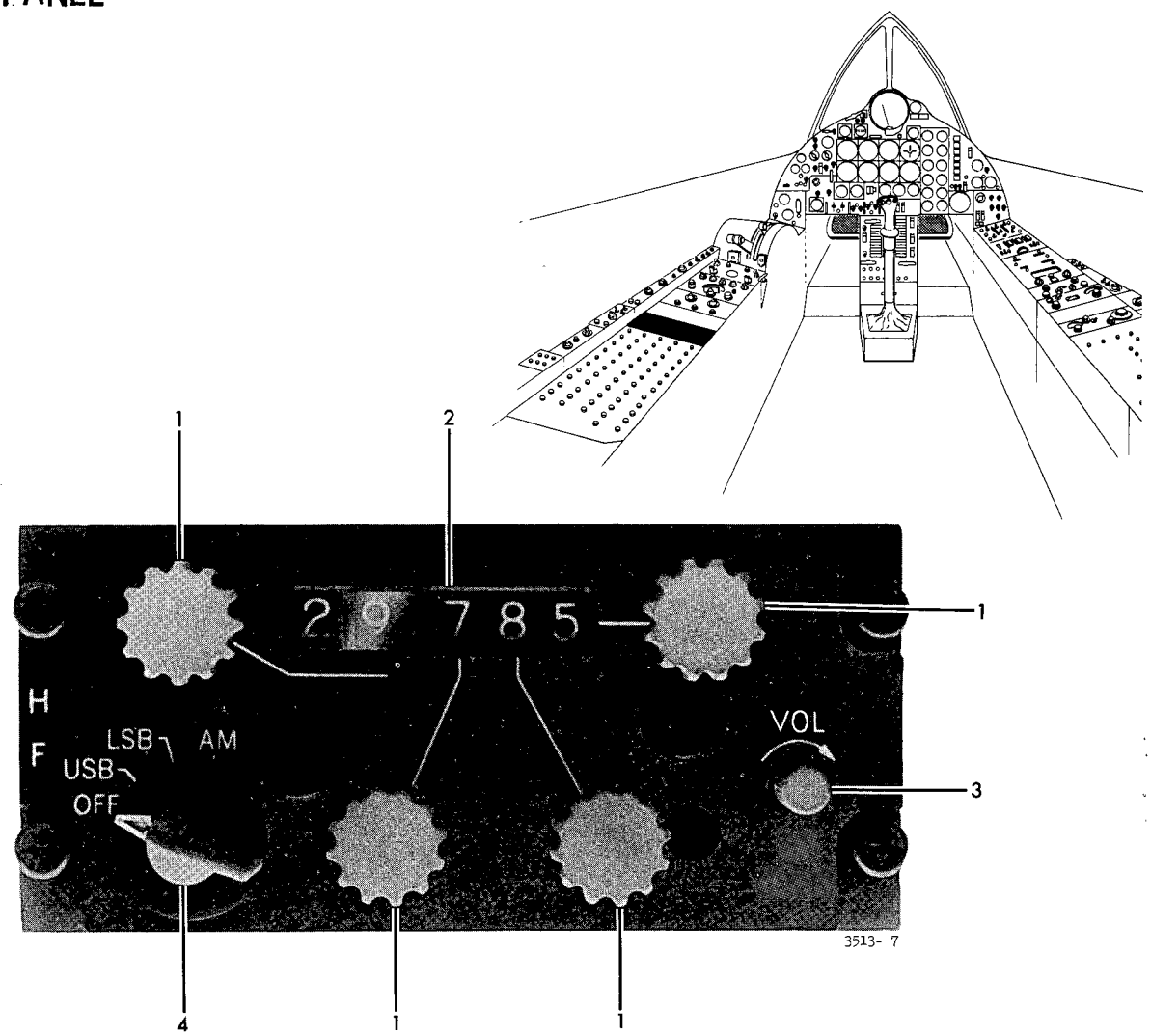
NOTE

Holding the Mic button until tone stops (0-8 seconds one way ADF and 0-12 seconds two way ADF) terminates the automatic ranging and ADF functions. The CONT and INT buttons will re-establish the continuous ranging and ADF cycles.

BEARING, DISTANCE, HEADING INDICATOR (BDHI)

The bearing, distance, heading indicator located on the left side of the instrument panel contains a rotating compass card, a range shutter labeled OFF covering the digital distance readout, and No. 1 and No. 2 directional indicating needles. The card displays true or magnetic heading depending on the position of the INS mode switch. In the NAV position, true heading using the INS as a reference will be indicated at the lubber line. In the FRS position, magnetic heading from the FRS will be indicated. The No. 1 needle will read an ADF bearing from the DF 203 unless the AN/ARC 50 is operating in the ADF mode; or TACAN bearing depending on the position of the No. 1 needle selector switch. The No. 2 needle will indicate the steering direction from the INS. When reliable TACAN information is being received the range shutter will be up and the range readout will represent slant range to the TACAN station being interrogated.

HF RADIO PANEL



1 FREQUENCY SELECTOR SWITCHES
2 FREQUENCY INDICATOR
3 RF SENSITIVITY CONTROL
4 SERVICE SELECTOR SWITCH

F200-41(b)

Figure 4-2

BDHI No. 1 Needle Selector Switch

This two position switch is located on the right console. It selects either the TACAN or DF-203 ADF inputs to the No. 1 BDHI needle, provided the AN/ARC-50 is not operating in the ADF mode. In the TACAN (forward) position, the No. 1 needle of the BDHI is connected to the TACAN receiver and the needle indicates the bearing to the selected TACAN station. In the ADF (aft) position, the No. 1 needle indicates the bearing to the selected station. When the AN/ARC-50 is operating in the ADF function, the switch is inoperative and the No. 1 needle indicates the bearing to the selected ARC-50 station.

COURSE INDICATOR (ID 249)

The ID-249 course indicator is installed on the center instrument panel. It is used in conjunction with the BDHI to indicate course deviation when operating the TACAN system. It is also used to indicate course and glide slope deviation and marker beacon passage when operating the ILS receivers. The indicator contains a course set knob, a course selector window to show course selected, a vertical CDI course deviation needle and dot deviation scale, a horizontal glide slope indicator needle and dot deviation scale, (GSI), a TO-FROM indicator window, GSI & CDI warning flags (OFF), a heading pointer with right and left pointer scales and a marker beacon light. The indicator is powered by signals from the respective receivers.

618T HF RADIO EQUIPMENT

The 618T is a long range airborne single side band (SSB) voice communications transceiver which transmits and receives in the 2 to 30 megacycle range. The transceiver can be tuned in one kilocycle steps. The primary operating mode is SSB, using either the upper or lower side of the modulated signal, which allows all the power to amplify the side band selected. The equipment can also transmit and receive AM signals.

The equipment consists of the transceiver with an antenna tuner which is mounted in the pressurized nose compartment. The antenna is the pitot boom and insulated forward portion of the aircraft nose. This equipment has been modified to use fixed frequency ac power from the No. 1 inverter for those circuits which are frequency critical and variable frequency ac power normally furnished from the left generator for non-critical main ac power. A frequency sensing relay is provided to transfer this main ac power source if the left or operative generator bus drops below 325 cycles (4500 engine rpm) to the ARC-50 inverter if the COMM selector switch is in the HF position. Control circuit power is supplied by the essential dc bus.

618T HF Control Panel (714 E-2)

The control panel for the HF equipment is located on the left console and contains the following:

Service Selector Switch

This switch turns the equipment on or off and selects the desired operating mode. In the USB (upper side band) position, only the upper side band signal is transmitted or received. This is the sum of the voice signal and the radio frequency (rf) signal. In the LSB (lower side band) position, only the lower side band signal is transmitted or received. This signal is the difference of the voice signal and the rf signal. In the AM position the signal is amplitude modulated and both side bands and the original rf signal are transmitted and received.

Frequency Selector Switches

The first switch selects the proper megacycle point as indicated by the digits in the first two windows. It will indicate from 02 to 29. The frequency will increase as the knob is rotated clockwise and decrease as the knob is rotated counterclockwise.

The 100 kc knob selects the proper one hundred kilocycle point and indicates from 0 to 9 in the third window. The 10 kc knob selects the desired ten kilocycle point and indicates from 0 to 9 in the fourth window. The one kc knob selects the desired one kilocycle point and indicates from 0 to 9 in the right window.

Volume Knob

This knob is used to adjust the audio level in the headphones.

NORMAL OPERATION

1. Service selector switch - Set to desired mode. This will turn the equipment on. For normal voice communication this may be USB, LSB or AM.

2. Frequency selector switches - Set to desired operating frequency. The muting of sound in the headphones will indicate the equipment is setting to the new frequency.

Note

The service selector switch may have been moved from the OFF position to an operating mode with the desired operating frequency already set up. In this case, rotate the ten kc select knob one digit off frequency and then back to the operating frequency. This will allow the equipment to return to the desired frequency.

3. COMM selector switch - HF.

When background sound is again heard in the headphone:

4. TRANS-button - Press. Wait for the equipment to tune - a 1000 cps tone will be heard until tuning is complete.

When the equipment is tuned (no 1000 cps tone):

5. VOL knob - Adjust so that background noise in headphones is barely audible.

EMERGENCY OPERATION

If a short circuit exists in the output of the power supply, a protective circuit turns off the equipment. Restore to operation as follows:

1. Service selector switch - OFF, then back to desired operating mode.

NOTE

When the antenna coupler is required to complete several consecutive tuning cycles, a thermal relay will de-energize the equipment. Restore to operation as follows:

1. Service selector switch - OFF. After two minutes the thermal relay will cool.

2. Service selector switch - To desired operating mode.

If HF and/or BW operation is required with inoperative engines or generators:

1. HF & BW power switches - On.

2. COMM selector switch - HF.

NOTE

The COMM selector switch must be in the HF position to provide continuous HF or BW communication with windmilling engines and/or inoperative generators. In this position automatic transfer of main ac power from the left generator to the ARC-50 inverter is accomplished if the frequency of the left generator bus drops below 325 cycles or 4500 engine rpm. At below 2800 engine rpm or 200 cycles the automatic bus transfer occurs and if the right engine or generator bus is above 325 cycles (4500 engine rpm) the frequency relay will reconnect the main ac power to the right generator power source.

SEL CALL DECODER

The Sel Call Decoder provides a convenient method for the selective reception of HF transmissions. It will recognize a call on a selected channel of the HF receiver and unmute the receiver when the proper call signal is received. The decoder operates in a preset Sel Call coder frequency and will recognize only this channel. A momentary contact switch and indicating light is on the left console to MUTE or UNMUTE the HF audio circuit. The indicator light is illuminated when the decoder is in the muted mode. The Sel Call Decoder is also automatically unmuted when the transmitter key is pressed which provides audio sidetone during transmission to the pilot's headset. Power for the Sel Call Decoder is furnished by the dc essential bus.

X BAND BEACON

The aircraft is equipped with an X band beacon and an EGG beacon. The X band beacon transponder is located in the nose compartment with the flush antenna mounted on the lower fuselage just aft of the nose boom. The EGG beacon transponder and antenna are mounted on the lower Q-bay hatch. Both beacons are controlled by a 3 position toggle switch located on the left console. The switch is labeled EGG-OFF-TNKR. Power for the transponder is furnished by the dc essential bus.

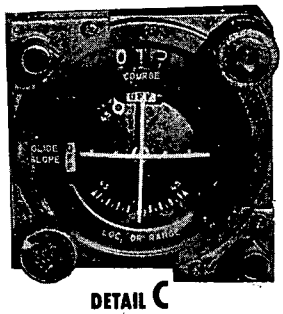
TACAN SYSTEM AN/ARN-52

The TACAN system provides continuous indications of bearing and slant distance to a selected surface beacon or to another aircraft containing the necessary transponder equipment. The system transmits interrogation pulses which trigger responding pulses from the selected ground station or aircraft. Slant distance to the station or aircraft is computed from the elapsed time. Both bearing and distance are visually displayed on the bearing, distance heading indicator on the instrument panel. The system is capable of operation on any one of the 216 channels and has a range of about 300 nautical miles. The transmitting frequency range is 1025 to 1150 megacycles. Frequency ranges for reception are; low band normal, 926-1024 megacycles, air to air 1088-1150 megacycles; high band normal, 1151-1213 megacycles, air to air 1025-1087 megacycles. Power for the equipment is furnished by the left ac generator and essential dc buses.

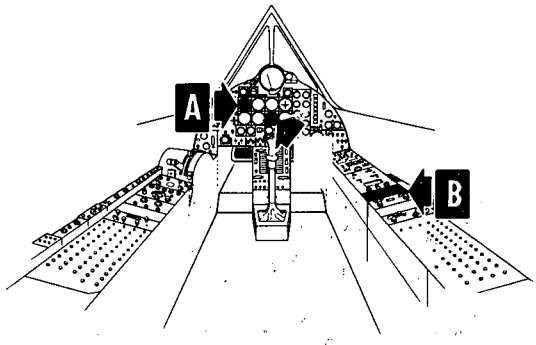
AN/ARN-52 Control Panel

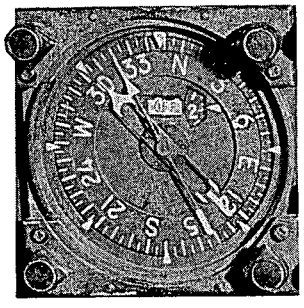
A control panel is installed on the right console. The panel contains a channel selector switch, mode selector switch and a volume control.

TACAN CONTROL PANEL AND INDICATORS

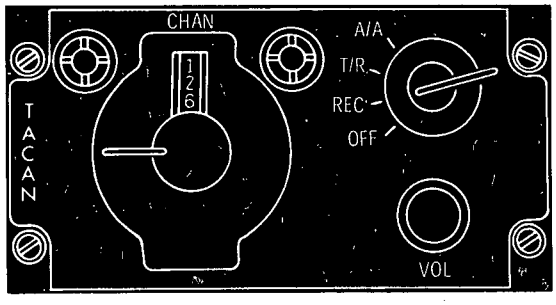


DETAIL C
COURSE INDICATOR





DETAIL A
BEARING DISTANCE HEADING INDICATOR (BDHI)



DETAIL B
TACAN CONTROL PANEL

F200-66(a)

Figure 4-3

Channel Selector Switch

A channel selector is used to select any one of the available channels. Selection is accomplished by setting the desired number in the channel window using the concentric knobs. The outer knob selects the first two digits and the inner knob selects the third digit of a desired channel.

Volume Control Knob

Audio level of the TACAN station identification signals is increased by rotating the volume (VOL) control clockwise.

Mode Selector Switch

The mode selector switch has four positions.

OFF - The set is de-energized.

REC - The set is energized and presents bearing and course information on the BDHI and course indicator.

