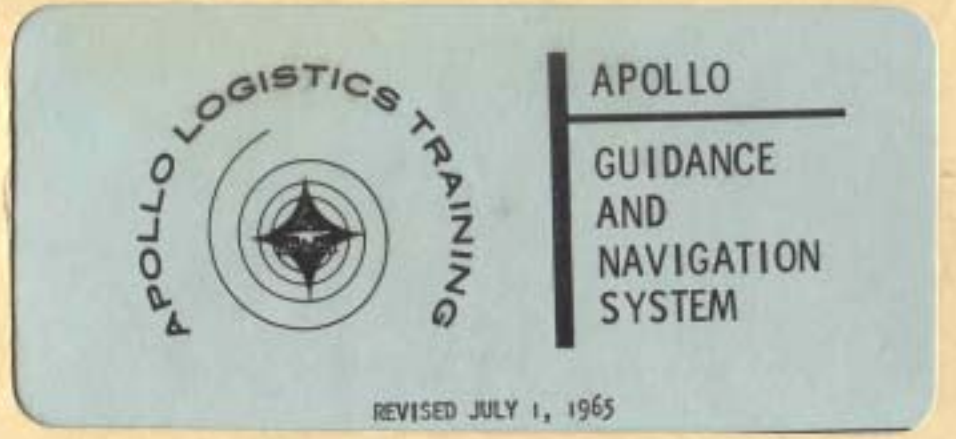


APOLLO

GUIDANCE AND NAVIGATION SYSTEM

REVISED JULY 1, 1965

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

APOLLO LOGISTICS TRAINING

APOLLO

GUIDANCE AND NAVIGATION SYSTEM

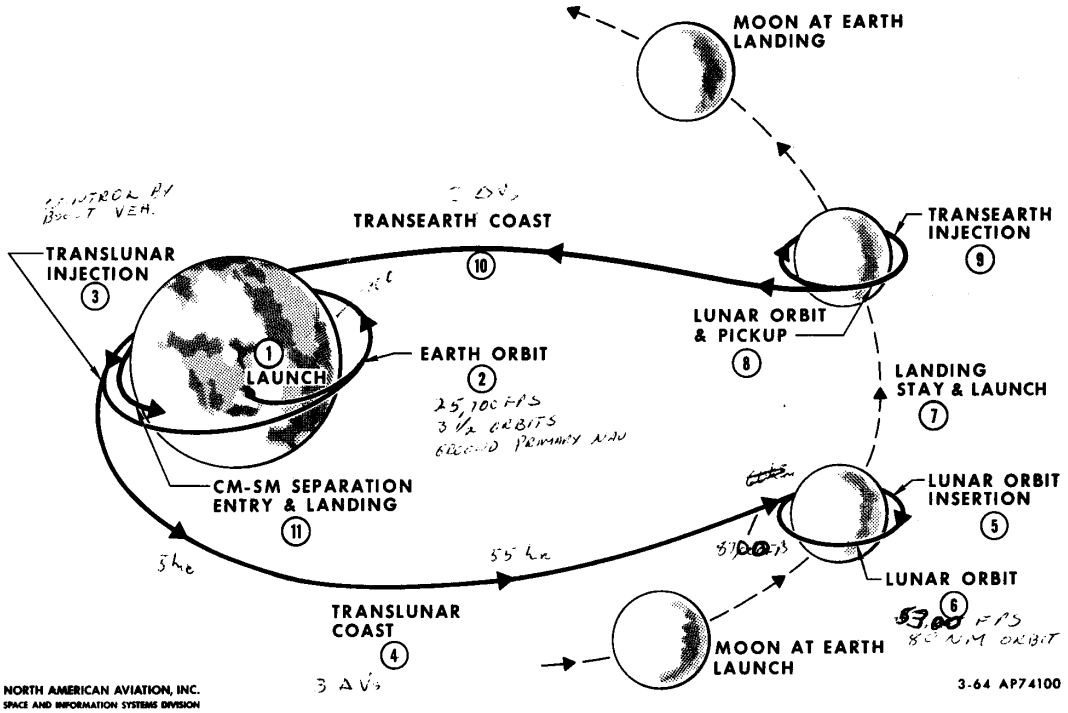
REVISED JULY 1, 1965

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

GN-0000

FORM M 158-D-9 NEW 2-65

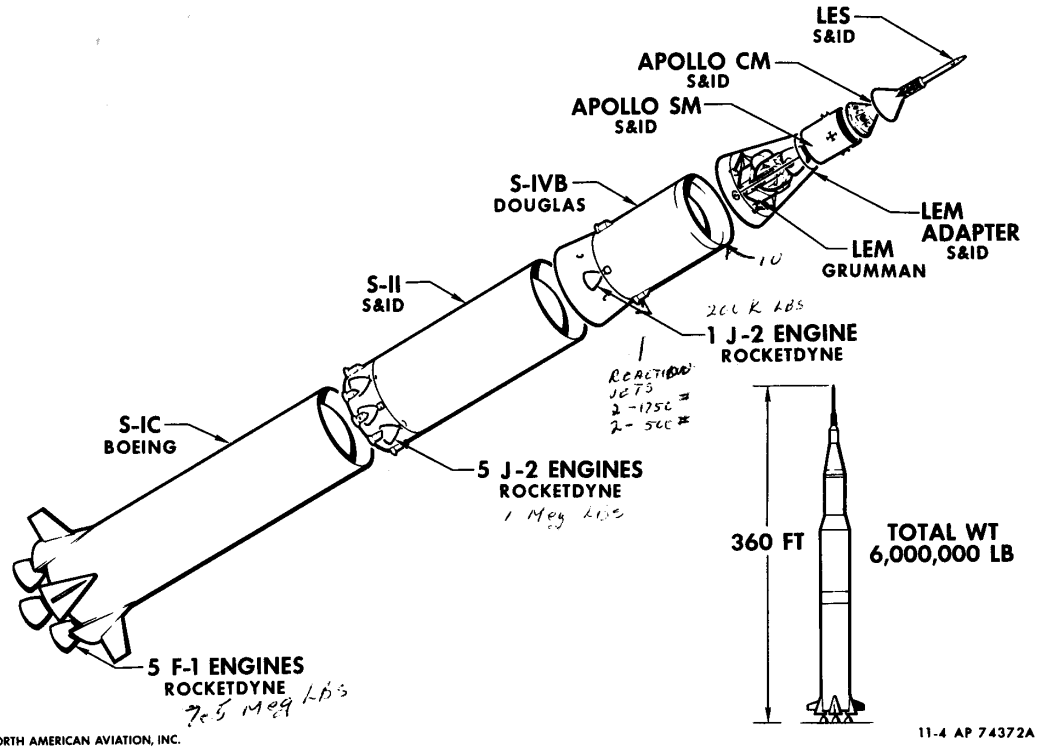
MISSION PLAN - LUNAR ORBITAL RENDEZVOUS MODE



