



APOLLO TRAINING

GUIDANCE AND CONTROL
SYSTEMS - BLOCK II

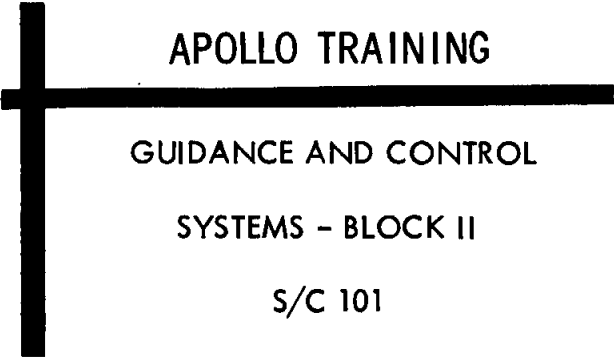
S/C 101

15 SEPTEMBER 1967

FOR TRAINING PURPOSES ONLY



30X 015-01



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QUESTIONS RELATIVE TO THE CONTENTS OF THIS
DOCUMENT SHOULD BE DIRECTED TO:

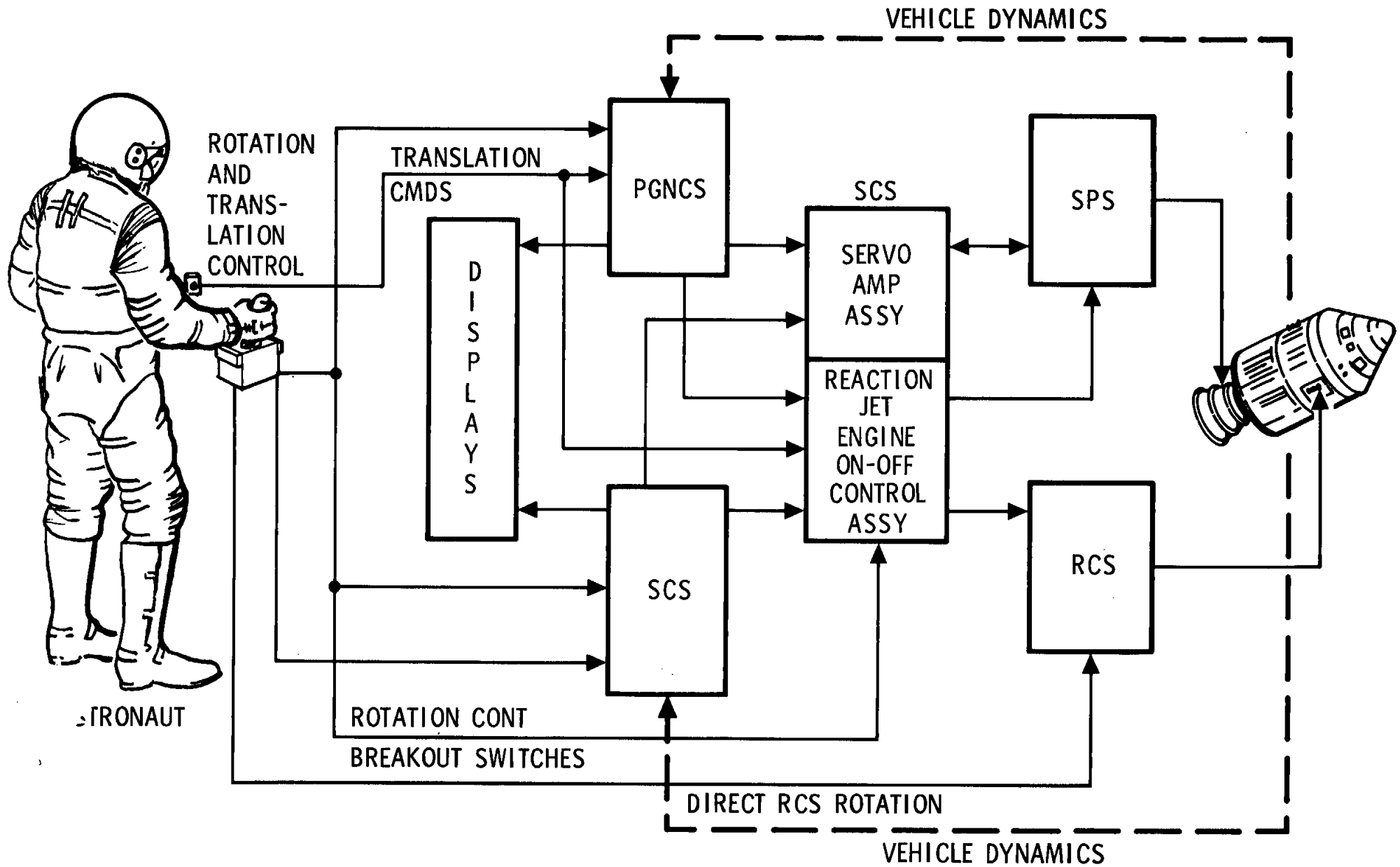
D.P. BENNETT
A.R. PAYNE
W.O. RUFFIN
A.H. SOHLER

NAA, SD
DOWNEY, CALIFORNIA
Extension 4325,6, or 7

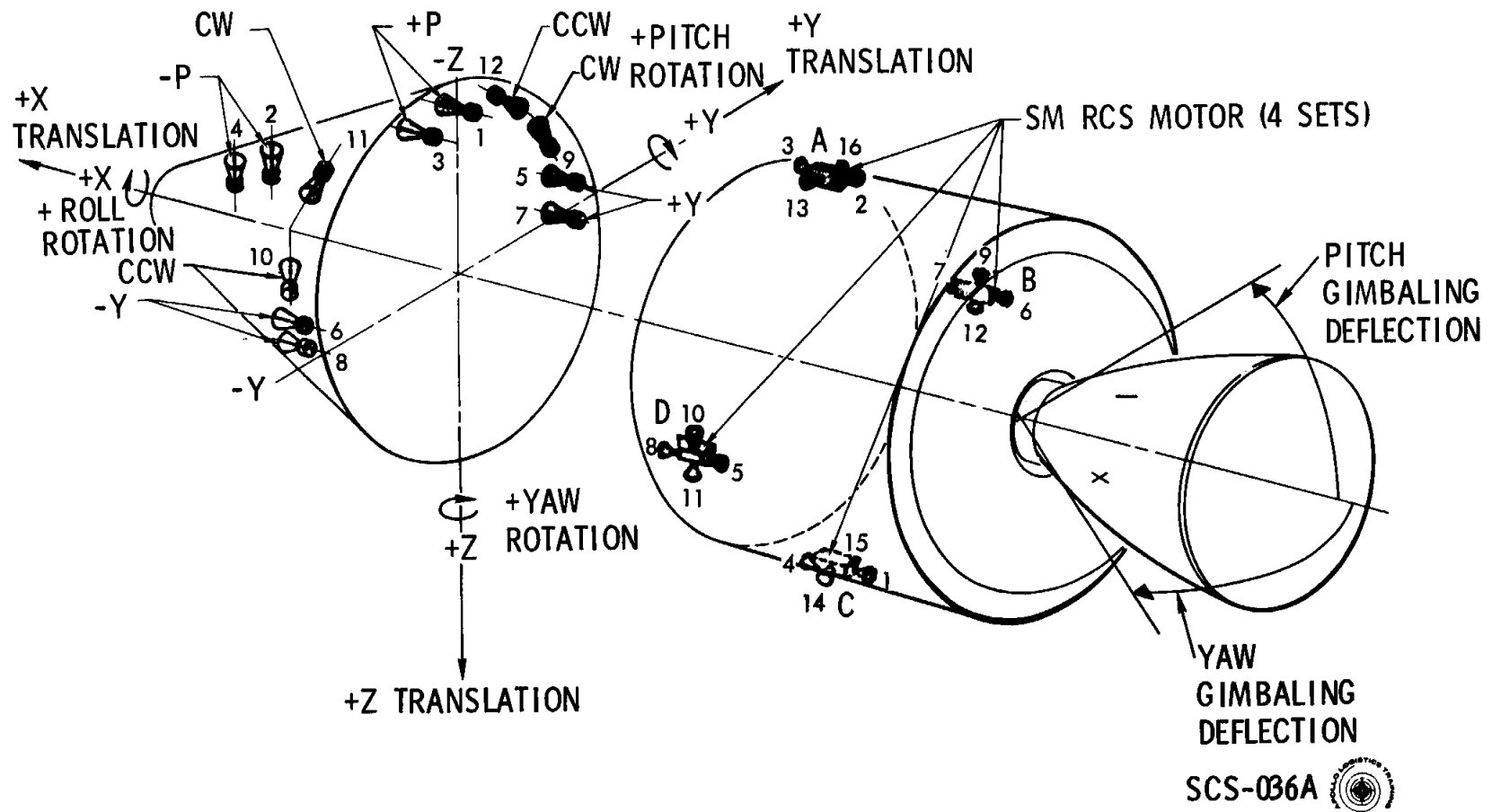
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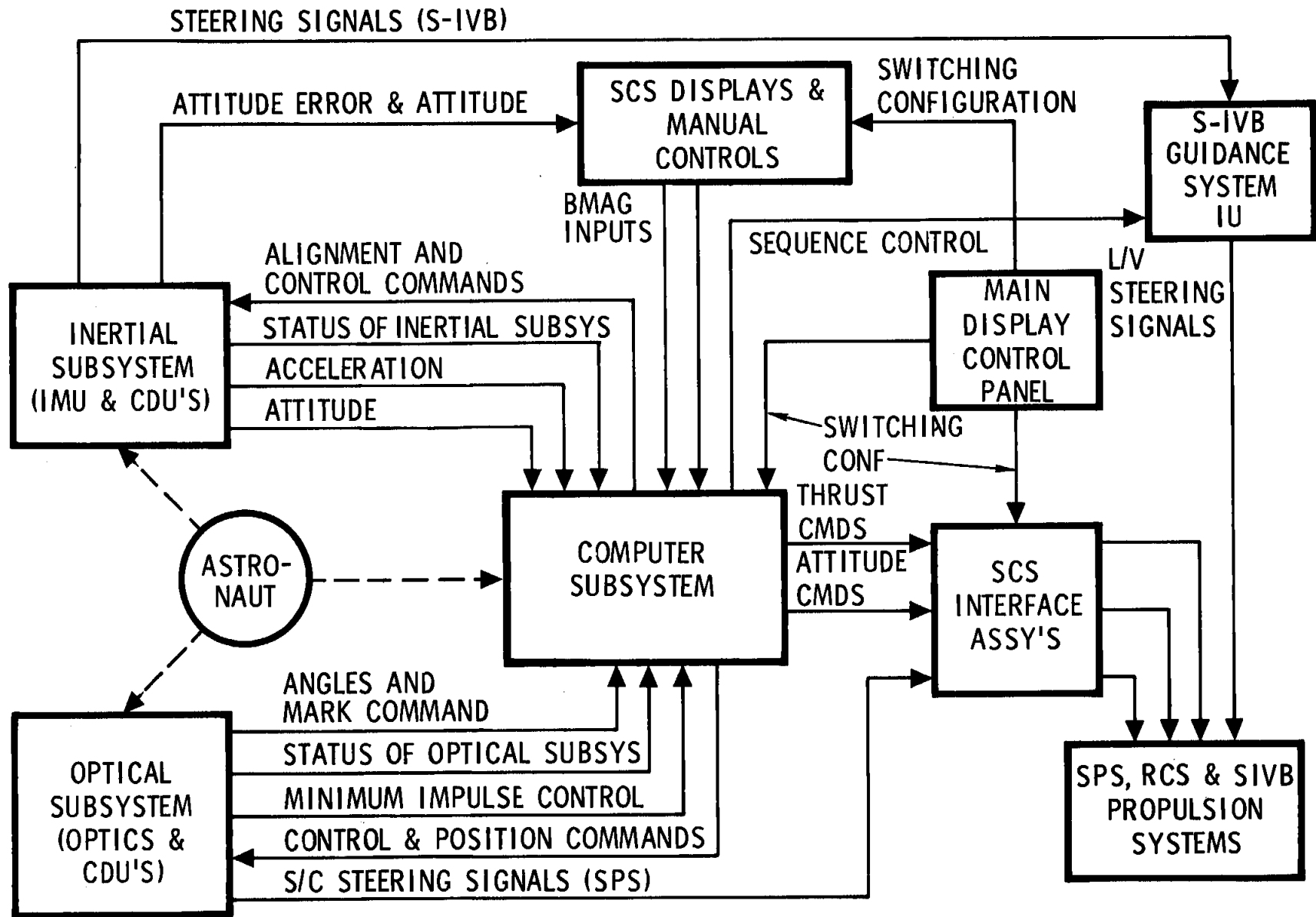
CSM GUIDANCE & CONTROL




PROPULSION TORQUE AND FORCE INPUTS TO THE S/C

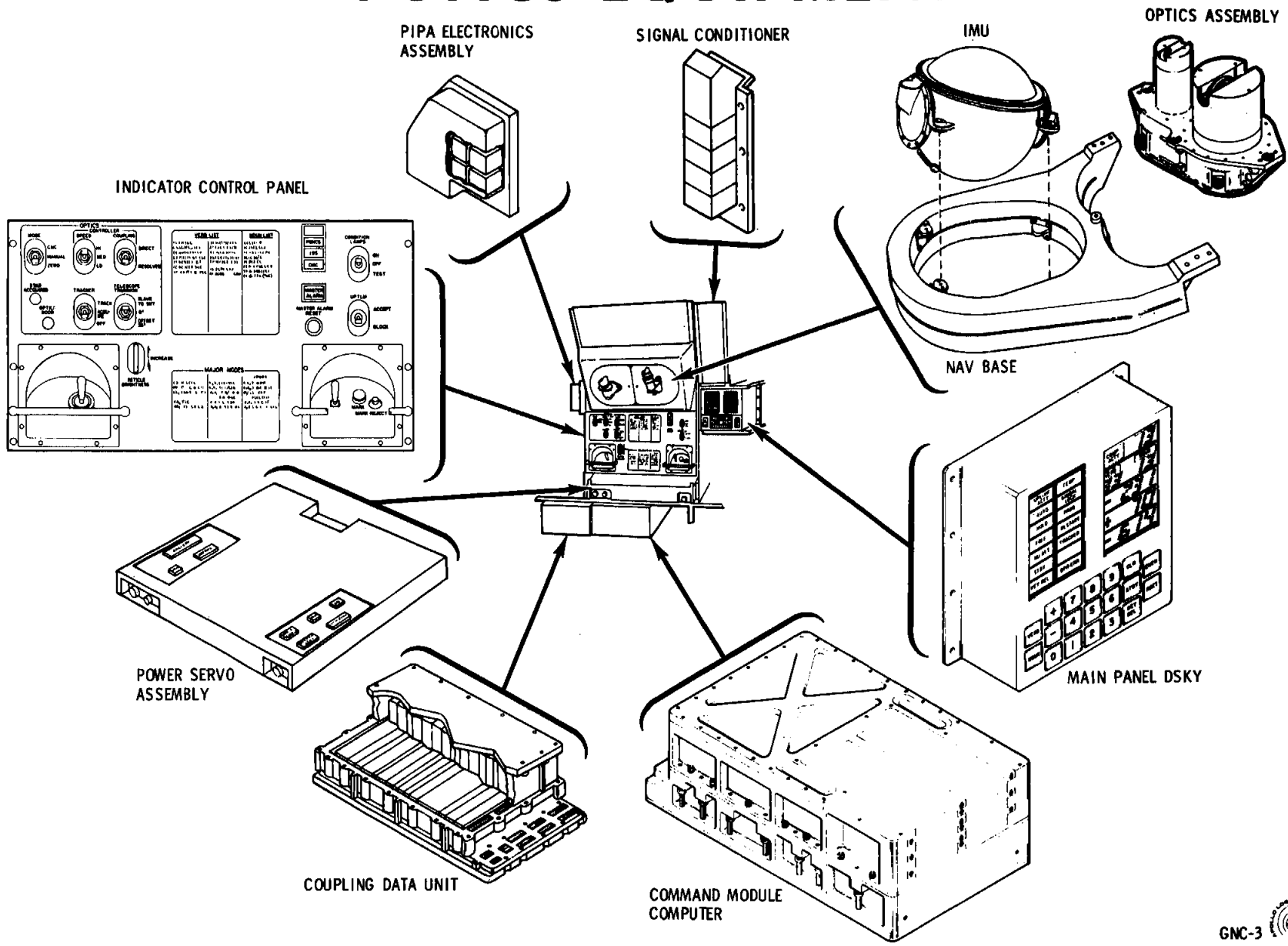


PGNCS DATA FLOW



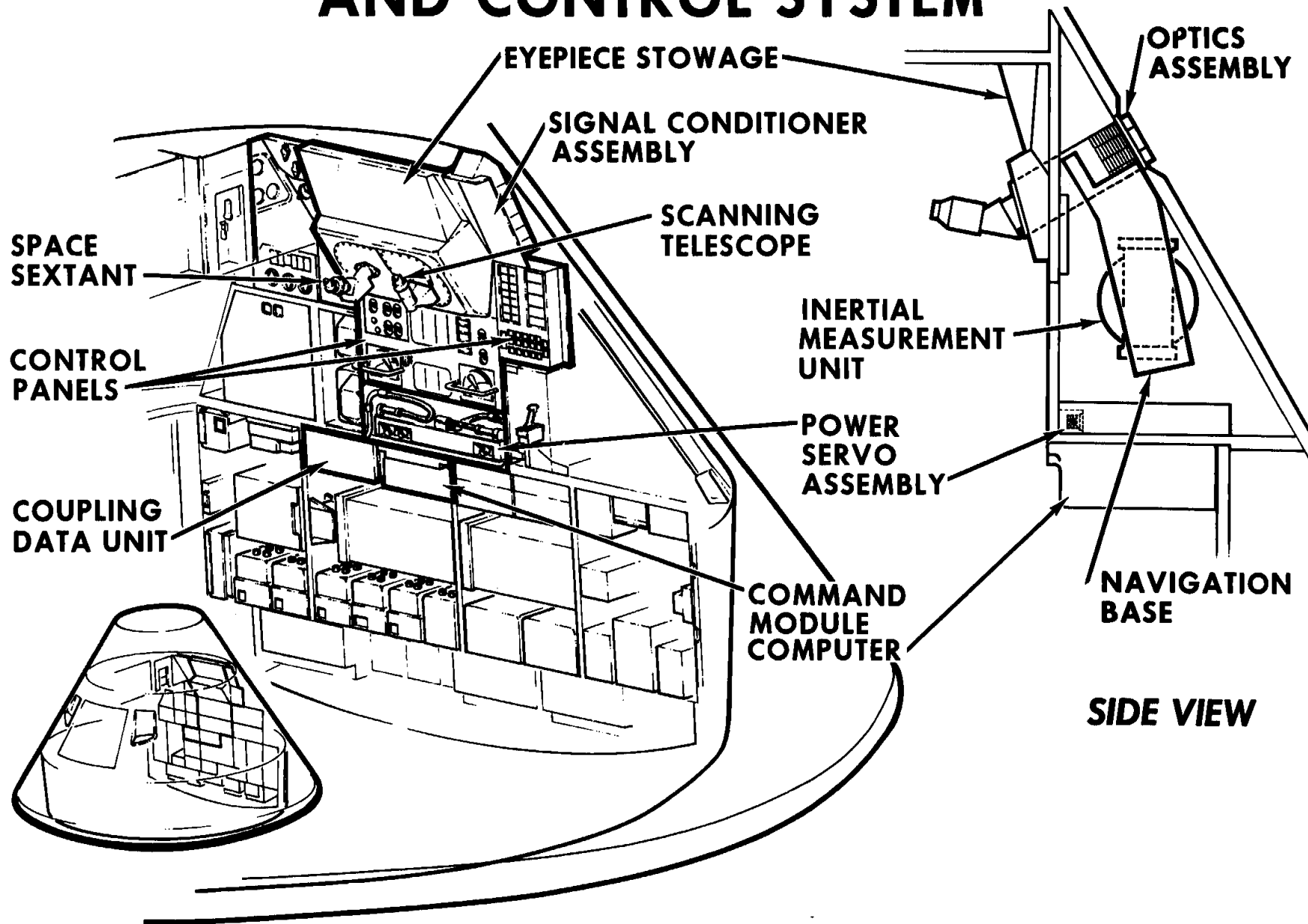
GNC-5D 

PGNCS EQUIPMENT



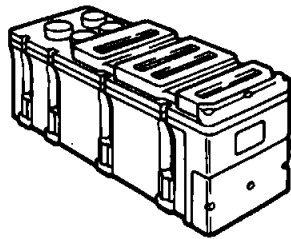
GUIDANCE, NAVIGATION, AND CONTROL SYSTEM

S86SD10793B

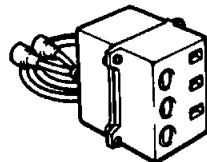


SCS FLIGHT HARDWARE

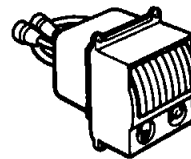
BLOCK II



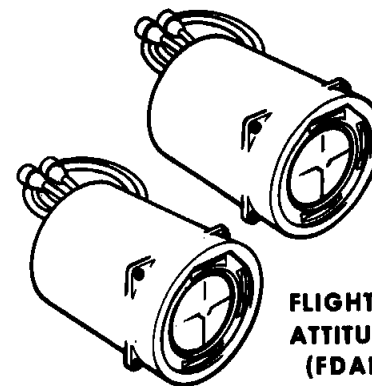
**ELECTRONIC CONTROL ASSEMBLY
(ECA)**



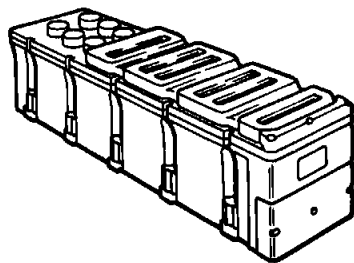
**ATTITUDE SET CONTROL PANEL
(ASCP)**



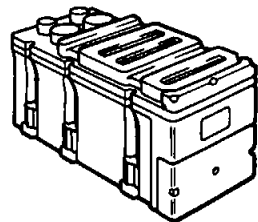
**GIMBAL POSITION/
FUEL PRESSURE INDICATOR
(GP/FPI)**



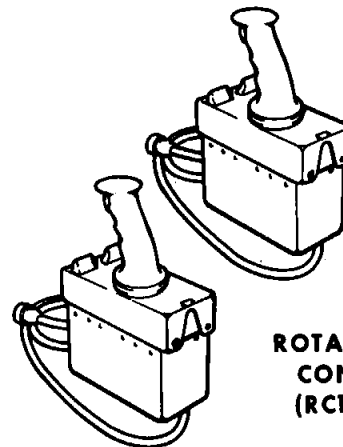
**FLIGHT DIRECTOR
ATTITUDE INDICATOR
(FDAI 1, FDAI 2)**



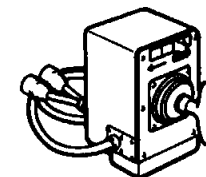
**REACTION JET AND ENGINE
ON-OFF CONTROL
(RJ/EC)**



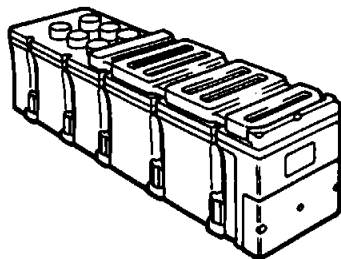
**THRUST VECTOR POSITION
SERVO AMPLIFIER
(TVSA)**