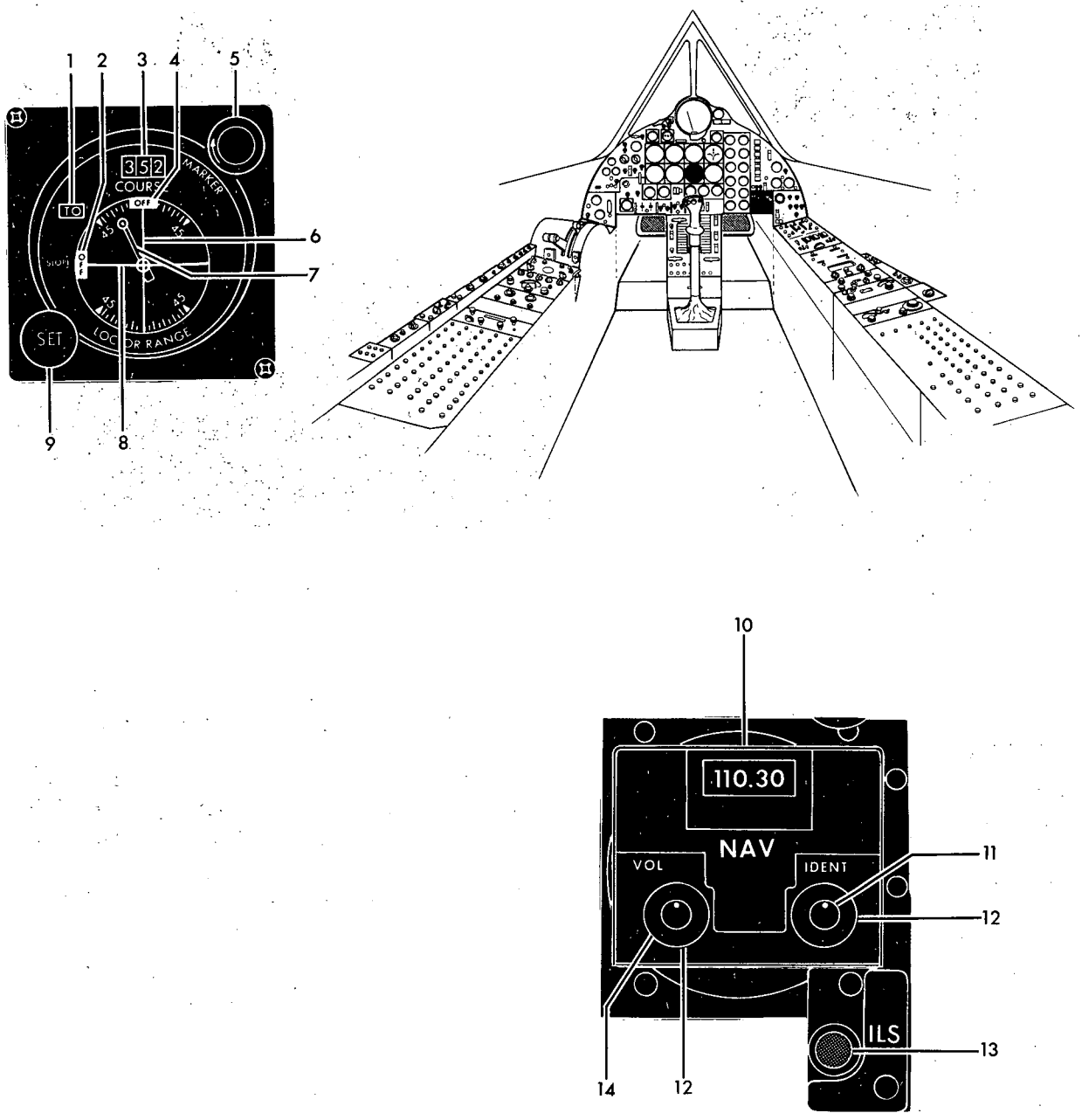
T/R - Same as the REC position and also presents range in nautical miles to a TACAN station on the BDHI.

A/A - Same as the REC position and also presents range in nautical miles and bearing to another properly equipped aircraft.

OPERATION OF THE TACAN SYSTEM

1. INS mode switch - FRS if operative.
2. TACAN mode selector switch - REC.

ILS CONTROL PANEL



1 TO-FROM INDICATOR
2 GLIDE SLOPE SIGNAL OFF FLAG
3 BEARING SELECTOR INDICE
4 LOCALIZER-VOR OFF FLAG
5 MARKER BEACON LIGHT
6 COURSE DEVIATION NEEDLE (C.D.I.)
7 HEADING INDICATOR
8 GLIDE SLOPE INDICATOR (GSI)
9 BEARING SELECTOR KNOB
10 FREQUENCY INDICATOR
11 AUDIO IDENTIFICATION CUTOUT
12 FREQUENCY SELECT SWITCH
13 ILS ON LIGHT
14 VOLUME-ON-OFF SWITCH

F200-31(a)

Figure 4-4

Allow 90 seconds for warmup:

3. Channel selector switch - Desired channel.

4. Adjust VOL as desired and verify station identification.

5. No. 1 needle selector switch - TACAN.

6. Observe bearing pointer on BDHI: To-From indication on course indicator.

7. Mode selector switch - T/R, or A/A.

8. Observe range to station or aircraft on BDHI.

Bearing, Distance, Heading Indicator (BDHI) No. 1 Needle

The BDHI No. 1 needle may be connected to the TACAN receiver by the BDHI No. 1 needle selector switch. If the receiver is tuned to a TACAN station, the No. 1 needle will indicate the bearing to the station. Refer to BDHI this section.

ILS EQUIPMENT

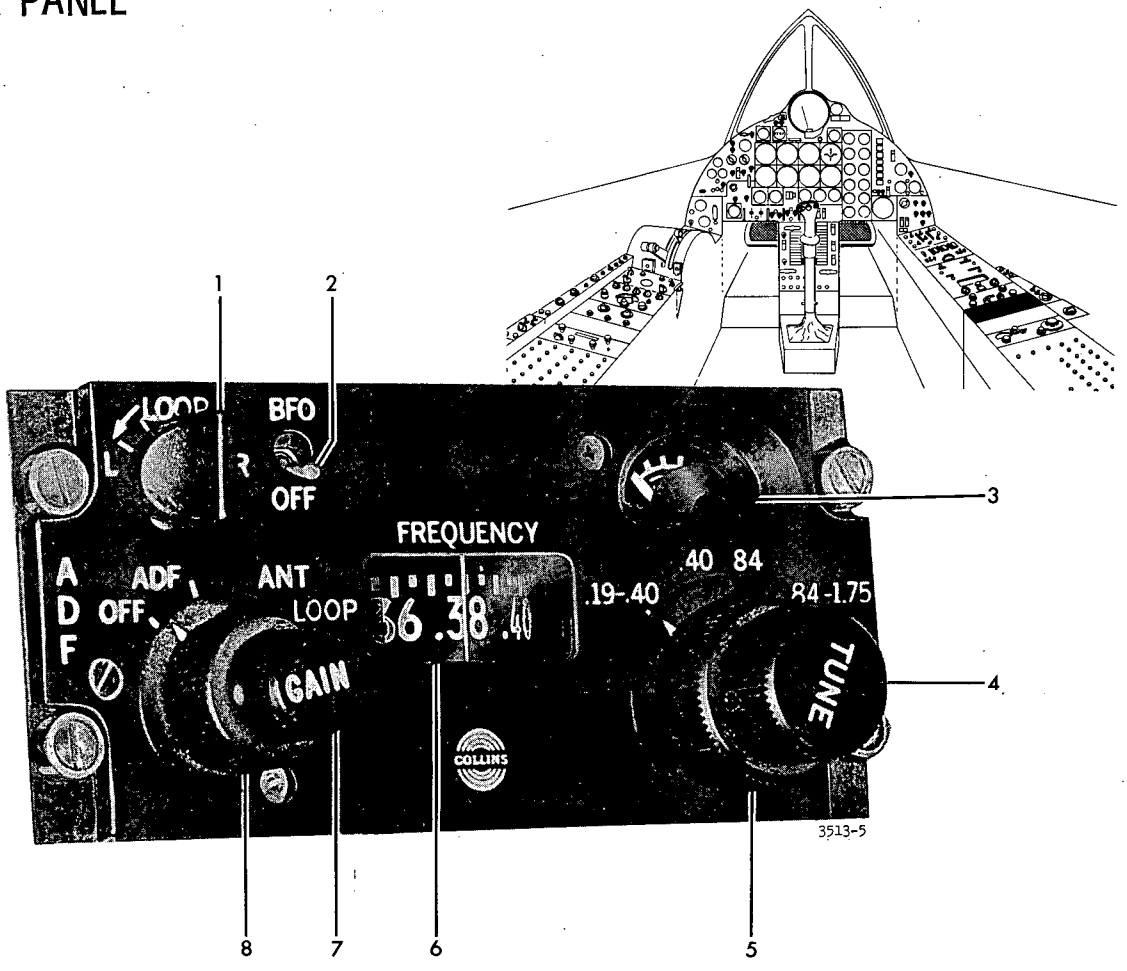
ILS equipment consisting of localizer, glide slope and marker beacon receivers are provided for ILS approaches. In addition the equipment includes a control panel and indicating light, the ILS converter and associated antennas. Localizer, glide slope and marker beacon signals are reflected on the ID-249 course indicator. Localizer signals are not reflected by the No. 1 needle of the BDHI which continues to show TACAN or HF/UHF ADF bearings as selected.

The localizer receiver tunes odd tenth megacycle localizer frequencies between 108.10 to 111.90 mc. It will also tune VOR voice or tone signals between even tenths from 108.0 to 112.0 and all tenths between 112.1 thru 117.9 mcs. VOR signals will not be reflected on the ID-249 course indicator. The associated glide slope frequencies between 329.3 to 335 megacycles will be automatically tuned when the receiver is tuned to the desired localizer frequency. The localizer ON-OFF-VOL control also activates the fixed tuned 75 megacycle marker beacon receiver and marker beacon signals are reflected by coded audio tones in the headset and coded flashes of the single marker beacon light on the ID-249 course indicator. As the marker beacon antenna is located on the inside of the nosewheel door the marker beacon will only be usable with the landing gear down. The ILS ON light is provided to indicate that the localizer is furnishing signals to the ID-249 course indicator and that TACAN signal inputs are disconnected from that instrument. TACAN bearing and range to selected stations will still be available on the BDHI. All receivers are solid state and operate with power furnished by the essential dc bus.

ILS Control Panel

The ILS control panel is located on the lower right side of the instrument panel. The panel controls consist of a ON-OFF-VOL control concentric with a larger frequency (megacycle) selector on the left side of the panel. The small knob turns the ILS equipment from off to on and further clockwise rotation will increase the volume of voice reception or tone identification. The larger knob selects the 3 digit megacycle frequency of the desired localizer station which is indicated in the window in the center of the panel. The right hand side control knobs are also concentric with the small center knob to eliminate tone identification from the headset. The larger concentric knob controls the 2 digit tenths and hundreth mc frequency selector which is indicated in the frequency window. The ILS ON light is located just above the panel

ADF CONTROL PANEL



1 LOOP CONTROL
2 BFO SWITCH
3 TUNE-FOR-MAX INDICATOR
4 TUNING CONTROL
5 BAND SELECTOR SWITCH
6 FREQUENCY INDICATOR WINDOW
7 GAIN CONTROL
8 FUNCTION SWITCH

3-16-65
FMA12-45

Figure 4-5

and indicates that the TACAN receiver is disconnected from the ID-249 course indicator and course and glide slope deviation indications are from the ILS equipment.

Operation of ILS

1. ON-OFF-VOL switch - ON.
2. Desired localizer frequency - Select.
3. Volume - Adjust.
4. Localizer station - Identify.
5. Front course heading - Select.
6. ILS light - Check ON.
7. Glide slope and localizer warning flags - Check not visible.

DF-203 ADF RECEIVER

The DF-203 ADF radio receiver is an automatic or manual direction finder and a low and broadcast range aural receiver. The equipment consists of a radio receiver, a control unit, a flush sense antenna, a flush fixed loop antenna, a BDHI and the connecting cabling, antenna coupler and a quadrantal error corrector. The receiver covers a frequency range of .19 to 1.75 megacycles in three bands. Power for the equipment is furnished by the essential dc bus and the 26-volt instrument transformer.

ADF Control Panel

The ADF control panel is installed on the right console of the cockpit. The controls are described below.

Function Switch

The function switch is the larger of the two concentric knobs on the inboard side of the panel. The labeled positions are OFF, ADF, ANT and LOOP. In the OFF position the equipment is de-energized. In the ADF position the equipment functions as an automatic direction finder with a continuous indication of the bearing to the radio station shown on the BDHI if the AN/ARC-50 is not operating in the DF mode. In this position both the sense and loop antennas are connected to the receiver. In the ANT position, received signals are obtained only from the sense antenna and the equipment functions as a conventional aural radio receiver. In the LOOP position received signals are obtained only from the loop antenna and the equipment functions as a manual direction finder to enable the pilot to determine the bearing to the radio station by aural null procedures.

Band Selector Switch

The band selector switch is the larger of the concentric knobs located in the outboard side of the control panel and is used to select the desired frequency band. The correct frequency scale will also appear in the frequency indicator window for the band selected as follows:

Band Frequency	Coverage
.19 - .40 MC	190 - 400 KC FAA Low Frequency Band
.40 - .84 MC	400 - 840 KC International Distress Frequency and Lower Broadcast Band
.84 - 1.75 MC	840 - 1750 KC Upper Broadcast Band

Tuning Control

The tuning control is the smaller of the outboard concentric knobs and tunes the receiver within the frequency band selected. The tuned frequency is indicated on the scale of the frequency indicator. The control is also rotated slightly for maximum reading on the tuning meter.

Loop Control

The control labeled LOOP is used to accomplish the electrical equivalent of rotating the loop (gonio) antenna. The control is labeled L and R and the left or right rotation effect will be apparent in the headset and the tuning meter. The speed of the rotating effect may be slowed by turning the loop control approximately half way to the L or R labeled position.

Gain Control

The gain control is the smaller of the inboard concentric knobs and is provided to adjust the audio level of the receiver.

BFO Switch

The BFO switch when in the BFO position provides a beat frequency oscillator to aid in tuning the receiver or to receive coded transmissions.

Bearing, Distance, Heading Indicator (BDHI) No. 1 Needle

ADF bearing indication is provided by the No. 1 needle of the BDHI when the BDHI No. 1 needle selector switch is in the HF/UHF (aft) position and the AN/ARC-50 ADF is not operating. Refer to BDHI, this section.

NORMAL OPERATION

Operation of the ADF Receiver as a Conventional Radio Receiver

1. Function switch - ANT.
2. Band selector switch - Select desired band.
3. Tuning control - Rotate to desired frequency and adjust for maximum reading on the tuning meter.
4. Volume - Adjust as desired.
5. The BFO switch can be used to tune in continuous wave signals or to zero beat modulated signals.

Operation of the ADF Receiver as an Automatic Direction Finder

1. Tune receiver as above and positively identify the station.
2. Function switch - ADF.
3. Tuning control - Tune for maximum signal reading on tuning meter.
4. BDHI No. 1 needle selector switch - ADF (aft).
5. Read bearing to station on BDHI No. 1 pointer.

Operation of the ADF Receiver as a Manual Direction Finder (Aural Null)

1. Tune receiver as above and postively identify the station.
2. Tuning control - Tune for maximum signal reading on tuning meter.

3. BDHI No. 1 needle selector switch - ADF (aft).

4. Function switch - Loop.

5. Loop control - R or L, as necessary, to acquire null.

NOTE

If the AN/ARC-50 ADF function is operating, the No. 1 BDHI needle will remain connected to the UHF equipment.

TRANSPONDER (IFF) - 914-X-1

The 914-X-1 transponder provides reception, detection, decoding, encoding and transmission of signals in the IFF Mark X (SIF) system and has a locally installed MODE X discrete operating function. The transponder will also recognize a Mode 4 interrogation; however, the set will not decode or encode a reply without accessory equipment. Any one of numerous coded replies available for Modes 1, Mode 3 or X can be selected by rotating the appropriate selector switches on the panel. The set is capable of transmitting an emergency reply regardless of the interrogation mode. A provision is also incorporated to identify position of the aircraft. Power for the set is furnished by the essential dc bus. Addition of the Mode X capability deletes the Mode 2 function from the transponder.

TRANSPONDER (IFF) CONTROL PANEL

The transponder control panel is installed on the upper left console. The panel contains two code selectors for Mode 1 and Mode 3/X codes, Mode 1 and Mode 3 toggle switches, an I/P switch, IFF power selector switch and an emergency switch bar.

Power Switch

The IFF power switch has three positions: Off, LO, and ON. When the switch is placed in the LO position only local (strong) interrogations are recognized and answered. With the switch in the ON position, there is full sensitivity for recognition and reply. The IFF power switch activates Mode X when in the ON or LO position. Response to Mode 1 and Mode 3 interrogations depends on the position of the Mode 1 and 3 toggle switches. When the Emergency switch bar is up, the power switch is forced to the ON position. A 30 second time delay is incorporated in the power switching before the equipment is operative.

