LIST OF ILLUSTRATIONS

DESCRIPTION

10A-1. SYSTEM DESCRIPTION.

10A-2. GENERAL. The NAS-14V2 astroinertial navigation system (ANS) is the primary navigation system for the SR-71 airplane. The system operates as an inertial system, computing geographic position and other navigational data. In its primary mode of operation the system employs star tracking to assist in limiting navigational errors. The system also utilizes a free azimuth platform, permitting operation in polar areas. In addition to the accuracy provided by star tracking, the system has provisions for updating computed present position using radar, viewsight, or the TACAN system.

10A-3. The ANS includes the following components (see figure 10A-1): a guidance group (containing an inertial platform, tracker telescope, electronics, and computer), a NAVIGATION control and display (NCD) panel (providing the RSO with manual control of the system and display of system data), a chronometer (time standard, supplying GMT and day of year data to the system), a V-scan junction box (an interface component between the ANS and the air data system, the viewsight, and the radar system), an interface box (used for ANS/OBC and TEOC camera roll signal interface), a sensor signal processor (part of the sensor event/frame count system), and an ANS window (installed in the air conditioning bay hatch over the guidance group to provide viewing for the star tracking telescope). In additon to these basic system components, a recorder kit may be installed in the airplane on an "as required" basis to record system telemetry data.

10A-4. ANS electrical interface with other systems is shown in figure 10A-2. The following is a brief description of the interface signals; a detailed description is provided elsewhere in this section.

10A-5. The ANS provides pitch, roll, heading, and steering command signals to the autopilot for airplane attitude stabilization

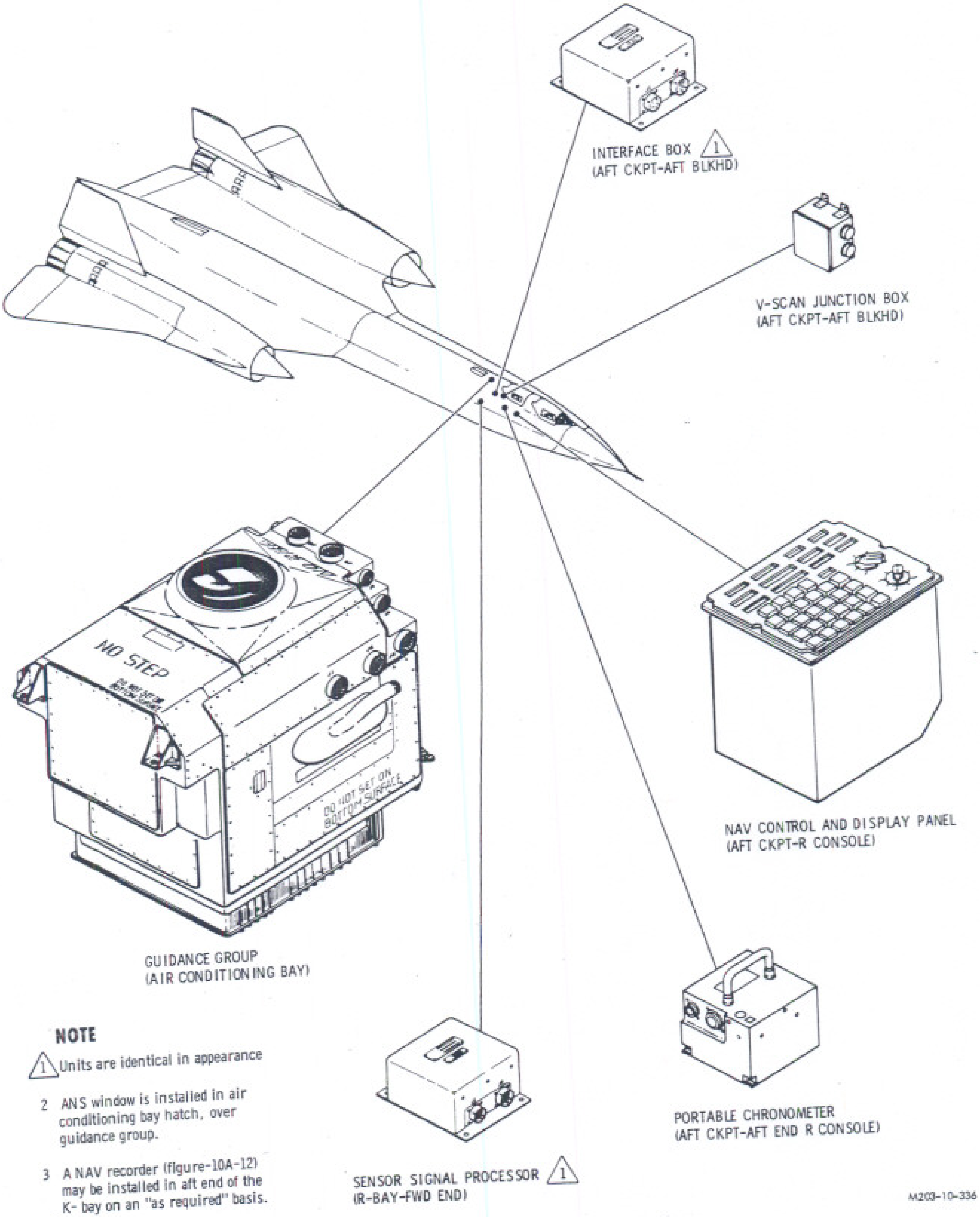


Figure 10A-1. ANS Components

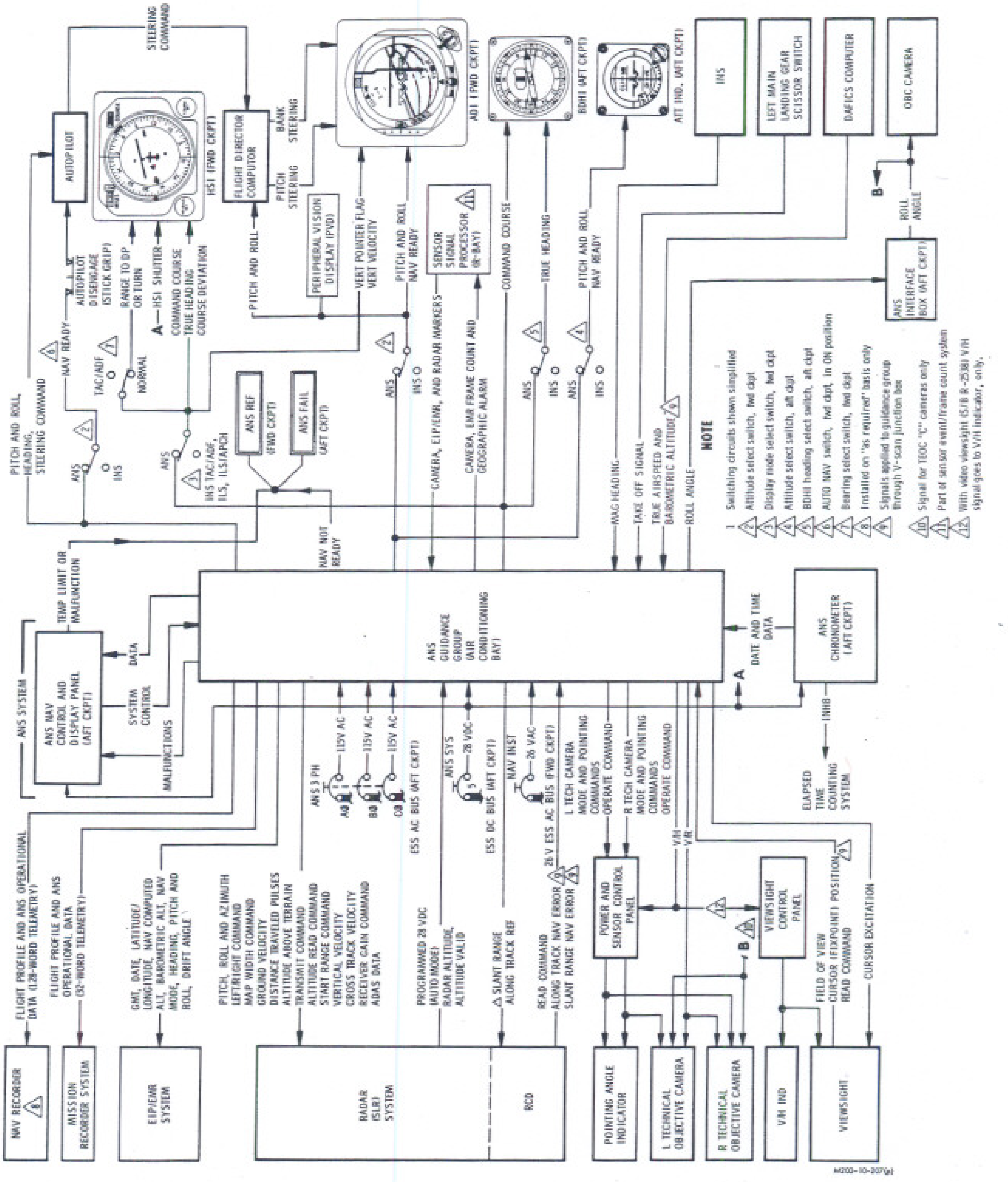


Figure 10A-2. ANS Interface Block Diagram and for flight on a given heading or along a predetermined flight path. Similar information is supplied to cockpit navigation instruments to assist in manual navigation of the airplane. The ANS supplies continuously updated navigation data to the MRS and EIP/EMR systems for recording purposes and can supply a variety of command signals for automatic control of the radar system and the TEOC cameras. In addition, the ANS supplies roll angle signals to the OBC camera and to the HR-308C TEOC cameras, a V/R signal to the TEOC cameras (B and C models), a V/H signal to the V/H system, and frame count data to the sensor event/frame count system.

10A-6. Present position correction information is applied to the ANS from the radar system or the viewsight during ANS present position update operations. INS heading information can be used as a heading reference during ANS alignment and is used for computation of dead reckon present position data. The air data system (ADS), a subsystem of the digital automatic flight control and inlet system (DAFICS), supplies true airspeed and altitude information. True airspeed is used during an airstart of the ANS and for computation of dead reckon data. The altitude signal from the radar is used, together with ADS barometric altitude, to develop Nav computed altitude. Nav computed altitude is used for ANS navigational computations and for computation of ANS control of the radar system and the TEOC cameras.

10A-7. ELECTRICAL POWER AND COOLING AIR REQUIREMENTS.

10A-8. Electrical Power. (See figure 10A-2.) The ANS requires three-phase 115 vac, single-phase 26 vac, and 28 vdc electrical power. Three-phase 115 vac is supplied to the guidance group and 28 vdc is supplied to the guidance group, the NCD panel, and the chronometer from ANS ac and dc circuit breakers on the aft cockpit right console. Single-phase 26 vac power; used for ANS roll, pitch, heading, command course and range output synchro excitation; is supplied from the NAV INST circuit breaker on the forward cockpit center stand. In addition, 28 vac from the light control panel on the aft cockpit left console is used for panel and title lights on the NCD panel.

10A-9. Cooling Air. Cooling air must be supplied to the guidance group when the ANS is in operation. During flight, air, at a temperature from -30°F to +40°F at a minimum flow rate of 3-3/4 pounds per minute, is supplied from the airplane cooling air turbines. During ground operations, the air is supplied from an air conditioning trailer connected to the airplane. Procedures for application of ground cooling air to the airplane are provided in T.M. SR-71-2-8. During ground operations, the air conditioning cart must be set to provide air at a temperature between 45° and 50°F, at a minimum pressure of 2.75 psig.

CAUTION

Aft canopy latch handle must be set in full aft (unlached) position in order to provide sufficient air to the ANS.

ANS ground air shutoff valve handle in nose wheel well must be set forward (valve open) during warmup, alignment, and operation of the ANS.

L and R REFRIG switches on forward cockpit left instrument panel must be left in OFF position until just before ground air is disconnected from airplane prior to taxi. This procedure assists in minimizing the entrapment of moisture in the air conditioning system and the possibility of water damaging the guidance group.

10A-10. PRINCIPLES OF SYSTEM OPERATION. (See figure 10A-3.)

10A-11. The primary sensing elements of the ANS are three orthoganally oriented accelerometers, mounted on a gyro-stabilized platform. Accelerometer output signals, resulting from airplane motion, are measured and applied to the system computer. Two of the accelerometers are maintained level to measure horizontal accelerations of the vehicle, the third accelerometer is oriented vertically and measures vertical

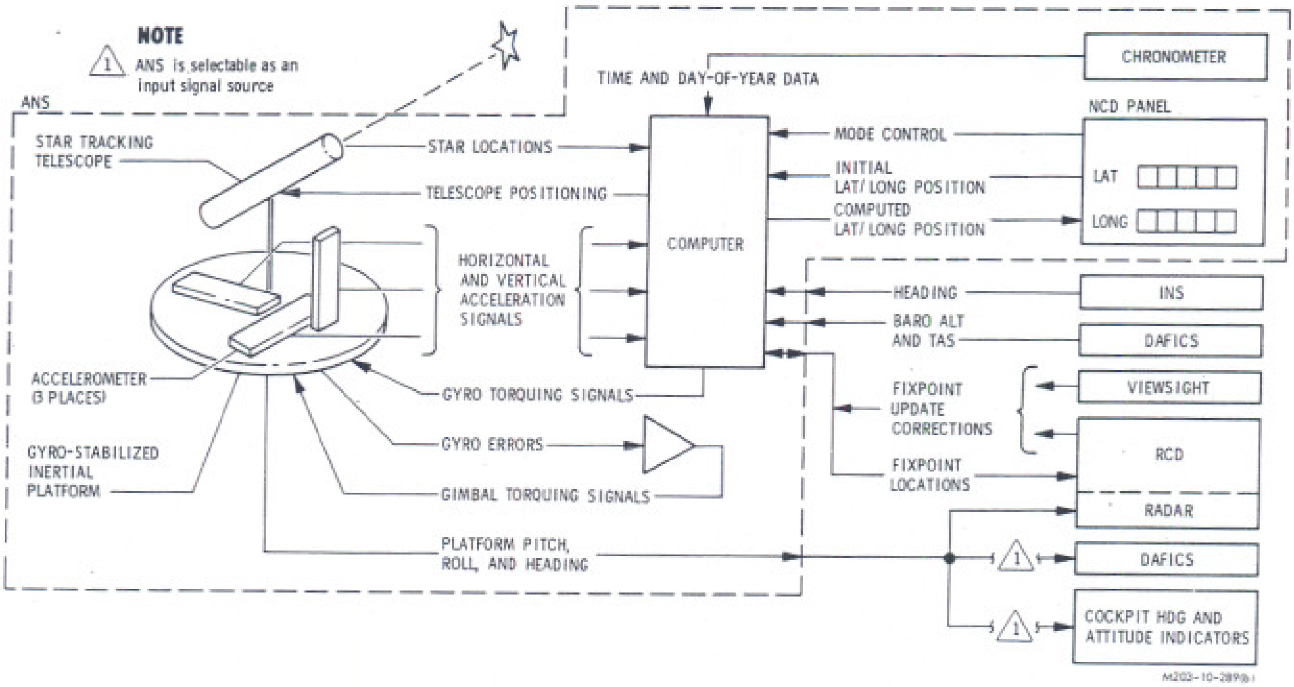


Figure 10A-3. Simplified ANS Functional Diagram

accelerations of the airplane. The platform, through gyro/gimbal servo loops, is isolated from airplane motion about its three axes and, through the navigation computation aspects of the system (Schuler loop), from rotation of the earth and motion of the airplane over the earth.

10A-12. In the computer, the acceleration signals are integrated into velocity signals representing airplane motion along its three axes. The vertical velocity information is required for some of the inertial navigation computations. The horizontal velocity signals, together with signals representing earth rotation, are used to rotate and maintain the platform level and heading stabilized. This is accomplished by application of torquing signals to the platform gyros. Gyro error signals, resulting from applied torquing signals and any vehicle motion sensed by the gyros, are amplified and applied as torquing signals to the platform gimbal motors which move the platform gimbals so as to cancel the gyro error signals. The acceleration signals are also used to update a mathematical model of the platform (computational triad), the three axes of which correspond to the three accelerometer axes of the platform.

10A-13. Rotation of the computational triad, as the result of airplane motion, changes computed present position latitude and longitude information displayed on the NCD panel. Ideally, the platform triad and computational triad remain aligned, indicating a level platform and correct computation of present position and orientation of the platform horizontal accelerometers relative to true north. Misalignment between the platform and computational triads can be the result of initial errors in inserted present position, errors in platform leveling or heading information, or can develop as the result of gyro drift or accelerometer errors. When operating as a pure inertial system, these errors, particularly the errors resulting from uncorrected gyro drift, tend to increase substantially with time. When operating as a astroinertial system, the star tracking telescope, using a preprogramed catalog of stars, measures the differences between calculated and actual star positions. Errors in star locations represent differences between the platform and computational triads. The computer translates these errors into corrections which, on a basis of statistical probability, are used to adjust platform orientation and computed position. Also, these errors are used to calculate and correct for any uncompensated gyro drift.

10A-14. In addition to star tracking as a means of reducing system errors, the viewsight and radar system can be used to monitor, and if necessary update, computed present position by using geographic fixpoints for which exact latitude/longitude values are known. Viewsight or radar developed corrections are usually not required when the system is operating in the astroinertial mode and stars are being tracked; however, these corrections may be very necessary when the system is operating in one of the other modes.

10A-15. With the system operating properly, the stable platform is a source of heading and attitude signals. These signals can be selected for use by DAFICS and the cockpit attitude and heading indicators. They are also used as stabilization signals for the radar system.

10A-16. A backup mode of operation (dead reckon) is provided in the event of failure of the platform or its related functions. When operating in this mode, the system functions as a dead reckoning computer, computing present position from INS heading, ADS true airspeed, and manually inserted wind velocity and magnetic variation.

10A-17. OPERATING MODES AND NAVIGATION ERRORS. The ANS is capable of operating in four distinct modes, as selected using the NCD panel MODE switch. The operating modes are: astroinertial, inertial only, airstart, and dead reckon. The mode employed depends on whether the system is operating properly and whether the airplane is on the ground or is airborne. The astroinertial mode is the primary operating mode with the other modes employed for backup purposes only. The following paragraphs give a brief description of system operating modes. More detailed information is provided under the heading of system operating procedures, paragraph and under operating modes.

10A-18. Navigation Errors. The magnitude of ANS navigation errors depend on the mode of system operation and the method of alignment. In general, most accurate navigation is obtained when the system is operated in the astroinertial mode following a gyrocompass or rapid alignment. A ground hot start alignment may result in reduced accuracy. Navigation accuracy is reduced when operating in the inertial only mode or following an airstart. Accuracy is worse when operating the system in the dead reckon mode. Refer to Flight Manual SR-71A-1 for navigation errors which may be expected when operating in the various modes, following the various alignment procedures. The navigation errors listed in SR-71A-1 are indicated as probable or CEP (circular error probability) radial errors. Actual errors may be expected to be less than the listed errors half of the time and greater than the listed errors half of the time.

10A-19. Astroinertial Mode. From a system accuracy and mission performance standpoint, the astroinertial mode is the preferred mode of operation. When operating in this mode, the system operates as an inertial system with star tracking used to improve system accuracy and performance. Navigation errors in the astroinertial mode can be expected to be very low (how low depends upon the method of system alignment employed) and, with continuous star tracking, will not increase after the first hour or so of operation.

10A-20. Inertial Only Mode. In the inertial only (inertial) mode, the system performs as a pure inertial system without star tracking data being used to improve navigational performance. The system effectively operates in the inertial only mode when the astroinertial mode has been commanded, but stars are not being acquired. The mode can also be chosen by the RSO if system star tracking capability is lost. Navigation errors in the inertial mode generally increase with time during system operation.

10A-21. Airstart Mode. This mode, also referred to as cold airstart or airspeed-damped astroinertial mode, is also a method of inflight alignment. This mode is used for restarting and operating the system following an inflight malfunction (airplane electrical or ANS) which grossly affects ANS operation or accuracy or which causes the system to become inoperative. Once the airstart mode has been achieved (star tracking in progress following an initial alignment period) the system operates in the astroinertial mode, with navigation errors reduced to reasonably low values. If, following alignment, star tracking becomes impaired, the system operates as a pure inertial system, with navigation errors increasing with time.

NOTE

Although not an operating mode, from the standpoint of being an NCD panel MODE switch selection, a hot airstart (automatic restart) operation (alignment) is available to restart the system following an inflight power interruption. When successfully used, the hot airstart returns the system to the astroinertial or inertial only mode of operation.

10A-22. Dead Reckon Mode. The dead reckon mode is normally selected only if ANS inertial navigation capability is lost. In this mode, the ANS operates as a dead reckoning computer using INS heading, ADS true airspeed, and RSO entered wind and magnetic variation data. As navigation errors in this mode can be expected to be large, this mode is chosen only as a last resort. Depending on the type of malfunction experienced, the ANS platform may or may not continue to be a valid source of pitch, roll, and heading data. During system operation in any of the other modes, a dead reckoning geographic reference is periodically updated to maintain dead reckoning navigation data as accurate as possible.

10A-23. SYSTEM ALIGNMENT. In order to operate in any mode except dead reckon, the ANS must be aligned before commensing operation as an inertial system. Alignment involves: (1) leveling the platform to the local vertical, (2) establishing platform (horizontal accelerometers) orientation relative to true north, (3) determining rates required to maintain platform level and stabilized in heading. Alignment is divided into two phases; coarse alignment, in which the platform is roughly leveled, and fine alignment, in which the platform is accurately leveled. There are three different ground alignment routines and two airborne routines. The ground alignment routines, in the order of system accuracy achieved are: (1) gyrocompassing, (2) rapid, (3) hot start. Airborne alignments include cold airstart, which involves starting (restarting) the system over a known geographic position, and hot airstart, which involves resumption of system operation following an electrical power dropout of over 1 second. All alignment routines are initiated from the NCD panel. Gyrocompassing and rapid alignments are normally performed with test equipment connected to the guidance group; however, these procedures can (if required) be performed without use of test equipment. Figure 10A-4 lists events and time periods associated with the various methods of alignment. The following paragraphs give a brief description of the alignment procedures. More detailed information is provided under the heading of alignment and operational checkouts.

10A-24. Conditions which are common to all alignment procedures are:

a. System computer programed with required routines.

b. System at operating temperature. Warmup can, depending on ambient air and guidance group temperatures, take up to 60 minutes.

c. Accurate heading, present position coordinates, and altitude entered into system.

10A-25. The following routines, performed from the NCD panel, are, or can be, associated with system alignment.

a. Update True Heading. Enters manually selected true heading into system.

b. Fill Magnetic Variation. Enters manually selected magnetic variation into system. Required when system is using INS as magnetic heading reference.

c. Fill Present Position. Enters manually selected latitude and longitude coordinates into system.

d. Fill Initial Altitude. Enters manually selected altitude into system.

e. Fill Day/Time. Enters manually selected day of year and GMT into system. Procedure is required only if chronometer fails and a replacement is not available.

f. Normal Display/Display Time/Display True Heading. NCD displays of GMT, etc; day of year; and system true heading.

g. Ground Alignment Correct. Returns system to final stage of fine alignment. Procedure is performed if system has been placed in operation and airplane departure is delayed. Airplane must be stationary. Procedure prevents buildup of navigational errors which would otherwise occur if system remained in operation in a navigate mode.

h. Runway Azimuth Alignment. Procedure performed during takeoff. Provides a true heading reference for system. Required following a rapid or ground hot start alignment where true heading reference was not accurate to within 0.1 degree and star tracking has not commenced.

10A-26. Gyrocompassing Alignment. From a standpoint of system navigational accuracy, gyrocompassing is the preferred method of alignment. Aside from the time required to set up and connect test equipment, fill ANS computer memory with required programs, and warm up the system, the time required for actual alignment is about 37 minutes. Alignment includes a 6-minute coarse alignment phase in which the computer initiates self test and system test routines and the inertial platform is roughly leveled. Following coarse alignment, the system enters a fine alignment phase in which two gyrocompassing routines are performed in succession, with the platform rotated 90 degrees in azimuth for the second

NAVIGATION MODE	ALIGNMENT METHOD	ALIGNMENT TIME	
ASTROINERTIAL OR INERTIAL ONLY (GROUND ALIGNMENT)	GYROCOMPASSING		
	Warm up	60 min (max)	
	Coarse Align	6 min	96 min 55 sec (max)
	Fine align	30 min 55 sec	
	1st align	12 min 10 sec	
	slew	1 min 30 sec	
	2nd align	17 min 15 sec	
	RAPID		
	Warm up	60 min (max)	
	Coarse align	6 min	78 min 15 sec (max)
	Fine align	12 min 15 sec	
	GROUND HOT START		
	Warm up	60 min (max)	
	Coarse align	Until platform is roughly leveled (< 10 arc min)	approx 61 min (max)
	Restart	30 sec	
COLD/HOT AIRSTART (INFLIGHT ALIGNMENT)	COLD/HOT AIRSTART		
	Coarse Align Phase	Until platform is rough leveled (< 40 arc min)	
	Restart	2 minutes	
	Navigate Phase	Continuous after platform leveling	
	Dead Reckon	Continuous from Fill Present Position (during coarse align) to steady ★ON light	
	Search for Star A & B	Continuous from platform leveling, plus 5 min, to steady ★ON light	
	Airmass-damped, astroinertial navigation	Continuous after steady ★ON light	

Figure 10A-4. Alignment Methods and Alignment Times gyrocompassing operation. Gyrocompassing involves monitoring the apparent horizontal drift rate of the platform gyros and using this information to determine the relationship of platform horizontal accelerometers to true north. This permits accurate determination of system (airplane) heading and gyro azimuth drift rates. Simultaneously with gyrocompassing, the system performs fine alignment (leveling) of the platform which includes determining gyro horizontal drift rates. Completion of fine alignment is indicated on the NCD panel by shifting of initially entered present position data to the PRESENT LATITUDE and LONGITUDE counters. The system does not start navigating until either manually initiated on the NCD panel or the airplane begins to move.

10A-27. Rapid Alignment. This is a slightly shorter alignment than gyrocompassing, requiring (in addition to time needed for connection and set up of test equipment, computer memory fill, and system warmup) approximately 18 minutes to perform. Following a coarse alignment phase, the same as in gyrocompassing, the system continues with a fine alignment phase in which the platform is accurately leveled and gyro horizontal drift rates are determined. Since gyrocompassing is not performed, either accurate heading (within 0.5 degree - preferably within 0.1 degree for optimum navigation accuracy) must be entered into the system during coarse alignment or system must be tracking stars (★ON light on); otherwise, a runway azimuth alignment routine must be performed during takeoff. Completion of fine alignment indication and start of system navigation is the same as described for gyrocompassing.

10A-28. Ground Hot Start Alignment. This is a minimum-time alignment, requiring approximately 1-1/2 minutes to perform following system warmup. Accurate present position and heading information must be stored in the ANS computer in order to perform the alignment. This is accomplished by having a gyroscompassing alignment or rapid alignment (with accurate heading data inserted) performed at an earlier time or by having the system, at turn off following prior operation, accurately indicate aircraft present position and heading. With accurate present position and heading data stored in the system computer, power can be removed from the airplane; however, the airplane cannot be moved (stored position and heading data will not be accurate) nor can a new mission tape be filled into the computer memory (stored position and heading data will be destroyed). Completion of alignment is indicated by F/A displayed by the MODE indicator. The system does not start navigating until either manually initiated on the NCD panel or the airplane begins to move.

10A-29. Cold Airstart Alignment. This alignment, which continues as long as the system operates in the airstart mode, is performed to start or restart the system during flight. A prerequisite for performing the alignment is that present position coordinates of a point to be overflown must be entered through the NCD panel when the airplane is at that location. During the coarse alignment phase and until at least three stars have been tracked (NCD panel ★ ON light on), the system navigates using dead reckoning processes. During this period, the airplane should remain on a constant heading at a constant airspeed. After star tracking is in progress, the system operates in the astroinertial mode.