NORTH AMERICAN AVIATION, INC.
SPACE AND INFORMATION SYSTEMS DIVISION

3-64 AP74100

SATURN V

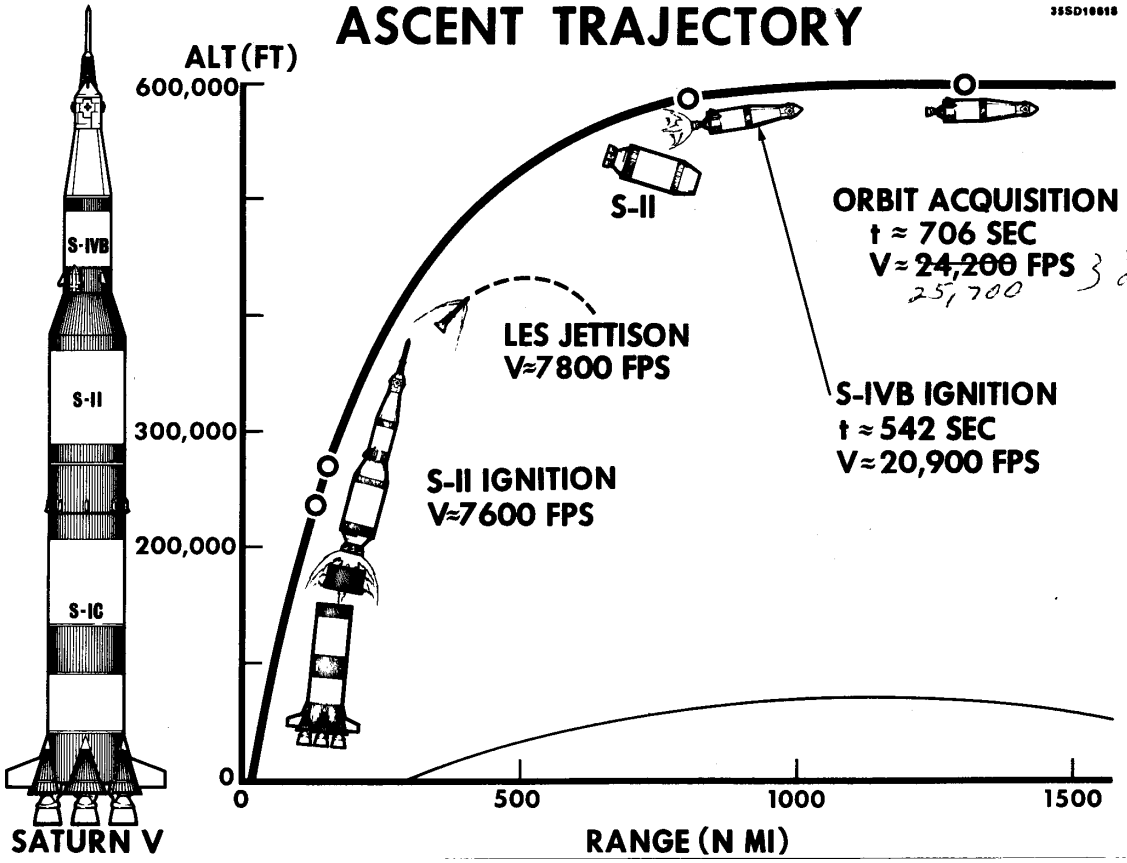


NORTH AMERICAN AVIATION, INC.
SPACE AND INFORMATION SYSTEMS DIVISION

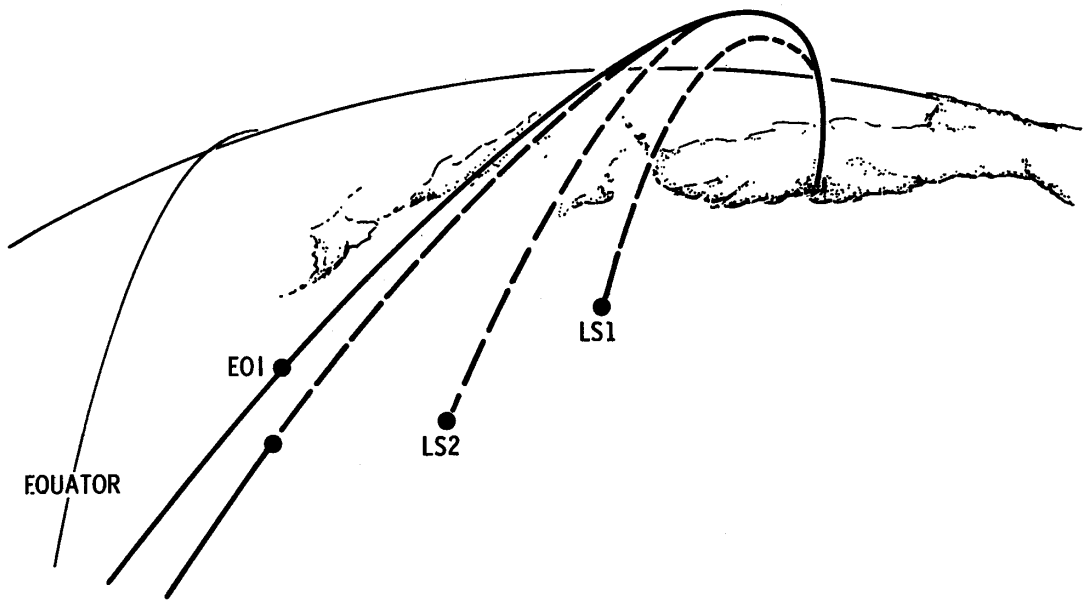
11-4 AP 74372A

ASCENT TRAJECTORY

35SD10618

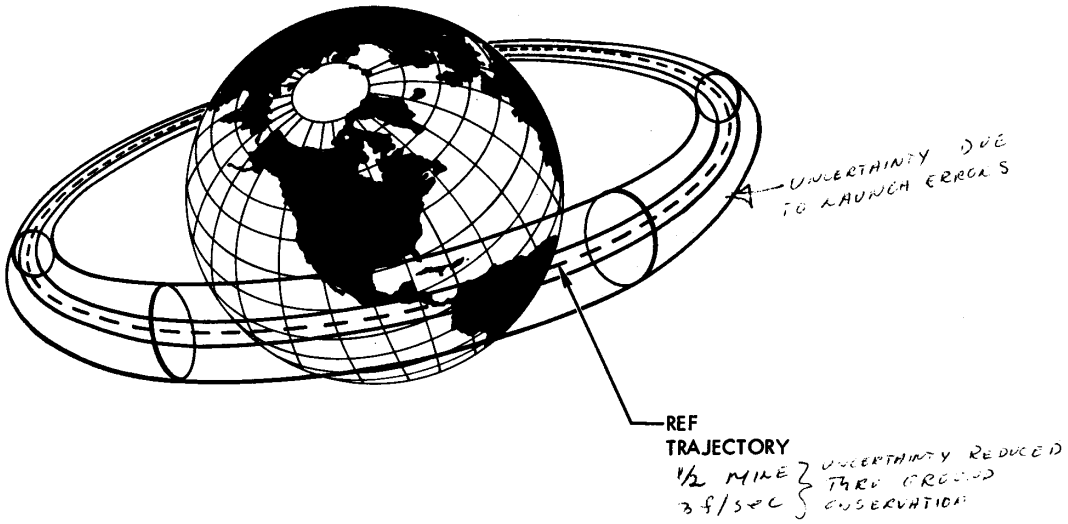


ASCENT PHASE



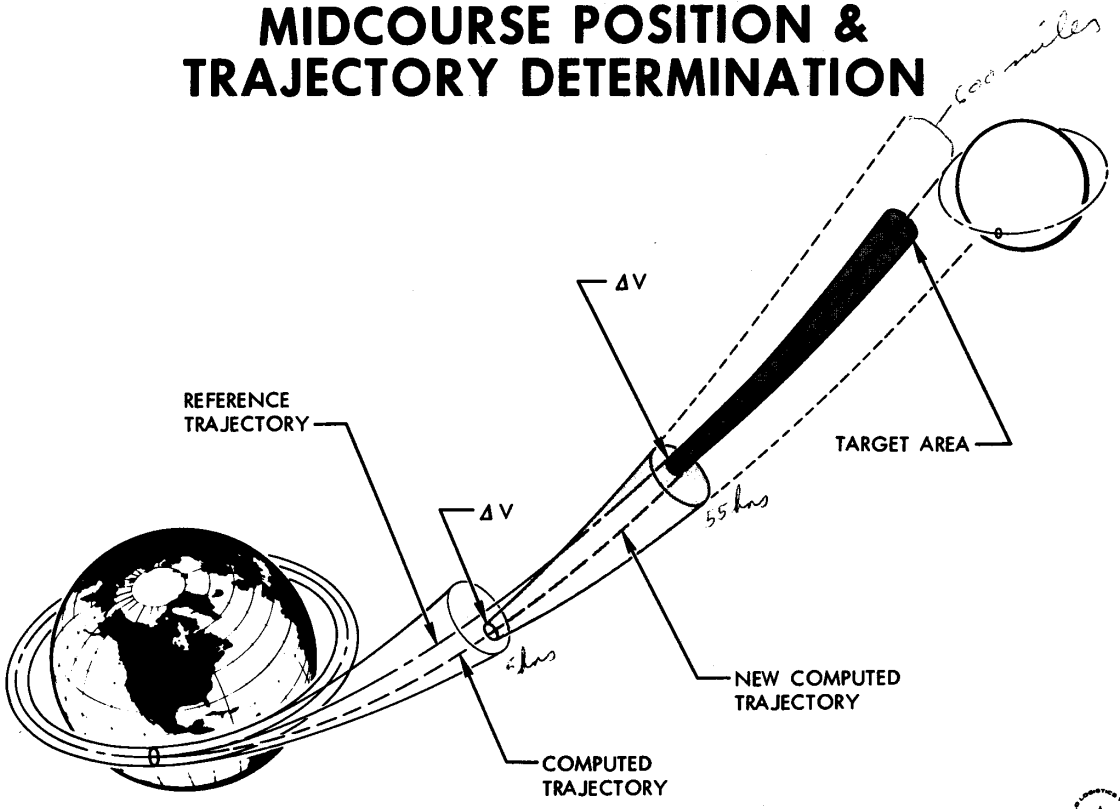
GN-211

EARTH ORBIT POSITION & TRAJECTORY DETERMINATION



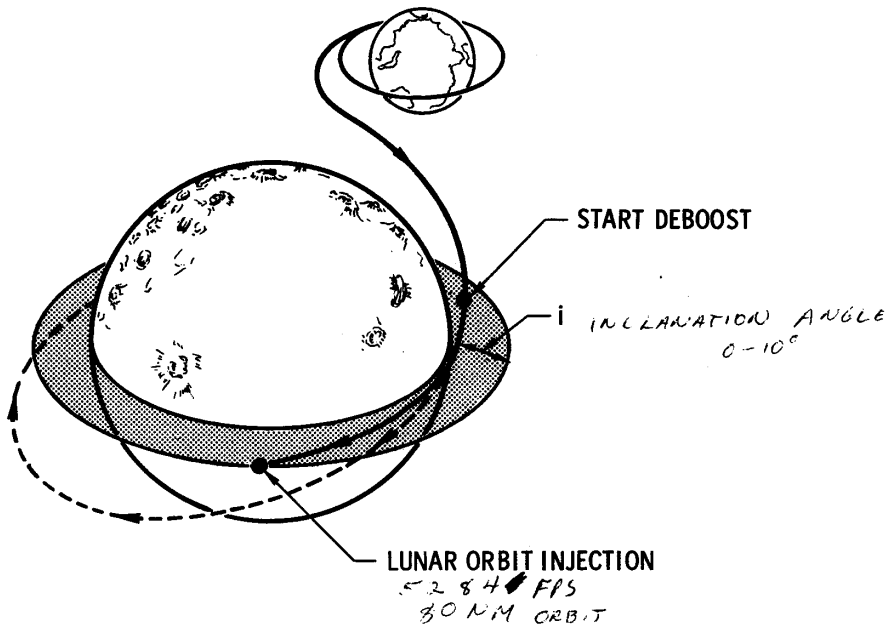
GN-180

MIDCOURSE POSITION & TRAJECTORY DETERMINATION



GN-182

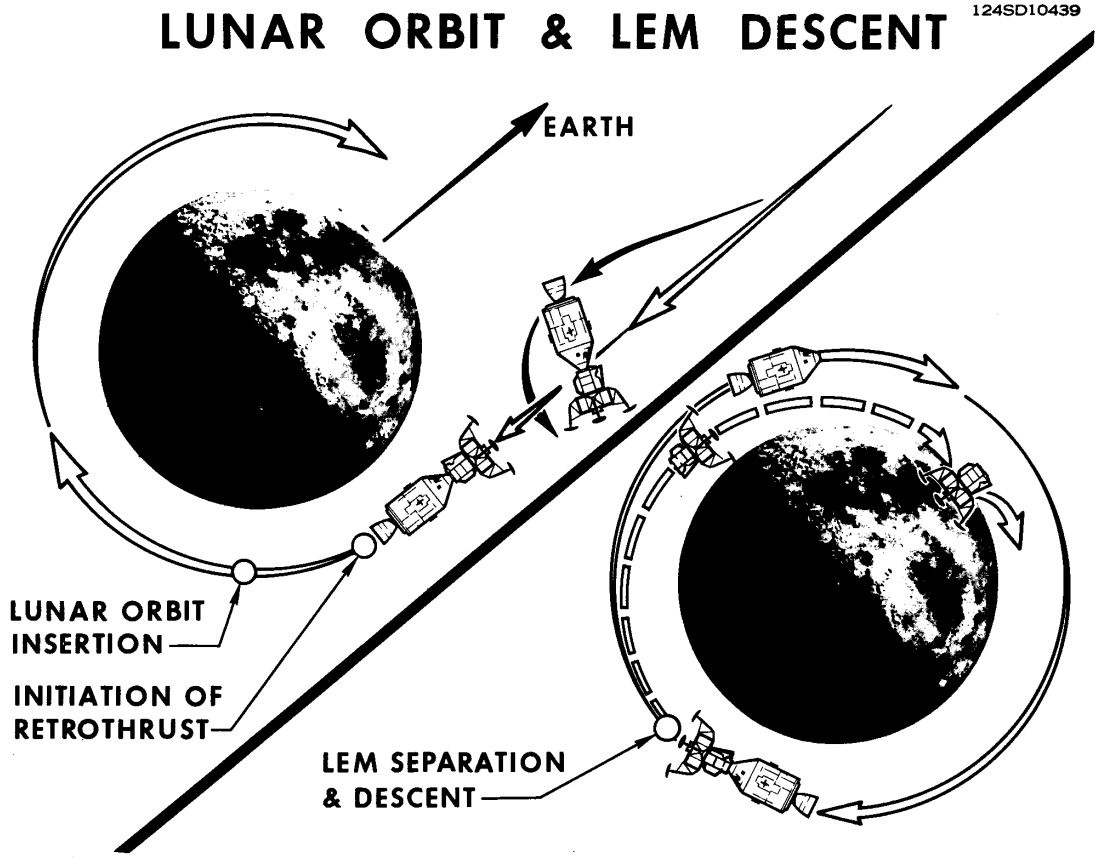
LUNAR ORBIT INJECTION



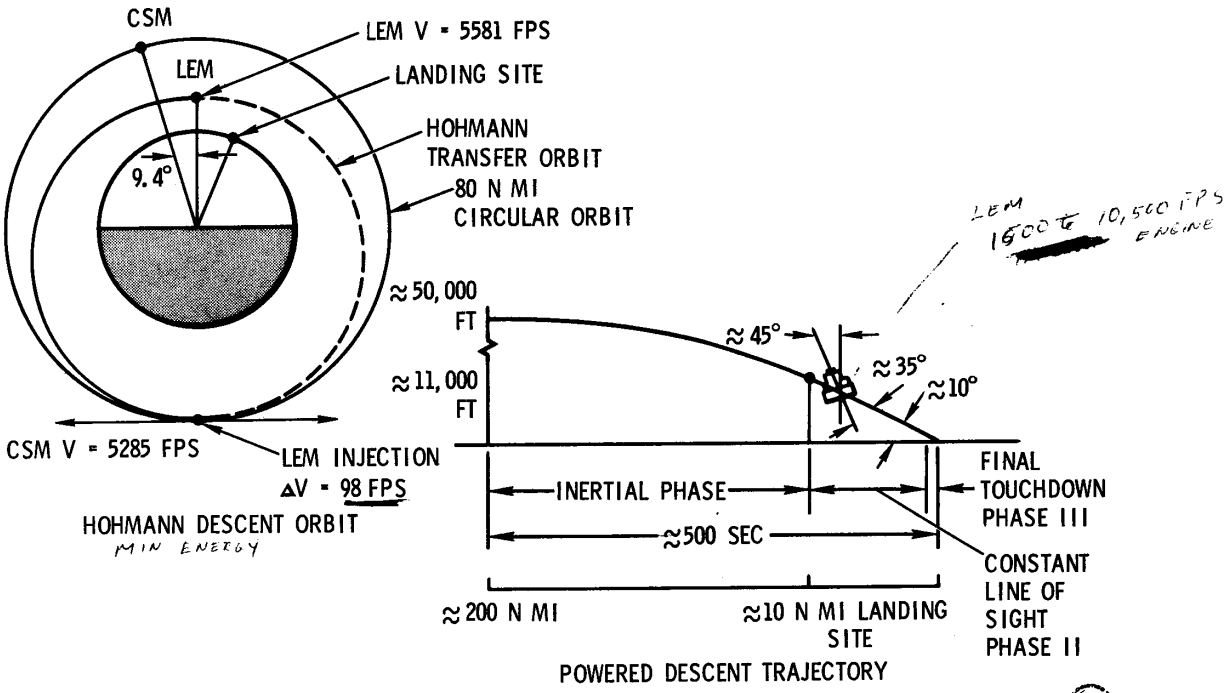
GN-206A

LUNAR ORBIT & LEM DESCENT

124SD10439

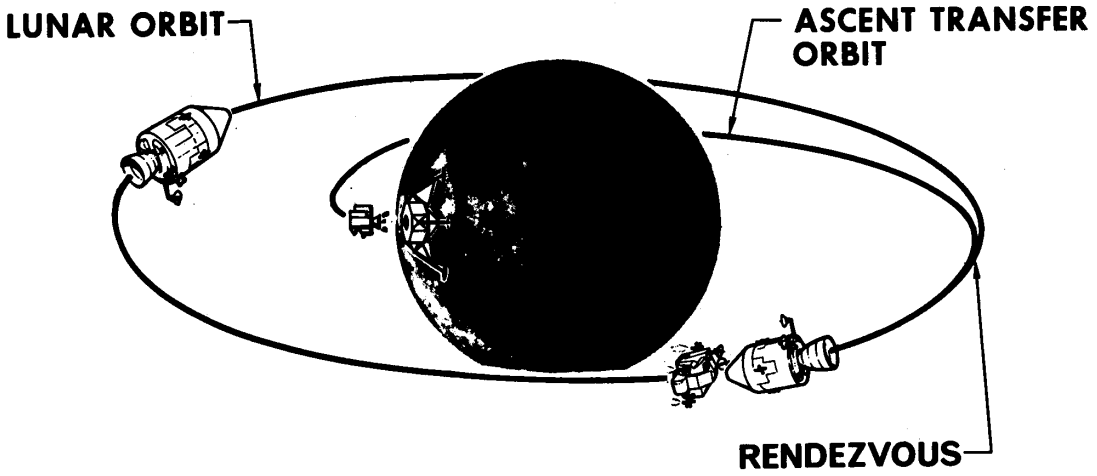


LEM DESCENT TRAJECTORY



GN-241

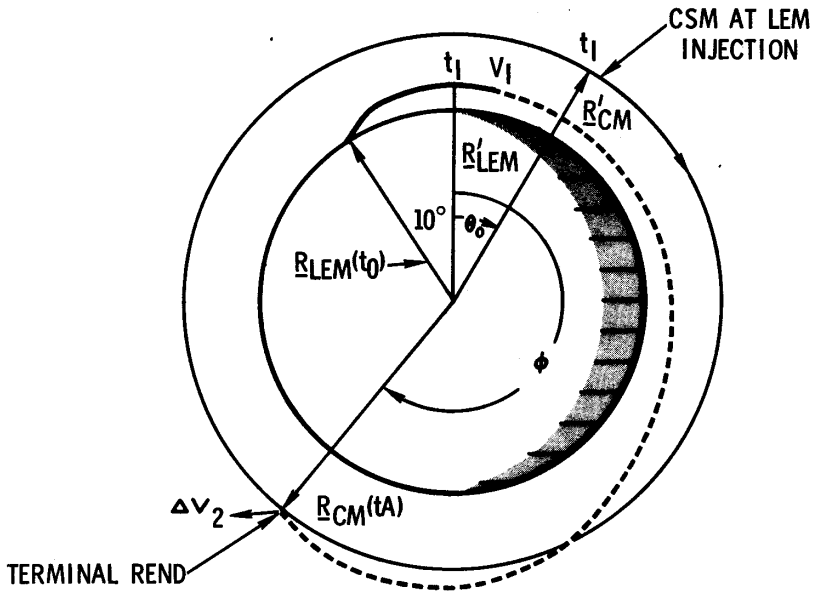
LEM ASCENT & LUNAR ORBITAL RENDEZVOUS



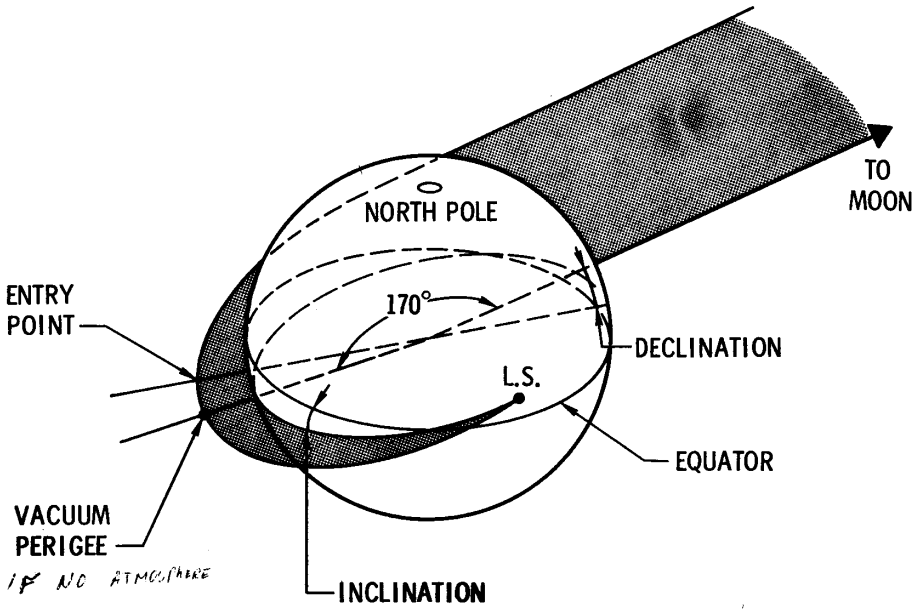
FAM-1006

64AP76945

LAUNCH AIM POINT DETERMINATION

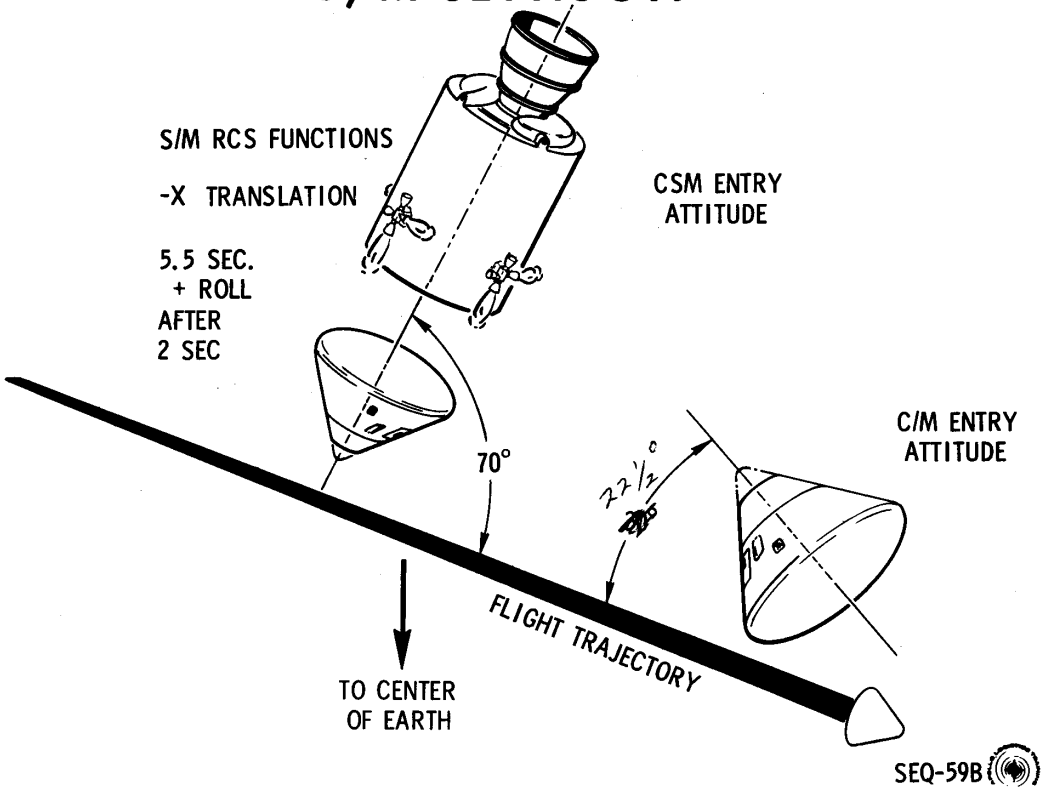


RETURN GEOMETRY



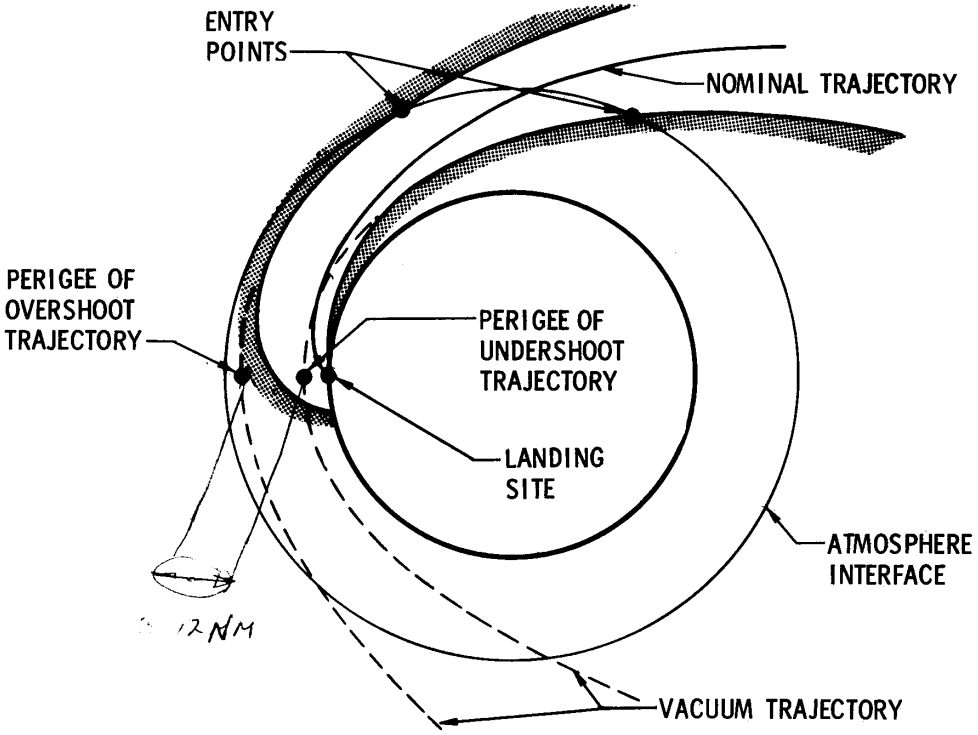
GN-204

S/M JETTISON



SEQ-59B

ENTRY BOUNDARIES

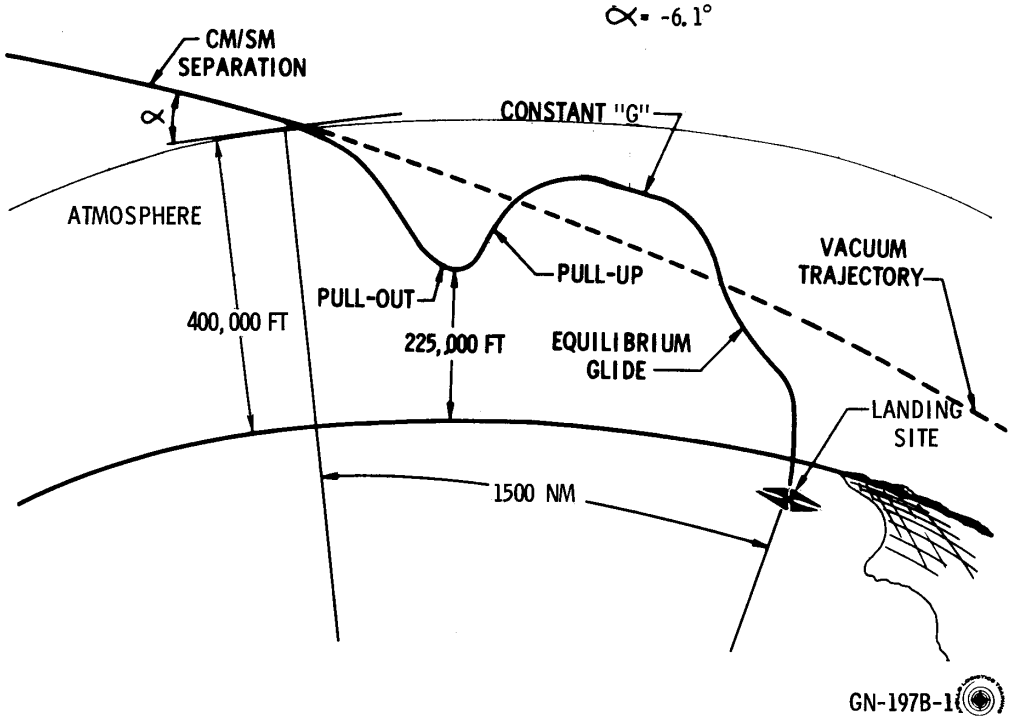


GN-205 A

ENTRY PROFILE

0 - 15 minutes

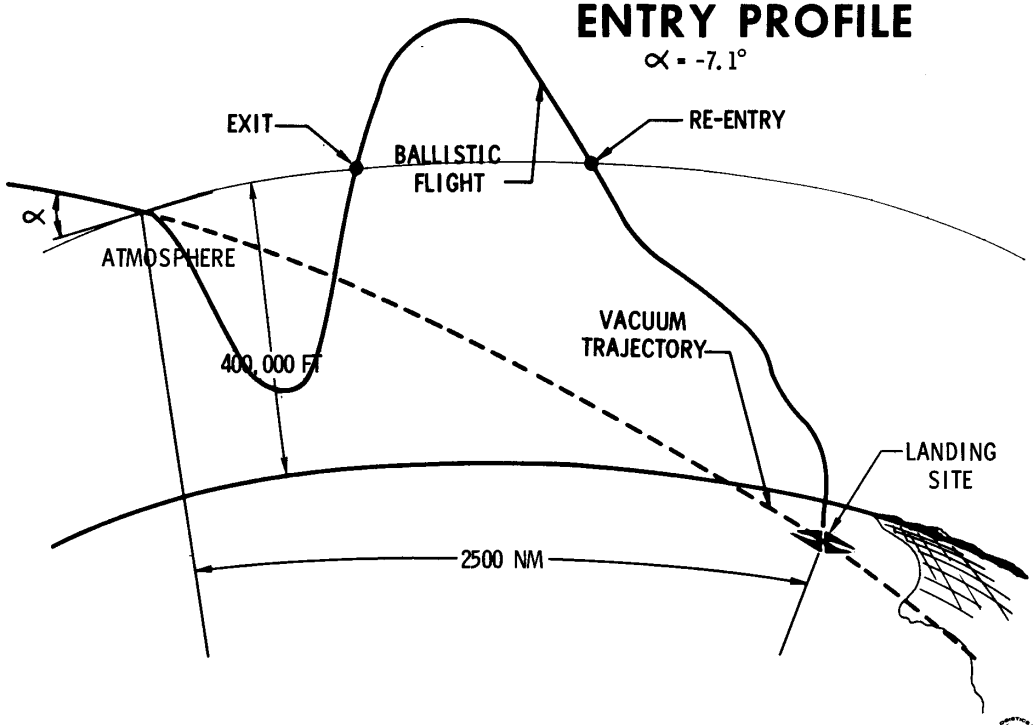
α = -6.1°



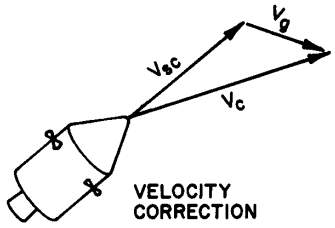
GN-197B-1

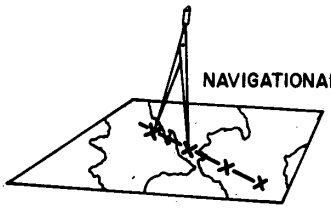
ENTRY PROFILE

α = -7.1°

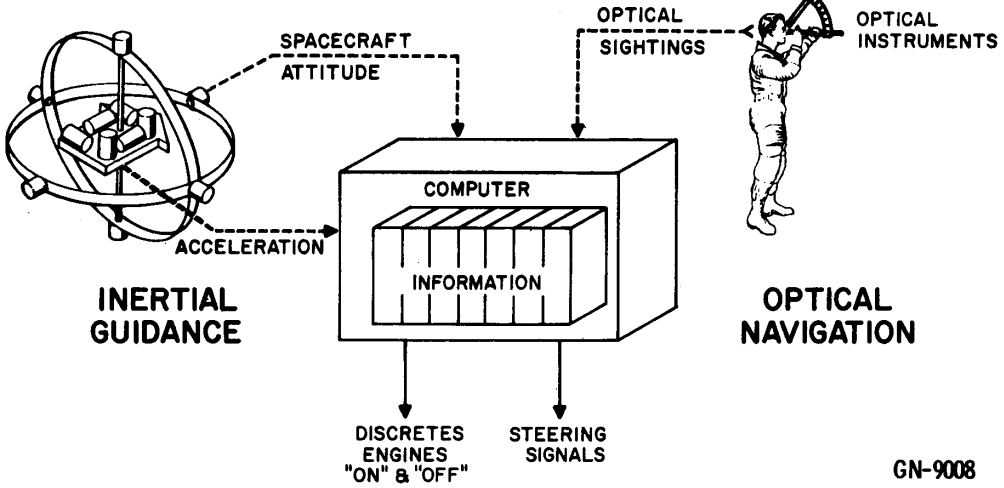


GN-197B-2





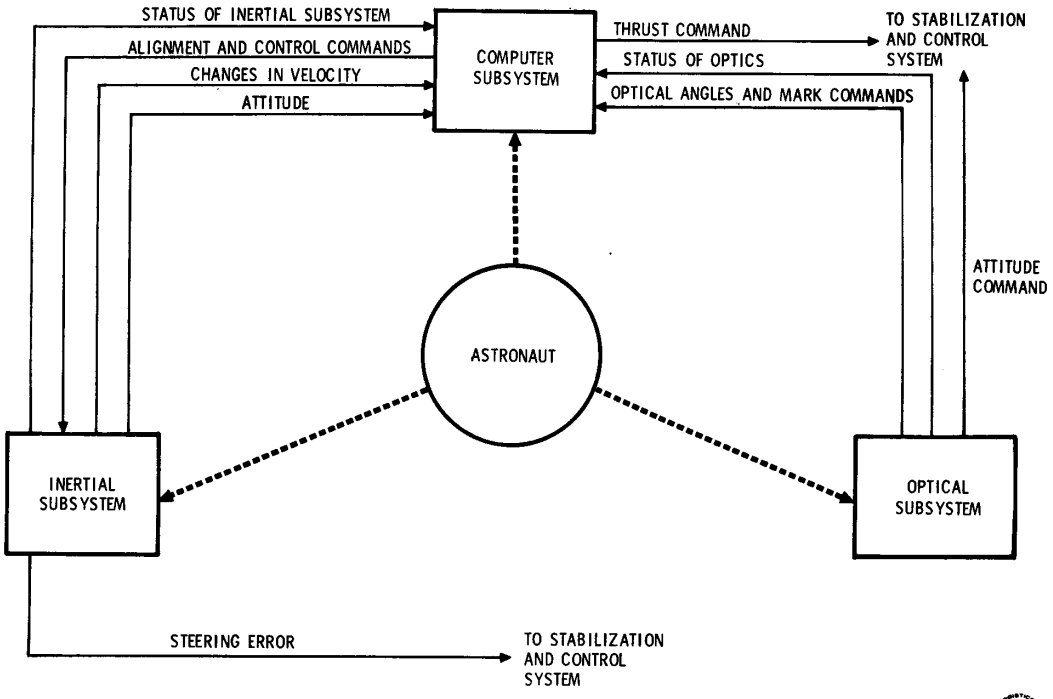
8



GN-9008

SPACECRAFT CONTROL

INTERFACE OF G AND N SUBSYSTEMS

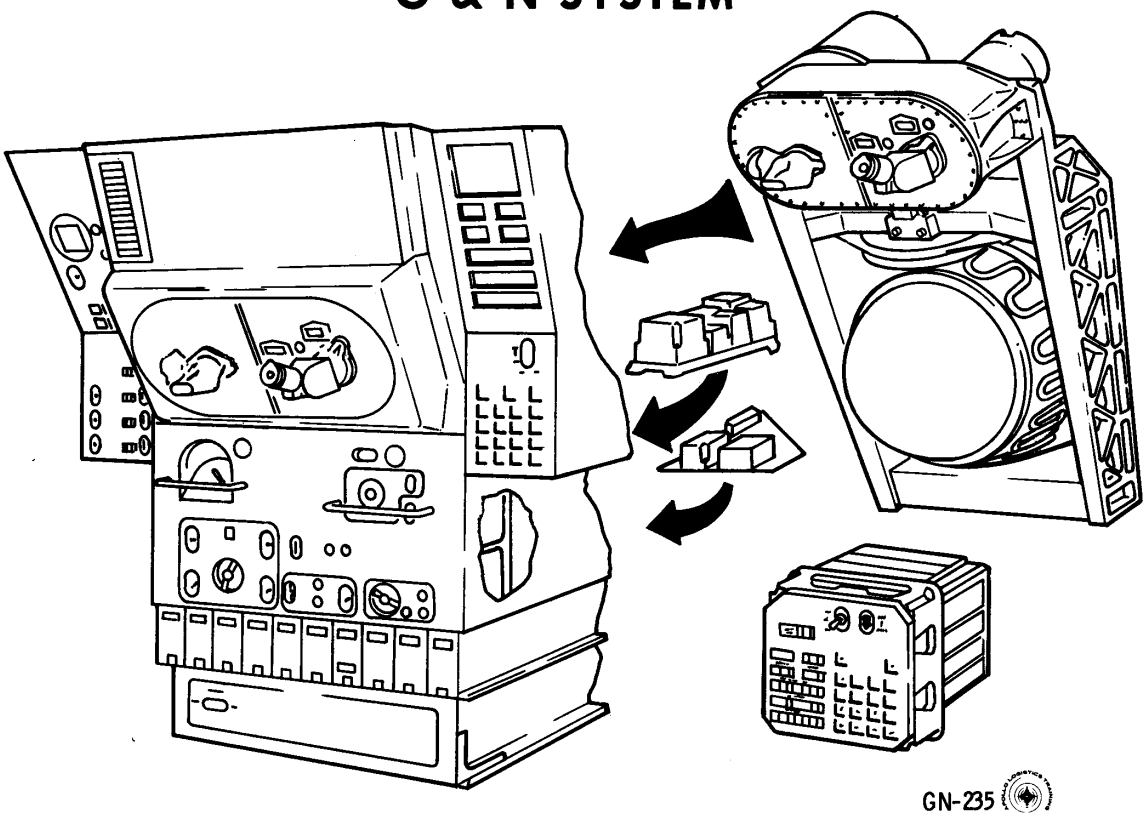


GN-9088A

G&N HARDWARE