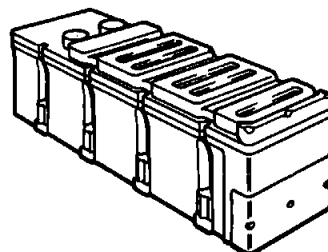
**ROTATION
CONTROL
(RC1, RC2)**



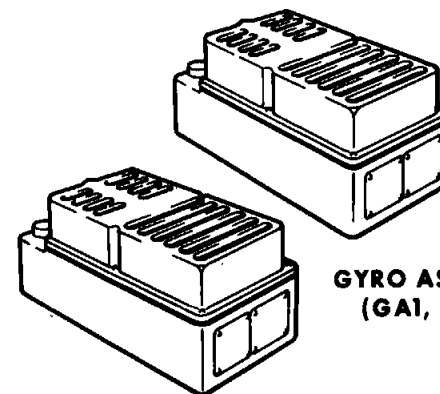
**TRANSLATION CONTROL
(TC)**



**ELECTRONIC DISPLAY ASSEMBLY
(EDA)**



**GYRO DISPLAY COUPLER
(GDC)**

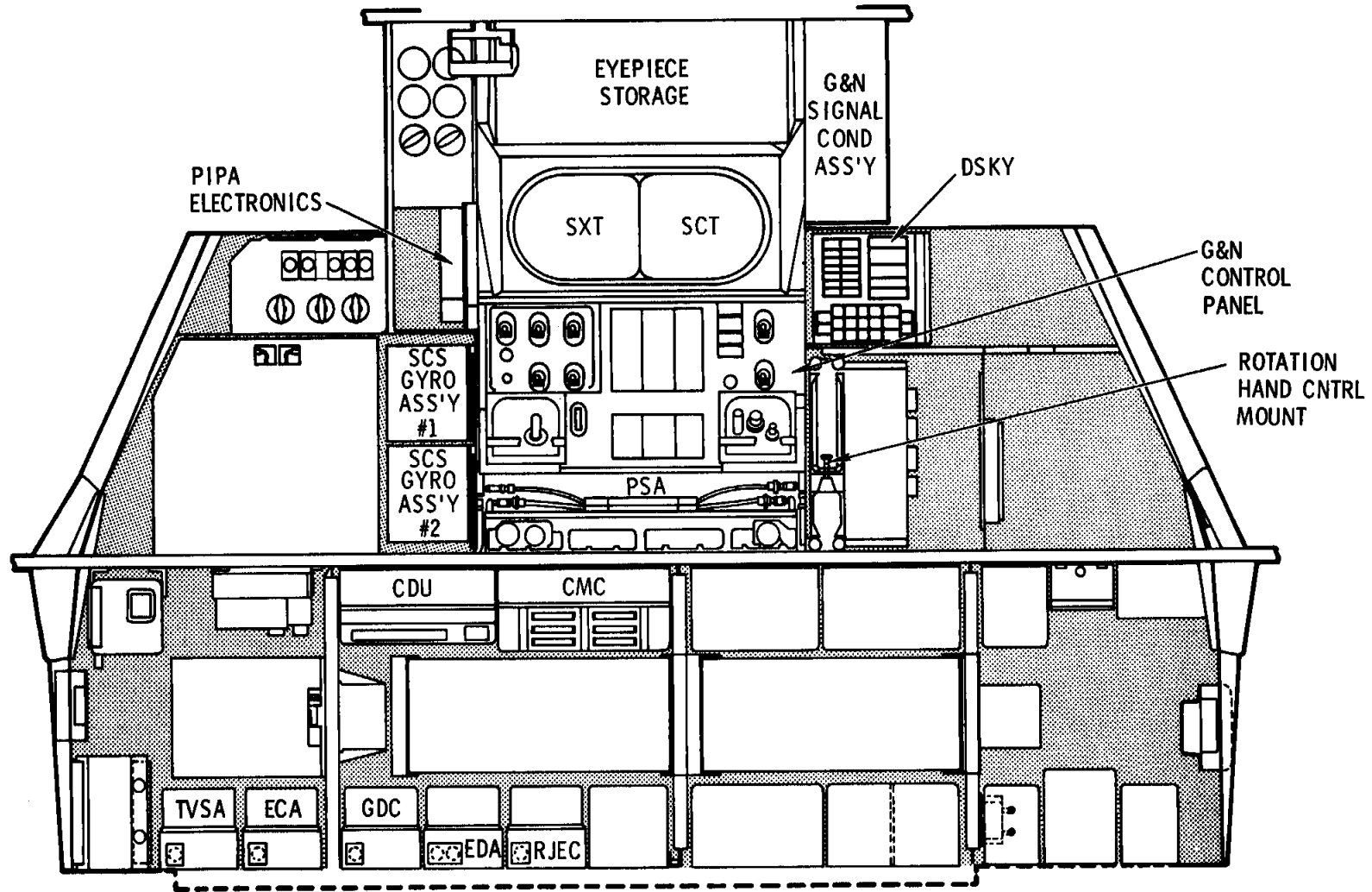


**GYRO ASSEMBLY
(GA1, GA2)**

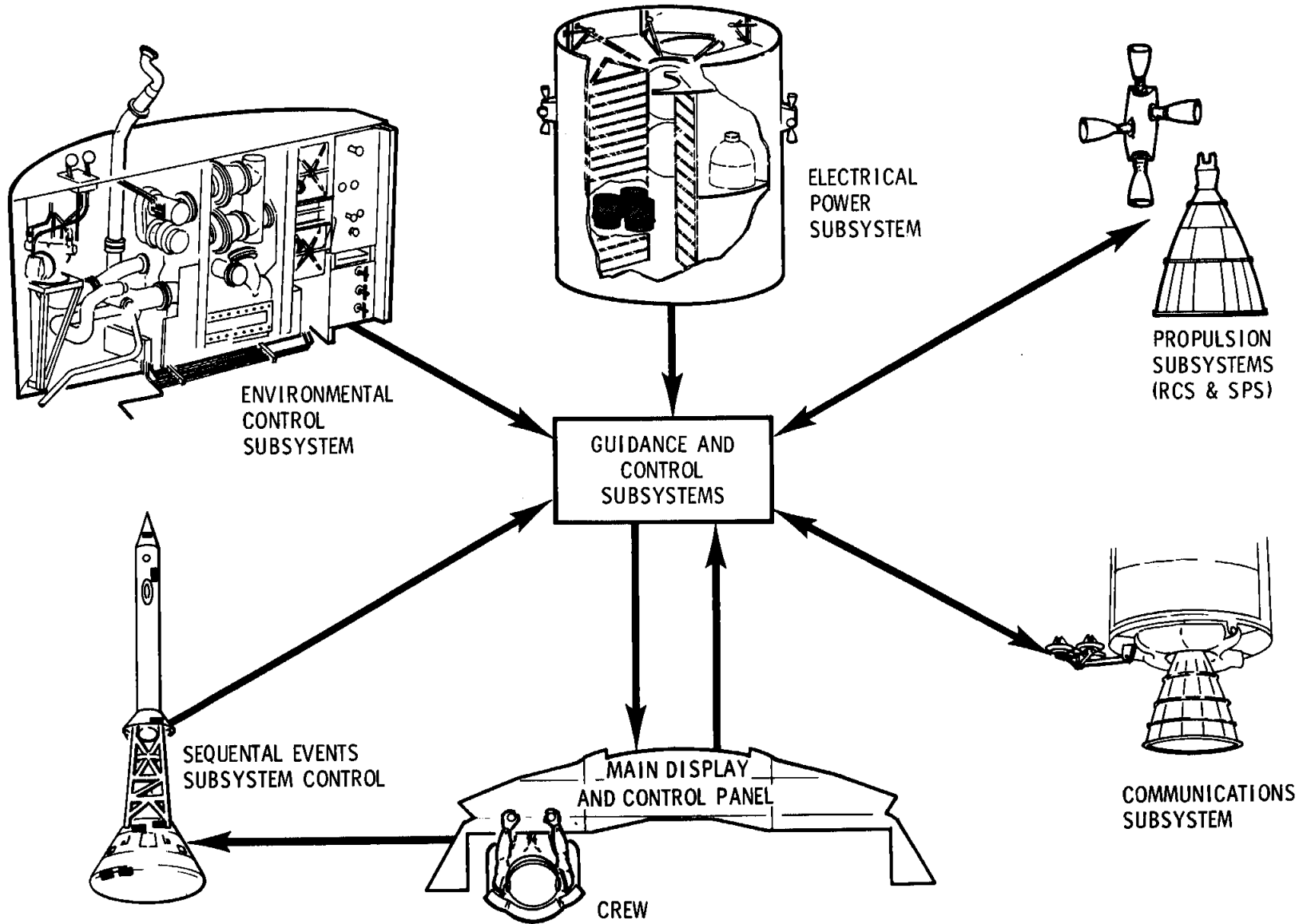
SCS-2010C



G&C EQUIPMENT LOCATION

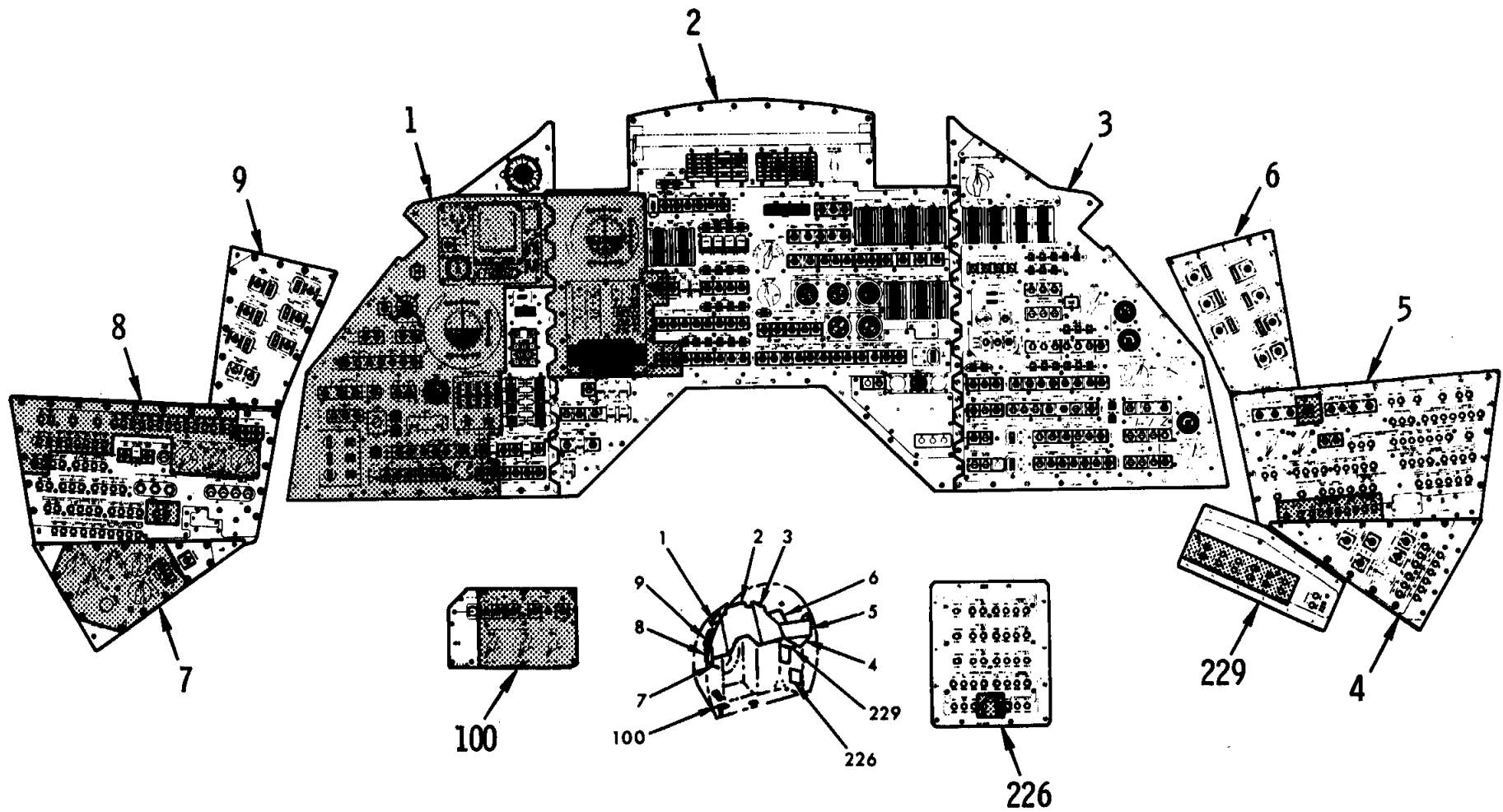


G&C AND APOLLO SUBSYSTEMS INTERFACE

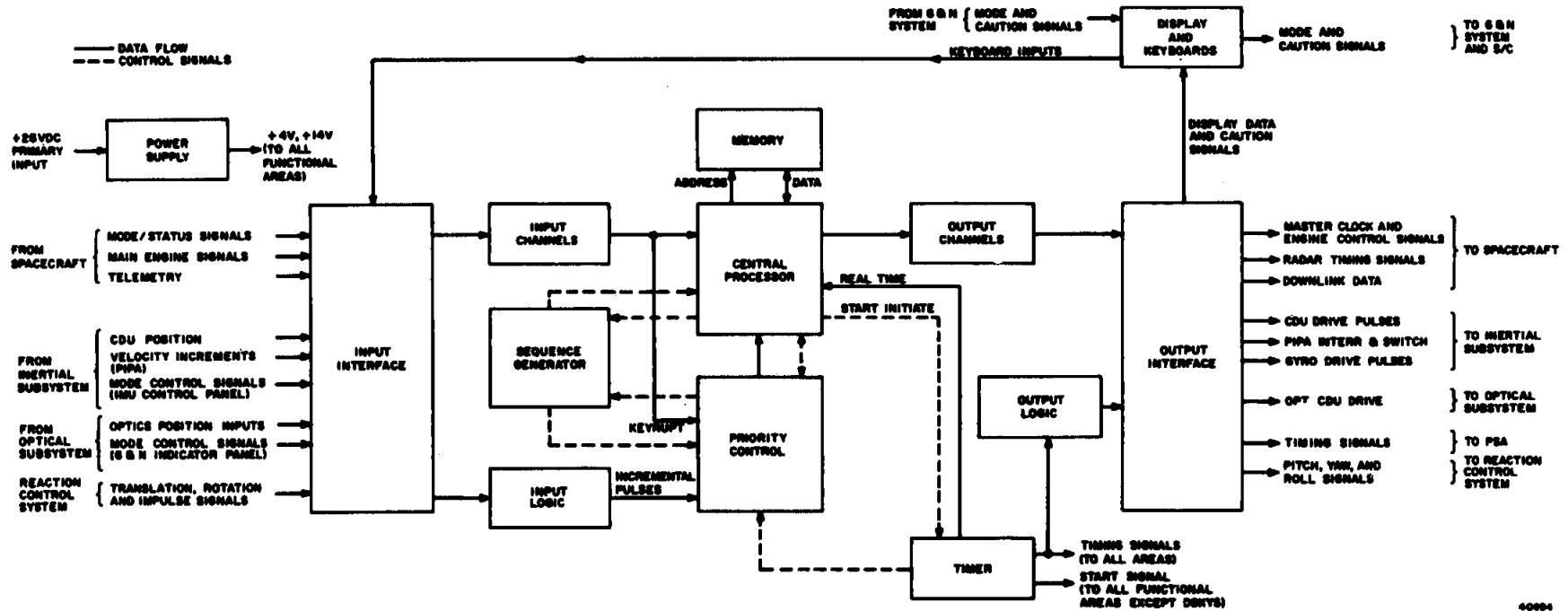


MAIN DISPLAY CONSOLE

G&C SWITCHING LOCATOR

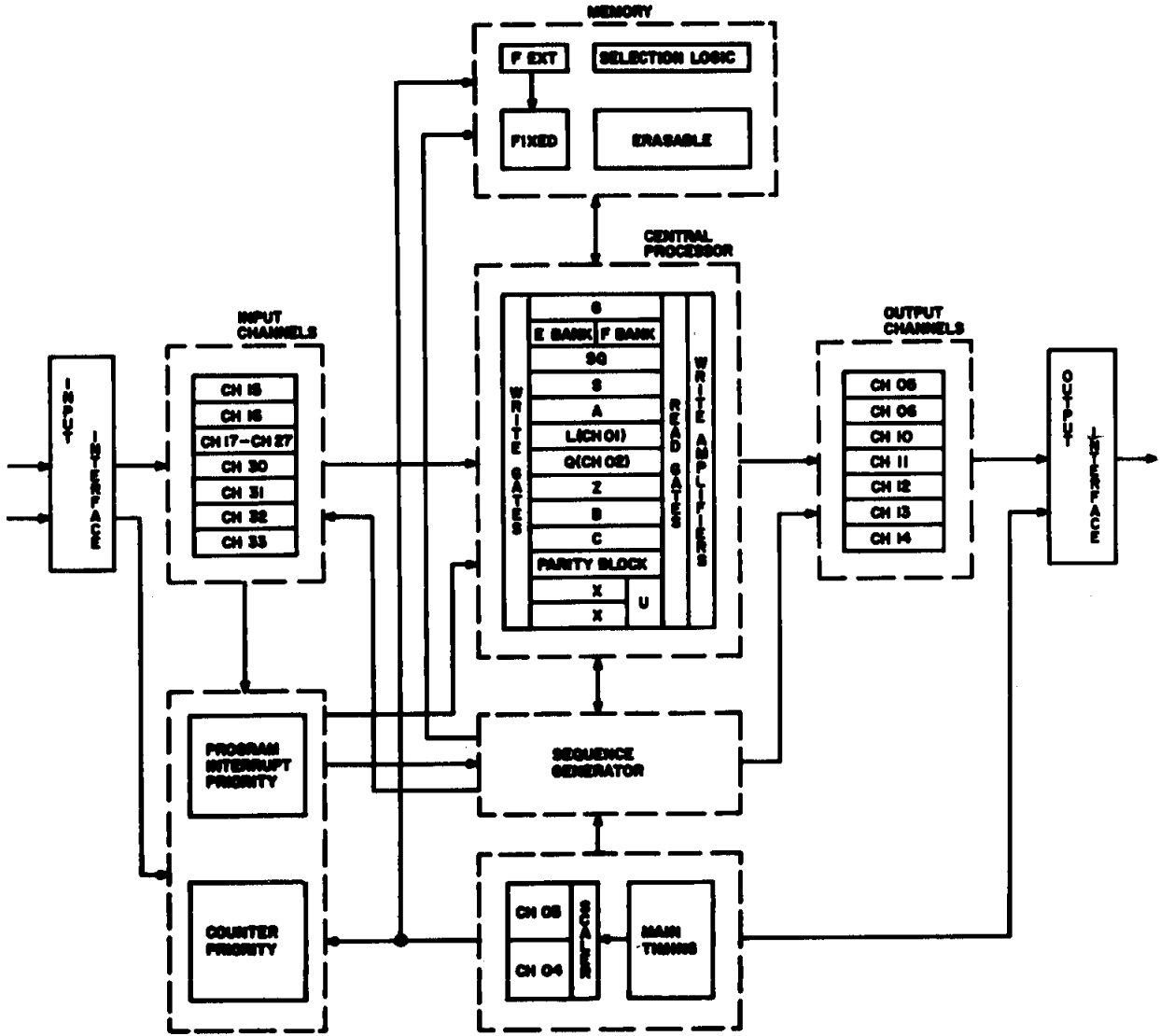


CSS BASIC FLOW



40004

CSS BASIC FLOW DIAGRAM



BIT CHANNEL	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0 (VACANT)	[Shaded]															
1	IDENTICAL TO (A) REGISTER															
2	IDENTICAL TO (Q) REGISTER															
3	HIGH 23.3 HRS MAX															
4	LOW 5.13 SEC MAX															
5 (IC1 (P&Y))	+X -Y, -YW -X +P, 10, 11, 20, 21, 30, 31, 40, 41, 5M, C.M., LEM															
6 (IC2 (ROLL))	+Y -R, -Y +R, 15, 45, 35, 25, 4F, 3F, 5M, C.M., LEM															
7 (P&R)	FIXED FE7, EXTENSION FE6, FE5, C.M., LEM															
10 ("R" RELAYS)	RELAY ADDRESS, RELAY BITS (OUTBITS, "R" RELAYS), 4, 3, 2, 1, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, C.M., LEM															
11 ("A" RELAYS)	ENGINE OFF, ENGINE ON, SPARE, SPARE, CAUTION RESET, TEST CONNECTOR OUTBIT, OPERATOR ERROR FLASH, VERT-NOUN FLASH, KEY RELEASE FLASH, TEMP CAUTION, UPLINK ACTIVITY, COMPUTER ACTIVITY, I.S.S. WARNING, C.M., LEM															
12 (GNBC)	ISS TURN-ON DELAY COMPLETE, SIVB CUTOFF, SIVB INJ SEQ START, ROLL GIMBAL TRIM, DISENGAGE OPTICS DAC, ZERO OPTICS, SIVB TAKE OVER ENABLE, TVC ENABLE, ENABLE IMU ERROR COUNTER, ZERO IMU CDUPS, COARSE ALIGN ENABLE, HORIZONTAL VELOCITY LO-SCALE, ENABLE OPTICS ERROR COUNTER, ZERO OPTICS CDUPS, C.M., LEM															
13 (RADAR & AGC)	ENABLE T6 RUPT, RESET TRAP 22, RESET TRAP 31-A, ENABLE STANDBY, TEST ALARMS, START RHC READ, SIVB COUNTER ENABLE, RHC COUNTER ENABLE, DOWNLINK WORD ORDER, BLOCK INLINK, SPARE, RADAR ACTIVITY, RADAR SELECTION A, RADAR SELECTION B, RADAR SELECTION C, C.M., LEM															
14 (IMU)	DRIVE CDU X, DRIVE CDU Y, DRIVE CDU Z, DRIVE CDU T, DRIVE CDU S, GYRO ACTIVITY, GYRO SIGN MINUS, GYRO SELECT A, GYRO SELECT B, GYRO ENABLE, SPARE, THRUST DRIVE, ALTITUDE METER ACTIVITY, ALTITUDE BYTE SELECT, SPARE, C.M., LEM															
15 (MAIN KEYBOARD)	KEY 5M, KEY 4M, KEY 3M, KEY 2M, KEY 1M, C.M., LEM															
16 (NAV KEYBOARD)	MARK REJECT, MARK REJECT, MARK Y, MARK X, C.M., LEM															
17 & 20 thru 27 (VACANT)	[Shaded]															
30 (GNBC)	TEMP OUT OF LIMITS, I.S.S. TURN-ON REQUEST, IMU FAIL, IMU CDU FAIL, IMU CAGE, S/C CONTROL OF SATURN, IMU OPERATE, OPTICS CDU FAIL, GURD REF RELEASE, LIFTOFF, SIVB SEPARATE ABORT, SPS READY, SM SEPARATE, URARGE THRUST PRESENT, C.M., LEM															
31 (TRANS & ROT)	GAC A/Y CONTROL, FREE FUNCTION, HOLD FUNCTION, -Z TRANSLATION, +Z TRANSLATION, -Y TRANSLATION, +Y TRANSLATION, -X TRANSLATION, +X TRANSLATION, -ROLL MAN ROT, +ROLL MAN ROT, -YAW MAN ROT, +YAW MAN ROT, -PITCH MAN ROT, +PITCH MAN ROT, C.M., LEM															
32 (IMPULSE)	SPARE, LEM ATTACHED, SPARE, ROLL GIMBAL OFF, THRUSTER 10 & 11 FAIL, THRUSTER 9 & 12 FAIL, THRUSTER 13 & 15 FAIL, THRUSTER 14 & 16 FAIL, THRUSTER 6 & 7 FAIL, THRUSTER 1 & 3 FAIL, THRUSTER 5 & 8 FAIL, THRUSTER 2 & 4 FAIL, C.M., LEM															
33 (OPTICS & AGC)	OSC ALARM, CMC WARNING, RFA FAIL, DOWNLINK TOO FAST, UPLINK TOO FAST, BLOCK UPLINK INPUT, LE RANGE LOW SCALE, LANDING VEL DATA GOOD, LR POS #2, LR POS #1, LR DATA GOOD, RE DATA GOOD, RE RANGE LOW SCALE, RE POWER ON/AUTO, C.M., LEM															
34	DOWNLINK #1 (FIRST OF TWO WORDS SERIALIZED), C.M., LEM															
35	DOWNLINK #2 (SECOND OF TWO WORDS SERIALIZED), C.M., LEM															

ALL SIGNALS INVERTED

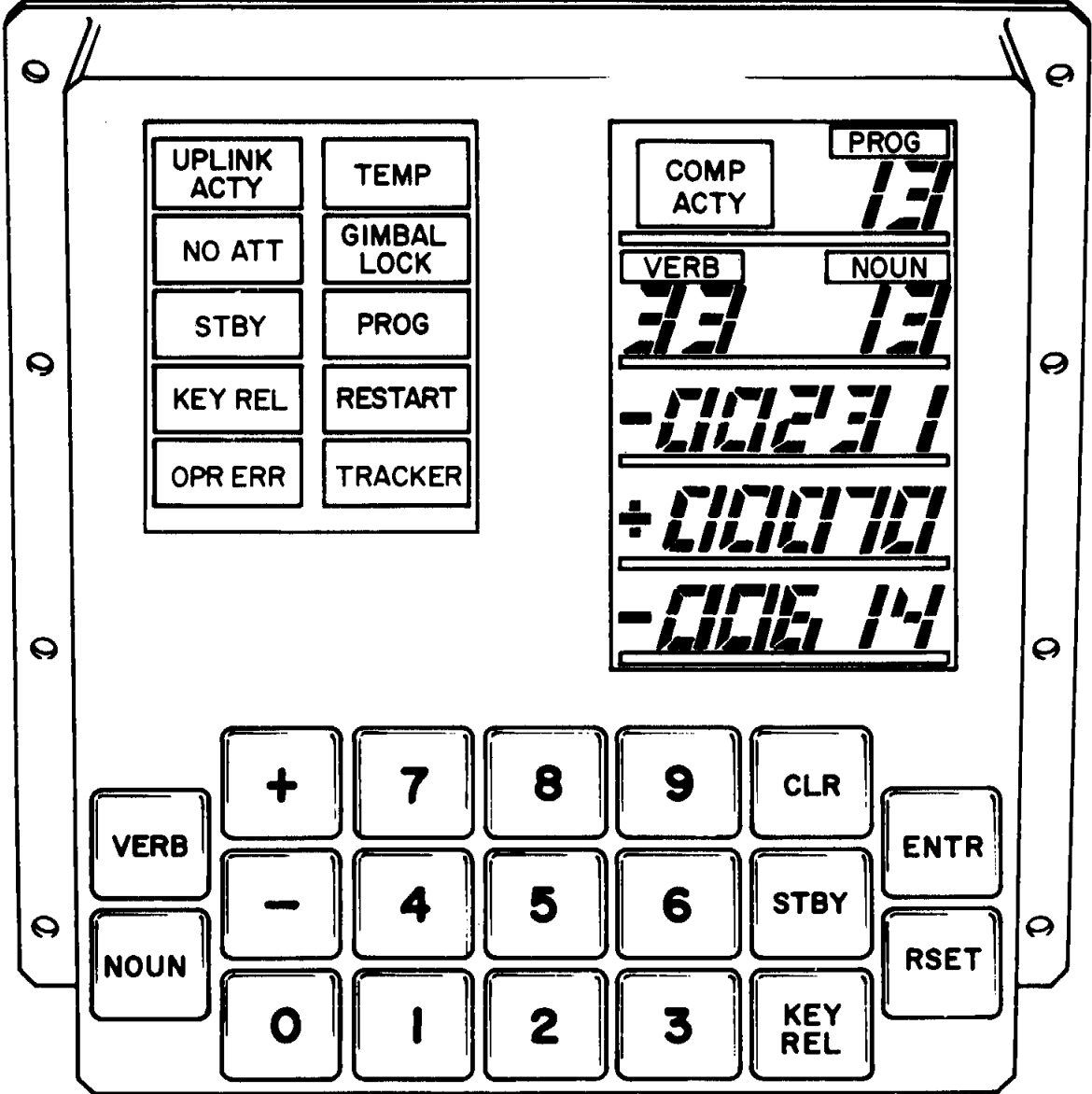
A	B	C	FUNCTION
0 0 0			
0 0 1	R,R		RANGE
0 1 0	R,R		RANGE RATE
0 1 1			
1 0 0	L,R		X VELOCITY
1 0 1	L,R		Y VELOCITY
1 1 0	L,R		Z VELOCITY
1 1 1	L,R		RANGE

A	B	GYRO
0 0		
0 1		X
1 0		Y
1 1		Z

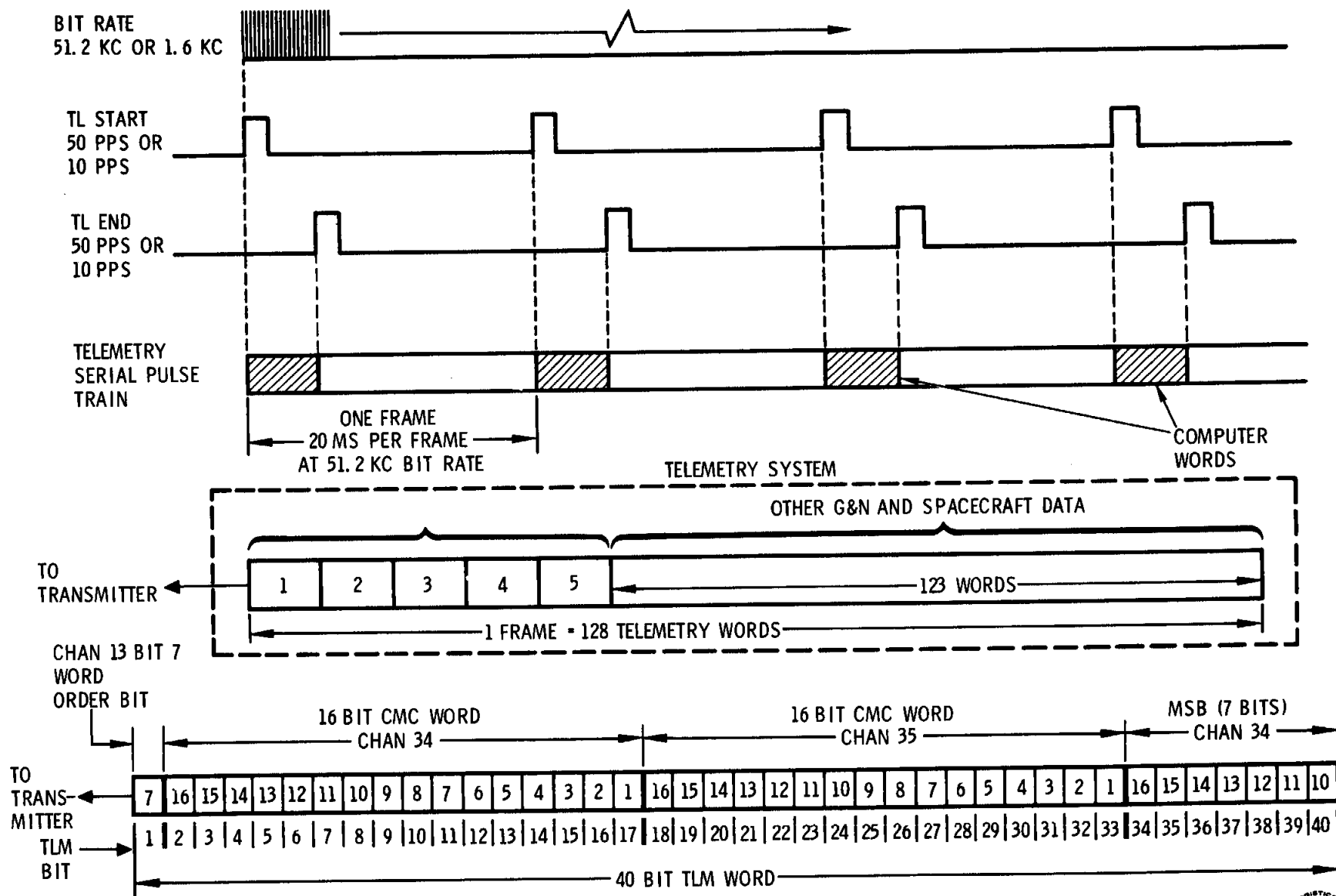
BLOCK II CMC & LGC CHANNEL-BIT ASSIGNMENTS