10A-30. Hot Airstart Alignment (Automatic Restart). This procedure commences following an electrical power interruption of over 1 second (power dropouts of less than 1 second do not affect system operation). Unlike the cold airstart alignment, hot airstart does not require entering present position coordinates of a point to be overflown. Instead, the system dead reckons from the point of power interruption until star tracking is resumed. The alignment processes are similar to cold airstart, with the system operating in the astroinertial mode once star tracking is in progress.

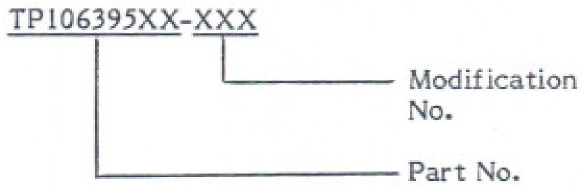
10A-31. COMPUTER PROGRAMMING. The ANS computer, mounted on the bottom of the guidance group, performs all the mathematical operations and storage of data related to basic functions of the system; computation of navigation information (present position latitude, longitude, altitude, heading, etc.); control of star tracking telescope and use of star tracking data; calculation of flight path data related to a specific mission flight profile; and automatic control of the radar system EIP/EMR and TEOC cameras. In performing these operations,- the computer must be programed with specific data and instructions. This is accomplished by using a computer memory fill procedure together with appropriate computer fill AGE and programming tapes.

10A-32. The tapes which are used for programming the computer, must be filled prior to preflight alignment, in the following sequence: (1) main program tape, (2) correction tape, (3) general instrument constant (GIC) tape, (4) star tape, (5) mission tape. In addition, an interface test tape may be filled if ANS interface tests with other airplane avionics equipment are required. Appropiate records must be maintained to ensure correct tape usage and that tapes are up to date.

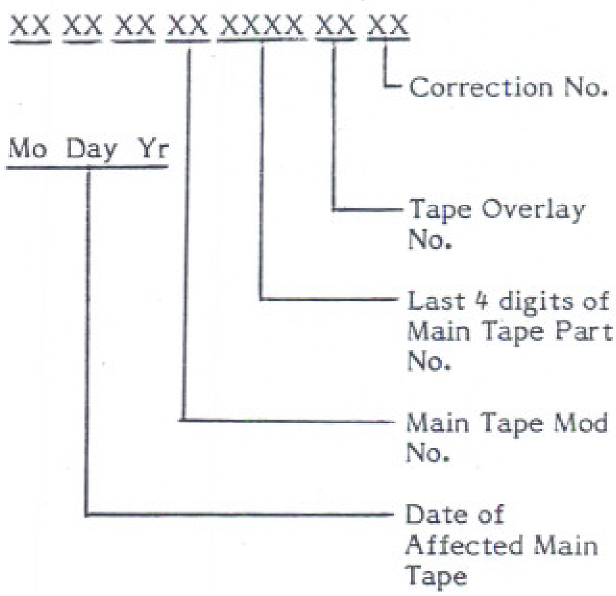
NOTE

It is not necessary that computer fill take place immediately before alignment, only that the required data be stored in the computer memory prior to that time. The actual fill operation may take place any time prior to alignment.

10A-33. Main Program Tape. The main program tape contains the basic instructions and constants for computer operation and all computational and control routines for performing the various modes of navigation. Routines provided by this tape perform all ANS-to-avionics data processing (radar system and TEOC cameras control and airplane control through the DAFICS using the constants in the mission tape. See figure 10A-30 for correct tape according to payload configuration. Main program tapes are identified as follows:



10A-34. Correction Tape. The correction tape includes data to modify or add to the instructions on the main program tape. New correction tapes are issued as routines are improved. Correction tapes are eliminated upon reissue of a new main program tape incorporating the improved procedures. Correction tapes are identified as follows:



10A-35. General Instrument Constants (GIC) Tape. Each astroinertial instrument (AI) (inertial platform and star tracking telescope module at top of guidance group) is provided with a tape that contains factory-measured performance factors (constants) for that specific instrument. These constants are used by the computer in performing ANS navigation computations and star tracking operations. Each tape can be used only for the AI for which it was developed. (ANS system performance is unpredictable if the wrong GIC tape is used.) The GIC tape is filled after filling the main program tape and correction tape, if any. Identification of GIC tapes is as follows:

TP10639510-XXX-AISN-XX-YYY-GICXX-

- Calibration No. (cumulative)
- AI Serial No.
- Tape Modification No.
- Part No.

XX XX XX

- Date Tape Made (day, mon, yr)

10A-36. Star Catalog Tapes. There are two different star catalog tapes; Normal (SR-71A airplanes) and TSC North (SR-71B/C airplanes). These tapes provide star location and brightness information for 61 stars, together with avoidance data for the sun, moon, and planets. The information provided in the star tapes is valid for the period from January 1 through December 31 of the designated year. These tapes can be used for an additional 146 days into the following year by setting the chronometer to the cumulative day count from the beginning of the previous calendar year. e.g. If star tape for 1979 is used on 25 January 1980, the chronometer day count must be 390 (365 + 25). (Leap years are 366 days long.) Star tapes are identified as follows:

TP10639520-XXX Type Valid 19XX

- Star Epoch Year
- ANS - Normal TSC - North
- Identification No. (Changes each Year)
- Part No.

10A-37. Mission Tape. The mission tape defines a specific mission profile to be flown. The tape includes the coordinates and other data for destination points (end points on legs of mission towards which the airplane will be automatically guided by the DAFICS), fixpoints (geographic locations at which the viewsight, CAPRE, ASARS, or TACAN is used to monitor/update ANS navigation), and control points (geographic locations for turn on/turn off or change in automatic operation of CAPRE, ASARS and TEOC cameras). The actual mission flown can be modified to some extent by the RSO during flight. New mission profiles require development of new mission tapes. Two types of mission tapes are identified as follows:

TP10639515-0XXX used with main program tape 12 (CAPRE only).

TP 10639515-8XXX used with main program tape 13 (ASARS only).

10A-38. COMPONENT DESCRIPTION. (See figure 10A-1 for illustration of ANS components and figure 10A-5 for listing of ANS component part numbers and approximate sizes and weights.)

10A-39. GUIDANCE GROUP. (See figure 10A-6.) The guidance group contains the inertial, star tracking, computational, and avionics interface components of the ANS.

Nomenclature	Part Number	Approximate Dimension (inches) Length	Width	Depth	Weight (pounds)
Chronometer	LW10631000-( )	7-3/4	7-3/4	4-1/2	10
ANS (Outer) Window	LW10631002-( )	9.0 dia	--	0.5	3
Isolator (4 reqd)	LW10631003-( )	--	--	--	--
Navigation Control and Display Panel	LW10636000-703B or 704A ⚠1	11-3/4	9-3/8	10-1/4	23
Guidance Group ⚠2	LW10638000-( )	31	21	29	316 (approx)
V-Scan Junction Box	4AR660	4-1/4	4-1/4	2-5/8	1
Sensor Signal Processor	LW10639155	6-1/3	5	4	2
Interface Box	LW10639195	6-1/3	5	4	2

⚠1 Panels with ECP LW-377 (Lamp modification)

⚠2 In order to operate ASARS with main program tape 13, the guidance group must be modified by ECP LW 378. Modified units will be placarded: ASARS Compatible. (On computer and astroinertial instrument).

Figure 10A-5. Table of ANS Components

The unit, an essentially rectangular object weighing approximately 316 pounds, is installed on four vibration isolators in the air conditioning bay. The upper portion of the guidance group is referred to as the rack assembly (rack). This assembly contains all of the functional components of the guidance group except for the digital computer which is attached to the bottom of the rack. Components of the rack include the following subassemblies:

a. Astroinertial Instrument (AI)

b. Platform Electronics and Power Supply

c. Tracker Electronics

d. Data Converters (3 separate modules)

e. Interface Servomechanisms (19 separate modules)

f. Interface Relays (1 subassembly)

g. Amplifiers, power filters, heaters, and thermoconditioner controls

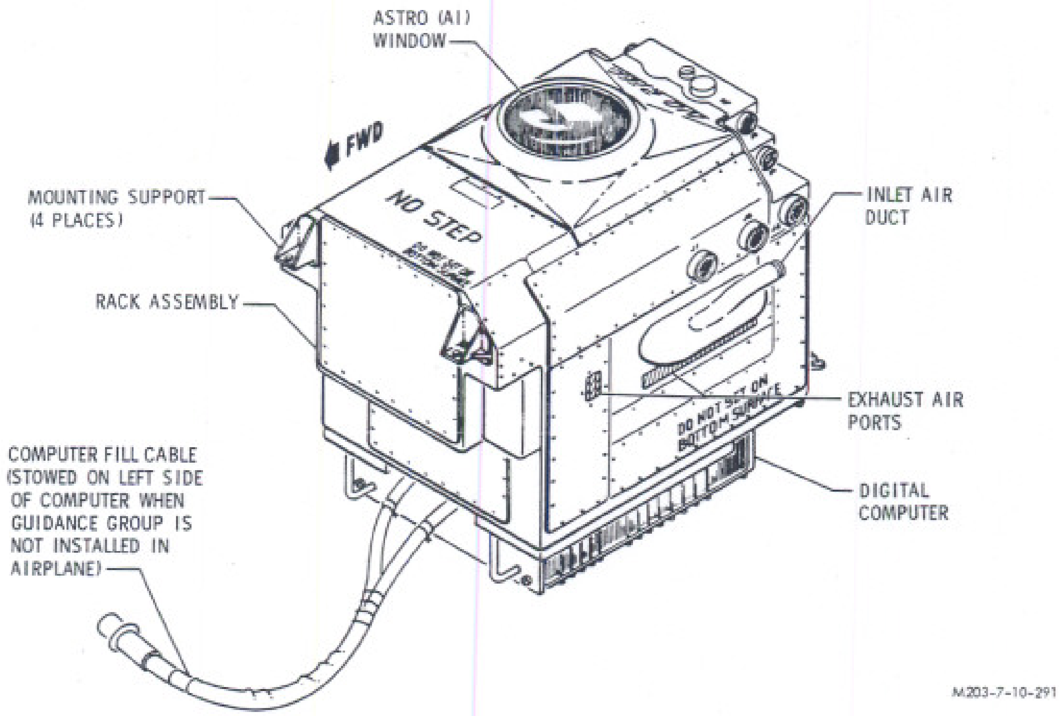
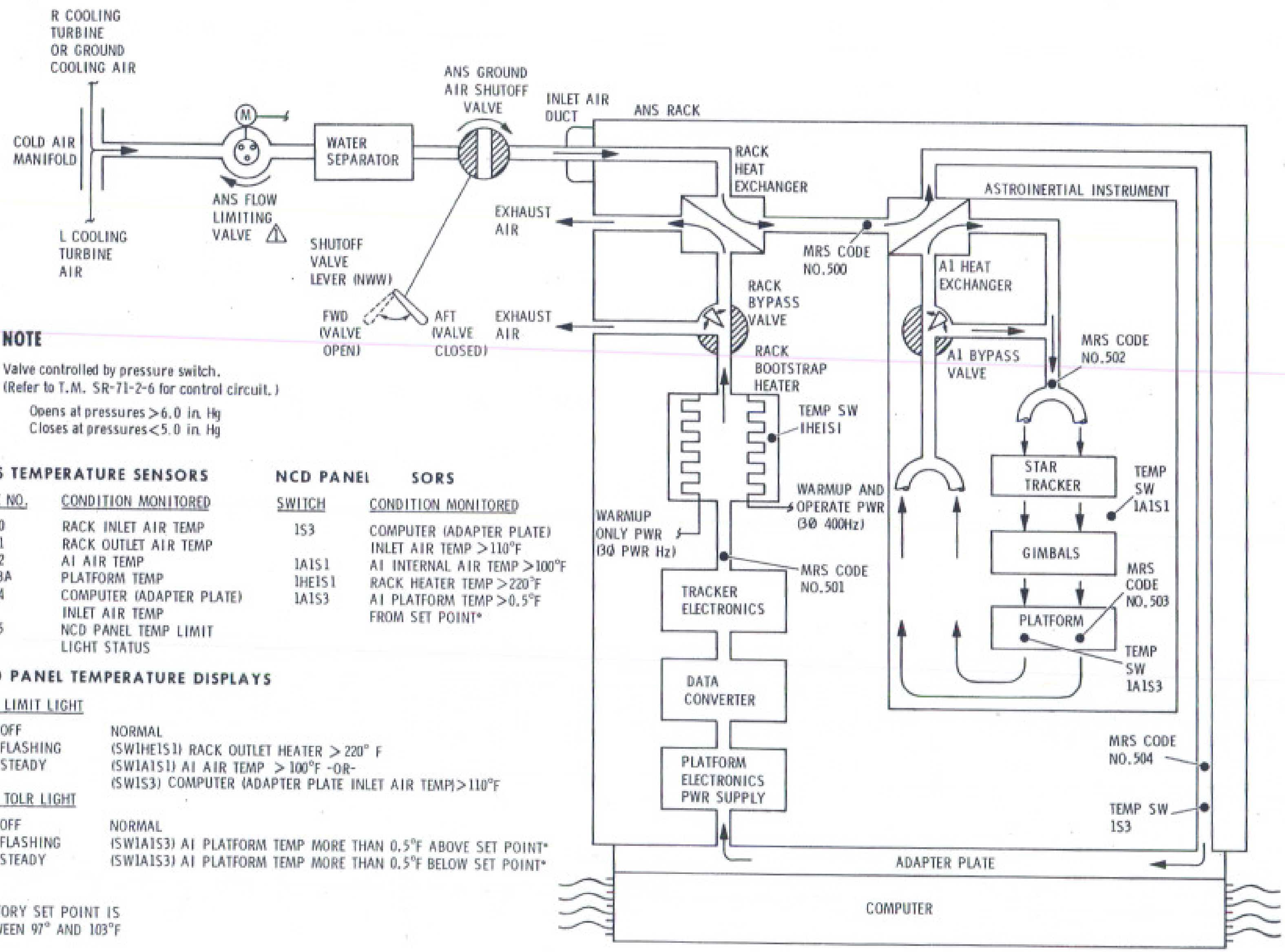


Figure 10A-6. Guidance Group

10A-40. Externally, the guidance group is characterized by an astro (AI) window in the top of the rack (a similar window, ANS window, is installed in the air conditioning bay hatch over the guidance group), by 12 electrical connectors (located in the aft portion of the rack), by four mounting supports (two at the forward end and two at the aft end), by a computer fill cable (connected to the forward end of the computer), and by an air inlet duct and two exhaust air ports on the left side of the rack.

10A-41. <u>Guidance Group Thermal Control.</u> (Refer to paragraph 10A-9 for guidance group cooling air temperature and flow requirements. See figure 10A-7 for simplified schematic of guidance group cooling air flow.) Cooling air applied to the guidance group, together with various internal heaters, is used to maintain the unit at an operational temperature. Out-of-limit or out-of-tolerance temperature conditions are displayed on the NCD panel by illumination (flashing or steady) of the TEMP LIMIT or TEMP TOLR lights.

10A-42. Cooling air, from the airplane cooling air turbines or from a ground air conditioning cart, is supplied to the guidance group through the airplane cold air manifold, a flow limiting valve, a water separator, and



NOTE

⚠ Valve controlled by pressure switch.
(Refer to T.M. SR-71-2-6 for control circuit.)

Opens at pressures >6.0 in. Hg
Closes at pressures <5.0 in. Hg

MRS TEMPERATURE SENSORS

CODE NO.	CONDITION MONITORED
500	RACK INLET AIR TEMP
501	RACK OUTLET AIR TEMP
502	AI AIR TEMP
503A	PLATFORM TEMP
504	COMPUTER (ADAPTER PLATE) INLET AIR TEMP
505	NCD PANEL TEMP LIMIT LIGHT STATUS

NCD PANEL SORS

SWITCH	CONDITION MONITORED
1S3	COMPUTER (ADAPTER PLATE) INLET AIR TEMP >110°F
1A1S1	AI INTERNAL AIR TEMP >100°F
1HE1S1	RACK HEATER TEMP >220°F
1A1S3	AI PLATFORM TEMP >0.5°F FROM SET POINT*

NCD PANEL TEMPERATURE DISPLAYS

TEMP LIMIT LIGHT

OFF	NORMAL
FLASHING	(SW1HE1S1) RACK OUTLET HEATER > 220° F
STEADY	(SW1A1S1) AI AIR TEMP > 100°F -OR- (SW1S3) COMPUTER (ADAPTER PLATE INLET AIR TEMP) >110°F

TEMP TOLR LIGHT

OFF	NORMAL
FLASHING	(SW1A1S3) AI PLATFORM TEMP MORE THAN 0.5°F ABOVE SET POINT*
STEADY	(SW1A1S3) AI PLATFORM TEMP MORE THAN 0.5°F BELOW SET POINT*

*FACTORY SET POINT IS BETWEEN 97° AND 103°F

N203-10-290(c)

Figure 10A-7. Guidance Group Air Flow Schematic a ground air shutoff valve. The motor-operated flow limiting valve is controlled by a barometric switch. The valve operates to reduce the flow of cooling air to the guidance group at higher altitudes. The ground air shutoff valve is manually operated by a lever-controlled cable. The lever, located overhead at the forward left portion of the nose wheel well, is maintained in the aft (valve closed) position when the ANS is turned off. This helps to prevent cold soaking of the guidance group and assists in reducing the collection of water in the unit, which would otherwise occur due to moisture in the ground cooling air. The lever must be moved forward to open the valve before the ANS is turned on.

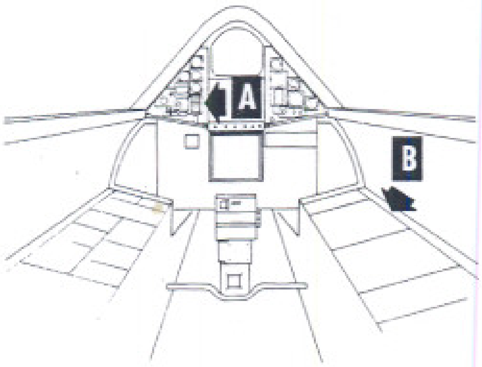
CAUTION

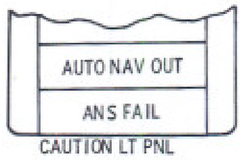
If out-of-limit or abnormal out-of-tolerance temperature indications occur during ground operation of the ANS, the ANS ground air shutoff valve lever and, if necessary,. the shutoff valve must be checked to ensure that the valve is open.

10A-43. Cooling air entering the guidance group is routed through two heat exchangers (a rack heat exchanger for warming, as required, inlet air and an AI heat exchanger for warming/cooling the AI) then through an adapter plate to which is attached the digital computer. The computer is cooled by conduction through the adapter plate and by convection and radiation from external fins. Air leaving the adapter plate flows through electronic subassemblies into a makeup or bootstrap heater which heats the air for application to the rack heat exchanger. The amount of heated air applied to the rack heat exchanger, determined by guidance group internal temperatures, is controlled by the rack bypass valve. Air leaving the heat exchanger and bypass valve is dumped into the air conditioning bay. Within the sealed AI, air flow through the secondary side of the AI heat exchanger and AI bypass valve maintains, together with operation of AI component heater circuits, the AI at a proper operating temperature (platform temperature stabilized to within 0.5°F of factory set point, between 97° and 103°F.)

10A-44. For the purpose of post-flight analysis, five temperature conditions are monitored within the guidance group by the MRS. The MRS temperature monitor points are indicated in figure 10A-7. In addition, four temperature switches are provided to control the temperature lights on the NCD panel. Temperature conditions monitored and resulting NCD TEMP LIMIT/TEMP TOLR light operation are indicated in figure 10A-7.

10A-45. NAV CONTROL AND DISPLAY (NCD) PANEL. (See figure 10A-8.) The NCD panel, installed in the aft cockpit right console, provides the manual controls and displays required for turn on, warmup, alignment, and operation of the ANS. Through use of the panel controls and displays the operator can select the mode of system operation, can monitor for abnormal guidance group temperature and malfunction conditions, can enter various data into the system computer (airplane true heading, magnetic variation, GMT/day of year, etc.), can modify the programed mission profile, can monitor and, as required, update system present position (using radar, viewsight, TACAN, etc.), and can display a variety of navigational data (present position, ground speed, true heading, altitude, etc.) NCD panel controls and displays are described in figure 10A-9 and panel routines and associated displays are indicated in figure 10A-10. NCD panel lighted indicators are checked by utilizing the TEST function on the NCD panel.





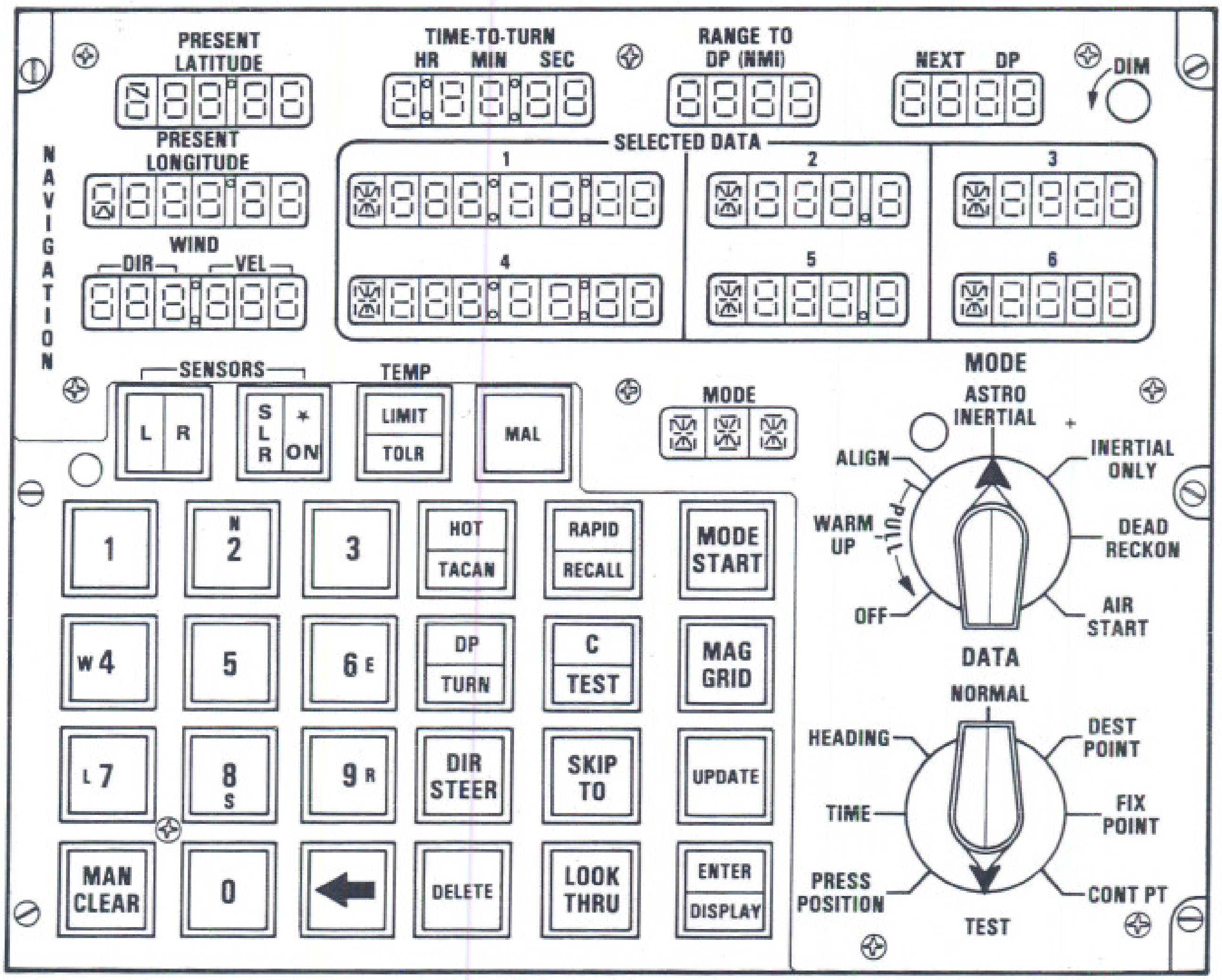
DETAIL A

ANS FAIL CAUTION LT ⚠1

NOTE

1. ANS REF caution light, forward cockpit center stand, is in parallel with ANS FAIL light.

2. Displays are shown in TEST mode. The first characters of PRESENT LATITUDE and PRESENT LONGITUDE are modified to allow display of N/S and E/W.