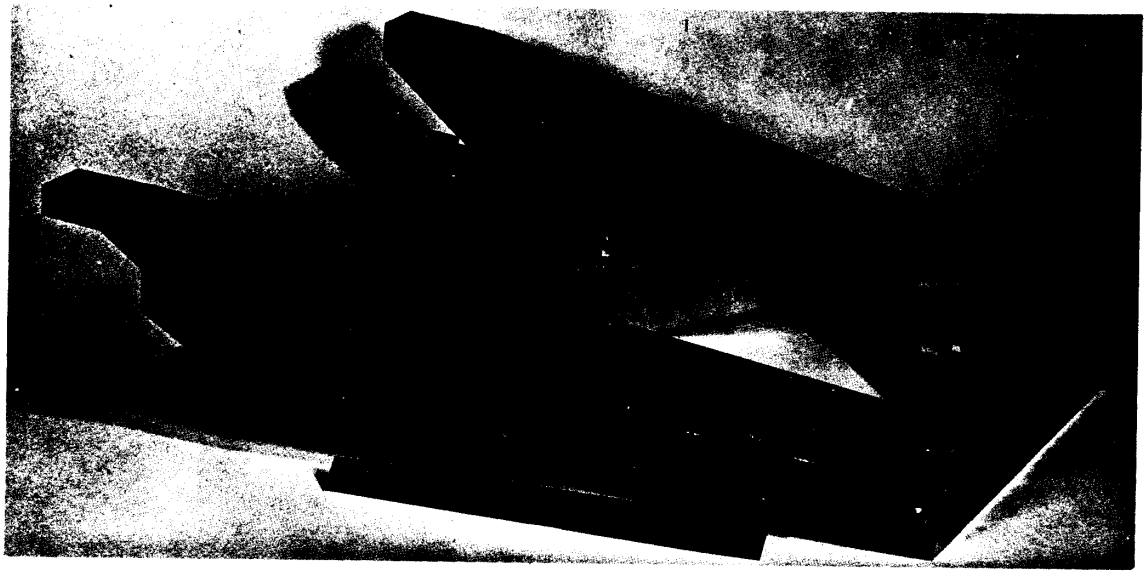
GN-223

G & N SYSTEM



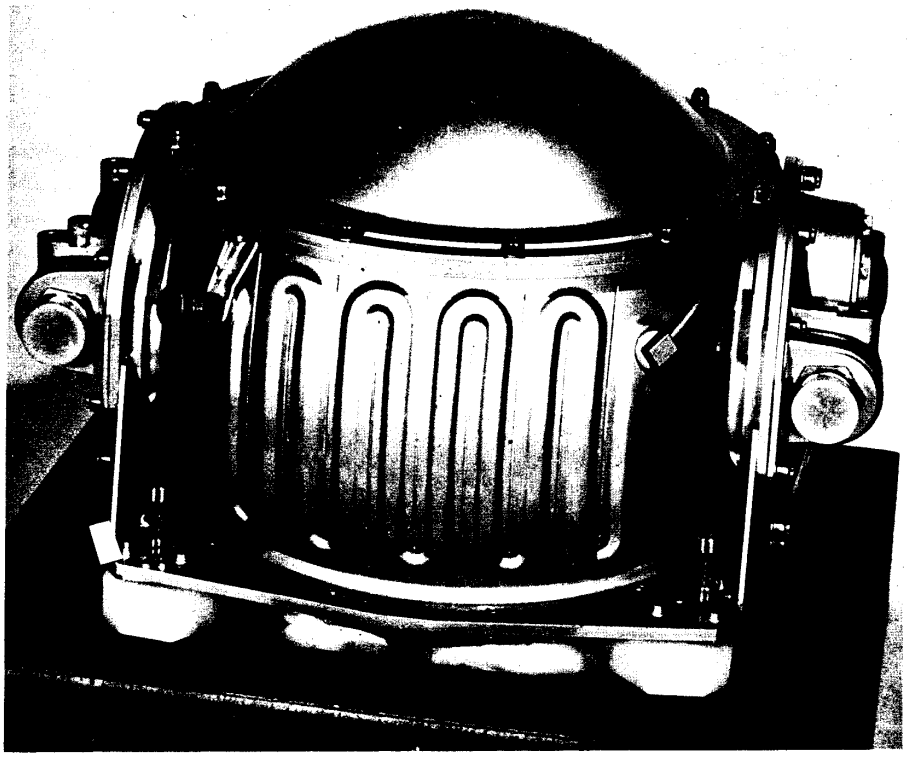
GN-235

NVB



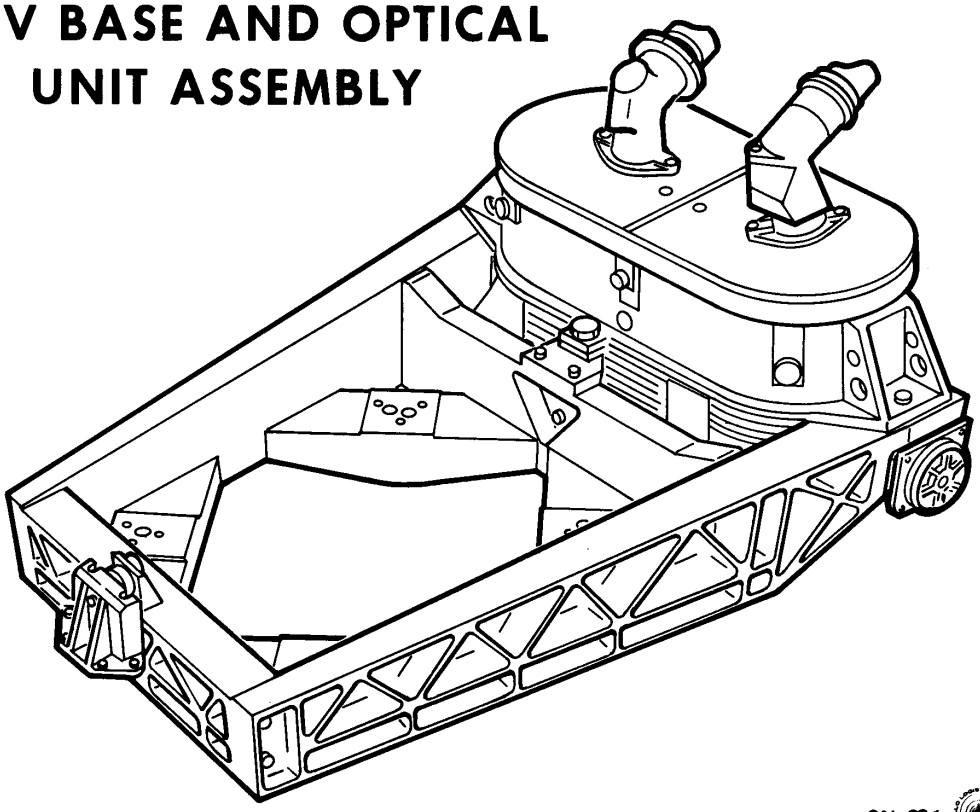
GN-190

IMU



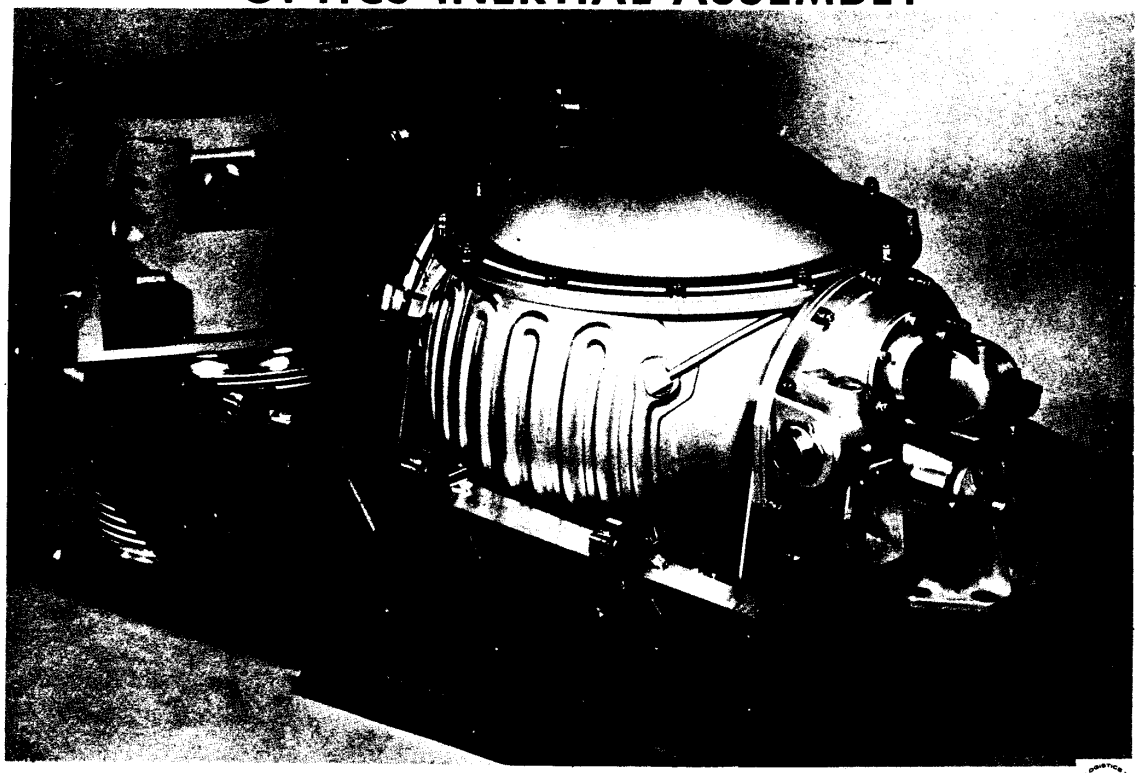
GN-189

NAV BASE AND OPTICAL UNIT ASSEMBLY



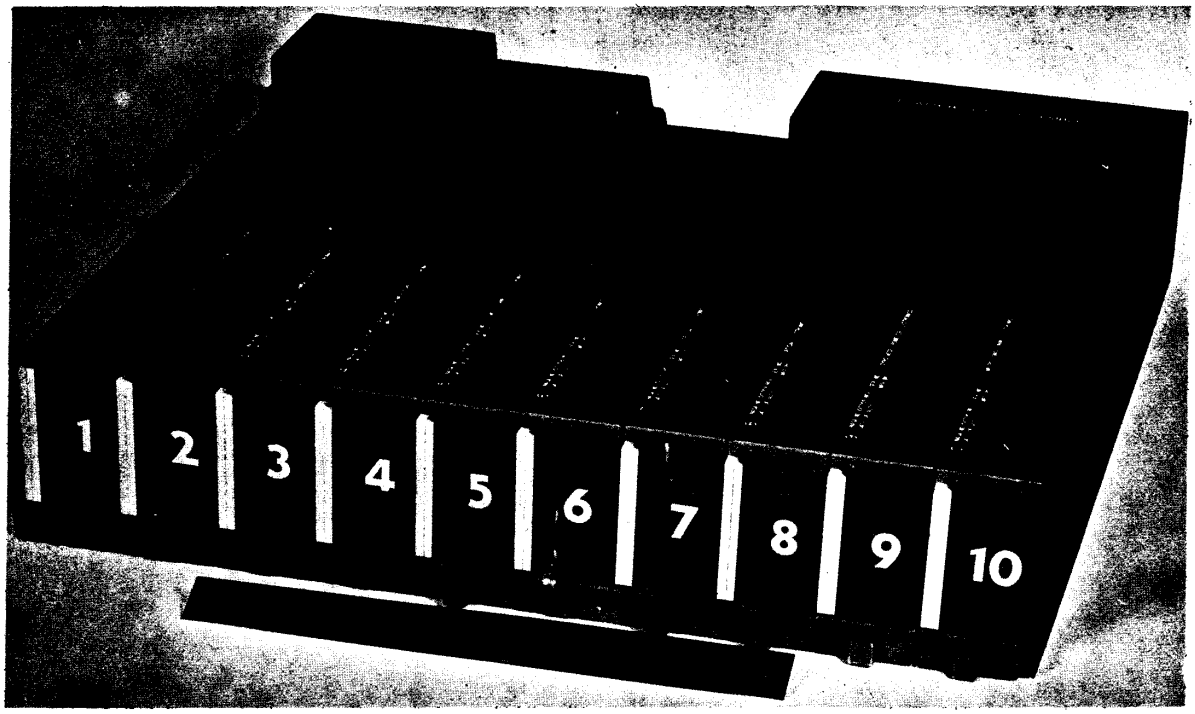
GN-236

OPTICS-INERTIAL ASSEMBLY



GN-195

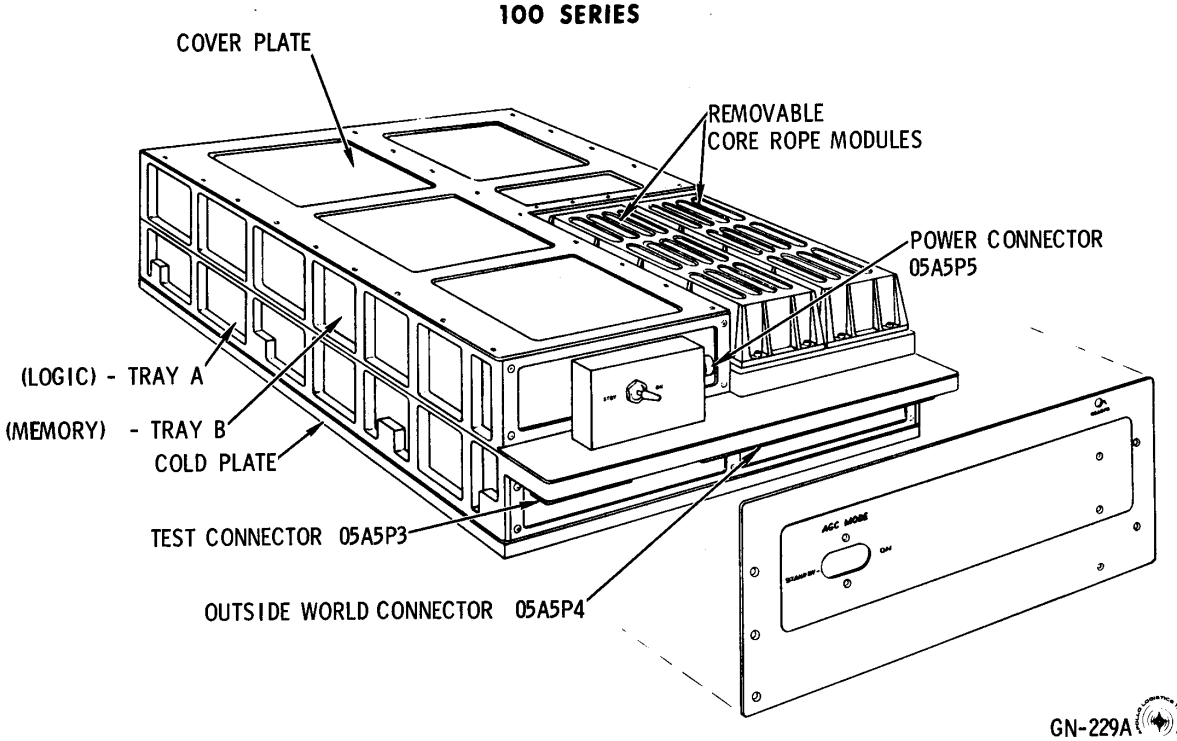
PSA



GN-192

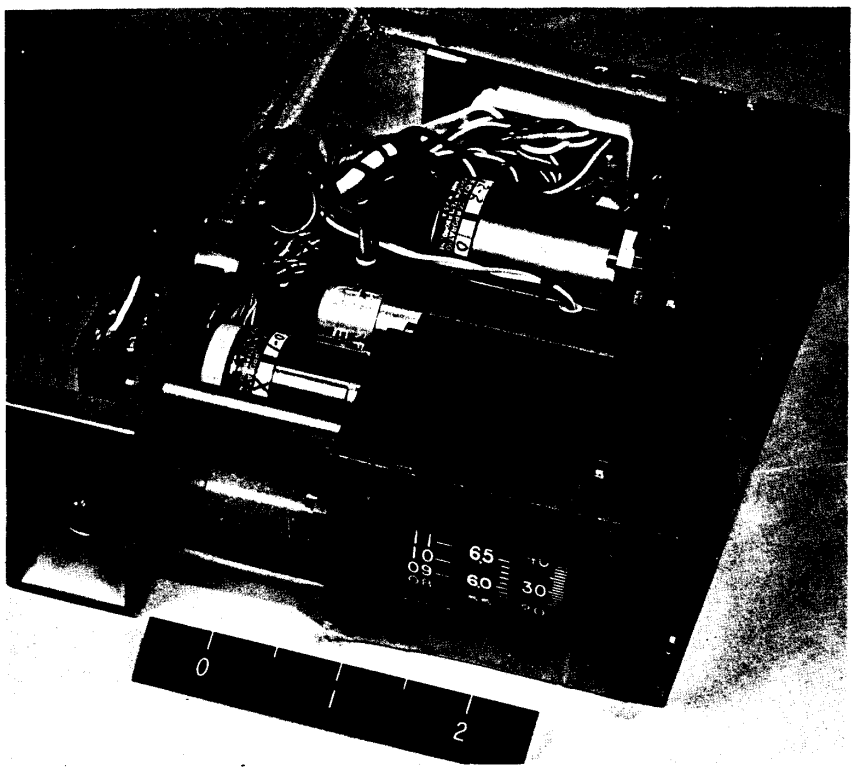
BLOCK I COMPUTER

100 SERIES

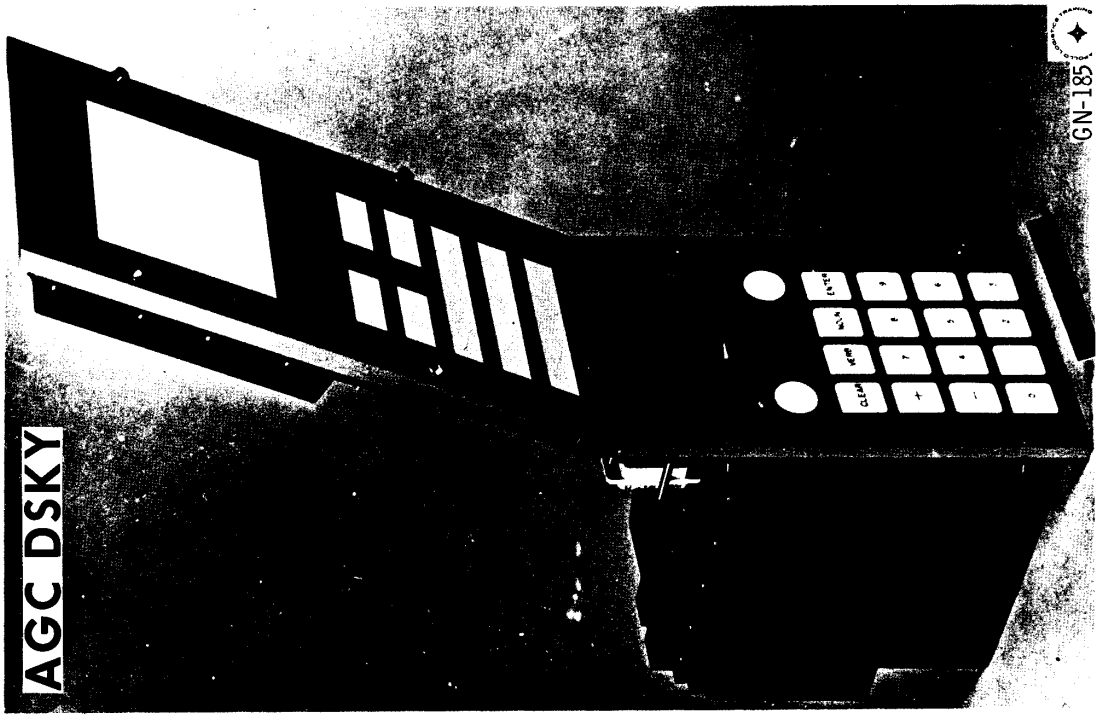


GN-229A

CDU

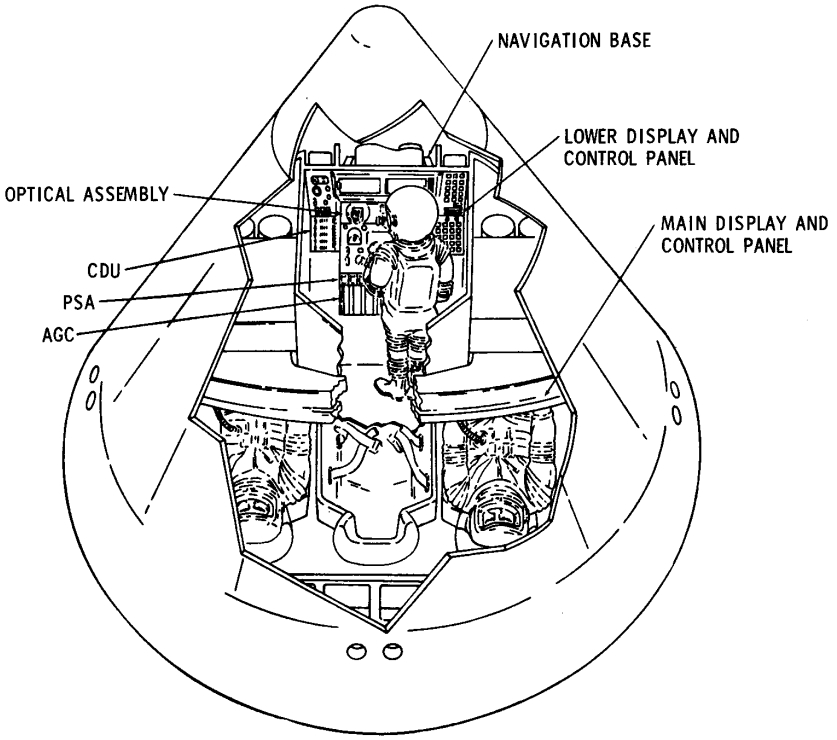


GN-191



GN-185

G&N SYSTEM EQUIPMENT LOCATION

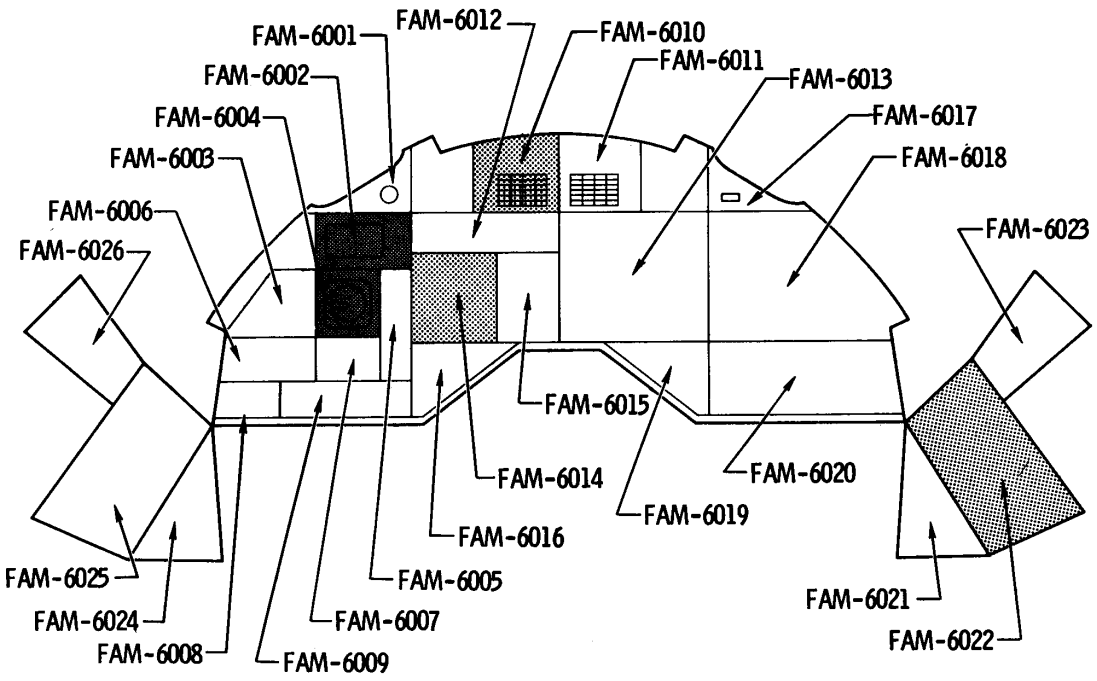


GN-9163A

LOCATION OF GUIDANCE AND NAVIGATION EQUIPMENT IN SPACECRAFT GN-9005

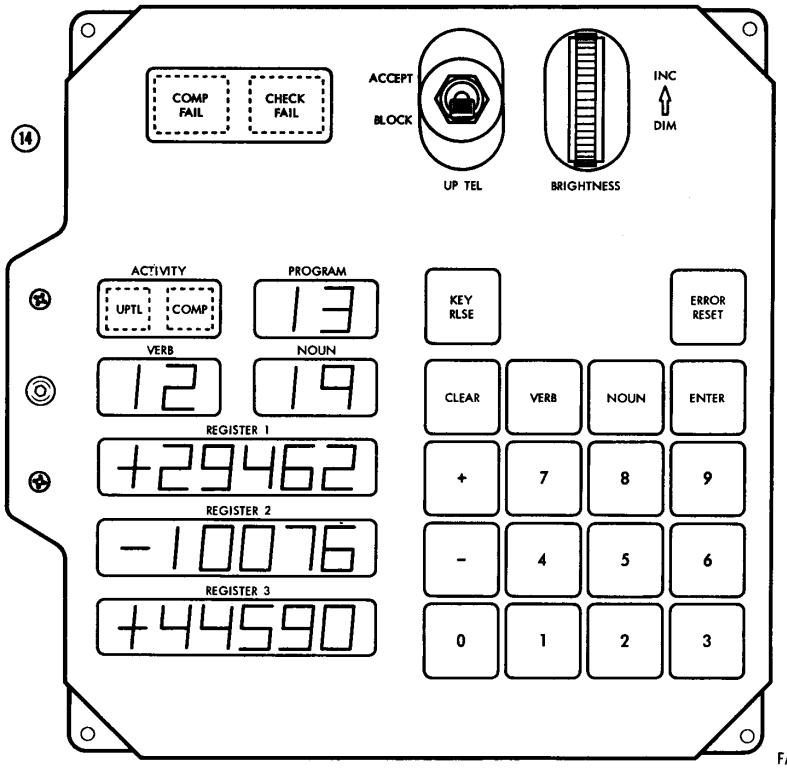
G&N CONTROL & DISPLAYS

MAIN DISPLAY CONSOLE LOCATOR

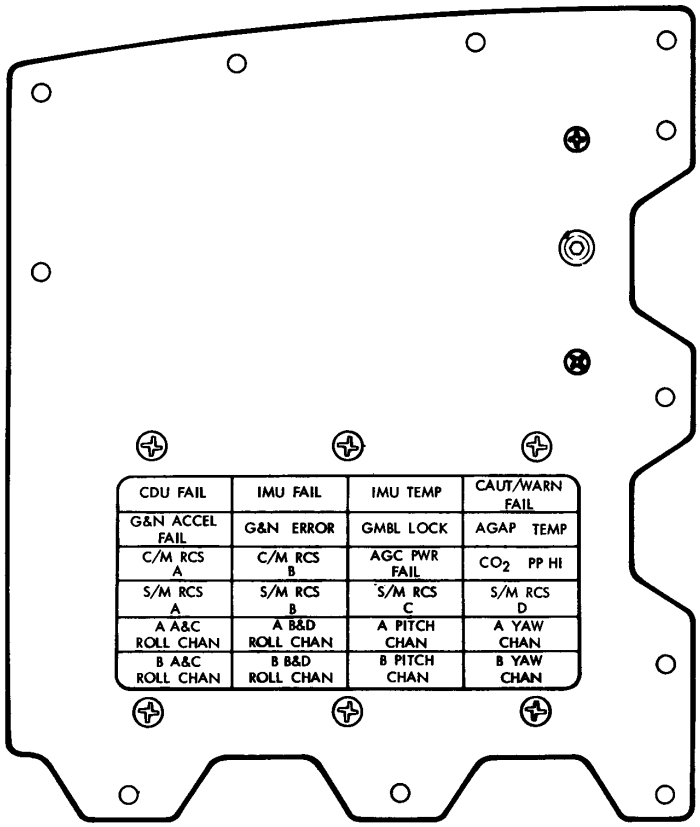


GN-207A

G & N COMPUTER CONTROL



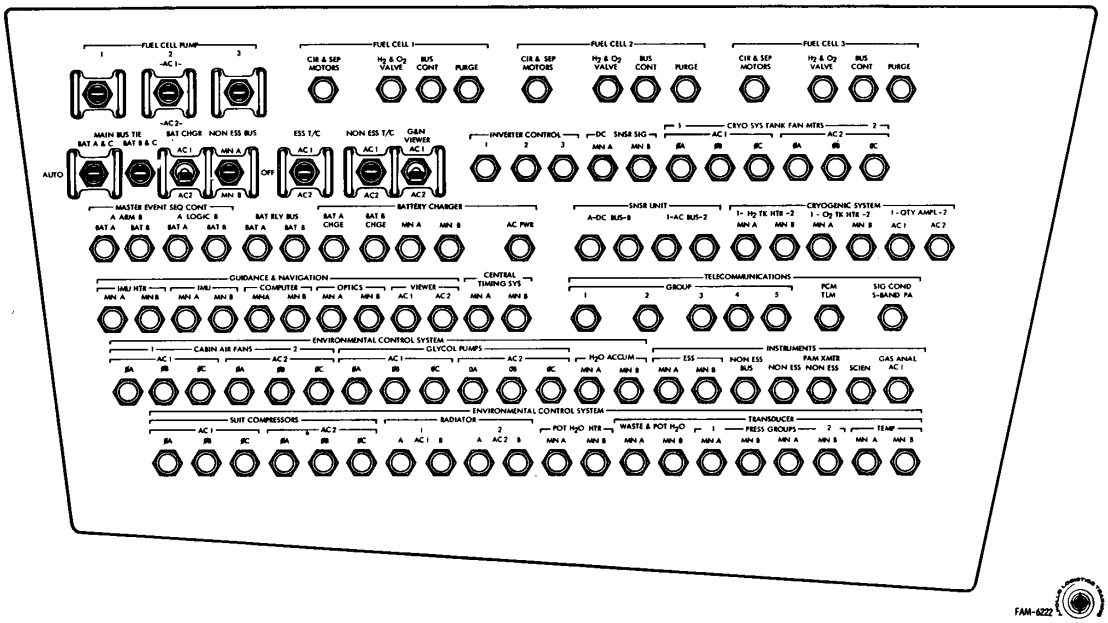
FAM-6014



10

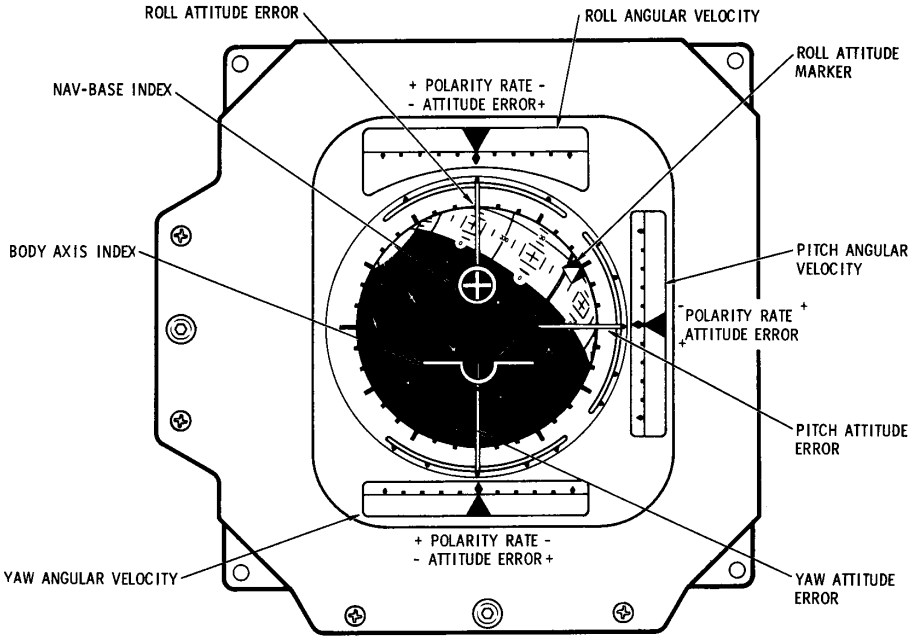
FAM-6210

22



FAM-6222

FLIGHT DIRECTOR ATTITUDE INDICATOR

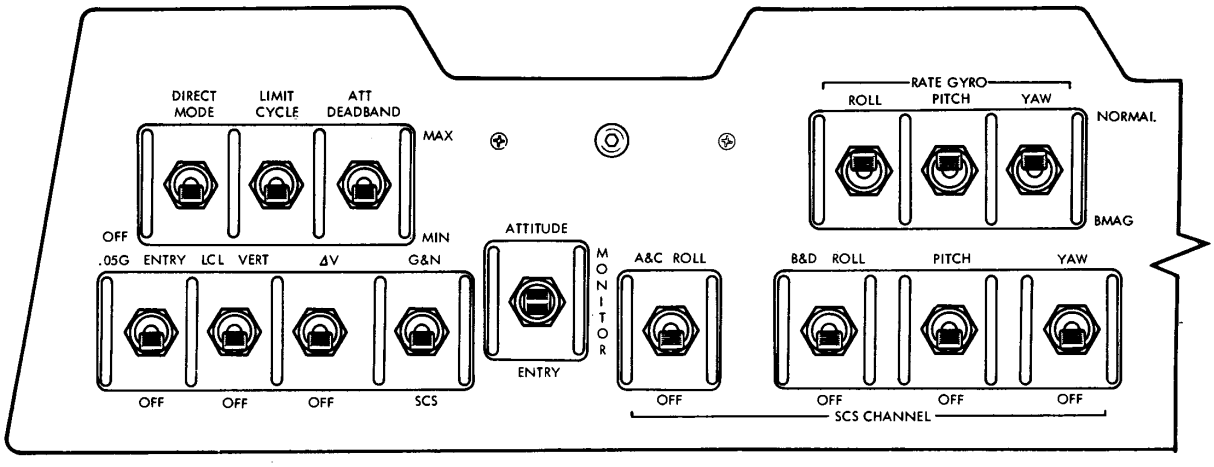


NOTES:
1. ATTITUDE ERROR = ATTITUDE DESIRED - ACTUAL ATTITUDE.
2. THE BALL IS OF THE INSIDE-OUT CONVENTION.
3. EULER ANGLE CONVENTION IS PITCH, YAW, ROLL.
4. THE BALL ATTITUDE SHOWN IS PITCH 345°, YAW 335°, AND ROLL 300°, WITH RESPECT TO THE NAVIGATION BASE INDEX.

SCS-100B

SCS CONTROL PANEL

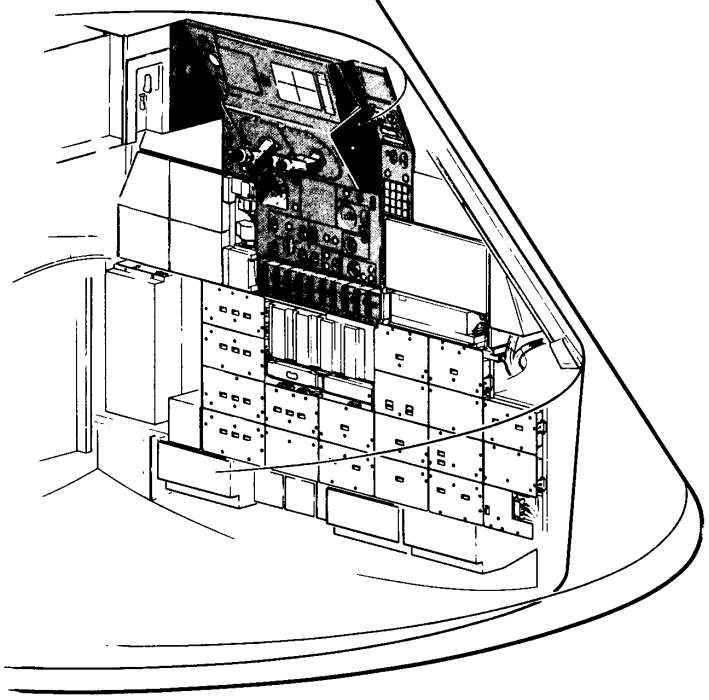
8



SCS-106B

LOWER EQUIPMENT BAY

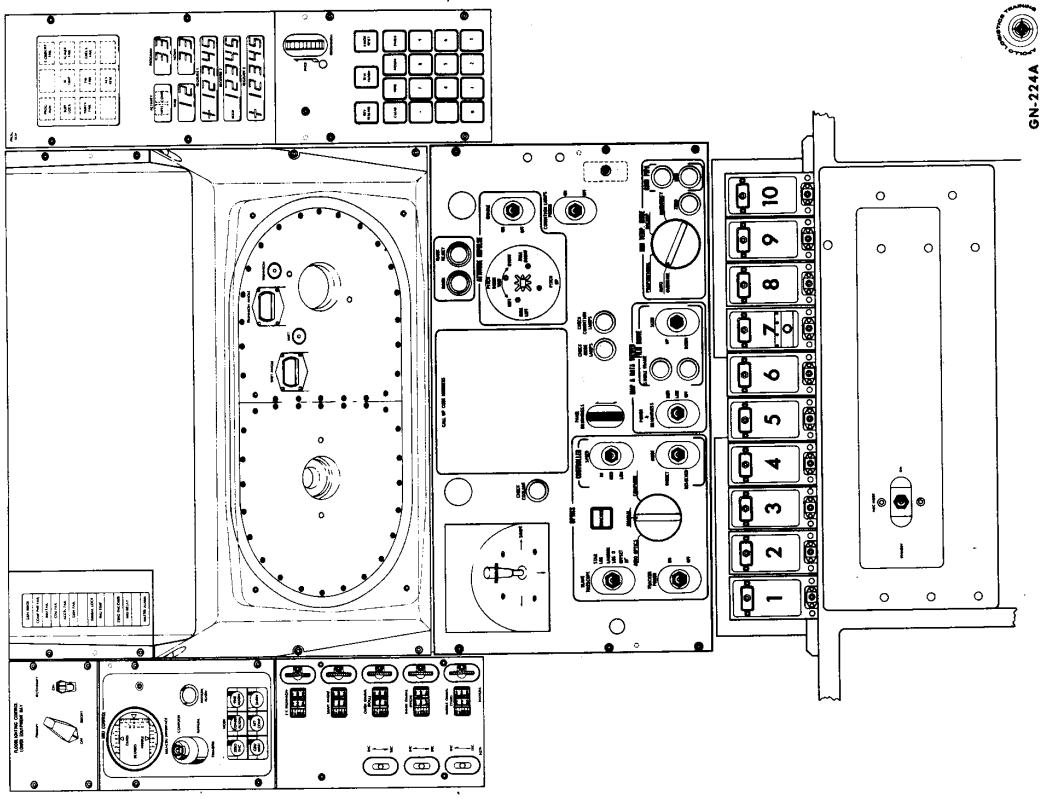
PERSPECTIVE



F-204A

G/N LOWER EQUIPMENT BAY

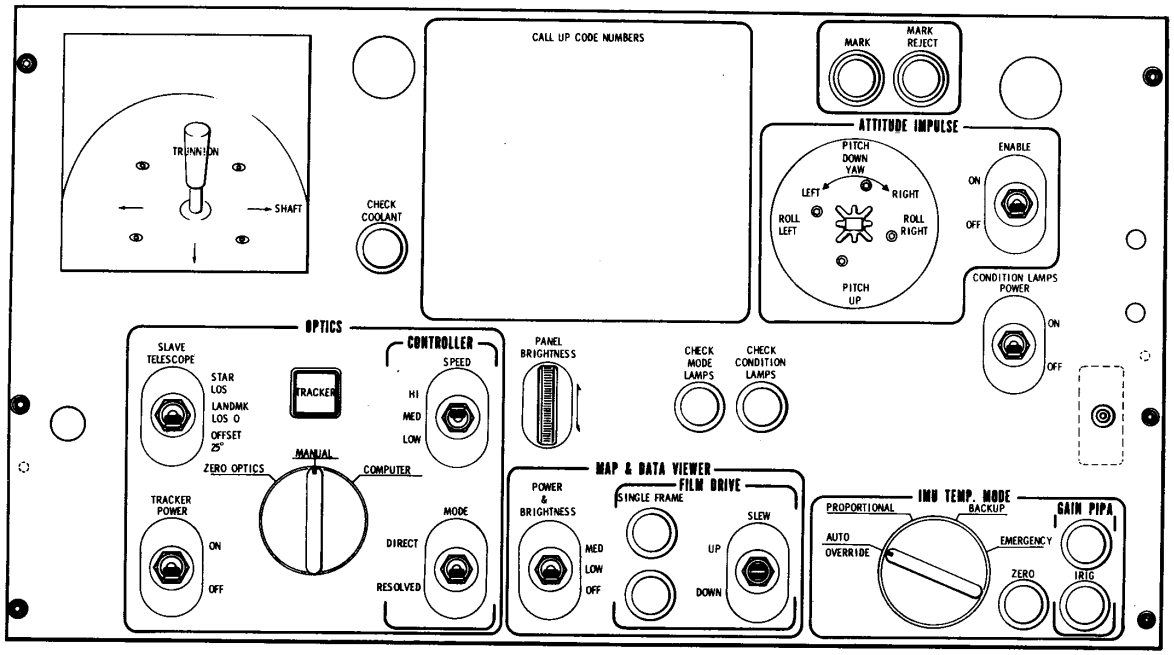
BLOCK I (100 SERIES)