FE7	FE6	FE5	FUNCTION
0 0 0			30-37
1 0 0			40-43
1 0 1			EMPTY
1 1 0			EMPTY
1 1 1			EMPTY

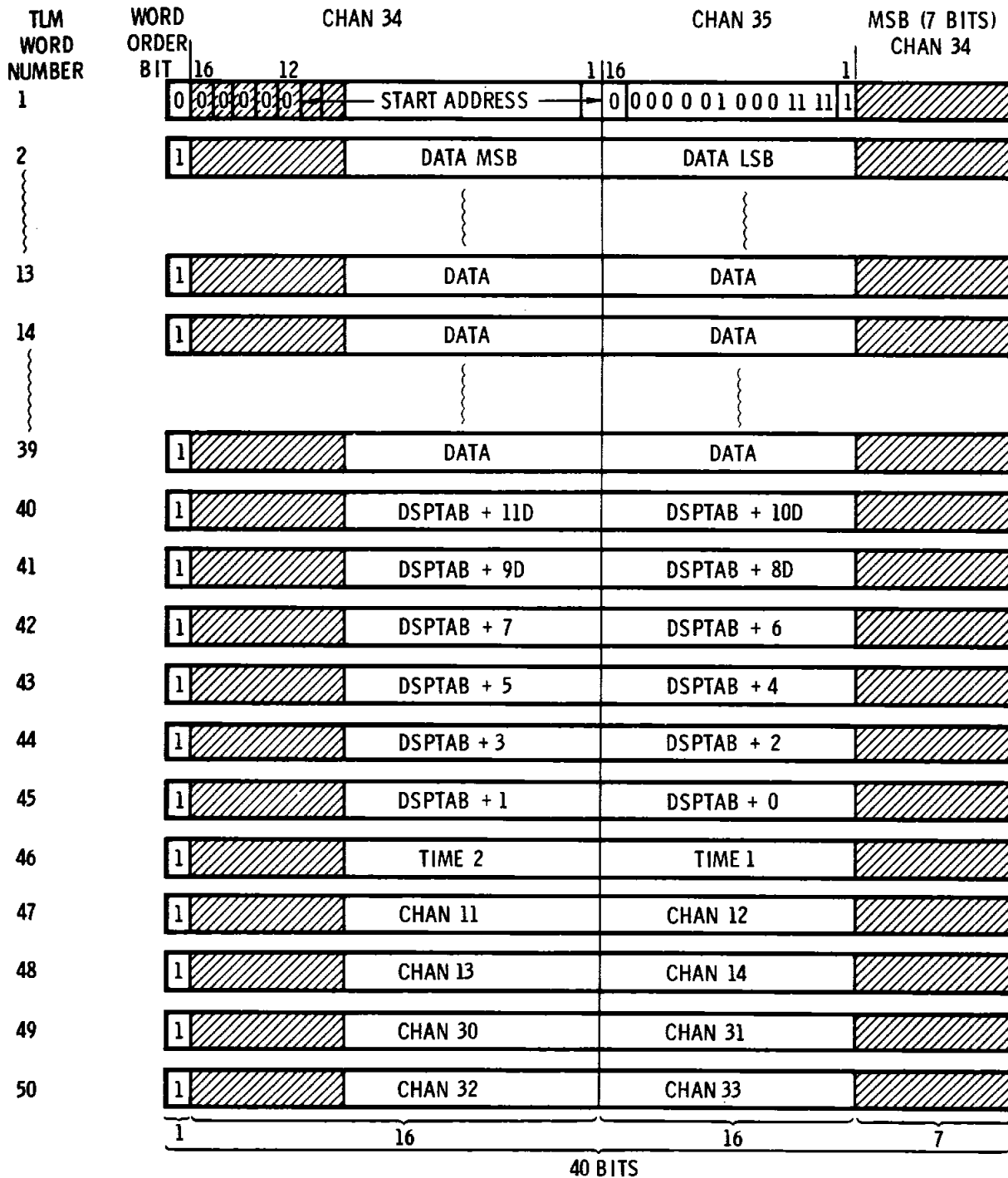
DISPLAY AND KEYBOARD (DSKY)



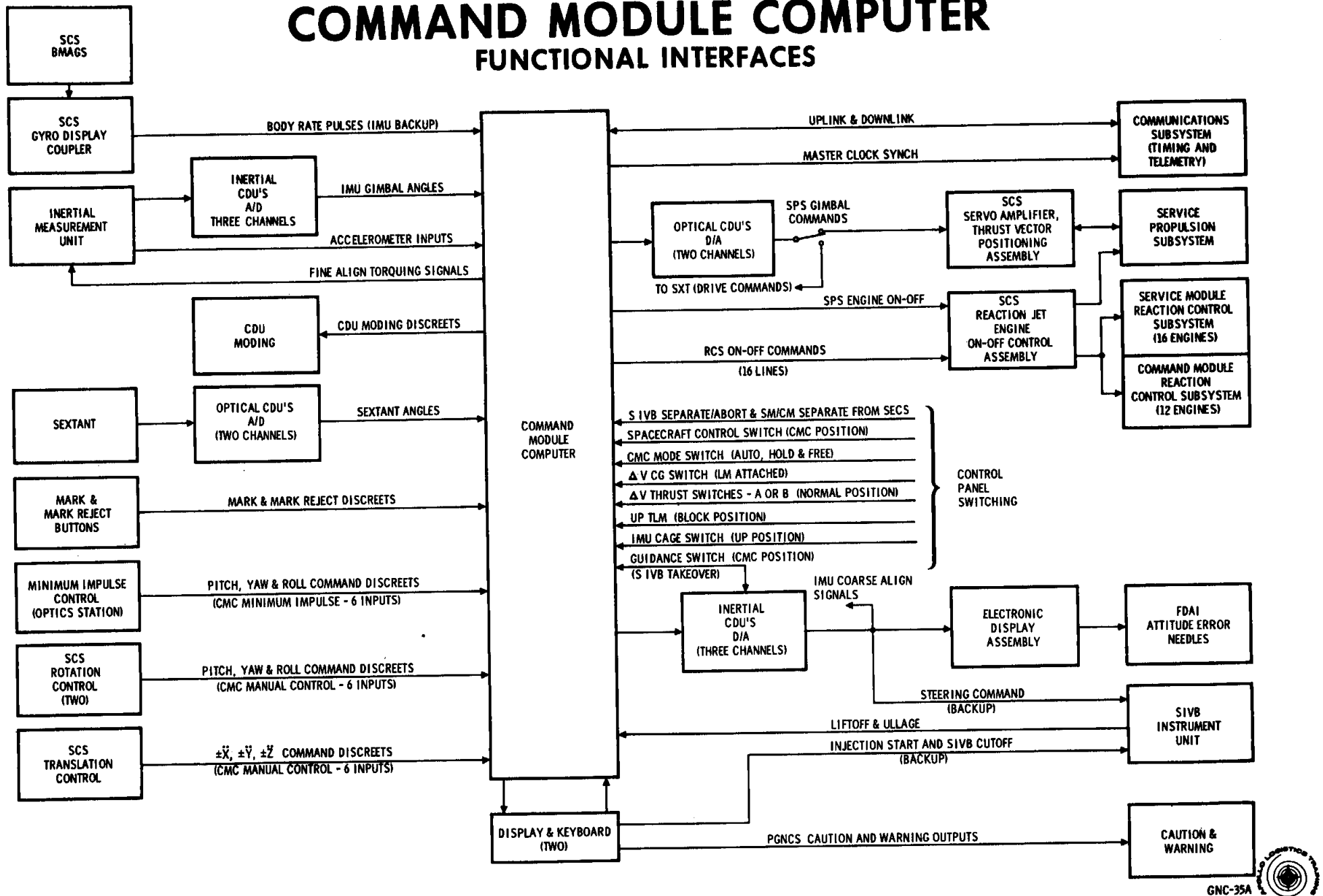
DWN TLM FORMAT



50 WORD DWNTLM LIST



COMMAND MODULE COMPUTER FUNCTIONAL INTERFACES



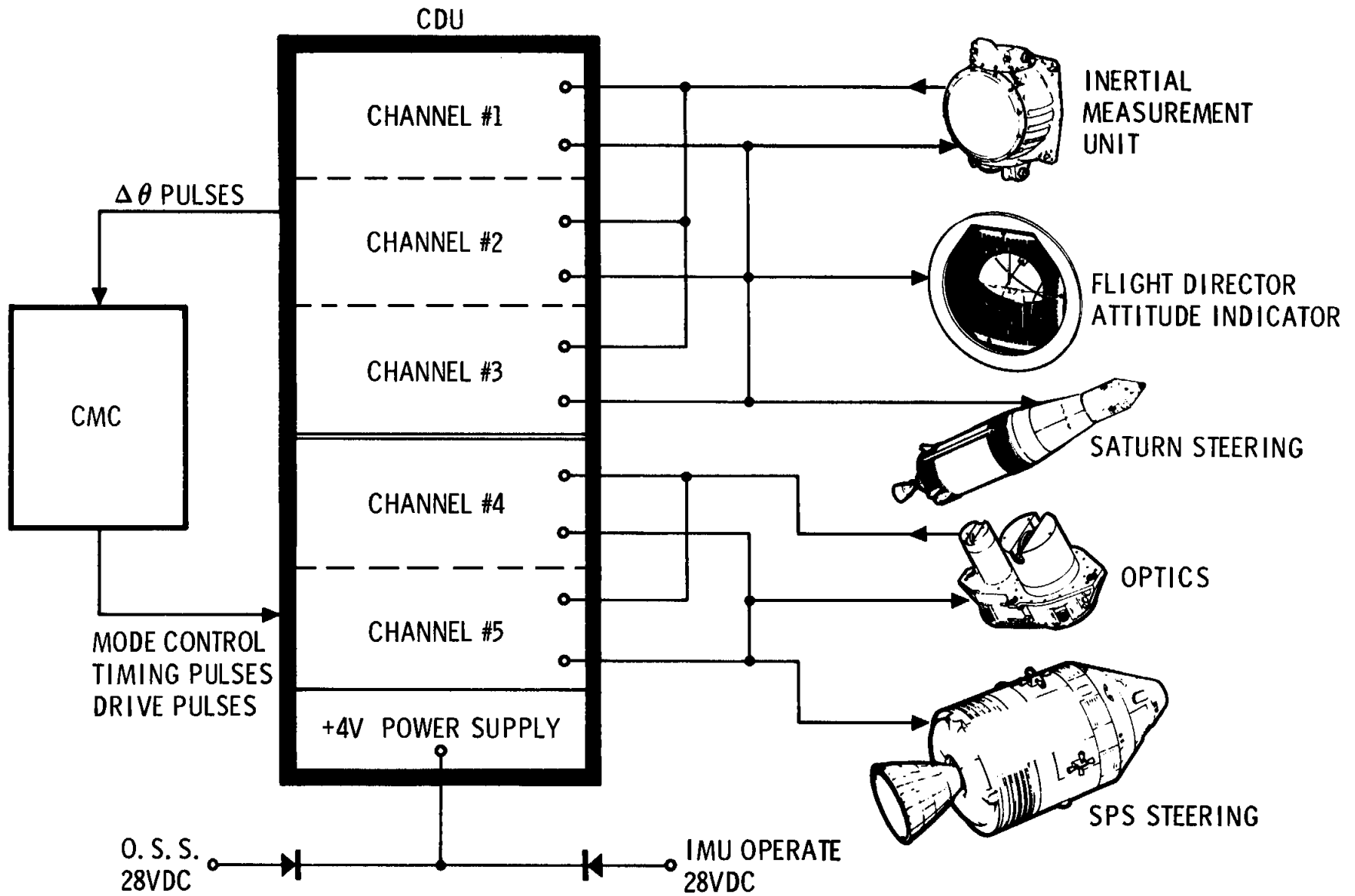
GNC-35A



CSM GUIDANCE COMPUTER MISSION PROGRAMS

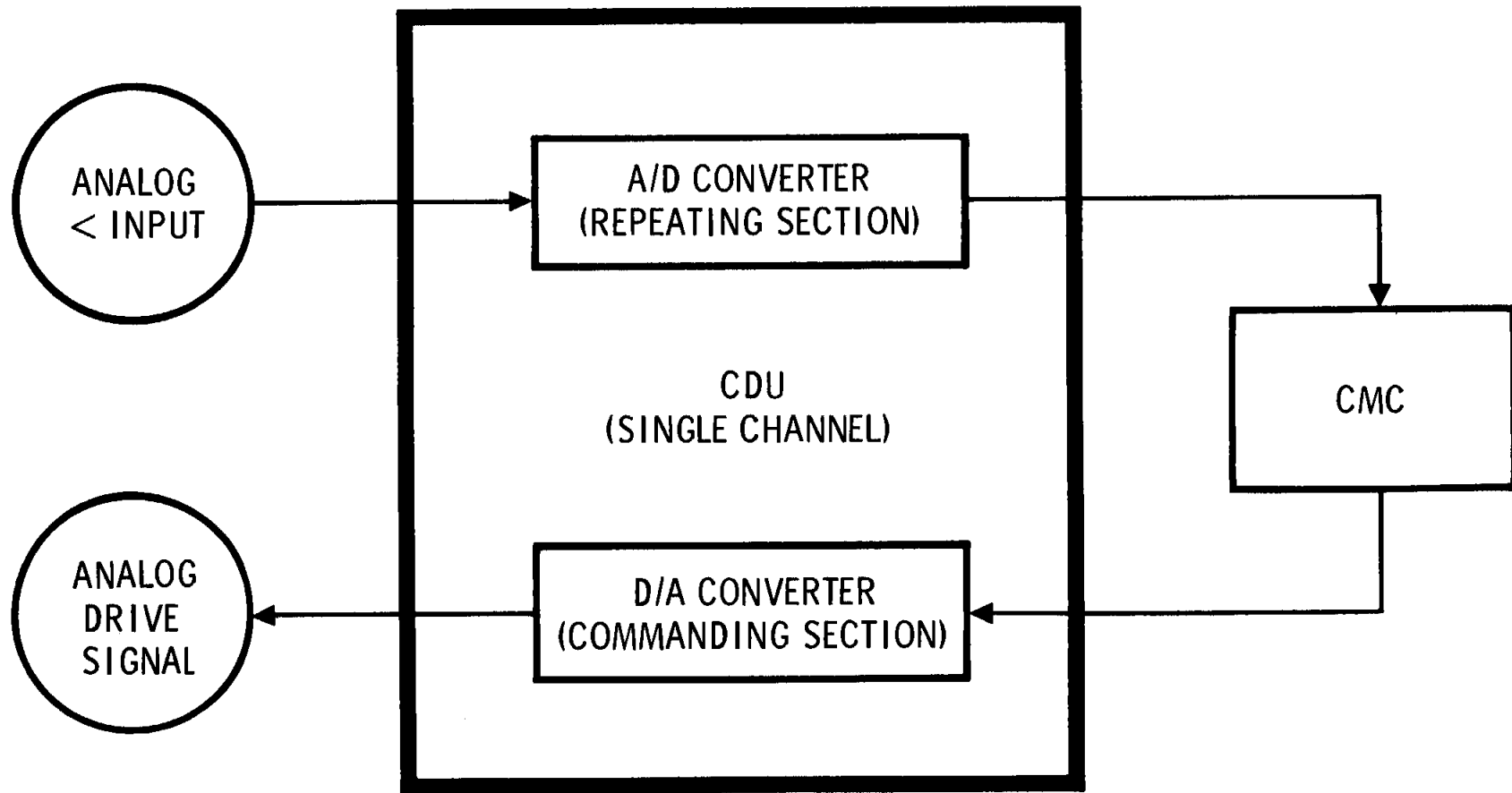
1. **Prelaunch & Service**
 - P00 CMC Idling
 - P01 Prelaunch Initialization
 - P02 Gyro Compassing
 - P03 Optical Verification of Azimuth
 - P05 GNCS Startup
 - P06 GNCS Power down
 - P27 CMC Update
2. **Boost**
 - P11 Earth Orbit Insertion Monitor
3. **Coast**
 - P20 Rendezvous Navigation
 - P21 Ground Track Determination
 - P22 Orbital Navigation
 - P23 Cislunar Midcourse Navigation
4. **Prethrust**
 - P30 External Delta V
 - P34 Transfer Phase Initiation (TPI)
 - P35 Transfer Phase Initiation (Midcourse)
5. **Thrust**
 - P40 SPS
 - P41 RCS
 - P47 Thrust Monitor
6. **Alignment**
 - P51 IMU Orientation Determination
 - P52 IMU Realign
 - P53 Backup IMU Orientation Determination
 - P54 Backup IMU Realign
7. **Entry**
 - P61 Entry Maneuver to CM/SM Separation Attitude
 - P62 CM/SM Separation & Pre entry maneuver
 - P63 Entry - Initialization
 - P64 Post .05 G
 - P67 Entry Final Phase
8. **Abort**
 - P74 LM Transfer Phase Initiation (TPI)
 - P75 LM Transfer Phase Initiation Midcourse
9. **Astronaut Service Routines**
 - R00 Final Automatic Request Termination
 - R02 IMU Status Check
 - R03 DAP Data Load ---- V48E
 - R21 Rendezvous Tracking Data Processing --- V57E
 - R22 Rendezvous Tracking Sighting Mark
 - R30 Orbit Parameter Display ---- V82E
 - R31 Rendezvous Parameter Display --- V83E
 - R32 Target Delta V ---- V84E
 - R34 Rendezvous Parameter Display ---- V85E
 - R50 Coarse Align
 - R51 Fine Alignment
 - R52 Automatic Optics Positioning
 - R53 Sighting Mark
 - R54 Star Data Test
 - R55 Gyro Torquing
 - R56 Alternate LOS Sighting Mark
 - R60 Attitude Maneuver
 - R61 Preferred Tracking Attitude
 - R62 Crew Defined Maneuver ---- V49E
 - R63 Rendezvous Final Attitude ---- V89E