DETAIL B

NCD PANEL

M203-10-334(c)

Figure 10A-8. Nav Control and Display (NCD) Panel and ANS Caution Lights

CONTROL/INDICATOR	FUNCTION
PRESENT DATA Indicators	All displays above and to the left of the SELECTED DATA block. Except for the PRESENT LATITUDE and LONGITUDE these displays are not selectable and indicate data as labeled.
PRESENT LATITUDE	Displays inertial present position latitude and longtitude in degrees and minutes of arc during normal system operation. Displays dead recon position while in dead recon mode of operation and during inflight alignment until star tracking commences then inertial position is displayed. During ground alignment the display is blank until completion of fine alignment.
WIND DIR VEL	Wind direction in degrees, wind velocity in knots. Displays zero while on ground.
TIME-TO-TURN HR MIN SEC	Time to turn start prior to current destination point. Displays zeros when the aircraft is not moving.
RANGE TO DP (NMI)	Range to current destination point (up to 9999 NM). Display is blank during align until present position is entered.
NEXT DP	Current destination point ID code. Blank during align until present position is entered. Only the last four digits of the five digit code are displayed. The first digit is always zero.
SELECTED DATA digital indicators, 1 thru 6	Six indicators which display various information during display, fill, update, and mission modification routines as shown in figure 10A-10.
MODE SWITCH	A seven position switch which permits selection of system warmup, alignment, or one of four operating modes. A detent prevents inadvertent turning of the switch from an operate position back to WARM UP. To return the switch to WARM UP, the knob must be pulled out slightly. A stop prevents moving the switch from AIR/START to OFF. After moving MODE switch from WARMUP to an operating mode, HOT, RAPID or MODE START (for gyrocompass) must be pressed to start the desired alignment.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 1 of 9)

CONTROL/INDICATOR	FUNCTION
Position OFF	All power except chronometer power, is removed from the system.
WARM UP	Without ECP LW-377, (-703 panels): Power is applied to guidance group temperature control circuits. All pinlight displays will be blank, the SENSORS and ★ ON light and all NCD panel pushbuttons come on except the unselected half of the MAG/GRID switch. With ECP LW-377, (-704 panels): Power is applied to guidance group temperature control circuits. The following lights come on; keyboard numbers 1 thru 0, MANUAL CLEAR, backspace, MAG or GRID, and MAL. **NOTE** Full operating power is applied to the entire ANS when the MODE switch is moved past WARMUP to ALIGN, ASTRO INERTIAL, INERTIAL ONLY, or DEAD RECON. C/A appears in the MODE window and the MAL light will flash. To continue alignment and extinguish the MAL light, MODE START, RAPID or HOT switch is pressed according to the type of alignment required.
ALIGN	Used to remain in fine alignment after ground alignment is completed, or to return to fine alignment after navigation (on the ground) has started (Ground Alignment Correct routine).
ASTRO INERTIAL	Used to select astroinertial navigation.
INERTIAL ONLY	Used to select inertial only navigation.
DEAD RECKON	Used to select dead reckon navigation.
AIR START	Used to perform a cold airstart (inflight) alignment which results in airspeed-damped astroinertial navigation.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 2 of 9)

CONTROL/INDICATOR	FUNCTION
DATA switch	An eight position switch which permits various routines to be performed as shown in figure 10A-10 and described in APPENDIX A. Switch positions versus applicable routines are as follows:

Position	Routine
PRES POSITION	(1) Display Present Position (alternate frame), Sun Angle, and Nav Altitude (2) Fill Present Position and initial altitude (3) Update Present Position Using Remote Source
TIME	(1) Display time, Day of Year and Star Data (2) Fill Time and day (3) Update Chart Convergence Factor (CCF)
HEADING	(1) Display True, Mag and Grid Heading, Track, CCF and Mag Var (2) Fill Magnetic Variation (3) Runway Heading Alignment (4) Update True Heading (5) Select Grid/Mag Mode
NORMAL	(1) Display Current Navigation and Mission Information (2) Skip to DP (3) Direct Steer to DP (4) Update Track Leg
DEST POINT	(1) Display Next DP (2) Display Selected DP (3) Add or Replace DP (4) Update Track Leg (5) Skip to DP (6) Delete DP (7) Direct Steer to DP (8) LOOK THRU (Display DP after next) (9) Clear 40 List
FIX POINT	(1) Display Next FP (2) Display Selected FP (3) Add or Replace FP (4) Delete FP (5) Update Present Position - Anytime TACAN FP plus RECALL (6) Clear 40 list

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 3 of 9)

CONTROL/INDICATOR	FUNCTION
CONT PT	(1) Display Next CP (2) Display Selected CP (3) Add or Replace CP (4) Delete CP (5) Clear 40 list
TEST	(1) Initiate Panel Functional Test (2) Fill Wind (3) Display Tape Numbers (4) Display Failure Codes and Internal Operating Parameters
SENSORS	Indicators come on to reflect automatic (ANS commanded) operation of associated sensor(s).
L indicator	Left technical objective camera selected for automatic operation (CP only)
R indicator	Right technical objective camera selected for automatic operation (CP only)
SLR indicator	Side-looking radar selected for automatic operation (CP or FP). If SLR indicator does not light for an approaching fixpoint, the viewsight is assumed to be the device used for the fixpoint operation.
SENSORS	
★ON indicator	Indicates tracking of platform collimator star during system coarse alignment by flashing once per second. Indicates progress in star tracking at completion of alignment in the ASTRO INERTIAL mode or during a cold or hot airstart, as follows: After tracking star A; indicator flashes once per second After tracking star B; indicator goes out After tracking star C; indicator comes on steady
TEMP LIMIT/TOLR indicators	A dual indicator which reflects guidance group internal temperatures (see figure 10A-8). Both indicators are normally off.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 4 of 9)

CONTROL/INDICATOR	FUNCTION
TEMP LIMIT indicator (red)	(1) Flashing: rack outlet heater temperature above 220°F (guidance group air flow below 2.5lb/min) (2) On steady: AI internal air above 100°F or computer adapter plate inlet air above 110°F. **NOTE** ANS REF caution light, forward cockpit, and ANS FAIL caution light, aft cockpit, (as well as associated master CAUTION lights in both cockpits) come on whenever the TEMP LIMIT light comes on. Status of TEMP LIMIT light is monitored and recorded by the MRS.
TEMP TOLR indicator (amber)	(1) Flashing: AI platform temperature more than 0.5°F above factory set point* (2) On steady: AI platform temperature more than 0.5°F below factory set point* * Set point located between 97° and 103°F
MAL indicator (red)	Indicates that system is not in an operate state or that a malfunction has occurred. Light is normally off when system is in operation. Light is on steady when MODE switch is in WARM UP position. When system is in an operating mode, a flashing MAL light indicates that ANS self tests have detected a malfunction or that a power dropout of more than 1 second has occurred. If MAL indicator comes on, MODE indicator will usually indicate the corrective action required. (Refer to paragraphs 10A-89, and 10A-295 for MAL light indications associated with system self tests and related trouble shooting procedures.) **NOTE** ANS REF and ANS FAIL caution lights, as well as associated master CAUTION lights, come on whenever the MAL indicator comes on.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 5 of 9)

CONTROL/INDICATOR	FUNCTION
MODE indicator	Displays the operating phase of the ANS, an operational error, or the corrective action to be taken in the event of a malfunction (refer to trouble shooting in this section).
Indication	
Blank	MODE switch in OFF or WARM UP (28 vdc applied to system)
C/A	Coarse Align. First phase of all alignments
CAL	Accelerometer null bias calibration
F/A	Fine Align. Final phase of gyrocompassing and rapid ground alignments
RES	Restart. Phase of alignment following coarse align for a cold or hot airstart and for a ground hot start alignment
A-I	Astroinertial navigation
I/O	Inertial only navigation
D/R	Dead-reckon navigation.
ENT	Coarse alignment phase is completed and present position coordinates must be filled and entered.
ERR	Operator error in performing a panel operation. Also numeric data in SELECTED DATA display flashes.
TST	Test Mode
DP ⊠	Mission Tape Error (nonexistent destination point)
EIP	EIP/EMR correlation code interface test in progress.
ENC	Gimbal angle encoder failure.
DIM knob	Controls intensity of numeric and alphanumeric pinlight displays. All other indicators, pushbuttons, and edge lights are controlled by the R CONSOLE knob located on the aft end of the left console.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 6 of 9)

CONTROL/INDICATOR	FUNCTION
PUSHBUTTON SWITCHES	
Keyboard: 1, N (north) 2, 3, W (west) 4, 5, 6 E (east), L (left) 7, 8 S (south), 9 R (right) and 0	Switches used to insert data into the system computer and for display of this data on the NCD panel. The proper geographic sign or direction and all required digits must be depressed each time position coordinates or corrections are inserted into the system.
MAN CLEAR	Switch is used to clear the SELECTED DATA registers if an error is made while performing a panel initiated routine. Each press of the switch erases one data register in reverse of the order in which they were filled. If no panel routines are in progress or ERR is displayed in system MODE indicator, pressing MAN CLEAR erases all registers and lights a cue letter in the next register that can be filled. Also used to bypass an ANS fixpoint or runway heading update and when attempting to clear malfunctions.
BACKSPACE (arrow symbol)	While filling data, prior to pressing an action button such as ENTER, each press of the backspace switch erases 1 character in reverse order. **NOTE** With the exception of the MAG/GRID switch which displays its status at all times and DP/TURN switch which comes on as explained below, the following switches or switch segments come on when they are legitimately available for use. When not available, they are off.
HOT	When power is applied to the system, pressing the HOT switch initiates a ground hot start or hot airstart.
TACAN	Switch is used when performing a TACAN fixpoint operation. Pressing switch marks the time of reading TACAN data and freezes ANS computed values of TACAN range and bearing.
RAPID	Initiates a rapid ground alignment.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 7 of 9)

CONTROL/INDICATOR	FUNCTION
RECALL	Recalls previously entered Anytime TACAN fixpoint on the current leg only.
MODE START	When power is applied to the system pressing the MODE START switch initiates a gyrocompass alignment or a cold airstart. After alignment is initiated the MODE START switch enables the mode selected by the MODE and MAG/GRID switches.
DP/TURN	This switch selects the ANS distance output to the HSI. With DP selected, the HSI displays distance to the current destination point. With TURN selected distance is to the turn start point at the end of the leg. With TURN, the indication decreases to zero and the aircraft should start a turn while the ANS indexes to the next DP. The distance display then becomes the along track distance around the turn to the next turn start point. Both legends are out during normal operation. To display the status of the switch, set DATA switch to TEST and press DISPLAY. The status of the switch can only be changed when the previously selected half of the switch is on.
C	Not Functional.
TEST	Provides a panel light test and display of internally stored ANS condition and failure data when used with TEST position of DATA switch.
MAG/GRID	An alternate action switch on which either the MAG or GRID light is on. Pressing the switch turns off one legend and turns on the other. This switch is normally maintained in the MAG position at all times.
DIR STEER	Switch is used to make an immediate change of course to a selected DP (in computer memory) or to a panel filled latitude and longitude.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 8 of 9)

CONTROL/INDICATOR	FUNCTION
UPDATE	Switch is used in conjunction with the DATA switch to command the ANS to correct computed present position, heading, or chart convergence factor or to immediately change to a new great circle course between two DPs (track leg update).
DELETE	Switch is used to delete a specific panel-filled mission point from the 40 list of panel filled points or to clear the entire 40 list.
LOOK THRU	When LOOK THRU is pressed with DATA switch in DEST POINT, SELECTED DATA registers display DP information for the DP following the current DP. Range and time-to-turn are a total of the range and time-to-turn, to turn-start at the end of current leg, plus the along-track range and time around the turn and to the following DP.
ENTER/DISPLAY	Switch is used in conjunction with the DATA switch to command the computer to accept panel-filled data or to display requested data.

Figure 10A-9. Description of NCD Panel Controls and Indicators (Sheet 9 of 9)

NOTE

Abbreviations DP, CP, and FP, stand for destination point, control point, and fixpoint respectively. These geographical mission points of interest represent end points of great circle legs of a mission; locations for ANS control of radar, TEOC cameras, or EIP/EMR geographic alarm; and locations for monitoring ANS navigation accuracy using the radar, viewsight, or TACAN are described in paragraphs 10A-127 through 10A-137.

10A-46. CHRONOMETER. The chronometer is a portable time standard which supplies GMT within an accuracy of 1/100 of a second and the sequential day of the year. A self contained battery permits continued operation for at least 3 hours when the chronometer is disconnected from a source of external dc power.

10A-47. Externally, the chronometer is a box with a carrying handle, two electrical connectors (one for electrical power and one for GMT/day data outputs), an elapsed time meter (which indicates total time external power has been applied to unit), and a GO/NO-GO indicator. Chronometer time/day outputs are enabled only when external dc power is applied to the unit. If the internal battery is discharged and external power is not connected to the unit, a NO-GO display is provided, indicating that chronometer outputs will be unreliable. A GO display is provided when either external power is connected or, if disconnected, the internal battery is operable. With a GO indication, the chronometer is functional; however, it is not assurance that the unit will provide correct time and day data. (A chronometer NO-GO indication changes to GO when external power is applied, regardless of whether GMT/day errors exist or not.) The only way of ensuring correct chronometer GMT/day data is to be sure that a GO indication is observed when installing the unit in an airplane, prior to application of airplane dc power to the device. During system alignment, the chronometer is checked to ensure correct time/day outputs.

10A-48. The chronometer is set to GMT and day of year in the shop, using a time standard which receives WWV time signals. After being correctly set, the unit is transported to the airplane where it is installed in a rack just aft of the aft cockpit right console. After checking for a GO indication, airplane electrical cables are connected to the power and time connectors on the unit then the aft cockpit ANS dc circuit breaker is closed to supply external power to the chronometer.

NOTE

The chronometer must be calibrated to a time standard within the 24-hour period preceeding installation; it is preferable that the chronometer be calibrated just before being transported to the airplane for installation.

10A-49. V-SCAN JUNCTION BOX. The V-scan junction box is installed on the aft bulkhead of the aft cockpit, behind the fiberglass cover (doghouse) near the floor of the cockpit. The box, has four electrical receptacles, and is attached to the bulkhead with four screws.

10A-50. The V-scan junction box permits the ANS to sample inputs from V-scan encoders in the ADS, the radar RCD, and the viewsight. Altitude and true airspeed data is sampled from the ADS continuously, while radar fixpoint data (along-track and slant-range errors) or viewsight fixpoint data (viewsight cursor position) is sampled only when the RCD READ ERR switch is pressed or the viewsight READ button is pressed. In sampling this information, the ANS supplies excitation signal(s) through the juction box to the proper encoder(s) in the ADS, RCD, or viewsight. In return, V-scan encoder output is applied through the junction box to the ANS.

10A-51. SENSOR SIGNAL PROCESSOR (SSP). The sensor signal processor is installed on the lower hinged shelf at the forward end of the R-bay. The unit is secured with four bolts to a mount assembly which straddles the antiskid control box, just forward of the UHF ADF amplifier and relay assembly. Two electrical receptacles on the unit provide for electrical connection with airplane wiring.

10A-52. The SSP operates as part of the sensor event/frame count system (sensor log system). (Refer to T.M. SR-71-2-11 for description of this system.) In general, the SSP functions as follows:

a. Conditions exposure-taken signals from the various cameras, and event strobe signals from the EIP/EMR, into 6-millisecond wide pulses for application to the guidance group.

b. Processes guidance group data matrix output into frame count data and clock signals for application to the cameras and the EIP/EMR system.

c. Stretches OBC camera center-of-scan signals into 210-millisecond wide pulses for application to the MRS as OBC "event" signals.

d. Processes guidance group data matrix output into EIP/EMR geographic alarm signals.

10A-53. ANS INTERFACE BOX. The interface box is installed on the right side of the aft cockpit aft bulkhead. The unit is secured to the bulkhead with four bolts. Two electrical receptacles on the box provide for electrical connection with airplane wiring. Externally, except for nameplates, the ANS interface box and the sensor signal processor are identical in appearance.

10A-54. The interface box, which has space provisions for future circuits, is currently used to develop airplane roll angle correction signals for the OBC camera and roll angle stabilization signals for the TEOC C cameras from the data matrix output of the guidance group.

10A-55. ANS WINDOW. The ANS window is installed in the air conditioning bay access panel. The ANS window in the panel and the AI (astro) window in the guidance group provide the star-tracker telescope in the AI with a 78-degree cone of vision.

10A-56. NAV RECORDER. The Nav recorder permits recording of 128-word ANS telemetry data while allowing continued recording of 32-word ANS telemetry data by the MRS. The recorder is installed in the forward end of the M-bay on an "as required" basis.

NOTE

The Nav recorder cannot be used on aircraft with a DEF M installed (S/B R-2513).

10A-57. Recorder Kit (4AT1021). The Nav recorder kit includes a tape recorder and a telemetry formatter, mounted on a tray, with associated electrical cables. The assembly is referred to as the Nav recorder assembly. (See figure 10A-11.) When the recorder assembly is installed in an airplane, an intercept cable must be connected between receptacle 1J3 and Plug 1P3 at the ANS guidance group.

10A-58. Electrical Power, Control, and Cooling Air. Electrical power for the recorder assembly is supplied from the IR system circuit breakers in the C-bay. Recorder operation (start-stop control only) is controlled by the NAV RCDR switch on the power and sensor control panel on the aft cockpit right console. The area in which the recorder assembly is installed is cooled by the airplane air conditioning system. Cooling air is not supplied directly to the recorder assembly.

10A-59. Operation. (See figure 10A-12.) When the recorder assembly is installed in an airplane, the ANS supplies 128-word telemetry data to the telemetry formatter which, in turn, supplies this data to the tape recorder. The formatter also extracts 32-word telmetry data which is then supplied to the MRS in the same manner as when the Nav recorder is not installed. The telemetry formatter, powered by 28 vdc from the IR circuit breaker in the C-bay, remains on as long as that circuit breaker is closed. The tape recorder has a recording capacity of approximately 6 hours. Operation of the recorder is controlled by the NAV RCDR power switch. Actuating this switch to light the ON legend places the recorder in a run condition. Actuating the switch to extinguish the ON legend (switch off) stops the recorder. The power switch has an interlock circuit which prevents the switch from being retained in an on condition or placed in an on condition (recorder commanded to run) when electrical power is removed from then reapplied to the airplane. Because of this feature, the power switch ON legend may not come on when the switch is first actuated. If this happens, press the switch a second time.

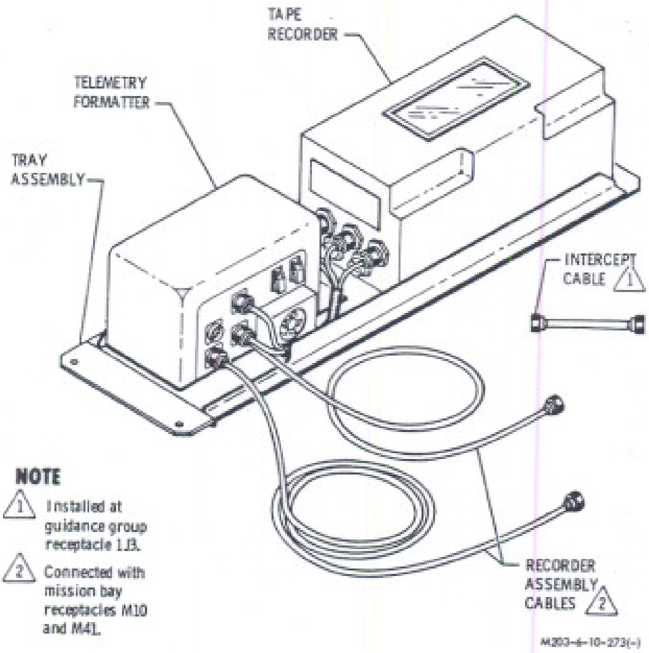


Figure 10A-11. Nav Recorder Assembly

10A-60. Recorder Fail Indication. Failure of the recorder is indicated by of the FAIL legend on the power switch. This light is controlled by a recorder clock-signal monitor circuit in the telemetry formatter. If the recorder clock signal is not received by the formatter because of tape transport or other failure within the recorder, the FAIL legend is turned on. Also, if the power switch on the recorder is inadvertently left in the OFF position during recorder upload (thereby preventing recorder operation) the FAIL legend comes on when the power switch is pressed on.

10A-61. SYSTEM OPERATING PROCEDURES.

NOTE

Unless otherwise indicated, all operating procedures are performed using the NCD panel.

10A-62. GENERAL. The ANS is normally placed in operation before flight. Either a gyrocompassing or rapid alignment is performed or, if accurate airplane position and true heading have previously been entered into the system's computer memory, a ground hot start may be performed. If time

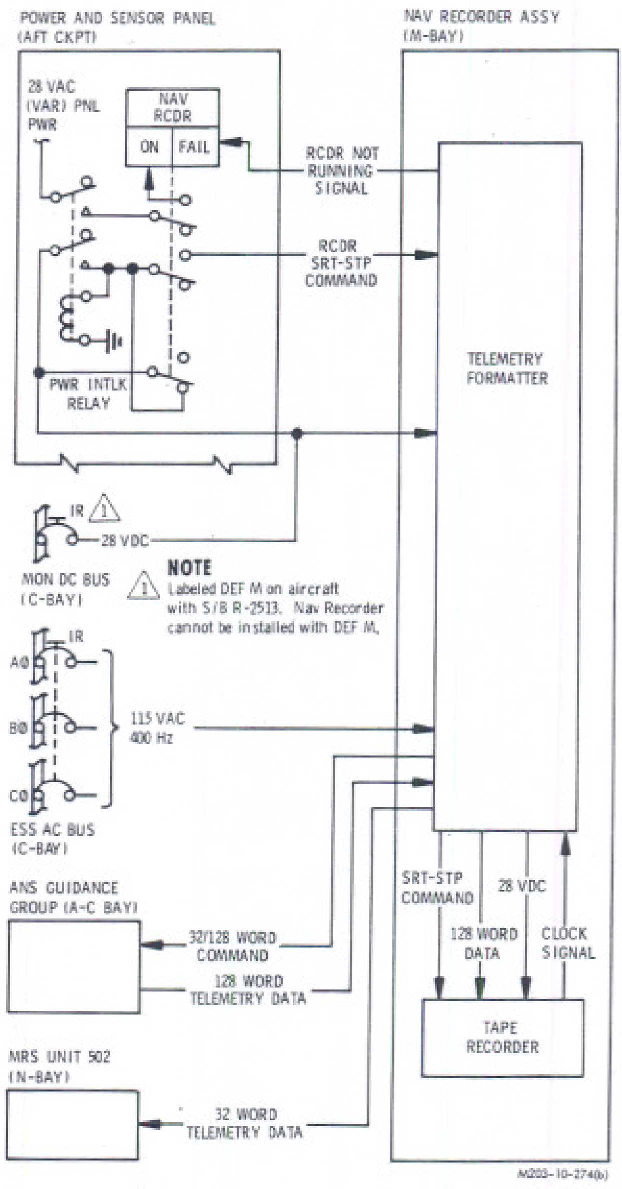


Figure 10A-12. Nav Recorder Interface Diagram permits, it is preferable to perform a gyrocompassing alignment; however, if airplane true heading is known within ± 0.5 degree (preferably within 0.1 degree for optimum navigation accuracy), a rapid alignment may be performed. If airplane true heading is not accurately known within ± 0.5 degree, either a rapid alignment can be performed, provided a Runway Heading Alignment routine is also performed during takeoff, or a gyrocompassing alignment is required. Airplane heading used in performing a gyrocompassing alignment (either entered true heading or INS magnetic heading and entered magnetic variation) must be accurate to within approximately 28 degrees. Prior to performing any ground alignment procedure, the computer must be filled with the proper programs and a properly operating and calibrated chronometer installed. The system must be warmed up before initiating fine alignment when performing either a gyrocompassing or rapid alingment, or before starting the alignment process when performing a ground hot start alignment. When performing either a gyrocompassing or rapid alignment, system warmup can be performed before system turn on, during system coarse alignment, or both; depending on the time available and ambient air and guidance group temperatures.

10A-63. Electrical power and cooling air must be supplied to the system during warmup, alignment, and operation. Once alignment has been started, a power interruption of over 1 second will, depending on when it occurs in the alignment process, and other factors, require either realignment or a hot start of the system. Normally system warmup and alignment are performed using external electrical power and cooling air applied to the airplane, with transfer to airplane power and cooling air following engine start. If necessary, warmup and alignment can be performed using airplane electrical power and cooling air only, after the engines are started.

10A-64. Normally the chronometer is installed and in a GO condition for system alignment and operation. If the airplane must operate from an alternate base without ANS support, the chronometer can be maintained in a GO state by continued application of dc power to the unit (electrical power applied to airplane, MODE switch on NCD panel set to OFF, and ANS dc circuit breaker closed on aft cockpit right console). In the event the chronometer changes to a NO-GO state, or for some reason is unavailable for installation, the ANS can be aligned and placed in operation in the astro-inertial mode by correctly filling time and day at the NCD panel or the system can be aligned and operated in the inertial-only mode. Operation of the system without a chronometer, or with a chronometer in a NO-GO state, should be done only as a last resort as the system will be adversely affected by power dropouts of any duration.

10A-65. SYSTEM WARMUP. System warmup is accomplished by setting the MODE switch to WARMUP. This allows warmup power to be applied to the system and permits a review of the TEMP LIMIT and TEMP TOLR lights before applying full operating power to the system. With the MODE switch set to WARMUP, the MAL light is on steady all pinlight displays will be blank, the SENSORS and ★ON lights and all NCD panel pushbuttons illuminate except the unselected half of the MAG/GRID switch, and power is applied to guidance group temperature control circuits. If the TEMP LIMIT light comes on (flashing or steady) the MODE switch should be immediately set to OFF and guidance group cooling air supply investigated. (A flashing TEMP LIMIT light infers an abnormally low flow of cooling air to the guidance group. A steady TEMP LIMIT light indicates a low flow of cooling air or cooling air temperature too high, or a combination of these conditions.) At operator's discretion, the system can be reactivated a second time to recheck the status of the TEMP LIMIT light. If light is still on, the MODE switch must be set immediately to OFF and investigation of the problem initiated.) The TEMP TOLR light indicates the temperature state of the AI platform. Correct platform operating temperature is ± 0.5 degree from a factory set point, located between 97° and 103°F. If platform temperature is within the correct range, the TEMP TOLR light will be out. If platform temperature is high, the TEMP TOLR light will flash. If platform temperature is low, the light will be on steady. With the TEMP TOLR light out, desired alignment can be initiated and completed. A steady or flashing TEMP TOLR light requires continued warmup (or cool down), either during the initial phase of alignment or before initiating alignment, depending on the method of alignment employed. If a gyrocompassing or rapid alignment is to be performed and the TEMP TOLR light is on (steady or flashing), the alignment can proceed to the point at which present position is to be entered into the system (coarse alignment completed), at which time the TEMP TOLR light must be off before continuing. If a ground hot start alignment is to be performed, it is desired the TEMP TOLR light be out before initiating the alignment. If a flashing TEMP TOLR light is observed, the MODE switch should be retained in the WARMUP position to allow the AI internal fan and AI heat exchanger bypass valve to operate, to assist in lowering platform temperature. In addition, it should be verified that the ground air conditioning cart is supplying air at the proper temperature and pressure to the airplane and that the ANS ground air shutoff valve is open (shutoff valve lever in nose wheel well positioned fully forward). Also, if airplane is in the open on a hot day, it may be helpful to shade the ANS window in the air conditioning bay hatch. If a steady TEMP TOLR light is observed, the coarse align phase of a gyrocompass or rapid alignment can be initiated to expedite warmup but heading update and present position and initial altitude entry must be delayed until the TEMP TOLR light goes out. This method of shortening warmup time cannot be used when conducting a ground hot start alignment as it will prevent that type of alignment from being successful.

10A-66. <u>Preparation for Alignment and System Warmup</u>. Detailed procedures for these operations are provided in the alignment and operational checkout portion of this section.

10A-67. GROUND ALIGNMENT PROCEDURES. The following paragraphs and System Operation provide a brief description of the alignment routines. Detailed alignment procedures are provided in the alignment and operational checkout portion of this section.

10A-68. <u>Delaying Navigation.</u> For optimum navigation accuracy, alignment should be initiated in the ALIGN mode. At completion of alignment, navigation will commence only upon manually enabling the ASTRO INERTIAL or INERTIAL ONLY mode or by forward motion of the airplane.

10A-69. <u>Alignment in Hanger.</u> When alignment is performed in a hanger, there is a possibility that the system will track false stars (ceiling lights, etc.) if permitted to transition from alignment into the astro-inertial mode. To prevent this from happening, the INERTIAL ONLY mode is selected and enabled after completion of an alignment. After the airplane taxies into the open, the ASTRO INERTIAL mode is selected and enabled. When alignment is performed in the open, in clear weather it is not necessary to enable the inertial only mode in the manner indicated. In overcast weather it is preferable to select and enable INERTIAL ONLY mode otherwise the star tracker will continuously cycle through the star catalog in attempting to track stars if left in ASTRO INERTIAL mode.

NOTE

When mode is changed from INERTIAL ONLY to ASTRO INERTIAL, star search begins with a B-mode star, using the star search pattern that normally would occur if the system went from fine align to ASTRO INERTIAL. If mode is changed from ASTRO INERTIAL to INERTIAL ONLY then back to ASTRO INERTIAL, star search begins with an A-mode star, providing a far larger star search pattern than the B-mode star.

10A-70. Malfunctions. Some possible system malfunctions are: (1) Loss of electrical power to the system, (2) Out-of-tolerance electrical power, (3) Inadequate supply of cooling air to the guidance group, (4) Failure within the guidance group (computer failure, platform failure, or star tracker failure), (5) Chronometer failure, or (6) NCD panel failure. The type of failure is indicated by the TEMP LIMIT light or the MAL light and the MODE and other indicators on the control panel. The various possible failures, resulting NCD displays, and corrective action are described in the TROUBLE SHOOTING portion of this section. In general, if a malfunction occurs before flight, the corrective action involves replacing the defective unit or correcting electrical power/cooling air inputs. If necessary, the system can be operated and flown if a chronometer failure or star tracker failure occurs. If a chronometer failure occurs at start of alignment and replacement cannot be made, time and day of year must be filled using a time reference accurate to within 2 seconds. (If chronometer failure occurs during or following alignment, there will be no visual indication of the malfunction and the system will operate properly but will be susceptible to power dropouts of any duration.) If a star tracker failure occurs and guidance group replacement is not possible, the system can be operated as a pure inertial system by enabling the INERTIAL ONLY mode.

10A-71. NAVIGATION. Navigation is normally performed in the astroinertial mode. Navigation cannot start until fine alignment has been completed. If an alignment has been initiated with the MODE switch in ALIGN, the system will remain in fine alignment until the ASTRO INERTIAL or INERTIAL ONLY mode is manually selected and enabled or until the airplane begins to move forward, in which case navigation in the astroinertial mode automatically commenses after a rapid or ground hot start alignment. Inertial only navigation commenses upon aircraft movement, after a gyrocompassing alignment.