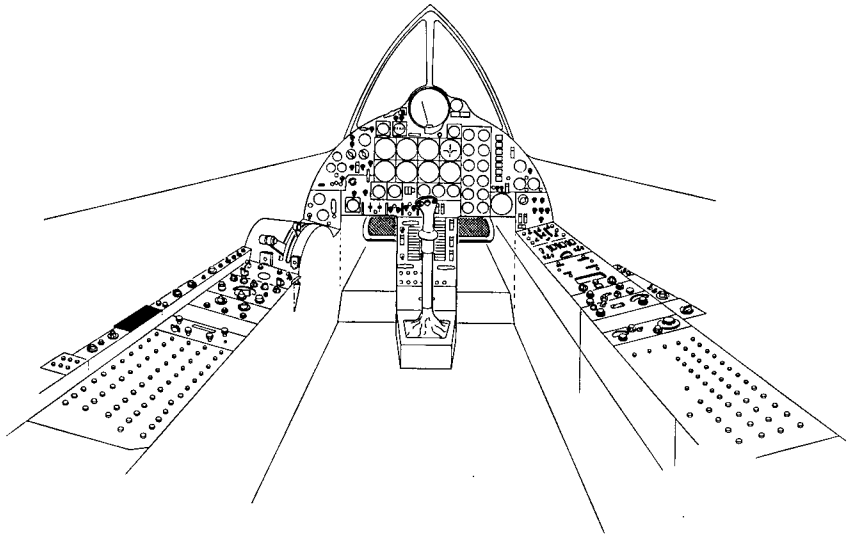
Mode Switches

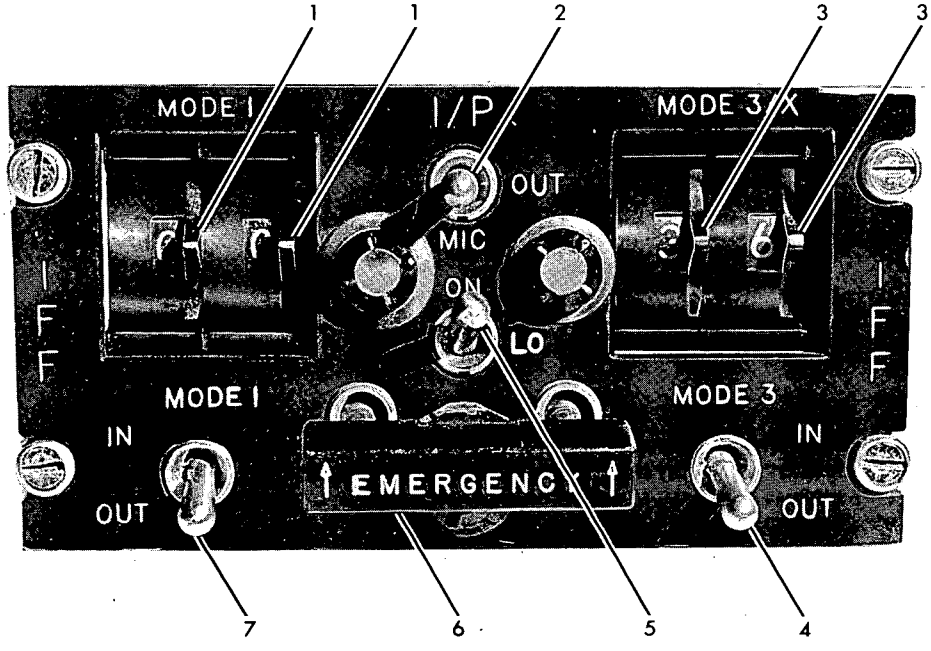
Two two-position mode switches, one for Mode 1 and one for Mode 3, control transmission of Mode 1 and Mode 3 replies. Correctly coded interrogations will be answered when a mode has been made active by selecting the IN position. When a Mode 1 or Mode 3 switch is in the OUT position, that mode is not active and does not transmit upon interrogation except in Emergency. Mode X is active at all times when the power switch is in the ON or LO position and is not affected by the Mode 1 or Mode 3 toggle switch positions.

Code Selectors

Two rotating type code selectors are provided. The code selector for Mode 1, consists of two rotary digital indicating switches. The first digit window will indicate 0, 1, 2, 3, 4, 5, 6, or 7. The second digit window will indicate 0, 1, 2, or 3. The Mode 3/X code selector will indicate 0, 1, 2, 3, 4, 5, 6, or 7 for each digital window. The mode 3 code selection also controls the Mode X code transmission.

IFF/SIF CONTROL PANEL





1 MODE 1 CODE SELECTORS
2 IDENTIFICATION OF POSITION (I/P) SWITCH
3 MODE 3/X CODE SELECTORS
4 MODE 3 SWITCH
5 IFF POWER SWITCH
6 EMERGENCY SWITCH BAR
7 MODE 1 SWITCH

REV 2-19-65
FMA12-32(b)

Figure 4-6

Emergency Switch Bar

The emergency switch bar, when placed in the EMERGENCY up position, operates two toggle switches that controls emergency response and also pushes the IFF power switch to the ON position if it is in the off or LO position. When the emergency bar is in the up position an emergency indicating pulse group (code 7700) is transmitted on Mode X each time an interrogation is made on Mode X. Mode 1 and 3 are also turned on by the emergency bar irrespective of the position of the Mode 1 and 3 In-Out switches. In the EMERGENCY position Mode 1 will respond on the code selected but Mode 3 will respond on code 7700 irrespective of code selected.

NOTE

The ground radar scope indication from this transponder is coded in a different manner than the normal AN/APX-46 transponder.

Identification of Position Switch

The identification-of-position (I/P) switch is used to control transmission of I/P pulse groups. The switch has three positions; MIC, OUT and a spring-loaded I/P position. When the switch is momentarily in the I/P position, the I/P timer is energized for 30 seconds. If an interrogation is recognized on any active mode within this 30 second period, I/P replies will be made. When the switch is in the OUT position, transmission of the I/P pulse groups is withheld. The MIC position is inoperative.

OPERATION OF THE IFF SYSTEM

1. Power switch - ON or LO.
2. Emergency bar - Down.
3. Mode 1 and Mode 3 IN-OUT switches - As required.

NOTE

Mode X operation is continuous when the power switch is in the LO or ON position. For secure IFF operation, both the Mode 1 and Mode 3 toggle switches must be in the OUT position.

4. I/P switch - As required.
5. Code selectors - As required.

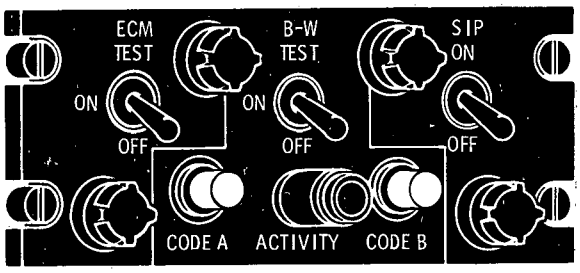
To make an emergency response to Mode 1, Mode 3 and Mode X interrogations:

6. Emergency bar - Push up.

BIRDWATCHER EQUIPMENT

Birdwatcher (BW) is an automatically operating aircraft monitoring system with data link from the aircraft to ground stations by means of HF radio transmissions. The BW senses each of 40 items. If the condition of any of these items becomes abnormal with respect to preset limits (figure 4-7) it causes the 618T HF radio to transmit one set of coded signals on the frequency in effect at that time. The coded signals are not repeated until another abnormality occurs or unless the first condition is corrected and becomes abnormal again. The coded signals consist of three consecutive 1/2 seconds bursts, each separated by a five second quiet period. Each transmission includes an aircraft identification code and the status of all items sensed. The signal bursts are normally transmitted regardless of the microphone switch, communications selector switch, or radio control panel settings if the HF radio is on. The BW signal can be heard by the pilot as a chirp or noise burst in his headset. The pilots HF voice communi-

BIRDWATCHER



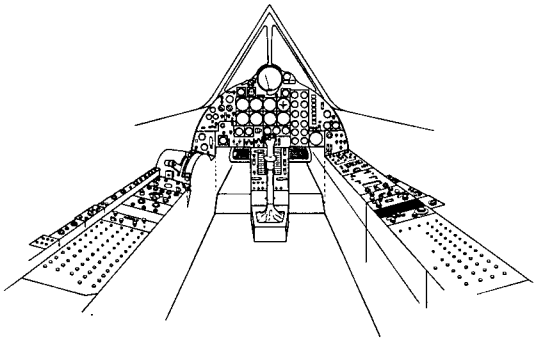


Figure 4-7

F200-48(b)

	Items monitored by B-W	Level at which system transmits
1	Both generators out	AC power to both busses off
2	Both TR out	
3	Altitude low	Less than 70000 ± 1500 feet
4	Fuel quantity low	Below 3000 to 6000 pounds (tank 1 & 4)
5	Destruct system activated	Arm & destruct switches on
6	L fuel flow low	Less than 7500 pph
7	R fuel flow low	Less than 7500 pph
8	L hyd pressure low	1700 psi .5 sec delay
9	R hyd pressure low	1700 psi .5 sec delay
10	System B & H active	
11	A hyd press low	2200 psi +0 -150 zero time delay or less than 1 gal.
12	B hyd press low	2200 psi zero time delay
13	Both LOX systems low	Less than 50 psi or 1 liter
14	System A active	
15	L CIT temp high	Greater than 440°C ± 5°C.
16	R CIT temp high	Greater than 440°C ± 5°C
17		
18	System B active	
19		
20	Excessive pitch acceleration	± 6g
21	Excessive yaw acceleration	± 2g
22	Cockpit pressure	Greater than 30,200 ± 1100 feet
23	Seat ejected	
24	Code A	
25	Code B	
26	Excessive nose up angle of attack	More than 14° nose up
27	L nacelle fire warning	1050 ± 50°F
28	R nacelle fire warning	1050 ± 50°F
29	System C active	
30	System F active	
31		
32		
33		
34	R EGT high - Derich on	860 ± 5°C
35		
36	L EGT high - Derich on	860 ± 5°C
38, 39, 40	Aircraft identification	

Figure 4-7

cation capability is cut off for the 1/2-second transmission periods, but BW normally does not otherwise interfere with any pilot communication capabilities on HF or UHF channels or on tanker intercom. The BW system operation requires that the HF radio be operating. Power for the BW equipment is furnished by the essential dc bus.

Birdwatcher Control Panel

The BW control panel is located on the right console immediately ahead of the circuit breaker panel. Controls consist of a power ON-OFF-ECM TEST toggle switch, Code A and Code B pushbutton switches and an activity light. The power switch turns on or deactivates the BW equipment. With BW power ON, placing the switch in the ECM TEST position should produce a signal code burst in the pilots headset, but it will not result in a signal transmission. Operation of the A or B pushbutton transmits a distinctly coded signal. By convention, transmission of the "A" signal indicates that the pilot is aware that the condition of a monitored item is or has been abnormal, but that there is no emergency. Also by convention, transmission of a "B" signal confirms the pilots awareness of an abnormal or emergency situation. Other conventions may be substituted.

AN/AIC -18 INTERPHONE

An AN/AIC-18 interphone control panel is located behind the pilot's seat. The panel contains a Call knob, Normal-Aux-Listen switch and a Volume control knob. Due to the location of the panel, the volume control must be preset prior to flight. No On-Off switch is provided and the equipment is operative whenever the essential dc bus is energized.

Call Knob

The call knob is inoperative.

Normal-Aux-Listen Switch

The Normal-Aux-Listen switch has two positions; NORMAL and AUX LISTEN. The NORMAL position allows all audio signals to pass through the AN/AIC-18 amplifier. The volume control knob on the AN/AIC-18 panel is used to adjust the audio signal intensity. The AUX LISTEN position bypasses the amplifier and audio intensity must be adjusted with the individual equipment volume control. The switch is safety-wired to the NORMAL position.

Microphone Switch

A transmitter-interphone mircophone switch is installed on the control stick. The momentary TRANS position (up) is used for UHF, or HF depending on the position of the microphone selector switch on the left console. The INPH position (down) provides interphone operation for communication with the ground crew and A/R interphone during refueling contact. This position is also used to activate the dictet recorder for pilot comments if recorder switch is in RECORD position.

Throttle Microphone Button

A microphone button is provided on the right throttle for use during taxi, takeoff and landing when the nose steering must be held engaged. This is a pushbutton switch which must be held down for radio transmission.

Communication Selector Switch

A three position rotary switch labeled COMM located on the left console selects the radio or interphone to which the microphone output will be connected. In the HF position the microphone output will be connected to the 618T HF radio. This position also automatically provides ARC 50 ac inverter power to the HF when the left generator is below correct frequency. In the UHF (center) position the microphone output is connected to the ARC 50 UHF radio. The right position labeled SIL disconnects the microphone from all transmitters to prevent inadvertent transmissions. The microphone connection to the interphone system and to the tanker is through the refueling probe and is accomplished by using the normal INTPH position.

IFR Volume Control

The IFR volume control is located on the upper left console and when turned clockwise increases the interphone audio volume.

LIGHTING EQUIPMENT

EXTERIOR LIGHTING

Beacon and Fuselage Lights

Two retractable lights are located near the midpoint of the fuselage. One is on the top of the fuselage and the other on the bottom. When the lights are retracted they are flush with the fuselage contour and when turned on will show a white light from above and below. The lights will extend approximately two inches and, when in this position and turned on, the red lights and reflectors rotate at 45 rpm, giving the effect of 90 flashes per minute. The lights are powered by the essential dc bus and the rotating and retracting mechanism is powered by the No. 1 inverter.

Beacon and Fuselage Light Switch

This three position switch is located at the forward end of the upper left console. In the center OFF position the lights are retracted and turned off. In the BCN LTS (forward) position the lights extend, illuminate and rotate. Extension and retraction time is approximately 30 seconds. In the FUS LTS (aft) position the white lights illuminate in the retracted position.

Landing and Taxi Lights

A 1000 watt landing light and a 450 watt taxi light are mounted on either side of the nose gear strut. Power for the lights is furnished by the left generator bus.

Landing and Taxi Light Switch

A luminous (3 dot) switch located on the left side of the instrument panel operates the landing and taxi lights. The switch has three positions; LAND (up), TAXI LT (down) and OFF (center).

INTERIOR LIGHTING

Cockpit Lighting System

The instruments and consoles are illuminated with edge and post lighting. In addition, two flood lights are provided on each side of the cockpit and a utility spotlight is mounted above each console. The spotlights are detachable and may be moved about the cockpit. Rheostats on the aft end of the spotlights are used to vary their intensity. Each spotlight is provided with a pushbutton switch which enables the pilot to obtain maximum brillance without use of the rheostat. Red or white light may be selected by rotating the lens color selectors on the front of the lights. Power for the instrument and console lights is furnished by the left generator bus. Power for the floodlights and utility spotlights is furnished by the essential dc bus.

Cockpit Light Switches

Rheostat type instrument and panel light switches are located on the cockpit left console. Ten rotary positions are available to vary light intensities from OFF to BRT. The floodlight switch located on the outboard side of the right console varies the intensity of both lights from OFF to BRT.

FLIGHT RECORDER

An automatic, continuously operating flight recorder is normally mounted in the right chine of the aircraft to record airspeed, altitude, vertical acceleration, heading and elapsed time on an aluminum foil tape. The recorder has its own pitot static system which may also be used as an alternate for the normal pitot-static system. Heading information for the recorder is furnished by the FRS compass system. Ac electrical power from the No. 3 inverter is used to keep a spring motor wound so that all in-

FLIGHT RECORDERS

To be furnished when available

Figure 4-8

FLIGHT RECORDERS

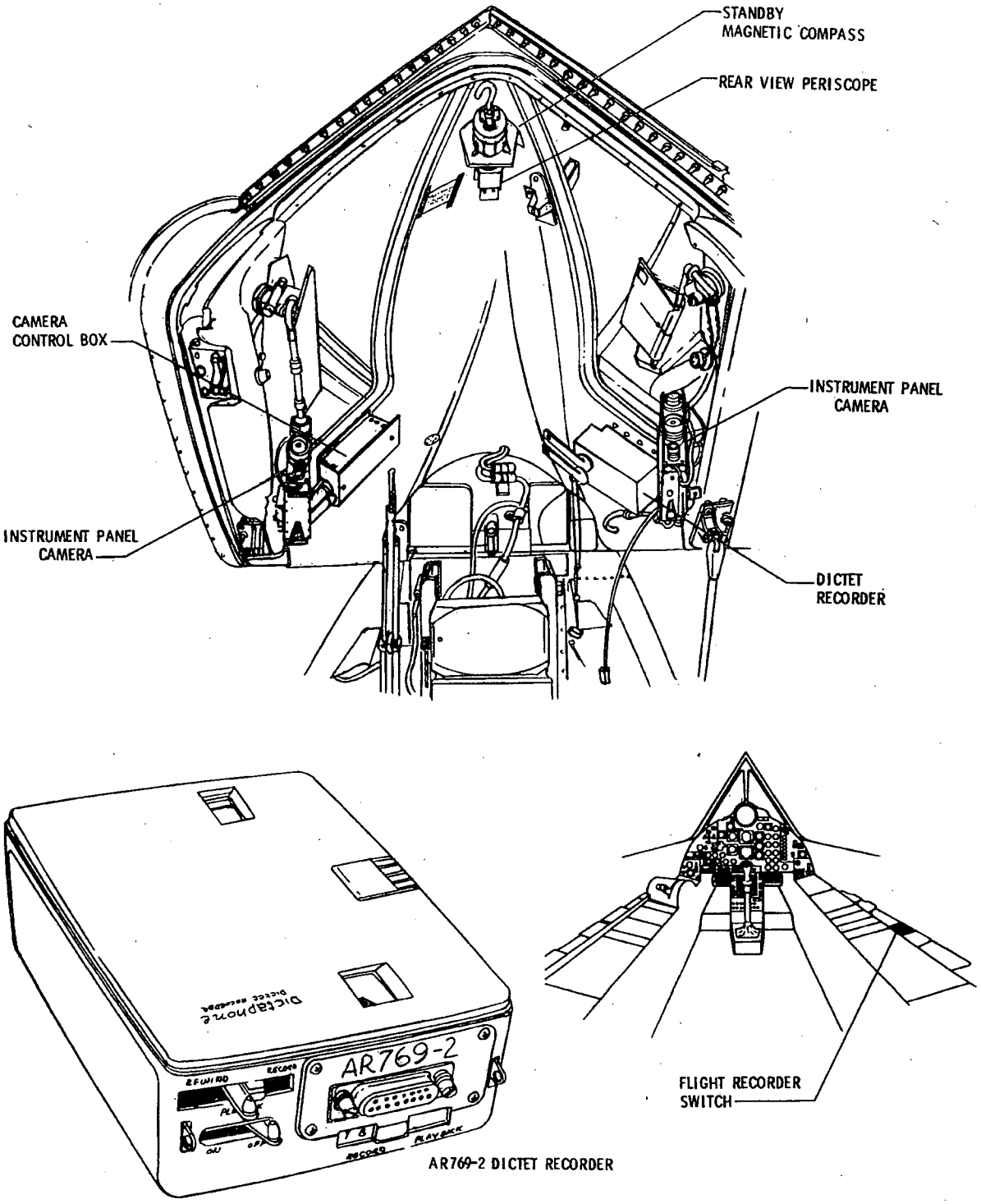


Figure 4-7

formation except heading will be recorded for approximately 10 minutes after electrical power is interrupted. The recorder pitot static system remains available as an alternate airspeed system when the recorder is not installed.