CDU FUNCTIONAL INTERFACES

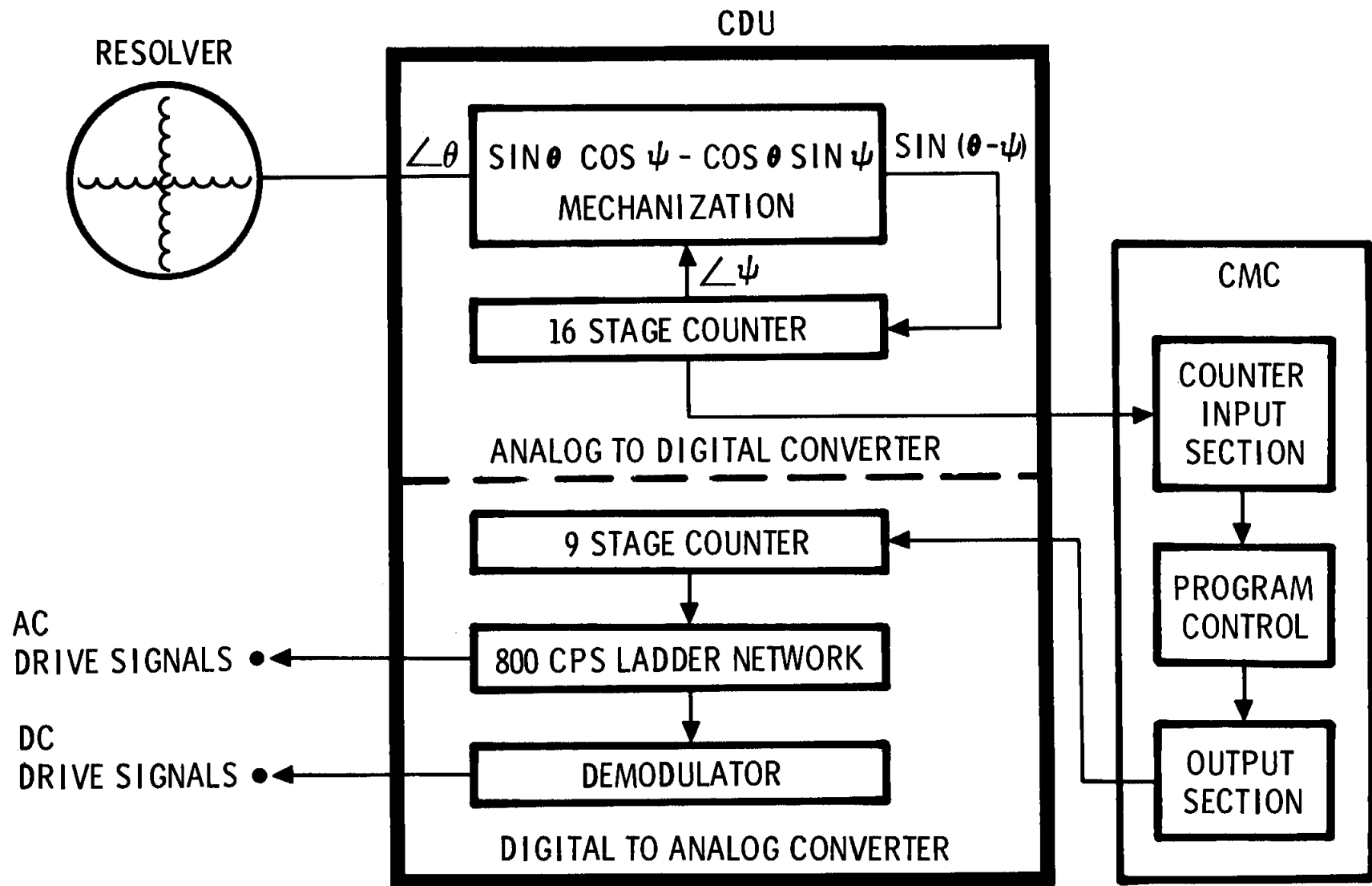


CDU

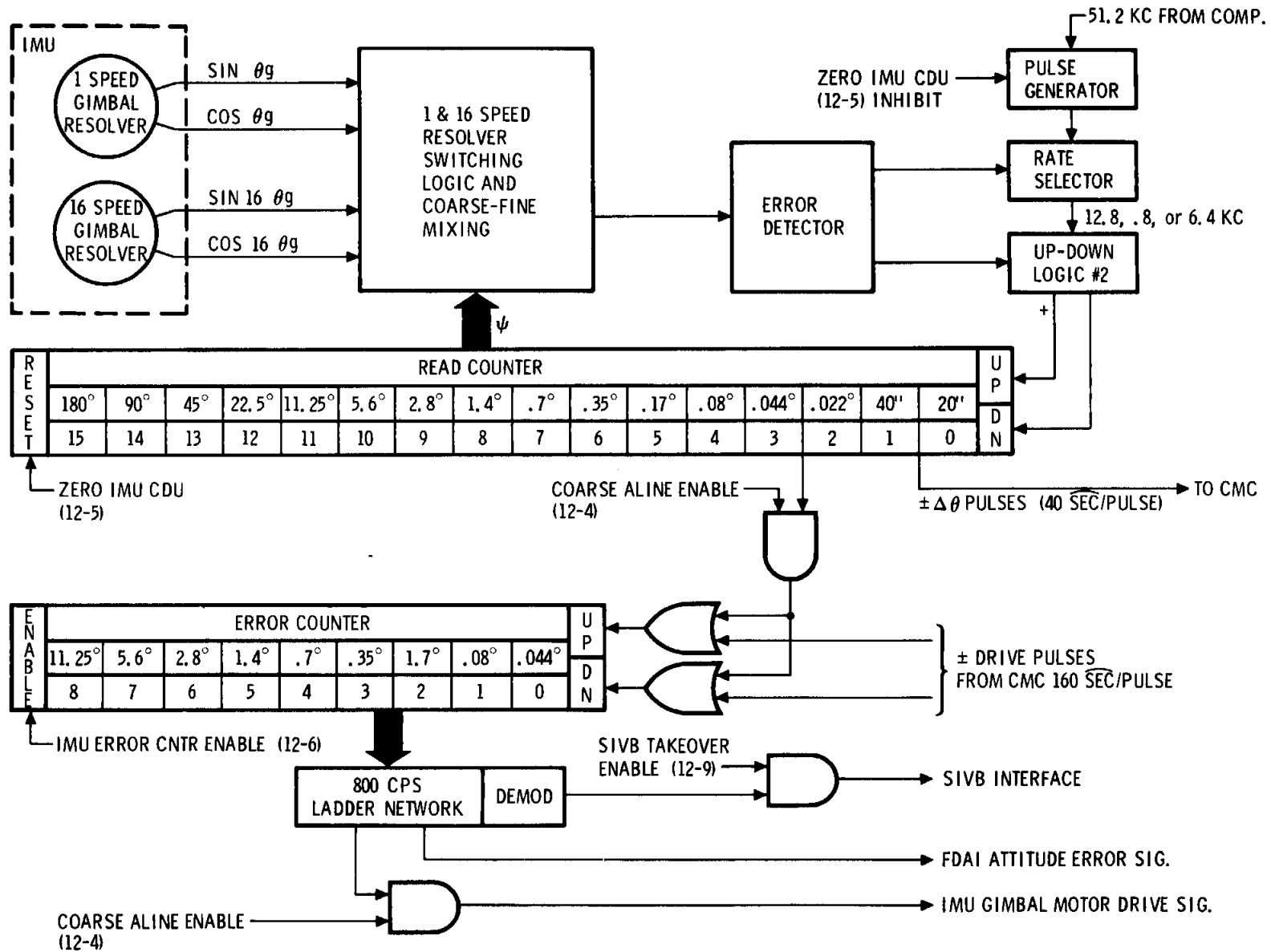
SINGLE CHANNEL SIMPLIFIED



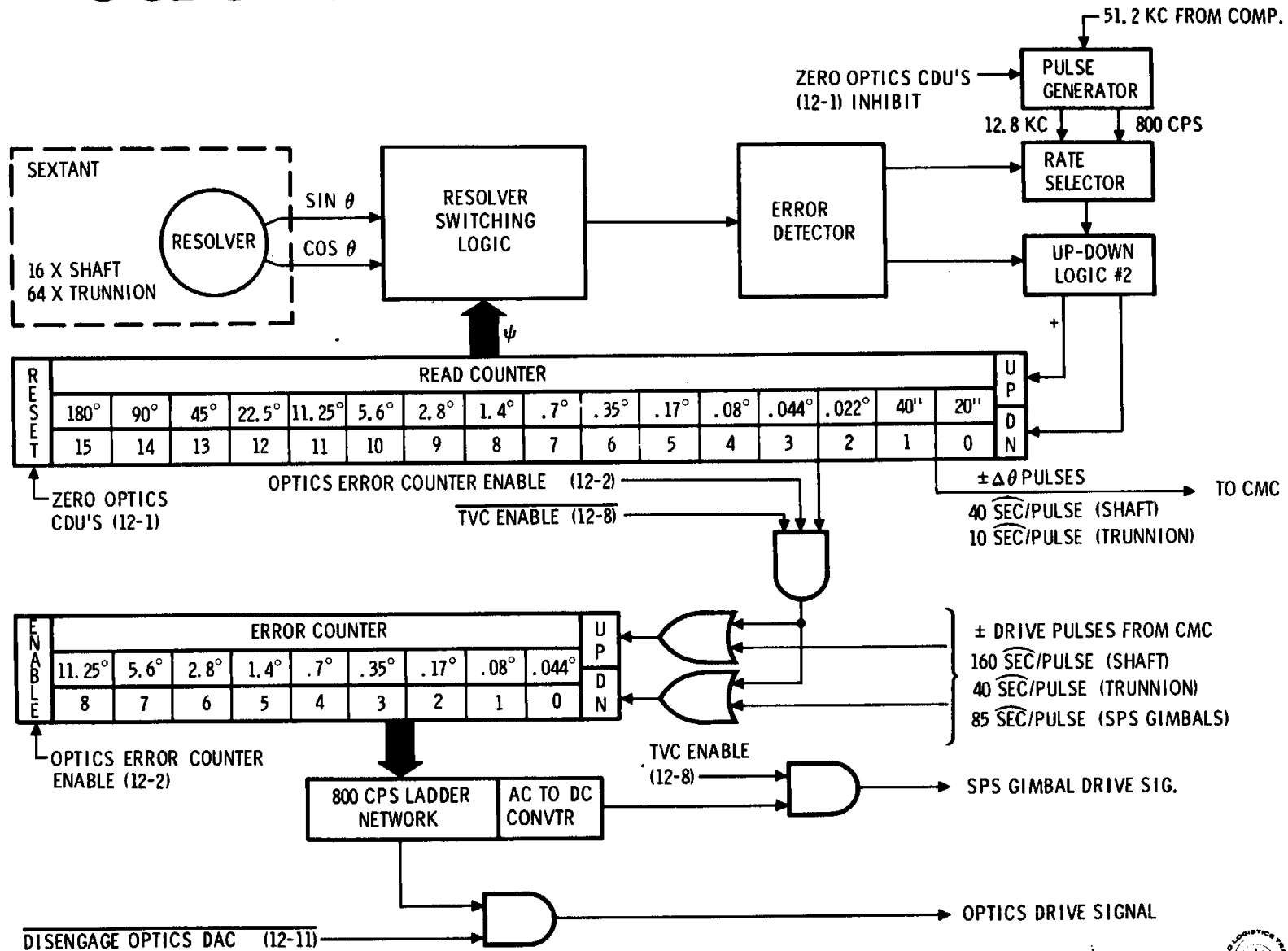
CDU SINGLE CHANNEL



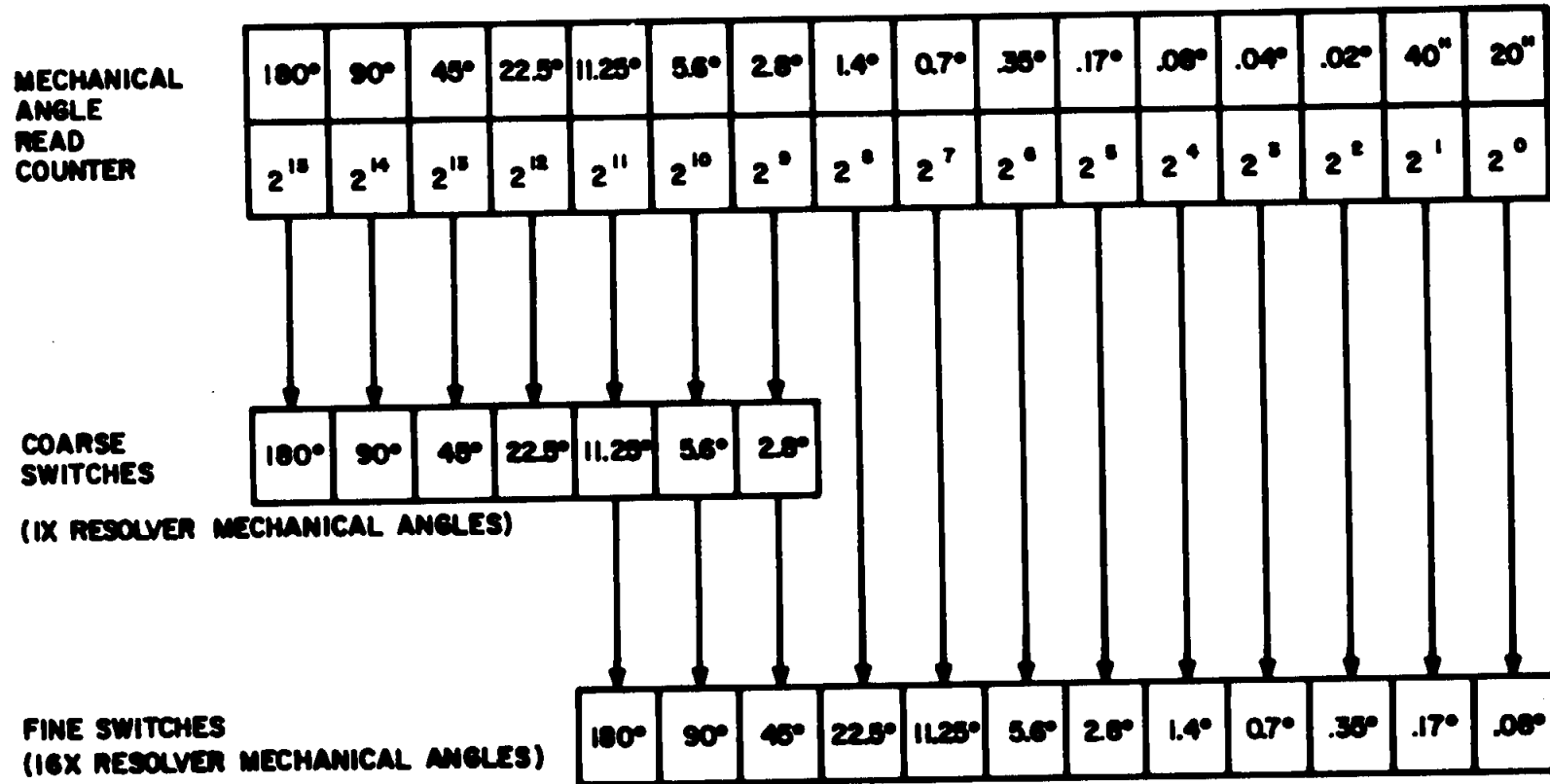
ICDU FUNCTIONAL BLOCK DIAGRAM



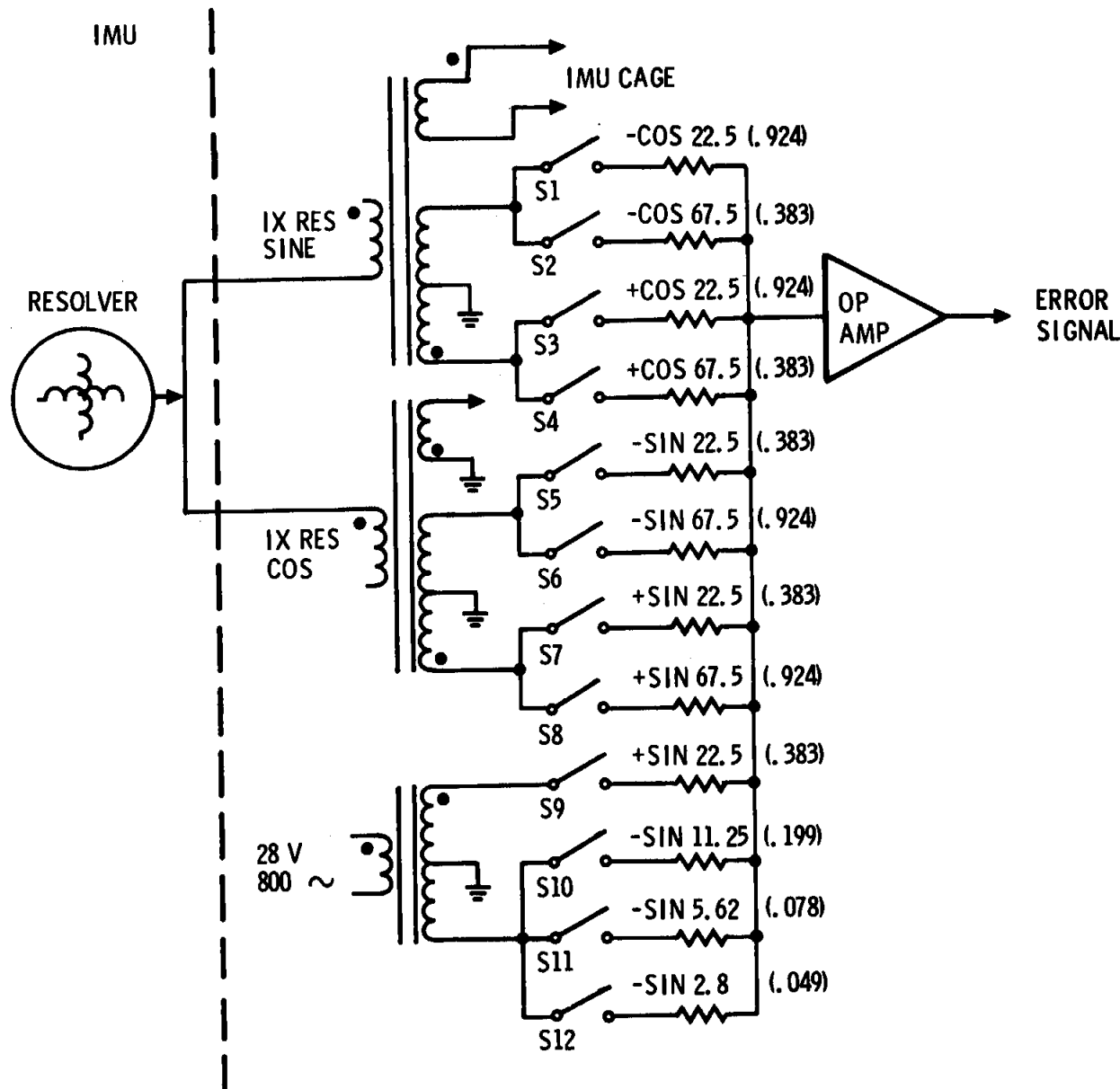
OCDU FUNCTIONAL BLOCK DIAGRAM



READ COUNTER RELATIONSHIP TO COARSE FINE SWITCHING



CDU COARSE MODULE BLOCK DIAGRAM



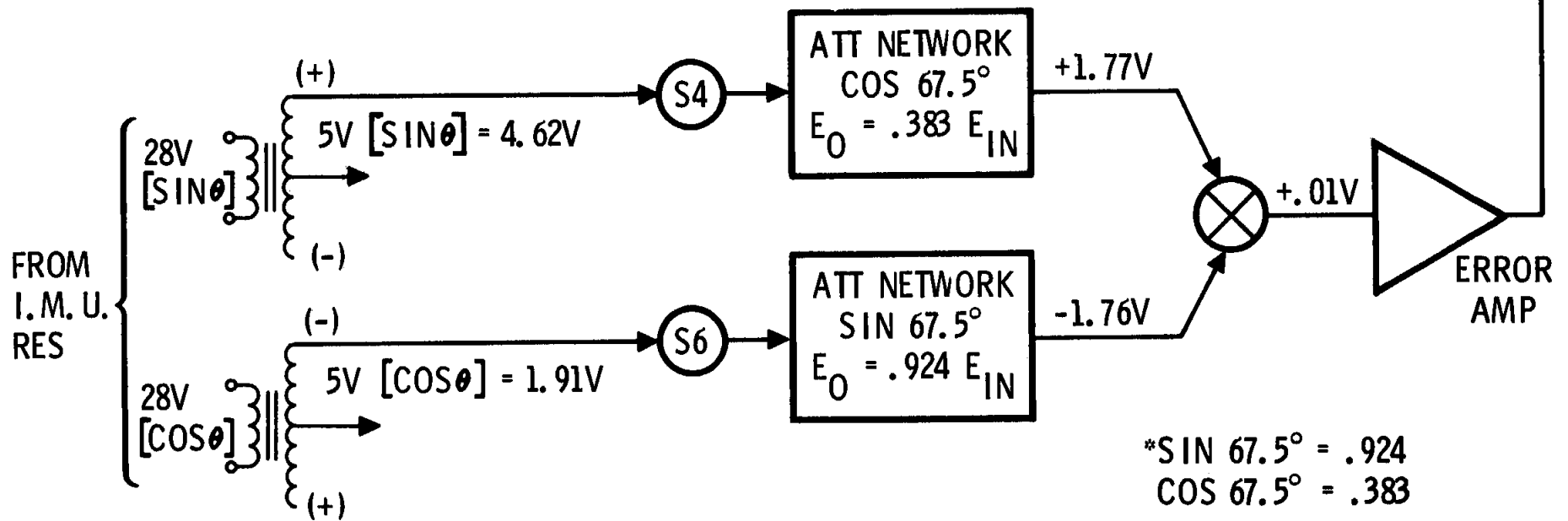
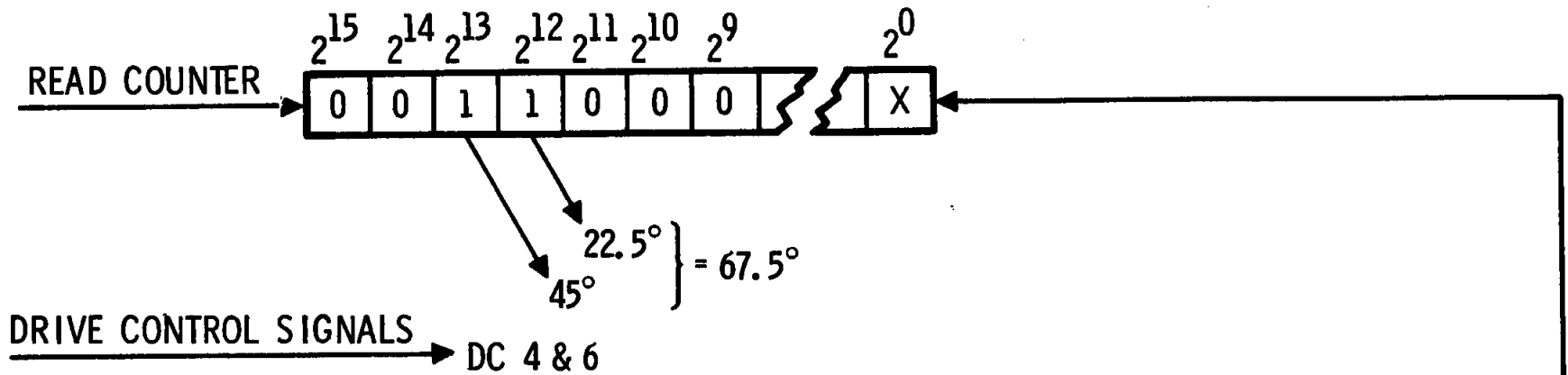
COARSE SWITCH LOGIC EQUATIONS

- DC 1 = $2^{15} 2^{14} 2^{13} + 2^{15} 2^{14} 2^{13}$
- DC 2 = $2^{15} 2^{14} 2^{13} + 2^{15} 2^{14} 2^{13}$
- DC 3 = $2^{15} 2^{14} 2^{13} + 2^{15} 2^{14} 2^{13}$
- DC 4 = $2^{15} 2^{14} 2^{13} + 2^{15} 2^{14} 2^{13}$
- DC 5 = $2^{15} [2^{14} 2^{13} + 2^{14} 2^{13}]$
- DC 6 = $2^{15} [2^{14} 2^{13} + 2^{14} 2^{13}]$
- DC 7 = $2^{15} [2^{14} 2^{13} + 2^{14} 2^{13}]$
- DC 8 = $2^{15} [2^{14} 2^{13} + 2^{14} 2^{13}]$
- DC 9 = 2^{12}
- DC 10 = 2^{11}
- DC 11 = 2^{10}
- DC 12 = 2^9

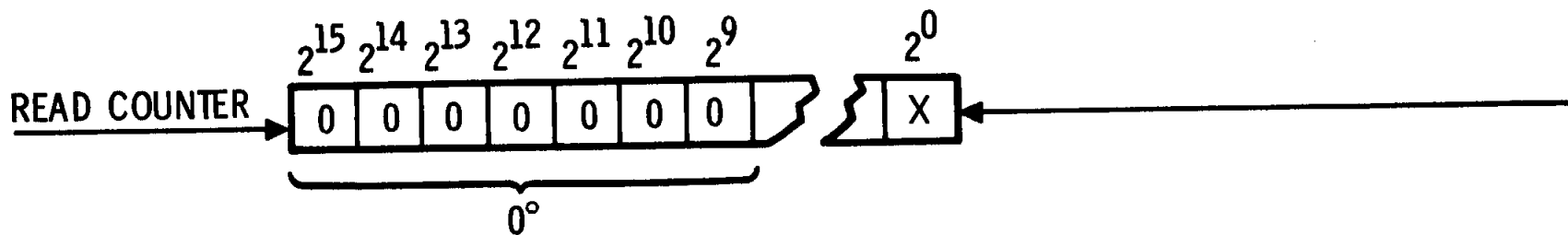
* 2^N - "N" REFERS TO BIT IN THE READ COUNTER

*DC "X" CLOSES SWITCH "X"