GN-224A

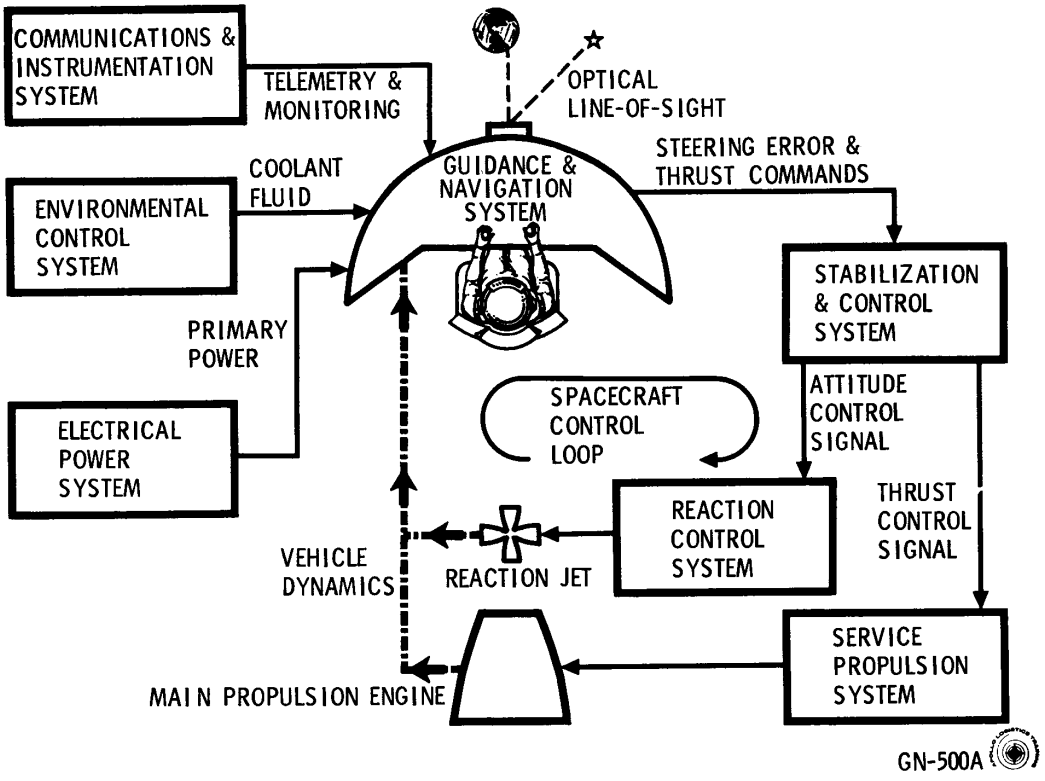
G&N OPTICS CONTROL PANEL

100 SERIES



GN-104A-1

G&N INTERFACE SYSTEMS

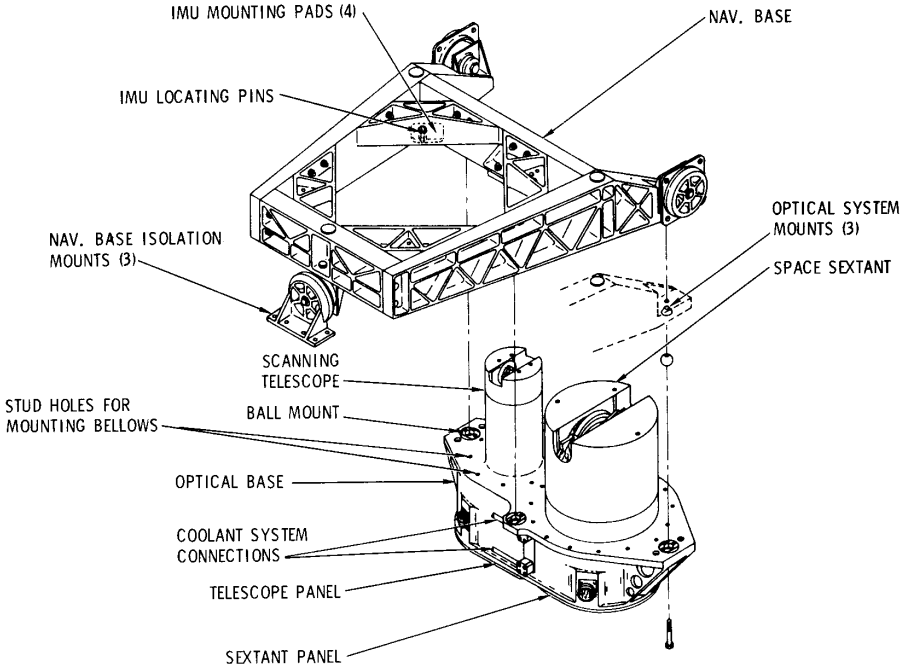


GN-500A

OPTICS SUBSYSTEM

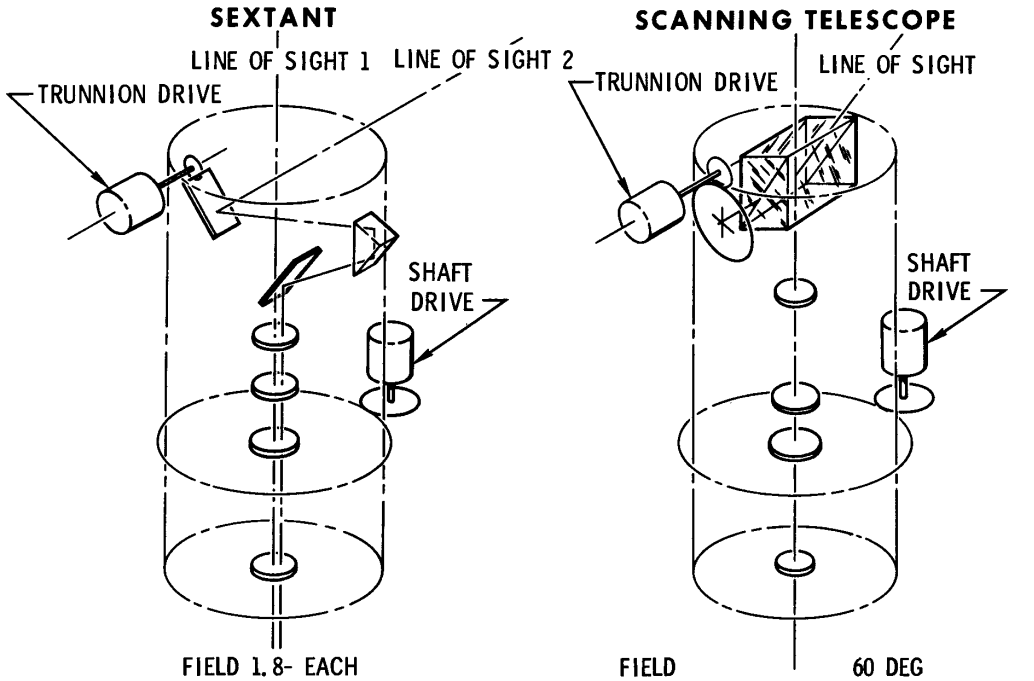
GN-220

OPTICAL SUBSYSTEM AND NAV. BASE



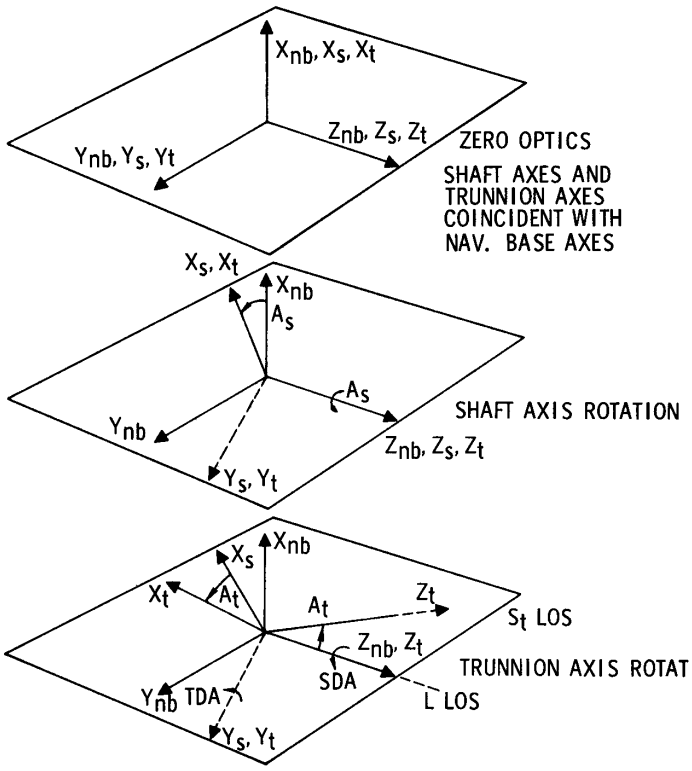
GN-9120A

OPTICAL SCHEMATIC



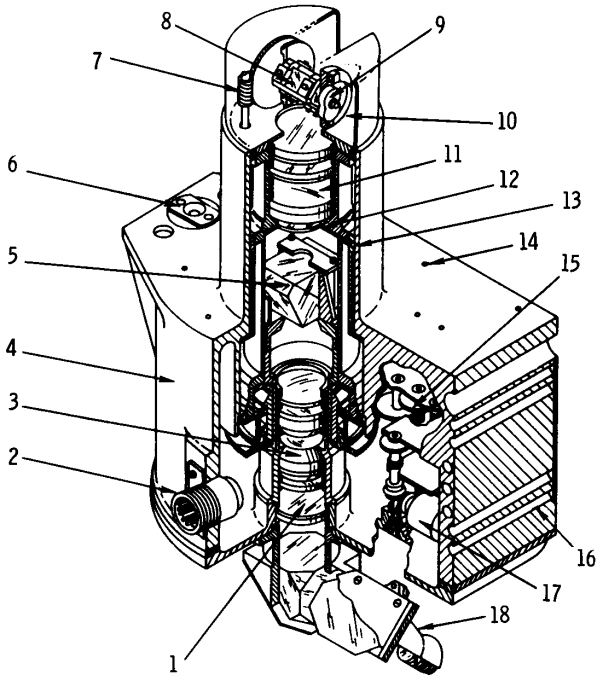
GN-176 A

OPTICAL SYSTEM AXES



GN-9175A

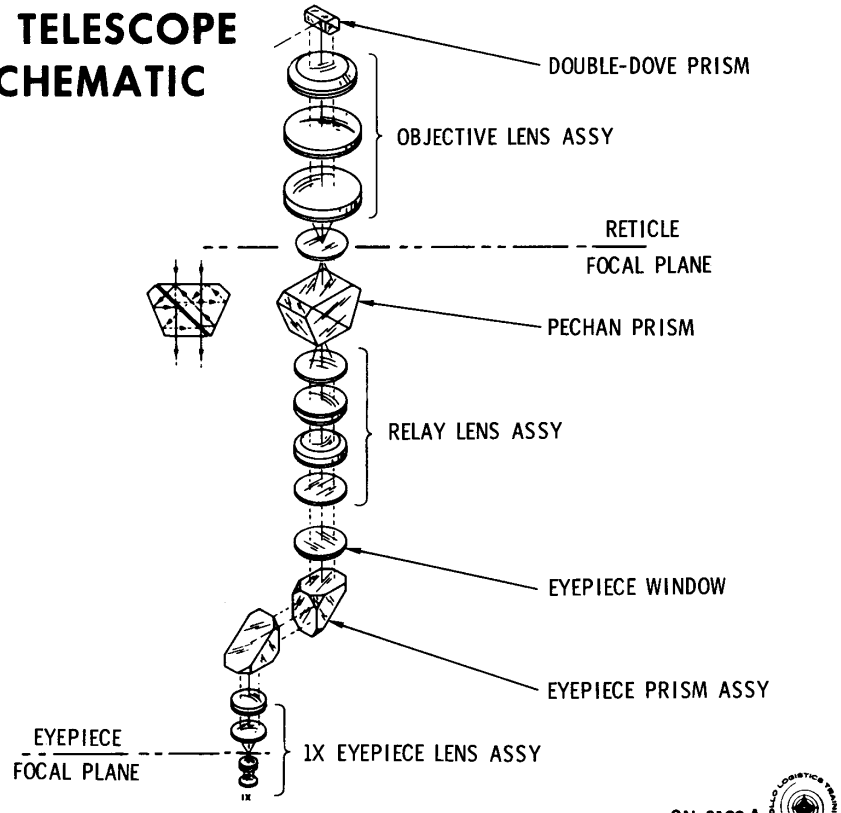
SCANNING TELESCOPE CUTAWAY



1. WINDOW
2. ELECTRICAL CONNECTOR
3. RELAY LENS ASSEMBLY
4. OPTICAL BASE
5. PECHAN PRISM
6. BALL MOUNT
7. TRUNNION DRIVE WORMSHAFT
8. PRISM & MOUNT ASSEMBLY
9. CAM
10. SPRING & CAMFOLLOWER (ANTIBACKLASH)
11. OBJECTIVE LENS ASSEMBLY
12. RETICLE
13. RETICLE ILLUMINATION
14. STUD HOLES FOR BELLOWS COVER
15. SHAFT DRIVE GEAR BOX
16. HEAT EXCHANGER CHANNELS
17. COUNTER (SHAFT AXIS)
18. EYEPIECE ASSEMBLY

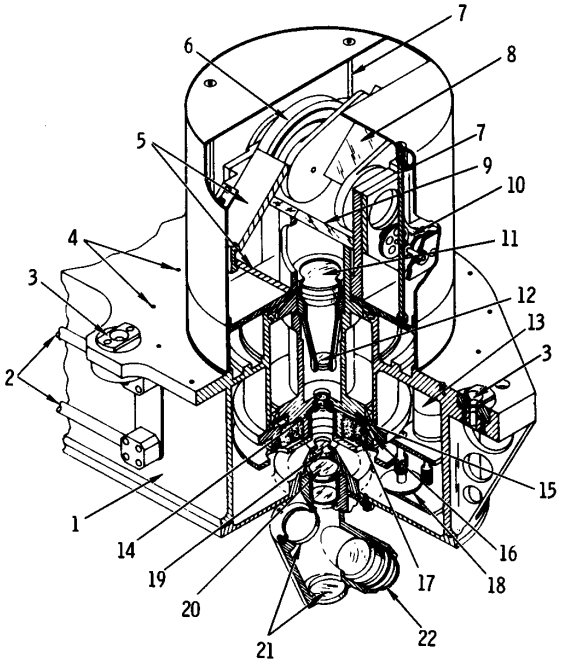
GN-9121A

SCANNING TELESCOPE OPTICAL SCHEMATIC



GN-9122 A

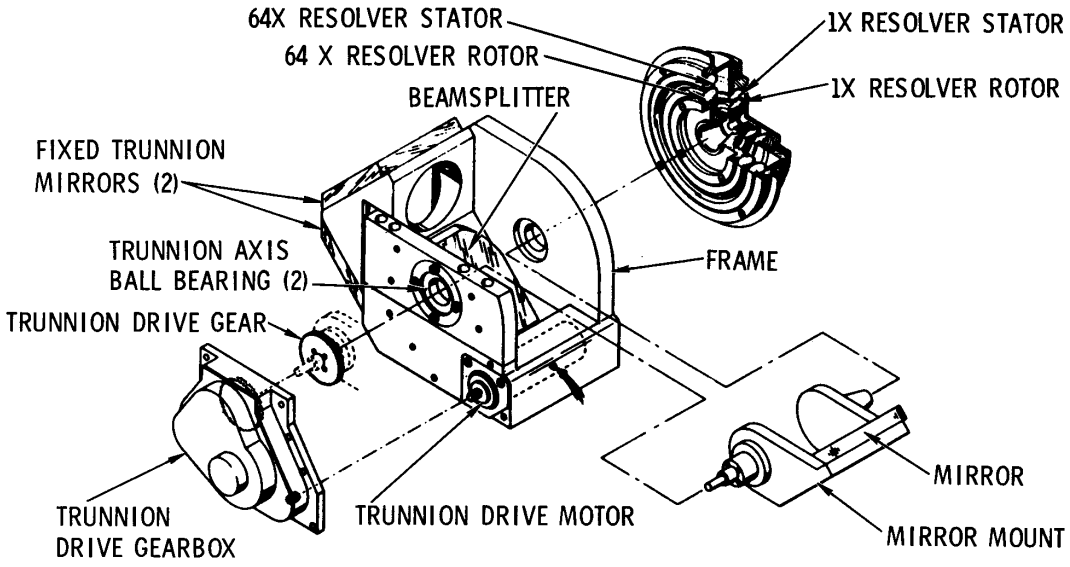
SEXTANT CUTAWAY



1. OPTICAL BASE
2. COOLANT CONNECTIONS
3. BALL MOUNT
4. STUD HOLES FOR MOUNTING BELLOWS COVER
5. FIXED RIGHT-ANGLE MIRRORS
6. TRUNNION AXIS RESOLVER (64X)
7. COVER-FASTENING ROD
8. INDEXING MIRROR
9. BEAM SPLITTER
10. TRUNNION DRIVE GEAR BOX
11. OBJECTIVE LENS ASSEMBLY
12. INTERMEDIATE LENS ASSEMBLY
13. SHAFT AXIS DRIVE MOTOR
14. RETICLE
15. LIGHT-TRANSMITTING ROD
16. RETICLE LAMP
17. SHAFT-AXIS RESOLVER (16X)
18. SHAFT DRIVE GEAR BOX
19. EYEPIECE SOCKET & SEAL
20. EYEPIECE OBJECTIVE LENS
21. EYEPIECE MIRRORS
22. EYEPIECE OCULAR