Flight Recorder Switch

This toggle switch is located outboard of the right console and has labeled positions ON and OFF.

Pitot Pressure Selector Lever

This lever is located on the forward right side of the cockpit wall. It is normally safety-wired in the NORMAL position. In the event of a malfunction of the normal pitot static position system, the lever may be moved to the ALT position. This furnishes pitot static pressure from the flight recorder system to the aircraft flight instruments and ejection seat speed sensor.

DICTET TAPE RECORDER

The Dictet Tape Recorder is located on the left side of the canopy. It has two levers; one labeled REWIND, RECORD and PLAYBACK and one labeled ON and OFF. It is preset prior to flight and is activated by the interphone switch. The tape is in motion only when the interphone switch is used and provides up to two hours of recording time.

AUTOPILOT SYSTEM

The autopilot portion of the AFCS relieves the pilot from manual aircraft control and provides a means for automatic navigation when coupled to the output of the INS. The autopilot functions are:

1. Pre-engage synchronization.
2. Attitude hold in roll and pitch.
3. Pitch and turn wheel inputs.
4. Automatic pitch trim.
5. Heading hold.
6. Mach or KEAS hold.
7. Auto navigation.

The autopilot is optimized for basic mission cruise speed and altitude but may be used at other flight conditions.

There are no restrictions on use of the roll autopilot. The autopilot authority is limited to prevent severe maneuvers due to an autopilot malfunction. The maximum pitch authority below 50,000 feet is 1.3° up and down elevon. Above 50,000 feet the maximum authority is 2.4° up and down elevon. The maximum roll authority is 4° differential elevon. The autopilot signals are summed with SAS signals and produce control surface motion through the SAS electronics and servos.

CAUTION

Do not use the autopilot when using BUPD.

Autopilot control movement of the elevons is not reflected in control stick motion. Automatic pitch trim is operative when the autopilot pitch channel is engaged. The slow speed pitch trim motor operates to correct for long period pitch trim changes and there should be no pitch transient at disengagement. Preengage synchronization of autopilot pitch and roll trim operates when the pitch or roll channels are disengaged.

Autopilot and Attitude Reference Selector Switch

This selector switch is located on the right console outboard of the INS control panel. The switch has three positions; FRS (forward), OFF (center) and INS (aft). In the FRS position directional signals from the FRS compass and attitude signals from the FRS pitch and roll gyros are supplied to both the autopilot and the attitude indicator. In the OFF position the autopilot can not be engaged but pitch and roll signals from the FRS are furnished the attitude indicator. In the INS position the INS stable platform furnishes pitch and roll signals to both the autopilot and the attitude indicator and true heading directional signals are furnished to the autopilot. In the OFF and FRS positions inverter power for autopilot, air data computer, and TDI indicator is furnished by the No. 1 inverter bus. In the INS position inverter power for these items is transferred to the No. 3 inverter bus. This switching provides the same phase of power for the autopilot and the air data computer as that provided for the FRS or INS.

CAUTION

Avoid excessive switching between FRS and INS positions as the resulting power transients tend to degrade INS accuracy.

AUTOPILOT CONTROLS AND INDICATORS

The autopilot controls and indicators are on the SAS panel located on the right console. The control stick is equipped with control stick command and emergency disengage switches. The circuit breakers are on the right and center console circuit breaker panels. Power is from the essential dc bus and the No. 3 or No. 1 inverter.

Autopilot Pitch Engage Switch

A two-position pitch engage switch is located on the inboard side of the autopilot control panel. In the ON (fwd) position, the pitch autopilot is engaged in the attitude hold mode.

NOTE

At least one active SAS pitch channel must be engaged and bank angle must be less than 50° before the pitch autopilot can be engaged.

The switch is held in the ON position by a solenoid. The pitch channel may be disengaged by placing the switch to the OFF position, by using the disengage switch on the control stick, or by turning the autopilot selector switch OFF.

Autopilot Pitch Trim Synchronization Indicator

The pitch trim synchronization indicator shows the amount of pitch signal existing prior to engagement. An up or down displacement of the needle indicates the direction of the transient which will occur when the pitch channel is engaged.

NOTE

The pitch trim synchronization needle will normally be centered within one needle width. Engagement of the autopilot pitch channel with more than one needle width of misalignment is not recommended.

Autopilot Pitch Control Wheel

A serrated pitch control wheel is located just forward of the pitch engage switch. The wheel is used to make pitch attitude corrections when engaged in the attitude hold mode. Forward rotation of the wheel commands nose down and aft rotation commands nose up. Pitch attitude changes 1° for 20° of wheel rotation.

Autopilot Roll Engage Switch

A two-position roll engage switch is located on the autopilot panel. In the ON (fwd) position, the roll autopilot is engaged in the attitude hold mode.

NOTE

At least one SAS roll channel and one active SAS yaw channel must be engaged before the roll autopilot can be engaged. Bank angle must be less than 50°.

The switch is held in the ON position by a solenoid. Autopilot signals are supplied by either the FRS or the INS, depending on the position of the autopilot selector switch. The roll channel may be disengaged by placing the switch to the OFF position, by using the disengage switch on the control stick or by turning the autopilot selector switch OFF.

Autopilot Roll Trim Synchronization Indicator

The roll trim synchronization indicator shows whether or not a roll signal exists prior to engagement. The needle always deflects to the right and does not indicate the direction of the transient which will occur at engagement.

NOTE

Roll engagement is not recommended if the needle is deflected to the side of the dial, indicating a hardover signal.

Autopilot Turn Control Wheel

A serrated turn control wheel is located on the autopilot panel. It allows the pilot to make roll attitude corrections when engaged in the attitude hold mode. Right rotation of the wheel commands right roll and left rotation commands left roll. Roll attitude changes 1° for 10° of wheel rotation. The pilot can command up to 50° of bank angle in the attitude hold mode. Above 50° of bank the roll autopilot automatically disengages to prevent the steady pitch rate from bottoming the pitch servos, as this would eliminate pitch damping capability.

Mach/KEAS Hold Switch

A Mach/KEAS hold switch is located on the inboard side of the autopilot panel. The Mach or KEAS hold mode is engaged when the switch is in the respective position, provided the pitch autopilot is engaged. The switch is held in by solenoid action. The autopilot then controls the pitch attitude to maintain the same Mach number or KEAS that existed at the time of engagement. When the Mach or KEAS hold is engaged, the pitch attitude hold is discontinued and the pitch control wheel setting should not be changed. Mach hold reference signals are supplied to the autopilot from the air data computer.

CAUTION

Do not use the Mach/KEAS hold mode when the TDI indication is known or suspected to be inaccurate.

Auto Nav Switch

An AUTO NAV switch is located between the Mach/KEAS hold and heading hold switches. The auto nav mode is engaged when the switch is in the ON position provided the

roll autopilot is engaged. The switch is held on by solenoid action. Steering signals are furnished by the INS and the autopilot controls the aircraft to follow the selected great circle course. If the heading hold mode was previously engaged, it will be disengaged when auto nav is selected. The bank angle is limited to 30° in the auto nav mode.

Heading Hold Switch

A heading hold switch is located on the outboard side of the autopilot panel. The heading hold mode is engaged when the switch is in the ON position provided the roll autopilot is engaged. The switch is held on by solenoid action. Heading signals from either the FRS compass or INS control the roll axis of the aircraft to maintain the heading existing at the time of engagement. Heading hold may be engaged while in a bank. The autopilot will roll the aircraft to a wings level attitude and lock on the heading at time of engagement. The heading hold and auto nav switches are interlocked to permit only one to be engaged at a time. The auto nav switch will be released when the heading hold switch is on.

NOTE

When in heading hold mode the drift rate is similar to a free gyro rate and will be approximately 8° per hour increasing to 15° per hour in polar areas.

Control Stick Command Switch (CSC)

A control stick command switch is located on the right side of the control stick. While the switch is depressed, both the roll and pitch autopilots revert to the preengage synchronization mode. This allows attitude and heading to be changed without opposition from the autopilot. When the switch is released, both the roll and pitch axes are engaged in the attitude hold mode, regardless of the mode that was engaged prior to depressing the CSC switch.

Autopilot Emergency Disengage Switch

A trigger-type switch located on the forward side of the control stick will disengage the autopilot completely. The autopilot is not reengaged when the switch is released.

NORMAL OPERATION

Engagement

The autopilot is placed in normal operation as follows:

1. Check SAS engaged, recycle lights out.
2. Check pitch and roll trim preengage synchronization indicators aligned.
3. Pitch and roll engage switches ON. These switches may be engaged together or separately as operation of the two is completely independent.

NOTE

Bank angle must be less than 50°.

4. Mach/KEAS hold switch - OFF.
5. Heading hold - As desired.

If Auto Nav is required:

6. Autopilot selector switch - INS.
7. Auto Nav switch - ON.

WARNING

Do not operate manual roll or pitch trim when the autopilot is engaged.

Disengagement

To change attitude or heading:

1. CSC switch - Depress.

After attitude and/or heading change:

2. CSC switch - Release.
3. Mach/KEAS hold switch - OFF.
4. Autopilot selector switch - As desired.
5. Heading hold or auto nav - As desired.

To disengage autopilot:

1. Autopilot disengage switch - Press.

or

2. Pitch and roll engage switches - OFF.

or

3. Autopilot selector switch - OFF.

Mach/KEAS Hold Engagement

Prior to engagement of Mach/KEAS hold the pilot will accomplish the following:

1. Attain desired KEAS, altitude and Mach number.
2. Throttle - As required.
3. Trim - As required.
4. Autopilot pitch - ON.
5. Maintain stabilized KEAS or Mach conditions for 60 seconds.

NOTE

Do not engage Mach/KEAS hold during turns or other maneuvers as undesirable transient will be produced. Mach/KEAS hold may however be left engaged during turns if already on.

6. Mach/KEAS hold switch - ON as desired.

CAUTION

The pitch control wheel must not be used during Mach/KEAS hold operation to prevent rapid pitch motion or disengagement.

To minimize altitude excursions during turns:

7. Throttle - Gradually advance during roll in.
8. Throttle - Gradually retard during roll out.

If changing flight conditions, retrim when power settings are changed more than 5%:

9. Mach hold - OFF.

NAVIGATION EQUIPMENT

FLIGHT REFERENCE SYSTEM

The Flight Reference System and SR-3 compass is a navigation system which supplies information for indication and control of aircraft heading and attitude. It can be used independently of the Inertial Navigation System. The FRS consists of a flight reference platform, turn rate servo, induction compass transmitter, heading and attitude couplers for the autopilot, control panel, and the rotating compass cards of the BDHI. Either a directional gyro (DG) or magnetic slaved (MAG) mode can be selected to provide directional reference to all latitudes. In either mode:

Heading information is furnished -

(1) To the autopilot when the autopilot selector switch is in the FRS position.

(2) To the BDHI compass card when the autopilot selector switch is in the FRS position.

Attitude information is furnished -

(1) To the autopilot when the autopilot selector switch is in the FRS position.

(2) To the attitude indicator when the autopilot selector switch is in the FRS position.

Directional Gyro Operating Mode

When in the directional gyro mode of operation, the FRS is free of magnetic influence and operates as a directional gyro, indicating heading relative to an arbitrary reference heading selected by the pilot. It may be used at all latitudes, but is most useful when the magnetic field is weak or distorted or when navigating in the polar regions. It is more reliable than the magnetic mode at latitudes near the magnetic poles. When in the DG mode, with proper hemisphere and latitude selection made on the control panel, the gyro is made to precess to compensate for apparent gyro drift due to earth rate at the selected latitude.

Magnetic Slaved Operating Mode

When operating in the magnetic slaved mode, the FRS is basically a gyro stabilized compass slaved to the induction compass transmitter. This mode provides heading without northerly turning error or oscillations. It is less reliable than the DG mode at latitudes near the magnetic poles as the MAG mode is subject to severe magnetic distortion near those poles.

FRS COMPASS CONTROL PANELS

The COMPASS controls are located on the right console, immediately forward of the circuit breaker panel. The panel contains a function selector switch, set heading knob, latitude selector knob and indicator window, synchronization indicator, malfunction indicator, hemisphere selector switch, and a take command button.

Take Command Button

A combination button and light on the control panel provides for transfer of control of the FRS by depressing the button and observing the green light. It is not operative on this installation.

Function Selector Switch

The two position function selector switch allows selection of either a magnetic heading or a free gyro reference. The DG (right) position selects directional gyro mode; the MAG (left) position selects the magnetic slaved mode.

Hemisphere Selector Switch

The Hemisphere Selector switch must be set to correspond to the hemisphere in which the aircraft is located. The left (S) position is used when in southern latitudes. The right (N) position is selected for northern latitudes.

Latitude Selector Knob and Indicator

The latitude selector knob may be rotated to select and display latitude in degrees and tenths of degrees in the indicator window. The knob is used only in the DG mode. The latitude setting is used in the DG mode to correct the directional gyro for the apparent drift due to the earth's rotation. For accurate operation of the FRS in the DG mode, the latitude indicator must be set to coincide with the actual latitude of the aircraft at all times.

NOTE

The proper corrections will not be made if the hemisphere selector switch setting does not correspond to the hemisphere in which the aircraft is located.

Malfunction Indicator

A malfunction indicator is provided which monitors the power supply and other prime system functions. Any deviation of the monitored functions from normal operation will cause the indicator to display three white triangles.

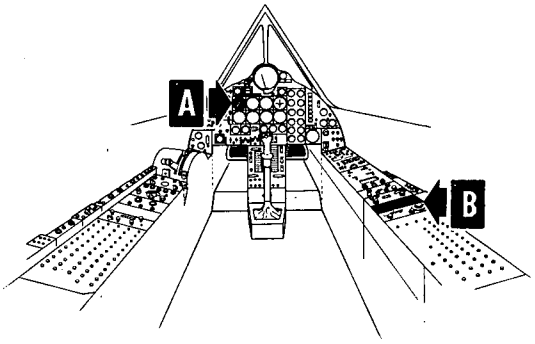
Heading Set Knob and Synchronization Indicator

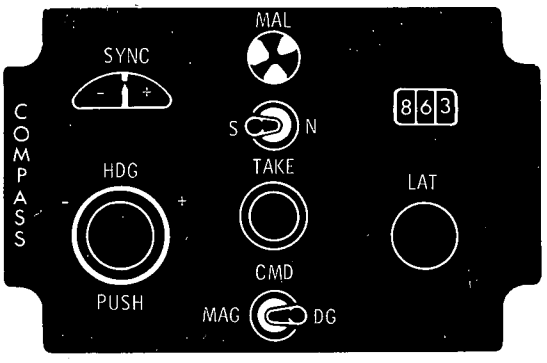
The heading set knob provides a means to fast slave or synchronize the rotating compass card of the BDHI to the correct magnetic heading or desired gyro heading, depending on the position of the function selector switch. When in the MAG mode, initial synchronization with the compass transmitter heading is obtained by pushing and holding the heading set knob until the synchronization indicator becomes centered. In the DG mode, the heading is set to the desired initial indication by pushing and turning the heading set knob. Turning the heading set knob clockwise produces an increasing heading, with the rate of change being indicated by the deflection angle of the synchronization indicator.