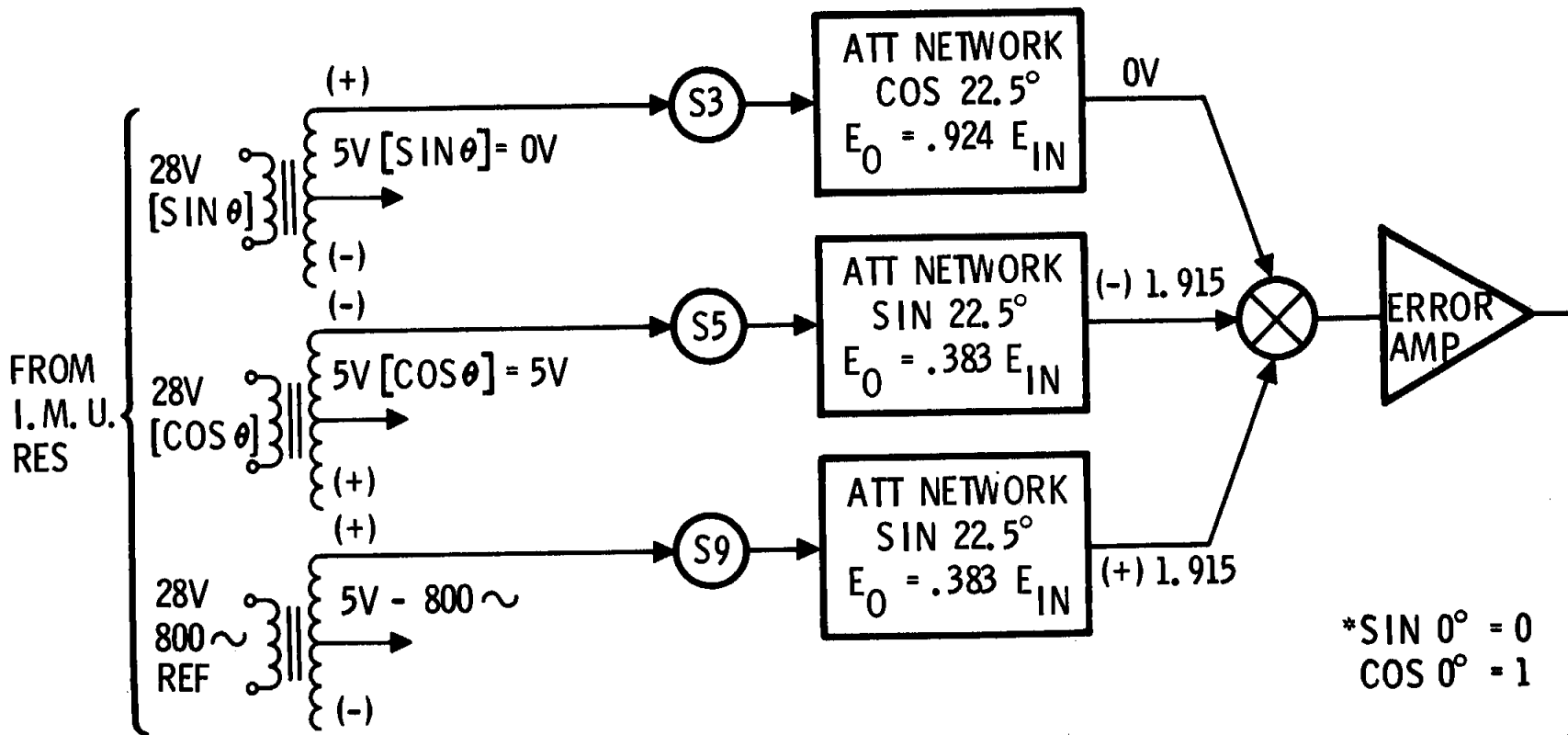
$\theta = 67.5$



$$\theta = 0^\circ$$

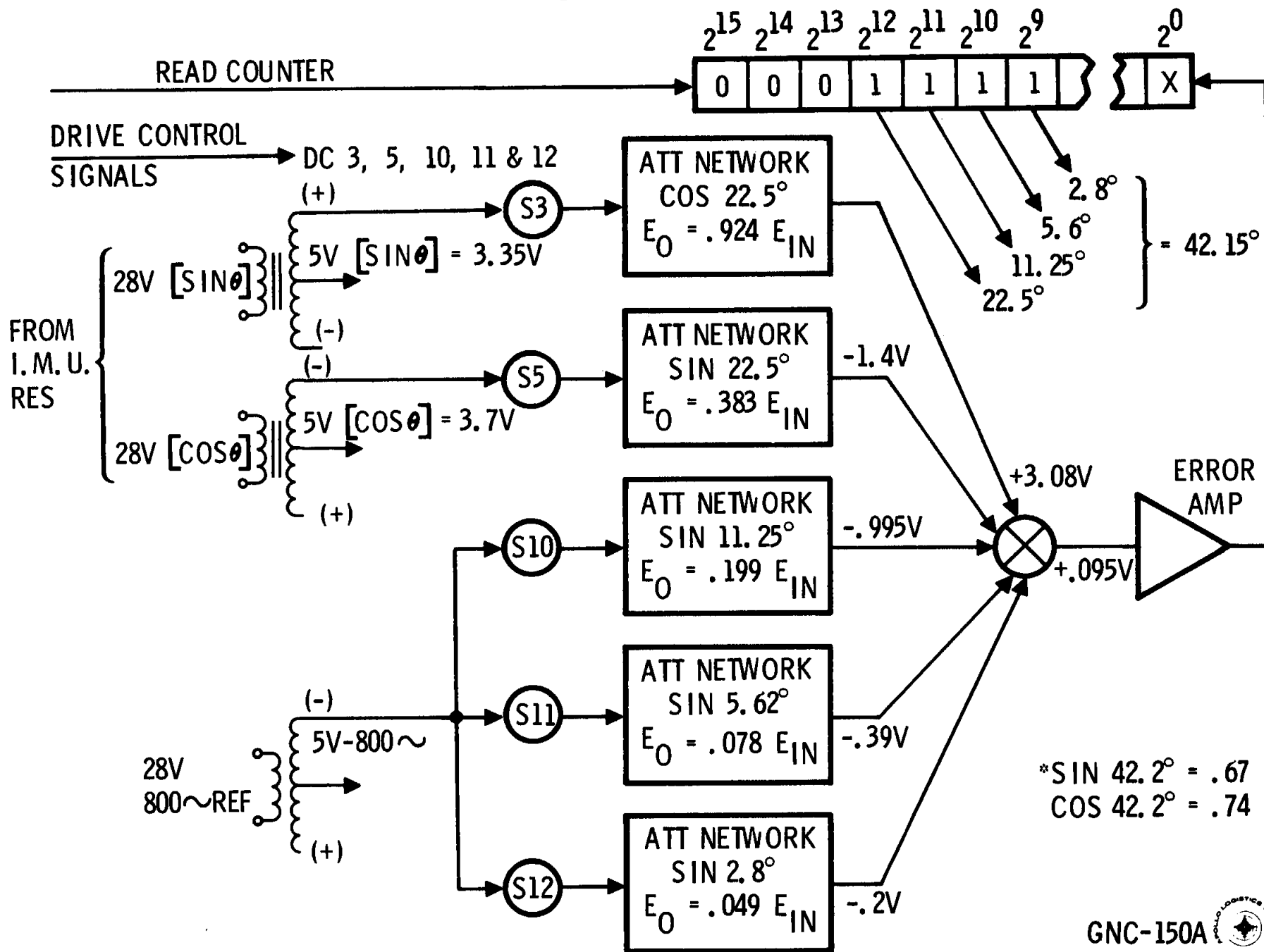


DRIVE CONTROL SIGNALS → DC 3, 5 & 9



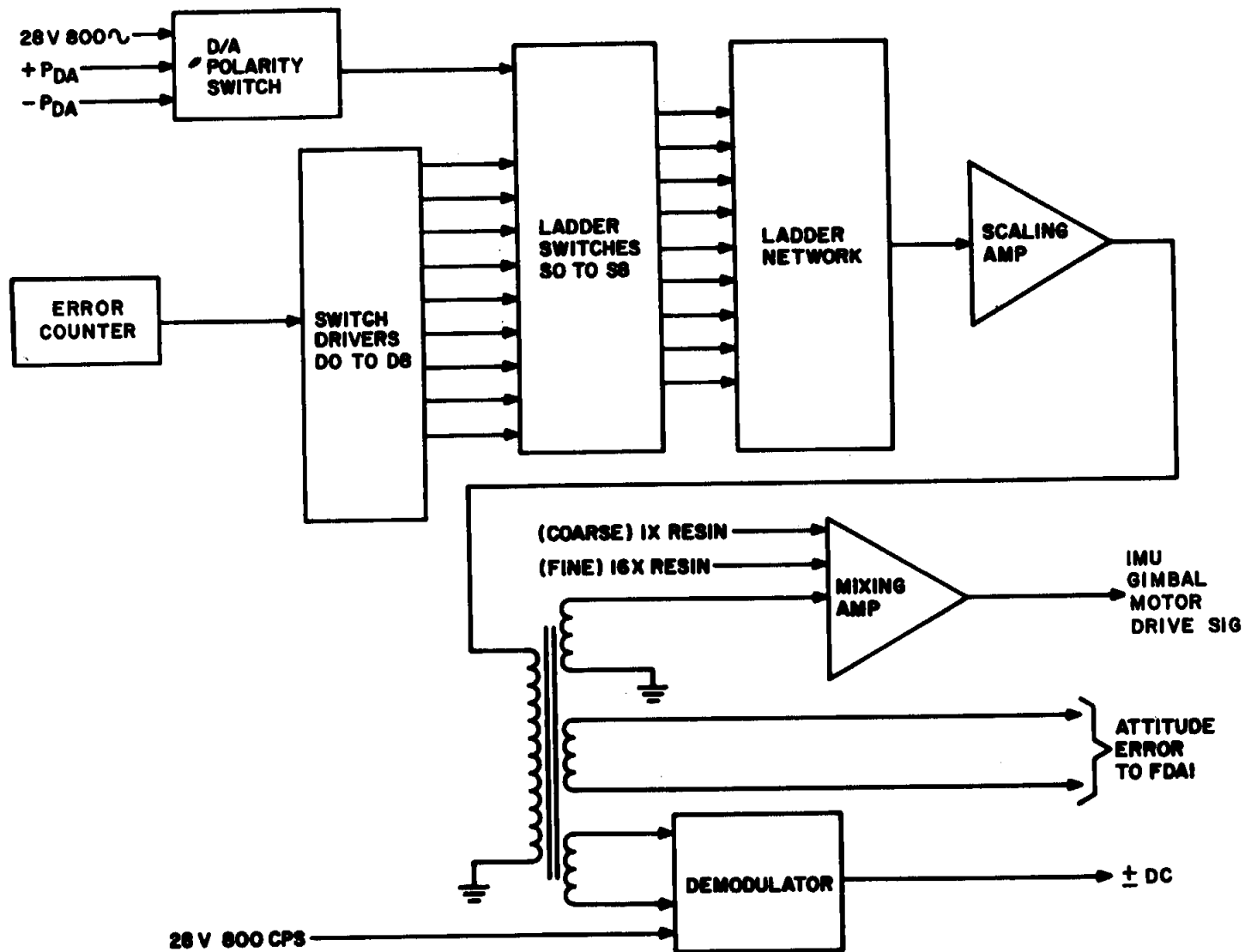
*SIN 0° = 0
COS 0° = 1

$$\theta = 42.2^\circ$$

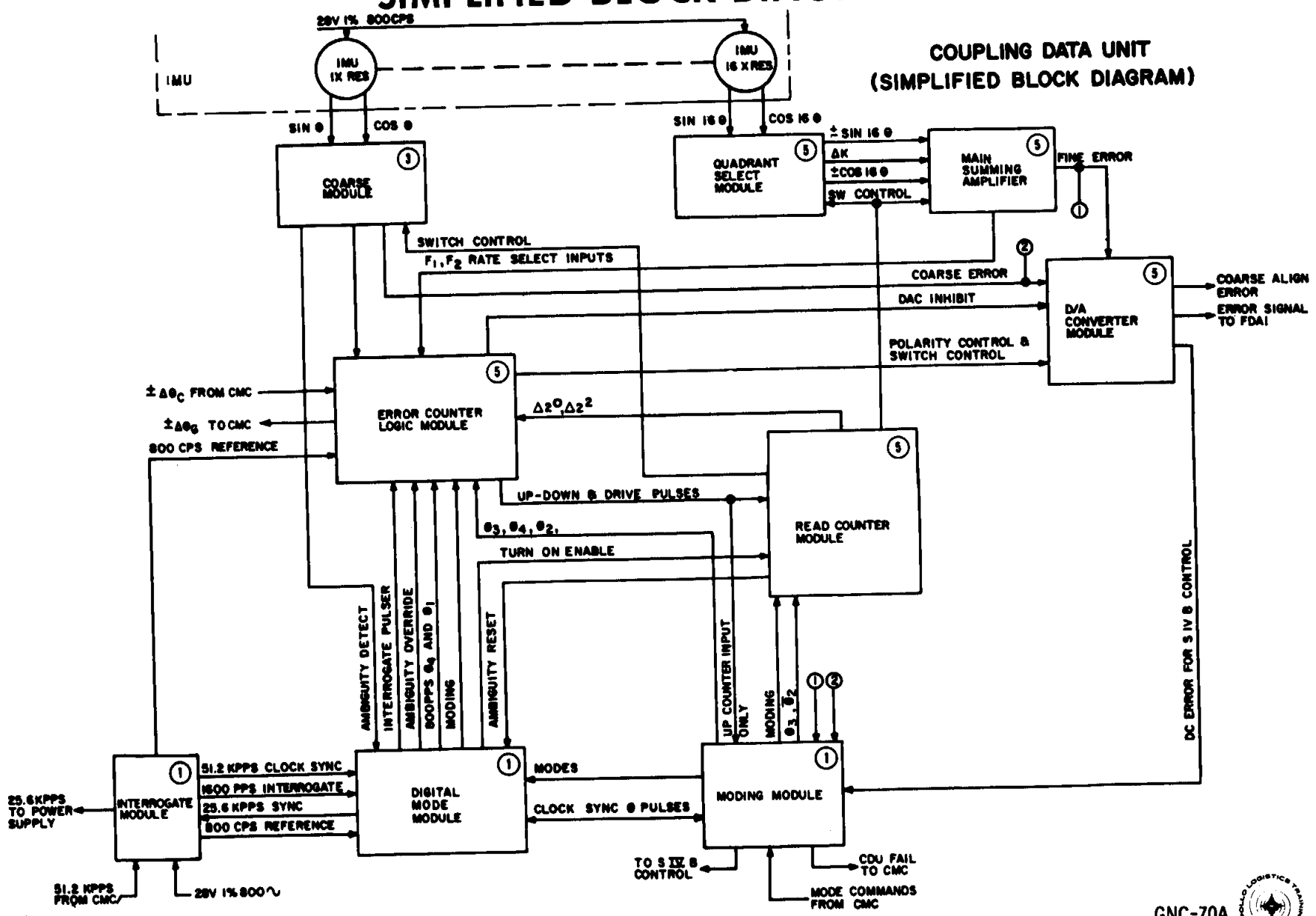


DIGITAL TO ANALOG CONVERTER MODULE BLOCK DIAGRAM

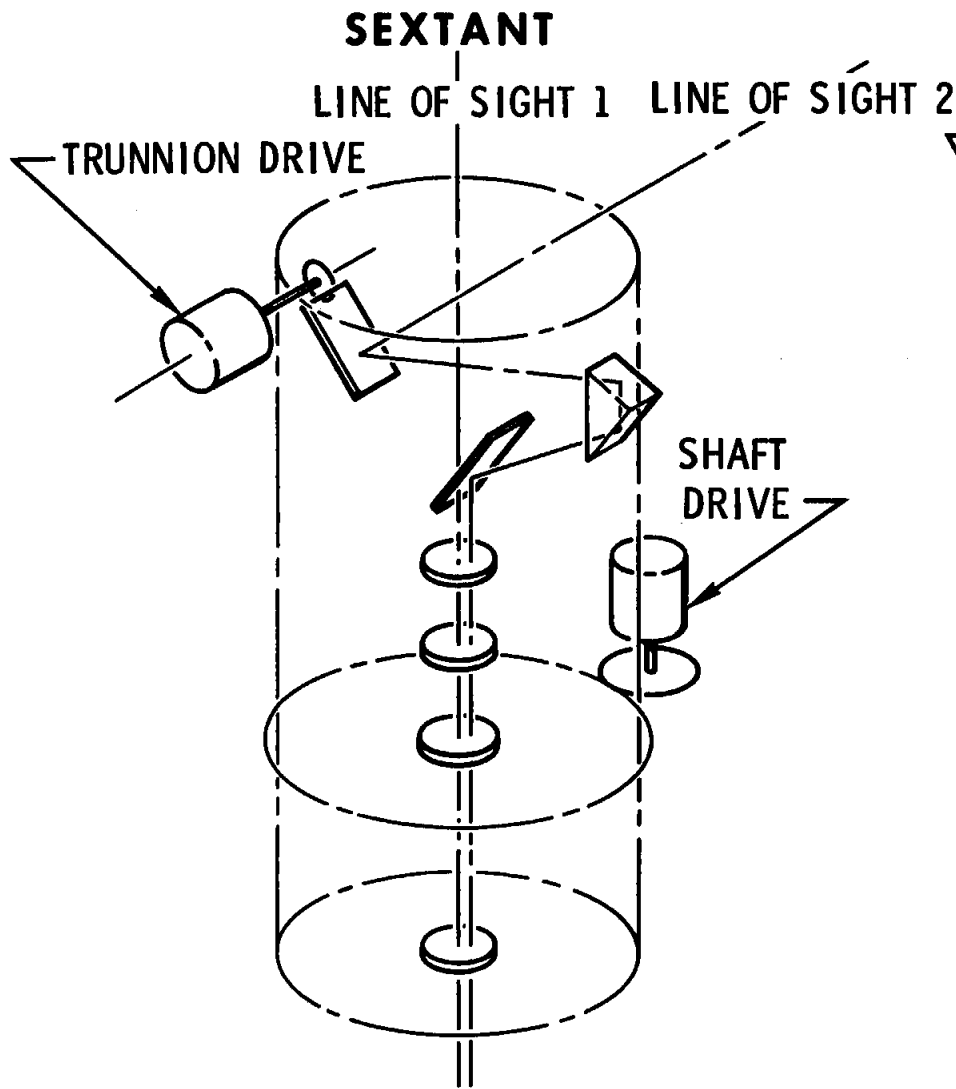
TYPICAL ICDU CHANNEL



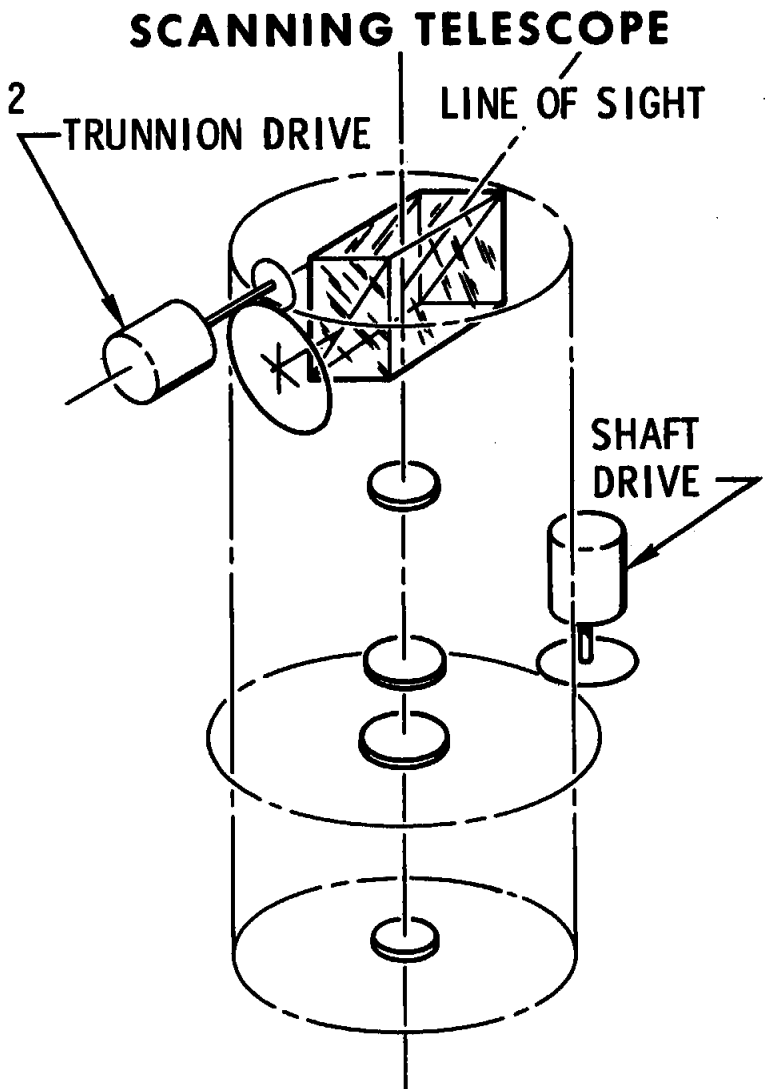
COUPLING DATA UNIT SIMPLIFIED BLOCK DIAGRAM