10A-72. Return to Fine Align. If, after navigation has commenced, taxi is delayed and it is determined that the airplane will remain stationary for more than 5 minutes, the system is returned to the fine align phase to prevent the buildup of navigational errors. This is accomplished by performing a Ground Alignment Correct routine, in which the MODE switch is set to ALIGN and the MODE START switch pressed. Navigation is resumed by manually selecting and enabling the ASTRO INERTIAL or INERTIAL ONLY mode or by forward motion of the airplane.

10A-73. Takeoff. If a gyrocompassing alignment has been performed, no action is required by the RSO during takeoff; however, if either a rapid or ground hot start alignment has been performed using heading data of questionable accuracy, the RSO has the option of performing a Runway Heading Alignment during the takeoff roll to improve system true heading data. The requirements for using this routine are that the true heading of the runway reference line be known within 2 arc minutes and that the airplane begin its takeoff run on the reference line and lift off within 20 feet of the line. The routine is initiated by the RSO entering the runway heading using the NCD panel and pressing the MODE START switch with the airplane aligned with the runway reference line prior to takeoff roll. The operation is terminated by operation of the left main gear scissors switch at liftoff.

When properly performed, the routine updates the true heading accuracy to within 6 minutes of arc.

10A-74. In-Flight Operation. After takeoff, the computer tape-filled mission plan is followed automatically. The tape-filled plan may be altered by NCD panel-filled mission modifications. Normally the autopilot is engaged in the auto-nav mode so as to automatically guide the airplane along the predetermined (or modified) flight path. (Refer to paragraphs on mission tape program and mission modification for description of system operation during great circle navigation and in sensor system control.) As a backup for autopilot control, the ANS supplies signals to the pilot's ADI and HSI instruments for manual control of the airplane in pursuing the desired flight path.

10A-75. During flight the RSO can monitor and, as required, update system computed position data by using radar, the viewsight, or the TACAN system. Position corrections measured by using these systems are displayed on the NCD panel and may, at the RSO's discretion, be either cleared or entered into the ANS to correct present position data. While the ANS may be monitored in this manner when operating in the astroinertial mode, in all probability position corrections will not be made, particularly when the NCD panel ★ ON light is on. When operating in other modes, monitoring and insertion of position correction data becomes much more important in order to maintain navigation accuracy. When fixpoint operations are performed, the computer weighs the amount of correction actually used according to prestored accuracy estimates for the type of fixpoint (radar, viewsight, or TACAN) and the current estimate of system accuracy. As a result, an update command by the RSO results in only a portion of the displayed correction being accepted. (If displayed correction for latitude or longitude is greater than 5 nmi, the total displayed correction is accepted.) If a total correction of lesser magnitude is desired, the Remote Update routine should be used.

10A-76. The ★ ON light on the NCD panel is an important indicator when operating in the astroinertial mode or in the event an airstart alignment (cold airstart or hot airstart) is performed. If the ★ ON light is on, reasonably accurate navigation can be expected. If the ★ ON light is out during astroinertial operation, navigational errors can be expected to increase at an inertial only rate.

10A-77. Operation in Alternate Modes. It is intended that the ANS will normally operate in the astroinertial mode; however, under certain conditions (principally as the result of a malfunction), other modes of operation may be selected. For further information on alternate modes and possible in-flight malfunctions refer to System Operation in this section and to Flight Manual SR-71A-1.

10A-78. Inertial Only Mode. This mode is entered by selecting INERTIAL ONLY with the MODE switch then pressing the MODE START switch. On the ground the inertial only mode can be selected for system operation if a star tracker failure occurs and a replacement guidance group is unavailable or time does not permit replacement, or if a chronometer failure occurs and replacment is not possible nor can time be filled within an accuracy of 2 seconds. This mode may also be selected (both on the ground and during flight) if it is apparent that tracking stars is impossible (such as with a heavy overcast). Switching the system from astroinertial to inertial only operation stops the motion of the tracker telescope, along with possible perturbations in the inertial platform which could result in degraded inertial navigation. The problem created in making such a selection is the possibility of forgetting to enable the ASTRO INERTIAL mode when star tracking becomes possible, thereby reducing the system's accuracy by not permitting it to operate in the astroinertial mode when it could otherwise do so. Making such a selection therefore is at the discretion of the operator and is his responsibility.

10A-79. Dead Reckon Mode. This mode is entered by selecting DEAD RECKON with the MODE switch then pressing the MODE START switch. On the ground, it is not intended that the dead reckon mode be selected except for test purposes. In flight, the dead reckon mode can be selected for training purposes, in which case astroinertial navigation continues simultaneously and separately; however, all ANS navigation outputs reflect dead reckon navigation. Dead reckon navigation is performed by the system following initiation of a cold or hot airstart and all ANS outputs reflect this form of navigation until the ★ ON light comes on, at which time astroinertial navigation replaces dead reckon navigation. Dead reckon navigation can also be selected as a last resort method of navigation in the event a platform failure occurs. Whenever dead reckon navigation is in progress, the MAG/GRID switch must be set to MAG and magnetic variation and wind must be entered and updated, as required, through the NCD panel. Also, as many present position updates as possible should be performed.

10A-80. Cold Airstart Mode. This mode is entered by: (1) selecting AIR START with MODE switch, (2) pressing MODE START switch, (3) entering wind (as necessary), and checking (and correcting if necessary) GMT and day of year, checking (and correcting if necessary) true heading, (4) entering position of point to be overflown, (5) pressing ENTER switch then airplane reaches that point, (6) performing Track Leg Update routine to desired great circle leg of mission. This mode of operation is a means of system in-flight alignment and navigation and is intended to be used to return the system to an operating state (if possible) following a malfunction which cannot otherwise be cleared. In situations where a power interruption has occured, a hot airstart routine (which is not based upon a knowledge of geographic location) should be attempted first, then, if unsuccessful, a cold airstart initiated when possible. Until the ★ON light comes on steady (at which time astroinertial navigation commences), dead reckon navigation is reflected in all ANS navigation outputs. During this period, as many present position updates as possible should be performed and the airplane should be flown as straight and level as possible to assist star aquisition and tracking.

10A-81. Hot Airstart (Automatic Restart). This method of operation is performed following an interruption of electrical power to the system (either the MAL light flashes and MODE indicator displays C/A as the result of a power interruption over 1 second in duration or the MAL light comes on steady as the result of loss of ac or dc power). If such an indication occurs, the HOT switch is pressed to signal a hot start. (If all displays are blank including MODE, the ANS ac or dc circuit breaker must be reclosed before pressing the HOT switch.) As with a cold airstart, the system performs dead reckon navigation until the ★ ON light comes on steady. During this period as many present position updates as possible should be performed to maintain navigation accuracy and the airplane should be flown as straight and level as possible to assist star aquisition and tracking.

10A-82. <u>SYSTEM OPERATION.</u>

10A-83. GROUND ALIGNMENT. Alignment of the ANS begins when the MODE switch is moved from WARMUP to an operate mode. When this is done, full operating power is applied to the system. Initially, the MODE indicator displays C/A and the computer starts self test and system test routines. The MAL indicator flashes when full operating power comes on. The MAL light is turned off and the type of alignment determined by pressing the MODE START switch (for gyrocompassing alignment), RAPID (for RAPID alignment), or HOT (for ground hot start alignment). The MAL light comes on again only if system self test routines detect a malfunction or a power dropout. During the alignment process the MODE indicator displays C/A then either F/A or RES, depending upon the type of alignment.

10A-84. Coarse Alignment. After successful completion of the test routines and the MAL light is extinguished, the computer automatically starts the alignment sequence, beginning with coarse alignment. In this phase, both coarse leveling of the platform and gimbal angle ambiguity routines are conducted. The ambiguity routine (not performed during a ground hot start alignment) involves slewing the platform about its vertical (azimuth) axis until the platform heading vector is about 90 degrees to the left or right of the airplane centerline. The platform is then rotated until the horizontal accelerometers are nulled (the sensing axis of each horizontal accelerometer is perpendicular to the direction of gravity), resulting in the platform being aligned within approximately 1 degree of the local geodetic vertical. The next alignment phase depends on the type of alignment being performed and, for a gyrocompassing or rapid alignment, is initiated by entering airplane present position coordinates using the NCD panel. Present position should not be entered until the TEMP TOLR light goes out, indicating that platform temperature is within tolerance for an accurate alignment and navigation. For a ground hot start alignment, the next alignment phase after coarse align is restart, in which fine alignment of the platform is accomplished using airplane position and heading data, together with gyro drift correction data, stored in the computer memory as the result of a previous alignment or previous system operation.

10A-85. Gyrocompassing. Gyrocompassing is the process by which the system accurately determines the orientation of the platform horizontal accelerometers relative to true north and, as a result, the true heading of the airplane. Throughout the gyrocompassing process, F/A is displayed by the MODE indicator. The gyrocompassing program involves two successive performances of fine alignment, in which the platform is accurately leveled with respect to the local vertical. Between the first and the second fine alignment phase the platform is rotated 90 ± 0.1 degrees in azimuth. During each fine align phase, gyro input rates required to maintain the platform level are measured and stored. Following the second fine align phase these gyro input rates are compared and used to compute earth rates and gyro horizontal and vertical drift rates. Since the earth rate sensed by each gyro depends only on platform heading and airplane latitude, the measured rates permit an estimate of platform heading, which is used to update the heading of the mathematical reference triad relative to true north. The ANS computer initially constructs a reference triad as a math analog of the platform axes using airplane true heading (entered through the NCD panel or determined using INS magnetic heading plus entered magnetic variation), together with airplane present position and GMT. The gyrocompassing routine increases the accuracy of true heading to within 7 arc minutes. As the orientation of the platform accelerometers relative to true north is determined within that degree of accuracy, the navigation accuracy of the system is thereby improved. The second phase of gyrocompassing fine alignment is completed when true heading has been determined and the platform remains aligned with the accelerometer sensed local vertical. This condition is displayed on the NCD panel by the present position data entered into the system appearing in the PRESENT LAT/LONG displays. If the system has not been commanded to remain in fine alignment the MODE indicator changes from F/A to the mode selected at initialization (I/O or A-I) and system navigation commences. If the system has been commanded to remain in fine align, the system does not start to navigate until manually commanded to do so or the airplane starts to move.

10A-86. Fine Alignment. When a rapid alignment has been commanded, the coarse alignment phase is followed by fine alignment of the platform relative to the local vertical. Gyrocompassing is not required as the assumption is that accurate true heading has been entered into the system. During the fine alignment phase, the MODE indicator displays F/A. Fine alignment involves accurately leveling the platform with respect to the local vertical (horizontal accelerometers at a null), using entered airplane position and true heading to determine the earth rate inputs to the gyros. In addition to platform fine leveling, the vertical accelerometer is tested and gyro drift rates are determined. At the completion of the leveling process, the present position data entered into the system appears in the PRESENT LAT/LONG displays. If the alignment was initiated with the MODE switch in ALIGN, the system remains in fine align until the astroinertial mode is enabled or the airplane begins to move, at which time the MODE indicator displays A-I. If the alignment was initiated with the MODE switch in ASTRO INERTIAL or INERTIAL ONLY, the system will automatically complete alignment in the selected mode.

10A-87. Restart. When a ground hot start has been commanded, the coarse alignment phase is followed by rapid leveling of the platform relative to the local vertical. During this phase of alignment, RES is displayed by the MODE indicator. Leveling the platform involves using the horizontal accelerometers to sense a level condition and supplying the gyros with input signals resulting from stored gyro drift rate corrections and earth rate values derived from stored airplane position and true heading. The restart phase is limited to approximately 30 seconds, at the end of which the MODE indicator changes to F/A.

10A-88. Accelerometer Null Bias Calibration. Accelerometer null bias calibration is not an alignment routine; however, the accuracy of stored accelerometer null bias values affects the accuracy of system alignment and navigation. The null bias calibration is performed in the shop, when required and on a time-phased and scheduled basis. The purpose of the calibration is to determine the current values for null bias in the accelerometers and to update the previously calibrated null bias coefficients in the computer memory. Calibration consists of either a four-position (No. 2 and No. 3 accelerometers) or a six-position (No. 1, 2, and 3 accelerometers) test. During the test the accelerometers are oriented so that the sensing axis of each is subjected to 1g (gravity). The test is conducted with an accelerometer's sensing axis first in one direction, then in the opposite direction. The difference in the two readings for each accelerometer yields the current null bias value. The new null bias values are retained in the computer memory following ANS power shutdowns, including those which result in hot/cold airstarts.

10A-89. ANS SELF TESTS. When in operation, the ANS performs self-test routines to determine if a malfunction has occured in the system input electrical power, the chronometer, the star tracker, the platform, or the computer. The following paragraphs describe the various self-test operations, possible malfunctions and resulting NCD panel indications, and possible corrective action. For trouble shooting procedures related to indicated malfunctions, refer to the trouble shooting portion of this section.

10A-90. Power Dropout Test. A decrease in the ANS ac supply voltage to less than 103 volts per phase causes the computer to stop operating. This voltage drop can be caused by a primary power transient, opening of the ANS system 3-phase ac circuit breaker or dc circuit breaker, or by turning the MODE switch to OFF or WARMUP. If, (1) voltage remains low, (2) the ac or dc circuit breaker is open, or (3) the MODE switch is set to OFF or WARMUP, the MAL light comes on steady and the MODE indicator and all display counters are frozen. When power returns to normal, the computer compares chronometer day and time with the day and time stored in memory at the time of power loss. If the duration of the power dropout is less than 1 second, system operation resumes as though nothing had occurred, with the exception that star tracking is suspended for a period of 70 seconds. If the duration of power interruption is greater than 1 second, the system returns to coarse alignment, the MAL light flashes, MODE indicator displays C/A, and all display counters clear. If the HOT switch is pressed, the system proceeds with an automatic restart (ground hot start or hot airstart). If the MODE START switch is pressed, the system proceeds with a cold start (ground alignment or airstart).

NOTE

> Any time the MODE START switch is pressed following removal of power from the system, the list of 40 NCD panel-filled mission points is erased from the computer memory. This includes the occurance of a power interruption during flight and subsequent actuation of the MODE START switch.

10A-91. Chronometer Test. The chronometer day and time outputs are checked each second when the system is in an operate mode. If day and time outputs are not present, a chronometer failure has occurred. This is indicated by the MAL light flashing, the MODE indicator displaying I/O, and by clearing of the PRESENT LAT/LONG displays. The system is hung up in coarse alignment and the MAL light cannot be cleared without corrective action. On the ground, the alternatives are: (1) replace the chronometer and realign, (2) fill time (accurate to within 2 seconds) and proceed with alignment, or (3) enable INERTIAL ONLY mode and proceed with alignment. In flight (since the only likely situation in which a chronometer failure would be observed is following a power dropout of any duration), the procedure would be to fill time as accurately as possible then reinitiate the cold airstart. Note that incorrect chronometer day or time does not represent a chronometer malfunction only in-correct day/time outputs to the guidance group. If the chronometer has failed, (loss of time/day outputs), the ANS cannot tolerate power dropouts of any duration.

10A-92. Star Tracker Test. During coarse alignment phase of a gyrocompassing or rapid alignment the star tracker searches for an artifical (collimator) star within the astro-inertial instrument. If the collimator star is acquired before the end of coarse alignment, the ★ ON light flashes until the system enters the fine align phase (F/A displayed in MODE indicator). If the collimator star is not acquired by the end of coarse alignment, the MAL light flashes and the system mode indicator displays I/O. When the MAN CLEAR switch is pressed, the MAL light goes out, the MODE indicator changes to F/A and the alignment should continue normally. Since the most common cause of this malfunction indication is a burned out artifical star bulb, rather than an actual tracker malfunction, an attempt can be made to track stars if time permits. If stars cannot be tracked the system may be operated in INERTIAL ONLY mode. Other alternatives are to repeat the alignment or replace the guidance group and realign. The only visual indication of star tracker failure during operation is the loss of the ★ON light with good sky conditions. (During the coarse align phase of a cold airstart, the collimator star is searched for but there are no NCD panel indications as to whether the search was successful.)

NOTE

> Collimator star search takes place whether the system has been commanded to operate in the astroinertial mode or the inertial only mode at completion of alignment.

10A-93. Platform Tests. During fine alignment and navigation the system checks computed groundspeed and cross-track speed. If these velocities are greater than 2150 and 300 knots respectively, indicating that platform is not level, the MAL light flashes and the MODE indicator displays D/R. This malfunction cannot be cleared unless the DEAD RECKON mode is enabled or the groundspeed or cross-track speed falls below their limits.

10A-94. Platform Disable Test. The platform electronics contain self test circuits which disable the platform stabilization loops if the redundant loop gyro circuit saturates. Disablement is momentary and reconnection of the stabilization loops is attempted at 5 second intervals until successful. When this type of malfunction occurs, the MAL light flashes and the MODE indicator displays D/R. There is a good probability that the platform will recover, resulting in system navigational performance approaching that of a hot start. If the malfunction does not clear, the system must be operated in the DEAD RECKON mode. If platform recovery occurs, the MAL light stops flashing and the MODE indicator displays A-I or I/O. If platform recovery does not occur and the airplane is on the ground, the guidance group must be replaced. If airborne, when the malfunction occurs, the operator should enable and retain the DEAD RECKON mode until it is determined whether the malfunction will clear and the degree of degradation in inertial navigation. If the malfunction clears and inertial navigation appears accurate, the system can be assumed to be operating properly. If star tracking was in progress at the time of the malfunction it will be discontinued for approximatley 70 seconds after which time tracking of star A is automatically commanded; also, the Kalman filter is adjusted to increase the weighing of air speed damping. If the malfunction clears but inertial navigation appears inaccurate, position updates should be performed.

10A-95. Computer Tests. The computer continuously performs self tests which check the operational status of various computer major and sub routines. There are two general types of computer failures which cause the MAL light to flash: (1) an intermittent malfunction (recoverable), (2) a gross malfunction (nonrecoverable). The following malfunctions are in the catagory of intermittent failures and are of a recoverable nature: (1) checksum failure, caused by an improper execution of a write instruction; (2) loss of type-6 interrupt, usually an intermittent hardware failure; (3) slot overflow, resulting from a computation that takes longer than is provided for in the program; and (4) improper entry into the program. If any of these types of failures occurs, the MAL light can be turned off by pressing the MAN CLEAR switch. System degradation may or may not be evident, depending on the source of the error. (An isolated loss of type-6 interrupt does not cause the MAL light to flash nor does it affect system performance; a persistent loss of type-6 interrupt can cause the MAL light to flash and also affect system performance.) If a gross computer failure occurs which prevents proper sequencing of the computer program, the MAL light will flash and the NCD panel displays will be frozen or may be random as the computer is coming to a stop. With this type of failure, the MAL light cannot be turned off except by setting the MODE switch to OFF and attempting to restart the system. In most cases, the ANS is unusable until the computer is replaced.

10A-96. ANS READY/NOT READY INDICATIONS. When the ANS is in an operational state, ready signals are supplied to cockpit attitude indicators, for a visual indication of this condition (warning flags out-of-view), and to the autopilot so that the pitch and/or roll channel and the auto-nav mode or the heading-hold mode can be engaged, using the ANS as an attitude and heading reference. When the ANS is not operational, the ready signals are replaced by not-ready signals, resulting in visual not-ready indications in the cockpits and by disengagement (or inability to engage) the autopilot, using the ANS as a reference. Any one of the following conditions cause a Nav not-ready signal to be produced:

a. MODE switch in OFF or WARMUP.

b. MODE indicator displays C/A or CAL.

c. An electrical power interruption of over 1 second in duration.

d. A platform failure or disable.

e. A gross computer failure.

10A-97. When a Nav not-ready situtation is present, the following conditions occur:

a. Forward cockpit:

1. ADI indicator.

(a) Vertical pointer flag comes into view (with DISPLAY MODE SEL switch in the ANS position).

(b) Power OFF flag comes into view (with ATT REF SELECT switch in the ANS position).

2. ANS REF caution light comes on.

3. Autopilot. Pitch and roll channels and auto nav or heading hold mode are disengaged or cannot be engaged (with ATT REF SELECT switch in the ANS position).

b. Aft cockpit:

1. Attitude indicator. Power OFF flag comes into view (with ATT IND switch in the ANS position).

2. ANS FAIL caution light comes on.

NOTE

In addition to indicating a not-ready condition, as described above, the ANS REF and ANS FAIL caution lights also come on if the TEMP LIMIT light or the MAL light comes on.

10A-98. OPERATING MODES.

10A-99. Astroinertial Mode. As previously described, when operating in the astroinertial mode the ANS functions as an inertial system to obtain navigation information on airplane position, heading, pitch, roll, velocity, etc; while using star tracking to limit the buildup of navigational errors (largely due to undetermined gyro drift) which are inherent in a pure inertial system.

NOTE

If the last mode enabled is INERTIAL ONLY, motion of the airplane initiates system operation in the inertial only mode.

10A-100. Star Tracking. Star tracking involves measuring the differences between calculated star positions and actual star positions as observed by the tracker telescope. Differences between calculated and actual star positions represent differences between the axes of the platform and the computational triad. This difference data is used to correct platform true heading, computed present position, computed airplane velocity, platform tilt, and gyro drift rates. Measured gyro drift rates are stored in the computer memory in order to improve any subsequent inertial only navigation. The star tracker automatically begins to search for stars as soon as the system starts to navigate in the astroinertial mode. Stars are normally tracked before takeoff, both at night and during the day, provided good sky conditions exist. If star tracking has not commenced before takeoff, it should start at an altitude where cloud cover and sky brightness conditions have improved. A catalog of 61 stars and their positions are stored in the ANS computer memory. Depending on the star tape loaded into the computer memory, either global or special area star coverage can be provided. Excessively bright and large celestial objects; such as the sun, moon, and planets; are automatically excluded from use as references by the star tracker. At least two different stars must be continuously tracked for optimum system performance.

NOTE

System accuracy, as the result of star tracking, is improved by a computer program which corrects for apparent shift in star positions due to (1) shockwave over ANS window, (2) pressure and temperature gradients acting on ANS window.

10A-101. Star selection is made by the computer based on aircraft position (latitude and longitude), day of year and time of day, aircraft pitch and roll attitude, and the location of the sun. For a given aircraft position, day of year and time of day, and orientation of the star tracker window based on aircraft attitude, a particular star should be visible and at a specific azimuth and elevation relative to the platform's azimuth gimbal. If star tracker measurements indicate that the star is not at the expected azimuth and elevation, there is an error in computed position or an error in platform orientation, or both. As the telescope is mounted on the platform, the star tracker only measures the angular difference between the physical triad formed by the platform axes and the computational triad formed by the vertical through the computed position and the calculated orientation of the platform in azimuth. As a result, the system cannot directly distinguish between a computed position error and a platform orientation error; however, the system attempts to use star tracker data to optimally adjust the various navigational parameters, based on statistical probabilities determined by prestored error models and flight dynamics preceding the measurement.

10A-102. To assist in correcting inertial navigation errors, the system employs a Kalman filter to optimally incorporate measurements made as the result of star tracker operation, air data system (ADS) inputs, and position fixpoint operations. The filter continually estimates the error state of the following 16 parameters:

1. Platform azimuth
2. Platform tilt axis 2
3. Platform tilt axis 3
4. Position error axis 2
5. Position error axis 3
6. Velocity error axis 2
7. Velocity error axis 3
8. Azimuth gyro drift rate
9. 2 axis gyro drift rate
10. 3 axis gyro drift rate
11. 2 axis accelerometer bias
12. 3 axis accelerometer bias
13. Telescope elevation bias
14. True airspeed scale factor
15. Axis 2 wind
16. Axis 3 wind

10A-103. Each of the parameters listed in paragraph 10A-102 has a calculated error probability which is initialized as a function of the type of alignment accomplished. During ground alignment, system position is monitored to detect deviations from the entered site coordinates. These deviations are supplied to the filter which utilizes them to refine the first ten listed parameters. When star measurements are obtained, the first thirteen parameters are refined and, when airborne, all sixteen elements are estimated and continuously refined. Because of wind variablility and the relatively poor accuracy of ADS true airspeed, the airspeed measurement has essentially zero influence on the first thirteen parameters, except in the case of a cold or hot airstart. When fixpoint measurements are entered by the RSO, the filter adjusts the 16 parameters according to the ratio of their current estimated error state to the programmed accuracy of the type of fixpoint operation (0.25 nmi for SLR, 0.5 nmi for viewsight, 1.0 nmi for TACAN). The system will accept 100 percent of entered correction, regardless of the type of fixpoint, if the correction is greater than 5.0 nmi in any direction.

10A-104. Stars are given arbitrary labels (A, B, and C) depending on if they are the first, second, or third star tracked after beginning navigtion. Star data, with definitions and a summary of the usage of star tracker measured errors, is listed in figure 10A-13. A single star cannot be used to determine all platform/computational triad errors, as errors about a line between the platform and the star are not measured. Sequential tracking of at least two different stars does determine all such existing errors, with the results of such tracking used to align the platform and the computational triads as described in the preceding paragraphs. After the initial two stars are acquired, the normal interval between acquiring stars, when at altitude, is about 30 seconds. Since the platform is almost continually brought into alignment with the computational triad, gyro drift errors have an almost negligible effect. In fact, the predominant ANS errors which do occur are those due to gyro drift that develops before stars are acquired and when star tracking is interrupted during aerial refueling or because of degraded sky conditions (due to descent, clouds, etc.). (Although gyro steady state drift rates are determined during gyrocompassing and rapid ground alignments, and these drift rates are further refined by star tracking, when star tracking is not in progress random gyro drift is not corrected for and navigation accuracy degrades as it would with a pure inertial system.)

10A-105. Star selection, tracker scan rate, and search patterns are dependent upon many factors and are under computer control. The computer selects a star by going through the star catalog, which is arranged in the order of decreasing star brightness, until it finds a star that is within the ANS window aperature, not within 10 degrees of zenith (not within 5 degrees of zenith for trainer aircraft), and not within 12-1/2 degrees of the sun. The tracker telescope is commanded to search for the selected star using a variably-sized pattern which is symmetrical about the computed star position. As shown in figure 10A-14, the star search pattern is an expanding rectangular spiral which starts at one side of the computed star position and then passes through that position before spiraling outward. Search patterns; which are chosen as a function of the type of alignment performed and whether an A, B, or C star is being searched for; vary in size from a maximum of 3 degrees by 1 degree for an A star, to a minimum of 12 minutes by 6 minutes of arc for a C star. Search (scan) rates, of which there are four available, are determined by the relative star-to-sky brightness ratio. The maximum possible search time, 23 minutes, is for an A star using the slowest search rate over a pattern which is approximately 1-1/2 degrees by 1/2 degree.

10A-106. When a star is detected during search, confirmation and reconfirmation patterns are made. If these are successful,

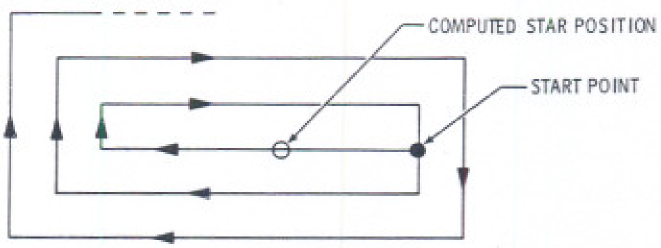
STAR	DEFINITION	DATA USAGE
A	First star tracked after a hot or cold airstart, ground hot start, or after changing from astroinertial to inertial-only mode then back to astro-inertial mode.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto-nav.
B	Second star tracked after an A star	Computational triad and platform are corrected and now in coincidence. Latitude, longitude, and auto-nav adjustments occur.
	or	
	First star tracked after a ground alignment.	Computational traid and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
C	First and subsequent stars tracked after B star.	Platform and computational triad are corrected. Auto-nav transients are allowed on first star C but suppressed on subsequent ones until a bank angle exceeds 5^{o} or position fix inserted.