FRS OPERATION

1. Function selector switch - MAG or DG, as desired.
2. Hemisphere selector switch - Set to correspond with aircraft location in Northern (N) or Southern (S) hemisphere.
3. Latitude selector knob - Set to correspond with existing latitude when DG mode selected.
4. Heading set knob - Synchronize or slave to heading desired.
5. Autopilot selector switch - FRS.

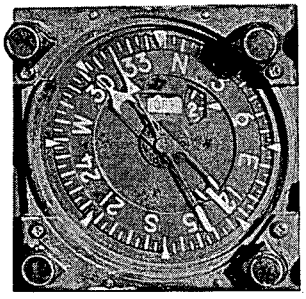
FLIGHT REFERENCE SYSTEM (FRS) COMPASS PANEL AND BDHI





DETAIL B

FLIGHT REFERENCE SYSTEM CONTROL PANEL



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DETAIL A

BEARING DISTANCE HEADING INDICATOR (BDHI)

F200-65(b)

Figure 4-9

Slaving

The normal slaving rate of the FRS is about 1-1/2° per minute. The gyro may be as much as 180° from the proper heading when the compass system is energized before takeoff, and as much as 1-1/2 hours would be required to slave to the correct heading at normal slaving rates. Manual fast slaving is provided by pushing and holding the heading set knob depressed. This increases the slaving rate to 720° per minute and will correct a 180° error in 15 seconds.

If the compass is properly slaved before takeoff, no in-flight manual fast slaving is required unless free directional gyro operation is selected. When operating in the free gyro mode, the desired heading can be established by using the heading set switch.

CAUTION

The roll autopilot must be disengaged before attempting manual slaving when the FRS is being used as a heading reference.

FRS OPERATING CHARACTERISTICS

The SR-3 flight reference platform consists of a single axis directional gyro which is attitude stabilized by a two axis vertical gyro. A compass transmitter is provided which establishes the directional reference while in level flight by detecting aircraft heading with respect to the horizontal component of the earth's magnetic field. When the system is operated in the magnetic mode, the directional gyro is slaved to the compass transmitter at a rate of 1-1/2 degrees/minute. When operating in the directional gyro (DG) mode, the compass transmitter signal is disabled and the heading reference is established by the directional gyro operating as a free gyro (except for earth's rate latitude correction). Electrolytic gravity sensors are used in conjunction with pitch and roll torquer motors to erect the attitude gyro to the local vertical. During periods of acceleration or deceleration along the flight path, heading and pitch attitude errors can be introduced due to the following effects:

a. The pendulously supported compass transmitter is displaced from the horizontal plane and becomes sensitive to the vertical component of the earth's magnetic field. This results in an erroneous heading reference. The magnitude of this error is a function of aircraft heading, transmitter tilt angle and the relative magnitude of the vertical field component. This error is introduced into the system at the normal slaving rate of 1-1/2 degrees/minute.

b. The pitch erection sensor, which is acceleration sensitive, provides an output signal to the pitch torquer causing it to precess the attitude gyro to a false vertical at a normal rate of 4 to 5 degrees/minute.

In order to minimize the above deficiencies, an electrolytic fore or aft acceleration cutout sensor (similar to the pitch erection sensor) is provided on the pitch gimbal of the attitude gyro. This sensor disables the pitch erection and slaving circuits when a threshold setting of .065 g along its sensitive axis is exceeded. However, operating as a free vertical gyro, it is subject to an apparent drift from the vertical due to the effect of the earth's profile and earth's rotation. These effects, coupled with the gyro free drift rate of 15 degrees/hr, results in a total drift from the vertical of about 1 degree/min. This displacement of the attitude gyro causes a gravity component to appear along the sensitive axis which acts as a bias to the horizontal acceleration signal (.065 g) which initiates slaving and pitch erection cutout. When the

bias signal acts in opposition to the sensed acceleration signal the effective value may drop below the .065 g threshold, thereby restoring pitch erection and slaving while the aircraft is still accelerating. The attitude gyro will then erect to a false vertical at the normal erection rate and the compass transmitter will precess the directional gyro to a false heading as determined by the transmitter tilt angle. When the attitude gyro drift exceeds 3-1/2 degrees, and the bias signal acts to aid the sensed acceleration signal; the system will maintain the cutout condition for an indefinite period after aircraft acceleration has ceased. In order to prevent this condition, the system is designed to limit pitch erection cutout to a maximum period of 4 minutes independent of acceleration.

In operational use the SR-3 system performs in the manner described above during periods of prolonged acceleration such as during acceleration-climb to supersonic cruise speed after takeoff and after refueling.

During climbout, pitch attitude and heading errors increase to about 6 degrees and 8 degrees respectively. These errors are eliminated at the normal rates when aircraft acceleration ceases. The heading error can be washed out very rapidly by pushing and holding the heading set knob on the FRS control panel until the synchronization indicator becomes centered. During aircraft turns in excess of 5 degrees/min the system operates as designed to cutout roll erection and slaving. Whenever a turn is initiated immediately following climbout, the accumulated climbout heading error will be increased and be maintained throughout the turn.

INERTIAL NAVIGATION SYSTEM (INS)

The inertial navigation system is self-contained and operates in all modes without the use of electromagnetic radiation or external references. The system consists of a gyro-stabilized platform, platform electronics, coupler and power supply, repeater and converter assembly, digital computer and computer power supply, control panels, and distance-to-go, groundspeed, and a direction indicator.

In operation the system displays present position, ground speed and the direction and distance to go to any of 42 preselected positions as continuous readouts. When operated in autopilot AUTO NAV, and INS STORED AUTO mode, the aircraft will be steered automatically to each point in the flight plan sequentially, with no pilot action required. If the flight plan is being flown in sequence in the STORED AUTO mode, the destination select light will illuminate if the destination displayed on the destination select panel does not agree with the destination towards which the aircraft is flying. This light is extinguished when the pilot sets the selector panel to the number of the stored destination being approached.

The destination select panel provides selection of destination numbered 0 through 41. The first 27 preselected positions are assigned to preplanned mission destinations, fix points, targets, rendezvous points, or other points occurring sequentially during the mission. The computer computes and stores the great-circle courses between each pair of these numerical points, and the aircraft will adhere to these great circle courses. Turns from one course to another will be made with bank angle optimized (with a maximum bank of 30 degrees) for the groundspeed and heading change required. The number 2 pointer of the BDHI will point toward the optimum path to follow to place the aircraft on the next course. If the pilot switches to a subsequent destination in STORED MANUAL

before completing the route segment he is on, the turn will be made in accordance with computer program directions.

Positions 27 to 41 provide ADF type steering for courses to these points and not meant to be used in the STORED AUTO mode. These positions are available for alternate destinations or may be used to employ an alternate flight path to a position included in the first 27. A sufficient number of alternate destinations is available to provide adequate coverage throughout the mission. Duplication of any of the first 27 positions in this group provides a steering indication on the BDHI number 2 pointer resembling that of ADF navigation, i. e., the pointer points directly to the next destination (within a 45 degrees needle deflection).

The basic reference of the inertial navigation system is provided by three single-axis accelerometers mounted at right angles to each other on a gyro-stabilized platform. The platform employs three floated integrating gyros, also mounted at right angles. The platform is initially aligned with a coordinate reference frame, represented by a plane tangent to the surface of the earth and oriented to any convenient azimuth at the point origin. The platform stable element is isolated from the airframe through a system of three gimbals which provide 360 degrees freedom of rotation in yaw and roll, and pitch angles of $\pm$ 60 degrees. All platform outputs are changed to digital form before entering the computer. In normal operation the platform also provides attitude outputs in analog form through resolvers and synchros to the autopilot, and the attitude indicator. Conversion of present position to latitude and longitude readout is accomplished continuously by the digital computer when in operational mode. Cooling air, necessary to the system, is supplied by the aircraft airconditioning and pressurization system. A self-contained heating system is incorporated in the platform to ensure that gyros and precision sensing components are maintained at temperature within an optimum operating range. The system is powered by the No. 3 inverter, the LH generator, and the monitored dc bus.

NOTE

Accuracy of INS information will be slightly degraded if pressure altitude data supplied by the air data computer is lost or is inaccurate.

The INS is controlled from two control panels, the navigation panel and the destination select panel. (See figure 4-10).

NAVIGATION PANEL

The navigation control panel, located on the right console, consists of a DEST/FIX selector switch, STORE pushbutton, MODE selector switch, FIX ADJ knob, two sets of geographic coordinate digital readout windows, labeled PRESENT POSITION and DESTINATION/FIX POSITION, a VARIABLE INPUT indicator labeled LAT and LONG, with thumbwheels for manual insertion of geographic coordinates and a switch for selection of N or S latitude. The controls and indicators are as follows:

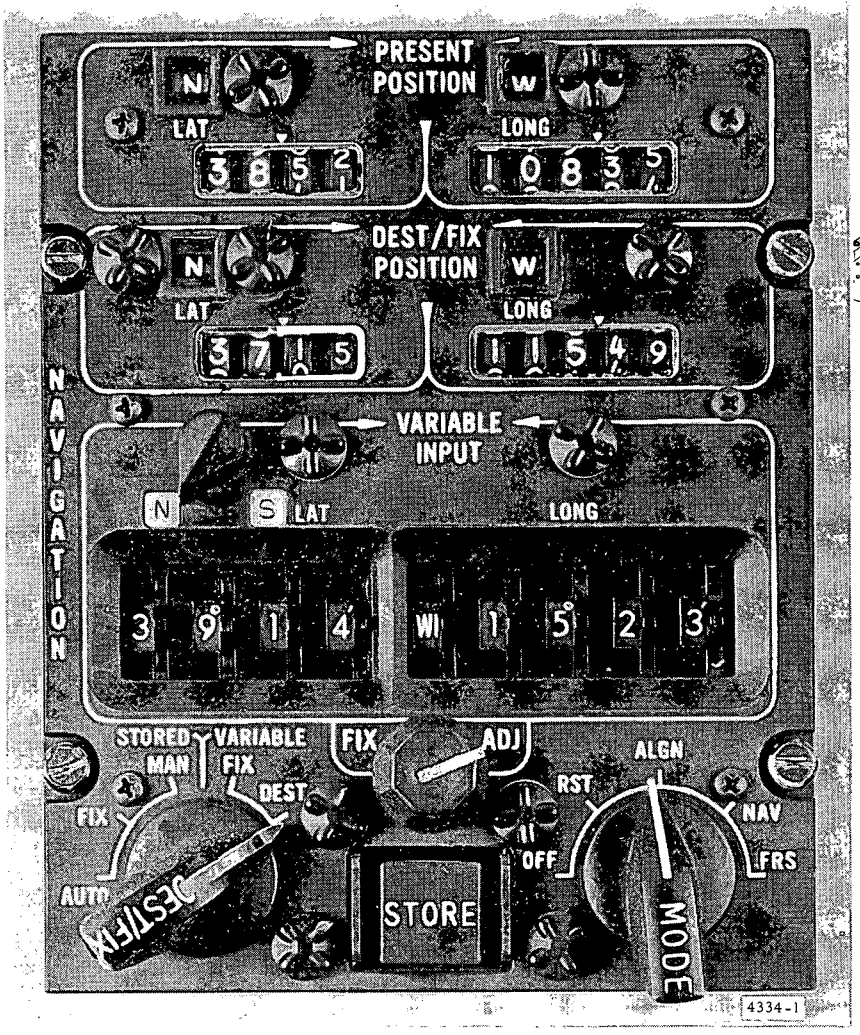
Mode Selector Switch

The mode switch is a rotary selector switch with five positions, labeled as follows: OFF, RST, ALGN, NAV, and FRS.

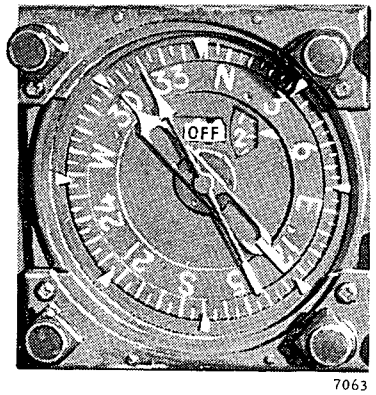
NOTE

During flight the MODE switch must not be switched to any position other than NAV or FRS, otherwise the INS will be deactivated and will not function until the switch is moved through OFF, RST, and ALGN positions in conjunction with the ground operating equipment and normal INS preflight procedure.

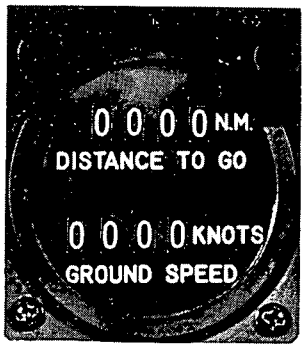
INS PANEL AND INDICATORS



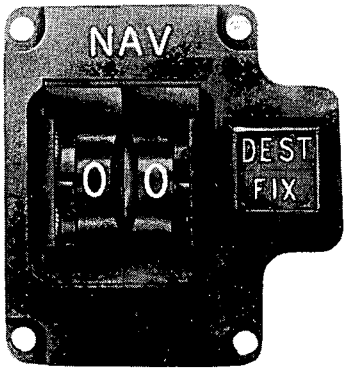
NAVIGATION CONTROL PANEL
(RIGHT CONSOLE)



BEARING DISTANCE HEADING INDICATOR (BDHI)



DISTANCE TO GO/GROUND SPEED INDICATOR



DESTINATION SELECT PANEL

F200-34(f)

Figure 4-10

CAUTION

Do not move the MODE selector switch from the OFF position in flight if the INS has not been cycled from OFF to the NAV mode prior to flight. The INS system will be damaged.

RST Mode

The RST (reset) mode is used only on the ground during INS preflight when the platform has reached operating temperature. It permits the ground operating equipment (GOE) operator to check correct power switchover from ground to aircraft power, start the gyro spin motors, and make the computer ready for use.

ALGN Mode

The INS must be completely warmed up, stabilized, and aligned to a coordinate reference frame before it can be operated. This is necessary to minimize the drift of the stable reference platform once it is aligned to the coordinate reference frame. The complete warmup and alignment procedure at normal ambient conditions takes about 1-1/2 hours. During this period the destination loading operation is accomplished, normally by use of a punched tape. However, the coordinates of the present location and 42 destinations or targets may be set in manually by the VARIABLE INPUT thumbwheels and N-S selector and entered into the computer memory by pushing the STORE pushbutton for each position. After a period of gyro stabilization, the platform is torqued to the coordinate reference frame and the gyros are drift-trimmed. The two transverse horizontal accelerometers are used to sense the local vertical and their outputs are used in the servo loops that torque the platform and measure the amount of gyro drift. The presence of output signals from each accelerometer indicates that the platform is not level in that axis. While level aignment of the platform is being accomplished automatically, platform azimuth is aligned with a selected reference which is transferred to the platform by the ground operator. The platform is drift-trimmed at the reference points thus established, and the drift will be reduced to certain preestablished rates before the system can be operated. There is a detent between NAV and ALGN positions and the MODE switch cannot be moved either way between these two positions unless it is depressed.

NAV Mode

Switching to the NAV mode permits the GOE to be disconnected, and places the platform in the operational mode. The gyros are essentially memory devices that memorize the coordinate frame established. The system operates using these memorized coordinates to perform the navigation problem, and the accelerometers measure translations of the platform caused by movement of the aircraft. The accelerometer outputs are integrated once to provide velocity on each axis, and a second time to establish their displacement from the point of origin. These displacements (distances flown) are translated into geographical position coordinates by the computer. In addition to indicating position coordinates to the pilot, this position is also used to torque the platform to the local vertical and azimuth as the aircraft changes position. The coordinate frame thus rotates about the earth to retain its orientation on a plane tangent to the surface of the earth at the position of the aircraft.

FRS Mode

The flight reference system is the primary backup for the INS. Normally, the INS is operated with the switch in the NAV position, but the pilot may switch to the FRS position at any time to check FRS operation. When the switch is in the NAV mode, the BDHI rotating compass card indicates INS true heading; when in the FRS mode, the card indicates magnetic heading. When the switch is moved from the NAV to the FRS mode, the INS system continues to operate normally.

WARNING

If the INS should fail, the MODE switch should be moved to the FRS mode without delay in order to retain a heading indication on the BDHI display.

DEST/FIX Switch

The DEST/FIX (destination or fix) switch is a five-position rotary selector switch with positions as follows:

STORED

AUTO, FIX, MAN

VARIABLE

FIX, DEST

STORED AUTO. The INS will automatically sequence consecutively through the 42 prestored destinations as each is reached when the switch is in the STORED AUTO position.