OPTICAL SCHEMATIC

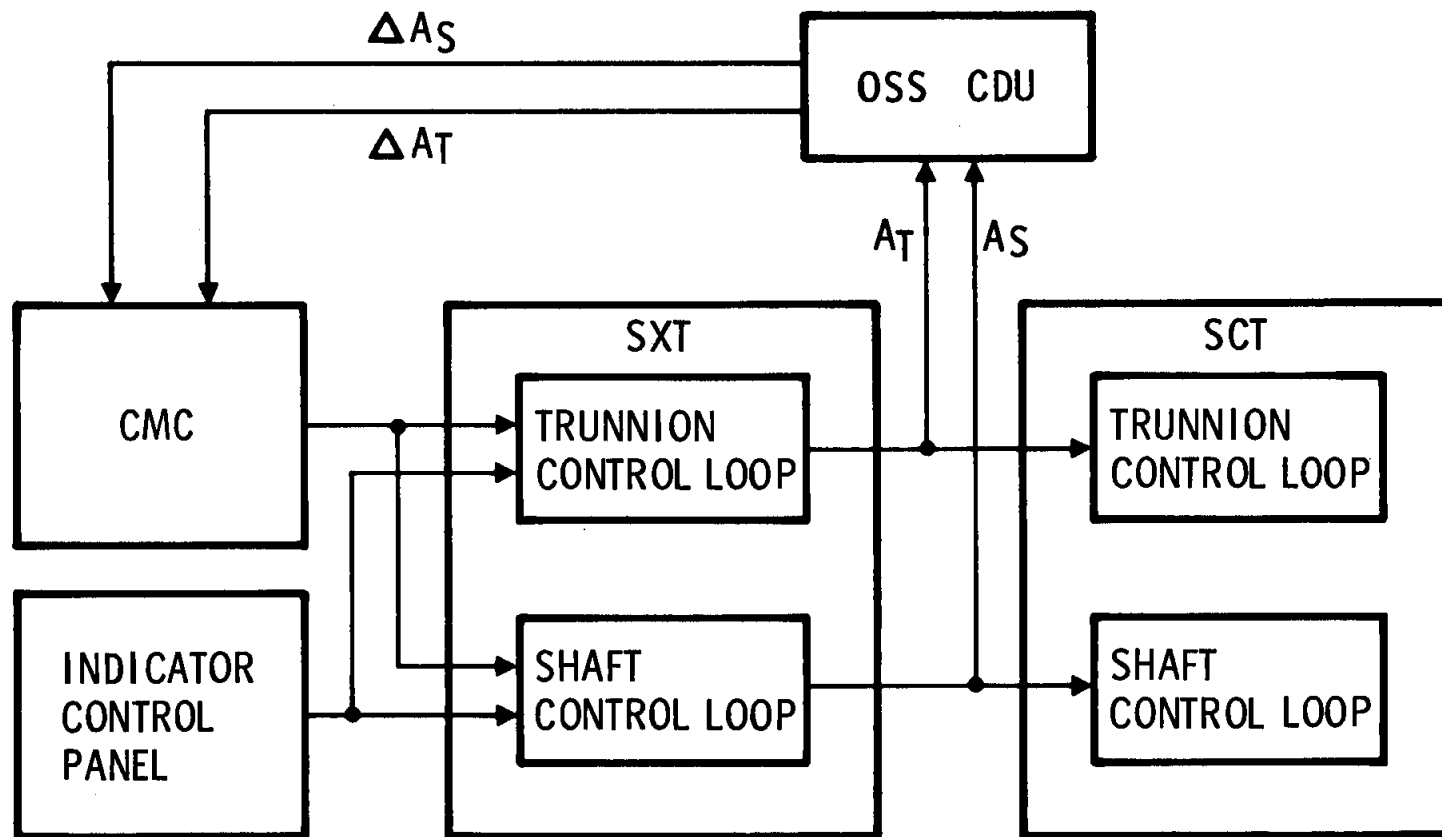


FIELD 1.8- EACH
MAGNIFICATION 28X

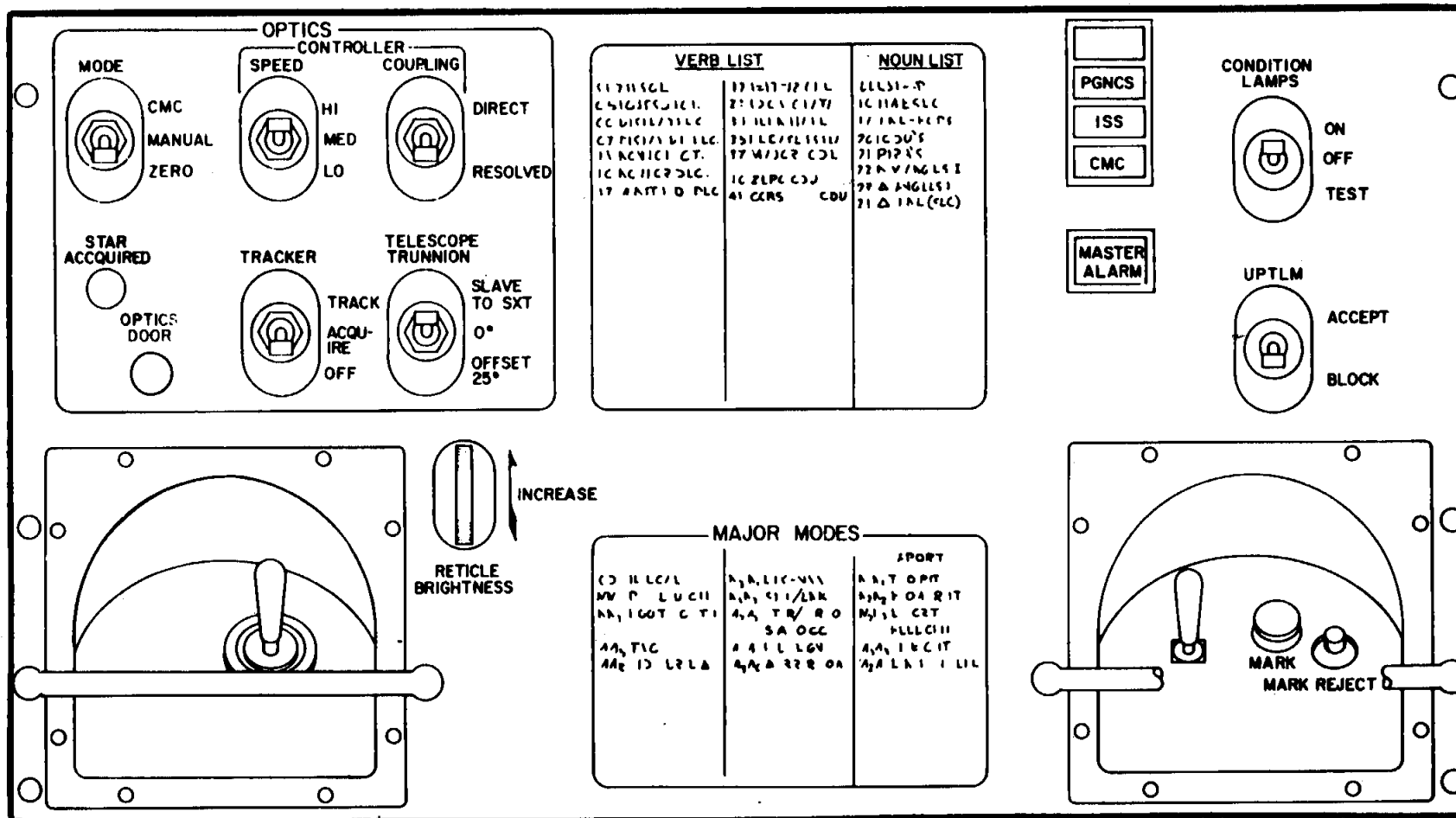


FIELD
MAGNIFICATION 60 DEG
IX

OPTICAL SUBSYSTEM

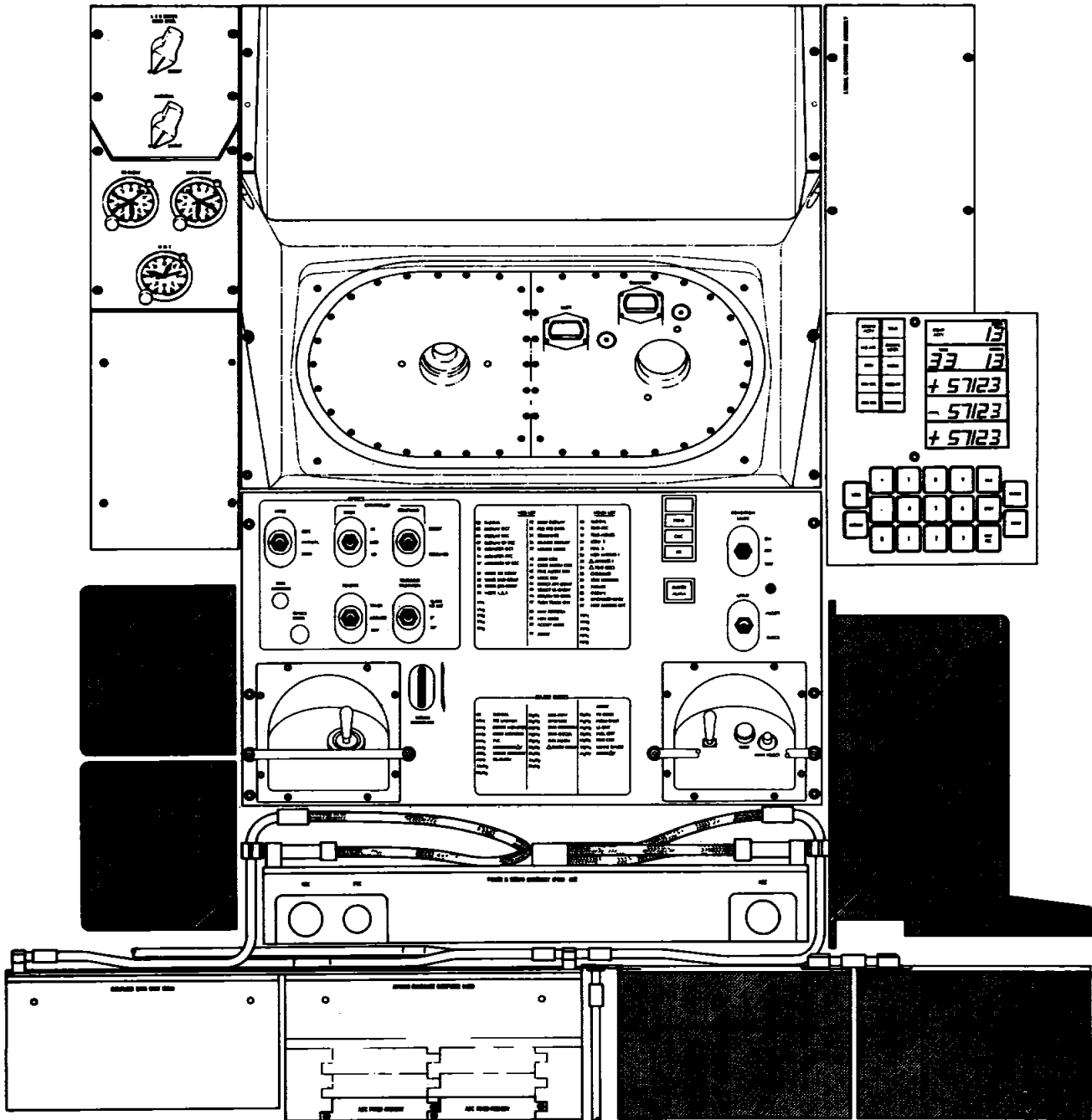


INDICATOR CONTROL PANEL

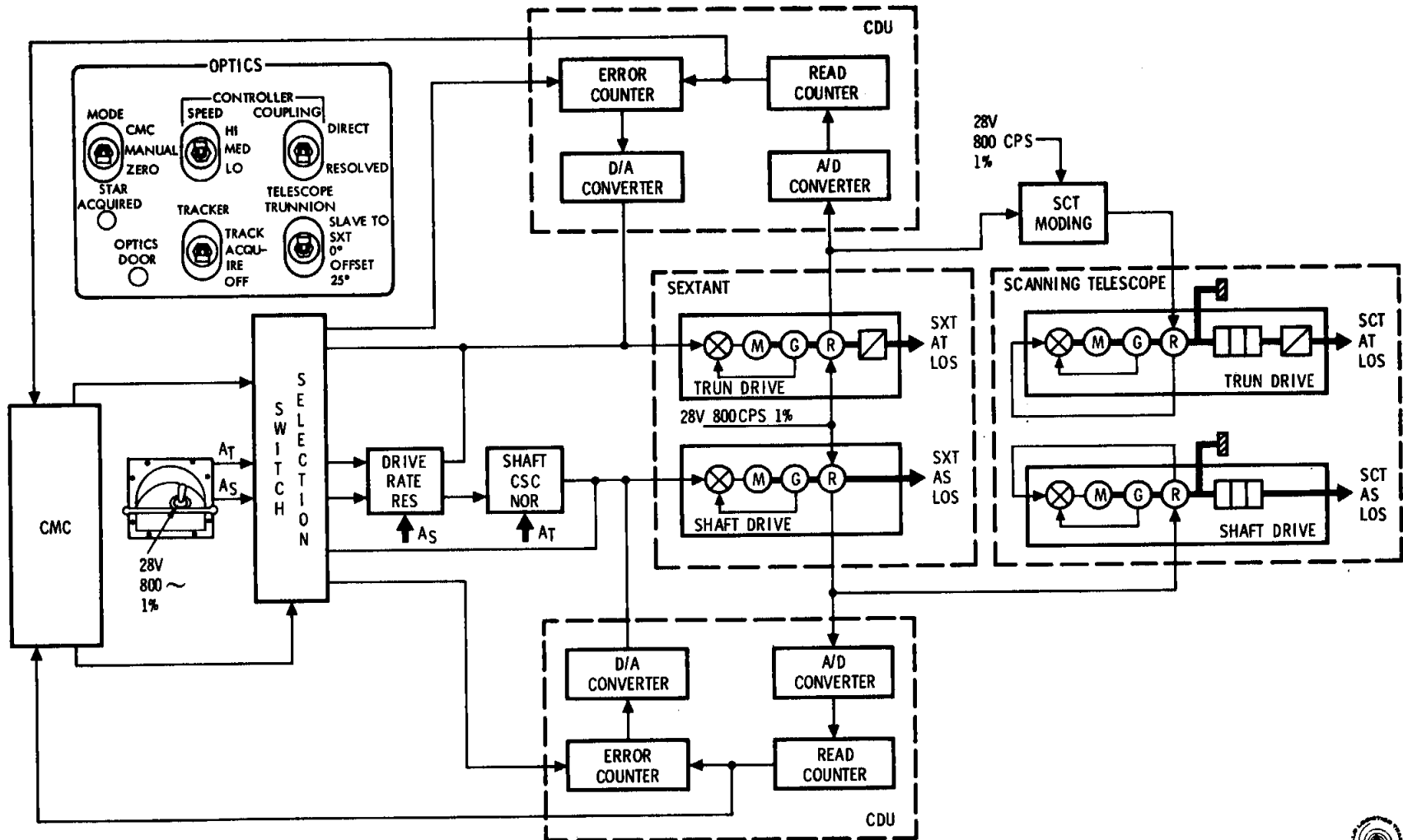



G&N LOWER EQUIPMENT BAY

BLOCK II

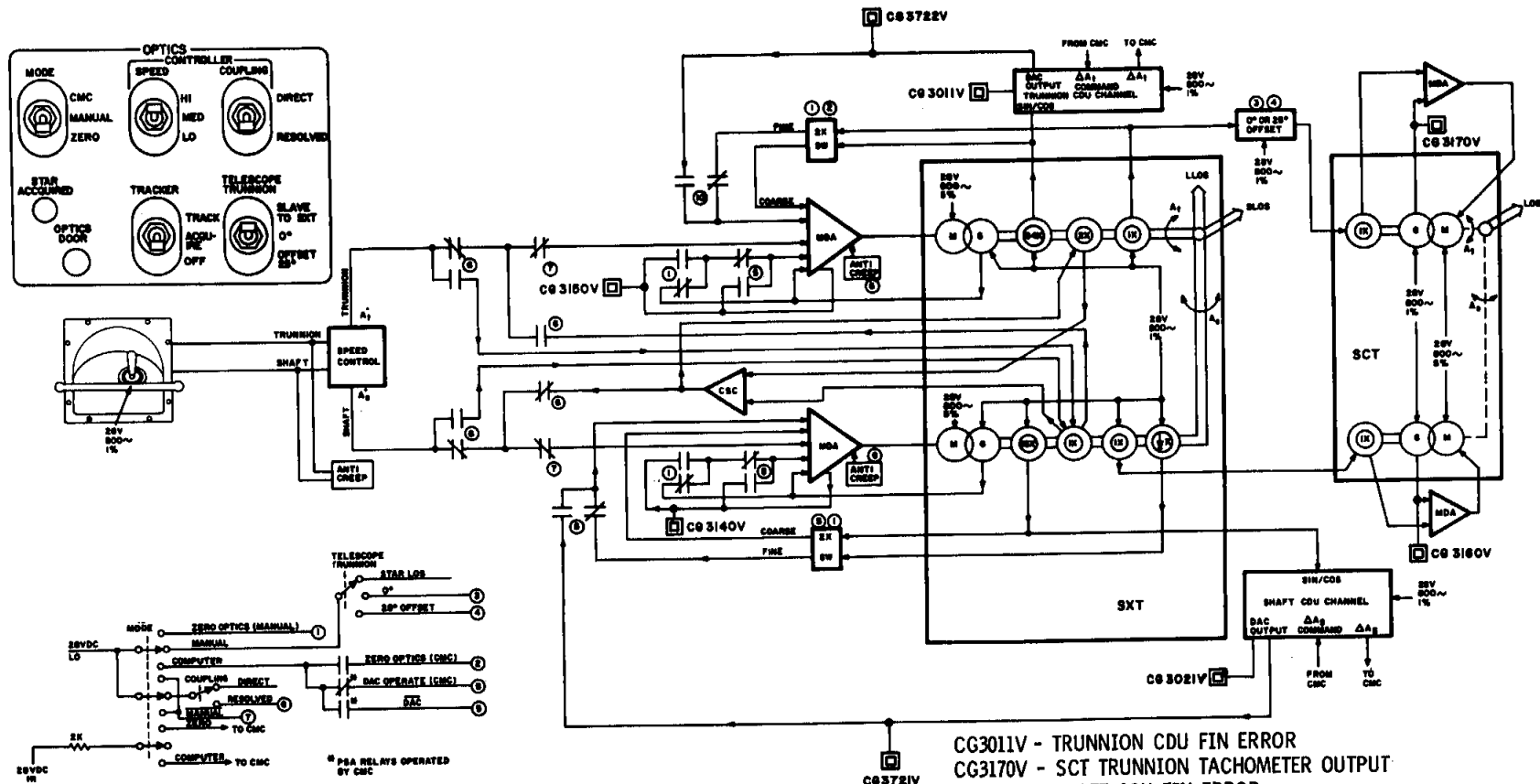


OPTICS MODES



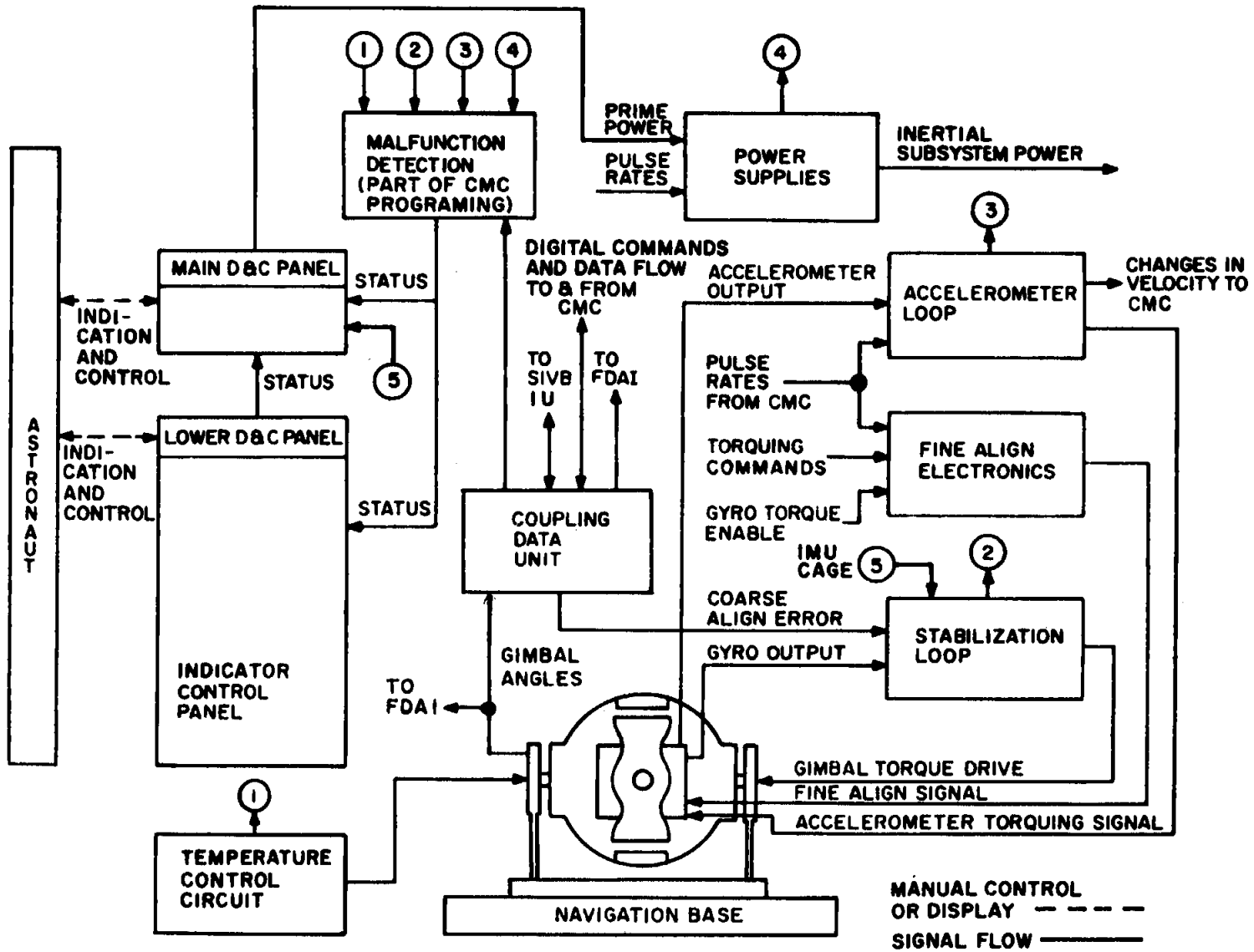
GNC-186 


OPTICS MECHANIZATION



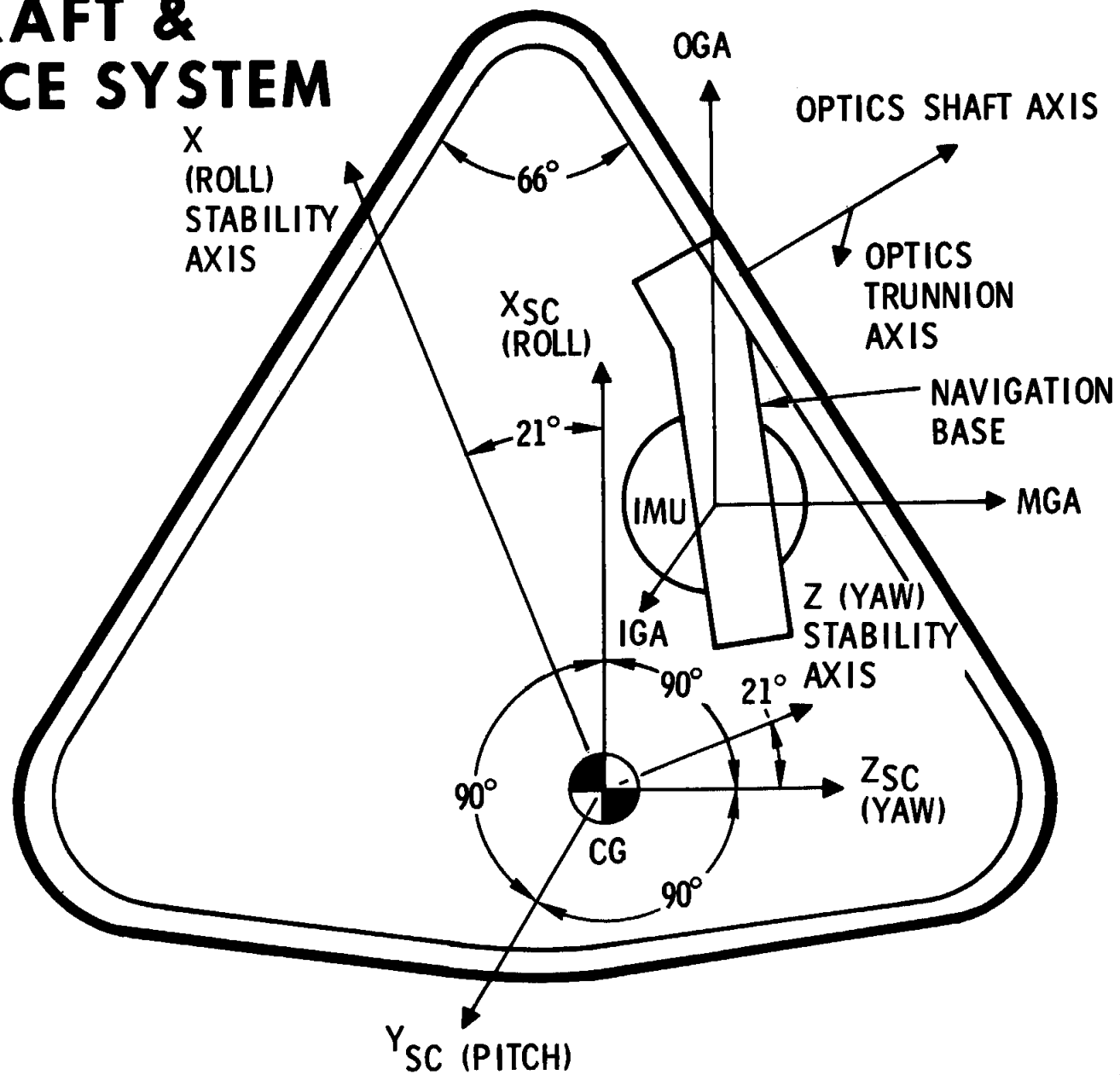
- CG3011V - TRUNNION CDU FIN ERROR
- CG3170V - SCT TRUNNION TACHOMETER OUTPUT
- CG3021V - SHAFT CDU FIN ERROR
- CG3160V - SCT SHAFT TACHOMETER OUTPUT
- CG3722V - TRUNNION CDU DAC OUTPUT
- CG3150V - SXT TRUNNION TACHOMETER OUTPUT
- CG3140V - SXT SHAFT TACHOMETER OUTPUT
- CG3721V - SHAFT CDU DAC OUTPUT