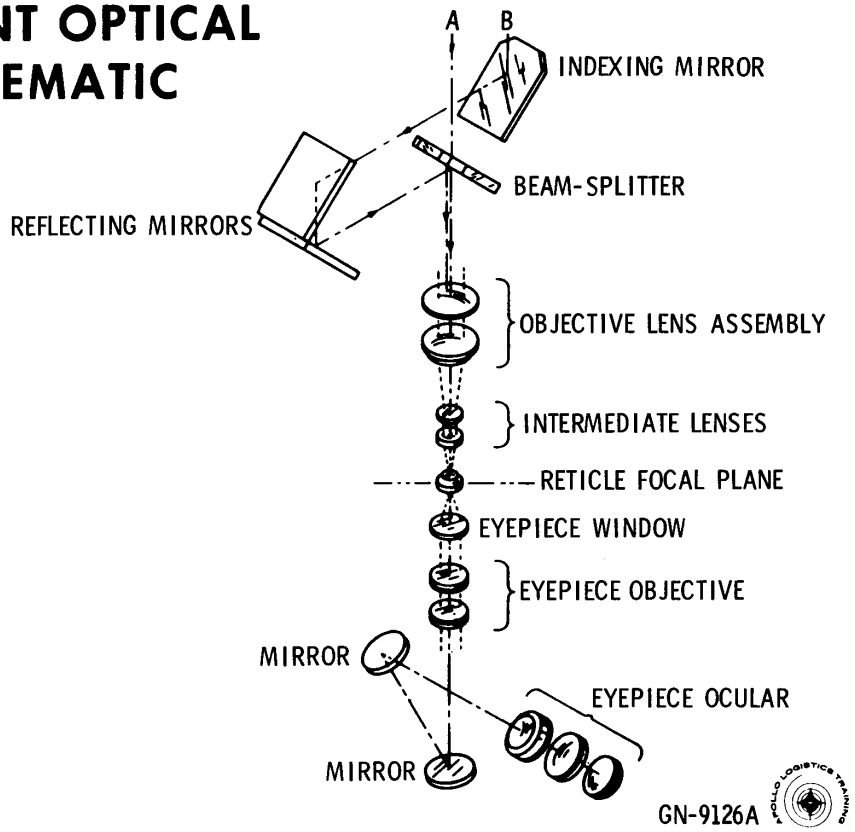
GN-9124 A

SEXTANT TRUNNION AXIS ASSEMBLY

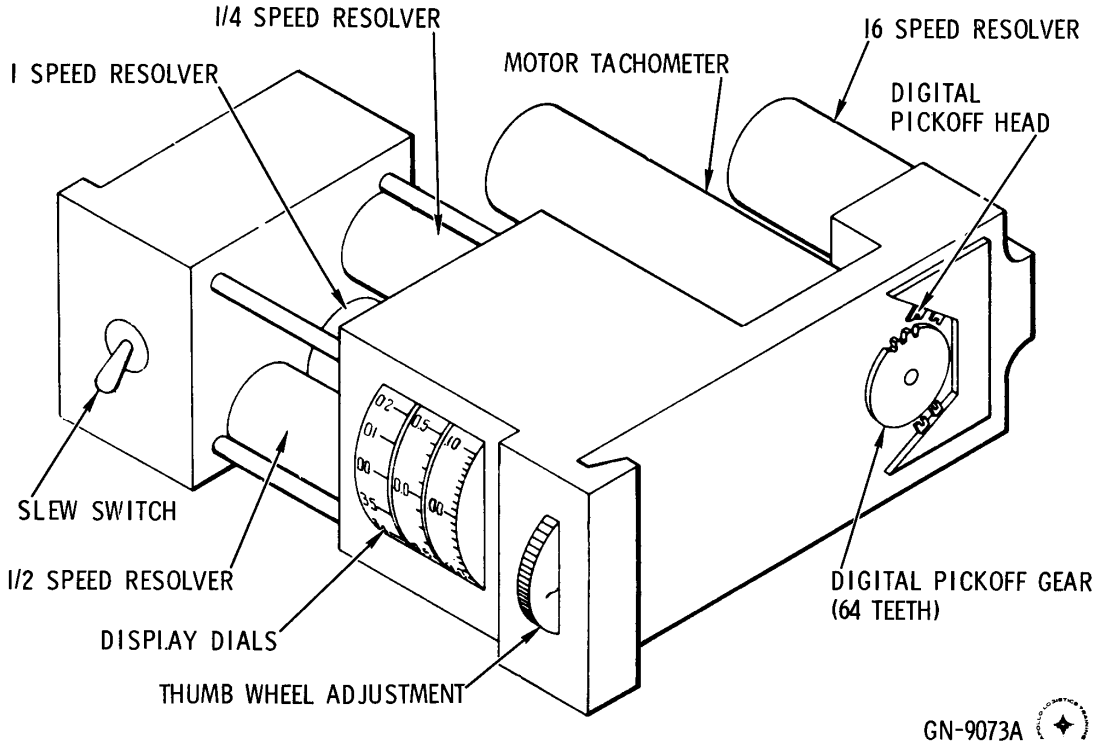


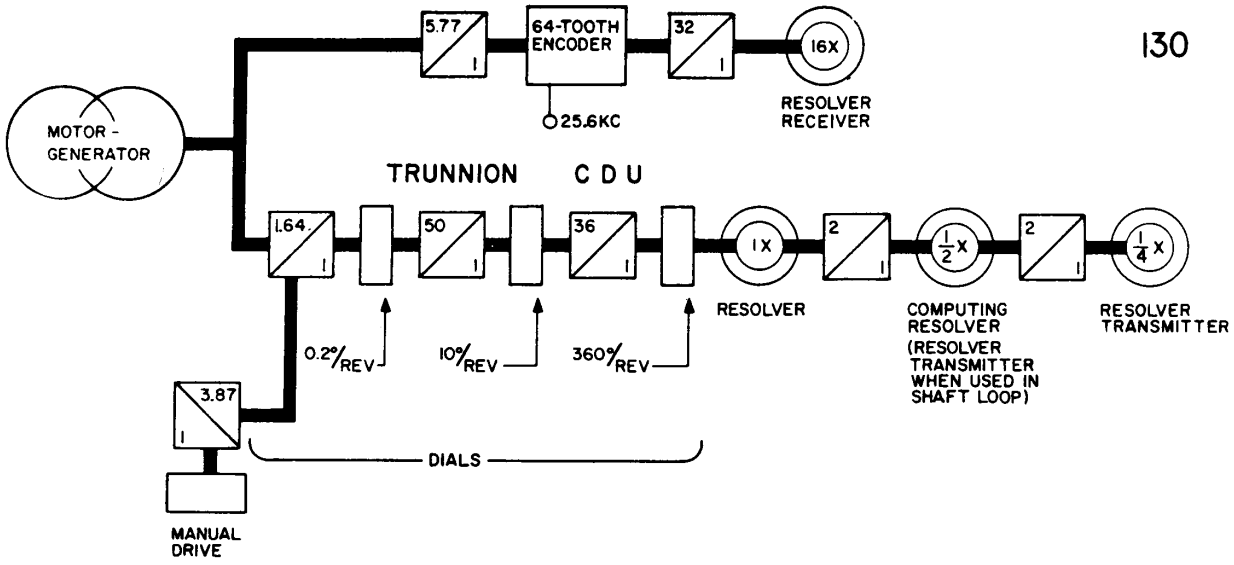
GN-9125A

SEXTANT OPTICAL SCHEMATIC



COUPLING DISPLAY UNIT



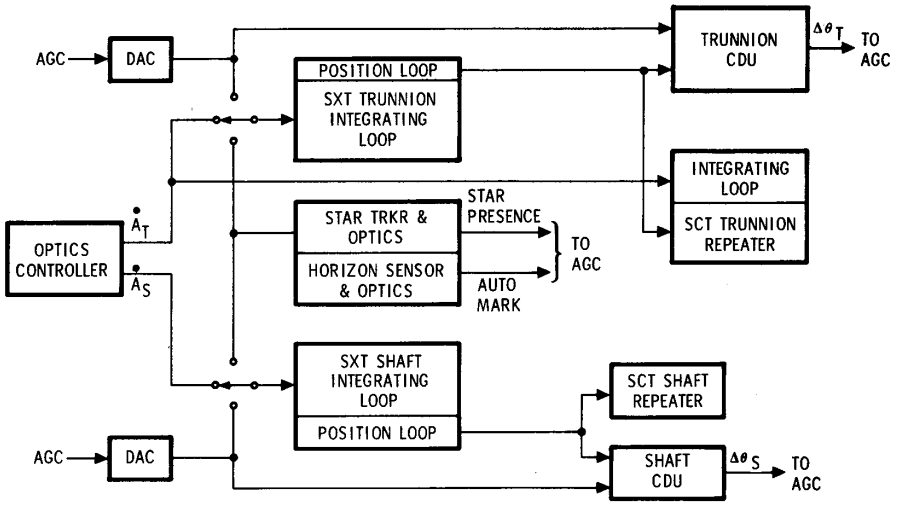


CDU BLOCK DIAGRAM

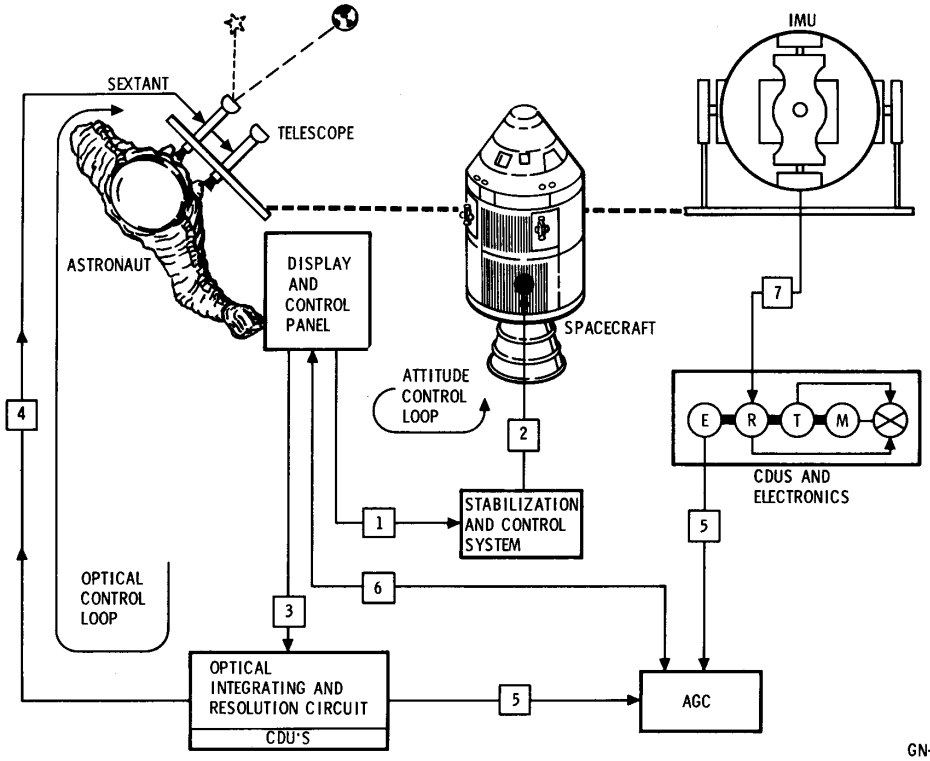
GN-9130

OPTICS MECHANIZATION

BLOCK I 100SERIES

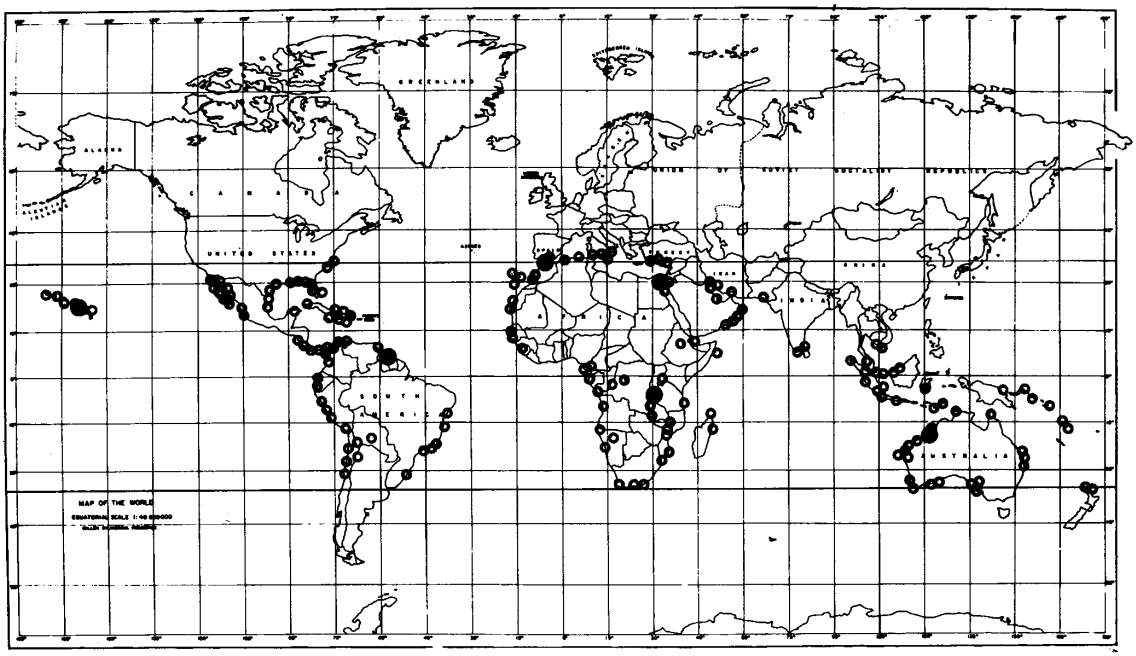


OPTICAL MEASUREMENT



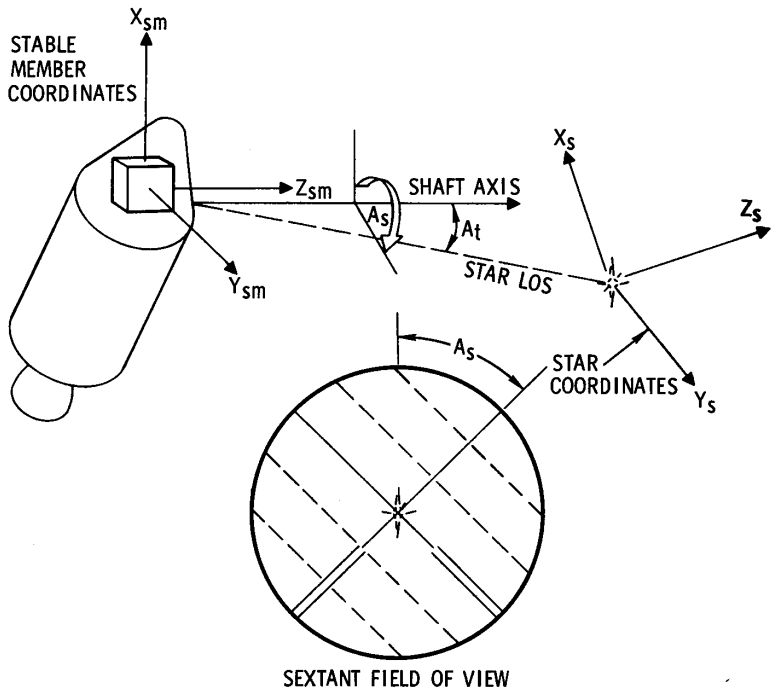
GN-9146A

LAND MARKS



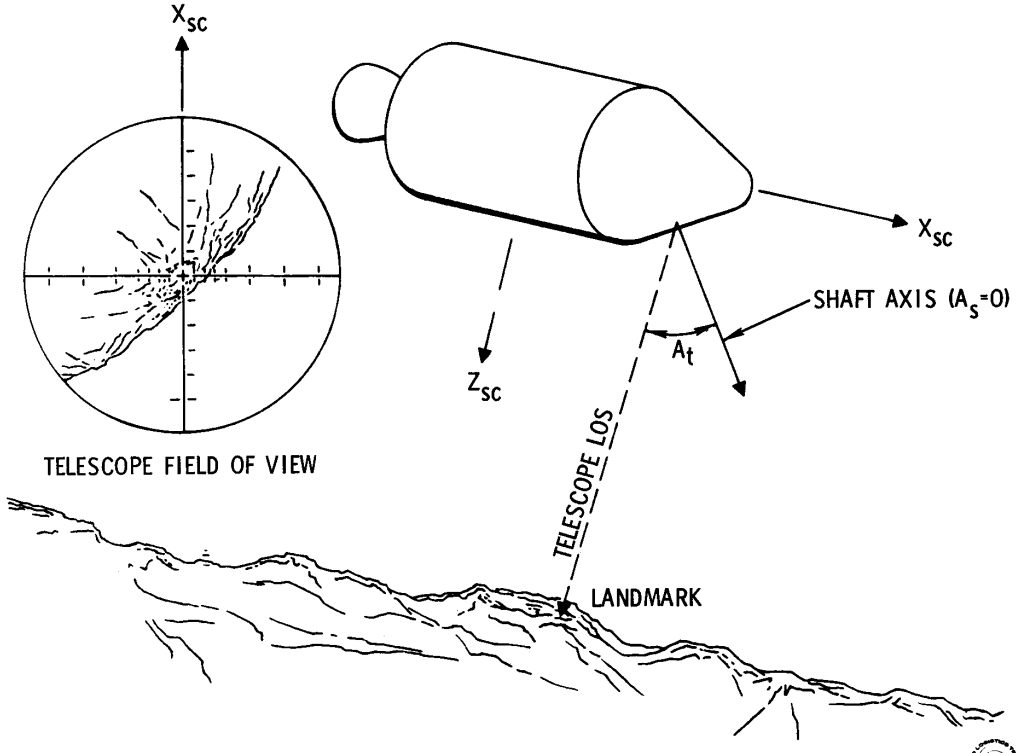
GN-198

IMU ALIGNMENT MEASUREMENT



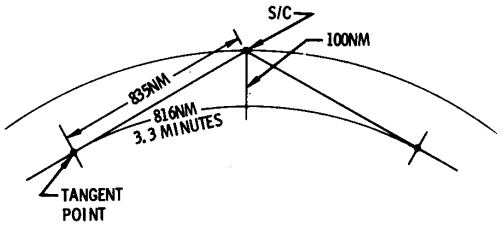
GN-9100A

ORBITAL NAVIGATION MEASUREMENT

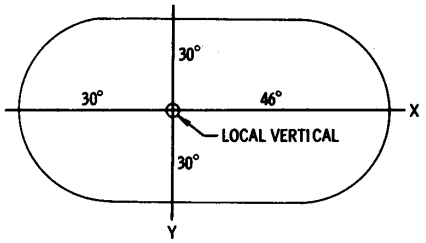


GN-9102A

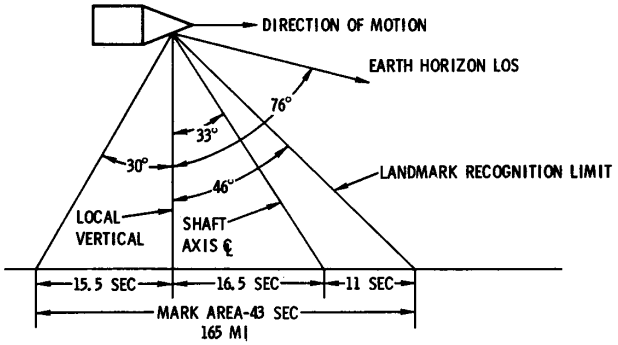
EARTH ORBIT NAVIGATION



EARTH ORBIT GEOMETRY FIGURE 1



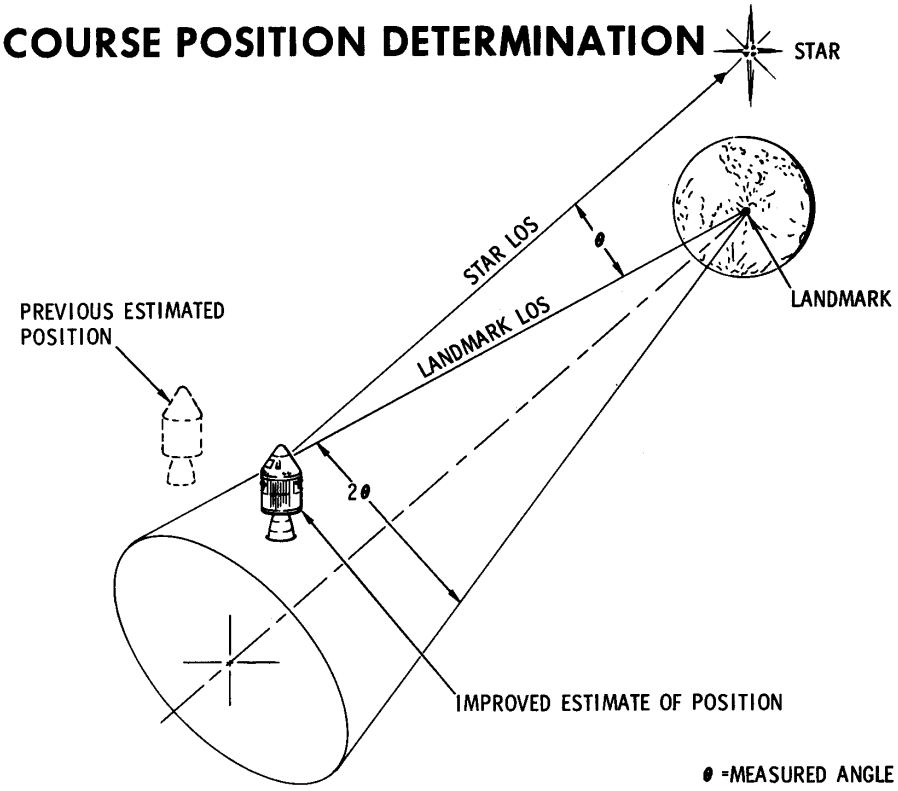
VIEW ON SURFACE FIGURE 3



COVERAGE ON SURFACE FIGURE 2

GN-183A

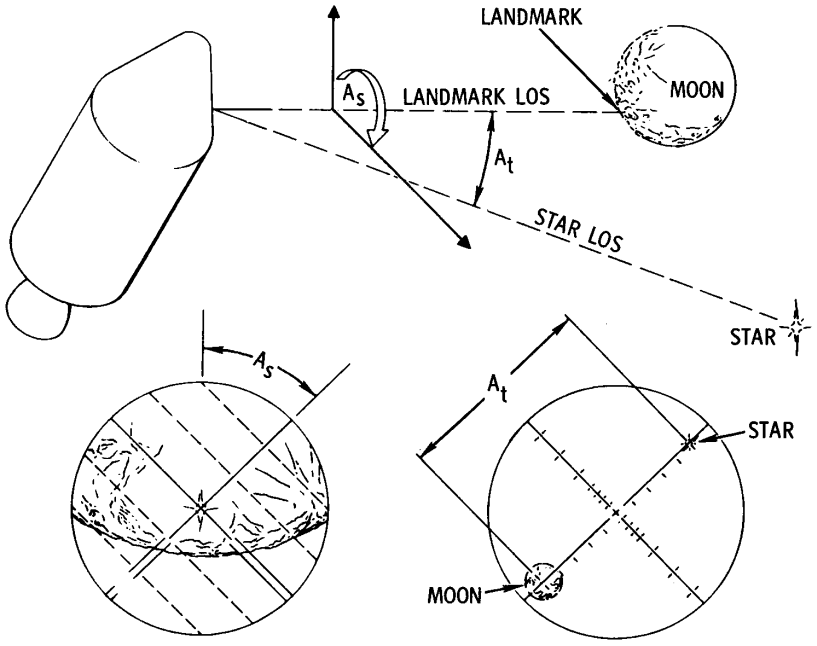
MIDCOURSE POSITION DETERMINATION



θ =MEASURED ANGLE

GN-9101A

MIDCOURSE NAVIGATIONAL MEASUREMENT

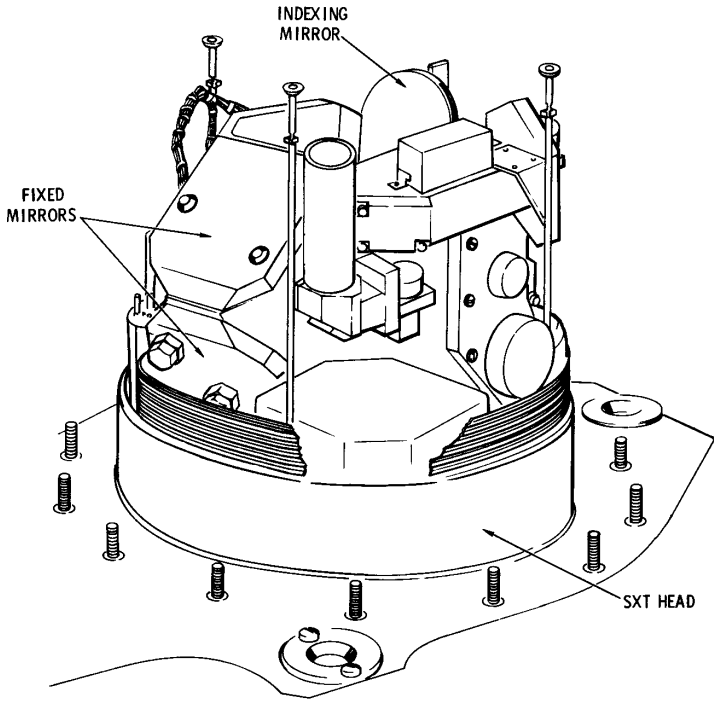


SEXTANT FIELD OF VIEW

TELESCOPE FIELD OF VIEW

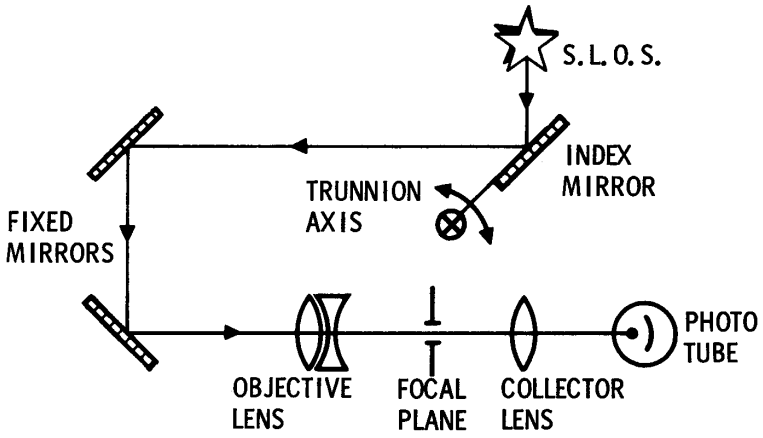
GN-9103A

TRACKER & HORIZON SENSOR LOCATION

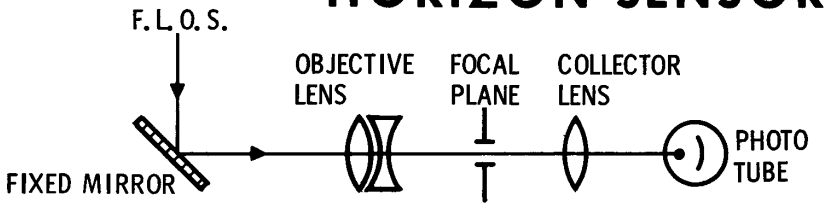


GN-212

TRACKER LINE OF SIGHT