STORED FIX. To use a prestored destination as a fix point, the switch is set to the STORED FIX position, the destination select panel is set to the desired destination number, and the STORE pushbutton is depressed when the fix point crosses the horizontal line on the periscope screen.

STORED MAN. To select any of the 42 prestored coordinate positions as a destination, out of the automatic consecutive sequence, the switch is set to the STORED MAN (manual) position, the destination select panel is set to the desired destination number, and the STORE pushbutton is depressed.

VARIABLE FIX. To use a variable (unstored) fix point as a point of reference, the switch is set to the VARIABLE FIX position, the VARIABLE INPUT thumbwheels are set to the fixpoint coordinates, and the STORE pushbutton is depressed when the fix point crosses the horizontal line on the periscope screen.

VARIABLE DEST. To select a variable (unstored) destination, the switch is set to the VARIABLE DEST (destination) position, the VARIABLE INPUT thumbwheels and N-S selector are set to the desired coordinates, and the STORE pushbutton is depressed.

FIX ADJ Knob

The fix-adjust knob, labeled FIX ADJ, controls a flight cursor on the periscope and is used to update the INS by means of visual fixes on known coordinate points. It is not necessary to fly directly over the fix point to obtain useful data. Viewing the fix point on the screen, the pilot positions the cursor with the FIX ADJ knob to coincide with the fix point as it crosses the horizontal reference line on the display. (Refer to discussion of fix-taking for further information.)

STORE Pushbutton

The STORE pushbutton is used to store in the computer memory either selected destination information or position information which has been selected by the VARIABLE INPUT thumbwheels and N-S selector. It also initiates the computations required to navigate to the coordinates selected.

CAUTION

Do not push this button unless a course change or fix is desired.

NOTE

The DEST/FIX pushbutton on the destination select panel is identical in function to the STORE button on the navigation panel. They may be used interchangeably.

N-S Hemisphere Selector Switch

The N-S selector switch may be placed in either N or S, depending in which hemisphere the desired destination or fix is located. This selector is only used in conjunction with the variable input thumb wheels to manually insert a destination or fix point in flight.

VARIABLE INPUT Indicator

The VARIABLE INPUT indicator has thumbwheels that are used to manually insert any desired reference coordinates into the system, thus giving the pilot added flexibility of operation in flight. (It is good practice to put the DEST/FIX switch in the VARIABLE DEST or VARIABLE FIX position prior to setting the coordinates in the indicator.) To insert variable destination coordinates into the system, select VARIABLE DEST on the DEST/FIX switch, then insert the desired destination coordinates with the VARIABLE INPUT thumbwheels; select desired hemisphere with the N-S selector and depress the STORE pushbutton. The DESTINATION/FIX POSITION indicator will read out the new coordinates immediately after the STORE button is depressed, and the INS will navigate the aircraft to the new destination using ADF type steering. Variable update fix coordinates are inserted in the computer in the same way as a destination, except that VARIABLE FIX is selected on the DEST/FIX switch.

PRESENT POSITION Indicator

The PRESENT POSITION indicator is set at the geographical coordinates of the flight origin site prior to takeoff. In flight it continuously indicates the coordinates of the aircraft position as computed by the INS.

DESTINATION/FIX POSITION INDICATOR

The DESTINATION/FIX POSITION indicator normally displays the latitude and longitude coordinates of the destination to which the INS is navigating. This display may be the coordinates of any selected destination from the 42 prestored positions, or the coordinates of any selected variable destination. This coordinate display normally changes at such times as the computer calculates a new course to a newly selected destination. For STORED MANUAL or VARIABLE DEST modes, this change will occur upon depressing the DEST FIX or the STORE pushbutton. For sequential or out of sequence destination selections in STORED AUTO mode, the destination coordinate display will change coincident with roll out to the new destination course. The minutes counter portion of the latitude display may also change whenever a fix is taken. When either a STORED FIX or VARIABLE fix is taken, the calculated cor-

rection (in nautical miles) is displayed on the latitude minutes display, without changing longitude, or the degrees portion of latitude on the DESTINATION/FIX POSITION indicator. The portion of the latitude display used for the fix distance indication is blocked off in white on the indicator (see figure 4-10). The calculated fix correction is displayed up to a maximum value of 59 nautical miles whether position is updated or whether the fix is rejected. The calculated fix correction will continue to be displayed until another fix is taken, or until a new destination is selected and displayed. When a new destination is selected, the latitude minutes counters will revert to a display of destination latitude until such time as another fix is taken.

DESTINATION SELECT PANEL

The destination select panel, labeled NAV, is located on the instrument panel. The panel has a two-place digital counter, controlled by thumbwheels, and a self-illuminated pushbutton switch which read out DEST FIX when lighted. The number of a stored destination or fix (0 through 41) may be set on the counter manually and inserted into the INS computer by depressing either the DEST FIX or the STORE pushbutton.

NOTE

Positions 42 through 49 can be displayed, but are inoperative.

The DEST FIX pushbutton illuminates when the destination number on the panel and the destination approached by the aircraft are not the same. When they are again the same (thumbwheels must be rotated), the light will go out. In all modes the light will come on when pilot action is required. When the DEST/FIX switch is placed in either STORED or VARIABLE FIX, the light will come on. When the STORE pushbutton is depressed the light will go out. In any mode in which a new destination is selected by depressing the STORE pushbutton, the light will go out when the system accepts the new destination selection. When a destination inside the aircraft's minimum turn radius is selected in the STORED MAN or VARIABLE DEST mode, the DEST FIX light will blink on and off. When the aircraft's location falls outside the minimum radius path, the blinking DEST FIX light will extinguish and the destination will be accepted. In the STORED MAN mode, the light will also come on if a destination is passed over by 15 miles without selecting a new destination. (DTG 15 NM or greater and increasing).

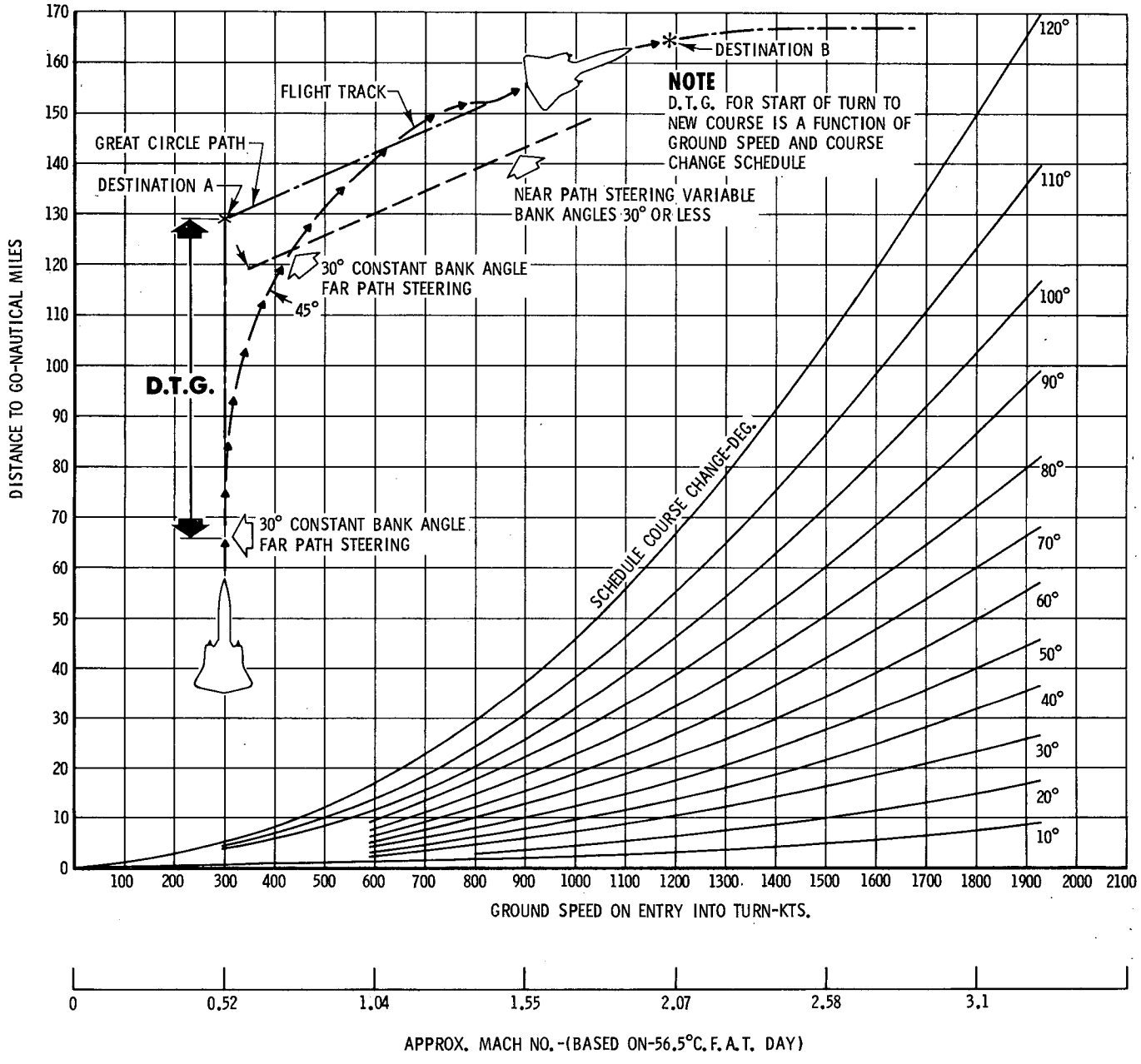
DISTANCE-TO-GO AND GROUNDSPEED INDICATOR

A distance-to-go and groundspeed indicator is installed on the instrument panel. Digital indicators display the distance between the aircraft position and the destination, and the groundspeed, in units of 1 nautical mile and knots, respectively. When a new destination is selected either automatically or manually the indicator will change to show the new distance-to-go. The distance-to-go indication will decrease toward zero while approaching the destination, then increase after passing the destination if flight is continued on the same course. Distance-to-go will not read zero at destination if the computed cross-course distance is greater than 1/2 nautical mile, since readout resolution is to the nearest nautical mile.

BEARING, DISTANCE, HEADING INDICATOR (BDHI)

The INS computes true heading and steering information and this information can be displayed by the BDHI installed on the instrument panel. The rotating compass card of

INS STEERING CHARACTERISTICS



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F200-16(d)

Figure 4-11

the BDHI receives the true heading signals as long as the MODE switch on the INS NAVIGATION control panel is in the NAV position. When the MODE switch is in the FRS position the compass card is driven by the FRS signals, although the INS system still generates true heading. Pointer 1 of the BDHI is driven by the ADF or TACAN as selected by the No. 1 needle selector switch. Pointer 2 is driven by the steering signal of the INS when the MODE switch on the NAVIGATION control panel is in the NAV or FRS position. Pointer 2 points to the direction of the great circle course or in ADF steering mode will point to destinations which are within 45 degrees of the aircraft heading (or indicate direction to turn if angular difference is greater than 45 degrees).

NOTE

- The aircraft will automatically fly the course computed by the INS and selected by the pilot only if the autopilot is in the AUTO NAV mode.

- A 45-degree turn indication on the BDHI pointer 2 commands a 30 degree bank angle to be made by the autopilot. The bank angle command is proportionately smaller when smaller turn angles are indicated on the BDHI.

COURSE SELECTION

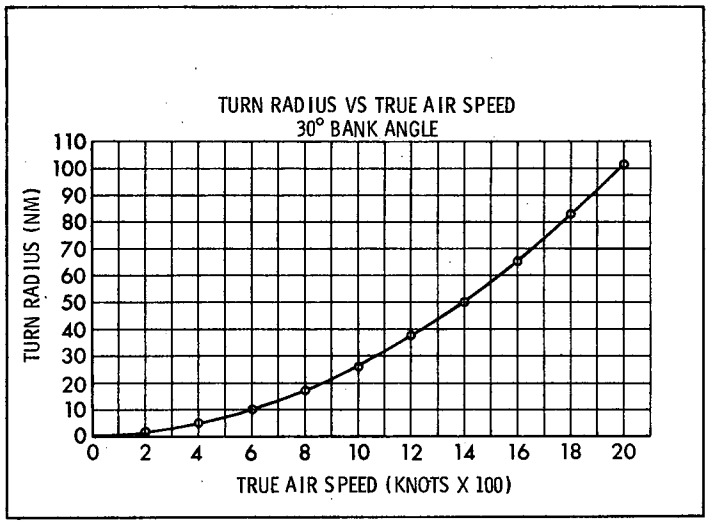
In the STORED AUTO mode, the INS is capable of providing steering information to any selected destination when the path from source to destination is greater than 30 nautical miles but less than 21,500 nautical miles (from 1/2 degree to 179 degrees of great circle arc). In the STORED MAN mode, the above restrictions exist only for destinations numbered 00 through 26. The sequence in which courses are provided depends upon the position of the DEST/FIX switch on the navigation control panel. In STORED AUTO position, course directions will be provided to stored destinations automatically in their numerical sequence; however, an out of sequence deviation can be made in STORED AUTO by selecting the desired out of sequence destination number on the destination select panel and depressing either the DEST FIX or STORE pushbutton. After the out of sequence deviation, other destinations will then continue to be automatically selected in numerical sequence. In the STORED MAN or VARIABLE DEST positions, steering directions to individual destinations are supplied after each destination is selected by depressing either the DEST FIX or STORE pushbutton. For STORED AUTO or STORED MAN modes, the steering information provided by the computer is a great circle flight path only if the destination selected is one of the first 27 sets of stored coordinates (00 through 26). ADF type steering will be commanded for STORED destination selections numbered 27 or greater and for all VARIABLE DEST mode selections. In STORED MAN mode, the computed course starting point is determined as follows:

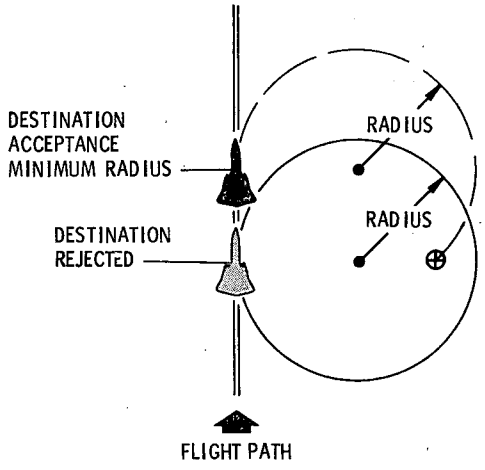
a. The position of the current destination is selected by the computer as the starting point for the new course if the aircraft computed position is within 100 miles of this point when the STORE button is depressed.