INERTIAL SUBSYSTEM INTERFACE

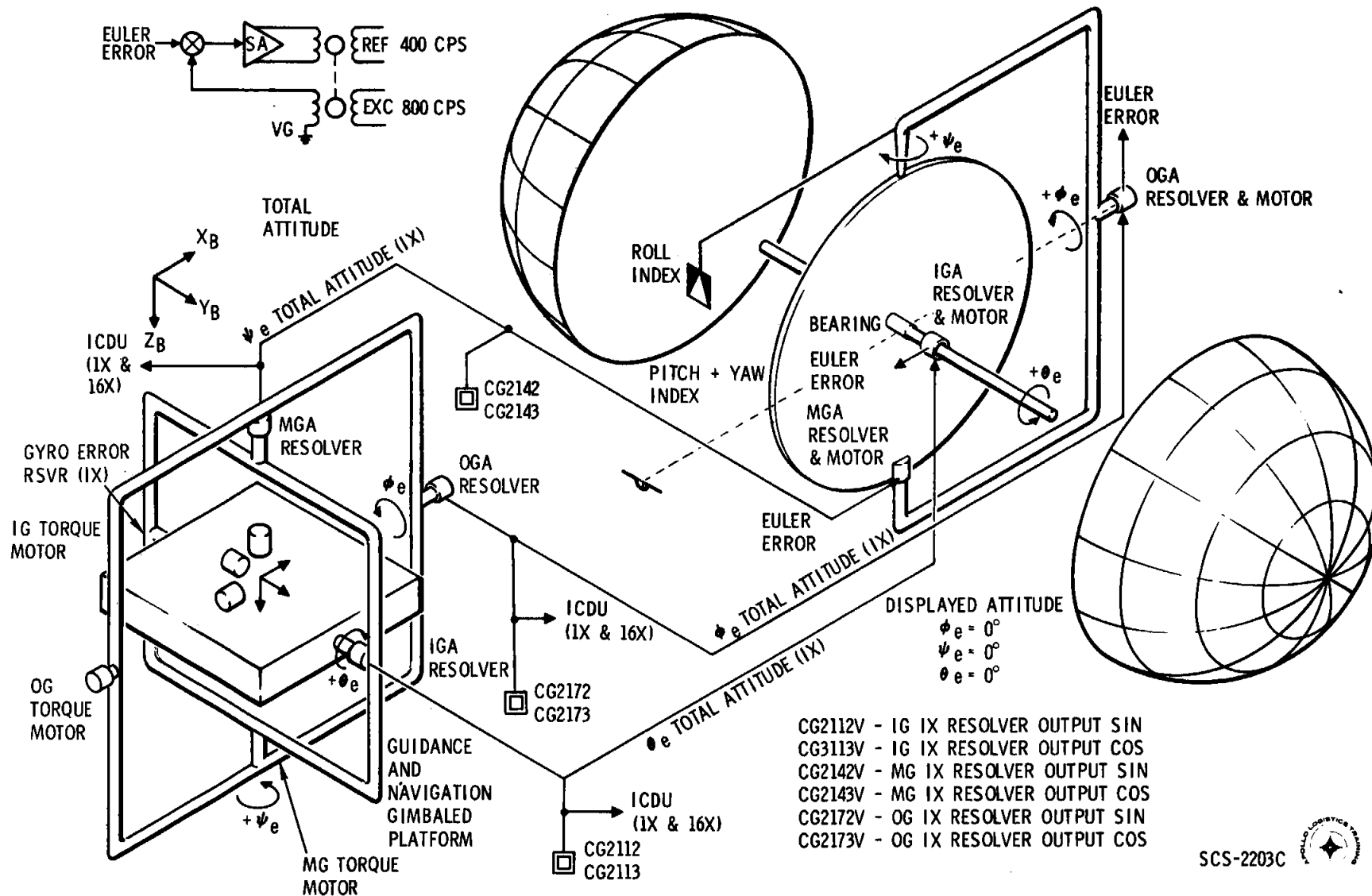


GNC-8 

SPACECRAFT & GUIDANCE SYSTEM AXES



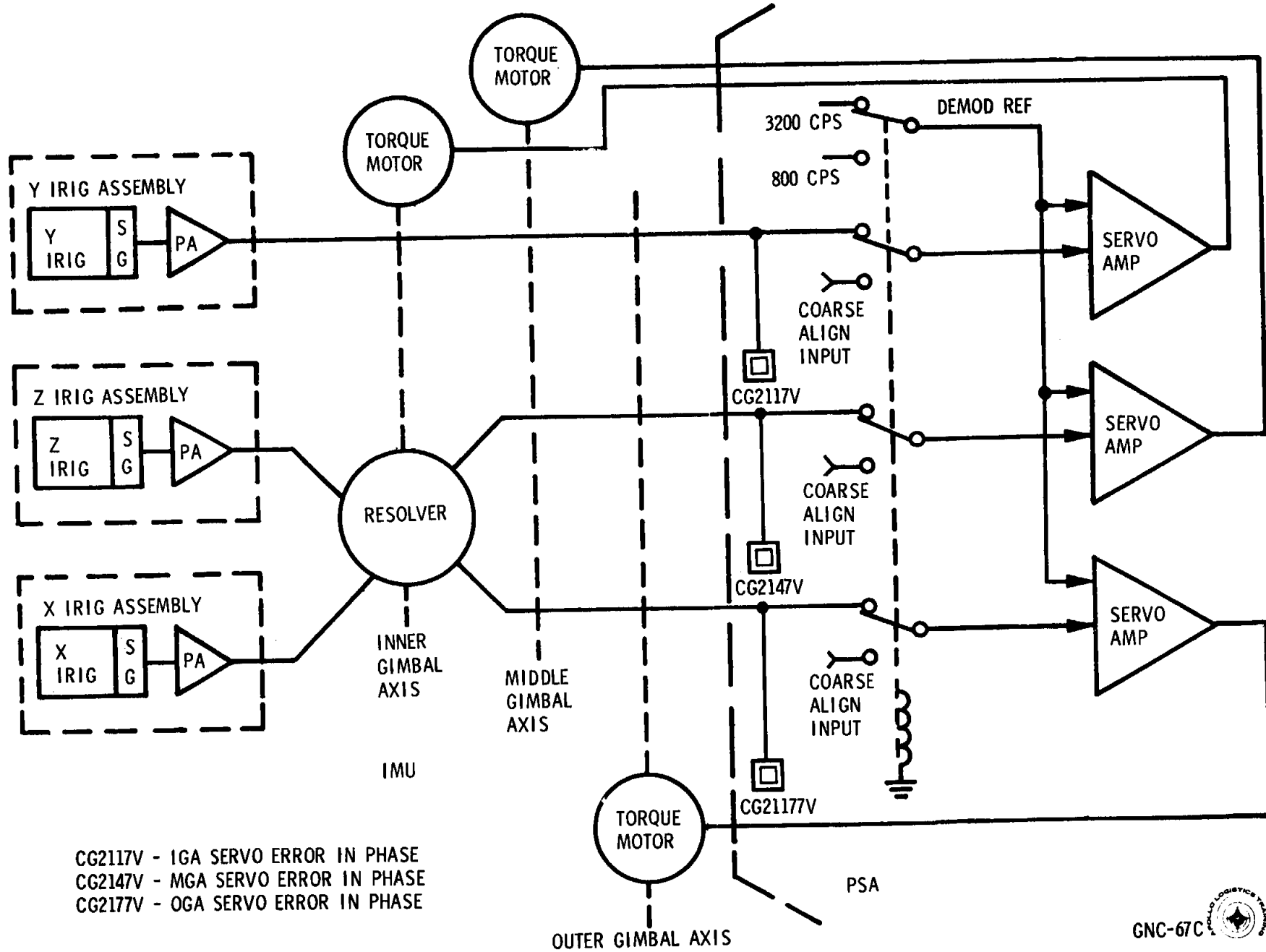
FDAI/IMU GIMBAL RELATIONSHIP



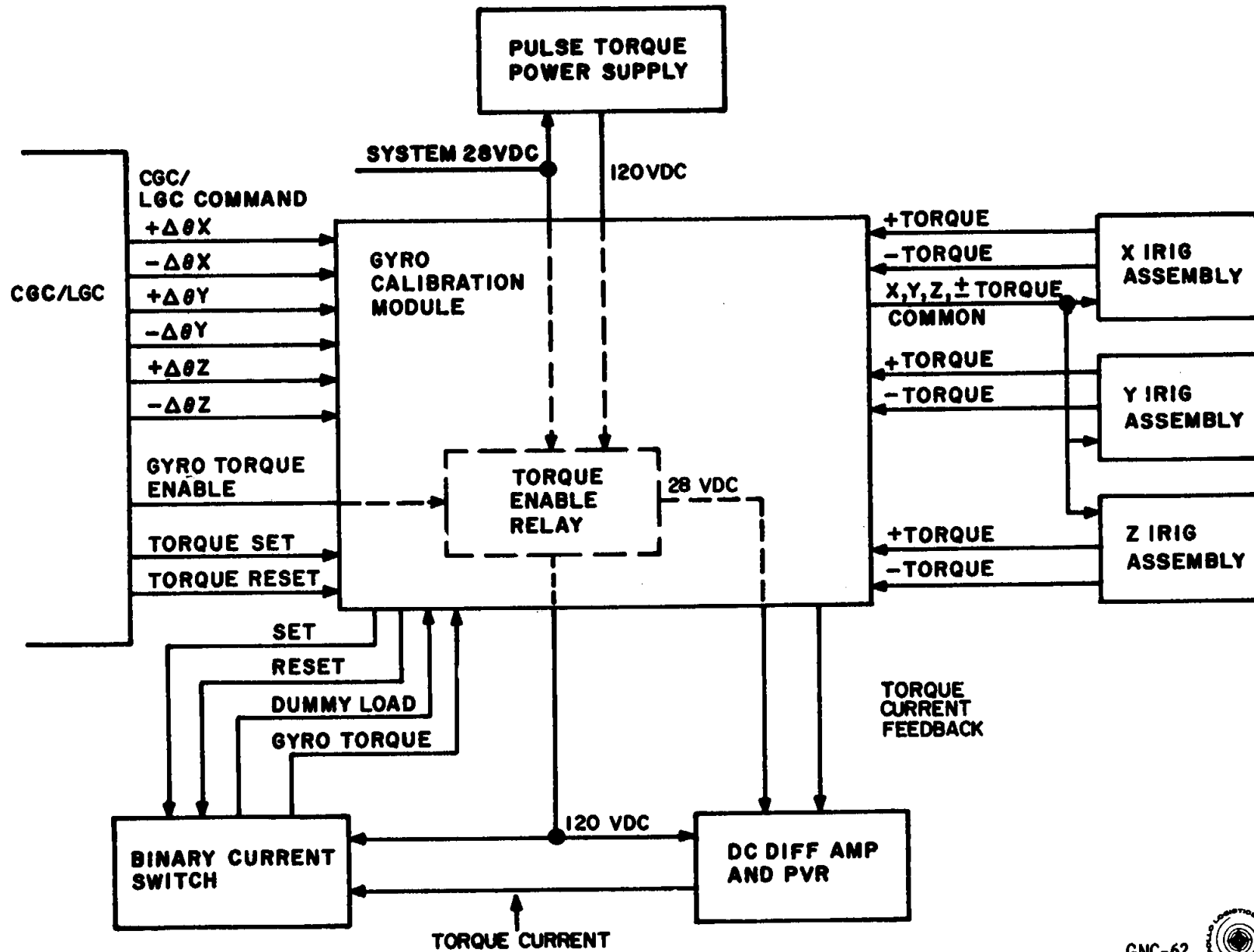
SCS-2203C



BLOCK II STABILIZATION LOOPS



FINE ALIGN ELECTRONICS

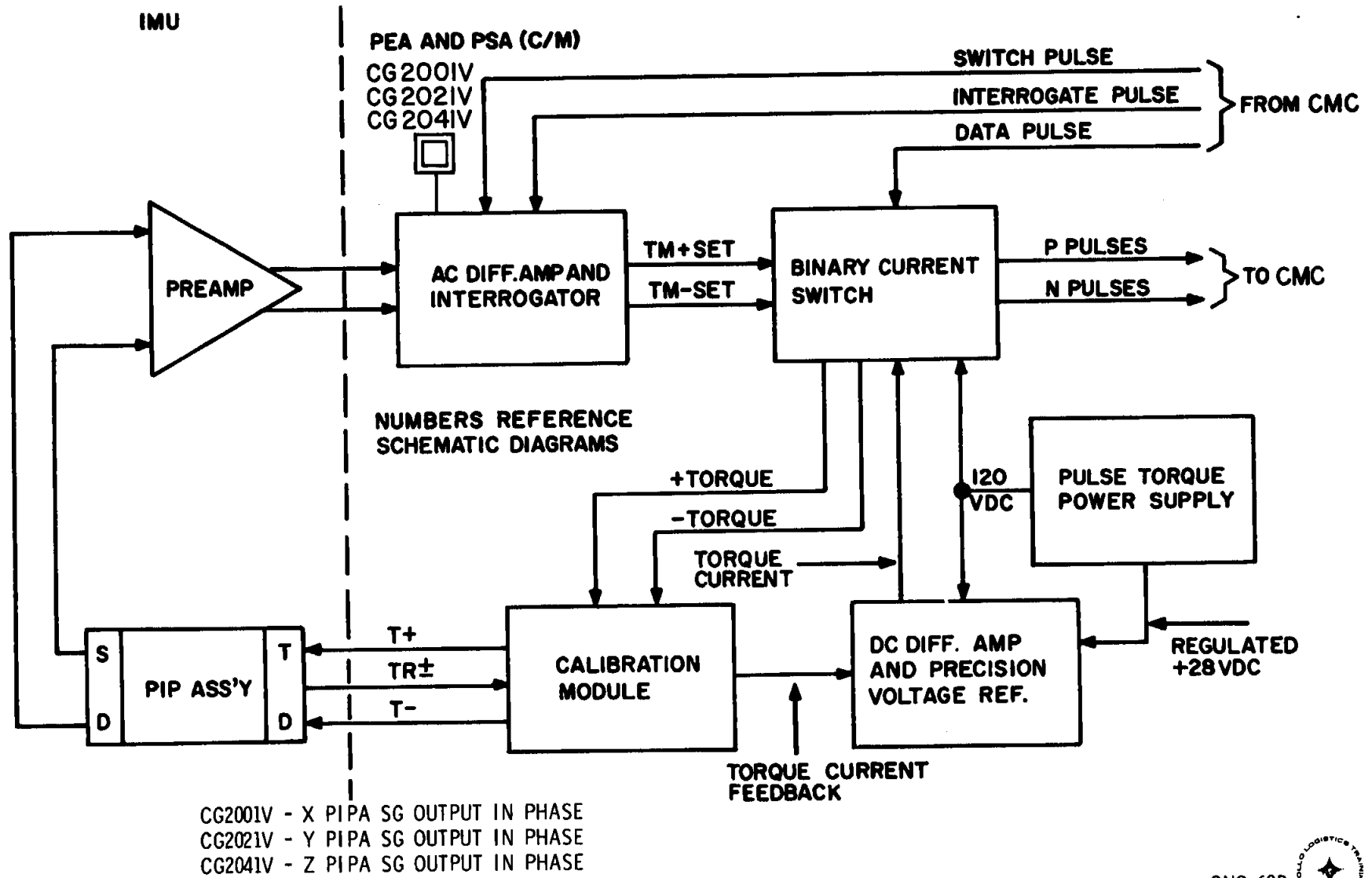


GNC-62

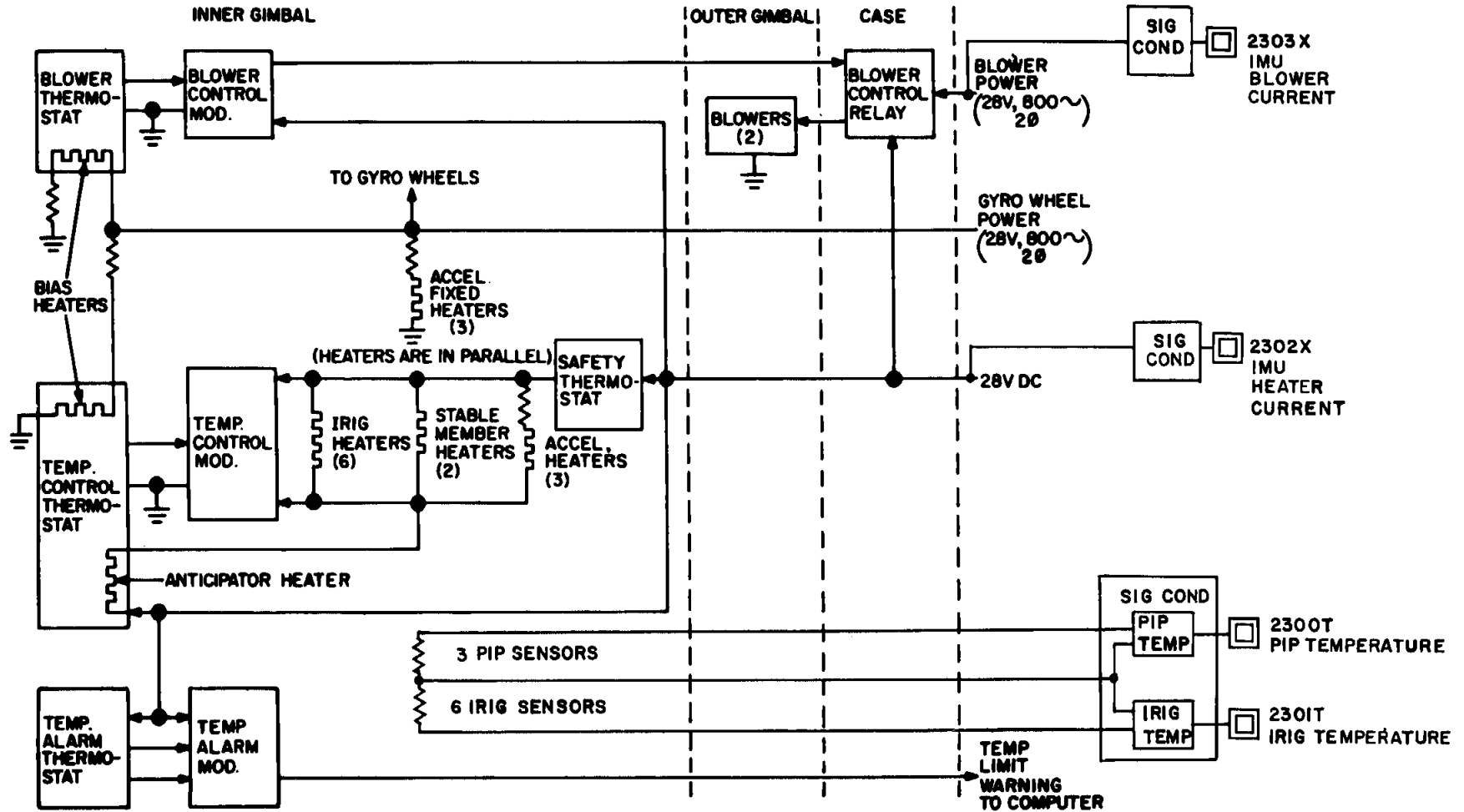


ACCELEROMETER LOOP

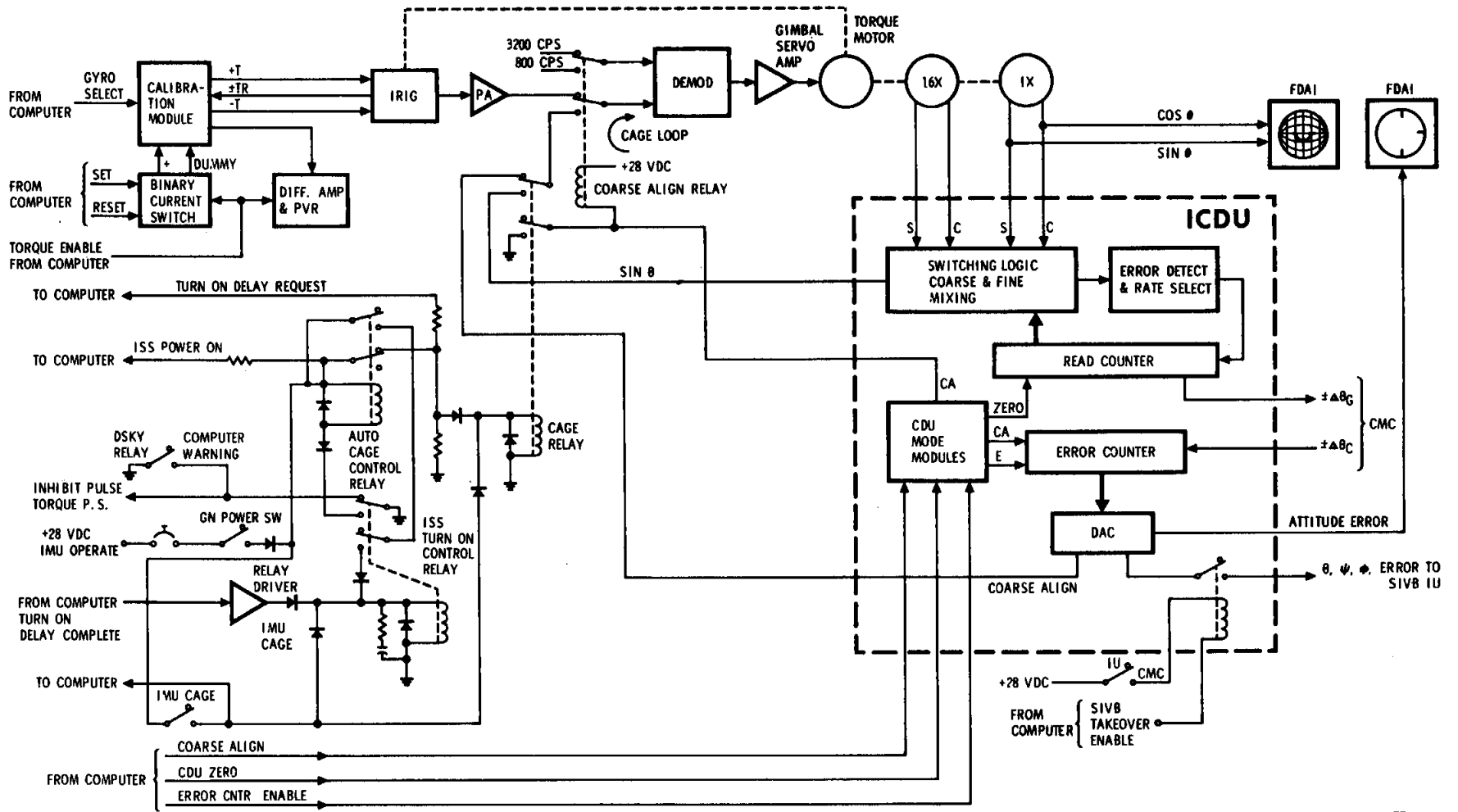
BLOCK II



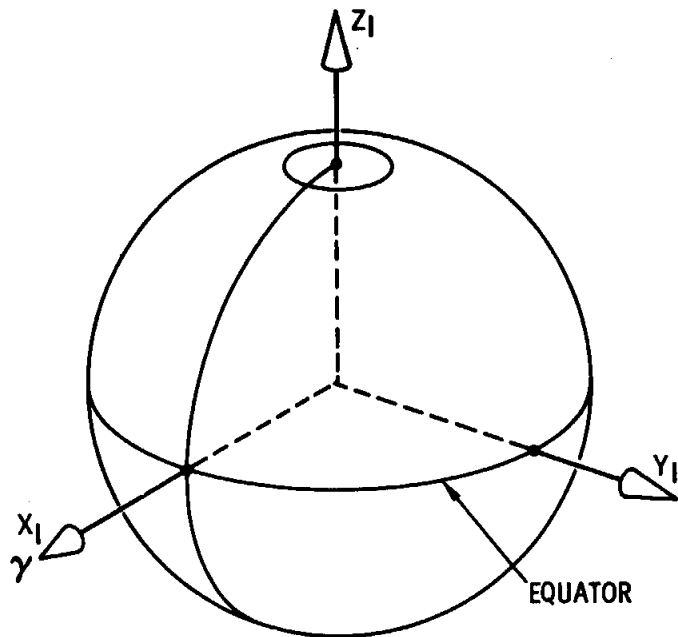
TEMPERATURE CONTROL SYSTEM



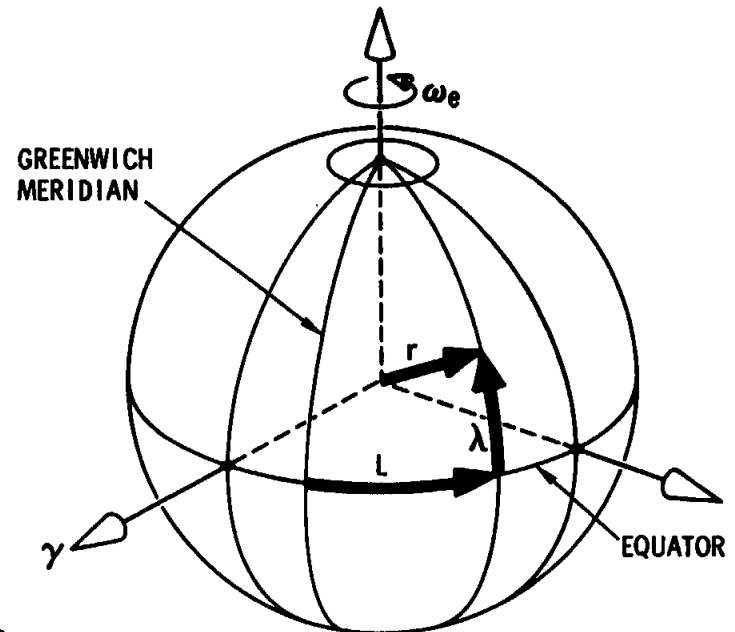
ISS MODES



REFERENCE COORDINATE SYSTEMS

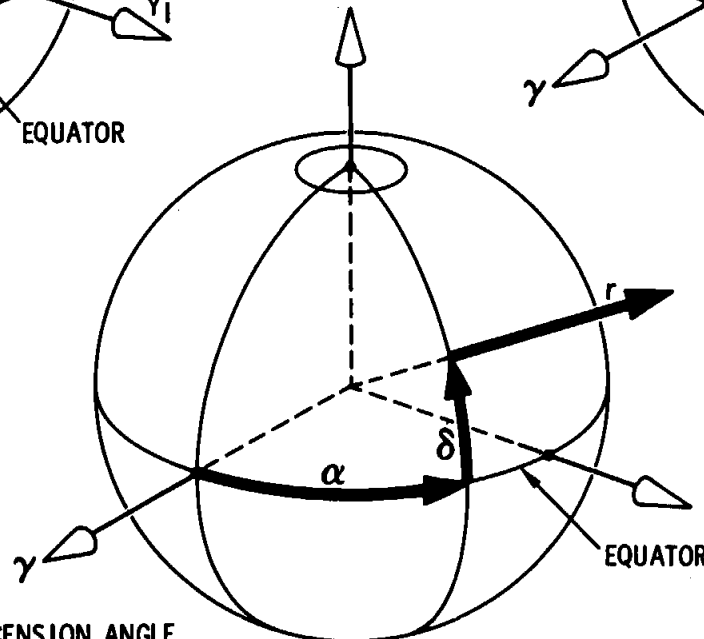


GEOCENTRIC CARTESIAN
INERTIAL FIXED



GEODETTIC POLAR
ROTATING

L = LONGITUDE
λ = LATITUDE
r = EARTH RADIUS VECTOR

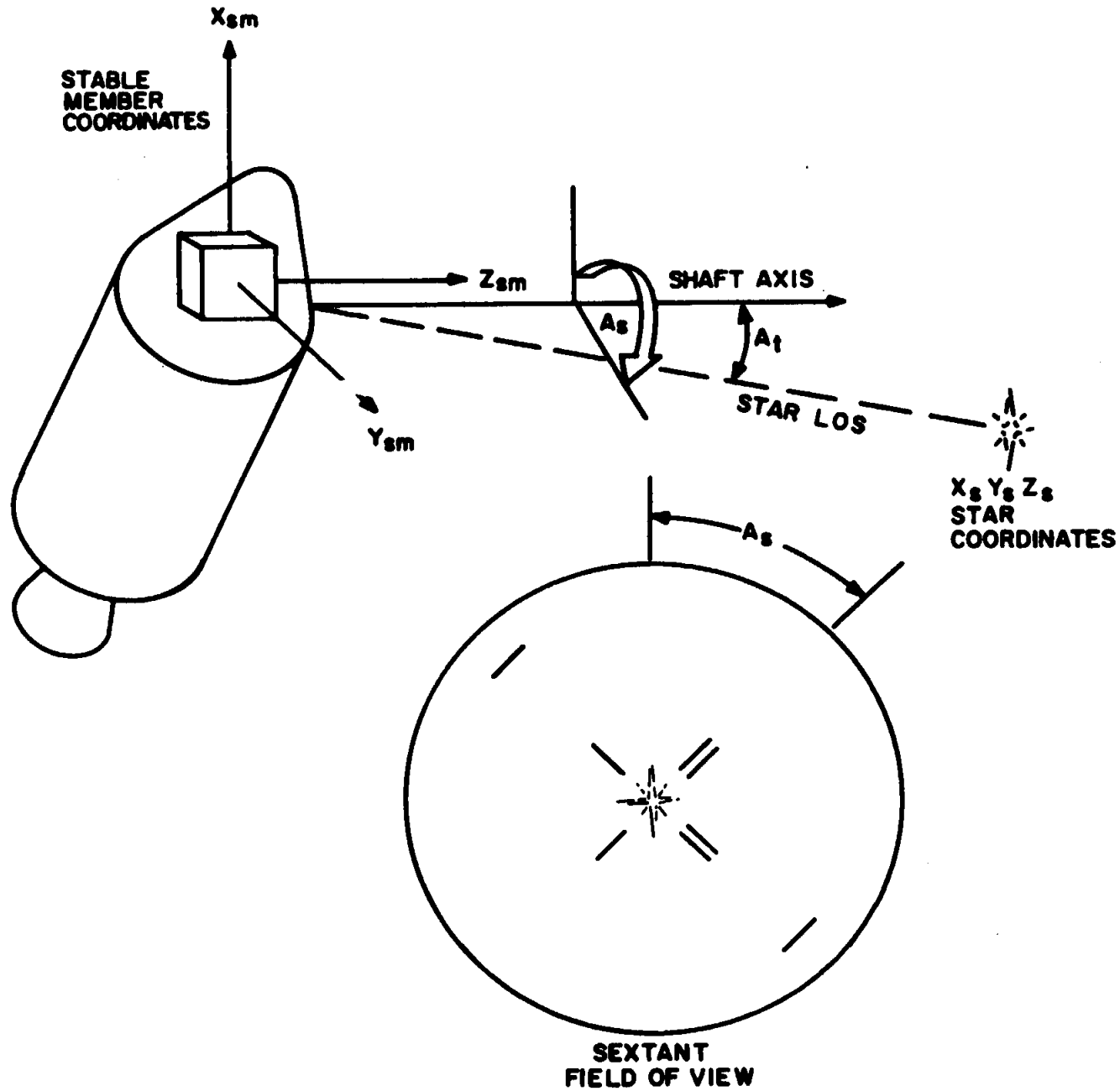


GEOCENTRIC POLAR
INERTIAL FIXED

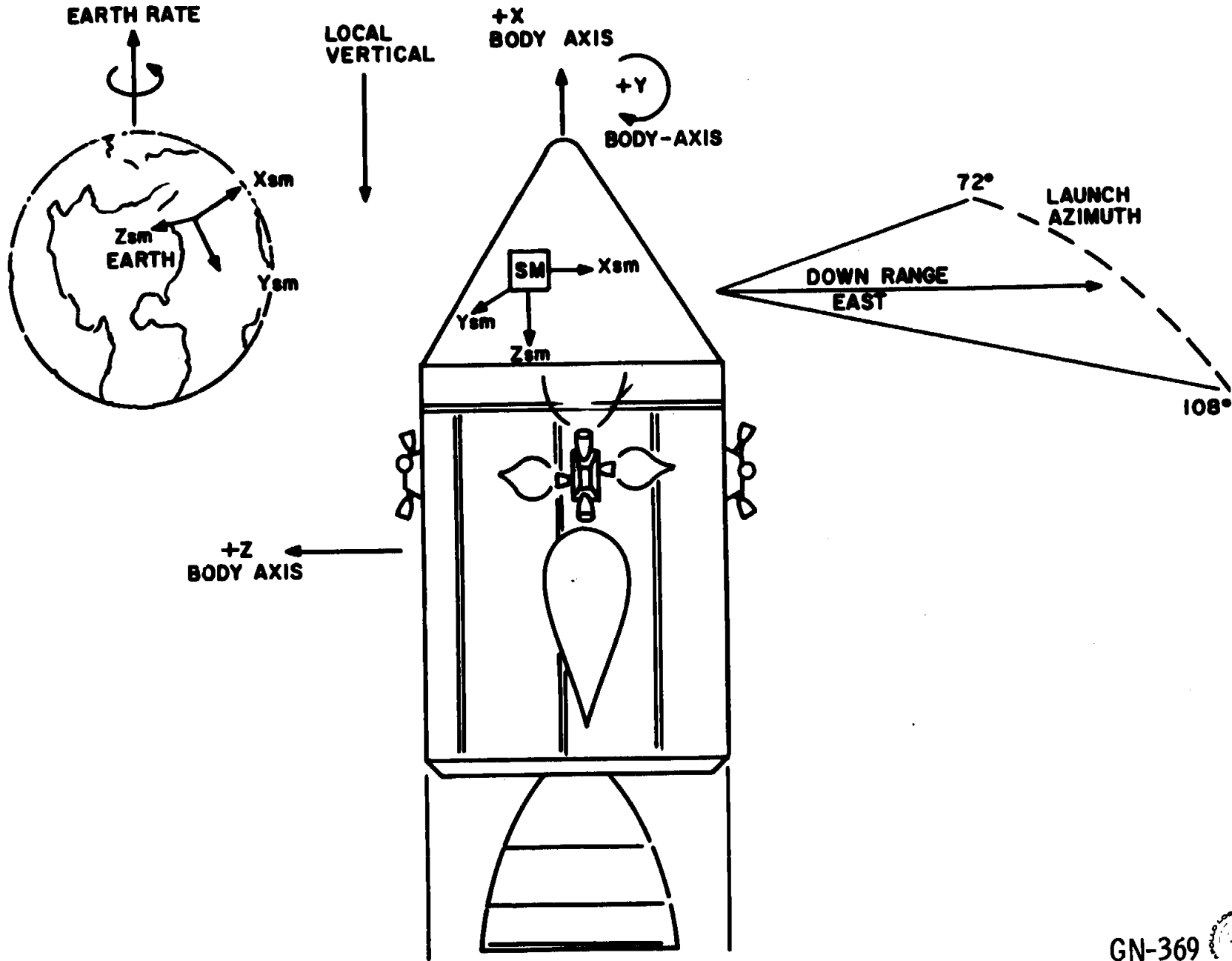
α = RIGHT ASCENSION ANGLE
δ = DECLINATION ANGLE
r = POSITION VECTOR