Figure 10A-13. Star Data Usage

the star is considered tracked. Star position errors, in azimuth and elevation, are determined by the difference between the star's actual position and its computed position. Star search and track operations are discontinued if star moves outside the window aperture, the sky is too bright, or a position update is performed. If a position update is performed, star search begins again at the top of the star list (brightest star). If the star moves out of the window, the computer goes to the next brightest star available. If the sky becomes too bright, the computer also goes to the next brightest star; however, if the ratio of star-to-sky brightness remains too low the computer continues on to the next available star, stopping at each such star to take a sky brightness test, until it has sequenced through the remainder of the star list; after which it starts again at the top of the list. When moving from one star to the next, repositioning the tracking telescope and performing a sky brightness test, which preceeds each star search, requires about 14 seconds.

SEARCH PATTERNS AND STAR-ON LIGHT INDICATIONS

TYPES OF ALIGNMENT	STAR	SCAN RATE arc sec/sec	SEARCH AZIMUTH	SEARCH ELEVATION	MAXIMUM TIME REQUIRED TO COMPLETE SEARCH	AFTER TRACKING ★ LIGHT WILL:
Hot or cold airstart or when search unsuccessfully completed for - A after ground hot start or INERTIAL ONLY navigation.	A	1250	3°	1°	17.3 min.	Flash at 1 second intervals.
	A	703	2.3°	.8°	18.1 min.	Flash at 1 second intervals.
	A	395.5	1.9°	.6°	20.8 min.	Flash at 1 second intervals.
	A	222.5	1.4°	.48°	22.7 min.	Flash at 1 second intervals.
	B	all	3°12'	6'	10.0 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Ground hot start or when changing mode from INERTIAL ONLY to ASTRO INERTIAL	A	all	36'	12'	3.9 min.	Flash at 1 second intervals.
	B	all	36'	12'	3.9 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
When INERTIAL ONLY was selected after ground alignment	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Rapid, gyro compass or runway heading alignment.	B	all	36'	12'	3.9 min.	Stay off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)



NOTE

1. All search patterns are expanding rectangular spirals with the first beginning at one side and passing horizontally across the computed star position.
2. Star B' (re-tracking of star B) is performed only if the azimuth error measured with star B is greater than 5.27 arc-minutes.
3. After tracking star C, the star light remains on until mode is changed to INERTIAL ONLY or five minutes have elapsed without tracking two different stars.

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Figure 10A-14. Star Search Patterns and Star-On Light Indications

10A-107. The RSO can assist the system in tracking stars. In doing so, the ★ ON light and the Time/Star display may be used as guides in determining what action is required. (Time/Star display indicates the number of stars acquired, the star number for the current star, the search time for that star, and the scan rate being used.) The following are some general guidelines which may be applied to improve acquiring and tracking stars.

★ ON Light Condition	Action
Light out (search in progress for A or B star)	Insofar as possible, maintain straight and level flight and make maximum number of position checks.
Light out (after entering a good sky condition)	Restart star search at the top of the star list by inserting zero error using Remote Update routine.
Light out (for more than 15 minutes after zero Remote Update and good sky conditions prevail)	Command star A tracking by changing mode to INERTIAL ONLY then back to ASTRO INERTIAL to increase search pattern size.

10A-108. Inertial Only Mode. As previously stated, the inertial only mode is a backup for the astroinertial mode. The mode permits operation of the system when star tracking or related functions are impaired (star tracker or chronometer failure) or when star tracking is not desired (prevention of tracking false stars while in a hangar or to prevent introduction of errors by movement of the tracker telescope when stars cannot be tracked). The inertial only mode is enabled by setting the MODE switch to INERTIAL ONLY then pressing the MODE START switch. The MODE indicator displays I/O. When operating in this mode, accelerometer data is used to maintain the platform level and to update the computational triad and displayed present position. Present position update procedures should be performed as frequently as possible to limit the buildup of navigational errors which otherwise will occur.

10A-109. Dead Reckon Mode. The dead reckon mode is a backup mode of ANS system operation. The mode may be enabled by the RSO in the event a platform failure during flight prevents operation of the ANS as an inertial system, it is the mode of navigation automatically performed by the system during the initial phase of a hot or cold airstart, and, when desired, the mode can be selected for training purposes. During system operation in the astroinertial or inertial only modes, dead reckon navigation is conducted simultaneously with and separately from inertial navigation. The computed dead reckon position data is updated every 4 minutes to agree with inertially derived position data. (During inertial operation, magnetic variation is also computed and updated by the system at the same rate.) When operating in the dead reckon mode, present position updates should be performed as frequently as possible to limit the buildup of unacceptable position errors. In addition to present position updates using the radar, viewsight, or TACAN, present position coordinates can be determined and directly entered by the RSO; the dead reckon mode is the only mode of navigation in which this can be done. When the dead reckon mode is enabled for training purposes, the system continues to generate all its normal outputs and it also continues astroinertial or inertial only navigation so that inertial operation can be resumed when desired. When the dead reckon mode is in progress as the result of a platform malfunction or during the coarse align phase of an air start, the autopilot auto-nav function is disengaged and FAIL flags appear in the ADI and aft cockpit attitude indicator displays, if ANS is chosen as a reference. Also, the ANS REF and ANS FAIL caution lights come on in the forward and aft cockpits respectively.

10A-110. Dead reckon navigation is a process of computing present position based on a knowledge of aircraft heading and ground speed. The process is generally inaccurate when compared with inertial navigation, as it is based on inputs from other systems and manually entered data which are not extremely accurate. The aircraft ground speed computed by the system is derived from true airspeed supplied by the air data system and manually entered values of wind speed and direction. Wind speed and direction must be updated by the RSO as frequently as possible in order to maintain reasonably accurate dead reckon navigation. With the exception of the heading used following the coarse align phase of a hot or cold airstart, heading used for dead reckon navigation is true heading derived from INS heading. The true heading is computed using INS magnetic heading plus manually inserted magnetic variation;

NOTE

The INS cannot produce a grid heading for use in polar areas. In case of ANS problems in polar areas the INS will still be capable of point to point navigation.

10A-111. Cold Airstart Mode. The cold airstart mode is a means of inflight alignment and operation of the ANS. The mode is principally intended to be used as a means of attempting a restart of the system following a malfunction which grossly affects system operation or accuracy. From an operational point of view, this mode of operation has a critical restriction; that is, navigation must be initiated when the aircraft is at a known geographic location which has been filled through the NCD panel by the RSO.

10A-112. During the initial phase of a cold airstart, the MODE switch is set to OFF then to WARMUP and the airplane is set on a straight and level course towards a point at which system navigation will be started. Prior to starting navigation, INS must be in NAV, the MODE switch is set to AIR START and the MODE START switch pressed (MODE indicator displays C/A), wind speed and direction are filled, GMT and day of year are checked and filled if necessary, true heading computation is maintained as accurate as possible by performing a True Heading Update or by filling magnetic variation, and present position coordinates of point to be overflown are filled on the NCD panel. As the aircraft reaches the point at which navigation is to be started, the ENTER switch is pressed. From that time until the ★ON light comes on steady, system outputs reflect dead reckon navigation. (Until the MODE indicator changes from C/A to RES, FAIL flags appear in the ADI and aft cockpit attitude indicator displays, the autopilot cannot be engaged in auto nav, and the ANS REF and ANS FAIL caution lights are on in the forward and aft cockpits respectively.) With RES displayed by the MODE indicator, inertial navigation is in progress and inertial heading is used for dead reckon navigation. At this time, the autopilot can be engaged in auto nav, the cockpit instruments indicate accurate pitch, roll, and heading, together with reasonably accurate dead reckon navigation data, and the ANS caution lights go out. When the MODE indicator displays A-I, true airspeed leveling of the platform is completed, star search is initiated, and air-mass damping is used to correct inertially derived velocity data. (The first air-mass damping correction is made at the end of the first minute, with corrections of diminishing magnitude made every minute thereafter for the balance of the flight.) After star C is tracked (★ ON light comes on steady) astroinertial navigation is in progress and all ANS navigation outputs reflect inertial navigation. If the autopilot is engaged at this time, a maneuver may occur. Airstart alignment is complete at this time. Present position updates should be performed as often as possible.

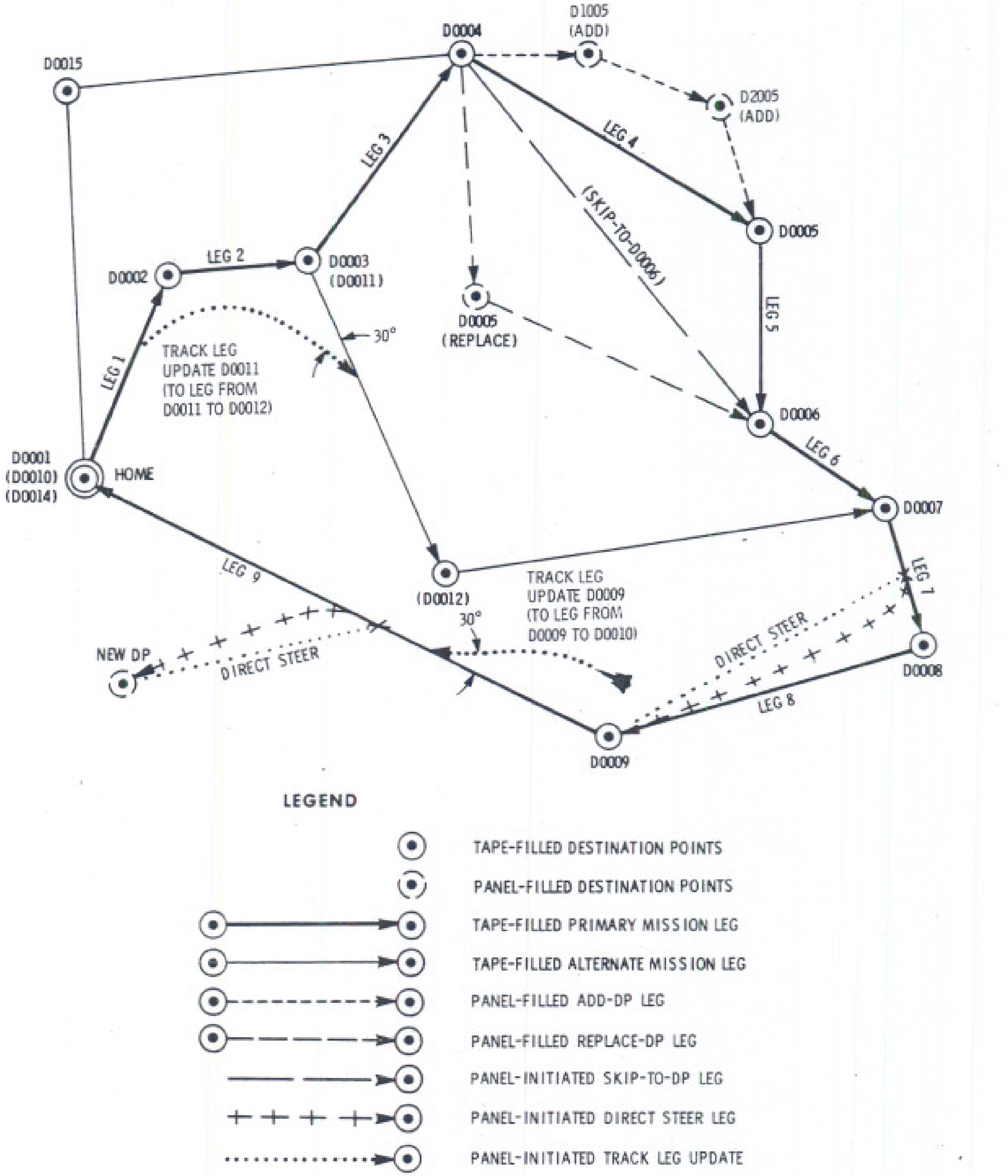
10A-113. Hot Airstart Alignment. The hot airstart alignment is a means of restarting the ANS during flight. The procedure is principally intended to be used in the event the system is disabled as the result of a power interruption over 1 second in duration. The hot start is an automatic restart process which is initiated when power is restored.

10A-114. If, during flight, the MAL light comes on and the MODE indicator displays C/A, a power dropout of over 1 second has occurred. If the MAL light is on steady, it is due to loss of primary ac or dc power. If loss of power is due to an opened ANS ac or dc circuit breaker in the aft cockpit, the breaker is closed and a hot start performed. If the MAL light is flashing, there has been a power interruption which has been automatically cleared by the aircraft electrical system and a restart has automatically been initiated by the restoration of power. The location of the aircraft at the time of power restoration is calculated by the system using the location at power interruption, the duration of the interruption (as determined by elapsed chronometer time), the true airspeed at the time of restoration, and the INS heading at the time of power interuption. From the time of power restoration until the ★ON light comes on to indicate restored inertial navigation outputs, the system performs dead reckoning navigation. During this period, the airplane should be maintained on as straight and level a course as possible to assist platform leveling and star tracking. Following reapplication of power, there is a 45-second platform disable period which allows the system to stabilize before torquing inputs are reapplied to the platform. On seeing the MAL light and C/A indication, the RSO presses the HOT switch, causing the MAL light to be extinguished and directing the system to perform a hot start alignment. (If a ANS circuit breaker had opened, it must be closed before pressing the HOT switch.)

10A-115. System operation during a hot airstart is essentially the same as with a cold airstart, with the basic difference being that the system does not need initial position data entered as it does during a cold start. Platform leveling (coarse alignment) begins at the end of the 45-second platform disable period or when the HOT switch is pressed, whichever occurs last. During restart, the MODE indicator changes from C/A, to RES, to ASTRO INERTIAL. As with a cold airstart, INS heading is used for dead reckon navigation until RES is indicated, at which time inertial heading is used instead. Also, until RES is displayed, the autopilot cannot be engaged in auto nav, the ADI and aft cockpit attitude indicator display FAIL flags, and ANS caution lights are on in both cockpits. When the ★ ON light comes on steady, the system is operating in the astroinertial mode with air-mass damping used to improve navigation. As with a cold start, magnetic variation (or true heading) should be updated during the COARSE ALIGN phase, wind speed and direction updated until the ★ ON light is on steady, and present position updates performed as frequently as possible. If the hot start is not successful (MODE indicator not changing from C/A to RES), a cold airstart should be attempted.

10A-116. MISSION PROGRAM. (See figure 10A-15.)

10A-117. GENERAL. The mission profile is defined in terms of mission points of interest; these are: destination points (DP), control points (CP), and fixpoints (FP). Destination points delineate the prescribed mission by representing the intersections of the great circle legs of the mission. Control points represent points adjacent to the mission path at which the ANS provides automatic control of the radar system and TEOC cameras. Fixpoints represent checkpoints along or adjacent to the mission path at which the radar, viewsight, or TACAN are used to monitor the accuracy of ANS navigation. The mission plan is loaded into the computer memory from a mission



NOTE

D is displayed in the first digit window of SELECTED DATA register #6, in place of the first zero of a DP ID code (5 digits). Points are depicted as displayed on the NCD panel.

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Figure 10A-15. Typical Destination Point Plan tape prior to or during preflight operations. The capacity of the computer memory permits up to 1511 points (256DP, 256FP and 999CP) of interest to be stored from the tape fill operation. In addition, temporary memory storage provides for up to 40 mission-point modification operations to be performed using the NCD panel. The mission modification operations, which consist of adding new mission points in addition to those which are tape filled, or of replacing tape-filled mission points, may be performed whenever the ANS is in an operate state. The NCD panel added/replaced mission points are referred to as the 40-list. Other mission modification routines, such as Skip to DP, Track Leg Update, Direct Steer to DP, and Opportunity and Anytime fixpoint operations may also be performed. These routines do not require additional memory storage capacity and therefore do not affect the 40-list of add/replace points; accordingly, they may be performed an unlimited number of times.

10A-118. The mission tape includes a primary flight plan and may, in addition, also include one or more alternate routes which the crew may elect to follow by exercising the Skip to DP routine. The add/replace 40-list capability permits additional routes to be formulated and allows last minute changes to sensor activity on programmed legs of the mission. Mission point data stored in the computer memory is identified by point-of-interest class and by order of use in the mission plan (eg. D0003, C0007, and F0021, etc.). Each point is further defined by its coordinates, sensor usage and control (for control points and fixpoints), and identification of the next mission point of the same type (tape-filled destination points also include information on the next control point and next fixpoint and whether they are next leg or not).

10A-119. AUTOPILOT STEERING. The mission path is a series of great-circle legs computed on the basis of DP coordinates. The ANS supplies a steering (bank angle) command to the autopilot in all ANS navigational modes; however, the signal is useable only when the Nav-ready signal is also present. When the autopilot is in the auto-nav mode, the autopilot automatically guides the airplane onto and along the preprogrammed flight path by rolling the aircraft to make the actual bank angle equal the bank angle commanded by the ANS. The bank angle steering command is computed using aircraft cross-track position and velocity relative to the desired course. If the mission planner has scheduled a bank angle of 35 degrees or less, the ANS will not command a bank greater than 35 degrees, even if a higher bank angle is required to place the aircraft on course. If a turn is planned above 35 degrees (up to 42 degrees) the ANS will command up to 45 degrees to keep the aircraft on course. The maximum bank angle commanded by the ANS is 45 degrees.

10A-120. If auto nav is engaged when the aircraft is considerably off track, the ANS will steer towards the desired track at a 30 degree intercept angle. Depending on existing ground speed, the ANS will compute where to initiate a turn to discontinue the entercept angle and smoothly fair onto track. During supersonic cruise this point is approximately 20 nmi off course. Once on course, the sensitivity of the ANS steering computation and the autopilot response is such that the airplane should usually be within 300 feet of the desired track, except during turns and exclusive of ANS navigational errors.

10A-121. <u>Closed Loop Turns.</u> When turning from one mission leg to the next in auto nav mode, the airplane follows a constant radius, as specified by the mission planner for each DP. The turn start distance (referred to by mission planners as Turn Start Automatic, or TSA) is the result of a fixed distance (determined by the programmed turn radius and the change in course heading) and a variable distance (0 to 4.5 nmi, as determined by aircraft groundspeed) which compensates for the distance required to roll into the turn. Commanded bank angles to achieve the desired turn are the sum of two components. One component is the nominal bank angle required to execute the programmed turn radius at the existing groundspeed. The second component is a bank angle trim which is computed as a function of the airplane radial speed and position relative to the programmed turn radius. If some distrubance causes the aircraft to deviate from the turn line, the bank angle trim is altered (within a range of up to ± 10 degrees) to return the airplane to the turn line. The sum of the nominal commanded bank angle and the bank angle trim is limited to 45 degrees maximum. Closed-loop steering is automatically terminated when aircraft course is within 2 degrees of the commanded new course, the new course is crossed, or the theoretical tangency point is passed. If the programmed turn radius has been maintained (zero cross track error) the airplane should smoothly roll out onto the new course without crossing over the new track or requiring further corrections at completion of rollout.

10A-122. If no turn radius is programmed, the system computes a TSA and a turn radius based on 32 degrees of bank and existing groundspeed and performs a closed loop turn. If speed is varied after the turn is started the airplane will increase (up to 35 degrees) or decrease bank angle to maintain the computed turn radius. Turn radius can be programmed for any nominal bank angle, which allows planning small bank angles for high gross weight turns. When a Skip to DP routine is used, the same fixed turn radius is used; however, a different TSA and turn line will result when the new leg is different from the primary (planned) leg. When a Direct Steer to DP routine is performed, the system will compute TSA and bank angle the same as when no bank angle has been entered as described above.

10A-123. MANUAL STEERING. The ANS provides navigation information to the cockpit indicators so that the pilot can manually steer the airplane along the programmed mission path. The ADI vertical pointer indicates the difference between the ANS commanded bank angle and the actual bank angle. Banking the aircraft to center the pointer steers the airplane onto and along the intended great circle course or along the prescribed turn line. The ADI horizontal pointer indicates altitude rate of change (from 0 to ± 3484 feet per minute). This information can be used to maintain constant altitude during turns.

10A-124. The HSI displays true heading, command course, range to DP or range to turn start according to the selection on the DP/TURN switch, and cross track position (from 0 to ± 1 nmi). During turns, the HSI course deviation bar and NCD panel cross track position display (Normal Display) indicate airplane position relative to the intended turn line and the range displays indicate the distance around the turn and along the next leg to the next DP or turn start (HSI only).

10A-125. MISSION POINTS OF INTEREST.

10A-126. Destination Points. As described in previous paragraphs, destination points define the intended mission by presenting the intersections of the great circle legs of the mission.

10A-127. Control Points. Control points are points along the mission path at which sensors (Left TEOC, right TEOC, and the side-looking radar) are turned on, pointed, or turned off. These mission equipments can also be manually controlled, when required.

10A-128. The technical objective (TEOC) cameras are turned on or off and pointed as the along-track range of the airplane to the next destination point coincides with the along-track range of the control point to the next destination point. Control points are selected to bracket the target, with the turn-on control point at the same cross-track position as the target. The ANS computes the camera pointing angle required to cover the control point and thus the target. (Target coordinates are not actually stored in the computer.) Camera control points can also be programmed along the turn line. When this is done, the control point is located at the same radial distance from the turn line as the target.

10A-129. The CAPRE radar is controlled in a manner similar to the TEOC cameras. In additon to turn-on, side L/R, and range commands, the ANS supplies altitude, groundspeed, cross-track and vertical velocities, and antenna stabilization signals to the radar. This data compensates for airplane motion during radar mapping. In addition, a map width (narrow/wide) command and a 2.5 nmi distance traveled marker are supplied to the radar. The radar system performs continuous altitude (terrain-clearance) measurements which are supplied to the ANS and can be used to update Nav computed altitude at the control point, provided the radar also supplies an altitude valid signal, airplane roll angle is less than 10 degrees, and terrain elevation is stored in the computer memory for the control point.

10A-130. The ASARS is controlled in a manner similar to the CAPRE radar with some variances. Refer to System contractor manual T.M. 33D2-NDC-1070-1 Programming and Tape Preparation.

10A-131. ANS digital data is supplied to the EIP/EMR system and has the same content as the 32-word ANS telemetry data supplied to and recorded in the MRS. This data includes: GMT; day of year; present position latitude and longitude; airplane magnetic and true headings; airplane pitch and roll attitudes; barometric, Nav computed, and radar altitudes; aircraft ground speed and ground track; ANS operational data; ANS commands to SLR and TEOC sensors; and event time and frame count for all installed sensor equipment.

10A-132. Fixpoints. Fixpoints are accurately known and readily identifiable points along the mission path, used for the purpose of checking and measuring ANS navigational errors. There are three types of fixpoints; radar, viewsight, and TACAN.

10A-133. At CAPRE fixpoints, the radar is automatically turned on and pointed when the airplane is at a prescribed distance in advance of the fixpoint. As the airplane passes abreast of the fixpoint (as determined by ANS navigation), the ANS supplies an along-track marker and computed fixpoint range to the radar. On receipt of the along-track marker, a MARK light appears at the bottom center of the radar display (part of the radar system's recorder correlator display, or RCD). The fixpoint along-track and range data supplied to the radar results in an L-shaped ANS fixpoint marker appearing on the RCD map display. If ANS navigation is perfect, the L-shaped marker will be coincident with the fixpoint image on the display. If there is an error in ANS navigation (or possibly in fixpoint location stored in ANS computer memory), the ANS fixpoint marker and the observed fixpoint will be displaced from each other. (Due to the time required for film processing in the RCD, the area of the fixpoint illuminated by the radar appears approximately 50 seconds after the airplane passes the fixpoint. The RCD MARK light goes out when the ANS fixpoint marker moves into view.) By first positioning crosshairs on the ANS fixpoint marker and zeroing RCD along-track and slant-range encoders, then moving the crosshairs to the observed fixpoint, ANS errors in computed position (in along-track and slant-range directions) are measured and displayed on the RCD. By pressing the READ ERR switch on the RCD, this data is transmitted to the ANS where the required position corrections appear, in north-south and east-west directions, on the NCD panel. The radar remains on until a CP or FP radar turnoff command occurs.

10-134. For ASARS fixpoints, a fixpoint warning flashes FIX on the top line of the inflight processor and display (IPD) at the start of an ASARS operation with a fixpoint available. When the ANS determines the fixpoint is in the field of view of the ASARS, the display stops with crosshairs over the computed fixpoint location. If there is a discrepancy between computed and actual fixpoint the RSO may move the crosshairs to the actual fixpoint. If the READ ERROR switch is pressed the current error corrections in nautical miles north/south east/west will be displayed on the NCD in SELECTED DATA registers 2 and 5. These values will be used to correct all subsequent ASARS activity and pointing angles.

10A-135. CAPRE radar update. The RSO has the prerogative of updating ANS computed position using the position corrections displayed on the NCD panel (to the degree permitted by the system Kalman filter as described in paragraph 10A-103) or of clearing this correction data entirely. To update computed position, the RSO presses the NCD panel UPDATE switch. To clear the correction data; the MAN CLEAR switch is pressed. In general, corrections are not entered when operating the system in the astroinertial mode, particularly when the ★ON light is on. Corrections will probably be required and entered when operating the ANS in other modes.

10A-136. ASARS update. During ASARS operation the ANS stores an algebraic summation of fixpoint corrections. Each time the READ ERROR switch is pressed on the RADAR control panel the current errors are sent to the ANS and displayed in SELECTED DATA registers 2 and 5. The current corrections are also added to the cumulative total of all past corrections displayed in SELECTED DATA registers 1 and 4. If the UPDATE switch is pressed the ANS uses the cumulative errors to update. After update the portion of corrections remaining after Kalman filtering will be displayed in SELECTED DATA registers 1 and 4.

10A-137. In viewsight fixpoint operations, the RSO searches for the fixpoint as it is approached, using the viewsight wide-angle field of view. After identifying the fixpoint the narrow field of view is selected if possible, for maximum accuracy in determining fixpoint position. As the fixpoint passes down the viewsight screen, a cursor on the viewsight is positioned to intercept the point as it passes the nadir line on the viewsight image and, at that instant, the viewsight READ switch is pressed. Pressing the READ switch transmits cursor (fixpoint) position to the ANS, where the observed fixpoint location is compared with computed fixpoint position based on ANS navigation. If any navigation (or viewsight operation) errors exist, position corrections, in north-south and east-west directions, appear on the NCD panel. As described in paragraph 10A-135, these corrections can either be entered or cleared, as determined by the RSO.

10A-138. At TACAN fixpoints, ANS computed values of slant range and bearing to a particular TACAN station are displayed on the NCD panel for comparison with similar data for this station, displayed on the BDHI. At his discretion, the RSO presses the TACAN switch on the NCD panel then enters the values of TACAN station magnetic bearing (XXX.X°) and slant range (XXX.X nmi) as displayed on the BDHI. The ANS computes and displays any required position corrections, in north-south and east-west directions, on the NCD panel. TACAN fixpoint accuracy is inherently worse than that obtained using the viewsight or the radar and that accuracy is further degraded at TACAN distances of less than 20 nmi or greather than 200 nmi. As described in paragraph 10A-135, these corrections can either be entered or cleared, as desired by the RSO.

NOTE

> TACAN system maximum operating range is in excess of 300 nmi for ground stations, 200 nmi for airborne stations. The maximum indication for TACAN fixpoint slant-range distance on the NCD panel is 999.9 nmi.

10A-139. TEOC camera or radar system operation may also be commanded at fixpoints. The point of control is at the along track position determined by the fixpoint abreast point plus the range to turn on value in the fixpoint data of the mission tape. The

TEOC cameras can be turned on or off at any tape-filled fixpoint. The cameras are pointed and operating modes are programmed at previous control points. The radar may be turned on or off at any tape-filled fixpoint and may also be repointed if the fixpoint is not a TACAN fixpoint. All control points and fixpoints on a leg are processed on that leg, even if a mission planning error or a panel-filled change puts a control point or fixpoint past the turn start (TSA) point at the end of the leg.

10A-140. MISSION MODIFICATION.