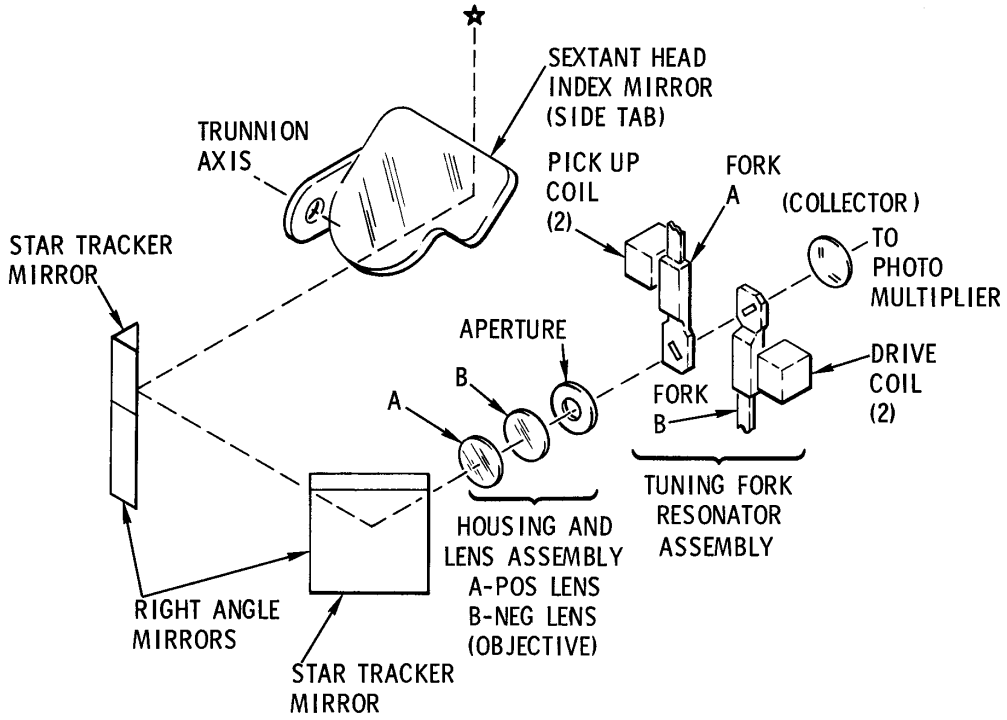


HORIZON SENSOR



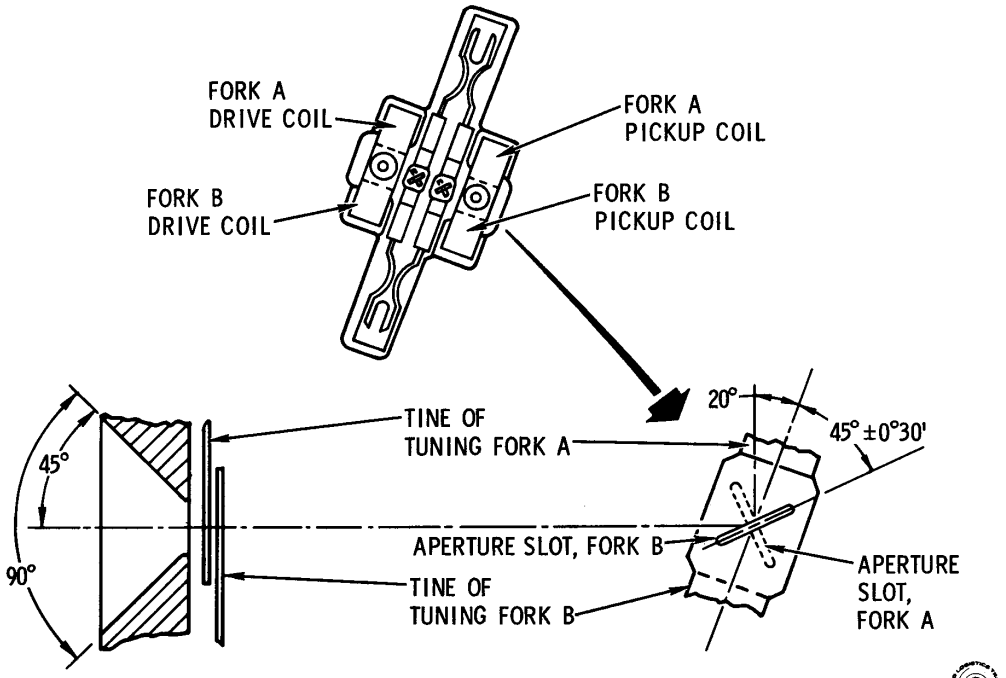
GN-214

TRACKER OPTICAL SYSTEM



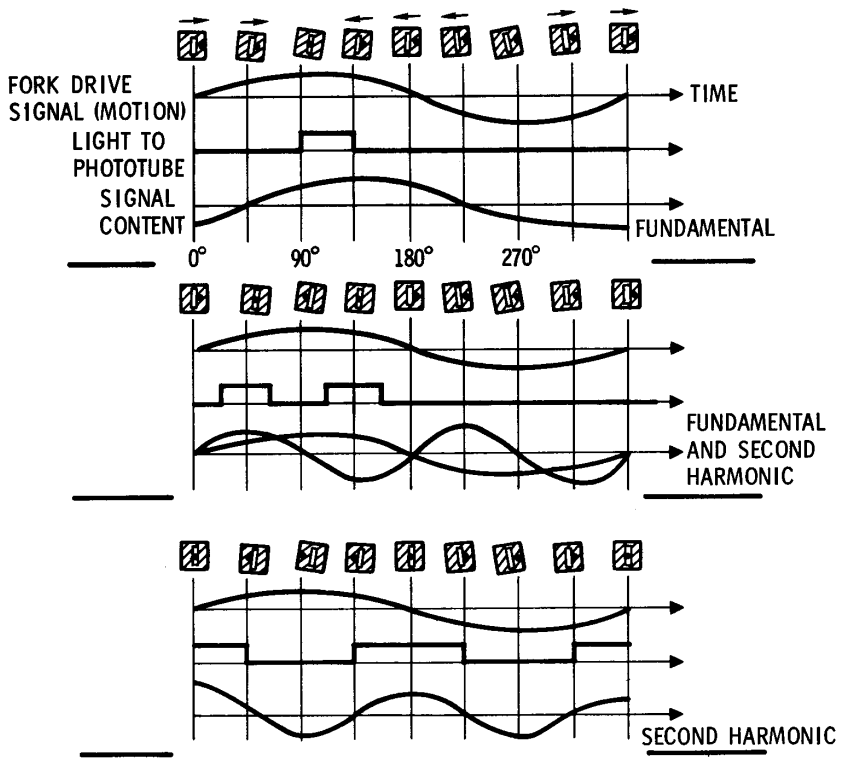
GN-230

TRACKER SCANNING MECHANISM



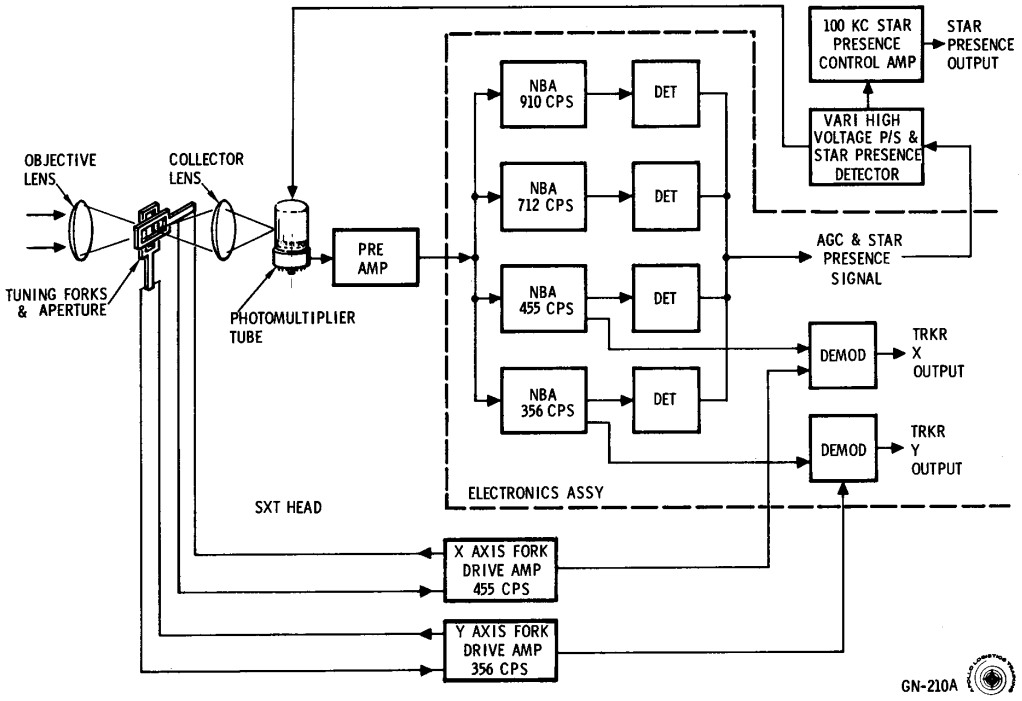
GN-213A

STAR SIGNAL WAVEFORMS

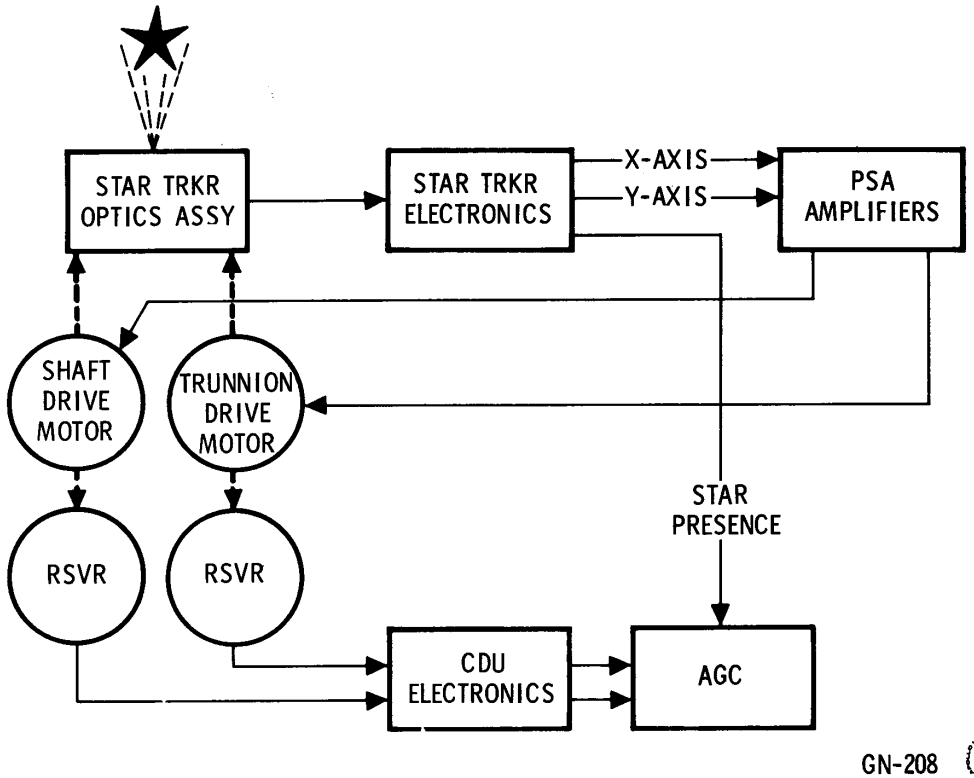


GN-217

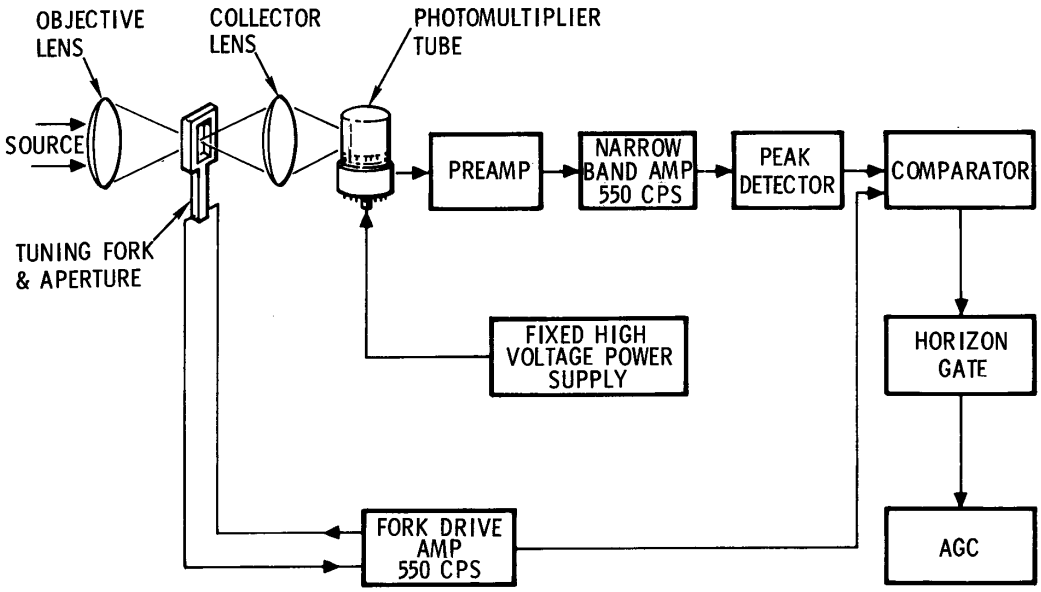
STAR TRACKER



STAR TRACKER MECHANIZATION

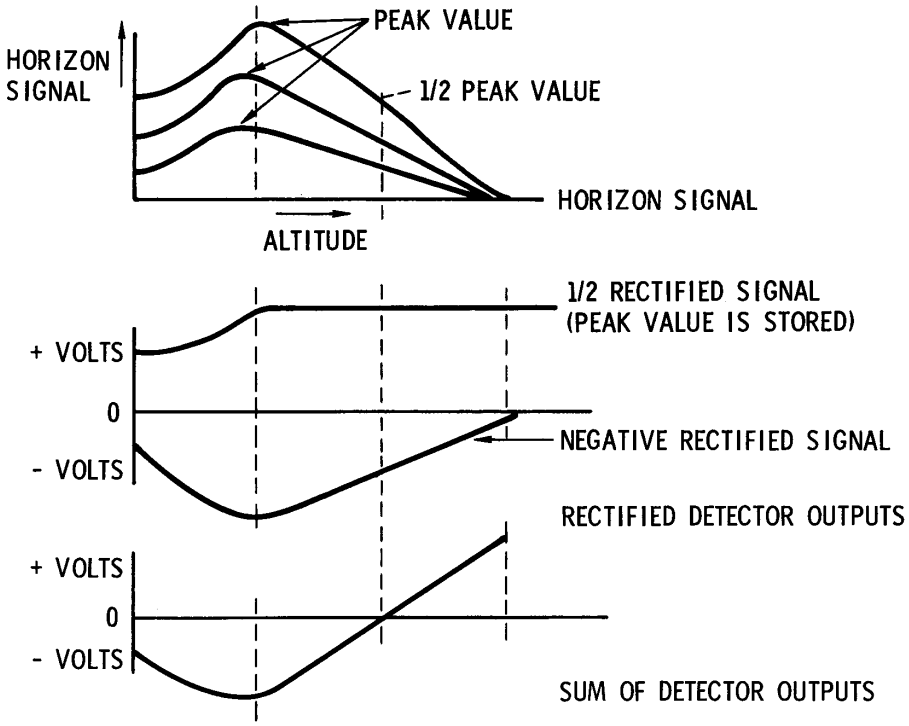


HORIZON SENSOR



GN-209A

HORIZON SENSOR WAVEFORMS

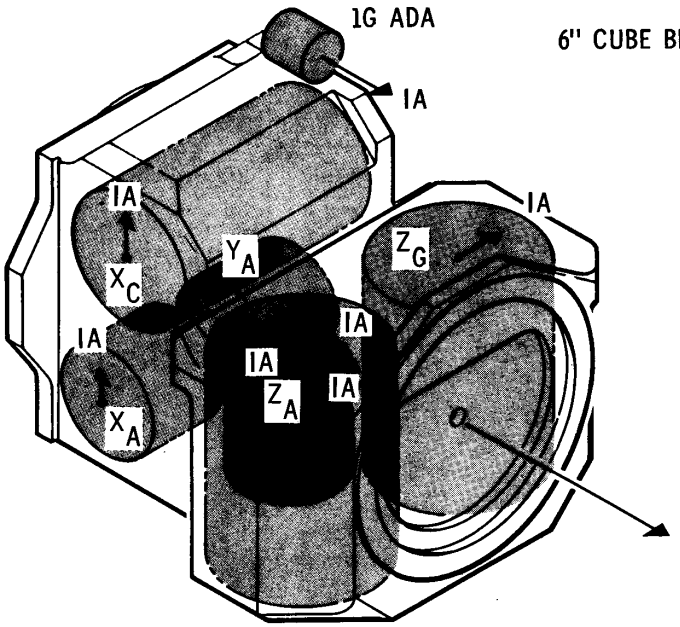


GN-218

INERTIAL SUBSYSTEM

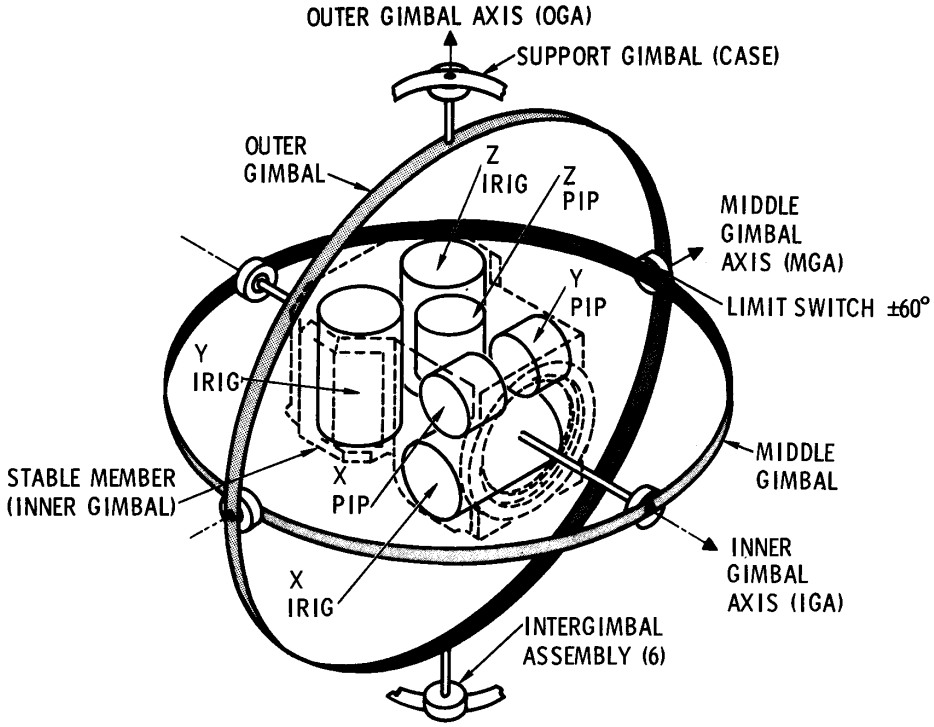
GN-221

APOLLO STABLE MEMBER CONFIGURATION



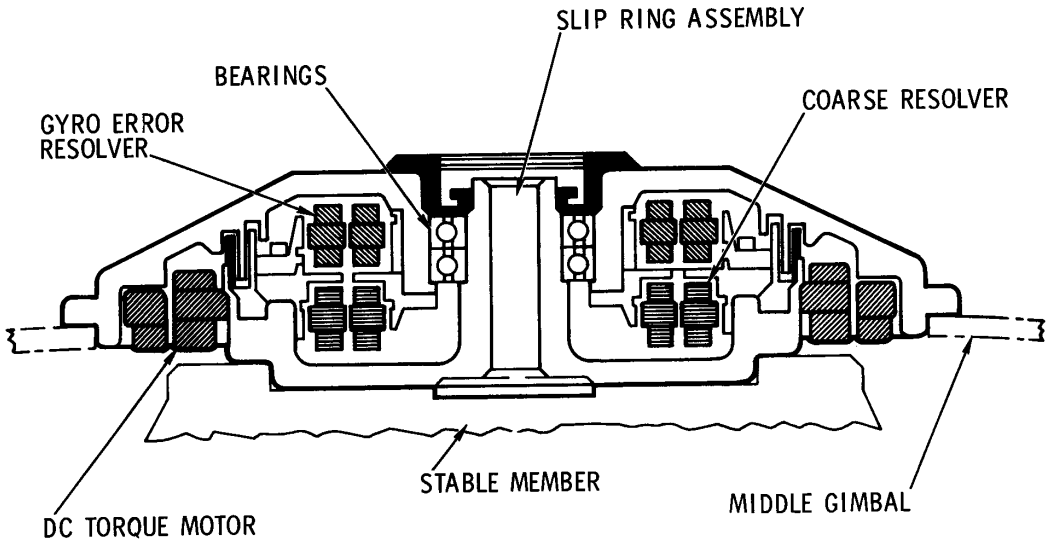
GN-9007A

IMU GIMBAL ASSEMBLY



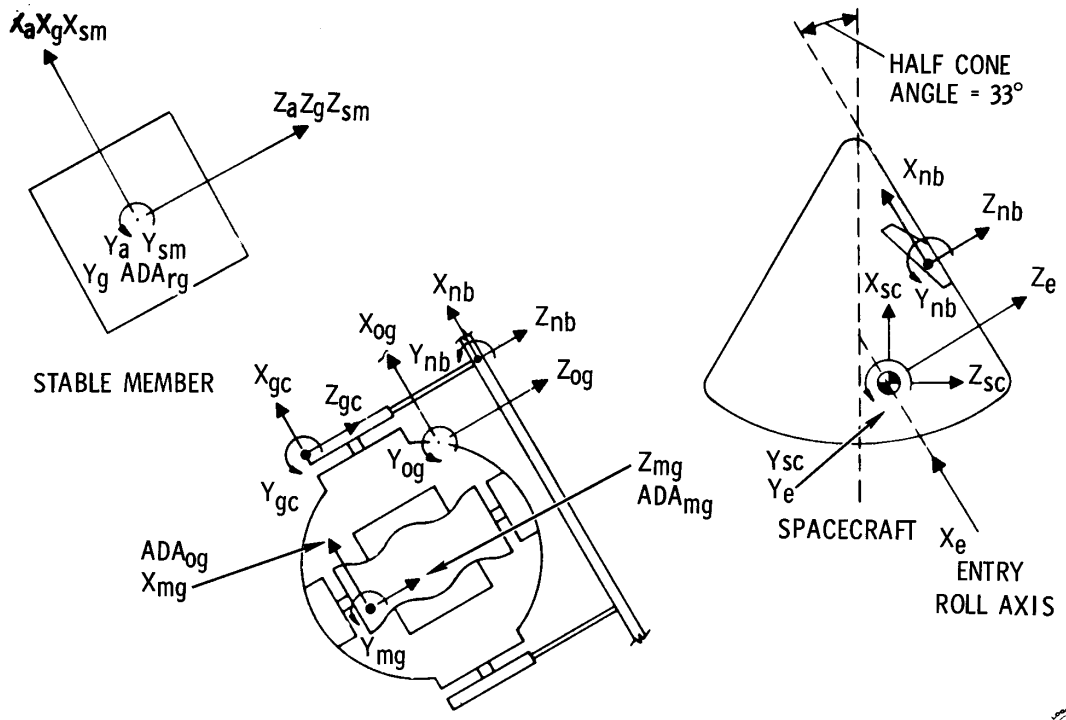
GN-9155A

INTERGIMBAL ASSEMBLY



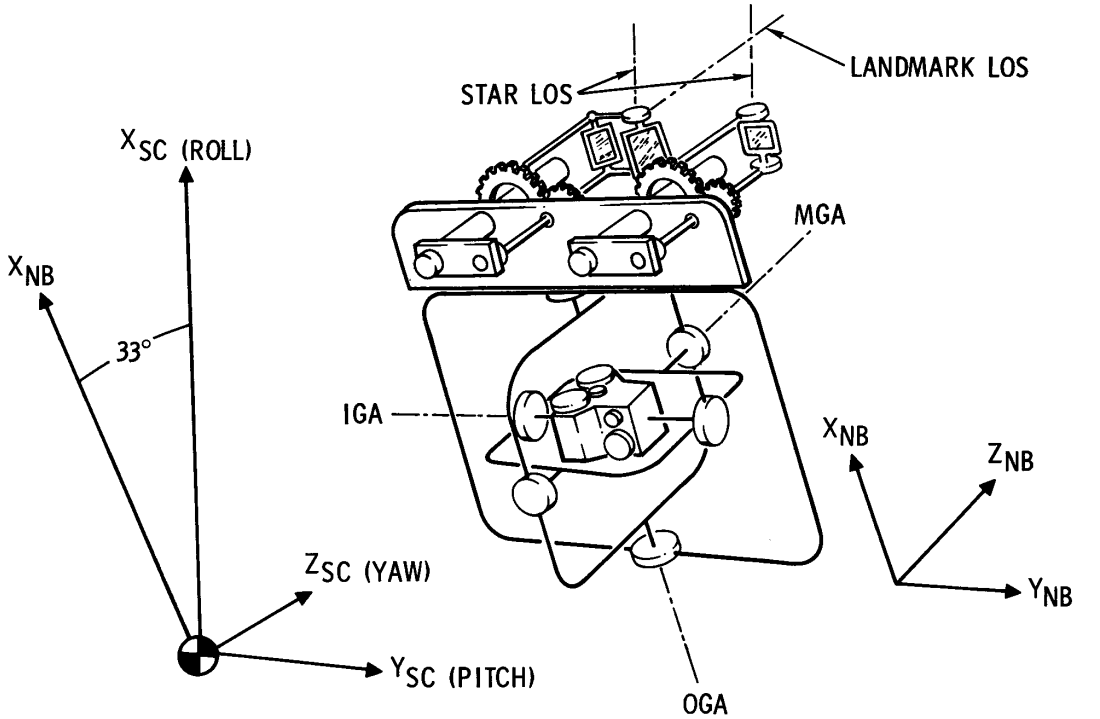
GN-9038A

ZERO AXIS ALIGNMENT



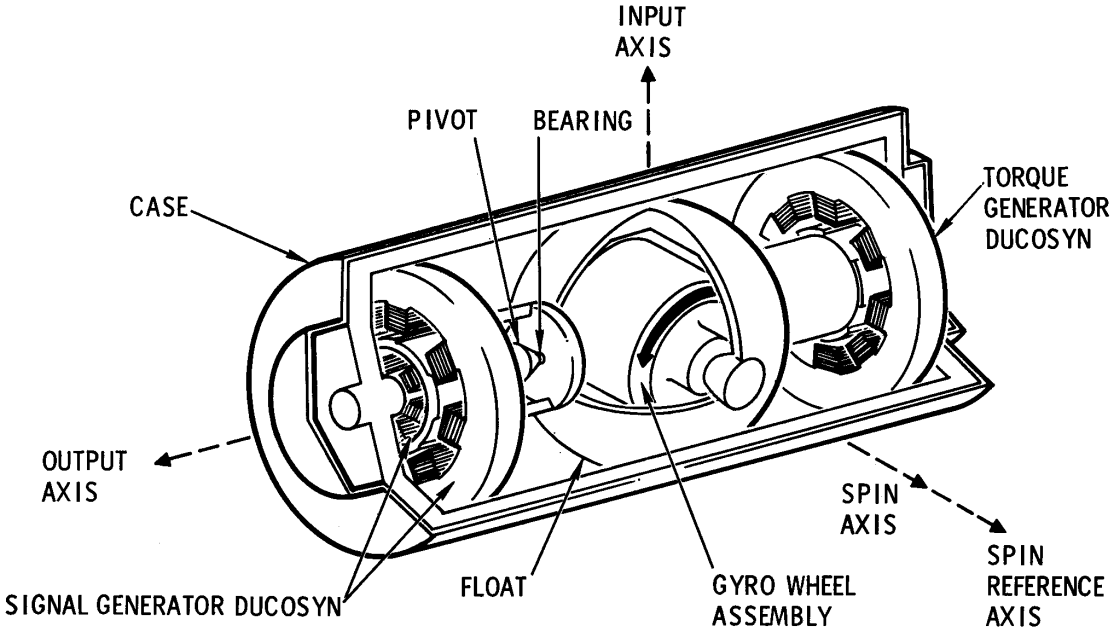
GN-9064A

G&N FUNCTIONAL SCHEMATIC



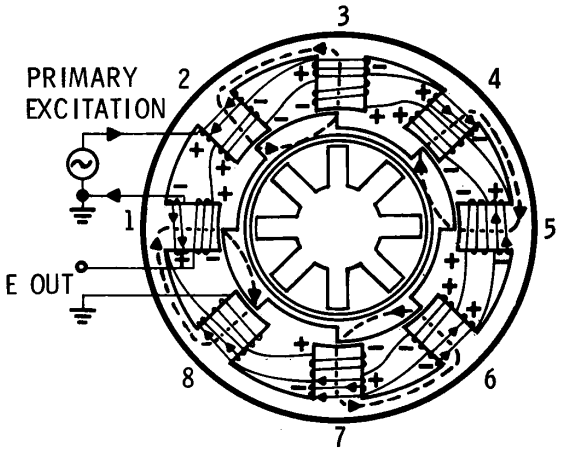
GN-196A

25 IRIG, SIMPLIFIED CUTAWAY VIEW

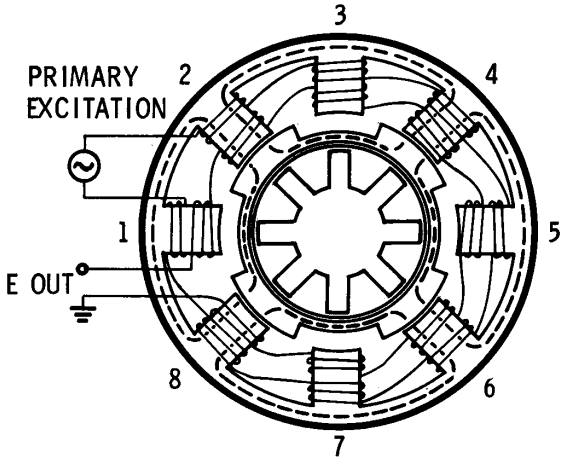


GN-240

DUCOSYN SIGNAL GENERATOR OPERATION



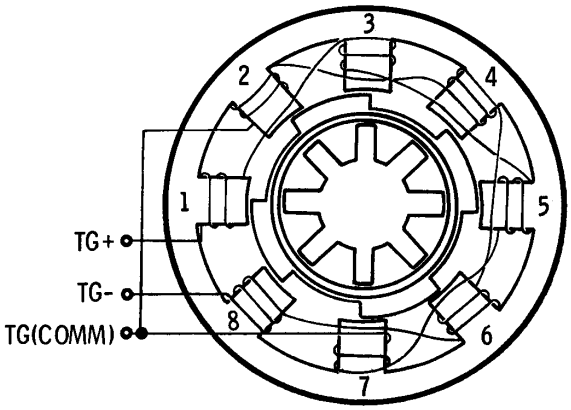
ROTOR AT NULL



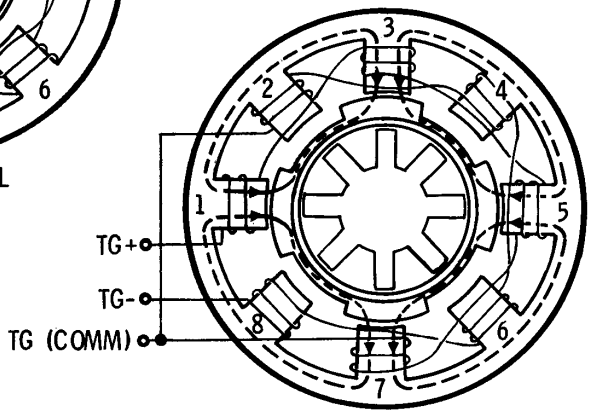
COUNTER-CLOCKWISE ROTATION

GN-239

DUCOSYN TORQUE GENERATOR OPERATION