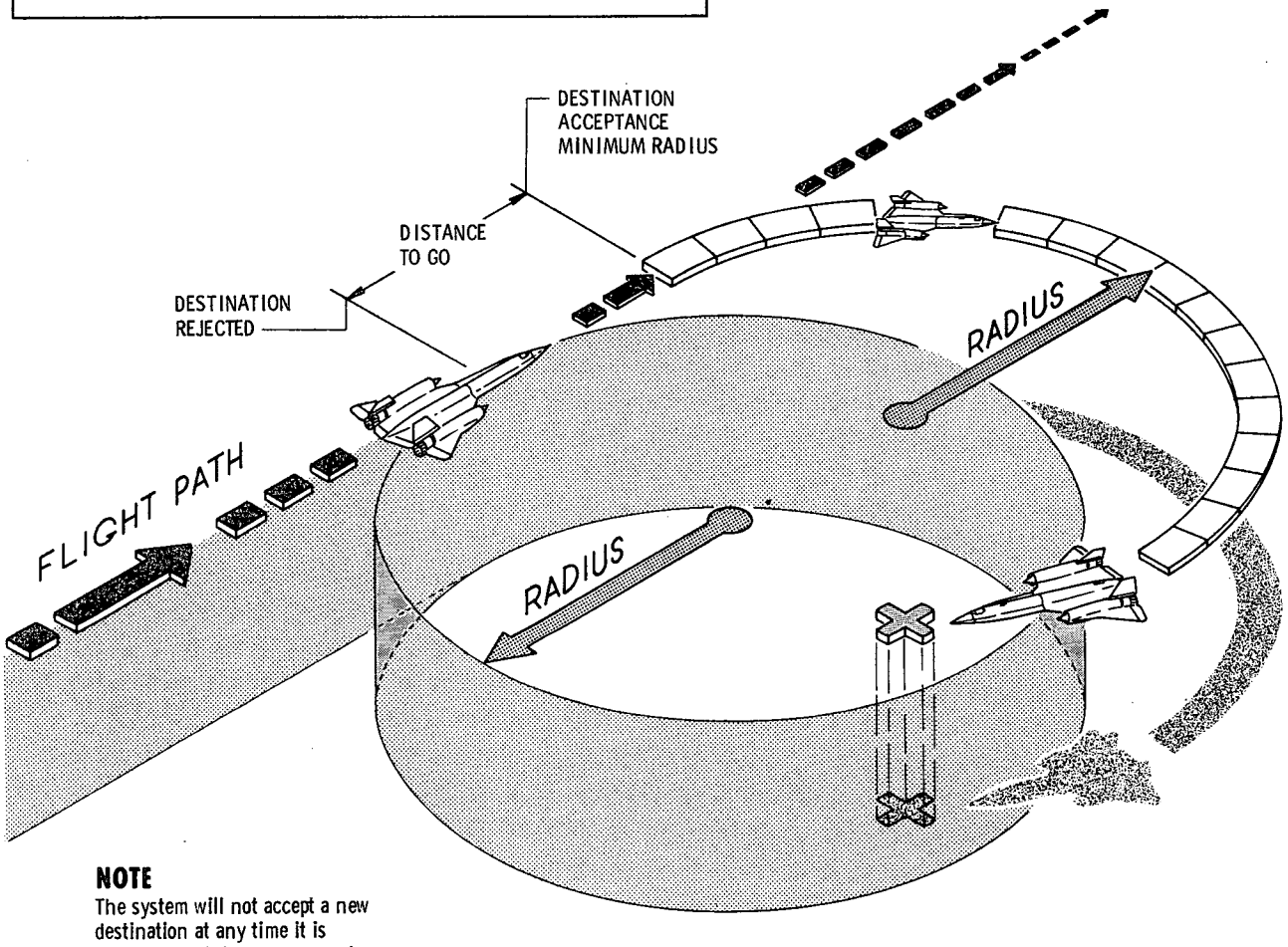
b. The computed position of the aircraft is selected by the computer as the starting point for the new course if the distance to go is more than 100 miles from the current destination.

After a course has been selected and calculated and either great circle or ADF type steering provided to navigate toward the course destination point, the INS will continue to navigate to that point regard-

INS DESTINATION REJECT PATTERN







NOTE

The system will not accept a new destination at any time it is within the minimum turn radius circles which move along with the aircraft. The radius is a functional of aircraft velocity for a 30° bank angle. $R \simeq 2.6 \times 10^{-5} V^2$ Where R is the turn radius in nautical miles and V is velocity in knots.

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Figure 4-12

less of any change of position of the DEST/FIX switch until a new destination is selected by either automatic sequencing in the STORED AUTO position or by depressing the STORE pushbutton in the STORED MAN or VARIABLE DEST positions. If a destination selection is made in which the new destination is aft of the present course direction by an angle greater than 135°, the initial steering direction is indeterminant and the aircraft may roll out either right or left in turning around to the new course.

Fixed-Path Flight Plan

A preselected-path flight plan will be flown in AUTO mode. Consecutive destinations 00 through 41 will be selected automatically. The point-to-point paths will be segments of great-circle arcs for destinations 01 through 26, and direct for destinations 27 through 41. The use of STORED AUTO mode results in smooth entry turns at required bank angle up to a maximum of 30 degrees to the next course. Turns will be initiated before reaching the destination and the turn point will depend on aircraft groundspeed and the degree of course change required.

Deviation from Fixed-Path Flight Plan Using Stored Destinations

Stored destinations may be selected manually in any arbitrary sequence, and a destination can be selected any number of times during a mission. Any partial sequence of the stored destination fixed-path plan can be used by manually selecting the first destination of the sequence, then switching to STORED AUTO mode until the desired sequence is accomplished. Then, manual selection of a new stored destination causes a new course to be computed as described above.

NOTE

In the STORED MANUAL mode, if the aircraft flys over the destination in great circle steering without selecting a new destination, the DEST/FIX light comes on and the vehicle will alternate between right and left steering signals. The DEST/FIX light operates similarly in ADF steering; however, the aircraft will fly in circles, always coming back over the selected destination.

Deviation from Fixed-Path Flight Plan Using Stored Auto

One or more destinations can be skipped by selecting the destinations desired on the digital counters of the DESTINATION SELECT PANEL and depressing the STORE pushbutton with the DEST/FIX switch in the STORED AUTO position. The INS will complete the track in progress when the STORE pushbutton is depressed but the next automatic sequence will select the course to the desired destination.

In the STORED AUTO mode, the destination select light is extinguished when the number on the destination select panel agrees with the stored destination which is presently selected. The stored destination which extinguishes the light will be the same as the stored destination toward which the aircraft is flying except when selecting a destination out of sequence in the STORED AUTO mode.

Example: The aircraft is flying towards destination 02 in the STORED AUTO mode and 02 is selected on the destination select panel. The destination select light is extinguished. The pilot decides to skip destination 03 and fly from destination 02 to 04. He selects 04 on the panel and depresses

the store button. The light will now be extinguished only on destination 04 even though he is still flying towards 02. This indicates to the pilot that 04 has been accepted as the next destination.

Use of the VARIABLE INPUT Indicator For Unstored Destinations

Use of destination coordinates set on the VARIABLE INPUT indicator and N-S selector requires that the DEST/FIX switch be set to the VARIABLE DEST position. ADF-type steering to the point selected is provided when the STORE pushbutton is depressed. The initial ADF-type steering heading is based on computed present position. Coordinates of stored destinations can be duplicated.

LIMITATIONS OF DESTINATION SELECTION

Maximum Path Length

The maximum great-circle arc between source and destination is 179 degrees to permit definition of direction. This constitutes a distance of approximately 17,800 nautical miles from source to destination.

Minimum Path Length

In the STORED AUTO mode, a course cannot be selected when the distance from the start point (either a stored destination or the aircraft's present position) to the next destination is less than 30 nautical miles. The computer will ignore any attempt to select such a destination. In the STORED MAN mode the 30 mile restriction exists only for destinations numbered 00 through 26. However, all destination selections are restricted by comparing the desired destination's relative location with the aircraft's minimum turn radius capability. (The minimum turn radius is computed as a function of ground speed.) The destination is accepted if it is outside the minimum turn radius path. If the desired destination is inside the minimum turn radius path, the DEST FIX light on the DESTINATION SELECT PANEL will blink on and off, indicating that the computer has acknowledged the destination. The aircraft will continue on its same course until its location falls outside the minimum turn radius path. At such time, the DEST FIX light will extinguish and the destination will be accepted. (See figure 4-12.)

Minimum Distance Between Destinations

In the STORED AUTO mode, a course cannot be selected when the distance from the start point (either a stored destination or the aircraft's present position) to the next destination is less than 30 nautical miles. In the STORED MAN mode the 30 mile restriction exists only for destinations numbered 00 through 26.

FIX TAKING

Since all rotating gyros are subject to some drift, alignment of the coordinate reference frame established by the gyro platform tends to depart from the true coordinate frame after a period of time. This introduces errors in position and azimuth which increase with time. (See figure 4-13.) The indicated position can be updated by taking visual fixes when the coordinates are known. These fixes are taken by use of the periscope and are inserted into the INS as follows:

1. Either select the desired prestored destination on the destination select panel or set the coordinates of the fix point in the VARIABLE INPUT indicator and N-S selector.

2. Turn the DEST/FIX switch to the appropriate STORED or VARIABLE FIX position. (Use STORED FIX position if the fix to be made is at a prestored coordinate point.)

INS POSITION AND AZIMUTH ERROR

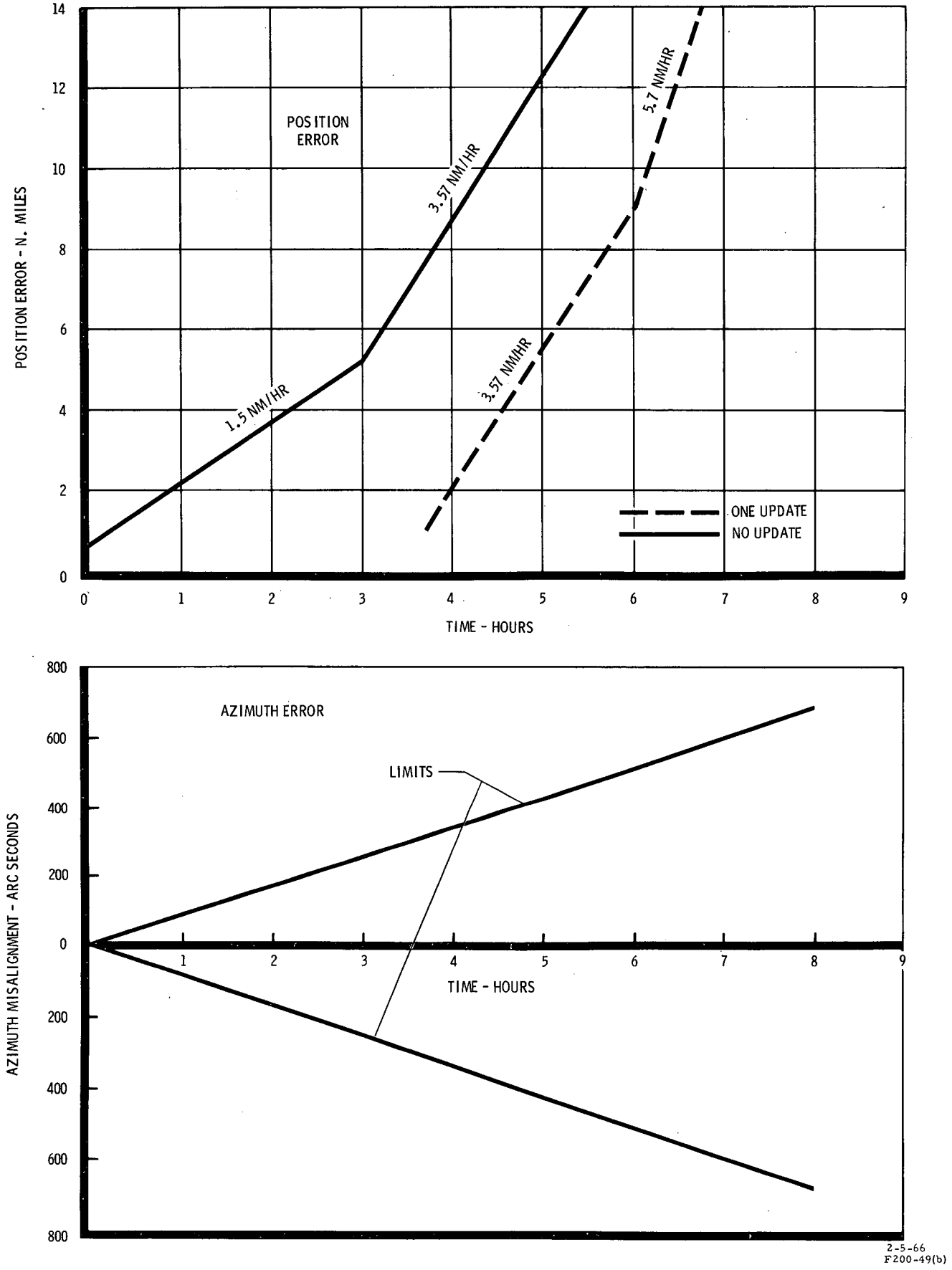

Figure 4-13

3. Pull the MIRROR SELECT handle to the aft position for surface viewing and select the narrow view magnification with the PERISCOPE control. When the fix point is identified visually, position the periscope cursor with the FIX ADJ knob so that it will intersect and track the fix point. Continue tracking until the fix point crosses the periscope horizontal reference line.

4. Depress the STORE pushbutton at the instant the fix point crosses the intersection of cursor and horizontal reference lines. (At high speeds, a 2-second delay in depressing the STORE pushbutton will result in a position fix error of approximately 1 nautical mile.) The computer will make the fix correction as follows:

   a. Correcting the inserted fix position to represent the position of a point immediately below the aircraft at the instant of STORE pushbutton depression.

   b. Comparing the fix position with the inertially computed position at the instant of STORE pushbutton depression, and displaying the updated position on the PRESENT POSITION indication.

   c. If the difference is greater than 15 nautical miles, the computer program will not make the fix. Indication that a fix was not made is indicated by illumination of the INS FIX REJECT light on the annunciator panel.

   d. The difference will be displayed, up to a maximum value of 59 NM, on the latitude minutes counter of the DESTINATION/FIX POSITION Indicator (section of the counter inside the white outline block). The fix difference will be displayed whether the fix updates or is rejected. The display will remain until either another fix is taken or another destination is selected.

NOTE

The fix correction only updates the coordinates displayed in the PRESENT POSITION windows and does not realign the platform. The rate of error buildup accrues from the time the INS system was switched to the NAV mode.

A stored destination may be used as a fix by selecting the destination number on the destination select panel, moving the DEST/FIX switch to STORED FIX position, and depressing the STORE pushbutton.

Fix Sequence

No position fix should be taken before at least 2 hours have elapsed (including ground operating time) in the NAV mode of operation. A fix should be taken as soon thereafter as practicable. The optimum time to take the first fix is between 2 and 2-1/2 hours after selecting NAV operating mode. Subsequent fixes should be taken at intervals not exceeding 1-1/2 hours.

Fix Limit

For all fixes except those taken on stored positions 38 and 39, the maximum position fix corrections that will be accepted are 15 nautical miles of latitude correction and/or 15 nautical miles of longitude correction. An attempt to make a position fix that exceeds these values will cause the master caution light and the INS FIX REJECT light on the annunciator panel to illuminate. The INS FIX REJECT light will remain on until a subsequent acceptable fix is taken, or until the DEST/FIX switch is moved to a non-

fix position. Inability to obtain an acceptable fix correction can be due to incorrectly stored fix point coordinates, incorrect fix point identification, or degraded INS accuracy. More than one attempt to achieve fix corrections should be made before concluding that the INS is not reliable. STORED FIXES 38 and 39 do not use the 15 nautical mile update limit for fix reject, but use a variable limit which is loaded to the desired value during preflight preparation. This variable limit capability can be used for INS performance prediction prior to a specific mission. For example, if it is known that INS had to be accurate within a certain limit to accomplish a specific mission, a STORED FIX on either 38 or 39 just previous to entering the mission area would give a criteria for mission abort. Position 38 or 39 fixes are the same as normal stored fixes except for the variable fix rejection criteria.

INS ACCURACY

Maximum position error will accrue at an average rate of 1-1/2 nautical miles per hour during the first 3 hours, and at an average rate of 3.6 nautical miles per hour thereafter.

INS Reliability Check

STORED FIXES 40 and 41 are designed to check INS performance before takeoff to attempt to predict INS accuracy during the flight. The aircraft is accurately positioned over a known spot and a STORED FIX is take as follows:

1. Stop aircraft at designated runway position.
2. Destination select switch - Pos. 40.
3. DEST FIX switch - STORED FIX.
4. STORE or DEST FIX pushbutton - Press.
5. INS FIX REJECT light - OFF.

This procedure updates the INS to a point 0.1 nautical mile or less from the starting point coordinates.

Acceptance of the position 40 fix indicates that the INS error is 0.4 nautical miles or less in error in either latitude or longitude and that computed north and east velocities are each less than 3 feet per second. These INS performance criteria are based on an anticipated time duration of 20 minutes from NAV entry until the position 40 or 41 fix.

If INS FIX REJECT light comes on - INS accuracy may be marginal.

6. DEST FIX switch - STORED MANUAL.
7. Destination select switch - As briefed.
8. STORE or DEST FIX pushbutton - Press.
9. INS FIX REJECT light - Off.
10. DEST FIX switch - STORED AUTO.

Effects of No. 3 Inverter Failure on INS

The No. 3 inverter supplies power to the INS. Consequently, a No. 3 inverter failure may have catastrophic results on the INS. The system performance may be degraded after switching to the emergency inverter. The degradation of system performance will directly depend upon the elapsed time between the No. 3 inverter failure and switch over to the emergency inverter. If the No. 3 inverter fails and the INS outputs are no longer meaningful, the pilot should turn the INS MODE switch on the Nav Panel to OFF. This will lessen the possibility of damage to the system.

PERISCOPE

The periscope viewing system provides the pilot with a means for observing or making visual fixes on terrestial objects which cannot be seen directly from the cockpit. It can also function as a sky compass, and includes a display unit which projects maps and selected data on the presentation screen in the cockpit. Ther periscope windows, viewing optics, and projection equipment are located forward of the cockpit pressure bulkhead.