NOTE

For the purpose of this manual, the terms DRO and NDRO represent those portions of computer memory which are erased (DRO, or panel filled memory) or retained (NDRO, or tape-filled memory) following removal and reapplication of electrical power to the system. The exception to this is that the DRO memory is retained when a hot start is performed following interruption of electrical power.

10A-141. GENERAL. The system has provisions for modifying the tape filled mission program by performance of various routines using the NCD panel. Using the NCD panel, up to 40 mission points (40-list) may be entered to replace or add to those mission points previously stored by the mission tape fill operation. In addition to the add/replace capability, the operator can further modify the mission by performing such routines as; Skip to DP, Track Leg Update, and Direct Steer to DP. The RSO also has the capability of using such routines as; Opportunity Viewsight Fixpoint or Add Anytime (Viewsight, Radar, or TACAN) Fixpoint. If necessary, the RSO can clear any or all of the mission modifiation (add/replace) data stored in DRO memory and then enter new data using the DRO memory over again. A detailed knowledge of the tape-filled mission is required in order to properly modify the mission, especially when adding or replacing mission points.

NOTE

Refer to SR-71-1 flight manual to add or replace ASARS fixpoints and control points, and for other mission modification procedures peculiar to ASARS missions.

10A-142. ADD OR REPLACE DP, CP, OR FP ROUTINES. (See figures 10A-15 and 10A-16.) The mission points of interest filled from the mission tape are stored in the NDRO (non-destructive readout) portion of the computer memory. The panel filled add/replace mission modification data is stored in the DRO (destructive readout) portion of the computer memory. Mission modification data stored in the DRO memory is retained during power interruptions (of any duration) provided the power interruption is followed by a hot start of the system (HOT switch pressed to start the system). The data in the DRO memory is erased during cold ground or air starts (MODE START or RAPID switch pressed to start the system).

10A-143. The primary use of the add/replace function is to alter or supersede the tape-filled mission plan before takeoff. This feature can also be used during flight, where mission points can be added or replaced by the RSO as required to properly conduct the mission. In general, the Add/Replace routine involves selection of proper type of mission point (DEST POINT, FIXPOINT, or CONT PT) with the DATA switch, entering the ID-code of the point to be added or replaced, and entering the latitude and longitude of the point. If a turn radius is not entered for destination points the system computes a turn radius and TSA for a 32 degree-bank turn, using existing groundspeed. For control points, the mission point elevation and sensor L/R range and sensor selection (LTEOC/RTEOC/SLR) codes are also inserted. For a viewsight or TACAN fixpoint, the fixpoint elevation is also entered and for a radar fixpoint, the fixpoint elevation and sensor L/R range code are also entered. The system automatically processes and uses added or replaced mission points as long as these points are not entered on the

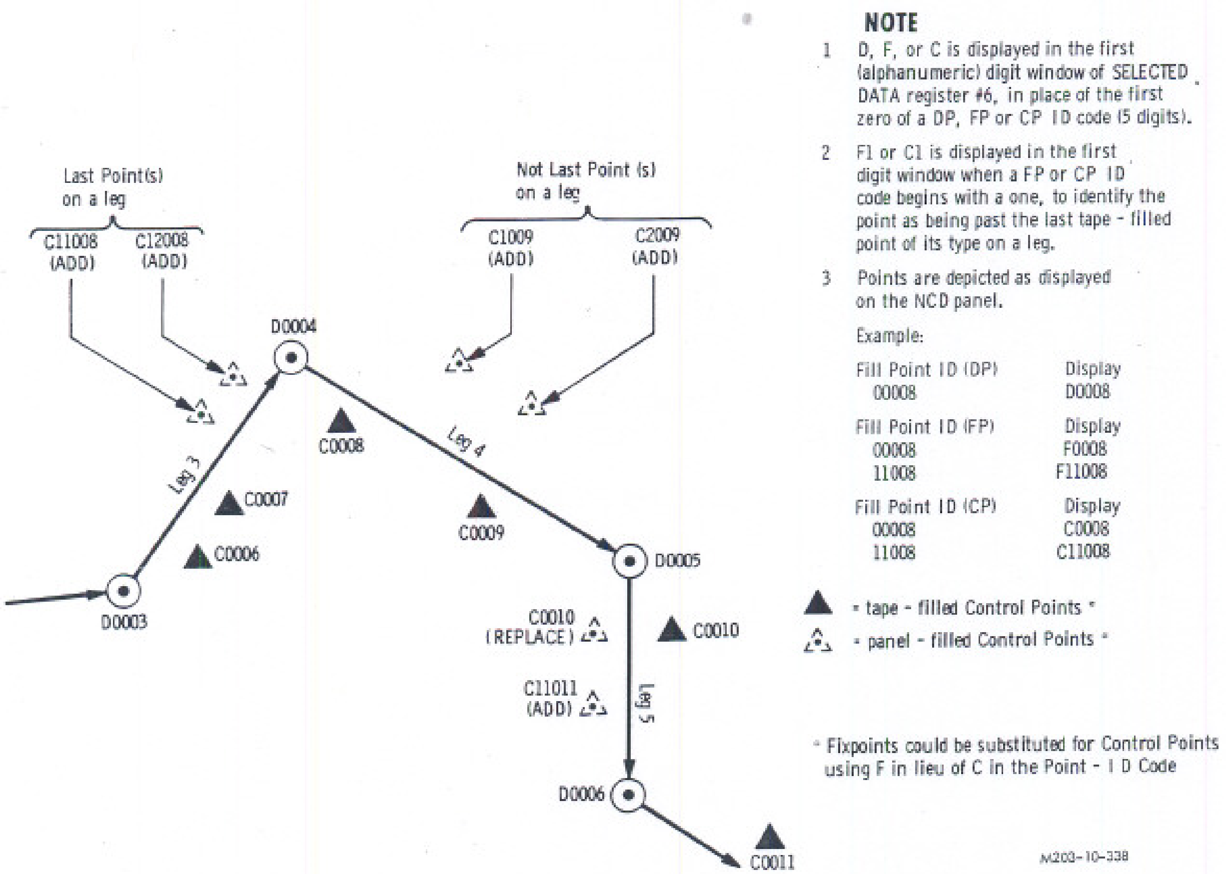

Figure 10A-16. Typical Add/Replace Plan for Fixpoints and Control Points

current leg of the mission (from TSA onward). If mission points must be added to or must replace mission points on the current leg, a Track Leg Update to the last DP must be performed following the Add/Replace routine.

10A-144. Point ID Code. Every tape-filled or panel filled mission point has an identification code. The code consists of five digits referred to in the following text as digits 1, 2, 3, 4, and 5, counting from the left. This is the order in which the point-ID code is entered in panel operations. The letter C, F, or D designates the point as a control point, fixpoint, or destination point, respectively and is displayed in the first digit window of SELECTED DATA register #6 in place of the first zero of a CP, FP or DP ID code. F1 or C1 is displayed in the first digit window when a FP or CP ID code begins with a one to identify the point as being past the last tape-filled point of its type on the leg. (See figure 10A-16.) When performing a mission modification, the ID code is entered after selecting FIXPOINT, CONT PT, or DEST POINT with the DATA switch.

10A-145. Digits 3, 4 and 5 of the ID code denote the number assigned to each tape-filled CP, FP, and DP. Tape-filled points are assigned numbers, ranging from 001 for the first CP, FP, and DP, up to a maximum of 999 control points and 256 each of fixpoints and destination points. In general, the points on the primary mission are numbered in sequence followed by the points on alternate legs. However, the sequence is not really important since the next point number of each type is listed with each tape-filled mission point; i.e., the data in NDRO for DP 002 can define DP 013 as the next DP, or vice versa. The same applies to CP's and FP's. As shown on figure 10A-16, the DP's which are the start points for alternate legs are doubly defined. This means that the same geographic point is contained in NDRO in two different locations with different numbers and different next-point numbers (example: D0003 and D0011). The alternate leg is selected by skipping to D0011 when on leg 1. Note that the alternate path rejoins the primary mission at D0007; thus, both D0006 and D0012 list D0007 as the next DP. Panel-filled (ADD or REPLACE) points are defined relative to tape-filled points, digits 3, 4 and 5 define the tape-filled point to be replaced, or the tape-filled or panel-replaced point following the point(s) to be added.

10A-146. Digit 2 is the "add" number for panel filled ADD points. Digit 2 can range from 1 to 7 for the first through seventh points to be added ahead of the tape-filled or panel-replaced point of the same type defined by digits 2, 3 and 4, where add point X1ABC is the first add point encountered in the mission, ahead of point 00ABC with add point X2ABC the second, etc. Digit 2 is zero for tape-filled points or replaced points.

10A-147. Digit 1 is zero for all tape-filled points, replaced control points or fixpoints, and panel filled destination points. When adding fixpoints or control points, however, digit 1 is used by the computer to determine the track leg location of the new added point. If the ADD point is past the last tape-filled point of its type on its track leg, this digit is 1; if the ADD point is not the last of its type on its track leg, then the digit is a zero. When digit 1 is zero it is displayed as D, C or F. When it is a one it is displayed as C1 or F1.

10A-148. Sensor Selection Code. The following sensor selection code (3 digits) is used to designate which sensor shall be activated in conjunction with panel filled control points.

Sensor	Code
LTEOC	1 0 0
RTEOC	0 1 0
SLR	0 0 1

Code insertion on panel is verified by observing illumination of appropriate sensor indicator.

10A-149. When control points are added or replaced, care must be taken not to disrupt prior turn-on commands to the technical objective cameras or radar system. If, for example, the left TEOC camera was automatically turned on 50 nmi prior to an add right TEOC camera control point, and the mission planner intended it to remain on for a total 100 nmi swath, the add control point sensor assignment code would be 110. This would tell the computer to leave the left TEOC camera on at the new control point and that the right TEOC camera is to be turned on. This is necessary because each CP will turn sensors off without an ON marker in the sensor code.

10A-150. Sensor L/R Range Code. The sensor left-right and range code is used to designate the direction (left or right) and distance to near edge of area to be mapped when CAPRE side-looking radar is selected for use at a fixpoint or control point. The code indicates direction and crosstrack range (start range) from nadir to near edge of mapped area. The following is an example of a range code:

L-R Range Code	Start Range (Cross-track nmi to near edge of beam)
(*)15.0	15

*R if CP or FP is to right of course,
L if CP or FP is to left of course

NOTE

(*) 05.0 is an illegal code.

10A-151. When adding or replacing TEOC camera control points, L000 is inserted for control points to the left of course, R000 for control points to the right of course. Code insertion is verified in the SELECTED DATA #5 indicator by observing R or L plus three zeros. When adding or replacing capre control points, the commanded mapping range is limited to the narrow width (5 mile width with one SLR recorder, 10 mile width with two recorders).

10A-152. Details and Limitations on Adding and Replacing Mission Points. The following criteria apply to the add/replace capability of the system:

a. The add/replace routines can be performed with the system in any mode except WARMUP or OFF.

b. A maximum of seven points of the same type can be added ahead of any tape filled point of the same type.

c. Points cannot be added after the last tape filled point of the same type.

d. Control points and fixpoints cannot be added to tracks which contain no tape-filled control points or fixpoints.

e. Points may be added ahead of replaced points of any type.

f. Once a mission point has been replaced, it cannot again be replaced until it has been deleted from the 40 list.

g. When adding a point ahead of the next point of the same type on the current leg, or when replacing the next point on the current leg, perform a Track Leg Update routine to the last DP after entering the add/replace data.

h. Modifications can be made to the first tape filled leg by performing the modifications before entering airplane present position during coarse alignment or, if alignment has been completed, by performing a Track Leg Update routine after making the modifications.

i. If a tape filled fixpoint is replaced, sensor activity programmed for the replaced point will not occur. If sensor activity is still required at the original fixpoint location, the sensor(s) must be operated manually.

j. Control points and fixpoints will continue to be processed on an original tape-filled leg although the system has been commanded to navigate from a tape filled DP to an added or replaced DP, or from a replaced DP to any type of DP. As the pointing and mapping commands for the sensors will generally be incorrect, the affected sensor should either be operated manually or the control points and fixpoints on the original leg should be replaced. No tape filled control points or fixpoints are processed when navigating from an added DP to any type of DP.

k. DP's can be replaced, or used as a reference in adding DP's, as long as the airplane has not reached the turn start (TSA) point to that DP.

10A-153. Delete DP, CP, or FP Routine. The delete DP, CP, or FP routine is used to erase a panel filled mission point from the 40-list so that the DRO memory for that point can be reused. The procedure can also be used to rectify a mistake in manually entering a point without having to clear the entire 40-list. Tape filled mission points cannot be deleted.

10A-154. OPPORTUNITY AND ANYTIME FIXPOINTS.

10A-155. Opportunity Viewsight Fixpoint. The opportunity viewsight fixpoint allows the RSO to update ANS present position using a visually identified point which has not been tape or panel filled into the computer memory. When performing this procedure, the RSO aligns the viewsight cursor and presses the READ button as in a normal viewsight fixpoint routine. As the coordinates of the opportunity fixpoint are not stored in the computer, the initial display of ANS position corrections are meaningless. These meaningless corrections are cleared as the RSO fills the latitude, longitude, and elevation of the opportunity fixpoint. When the ENTER switch is pressed at completion of fixpoint entry, new position corrections are displayed for the RSO's evaluation. The displayed corrections can either be entered or cleared by the RSO. If the RSO makes an error in fixpoint coordinate/elevation entry, the entry can be repeated. If correction of ANS computed position is desired, the UPDATE switch is pressed. If ERR is displayed by the MODE indicator, the MAN CLEAR switch must be pressed to terminate the routine. If a new leg has been sequenced to before pressing the ENTER switch, the routine is invalidated and the MAN CLEAR switch must be pressed to terminate the routine.

10A-156. Add Anytime (Viewsight, CAPRE Radar, or TACAN) Fixpoint. The add anytime fixpoint routine is the same as the add fixpoint routine described in paragraph 10A-143, except that no ID code is entered and, therefore the entry does not go into 40-list. The routine provides a capability of adding fixpoints on legs that have no tape filled fixpoints, during critical phases of hot or cold airstarts, on Skip To or Direct Steer legs, or any time an additional fixpoint is needed. Add anytime fixpoints can be entered only when on the great circle leg on which they will be used. Anytime fixpoints are cleared if a Direct Steer or Track Leg Update routine is performed. The following paragraphs describe conditions unique to particular add anytime fixpoints.

NOTE

There is no provision for ASARS Add Anytime Fixpoints.

a. Add Anytime Viewsight Fixpoint. When a viewsight add anytime fixpoint routine is performed, tape filled or panel filled viewsight fixpoints are not processed until the viewsight READ button is pressed. Pressing the viewsight READ button also clears any radar anytime fixpoint routine which may have been started. Camera and radar control points are not affected by performance of the anytime viewsight fixpoint operation.

b. Add Anytime Radar Fixpoint. When a CAPRE radar anytime fixpoint routine is performed, the radar is commanded to operate 60 nmi ahead of the anytime fixpoint. Any tape filled or panel filled radar commands (at control points or fixpoints) are inhibited until 24 nmi past the anytime fixpoint. The radar remains on and pointed at the anytime fixpoint range until subsequent tape filled or panel filled radar control points or fixpoints turn the radar off or repoint it; or a new great-circle leg is reached. Camera control points are not affected by the anytime radar fixpoint operation.

c. Add Anytime TACAN Fixpoint. Unlike anytime viewsight or radar fixpoints, anytime TACAN fixpoints do not affect sensor programming at tape filled or panel filled control points or fixpoints on the same leg of the mission.

NOTE

By actuation of the RECALL switch the last previously entered and used anytime TACAN fixpoint can be recalled and reused without reëntering fixpoint data.

10A-157. MISSION COURSE MODIFICATION ROUTINES.

10A-158. Skip To DP Routine. (See figure 10A-15.) The Skip to DP routine can be performed any time after the ANS has started navigation. When the routine is performed, the following DP number associated with the current next DP is replaced with the skipped-to DP number. This procedure can be used to select an alternate route during flight. For example; a skip to D0011 can be performed while enroute from D0001 to D0002, and before reaching the range-to-turn to D0003, in order to select the alternate route from D0002 to D0011 to D0012; etc. This procedure can also be used to skip any portion of the programmed mission. For example; to skip from D0004 to D0006, a skip to D0006 is performed while enroute from D0003 to D0004, and before reaching the range-to-turn to D0005. A skip from a doubly defined DP to its alternate destination should not be attempted, since this creates a zero-length leg and unpredictable navigation will result. For example; while enroute to D0003, a skip to D0011 should not be attempted after reaching the range-to-turn to D0003, since the leg from D0003 to D0011 has zero length.

10A-159. Skipping to a DP does not erase control point or fixpoint operation on the original programmed leg following the current next DP. Consequently, skipping to D0011 to select the alternate route does not eliminate the sensor operation still desired on the leg from D0002 to D0003. On the other hand, skipping to D0006, while enroute to D0004, will not eliminate the control points and fixpoints now undesired along the original leg from D0004 to D0005; and the system will process these points. In this type of situation, the sensor(s) should be operated manually until the aircraft is back on the programmed course.

10A-160. Direct Steer To DP Routine. (See figure 10A-15.) Performing the Direct Steer routine results in an immediate change in destination. When commanded, the ANS computes a new great-circle course from the present position to the DP (tape or panel filled) selected. The airplane starts to turn to the new course immediately after the DIR STEER switch is pressed. The ANS automatically computes new great-circle courses to the DP until the aircraft has turned to within 2 degrees relative bearing to the destination. This results in the most direct path to the DP. If aircraft track subsequently deviates more than 2 degrees from the commanded course, the Direct Steer operation is automatically restarted. When a Direct Steer routine is performed, ANS operate commands to the sensors are turned off. The Opportunity Viewsight Fixpoint and Add Anytime Fixpoint routines may be used while in Direct Steer as long as the aircraft velocity vector (track) remains within 2 degrees of the bearing to the DP.

10A-161. Track Leg Update Routine. (See figure 10A-15.) The Track Leg Update procedure allows the RSO to regain or change the current ANS track leg. Any track leg segment in the mission plan may be selected. When performing this procedure, the RSO fills the ID code number of the beginning DP of the leg desired. The ANS then initializes to the leg from that DP to the next sequential tape-filled or panel-filled DP. Great circle navigation and sensor control are immediately conducted relative to this new leg. The ANS sequences through all control points and fixpoints on the new leg up to the current computed along-track position, where sensor commands will be as programmed for that point on the track. Normal auto-nav steering is performed, using a 30-degree approach to the new track, if necessary.

10A-162. The RSO normally performs a Track Leg Update during a hot or cold airstart, as the computer automatically reinitializes to the first track leg segment on the mission tape at system turn on. If aircraft speed and/or present position satisfy turn start (TSA) criteria, the ANS will accept the updated track leg but will then immediately index to the next leg.

10A-163. ANS INTERFACE.

10A-164. GENERAL. In addition to the electrical and cooling air interfaces described in the beginning of this section (paragraphs 10A-7 and 10A-41), the ANS interfaces with the following systems and equipment: air data system (ADS), inertial navigation system (INS) autopilot, flight director computer (FDC), forward cockpit ADI, HSI indicators, and peripheral vision display (PVD), aft cockpit attitude and BDHI indicators, radar system, viewsight, TEOC cameras, OBC camera, V/H system, EIP/EMR system, mission recorder system (MRS), and the left main gear scissor switch relay. The ANS also interfaces with the various sensor equipment through the sensor event/frame count system, for the purpose of correlating data collected by the sensors with ANS navigation data. The following paragraphs describe the interface signals between the ANS and the above listed systems/equipment.

10A-165. AIR DATA SYSTEM INTERFACE. (See figure 10A-17.) When supplied with time-shared encoder excitation signals from the ANS, the ADS supplies the ANS with encoded barometric altitude and true airspeed signals. The altitude signal is used, together with radar terrain clearance data and fixpoint/control point elevation data, to develop Nav computed altitude. The true airspeed signal is used to update the dead-reckon math reference and, during an air-start, for airmass damping of inertial velocities.

10A-166. INS SYSTEM INTERFACE. (See figure 10A-17.) The INS provides the ANS with a magnetic heading signal for use during ground or airstart alignment and when in dead-recon mode.

10A-167. LANDING GEAR SCISSOR SWITCH INTERFACE. (See figure 10A-17.) The ANS utilizes operation of the left main gear scissor switch as an indication of takeoff landing. The ANS receives the 28 vdc takeoff/landing signal by operation of the left scissors switch relay, which operates in response to action of the left main gear scissors switch. The takeoff/landing signal is used as a marker which is included in ANS 32-word telemetry data recorded by the MRS. The takeoff signal is used to terminate a Runway Heading Alignment routine (if initiated by the RSO). The takeoff signal also stops operation of the cooling air blower in the NCD panel.

10A-168. AUTOPILOT INTERFACE. (See figure 10A-18.) The ANS supplies the following signals to the autopilot: Nav ready signal, pitch and roll attitude signals, a heading signal, and a steering (bank angle) command signal. Excitation for the Nav ready signal is from the AUTOPILOT dc circuit breaker. Excitation for the ANS pitch, roll, heading, and steering signals is from the AUTOPILOT ac circuit breaker, through the autopilot power circuits. In order for the ANS signals to be used by the autopilot, the ATT REF SELECT switch (forward cockpit center instrument panel) must be in the ANS position.

10A-169. Nav Ready Signal. The 28 vdc Nav ready signal is available when the ANS is in an operational condition (refer to paragraph 10A-96), the ATT REF SELECT switch is in the ANS position, and the autopilot disengage switch (pilot's control stick grip) is not pressed. Presence of the Nav ready signal permits engagement of the autopilot pitch and roll channels and, with the roll channel engaged, selection of either the heading hold mode or the auto nav mode of autopilot operation. Loss of the ready signal disengages (or prevents engagement of) the autopilot pitch and roll channels and the heading hold or auto nav mode.

10A-170. ANS Pitch and Roll Signals. The ANS supplies pitch and roll synchro signals directly to the autopilot. These signals are applied to the autopilot pitch and roll channels, for aircraft pitch and roll stabilization, provided that the ATT REF SELECT switch is in the ANS position and the PITCH and ROLL switches (on the AFCS function selector panel) are set to ON.

10A-171. ANS Heading Signal. The ANS supplies a heading synchro signal to the autopilot. This signal is applied to the autopilot roll channel as a reference to maintain a fixed heading, provided the ATT REF SELECT switch is in the ANS position and, on the AFCS panel, the ROLL and HEADING HOLD switches are set to ON.

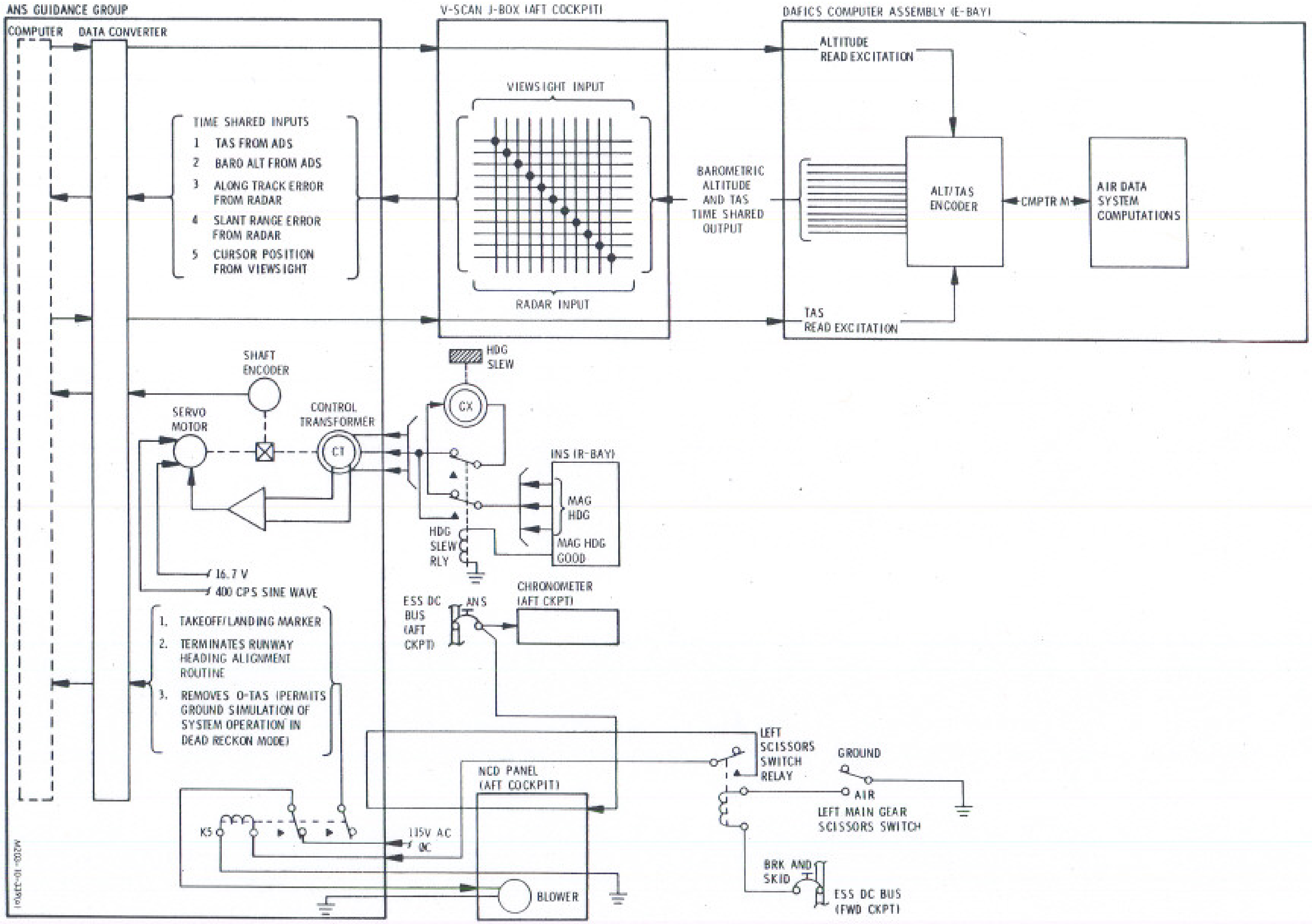

Figure 10A-17. ANS/ADS, INS, and Scissors Switch Signal Flow Diagram

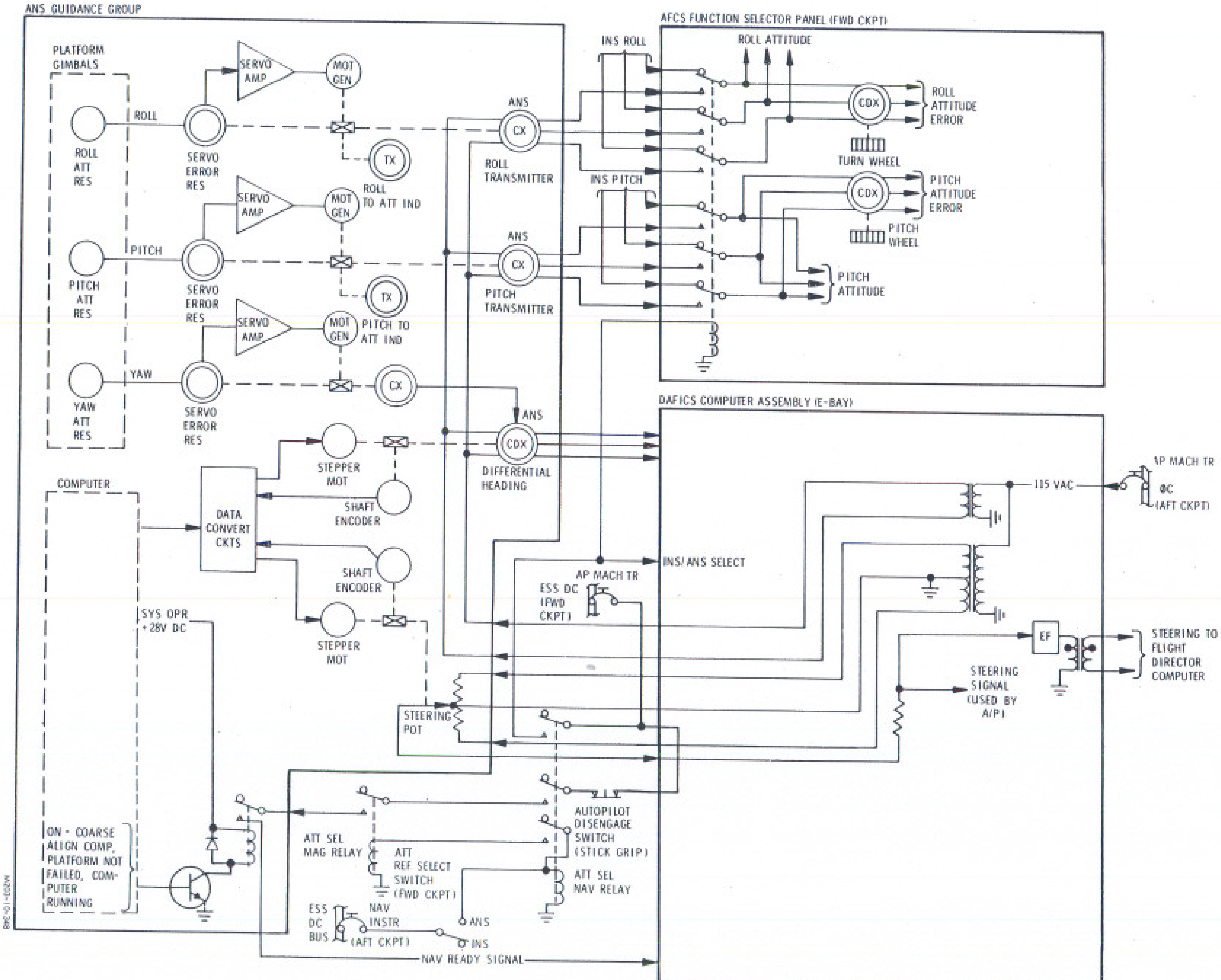

Figure 10A-18. ANS/Autopilot Signal Flow Diagram

10A-172. ANS Steering (Bank Angle) Command Signal. The ANS supplies a signal representing the difference between the bank angle required to steer the airplane along the intended flight path and the actual bank angle of the airplane. This signal varies in phase and amplitude with the direction and magnitude of the bank action required, and is of zero amplitude when the required and actual bank angles are equal. The steering command signal is applied to the autopilot roll channel provided the ATT REF SELECT switch is in the ANS position and, on the AFCS panel, the ROLL and AUTO NAV switches are set to ON.