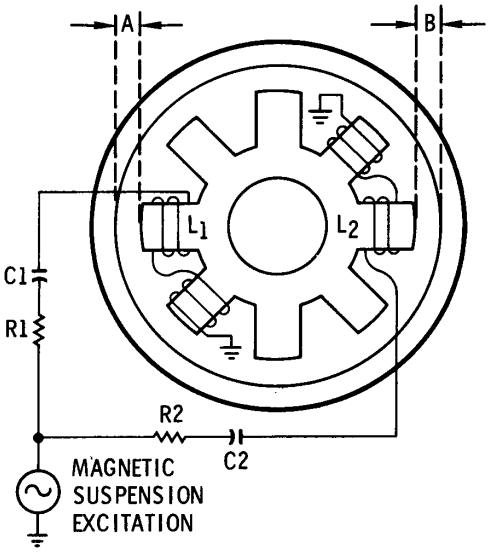
ROTOR AT HULL

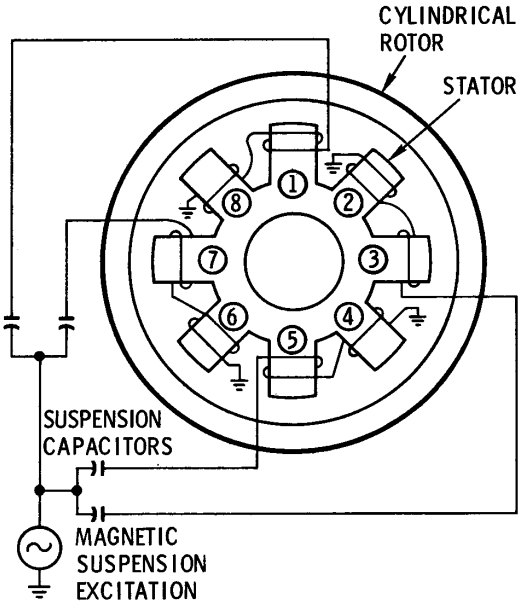


POSITIVE TORQUING SIGNALS APPLIED

GN-238

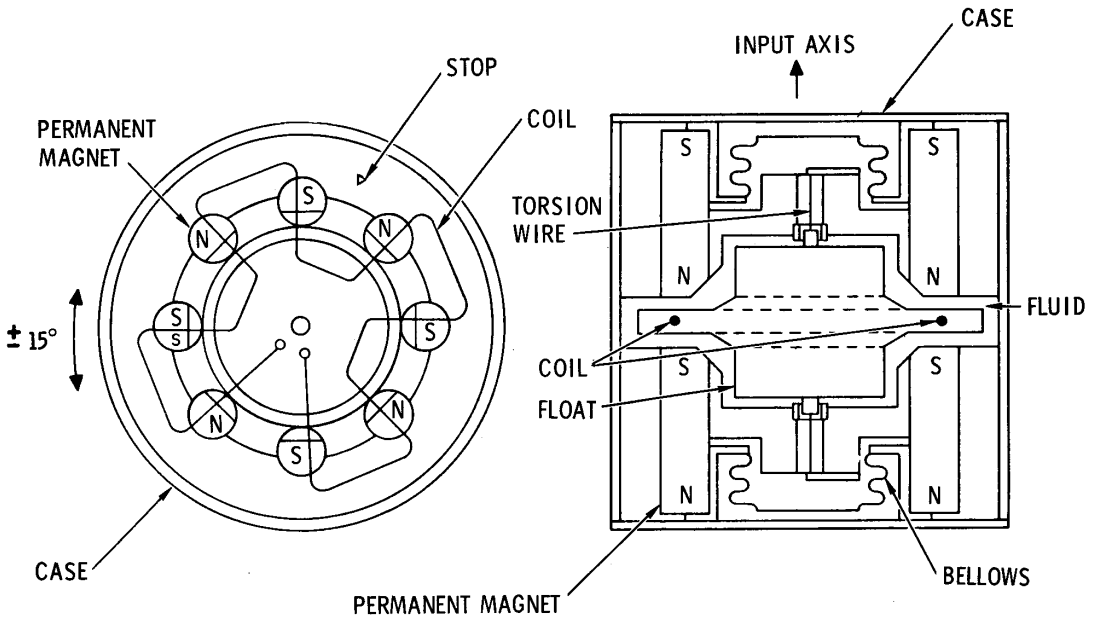
MAGNETIC SUSPENSION





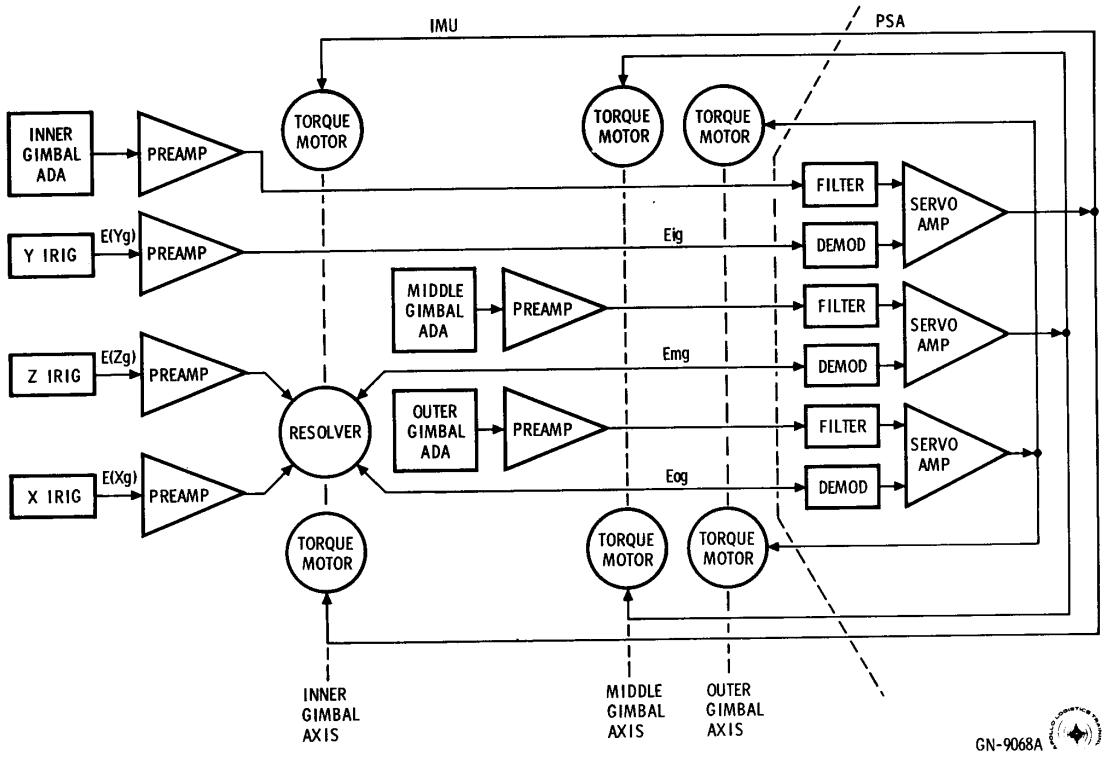
GN-237

ANGULAR DIFFERENTIATING ACCELEROMETER



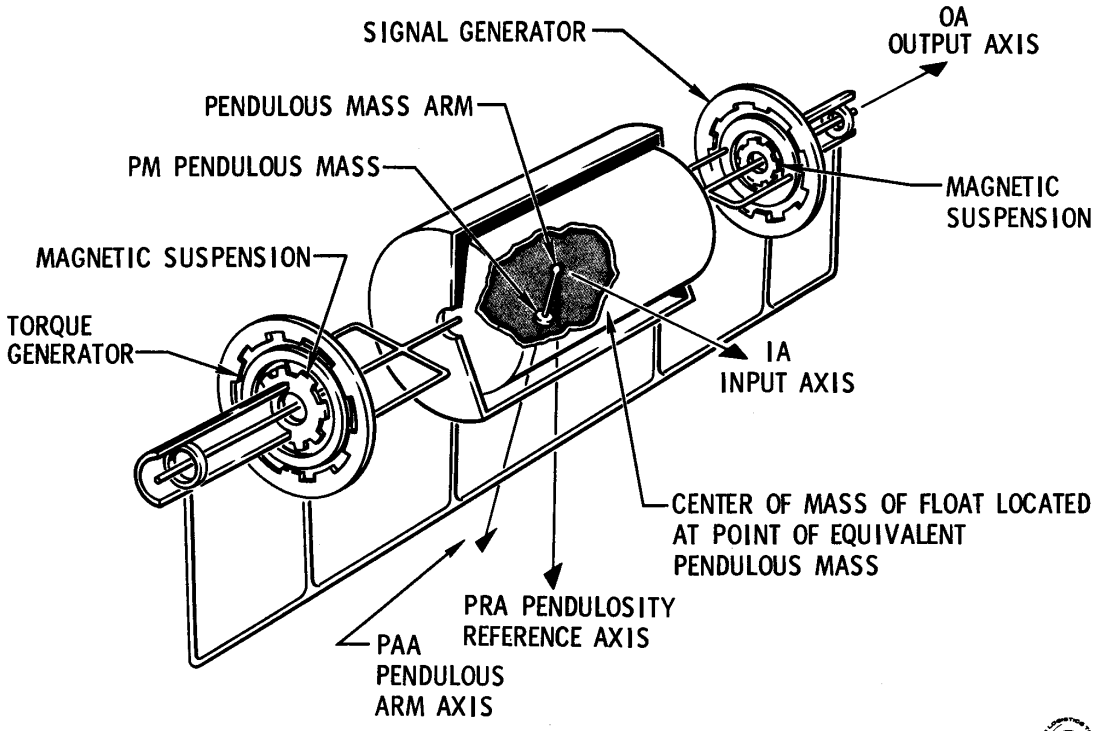
GN-9048A

STABILIZATION LOOP



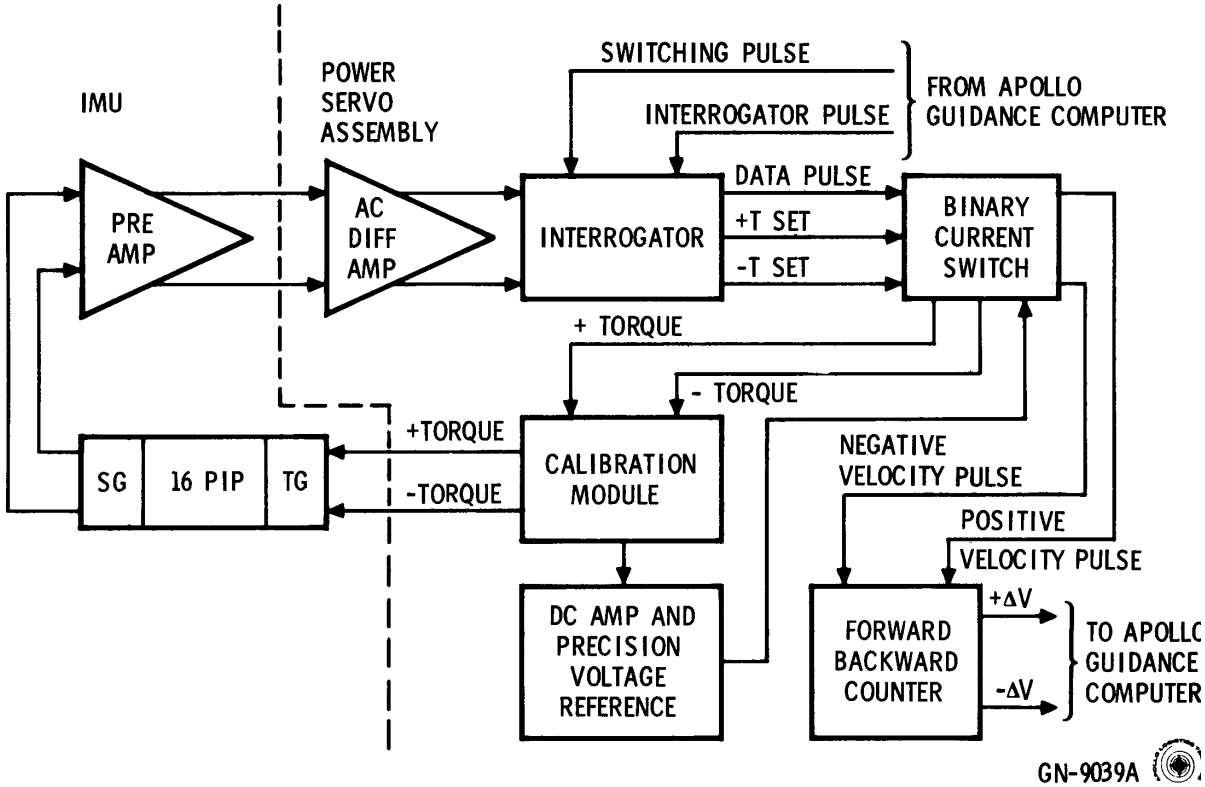
GN-9068A

FLOATED PENDULUM UNIT



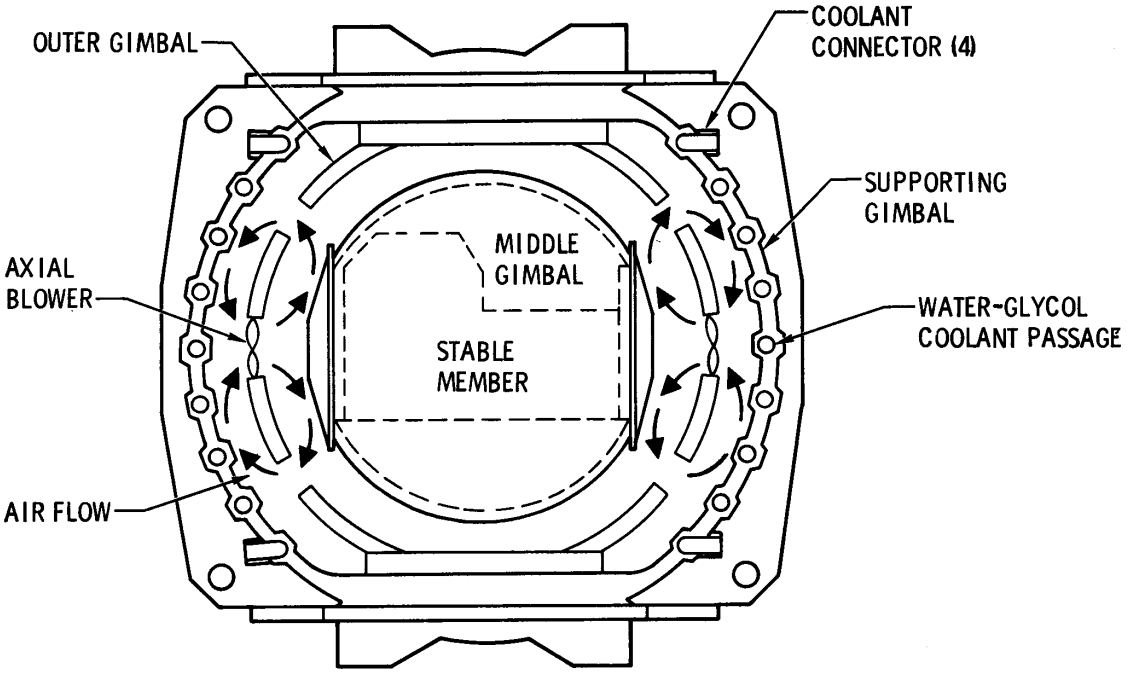
GN-179

ACCELEROMETER LOOP



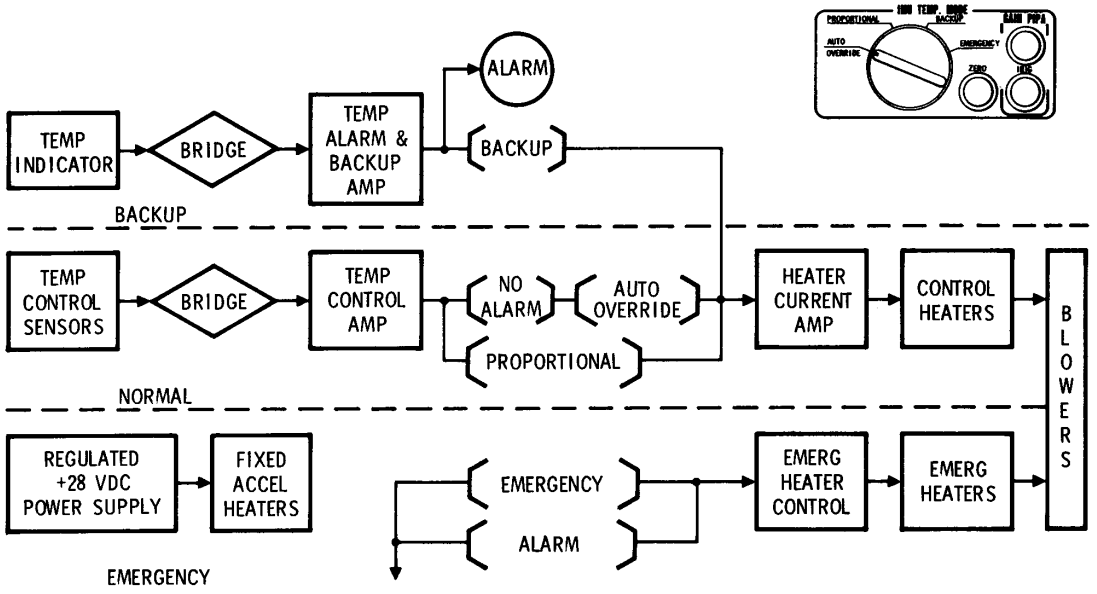
GN-9039A

FORCED CONVECTION IN IMU



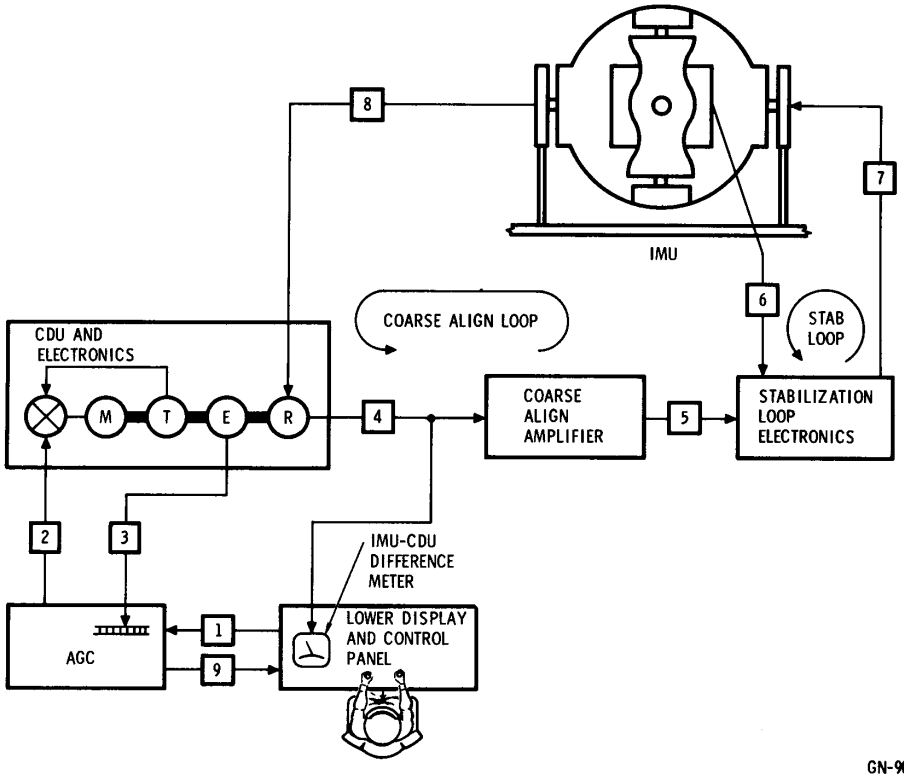
GN-9033

IMU TEMPERATURE CONTROL



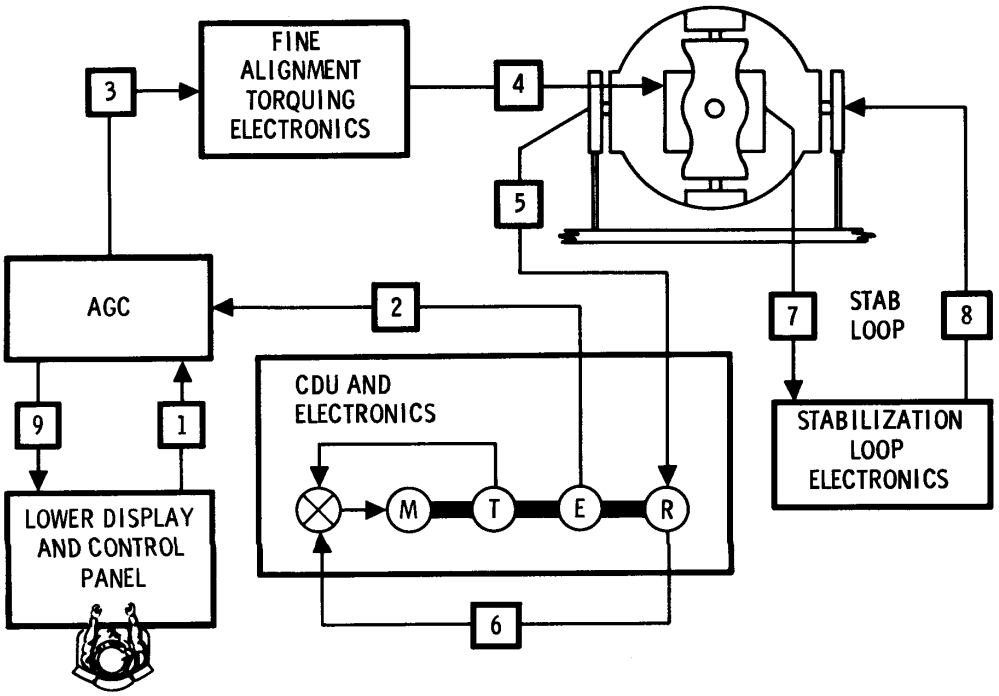
GN-219

COARSE ALIGN



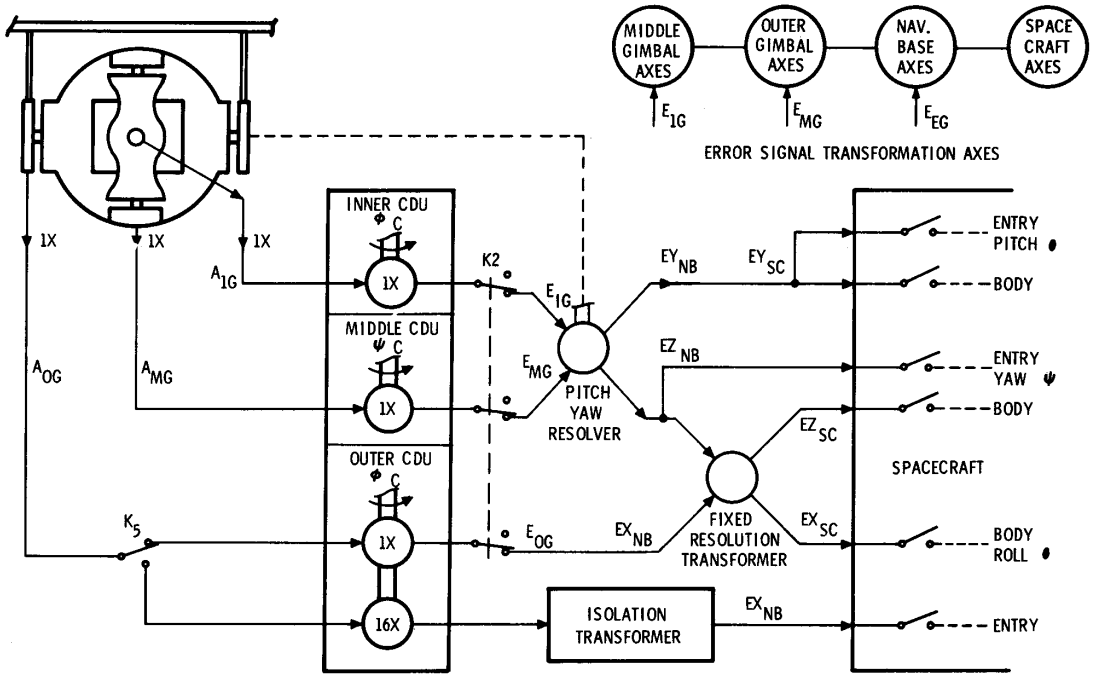
GN-9099A

FINE ALIGN



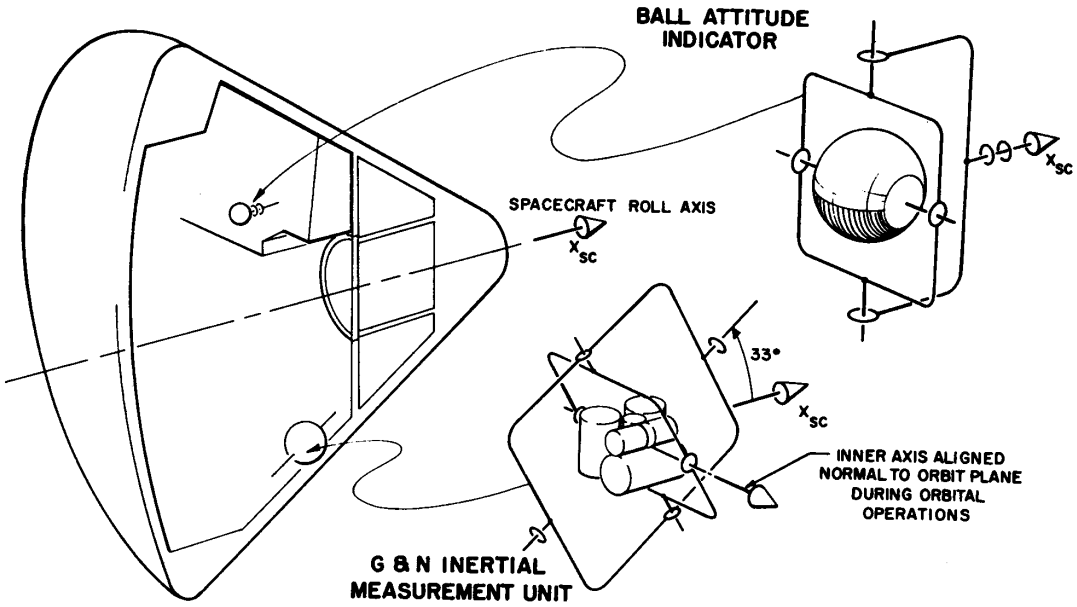
GN-9104

ATTITUDE ERROR TRANSFORMATION

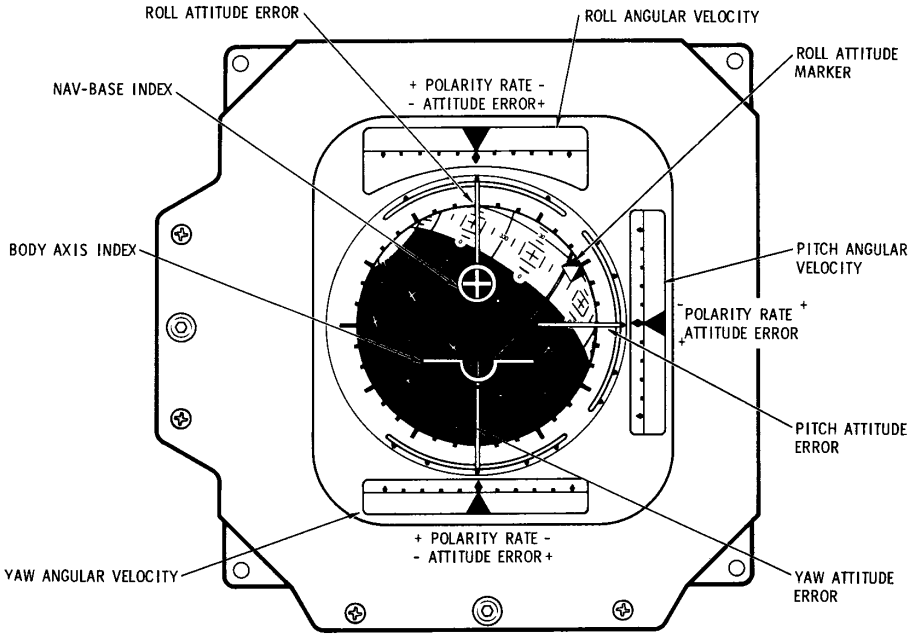


GN-9144A

RELATIONSHIP OF BALL INDICATOR AND IMU



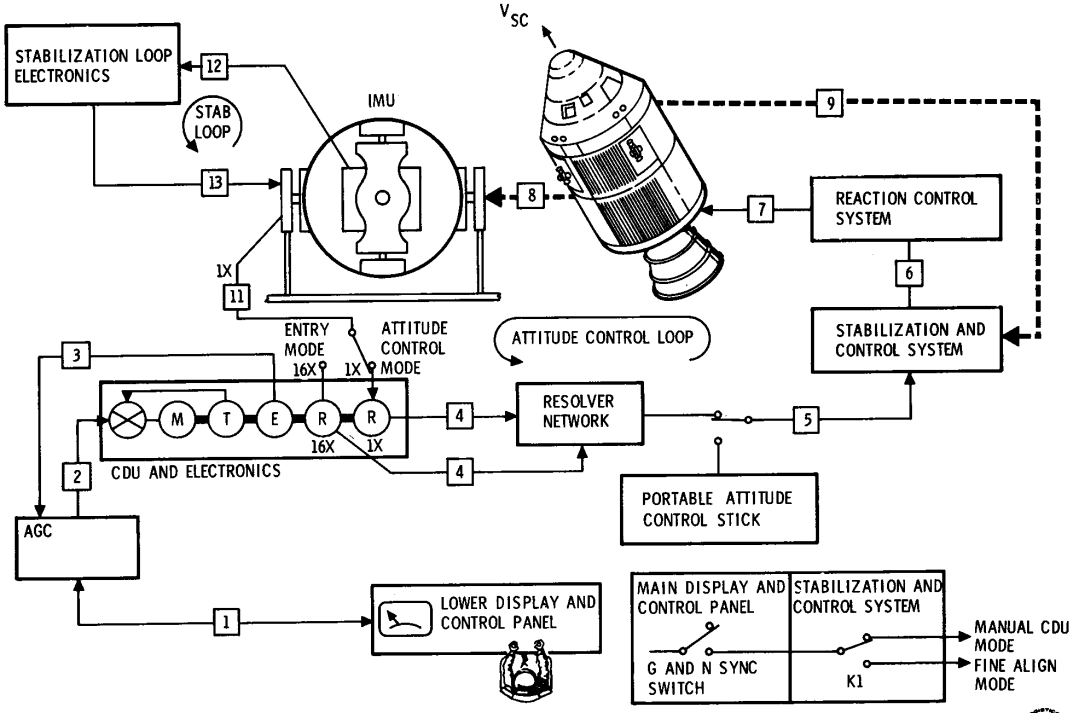
FLIGHT DIRECTOR ATTITUDE INDICATOR



NOTES:
1. ATTITUDE ERROR = ATTITUDE DESIRED - ACTUAL ATTITUDE.
2. THE BALL IS OF THE INSIDE-OUT CONVENTION.
3. EULER ANGLE CONVENTION IS PITCH, YAW, ROLL.
4. THE BALL ATTITUDE SHOWN IS PITCH 345°, YAW 335°, AND ROLL 300°, WITH RESPECT TO THE NAVIGATION BASE INDEX.