GROUND OBSERVATION

The basic downward looking function of the periscope system presents a minified image of a ground object, utilizing a fixed lens two-field system. The wide or narrow angle field of view is controlled by the PERISCOPE control. The modified wide-angle lens system provides a coverage of approximately 85° forward of nadir and is intended to be used for observations of large prominent ground objects. INS update fixing is possible when in the wide angle field of view. The modified narrow angle lens system provides a coverage of approximately 47° forward of nadir and is intended to be used for update fixing of the INS system by fixing on pre-selected ground objects. The forward look distance possible with either field of view is dependent upon the altitude and attitude of the aircraft at the time of the observation. Figure 4-15 gives the forward look range as a function of the aircraft attitude and altitude. The resolution of the optical system in all modes is better than that of the unaided eye. Due to the minification imposed by a fixed lens system, however, the pilot is only expected to identify prominent ground objects such as a coast line, lake or town. Also, due to the extreme slant viewing angle, there will be some apparent distortion when an object appears near the top of the reticle plate; especially when using the wide angle field of view. It is equipped with a tri-prism plastic grooved diffuser which provides for two eye viewing of the periscope image.

PROJECTOR DISPLAY

The periscope mirrors can be shifted so that a 35-mm strip film projector displays maps or other selected data on the presentation screen. The pilot may regulate the projector light intensity and advance or reverse the film as necessary in order to refer to the desired information. A film destruct capability is available and is actuated manually or automatically in case of ejection.

PRESENTATION SCREEN

A six inch presentation screen is installed at the top center of the cockpit instrument panel. The ground area displayed depends on the lens system selected; wide angle or narrow angle. When using the wide angle lens, the circle drawn near the center of the reticle plate indicates what will be visible with the narrow angle lens. The nadir point of the wide angle view is indicated by the intersection of the chord drawn across the lower half of the narrow angle view circle and the center vertical line on the reticle plate. The nadir point of the narrow angle view is indicated by the intersection of the horizontal line and center vertical line on the reticle plate. The nadir point, as indicated on the reticle plate, has been compensated to correct for the angle that the optical axis has been shifted forward due to the normal level flight attitude of the aircraft and the physical placement of the periscope system in the aircraft.

A compass rose is incorporated in the reticle plate; the numbers appear around the edge of the plate and are back lighted when the system is in the sun compass mode.

A pair of vertical dashed lines are provided to show the path of a ground object as it moves from top to bottom on the presentation screen. The dashed lines are tangent to the narrow angle circle and show the pilot what will be visible in the narrow angle view as soon as the object appears in the wide angle view.

PERISCOPE

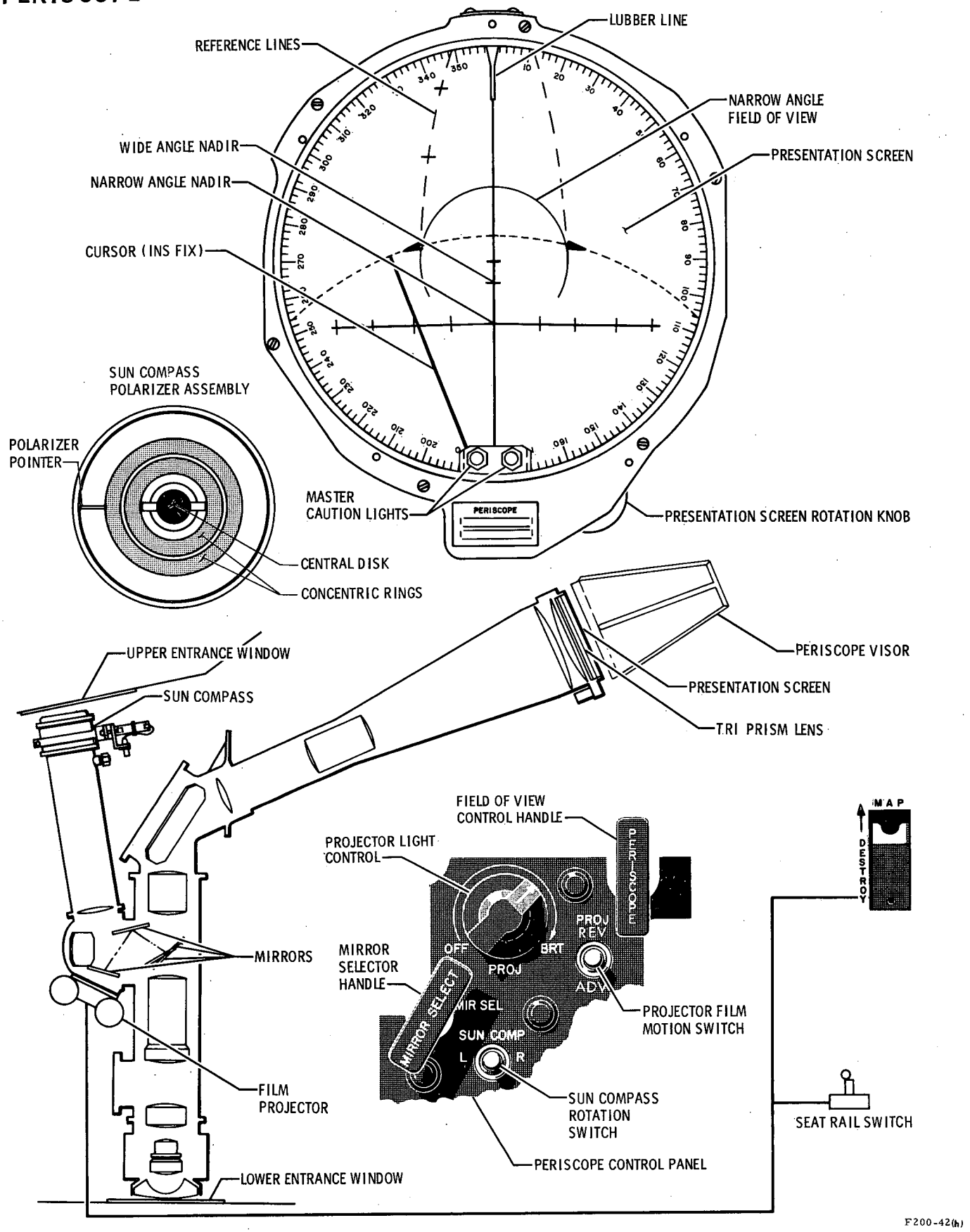

Figure 4-14

A movable cursor, remotely controlled from the INS navigation control panel, is used with the narrow angle "nadir" line to correct the INS for position error. The reticle plate or cursor is not illuminated. A serrated thumb knob in the lower right side of the presentation screen is used to rotate the reticle plate.

Periscope Lens Control Handle

A handle, labeled PERISCOPE and located on the lower left side of the cockpit instrument panel, is used to select the desired lens system wide or narrow angle view. The wide angle lens is selected by pulling the handle to the out (aft) position. The narrow angle lens is selected by placing the periscope handle in the in (forward) position.

Mirror Selector Handle

A T-handle, labeled MIRROR SELECT, controls the mirrors within the basic periscope system. The handle can be positioned to one of three positions as follows:

a. In (forward) position selects film projection.

b. Mid detented position selects the sun compass for overhead viewing. (Approximately 1/3 distance to OUT).

c. Out (aft) position selects the surface viewing periscope.

Projector Light Switch

A rheostat switch, labeled PROJ, controls the film projector light intensity. The projector light is switched OFF at the full counterclockwise position. The projector light is turned on by rotating the rheostat toward the BRT position. Intensity of the image on the presentation screen is increased by further clockwise rotation. Power for the light is furnished by the essential dc bus.

Projector Film Switch

A momentary three-position toggle switch, labeled PROJ, controls movement of map and data film. When the switch is held in the down position the film will advance. When the switch is held in the up position, the film strip will rewind. The center position is OFF. Power for the switch is furnished by the essential dc bus.

SUN COMPASS

The sun or sky can be observed with the periscope by shifting the mirrors for upward viewing. A midpoint detent is provided in the mirror selector control for positioning the periscope optics in this position. A knurled thumb knob located at the lower right of the presentation screen is used to rotate the reticle plate, and a toggle switch labeled sun compass with L and R positions located on the periscope control panel controls an electric motor which rotates the polarized disk. The sun compass is used as a backup to other heading devices when in locations where other devices might not function accurately. It is used to make 180° turn-arounds or emergency heading determinations. It is also used to make periodic cross checks of other heading devices at any point along the flight path.

The sun compass utilizes the precomputed azimuth (Zn) of sun and the sun's image on the presentation screen. Accuracy is within 2° when the sun's elevation is $+6^{\circ}$ to 50°. At elevation values above 50°, the heading error becomes greater. It also utilizes the precomputed azimuth of sun and the sky polarization phenomenon. Accuracy is within 2° when the sun's elevation is -8° to $+20^{\circ}$.

PERISCOPE DATA

Representative capabilities of Periscope in Ground View Mode. Airplane Angle of Attack Nominal 7°.

ALTITUDE ABOVE TERRAIN	NARROW ANGLE FIELD OF VIEW			WIDE ANGLE FIELD OF VIEW		
(Feet)	Forward (NM)	Lateral (NM)	Time * (SEC)	Forward (NM)	Lateral (NM)	Time* (MIN)
20,000	3.7	1.5	-	53	6	-
30,000	5.6	2.6	-	80	10	-
40,000	7.3	3.5	-	107	14	-
50,000	9.4	4.3	-	134	18	-
60,000	11.3	5.2	-	161	21	-
70,000	13.2	6.1	26	188	25	6.2
80,000	15.1	7.2	30	215	29	7.1
90,000	17.	7.9	34	242	32	8.

* The approximate time required for an object to appear at the top of the reticle plate and move down to the nadir fix line. Mach 3.1 and an attitude of + 7° is assumed.

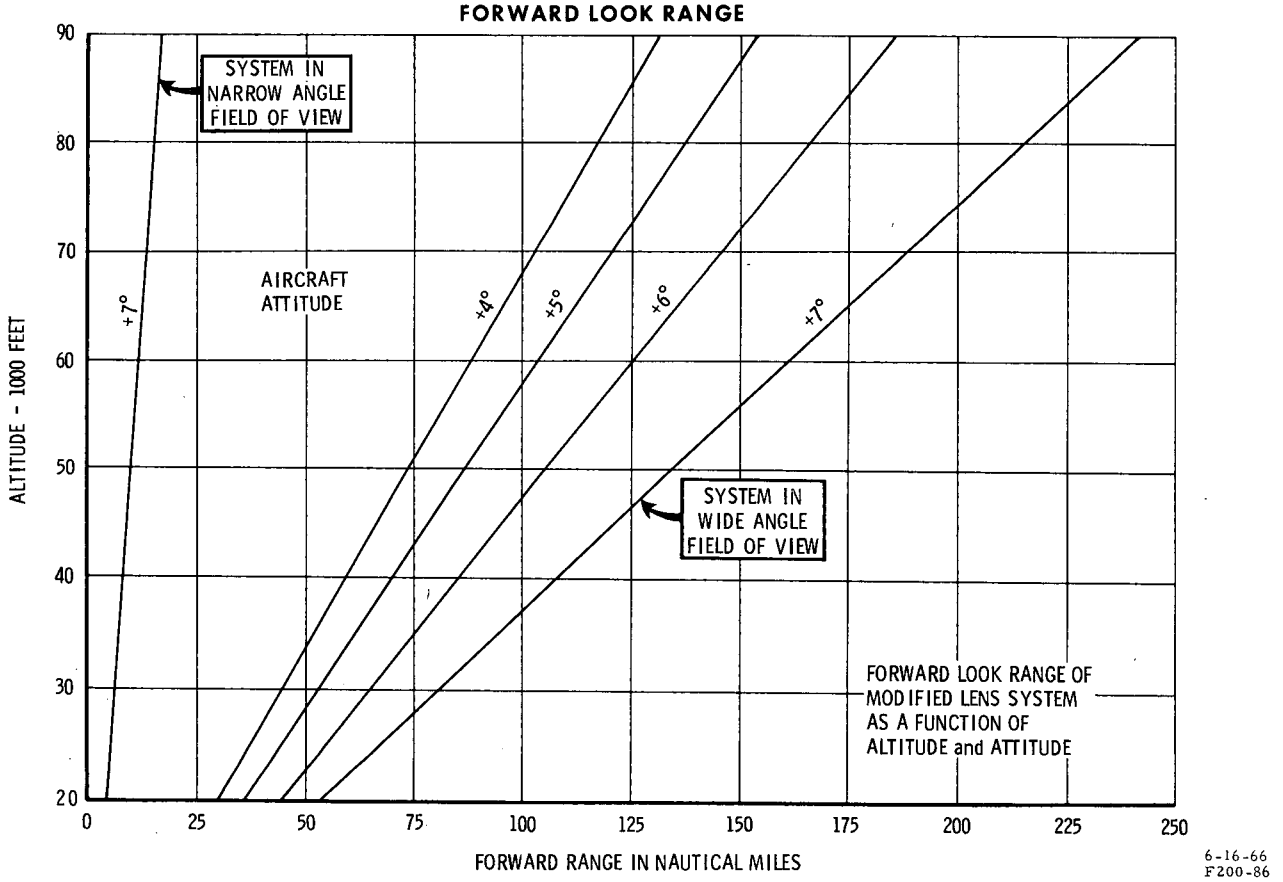

Figure 4-15

The following definitions are applicable to the sun compass procedures:

Polarizer pointer - The red pointer on the electrically driven polarizer disk. It takes the place of the sun when the sun is too low in the sky.

Lubber line - The fixed pointer at the top of the presentation screen.

Compass Rose - A set of numbers around the periphery of the manually rotated reticle plate.

Zn - Azimuth of Sun - True bearing of the sun relative to a particular position on the ground at a specific time.

RB - Relative Bearing of Aircraft - The horizontal angle between the true heading of the aircraft and the true bearing of the sun.

TH- True Heading of Aircraft - The heading of aircraft relative to the north pole.

Zn = TH + RB

Sun Image - Reflection of direct sun image as it appears at the edge of the reticle plate.

Polarized Sky Light - The characteristic of the atmosphere to polarize sun light by scattering. The maximum polarization appears at a direction 90° from the sun.

Sun Compass Switch

A three- position momentary toggle switch, labeled SUN COMP, on the periscope panel controls the rotation of the sun compass polarizer disk. The switch positions are labeled L and R. In the L position the polarizer disk will rotate in a counterclockwise direction. In the R position the polarizer disk will be rotated in a clockwise direction. Power is provided by the essential dc bus.

NORMAL OPERATION

DIRECT SUN (+6° to 50°)

A. True Heading Method

1. Determine the precomputed value for azimuth of sun (Zn).
2. Manually rotate compass rose until Zn value is over the sun's image.
3. Read True Heading (TH) of aircraft on compass rose, indicated by the lubber line.

B. Relative Bearing Method

1. Manually rotate compass rose so the lubber line indicates zero.
2. Determine the precomputed Relative Bearing (RB).
3. Read the Relative Bearing of aircraft on compass rose at point indicated by sun's image.

POLARIZED SKY LIGHT (-8° to 20°)

A. True Heading Method

1. Determine the precomputed azimuth of sun (Zn).
2. Electrically turn polarizer pointer toward the visible sunlight.
3. Adjust the central disk as dark as possible when the concentric rings are of equal brightness.
4. Manually rotate compass rose until Zn value is in line with the polarizer pointer.
5. Read the True Heading (TH) of aircraft on compass rose, as indicated by Lubber line.

B. Relative Bearing Method

1. Manually rotate compass rose so that lubber line indicates zero.

2. Determine the precomputed Relative Bearing (RB).

3. Electrically turn polarizer pointer toward the visible sunlight.

NOTE

If pointer is not positioned toward sun, 180° ambiguity will be encountered.

4. Adjust the central disk to be as dark as possible when the concentric rings are of equal brightness.

5. Read the Relative Bearing of aircraft on compass rose, as indicated by the polarized pointer.

DESTRUCT SYSTEM

A destruct system is incorporated in the airplane to destroy the projector film, and the maps. The film strip in the projector are destroyed by electrically igniting small thermite assemblies which burn at approximately 2000° for a minimum of 30 seconds. The water soluble maps are destroyed by forcing water from a small reservoir into the map case using nitrogen gas pressure from the canopy accumulator. The destruct system is actuated manually by a guarded switch labeled DESTROY located on the right forward panel. The system is activated when the switch is placed in the up position. A roller type micro switch on the seat ejection rails will automatically activate the destruct system if the pilot ejects. Power for the system is from the essential dc bus.

CAUTION

After landing nitrogen pressure will not be available to assist in raising the canopy if the destruct system has been actuated. The canopy may be jettisoned if pressure is depleted and help is not available.