NOTE

Autopilot heading hold and auto nav modes cannot be engaged at the same time. Engaging one of these modes with the other mode already engaged, disengages the already engaged mode, allowing the last selected mode to be engaged. (e.g. If the heading hold mode is engaged and the AUTO NAV switch is set to ON, the HEADING HOLD switch returns to the off position, disengaging the heading hold mode, and the AUTO NAV switch is retained in the ON condition, initiating the auto nav mode.)

10A-173. FLIGHT DIRECTOR COMPUTER INTERFACE. (See figure 10A-19.) The ANS supplies steering command and pitch and roll synchro signals to the FDC for processing into signals for display on the pilot's ADI. The steering (bank angle) command signal, routed through the autopilot circuits, is applied to the FDC when the ANS position is selected with the pilot's DISPLAY MODE SEL switch. The pitch and roll input signals to the FDC are from the ANS or INS, as controlled by the pilot's ATT REF SELECT switch. Depending on the position of the DISPLAY MODE SEL switch, the roll signal is combined in the FDC with the HSI steering signal (INS position), TACAN course deviation signal (TACAN/ADF position), or ILS localizer course deviation signal (ILS or ILS APPROACH positions), for control of the ADI vertical pointer. With ANS selected with the DISPLAY MODE SEL switch, the roll signal is disconnected (by the roll disconnect relay) and the ANS steering (bank angle) command signal is processed by the FDC for control of the ADI vertical pointer. The pitch signal is used only when the ILS APPROACH position is selected with the DISPLAY MODE SEL switch. In this mode, aircraft pitch and ILS glide slope signals are processed by the FDC for control of the ADI horizontal pointer.

10A-174. ADI INDICATOR INTERFACE. (See figure 10A-19.) The ANS supplies pitch and roll signals, Nav ready signals, and a vertical velocity signal to the ADI. The pitch and roll synchro signals, used to position and move the ADI attitude sphere, are applied to the instrument when the ANS position is selected with the pilot's ATT REF SELECT switch. A Nav ready signal (ground) is applied to the ADI power OFF flag (moving it out of view) when the ATT REF SELECT switch is set to the ANS position. When the pilot's DISPLAY MODE SEL switch is in the ANS position, the ANS supplies a dc vertical velocity signal to the ADI horizontal pointer (to indicate rate of assent/descent) and a Nav ready signal (28 vdc) to the ADI vertical pointer flag (to move it out of view). ADI vertical and horizontal pointers also receive ANS signals via the flight director computer, as described in pargaraph 10A-173.

10A-175. ATTITUDE INDICATOR (AFT COCKPIT) INTERFACE. (See figure 10A-19.) When the aft cockpit ATT IND switch is in the ANS position, the ANS supplies pitch, roll, and Nav ready signals to the aft cockpit attitude indicator. The pitch and roll synchro signals are used to position and move the attitude sphere and the Nav ready signal (ground) is applied to the OFF flag (to move it out of view).

10A-176. PVD INTERFACE (See figure 10A-19.) When the pilot's ATT REF SELECT is in ANS position, the ANS supplies pitch and roll signals to the PVD processor.

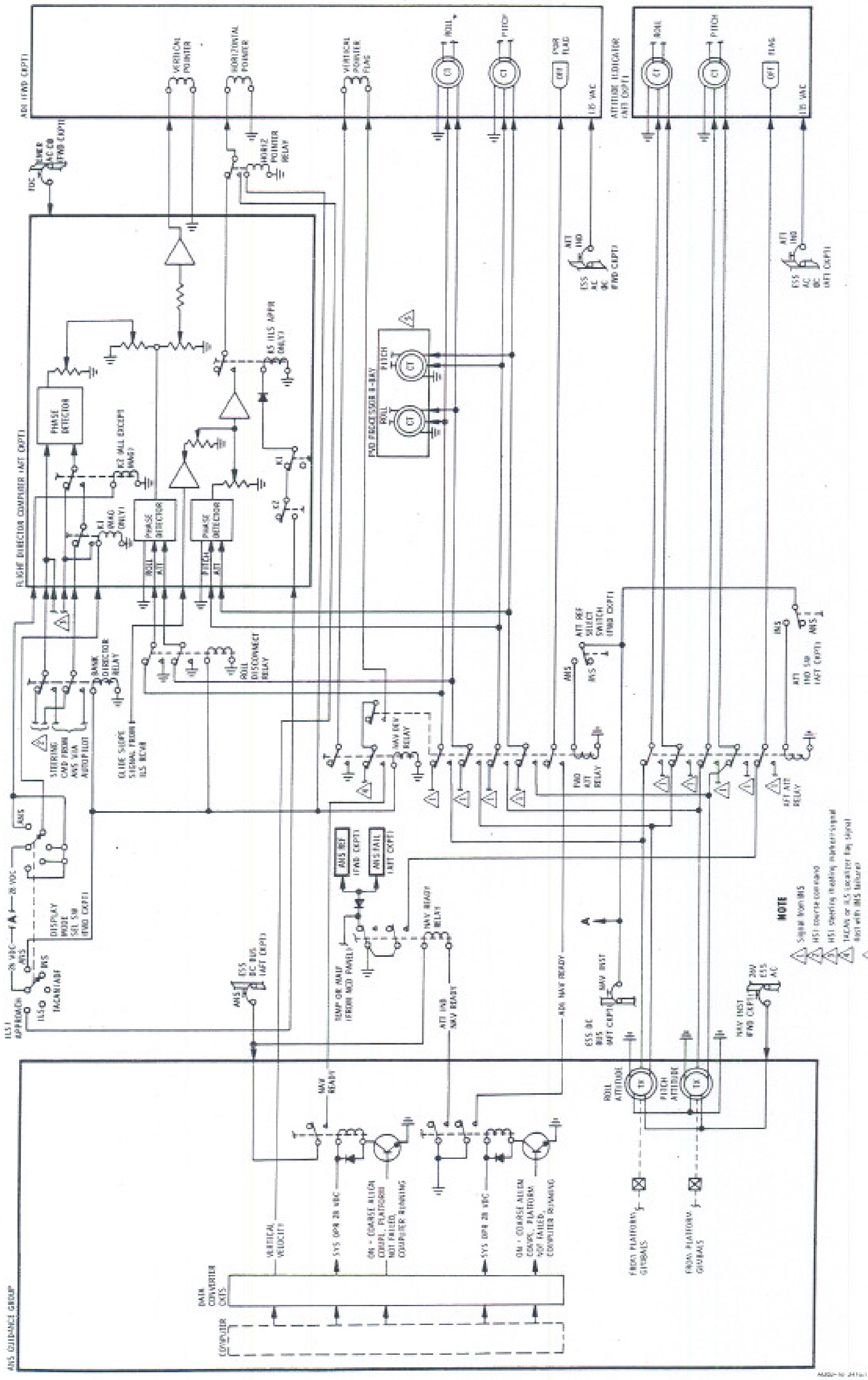

Figure 10A-19. ANS/FDC, ADI, Attitude Indicator, and PVD Signal Flow Diagram

10A-177. HSI INDICATOR INTERFACE. (See figure 10A-20.) When the pilot's DISPLAY MODE SEL switch is in the ANS position, the ANS supplies the following signals to the HSI: true heading synchro signal, to position the compass card; command course synchro signal, to position the course arrow and drive the COURSE display; and a dc course deviation signal, to position the course deviation bar. In addition, with the pilot's BEARING SELECT switch in NORMAL, the ANS supplies synchro range signals and a 28 vdc thousand shutter signal to the HSI MILES display. A 28 vdc range shutter open signal is provided when the ANS dc circuit breaker is closed.

10A-178. BDHI INDICATOR INTERFACE. (See figure 10A-20.) When the aft cockpit BDHI HDG switch is in the ANS position, the ANS supplies a true heading synchro signal to the BDHI compass card. The ANS also supplies a command course synchro signal to position the BDHI No. 2 pointer. The command course signal is applied directly to the instrument and is not affected by cockpit instrument switches or relays.

10A-179. ASARS INTERFACE. The ANS output signals which control ASARS operation are frame gate, word gate, data clock, and serial data. These four signals make up the navigation data bus. The navigation data bus provides on/off and mode commands, geographic coordinates, aircraft heading and attitude, ground track, sensor frame count and time. Refer to SR-71-2-11 section XIII for further details.

10A-180. CAPRE RADAR SYSTEM INTERFACE. (See figure 10A-21.) ANS/radar interface signals are described in the following paragraphs.

NOTE

The ANS also interfaces with the radar system through the sensor event/frame count system. (Refer to paragraphs 10A-203 and 10A-208.)

10A-181. ANS Signals to CAPRE Radar.

10A-182. ANS Programmed Commands. (Transmit On, Left/Right, Map Width, Range Data, Receiver Gain.) Radar command instructions are stored in the ANS computer memory along with coordinates of radar control points and fixpoints. With auto mode selected on the radar control panel, the radar supplies 28 vdc (programmed 28 vdc) to the ANS. When the airplane passes a transmitter operate point, relays in the ANS return the 28 vdc to the radar as command signals. The ANS provides these commands based upon computed airplane present position and preprogrammed instructions stored in its memory (for tape-filled mission points) or manually entered through the NCD panel (for panel-filled mission points).

a. Transmit-On (Operate) Command. The transmit-on signal is generated a prescribed distance in advance of a radar fixpoint or abeam of a radar control point. For tape-filled fixpoints, the backset distance is preprogrammed. For manually entered fixpoints, the distance is fixed at 60 nmi. Radar control points are selected at some along-track distance in advance of the target, but at the same range. The transmit-on signals turns on the OPR legend on the radar control panel, resets the motion compensation circuits in the SLR synchronizer, and turns on the radar transmitter. The transmit-on signal also turns on the SLR recorder and the RCD.)

b. Left/Right Command. The left/right command signal (left command is 28 vdc, right 0 vdc) turns on the L or R legend on the radar control panel, directs the radar antenna to look to the left or to the right, and controls direction of CRT sweep in the radar recorder(s) and RCD to agree with commanded side to be mapped.

c. Map Width Command. The map width (range increment) command (wide command is 28 vdc, narrow command is 0 vdc) turns on the N or W legend on the radar control panel, controls CRT sweep speed (map width) in the radar recorder(s), controls

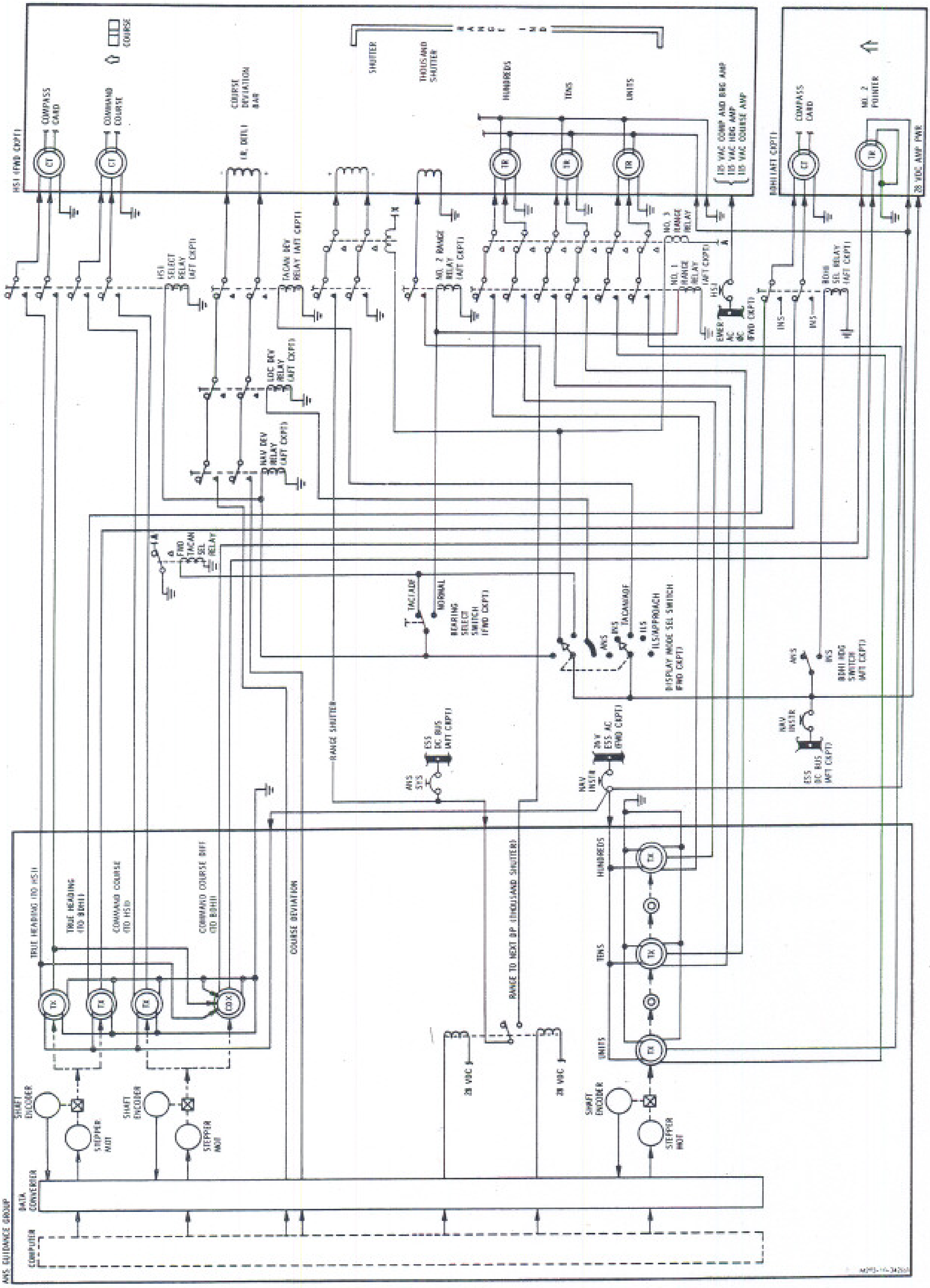

Figure 10A-20. ANS/HSI and BDHI Signal Flow Diagram

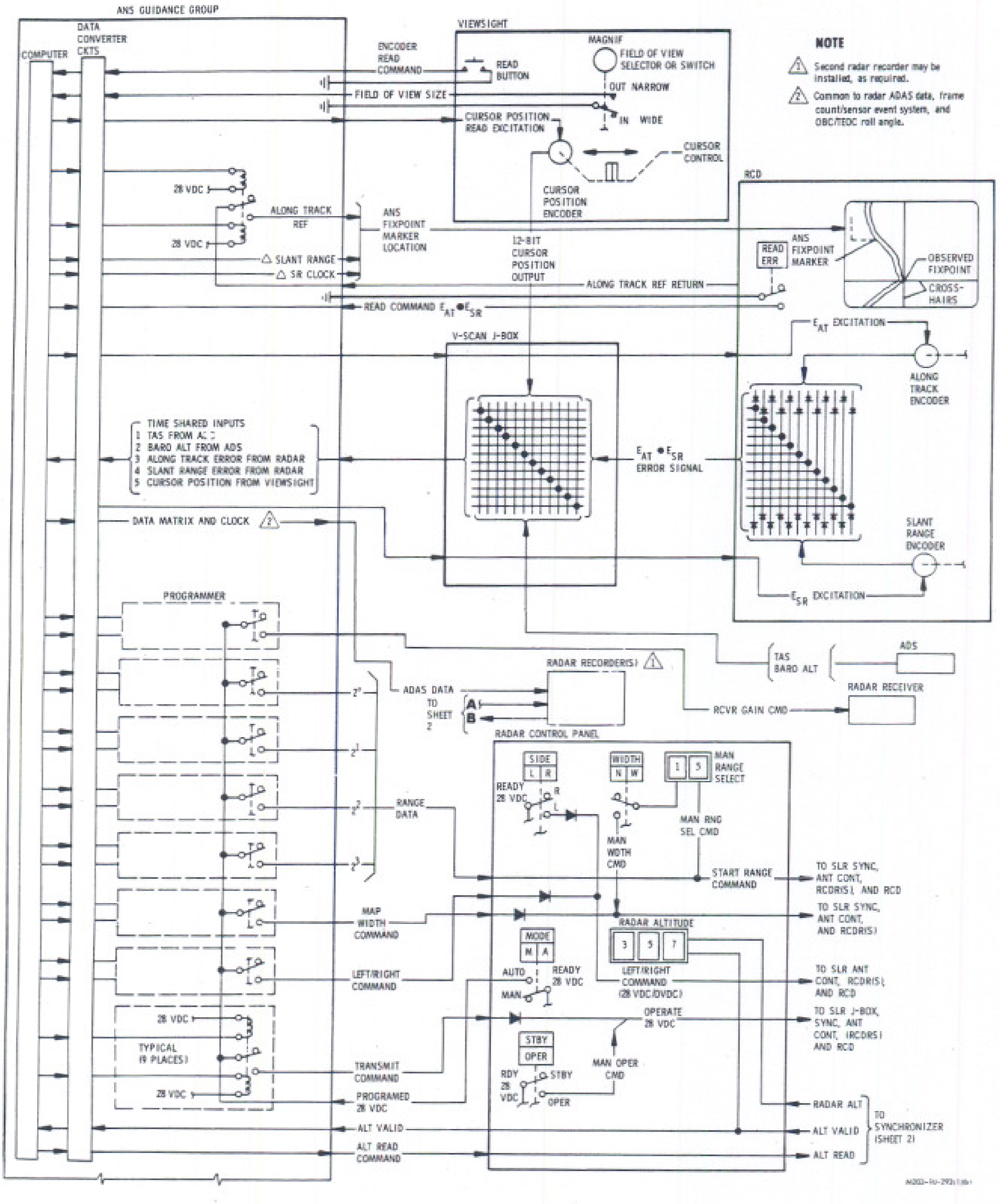

Figure 10A-21. ANS/Viewsight and CAPRE Radar Signal Flow Diagram (Sheet 1 of 2)

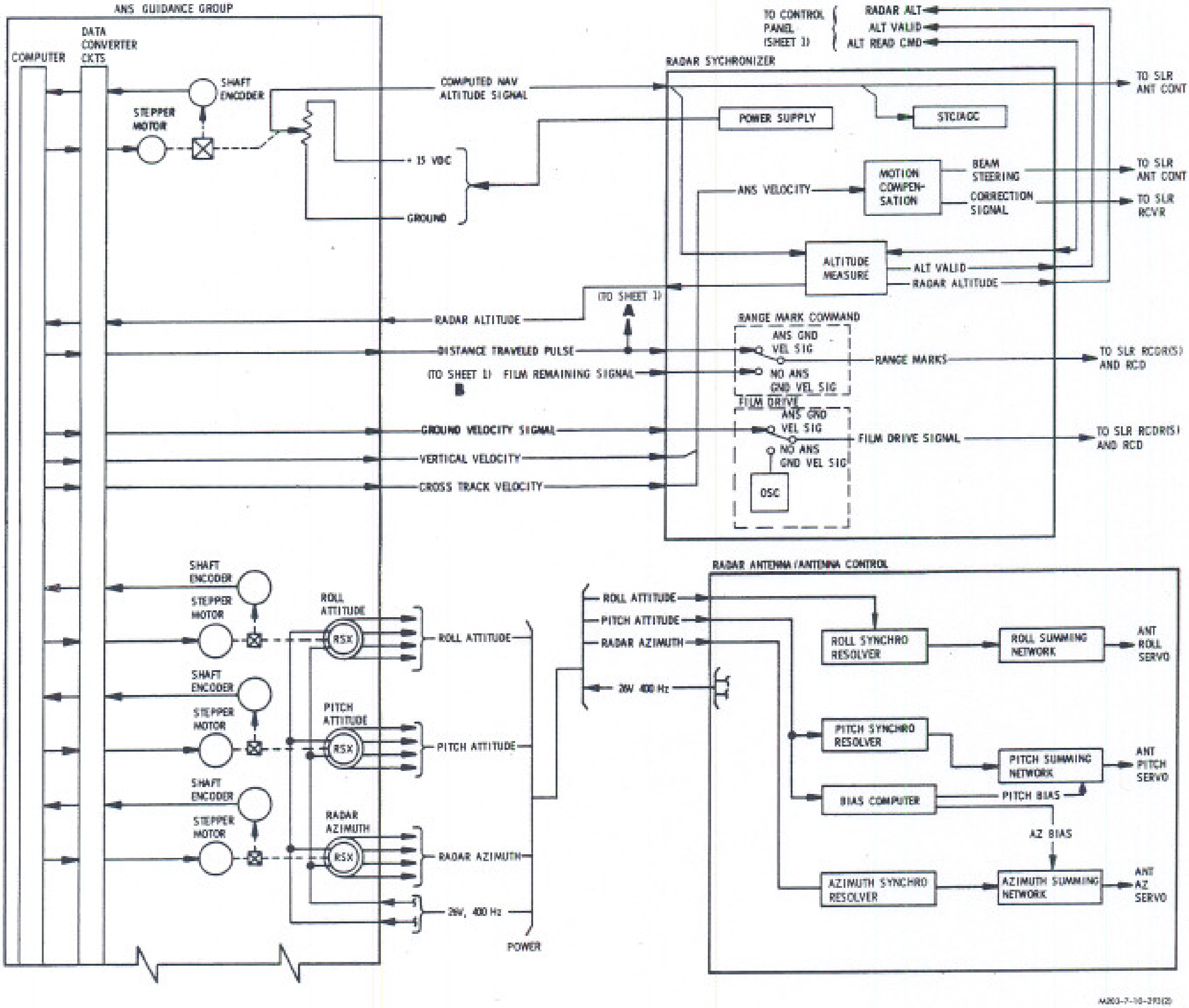

Figure 10A-21. ANS/Viewsight and CAPRE Radar Signal Flow Diagram (Sheet 2 of 2)

(together with range data) antenna tilt and elevation beam-width of antenna, and controls (together with range data) radar synchronizer STC, motion compensation, PRF, and recorder and RCD trigger circuits.

d. Range Data Command. The range data command represents start range (cross track range to near edge of area to be mapped). Range data command consists of a 4-bit binary code. The coded command causes the proper start range indication to appear on the radar control panel, controls radar antenna tilt and elevation beam width of antenna, controls ANS marker location and range imaging of map film in radar RCD; and controls STC, motion compensation, PRF, receiver/transmitter triggers, recorder and

RCD sweep triggers and range marks generated in radar synchronizer. (Range code lines carry values of 5 nmi times 2^0, 2^1, 2^2, and 2^3. Refer to paragraph 10-150 for related codes and commanded ranges.)

e. Receiver Gain (Range-Gated AGC) Command. The receiver gain command controls the gain of the radar receiver. High (normal) gain command is 28 vdc, low gain command is 0 vdc. Normal gain command is replaced with low gain command only at specific geographic coordinates, when the ANS is so preprogrammed.

10A-183. ANS Pitch, Roll, and Azimuth Signals. ANS pitch, roll, and azimuth synchro signals are used by the radar for antenna stabilization about these three axes. The synchro signals are applied to the radar antenna control unit which in turn, through servo loops for each channel (pitch, roll, and azimuth), supplies drive signals to maintain antenna stabilization. The radar antenna control unit supplies the ANS with 26 vac excitation for these synchro signals.

10A-184. ANS/ADAS Data Matrix and Clock Signals. The ADAS (auxiliary data annotation system) matrix signal consists of 96 characters, with 7 bits per character. The data matrix, together with a clock signal, is applied to the radar recorder(s) where this signal is processed and part of the information recorded on the data film. Following correlation of the data film this information (GMT, day, latitude, longitude, altitude, ground track, SLR frame count, and mission number); together with radar supplied start range, L/R, and width commands; is displayed on the completed SLR map film, adjacent to the radar image.

10A-185. ANS Ground Velocity Signal. The ground velocity signal is a square wave with a frequency proportional to airplane velocity along the flight path. This signal is processed in the radar synchronizer and applied to the recorder(s) and the RCD as film drive motor control, causing the film to be transported at a rate proportional to airplane along track velocity. If the signal is not present, a fixed velocity signal developed in the synchronizer is used as the film drive signal.

10A-186. ANS Distance Traveled Pulses. The ANS supplies the radar synchronizer with distance traveled pulses which occur at the rate of one pulse every 2-1/2 nautical miles of distance traveled along the flight path. The ANS pulses are used in the radar synchronizer to develop range marks which appear on recorder and RCD map films in the slant range direction. If the ANS ground velocity signal is missing, film motion pulses from the recorder are used to generate the range marks. The range marks are spaced 2-1/2 nautical miles apart along track and 1 nautical mile apart in slant range. In addition to being used for range mark generation, ANS distance traveled pulses are also applied to radar recorder(s) to enable recording of ADAS data.

10A-187. ANS Cross-Track and Vertical Velocity and Clock Signals. The ANS supplies the radar synchronizer with digital cross track and vertical velocity signals, together with clock signals, proportional to airplane motion in these directions. These velocity signals are used to develop motion compensation signals to cancel the effects of airplane motion in the direction of the radar antenna beam, which otherwise would cause a distorted radar map.

10A-188. ANS Altitude Read Command. When a transmit-on command signal is applied to the radar (refer to paragraph 10A-182), the ANS also transmits a series of 500 microsecond wide pulses, repeated at 96 millisecond intervals. Within the radar synchronizer, these pulses enable the readout of radar measured altitude to the ANS.