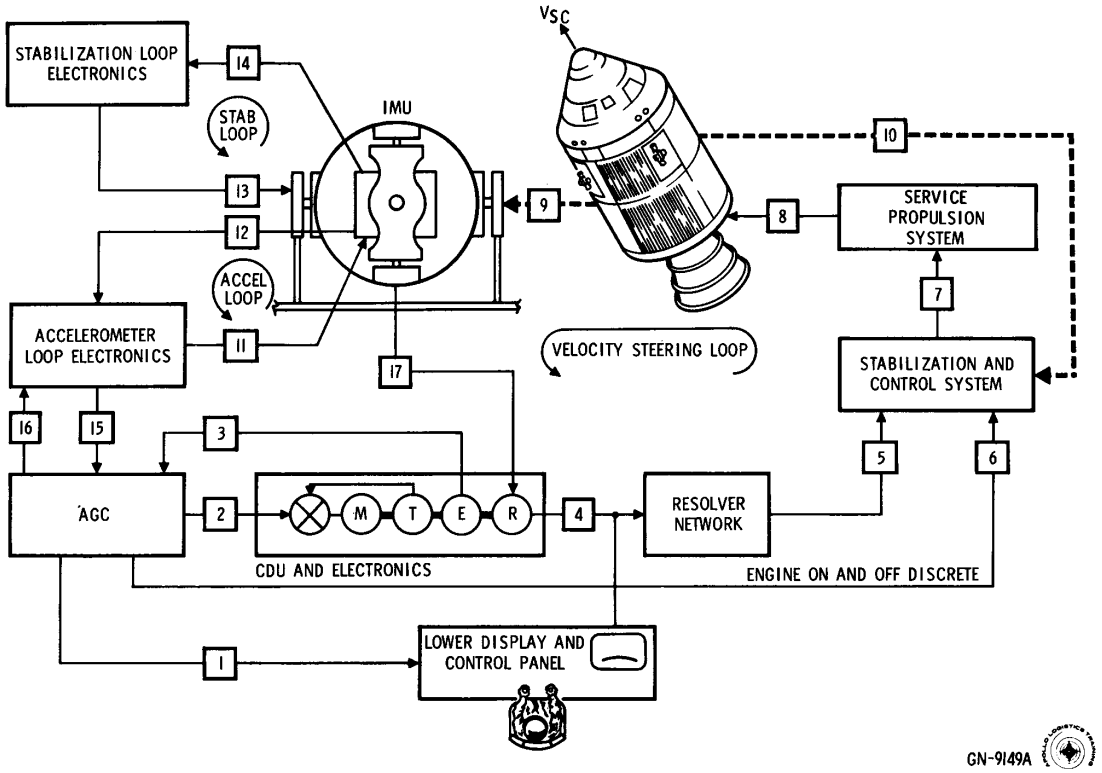
SCS-100B

SPACECRAFT ATTITUDE CONTROL



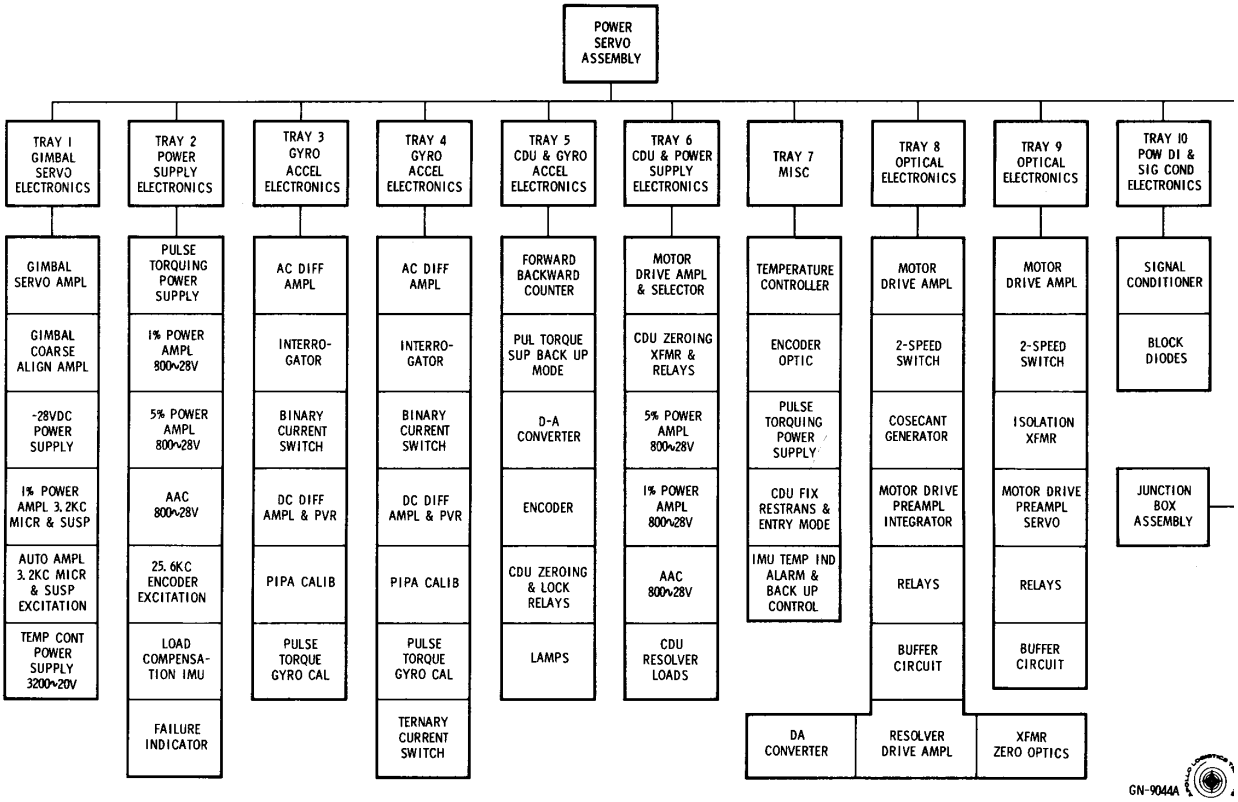
GN-9150A

SPACECRAFT THRUST VECTOR CONTROL



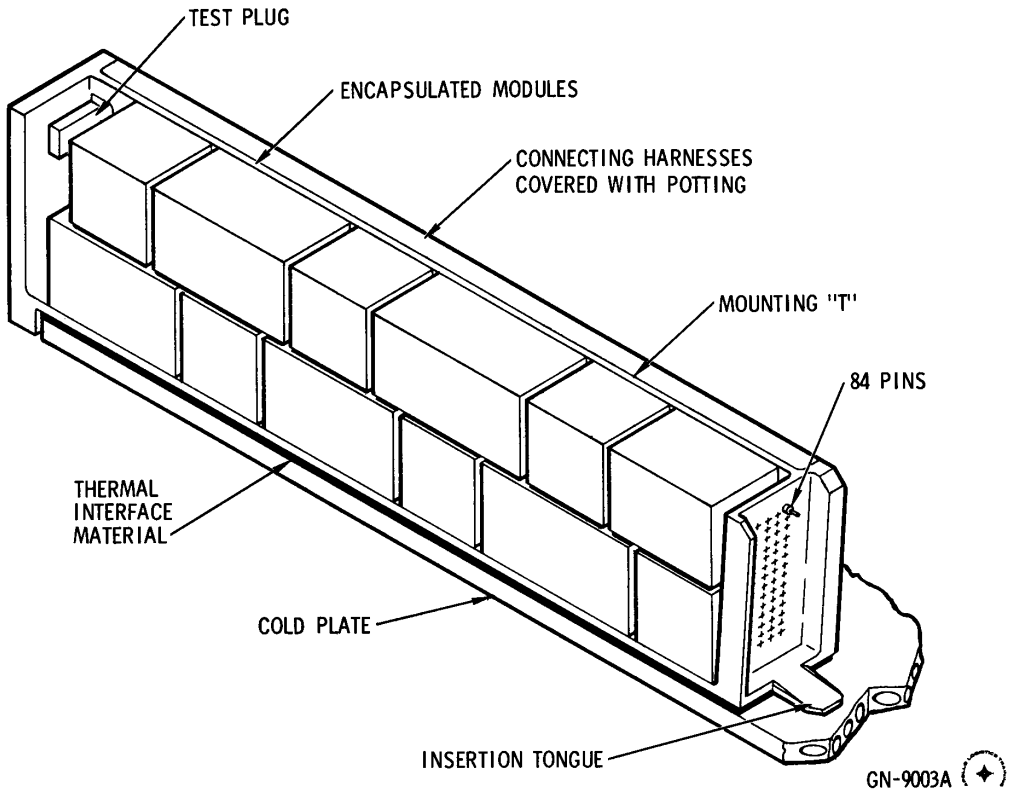
GN-9149A

PSA FAMILY TREE



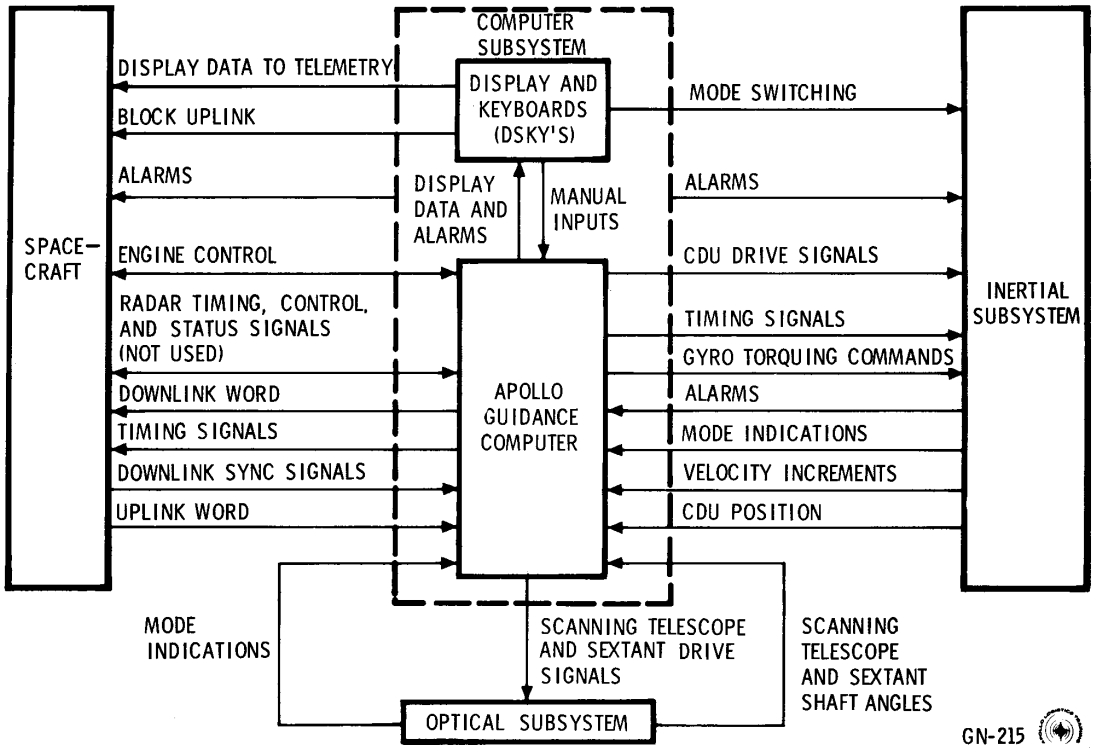
GN-9044A

PSA TRAY

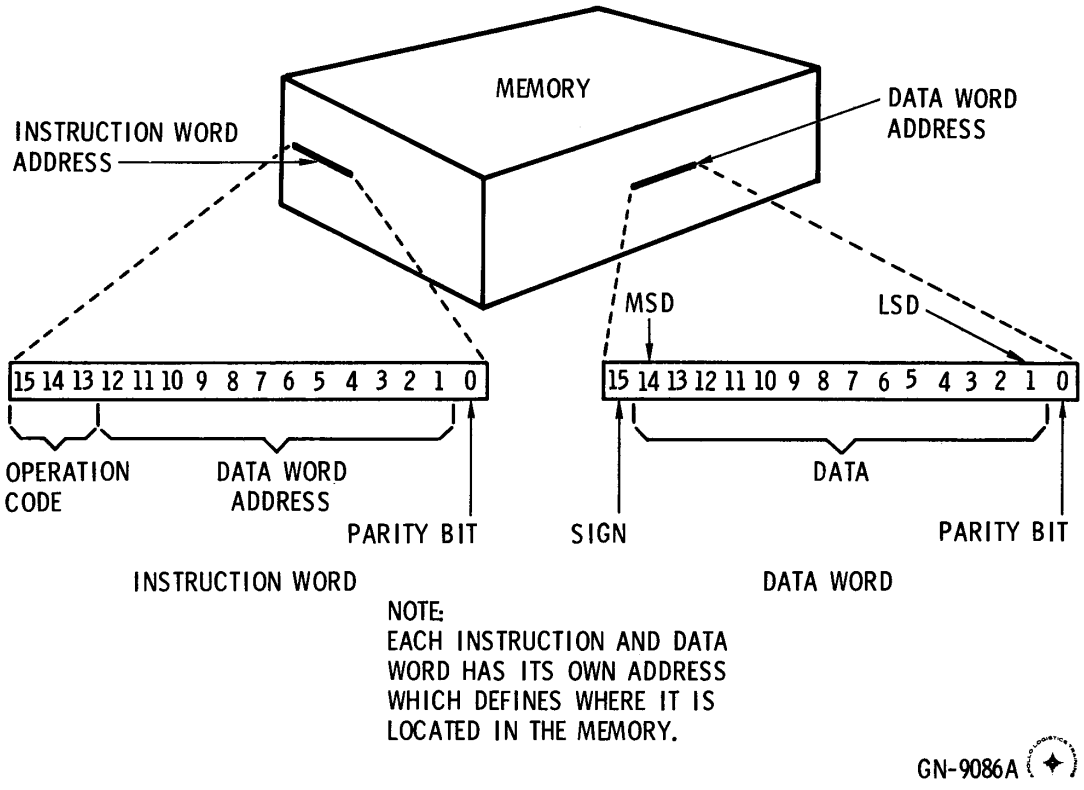


COMPUTER SUBSYSTEM

COMPUTER SUBSYSTEM, GENERAL INTERFACE



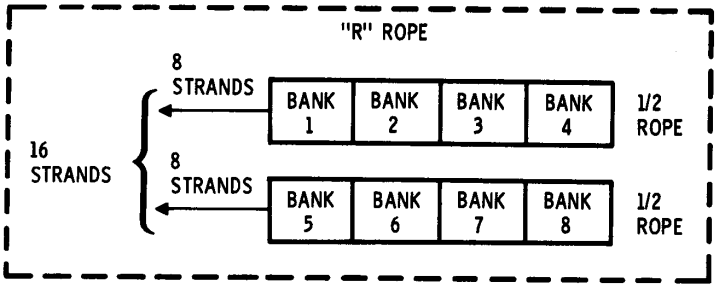
AGC WORD FORMAT



NOTE:
EACH INSTRUCTION AND DATA WORD HAS ITS OWN ADDRESS WHICH DEFINES WHERE IT IS LOCATED IN THE MEMORY.

GN-9086A

FIXED MEMORY ORGANIZATION



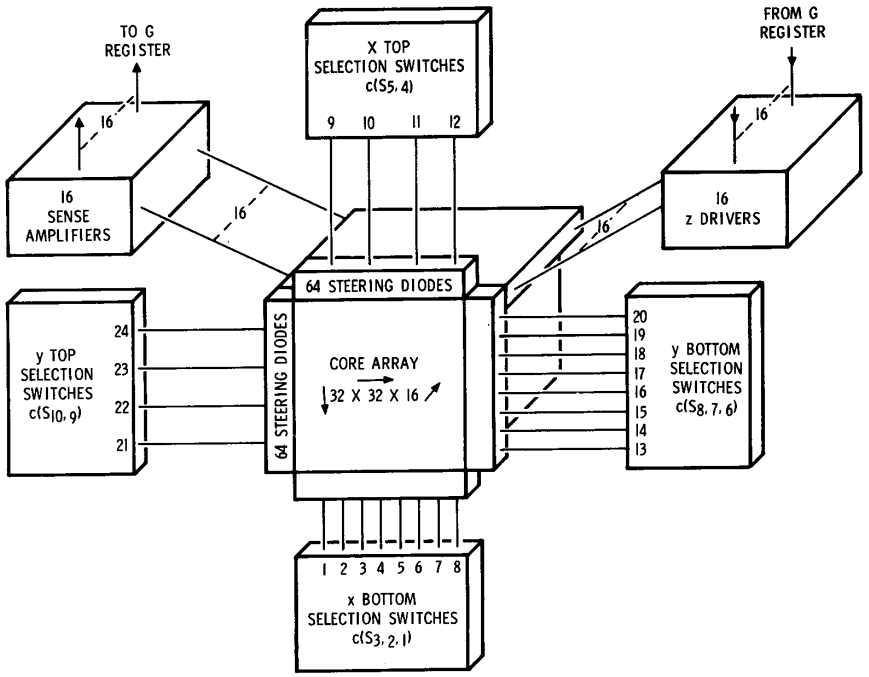
TOTAL WORDS - 24,576
TOTAL CORES - 3,072
1 ROPE - 8,192 WORDS
- 8 BANKS
- 128 SENSE LINES
- 16 STRANDS
1 BANK - 128 CORES
-1024 WORDS
1 CORE - 8 WORDS

WORD SELECTION

1. SELECT 1 OF 3 ROPES (8,192 WDS OF 24,576 WDS)
2. SELECT 2 OF 8 BANKS (2,048 WDS OF 8,192 WDS)
3. SELECT 2 OF 256 CORES (16 WDS OF 2,048 WDS)
4. SELECT 1 OF 16 STRANDS (1 WD OF 16 WDS)

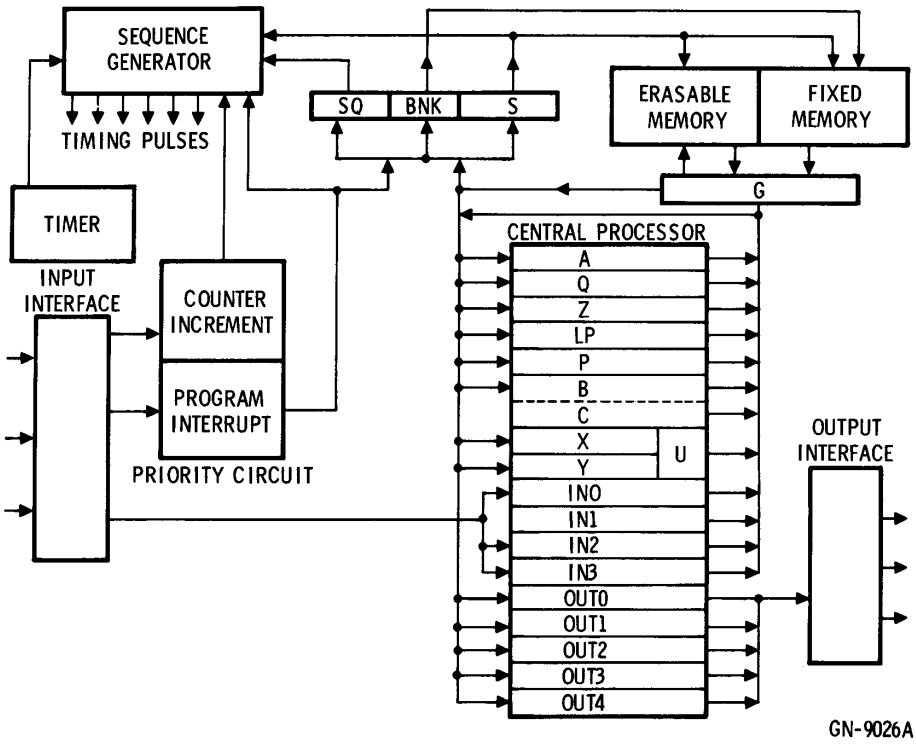
GN-9021B

ADDRESSING, READING, AND WRITING INTO CORE ARRAY

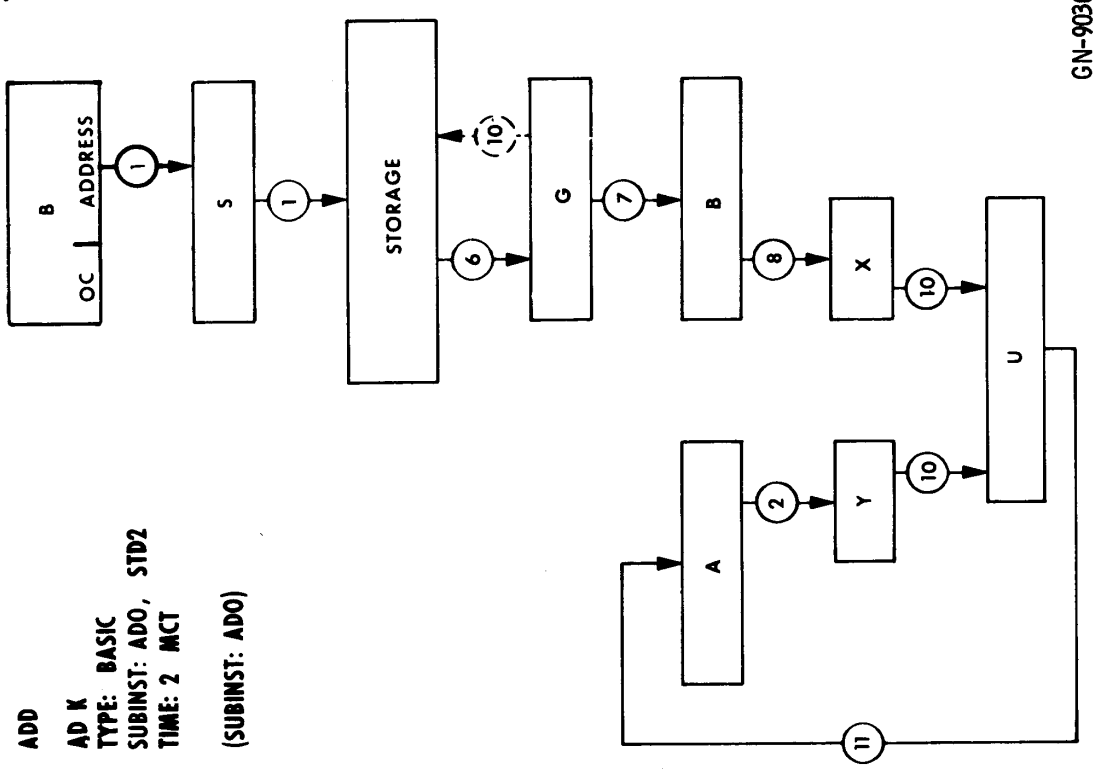


GN-9020A

AGC GENERAL BLOCK DIAGRAM



30



ADD

AD K

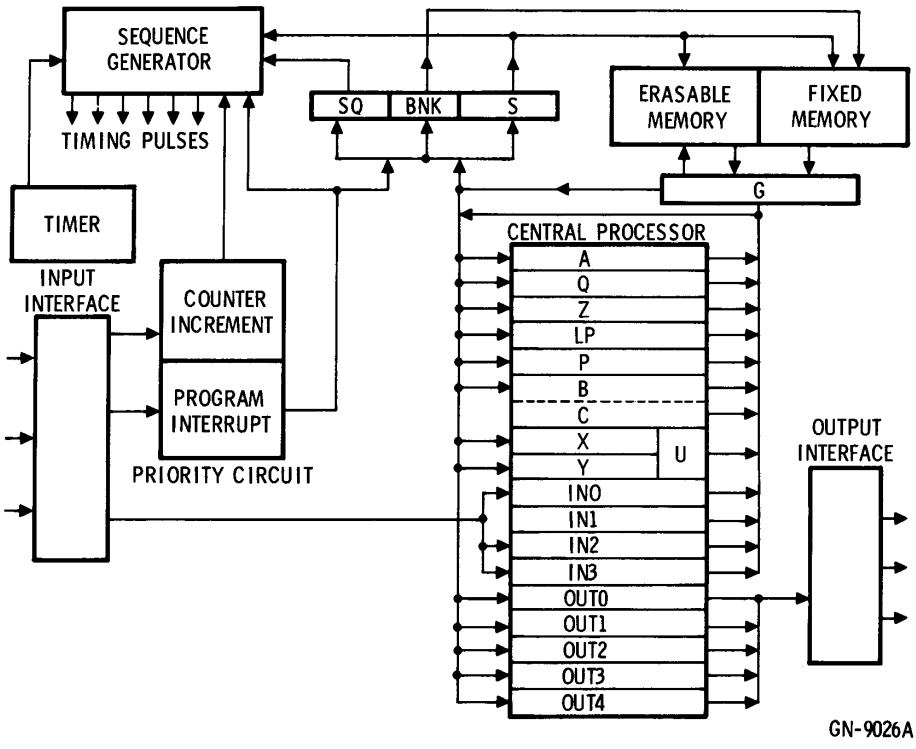
TYPE: BASIC

SUBINST: ADO, STD2

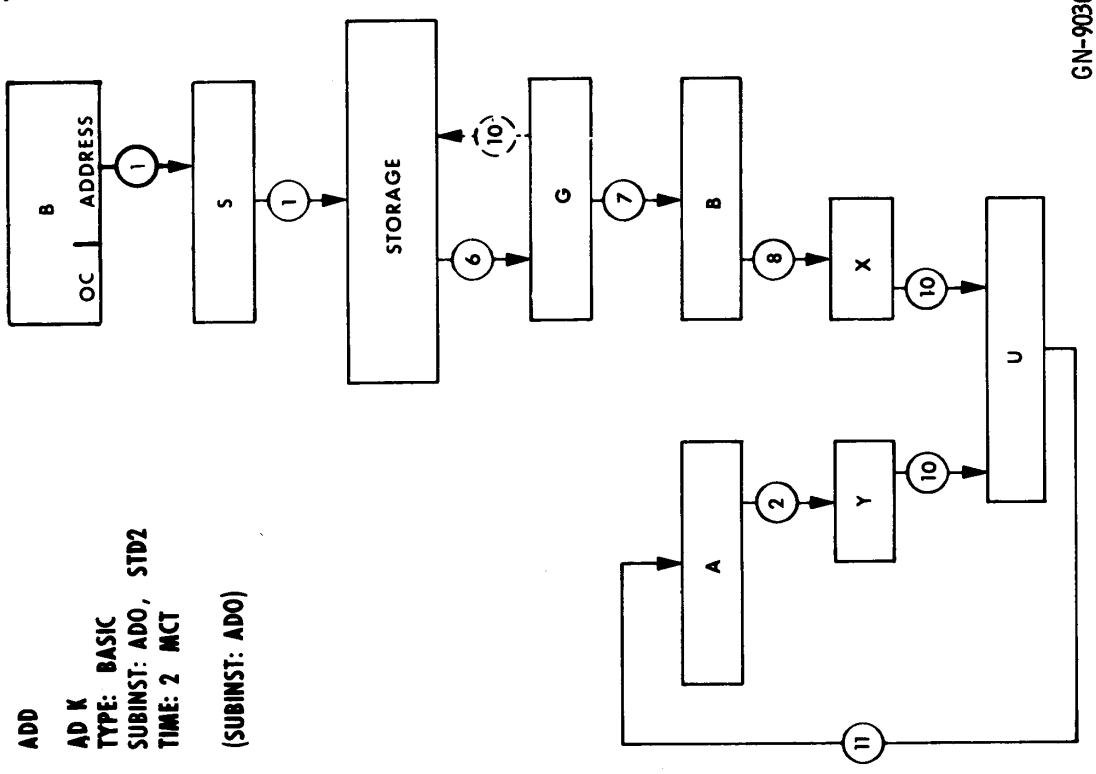
TIME: 2 MCT

(SUBINST: ADO)

AGC GENERAL BLOCK DIAGRAM



30



ADD

AD K

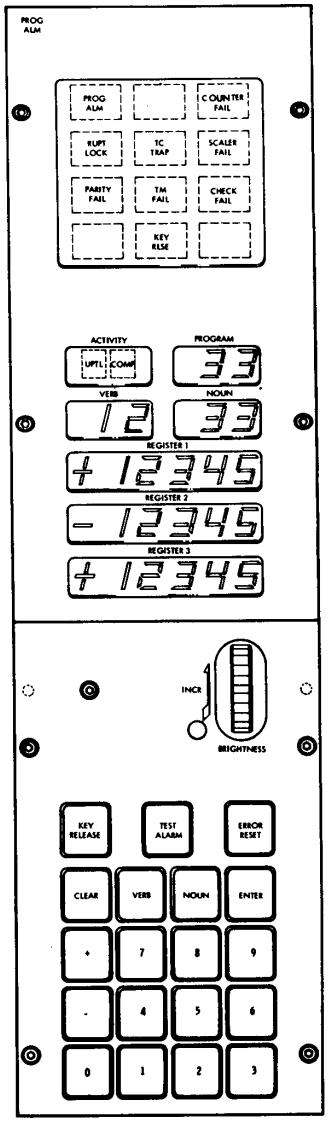
TYPE: BASIC

SUBINST: ADO, STD2

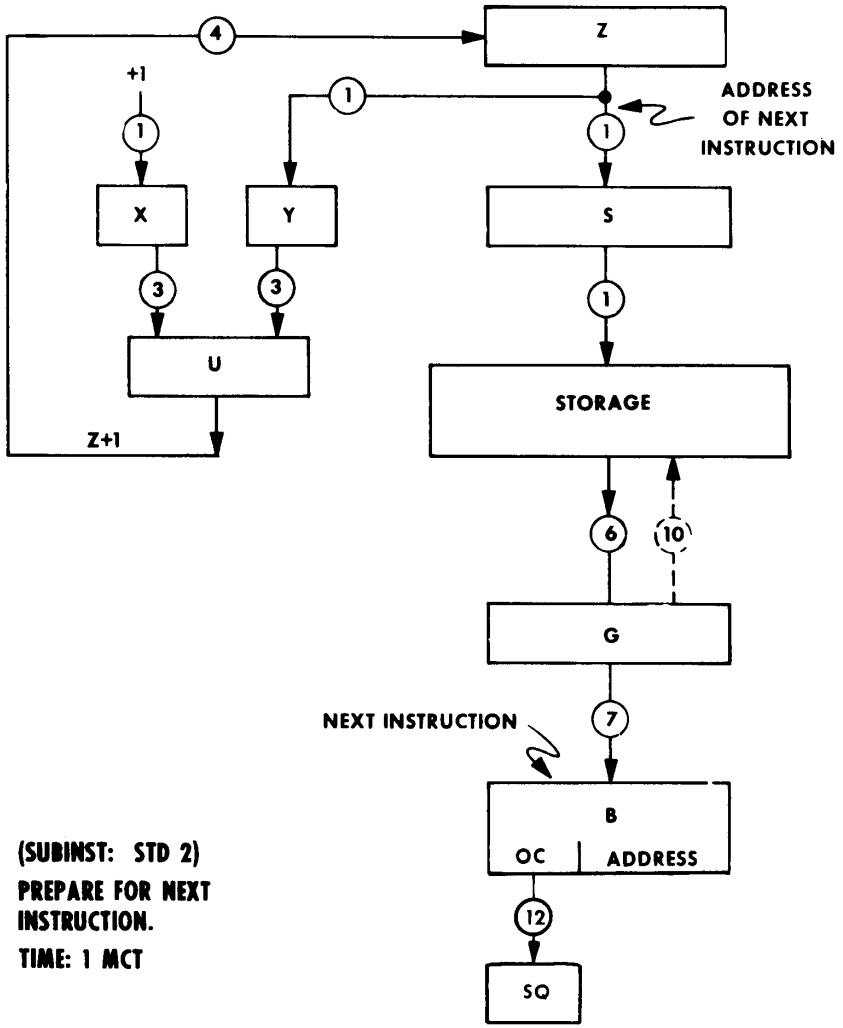
TIME: 2 MCT

(SUBINST: ADO)

AGC DISPLAY & KEYBOARD



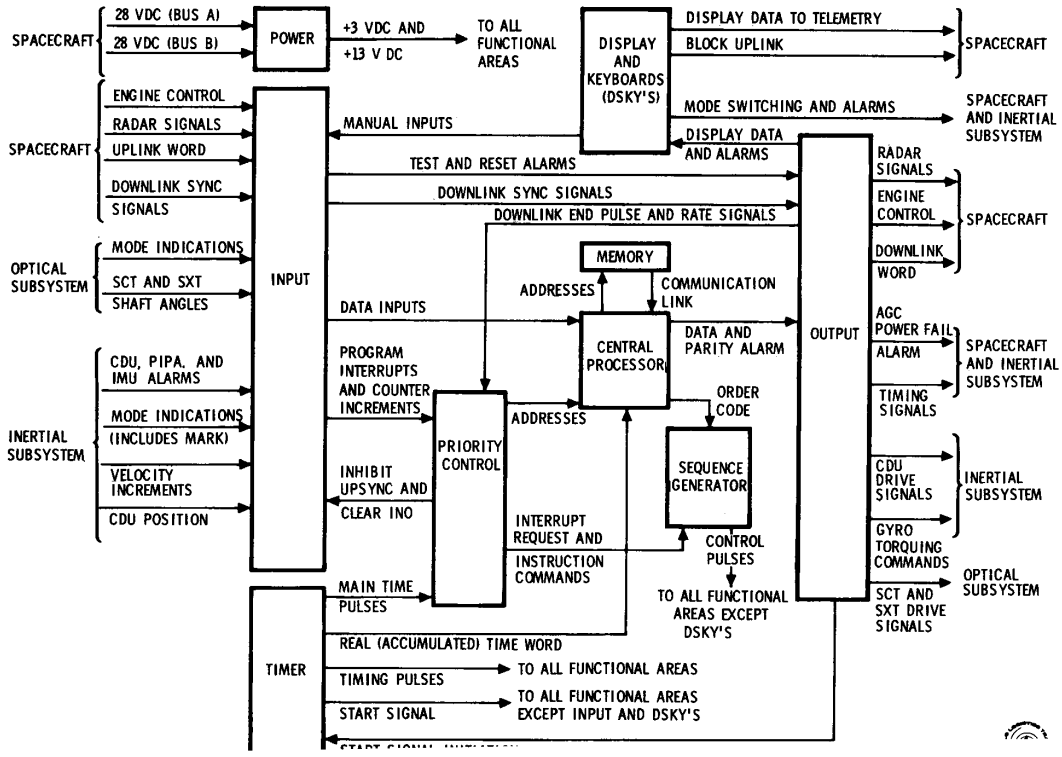
GN-1021C



(SUBINST: STD 2)
PREPARE FOR NEXT INSTRUCTION.
TIME: 1 MCT

GN-9028

COMPUTER SUBSYSTEM



GUIDANCE & NAVIGATION ABBREVIATIONS

ACSP	A.C. SPARK PLUG
ADA	ANGULAR DIFFERENTIATING ACCELEROMETER
AGC	APOLLO GUIDANCE COMPUTER
AGE	APOLLO GUIDANCE EQUIPMENT
AMR	ATLANTIC MISSILE RANGE
CDU	COUPLING DISPLAY UNIT
c.g.	CENTER OF GRAVITY
CSS	COMPUTER SUB SYSTEM
DNLK	DOWNLINK
DSPY	DISPLAY
DSKY	DISPLAY & KEYBOARD
ECS	ENVIRONMENT CONTROL SYSTEM
E/M	ERASABLE MEMORY
EOI	EARTH ORBIT INJECTION
EPS	ELECTRICAL POWER SYSTEM
FDAI	FLIGHT DIRECTOR ATTITUDE INDICATOR
F/M	FIXED MEMORY
G.C.	GIMBAL CASE
IA	INPUT AXIS
IRIG	INERTIAL REFERENCE INTEGRATING GYRO
IGA	INNER GIMBAL AXIS
IMU	INERTIAL MEASUREMENT UNIT
ISS	INERTIAL SUB SYSTEM
IU	INSTRUMENT UNIT
G&N	GUIDANCE & NAVIGATION
KYBD	KEYBOARD
LNDMK	LANDMARK
LOI	LUNAR ORBIT INJECTION
LOS	LINE OF SIGHT
LLOS	LANDMARK LINE OF SIGHT
LSB	LEAST SIGNIFICANT BIT
MGA	MIDDLE GIMBAL AXIS
MIT	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MAG AMP	MAGNETIC AMPLIFIER
MSB	MOST SIGNIFICANT BIT
M&DV	MAP & DATA VIEWER
NVB OR NB	NAVIGATION BASE
OGA	OUTER GIMBAL AXIS
OA	OUTPUT AXIS
OSS	OPTICAL SUB SYSTEM
PIP OR PIPA	PULSED INTEGRATING PENDULOUS ACCELEROMETER
PSA	POWER SERVO ASSEMBLY
PRA	PENDULOSITY REFERENCE AXIS
RCS	REACTION CONTROL SYSTEM
RSVR	RESOLVER
SA	SPIN AXIS
S/C	SPACECRAFT
SLOS	STAR LINE OF SIGHT
SCT	SCANNING TELESCOPE
SCS	STABILIZATION & CONTROL SYSTEM
SDOF	SINGLE DEGREE OF FREEDOM
SM	STABLE MEMBER
SRA	SPIN REFERENCE AXIS
SPS	SERVICE PROPULSION SYSTEM
SXT	SPACE SEXTANT

TEI	TRANS EARTH INJECTION
TACH	TACHOMETER
TLI	TRANS LUNAR INJECTION
TRKR	TRACKER
TVC	THRUST VECTOR CONTROL
T/M	TELEMETRY
UPLK	UPDATE LINK
V OR DELTA V	CHANGE IN VELOCITY