10A-189. ANS Computed Altitude Above Terrain (Computed Nav Altitude. Using excitation voltage supplied by the radar, the

ANS supplies the radar with a dc voltage proportional to ANS computed altitude above terrain (airplane altitude above sea level computed by ANS minus altitude of the last control point or fixpoint). Within the radar system the altitude signal is processed and used to control antenna tilt angle, to modify the receiver STC/AGC signal, and for comparison with radar measured altitude to prevent measurement of cloud returns rather than actual terrain clearance.

10A-190. ANS Along Track Reference and Delta Slant Range Signals. Radar fixpoint coordinates are stored in the ANS computer memory or entered through the NCD panel. As the airplane passes abeam of a fixpoint, an along-track reference marker and a delta slant range signal and clock are applied to the radar RCD. The along track reference marker indicates the along track position of the fixpoint. The delta slant range signal represents the difference between ANS computed slant range to the fixpoint and slant range to the near edge of the radar beam. The along track marker and delta slant range signal are processed by the RCD together with radar video. The result is an L-shaped ANS fixpoint marker correctly positioned on the RCD display. Using controls on the RCD, the difference between ANS computed fixpoint position (ANS fixpoint marker location) and observed fixpoint on radar map are measured and applied to the ANS for position update purposes (refer to paragraph 10A-192).

NOTE

To compensate for known delays in the ANS and radar, the along track marker is applied to the RCD 0.3125 nautical miles prior to reaching the along track position of the fixpoint.

10A-191. CAPRE Radar Signals to ANS.

10A-192. Radar RCD Read Command and Along Track and Slant Range Error Signals. When performing an ANS position update routine using the radar, the RCD cross hairs are first positioned over the ANS fixpoint marker then, after zeroing encoders and counters on the RCD, over the observed radar fixpoint. Pressing the RCD READ ERROR switch applies a read command signal to the ANS which, in turn, supplies excitation to slant range and along track V-scan encoders in the RCD. With the encoders energized, ANS along track error (E_{AT}) and slant range error (E_{RS}), measured on the RCD, are transmitted to the ANS. Within the ANS the along track and slant range errors are resolved into N-S and E-W components which are displayed on the NCD panel and may be used, at the discretion of the RSO, to update ANS computed present position.

10A-193. Radar Altitude and Altitude Valid Signals. When placed in operation, the radar system performs continuous measurement of aircraft height above terrain. If valid, the measured altitude is displayed on the radar control panel and, with altitude read command pulses present, applied to the ANS (as a 10 bit parallel binary word), where it is used to update computed Nav altitude using stored or NCD panel inserted terrain elevation. The altitude valid signal, which enables the altitude display on the radar control panel and usage of radar altitude data by the ANS, is provided unless one of the following conditions exists: radar is off or in standby, radar BIT fails, or radar and Nav altitude above terrain differ by more than 5000 feet for 10 or more consecutive measurements. Signal to ANS is an open for valid, a ground for invalid.

10A-194. VIEWSIGHT INTERFACE. (See figure 10A-21.) During flight, the viewsight is used for measuring ANS present position errors. As the airplane approaches a fixpoint whose coordinates are stored in the computer memory, the cursor on the viewsight is positioned to the fixpoint cross-track position. The READ switch on the viewsight is pressed as the fixpoint passes the nadir line on the viewsight reticle image. When the READ switch is pressed, the ANS supplies excitation to the viewsight system and, in turn, reads the cursor position and the selected viewsight field of view (wide or narrow). Simultaneously with receipt of the READ command, the ANS stores computed aircraft present position, altitude, pitch, roll, and heading. The cursor position and field-of-view size inputs are used, together with altitude, pitch, roll, heading, and known coordinates of the fixpoint, to calculate actual airplane present position. Actual present position is compared with computed present position to determine ANS present position error, the correction for which is displayed, in N-S and E-W distances on the NCD panel. The RSO decides whether or not to update ANS computed present position using the displayed correction, then presses the NCD panel UPDATE or MAN CLEAR switch. An Opportunity Viewsight Fix operation is the same as described above except that the fixpoint coordinates are entered through the NCD panel after making the fix.

10A-195. V/H SYSTEM INTERFACE. (See figure 10A-22.) V/H represents the relative angular rate of motion between the aircraft and the terrain over which it is moving. This rate of motion (angular velocity) may be expressed as the forward velocity of the airplane (V) divided by the height of the airplane above the terrain (H). The V/H system provides dc voltages, scaled to represent V/H, to the various camera systems for image motion compensation and cycling control. The ANS supplies the V/H system with signals computed using inertially derived groundspeed and Nav computed altitude above sea level minus the known elevation of the control point or fixpoint most recently passed. Other sources of V/H signals are the viewsight (airplanes without S/B R-2538) and the V/H indicator. The ANS also computes V/R signals used by the TEOC cameras when photography is required during turns from one mission leg to the next. (Refer to paragraph 10A-196d for description of V/R signals.) The V/H and V/R signals are scaled the same; 0.20 vdc per MR/SEC (milliradian per second).

10A-196. TEOC CAMERA INTERFACE. (See figure 10A-22.) ANS interface with left camera is shown, interface with right camera is similar. The ANS supplies the following signals to the TEOC cameras (these signals are applied separately to the left and right cameras): film drive command, pointing angle command, mode command, V/H signal (through V/H system), V/R signal, and roll angle signal. The ANS film drive, pointing angle, and mode commands are effective in controlling the TEOC cameras only if automatic control has been selected on the power and sensor control panel. The TEOC cameras can be placed in operation along the great circle legs of a mission and, when required, during turns.

NOTE

> The ANS also interfaces with the TEOC cameras through the sensor event/frame count system. (Refer to paragraphs 10A-204 and 10A-205.)

a. Film drive command. The 28 vdc film drive command places the camera film drive mechanism in operation, thereby initiating photography. The command can be applied or removed at control points or at a tape-filled fixpoints, if the mission tape is so programmed.

b. Pointing angle command. The pointing angle command synchro signal controls the position of the camera's oblique head and therefore the look angle of the camera to the side of the aircraft (from zero to 45°). (The camera pointing angle is measured relative to the vertical axis of the airplane, not the true vertical; therefore, a 30° pointing angle provides a look angle of 30° relative the airplane ground track only when the airplane is wings level. When the

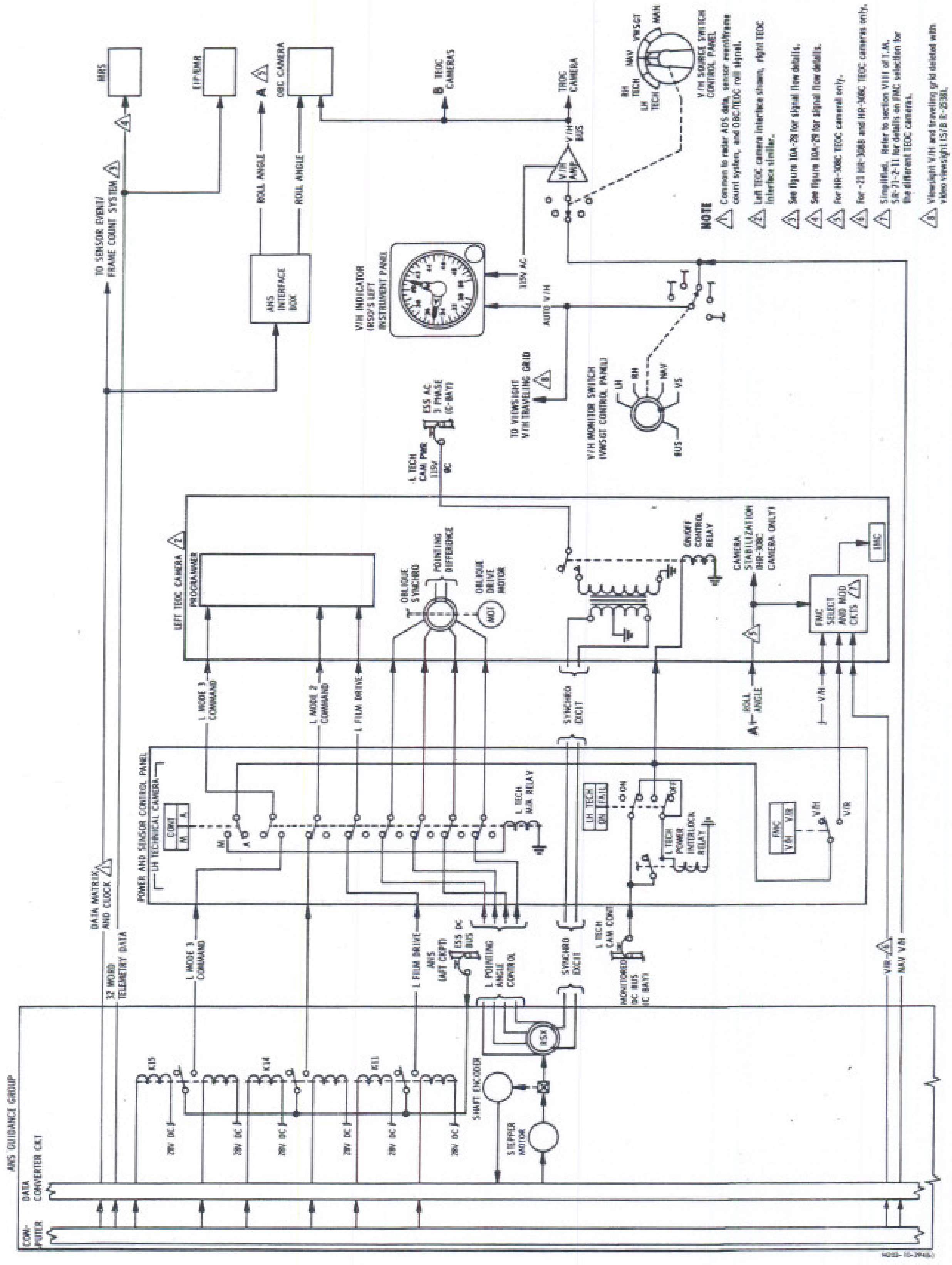

Figure 10A-22. ANS/V/H, TEOC, OBC and EIP/EMR Signal Flow Diagram airplane is in a bank, the look angle differs from the pointing angle by the degree of bank.) The pointing angle commands are calculated by the ANS computer on the basis of airplane present position, altitude, bank angle and control point position and elevation. Pointing angle commands to the camera(s) begin to change to the proper value as the airplane passes abreast of the control point. These commands may be changed at camera turn-off control points as well as turn-on control points.

c. Mode command. The mode command determines the exposure rate, exposure overlap, and cross-track area covered (stereo/no stereo) by the TEOC photography. The mode command can be changed as the airplane passes a camera control point. The ANS can supply only 28 vdc mode 2 or mode 3 command signals. If neither of these commands are received by the camera, the camera operates in mode 1. (Mode 3 is automatically selected by the ANS for panel-filled control points.)

d. V/H and V/R signals. Like other cameras installed in the SR-71 airplane, the TEOC cameras must be supplied with signals for image motion compensation (IMC) and exposure rate control. V/H signals from the V/H system suffice if the airplane is flying straight and level and the cameras are directed vertically downward (0° pointing angle); however, if the airplane is in a bank (turn) or the pointing angle is other than zero, applied V/H will not be correct for the area being photographed and incorrect exposure rate and image smearing will result. The signal required for exposure rate and image motion compensation is V/R, not V/H. V/R represents the angular rate of motion between the airplane (camera) and the terrain, at the angle at which the cameras are commanded to point. V/R may be expressed as the forward velocity of the airplane (V) divided by the range to terrain at commanded pointing angle (R). Whether the camera uses applied V/H or Nav V/R signals depends on the type of TEOC camera and the condition (V/H or V/R) of the TEOC FMC select switch on the power and sensor control panel.

1. HR-308B cameras. These cameras are modified to use Nav V/R signals. When the FMC select switch is set for V/R, the camera uses Nav V/R, compensated in the ANS for airplane bank angle and commanded pointing angle. When the FMC select switch is set for V/H, the camera modifies V/H from the V/H bus into V/R as the result of camera pointing angle only. As airplane bank angle is not taken into account, this FMC select switch position is good for level flight only.

2. HR-308C cameras. These cameras are also modified to use Nav V/R signals. When the FMC select switch is set for V/R, the roll-stabilized camera modifies V/H from the V/H bus into V/R as the result of camera look angle (pointing angle and bank angle) and turn rate. This FMC switch position provides the best IMC. When the FMC select switch is set for V/H, the camera uses Nav V/R, compensated in the ANS for airplane bank angle and commanded pointing angle.

e. Roll angle signal. The ANS supplies, through the ANS interface box, a dc voltage representing the roll condition of the airplane. This signal is used by the HR-308C camera only. When the FMC select switch is in the V/R condition, the ANS roll angle signal is used, together with camera roll position and oblique head position and rate signals, to generate accurate V/R signals for camera IMC. The ANS roll angle signal is also used to isolate the camera stabilization mechanism from g-forces which otherwise would affect it when the camera is placed in operation during a turn.

10A-197. OBC CAMERA INTERFACE. (See figure 10A-22.) The ANS furnishes, through the ANS interface box, a dc voltage representing the roll condition of the airplane. This signal is used by the OBC camera to correct image motion compensation for changes in camera look angle which occur during turns.

10A-198. ELECTROMAGNETIC RECONNAISSANCE (EIP/EMR) SYSTEM INTERFACE. (See figure 10A-22.) The ANS supplies ANS navigation data and geographic alarm signals to the EIP/EMR. The EIP/EMR supplies the ANS with a reset event signal. These interface signals are described in the following paragraphs.

NOTE

The geographic alarm signals are applied to the EIP/EMR system through the sensor signal processor, which is part of the sensor event/frame count system. (Refer to paragraphs 10A-204 and 10A-207.)

10A-199. Navigation Data. ANS navigation data (consisting of GMT, latitude, longitude, computed altitude, drift angle, heading, roll, and pitch) is supplied to the EIP/EMR where it is recorded, together with received and processed ELINT signals, in the EIP/EMR digital recorder. This data may also be recorded in the EIP/EMR continuous analog recorder if that recorder is installed and Nav data has been selected for recording.

10A-200. Reset Event Signal. As described in the previous paragraph, ANS navigation data is recorded in the EIP/EMR digital recorder; thereby providing a correlation between received ELINT signals and GMT and aircraft position. An alternate means of determining the time and location of recorded ELINT signals is by using ANS navigation data recorded in the MRS. For this purpose a marker signal (reset event) is supplied to the ANS when the EIP/EMR is turned on. This marker signal, recorded by the MRS as part of the ANS 32 word telemetry data, provides the means of correlating NAV data recorded by the MRS with ELINT data recorded by the EIP/EMR system.

10A-201. EIP/EMR Geographic Alarm. The ANS has the capability of controlling the EMR continuous analog (CA) recorder by means of a geographic alarm. During flight when the aircraft reaches programmed geographic coordinates a geographic alarm is transmitted to the EIP/EMR via the sensor signal processor. (The geographic alarm uses the same data block lines between the guidance group and the sensor signal processor as used for sensor frame count. The frame count data has priority over the geographic alarm. Refer to paragraph 10A-204 for description of frame count system.)

10A-202. The geographic alarm signal consists of a correlation code (representing the EIP/EMR control point) which is compared with a similar code stored in the EIP/EMR ASTG program tape together with the characteristics of the desired ELINT signals. When aircraft location (geographic alarm) and desired ELINT signals occur together the CA recorder is turned on.

10A-203. SENSOR EVENT/FRAME COUNT SYSTEM (SENSOR LOG SYSTEM) INTERFACE. (See figure 10A-23.) The sensor event/frame count system provides the capability of accurately correlating data collected by the various sensor systems with ANS time and navigation data recorded by the MRS. The purpose of the system is to accurately establish the exact time, location, and other conditions (aircraft altitude, attitude, heading, etc.) under which sensor data was collected. Correlation of sensor system data is accomplished as follows:

System	Data Correlation
TEOC/OBC and TROC cameras	Frame numbers exposed onto camera film are also recorded by the MRS together with ANS time and navigation data
EIP/EMR	Emitter data collected by the EIP/EMR and recorded by EIP/EMR continuous analog (CA) recorder is accompanied with frame count numbers which are also recorded by the MRS together with ANS time and navigation data. In addition to EIP/EMR frame count, the system processes EIP/EMR geographic alarm and signals generated by the ANS.
SLR	Radar terrain return data collected and recorded by the SLR is accompanied with frame count numbers (part of ANS ADAS data) which
SLR (Contd)	are also recorded by the MRS together with ANS time and navigation data. In addition, the radar supplies a BITE (built-in test) go/no-go indication which is also recorded along with ANS data in the MRS.

NOTE

The OBC camera and the SLR system share common signal conditioning circuits in the signal sensor processor and a common frame count register in the ANS guidance group, together with common signal input lines to the signal sensor processor and between that unit and the guidance group. There is no problem with identifying the resulting frame count data as only the OBC camera or the SLR can be installed for any one flight.

10A-204. System Operation with Cameras. When an exposure is made by a TEOC, OBC, or TROC camera, and exposure taken signal (TEOC center-of-format signal, OBC center-of-scan signal, or TROC pinpoint-of-light signal) is applied to the sensor signal processor. The signal, varying in duration from 0.5 to 13 milliseconds, is conditioned in the signal processor and then applied to the ANS guidance group as 6 millisecond long event marker pulse. The ANS monitors the event marker pulse lines and, if a camera marker pulse is received, increments a frame count register associated with that particular camera and stores the time of the event. The ANS applies the updated camera frame count number to the sensor signal processor as serial data and clock signals. After processing, these signals are applied to the LED frame count data block in the appropriate (LTEOC, RTEOC, OBC, or TROC) camera. The LED block produces a

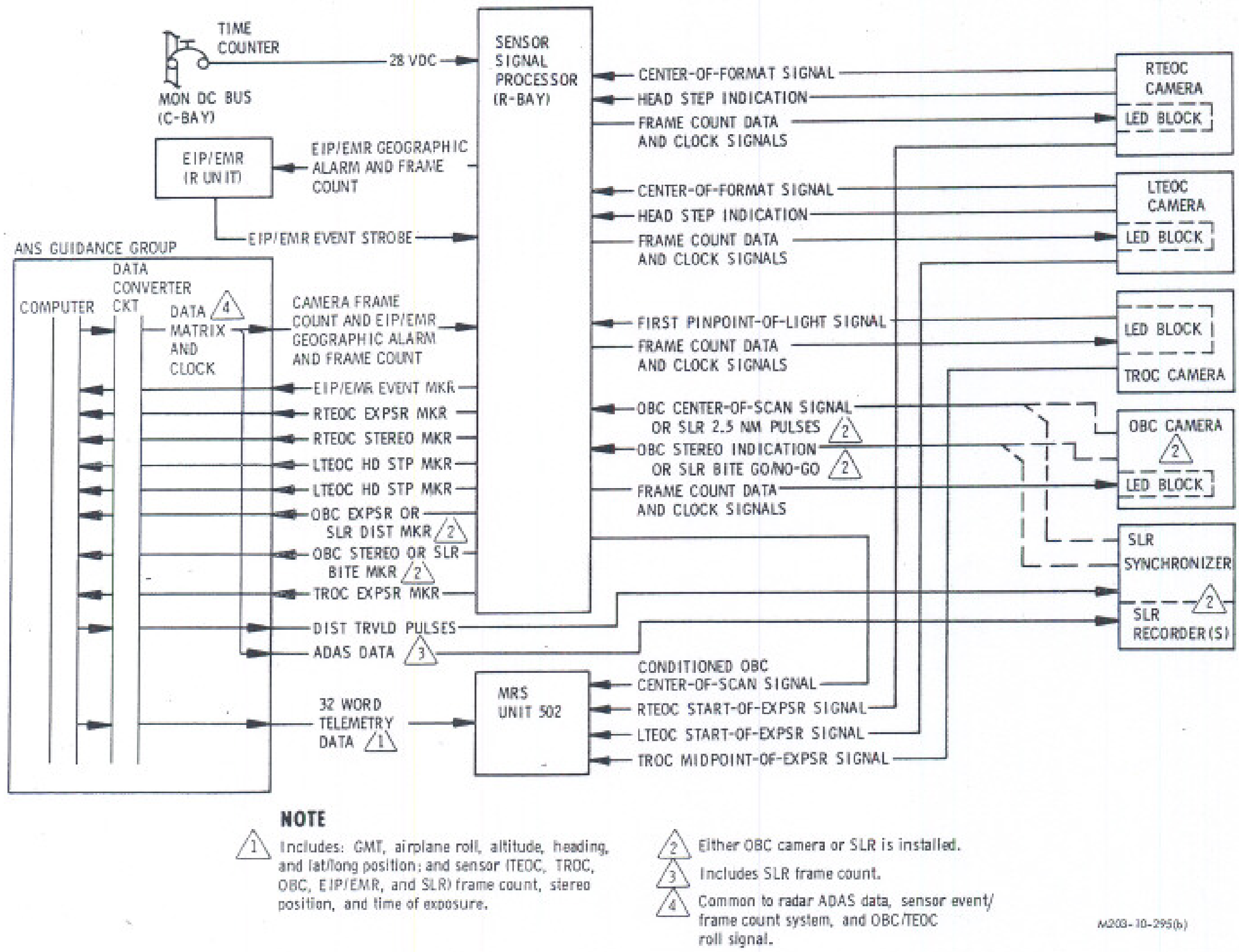

Figure 10A-23. ANS-Sensor Event/Frame Count System Signal Flow Diagram

frame count image which is exposed onto the film adjacent to the terrain image. Within the ANS, the updated TEOC, OBC, or TROC frame count number and the time the exposure occurred (together with navigation data and the time from the last present position latitude/longitude update) are stored in the 32-word telemetry register for recording by the MRS. As a result, the frame number on the camera film can be directly related with the frame number and navigation data available on processed MRS data printouts. Frame count numbers start at 0000, counting upwards by one with each exposure. These numbers are reset to zero when the ANS is turned on.

NOTE

It is possible that a transient pulse will occur on the camera marker pulse line when a camera is turned on or turned off, thereby causing that camera's frame count number to be advanced by one. If this happens, there will be a frame number recorded by the MRS but no corresponding frame on the camera film, as the camera was not in operation when the erroneous pulse occurred. This should cause no problem in determining where and when a photograph was taken as each frame of photography will have a corresponding frame number and related ANS data recorded by the MRS.

10A-205. In addition to the frame count function, the system also permits head step position data from TEOC cameras (mode 3, left or right) and OBC camera stereo mode (forward or aft) to be recorded in the MRS, together with other ANS data. Event signals from the cameras (TEOC start-of-exposure, OBC, center-of-scan, and TROC midpoint-of-exposure signals) are also applied to the MRS as a backup means of photography identification and correlation with ANS navigation data.

10A-206. System Operation with EIP/EMR. Generation of EIP/EMR frame count numbers is similar to generation of camera frame count numbers described in paragraph 10A-204. 100 us-wide event strobe pulses, produced by the EIP/EMR every 1.28 seconds following EIP/EMR system warmup, are applied to the sensor signal processor where they are conditioned into 6 millisecond-wide event marker pulses and applied to the ANS. On receipt of an EIP/EMR event marker pulse, the ANS increments an EIP/EMR frame count register, stores the time of receipt of the pulse, and returns updated EIP/EMR frame count data and clock signals to the EIP/EMR, through the sensor signal processor. As with camera frame count generation, the EIP/EMR frame count and event time are supplied to the MRS as part of ANS 32-word telemetry data. The frame count numbers (data and clock signals) returned to the EIP/EMR from the ANS are recorded in the EIP/EMR CA recorder, together with EIP/EMR collected emitter data. As a result of the rate of EIP/EMR event strobe pulses, EIP/EMR frame count numbers recorded by the MRS and the EIP/EMR CA recorder are updated every 1.28 seconds. As with camera frame count, EIP/EMR frame count starts at 0000 and is reset to zero when the ANS is turned on.

10A-207. In addition to the EIP/EMR frame count interface, the ANS supplies, through the sensor signal processor, geographic alarm. The geographic alarm signals turn on the EIP/EMR CA recorder when the airplane geographic position agrees with that programmed into the EIP/EMR and emitter signals with desired characteristics are being received. Refer to section XIA of T.M. SR-71-2-11 Vol II for more details on these signals.

10A-208. System Operation with SLR. Generation of SLR frame count numbers is similar to generation of camera frame count numbers described in paragraph 10A-200. When the ANS applies an operate command signal to the radar, the ANS also supplies (beginning 1 second later) a series of distance traveled pulses (31 ± 6 us-wide pulses, occuring every 2-1/2 miles) to the SLR synchronizer. The synchronizer expands the width of these pulses to between 0.5 and 3 milliseconds. The expanded pulses are conditioned into 6 millisecond-wide pulses by the sensor signal processor and are applied to the ANS as SLR distance marker pulses. On receipt of an SLR distance marker pulse, the ANS increments a frame count register used by both the OBC camera and the SLR. The updated frame count, together with the time of receipt of the SLR marker pulse, is supplied to the MRS as part of ANS 32-word telemetry data. In addition, the frame count number is included in the ANS supplied ADAS data which is recorded on the data film in the radar recorder(s). As with camera frame count, SLR frame count starts at 0000 and is reset to zero when the ANS is turned on.

10A-209. In addition to SLR frame count, the radar supplies a BITE go/no-go status signal to the ANS through the sensor signal processor. (The signal lines and circuits used are the same as used for OBC camera stereo position.) The BITE status is processed together with SLR frame count and is included in the ANS 32-word telemetry data recorded by the MRS.

10A-210. MISSION RECORDER SYSTEM (MRS) INTERFACE. The ANS supplies digital and analog data to the MRS. The digital data is identified as ANS telemetry word output, which consists of 32 words and contains the parameters listed in the slot map on figure 10A-24. (Refer to section XIV and APPENDIX A for more complete description of ANS telemetry output data.) The ANS analog data provides information on internal temperatures within the guidance group and the status of the TEMP LIMIT and TEMP TOLR lights on the NCD panel.

10A-211. The 32-word data (24 bits per word) is transferred from the ANS to the MRS on 4 data lines and one parity line. To make up the 32 words, four bits of digital data, plus a parity bit, are recorded in parallel on channels 3 through 7 of the MRS tape, at a rate of approximately 10-1/2 words per second. The thirty-second word is always all one's to sync the data processing equipment with the recorded data.

10A-212. With a few exceptions, all of the ANS telemetry data parameters are generated within the ANS. Exceptions are inputs to the ANS as follows:

EXCEPTION	SOURCE
True Airspeed	ADS
Barometric Altitude	ADS
Take-off Signal	Scissors Switch
Mag Heading	INS
Altitude (above terrain)	Radar
Position Fix	Radar/Viewsight/ TACAN*
Camera Frame Count Data	LED (Sensor Log) System

*TACAN position fix data is entered manually via the NCD panel; there is no direct TACAN/ANS interface

10A-213. Sensor control parameters included in the ANS telemetry data are ANS commands to the sensors and are generated by the ANS strictly in accordance with the mission instructions stored in the computer memory. Unless the sensors are operated in automatic modes, the ANS commands do not reflect actual sensor operation. The ANS will generate sensor commands even though a particular sensor is not installed. The mission instructions stored in the computer memory contain instructions for that sensor's operation. The positions of the auto-manual select switches for the left and right TEOC cameras and the radar system are also monitored by the MRS.

10A-214. The following is a list of ANS analog data monitored and recorded by the MRS. (See figure 10A-7 for schematic of guidance group air flow. Refer to section XIV for further details on ANS analog signals.)

MRS Code/Parameter	Description
500/ANS rack (guidance group) inlet air temp	Air temperature at exit of rack heat exchanger and inlet to AI heat exchanger (normally controlled at 40 ± 5°F).