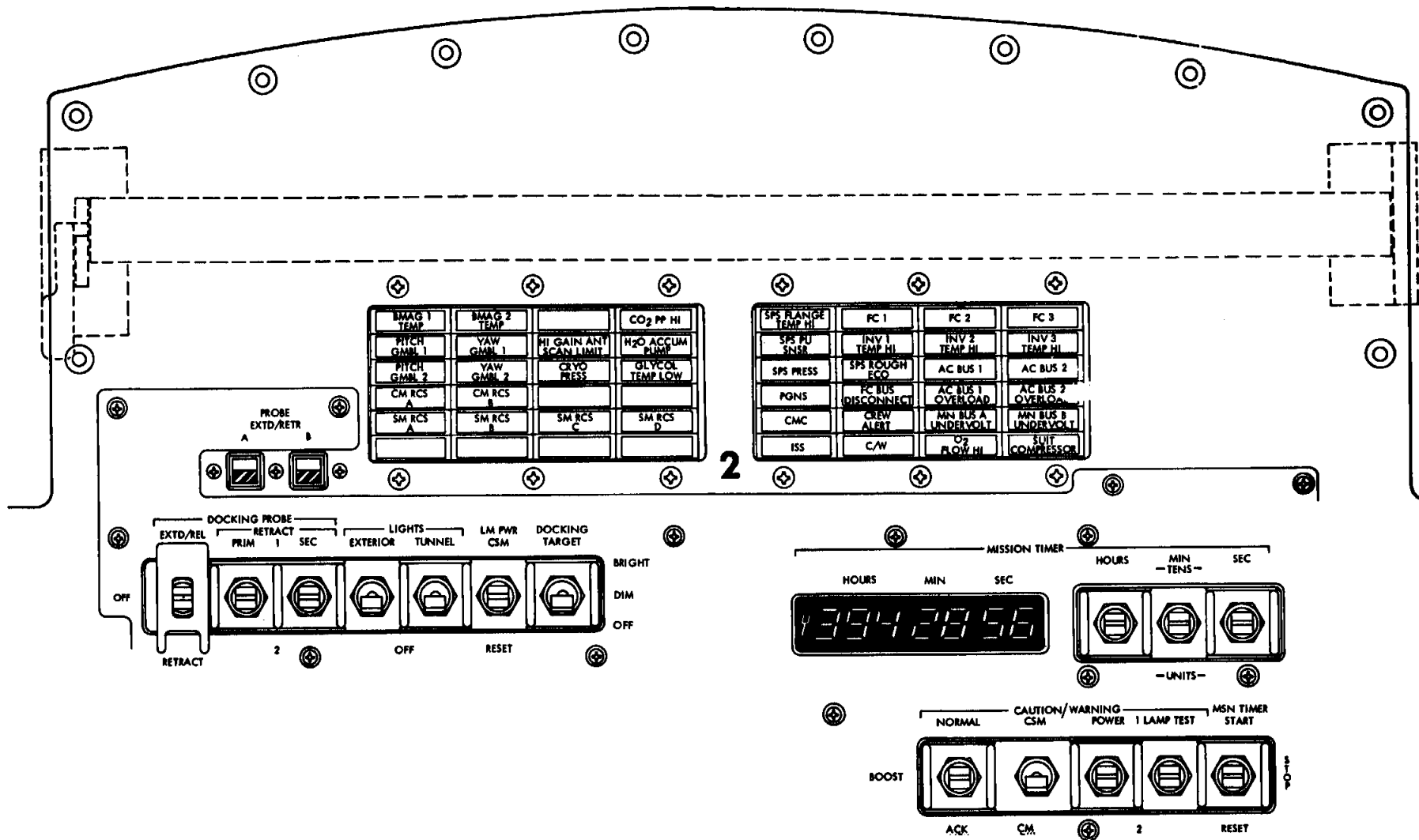


IMU ALIGNMENT MEASUREMENT



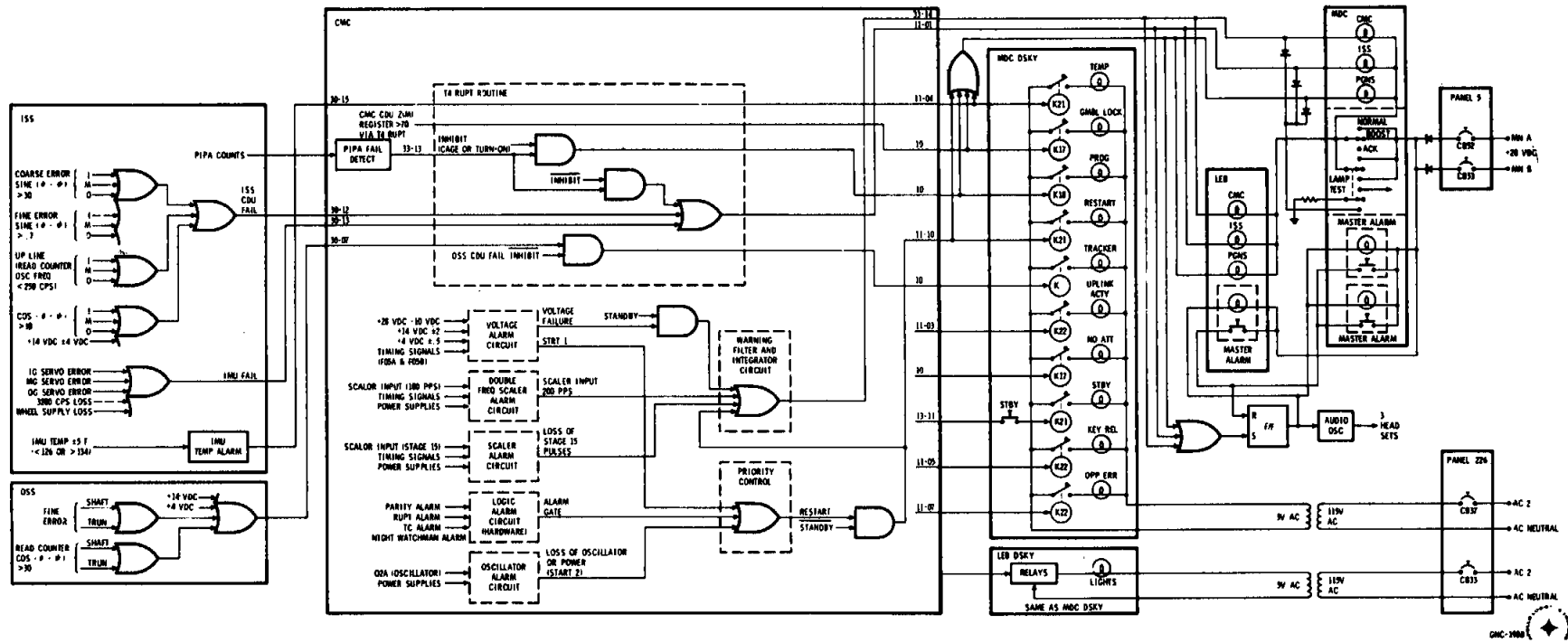
PRELAUNCH ALIGNMENT



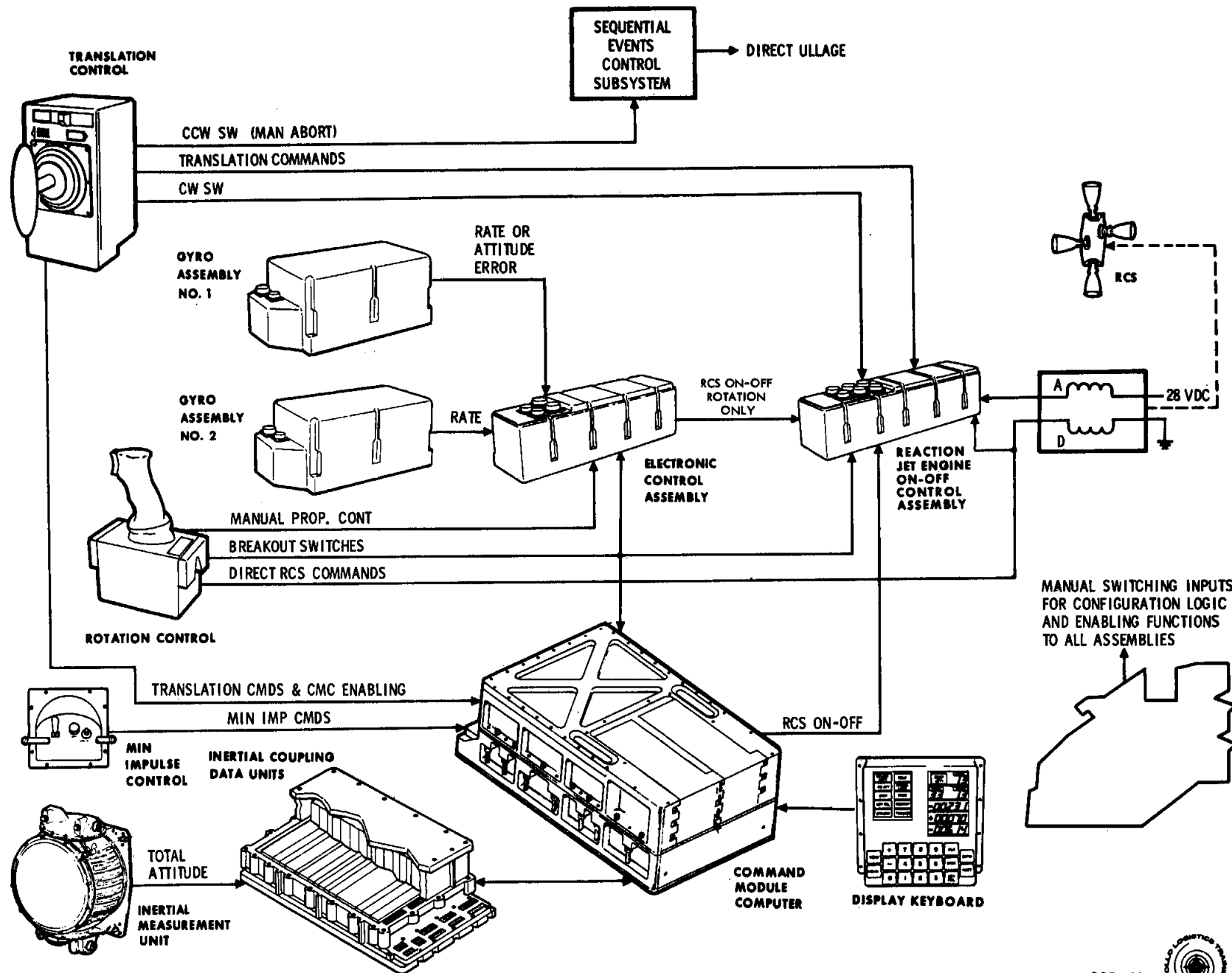


PN-2C-1

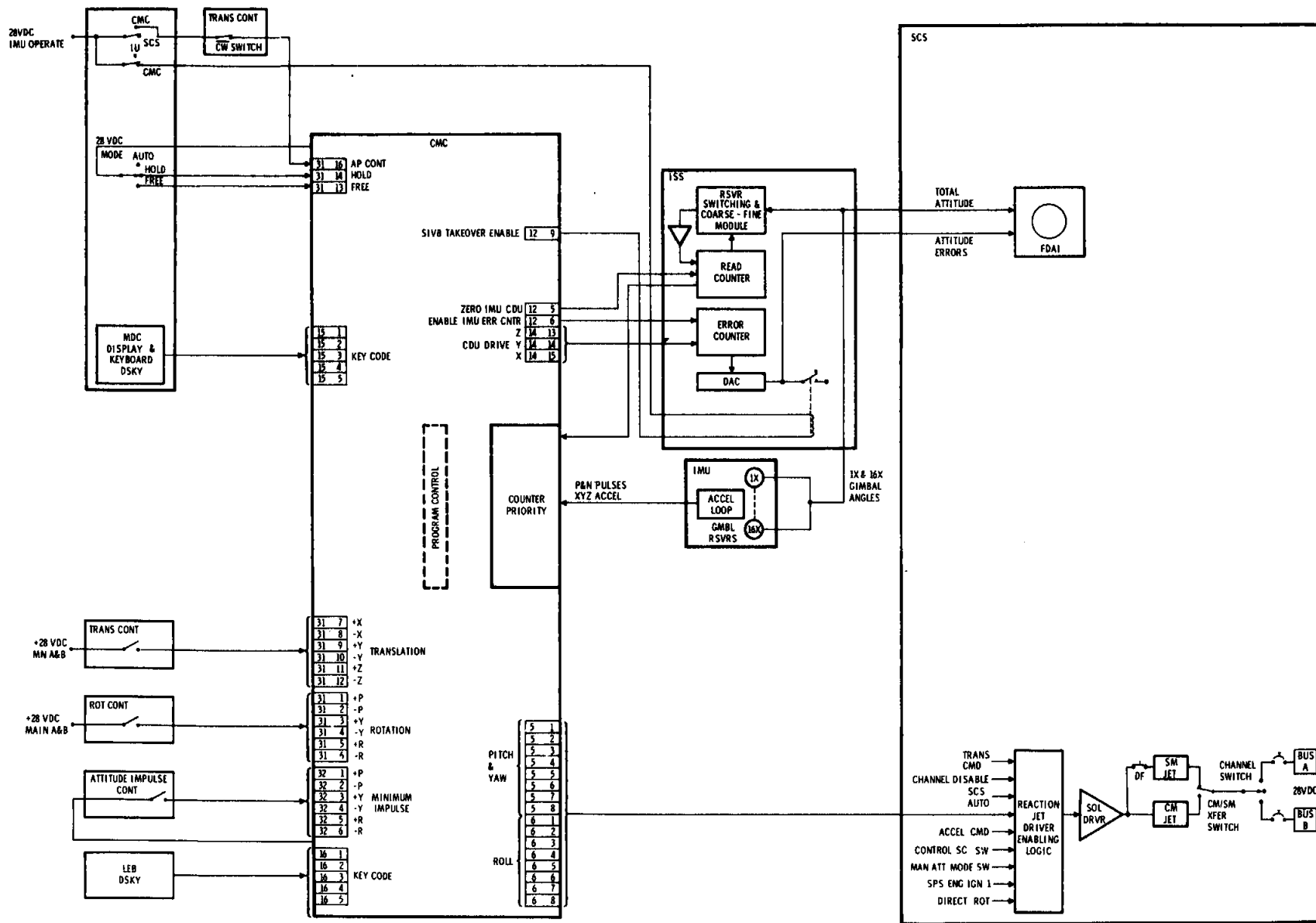
CAUTION & WARNING



G&C ATTITUDE CONTROL

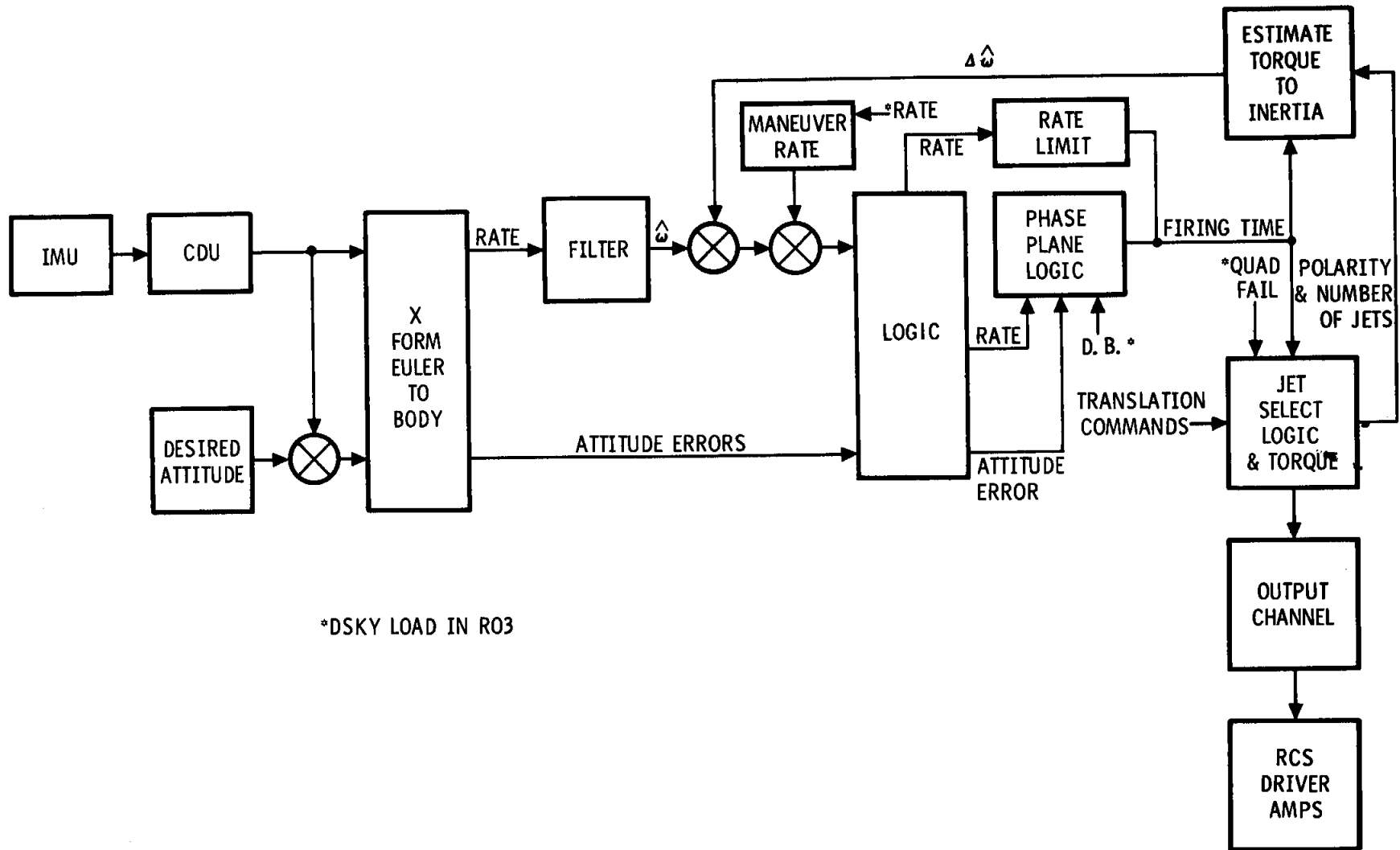


ATTITUDE CONTROL FUNCTIONAL BLOCK DIAGRAM



RCS DAP

SIMPLIFIED BLOCK DIAGRAM



*DSKY LOAD IN R03

DAP DATA LOAD PROCEDURE (RO3)

1. V48E
2. DAP DATA 1 (Specify A/P configuration)
FLV04 N46 (Request data load)
Load data

	Vehicle Config.	Quad A/C for \ddot{X}	Quad B/D for \ddot{X}	Err Deadband	Rate Select
R1	0 = CM 1 = CSM 2 = CSM & LM 3 = CSM & SIVB	0 = No A/C 1 = A/C	0 = No B/D 1 = B/D	0 = $\pm 0.5^\circ$ 1 = $\pm 5.0^\circ$	0 = 0.05°/sec 1 = 0.2°/sec 2 = 0.5°/sec 3 = 4.0°/sec
	Roll Quad Select	Quad A Fail	Quad B Fail	Quad C Fail	Quad D Fail
R2	0 = A/C 1 = B/D	0 = Fail 1 = No Fail	0 = Fail 1 = NoFail	0 = Fail 1 = No Fail	0 = Fail 1 = No Fail

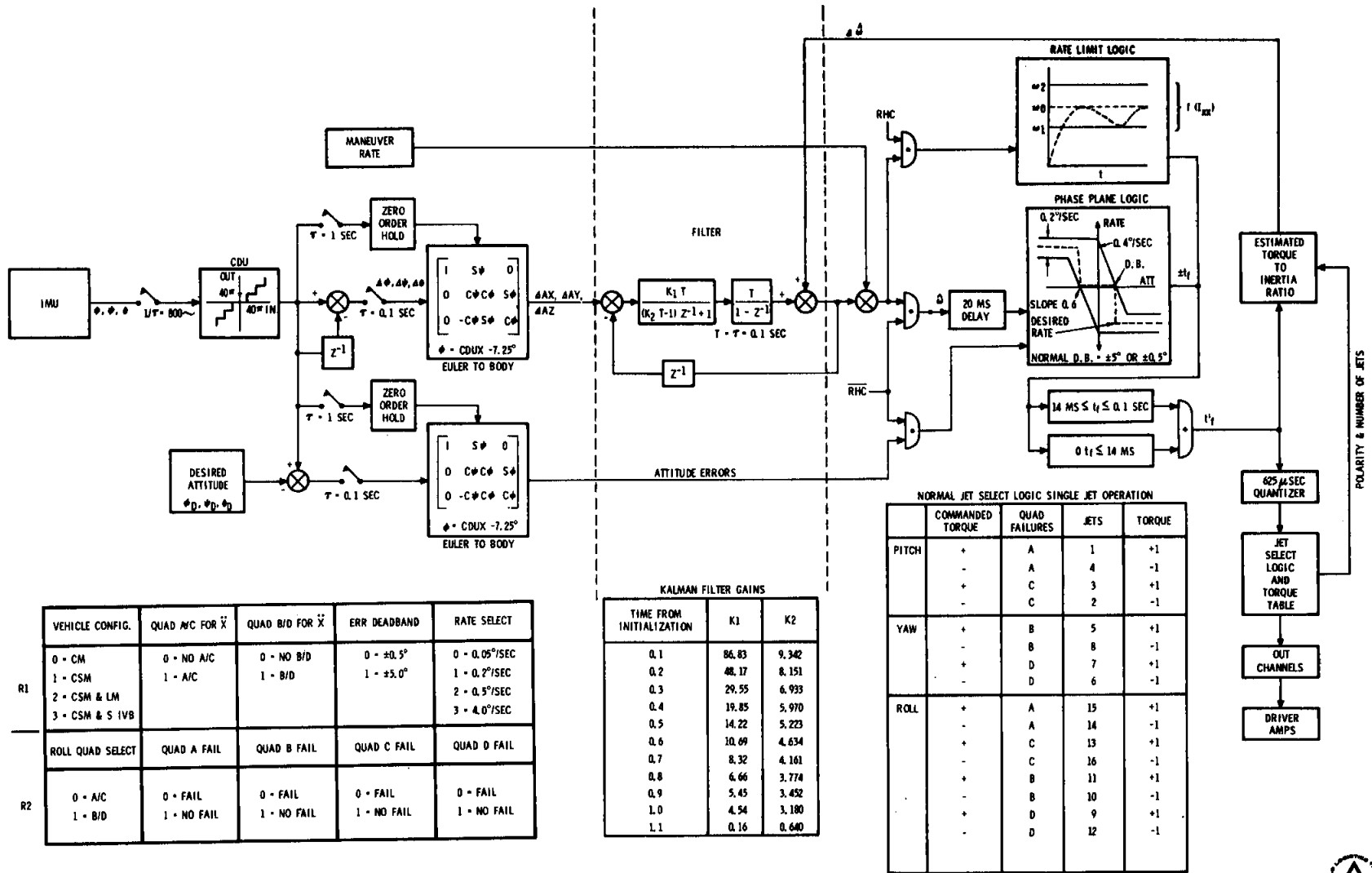
Accept V33E
Reject V24E (Reload data)

3. DAP DATA 2 (Mass parameters)
FLV06 N47 [\ddot{X} , 1/2 ($\dot{Y}+\dot{Z}$), \dot{W}]
Accept V33E
Reject V25E (Reload data)
4. DAP DATA 3 (Mass/propulsion parameters)
FLV06 N48 (P trim, Y trim, TLX)
Accept V33E
Reject V25E (Reload data)
5. V46E [Establish G/C control (DAP active)]

NOTE:
EXTENDED VERB 48 PROGRAMS
AND CALLS DAP DATA 1, 2, & 3 IN
SEQUENTIAL ORDER. DAP DATA 1 OR 2
OR 3 MAY ALSO BE CALLED AND/OR
LOADED INDIVIDUALLY BY USING
THE RESPECTIVE VERB, NOUN
COMBINATIONS. I.E. V04 N46,
V06 N47 OR V06 N48.

SM-2A-1305A

RCS DAP MODEL



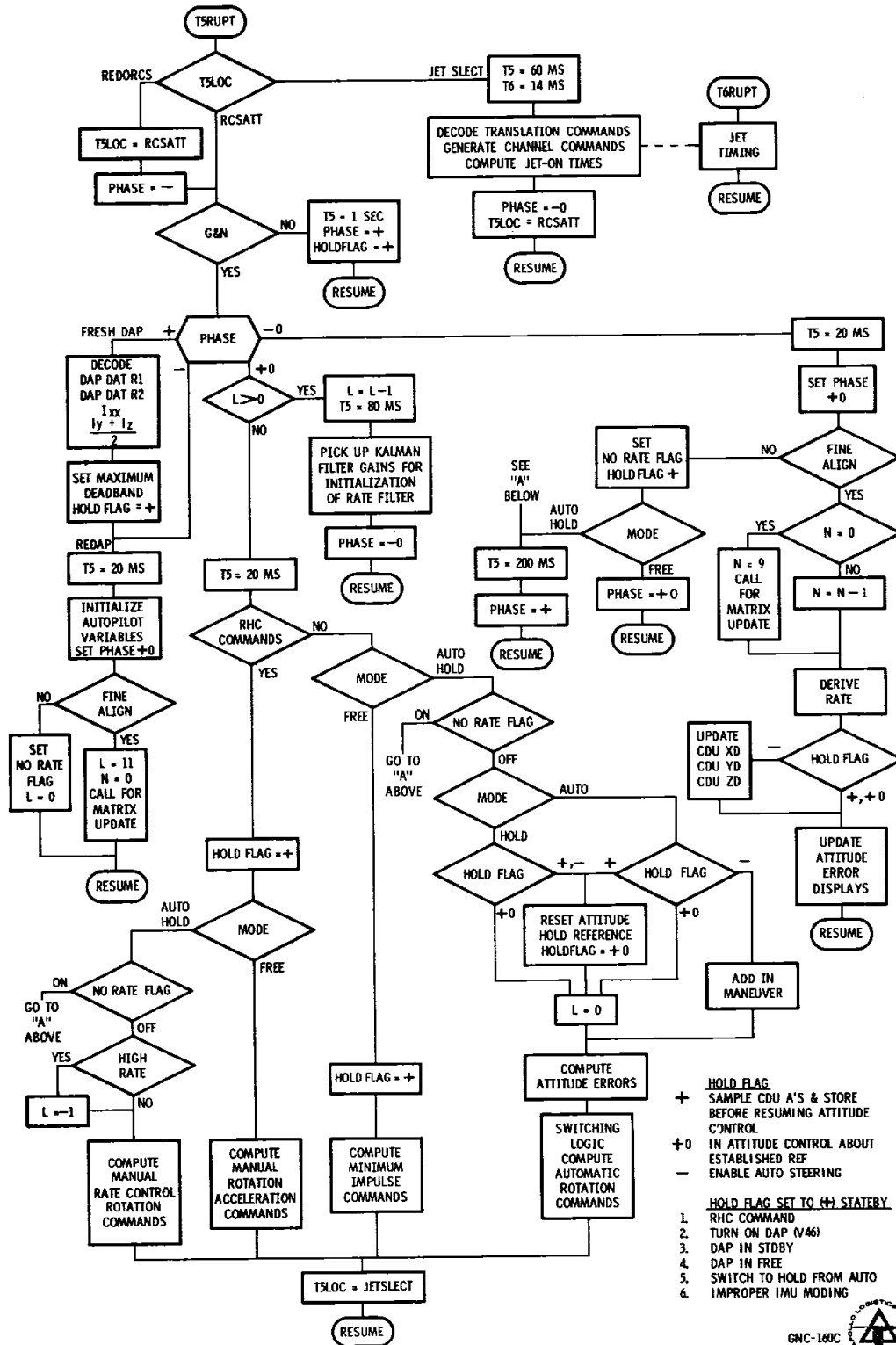
VEHICLE CONFIG.	QUAD A/C FOR \ddot{x}	QUAD B/D FOR \ddot{x}	ERR DEADBAND	RATE SELECT
0 - CM	0 - NO A/C	0 - NO B/D	0 - $\pm 0.5^\circ$	0 - $0.05^\circ/\text{SEC}$
1 - CSM	1 - A/C	1 - B/D	1 - $\pm 3.0^\circ$	1 - $0.2^\circ/\text{SEC}$
2 - CSM & LM				2 - $0.5^\circ/\text{SEC}$
3 - CSM & S IVB				3 - $4.0^\circ/\text{SEC}$
ROLL QUAD SELECT	QUAD A FAIL	QUAD B FAIL	QUAD C FAIL	QUAD D FAIL
0 - A/C	0 - FAIL	0 - FAIL	0 - FAIL	0 - FAIL
1 - B/D	1 - NO FAIL	1 - NO FAIL	1 - NO FAIL	1 - NO FAIL

TIME FROM INITIALIZATION	K1	K2
0.1	86.83	9.342
0.2	48.17	8.151
0.3	29.55	6.933
0.4	19.85	5.970
0.5	14.22	5.223
0.6	10.69	4.634
0.7	8.32	4.161
0.8	6.66	3.774
0.9	5.45	3.452
1.0	4.54	3.180
1.1	0.16	0.640

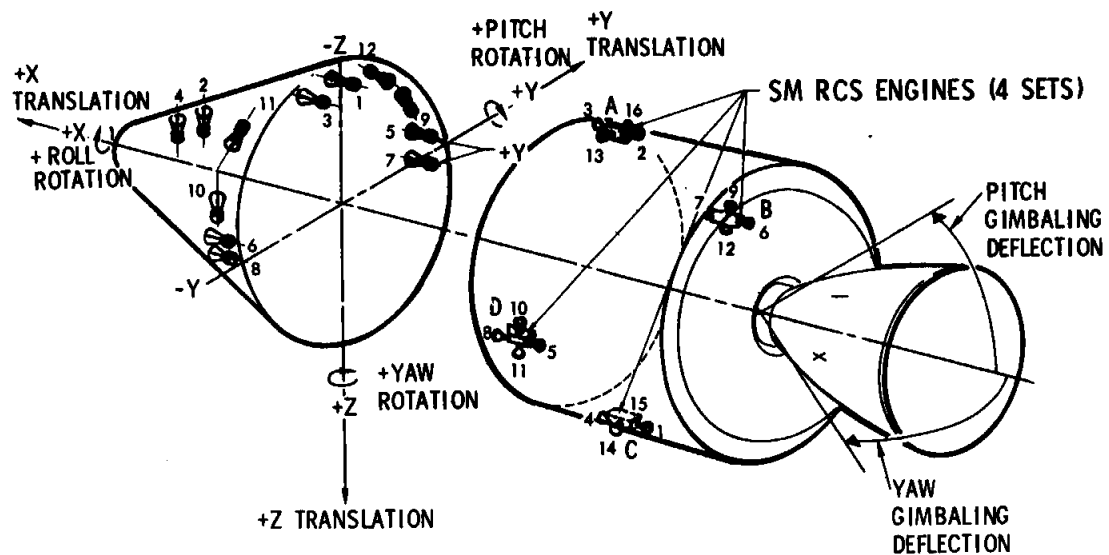
	COMMANDED TORQUE	QUAD FAILURES	JETS	TORQUE
PITCH	+	A	1	+1
	-	A	4	-1
	+	C	3	+1
	-	C	2	-1
YAW	+	B	5	+1
	-	B	8	-1
	+	D	7	+1
	-	D	6	-1
ROLL	+	A	15	+1
	-	A	14	-1
	+	C	13	+1
	-	C	16	-1
	+	B	11	+1
	-	B	10	-1
	+	D	9	+1
	-	D	12	-1



PROGRAM LOGIC FLOW RCS DAP



RCS ENGINE FUNCTIONS



RCS ENG NO.	COMMANDS	QUAD	CHANNEL	CHANNEL SWITCH	
				A	B
1	+X + θ	C	PITCH	A CB'S	B
2	+X - θ	A	PITCH	A CB'S	B
3	-X + θ	A	PITCH	B CB'S	A
4	-X - θ	C	PITCH	B CB'S	A
5*	+X + ψ	D	YAW	B CB'S	A
6	+X - ψ	B	YAW	B CB'S	A
7*	-X + ψ	B	YAW	A CB'S	B
8	-X - ψ	D	YAW	A CB'S	B
9	+Z + ϕ	B	ROLL	A BD ROLL 1 CB'S	B

RCS ENG NO.	COMMANDS	QUAD	CHANNEL	CHANNEL SWITCH	
				A	B
10	+Z - ϕ	D	ROLL	A BD ROLL 2 CB'S	B
11	-Z + ϕ	D	ROLL	A BD ROLL 2 CB'S	B
12	-Z - ϕ	B	ROLL	A BD ROLL 1 CB'S	B
13	+Y + ϕ	A	ROLL	A AC ROLL 1 CB'S	B
14	+Y - ϕ	C	ROLL	A AC ROLL 2 CB'S	B
15	-Y + ϕ	C	ROLL	A AC ROLL 2 CB'S	B
16	-Y - ϕ	A	ROLL	A AC ROLL 1 CB'S	B

* SM ONLY

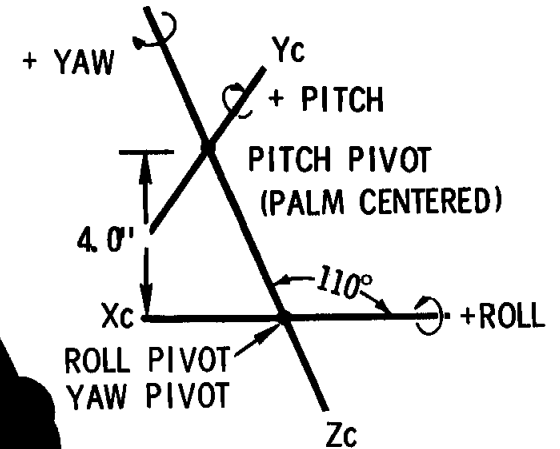
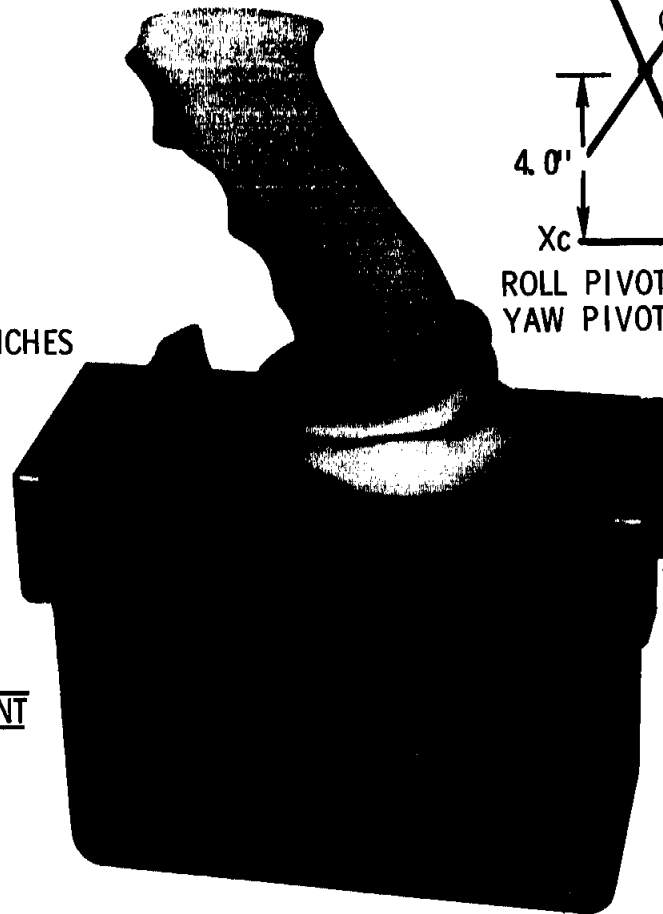
ROTATION CONTROL

PUSH TO TALK SWITCH PARAMETERS

TRAVEL PRIOR TO SWITCH ACTUATION	8.0° MIN
TRAVEL TO HARDSTOP	25.0° MAX
MAXIMUM TORQUE	1.0 POUND INCHES

ROTATION CONTROL PARAMETERS

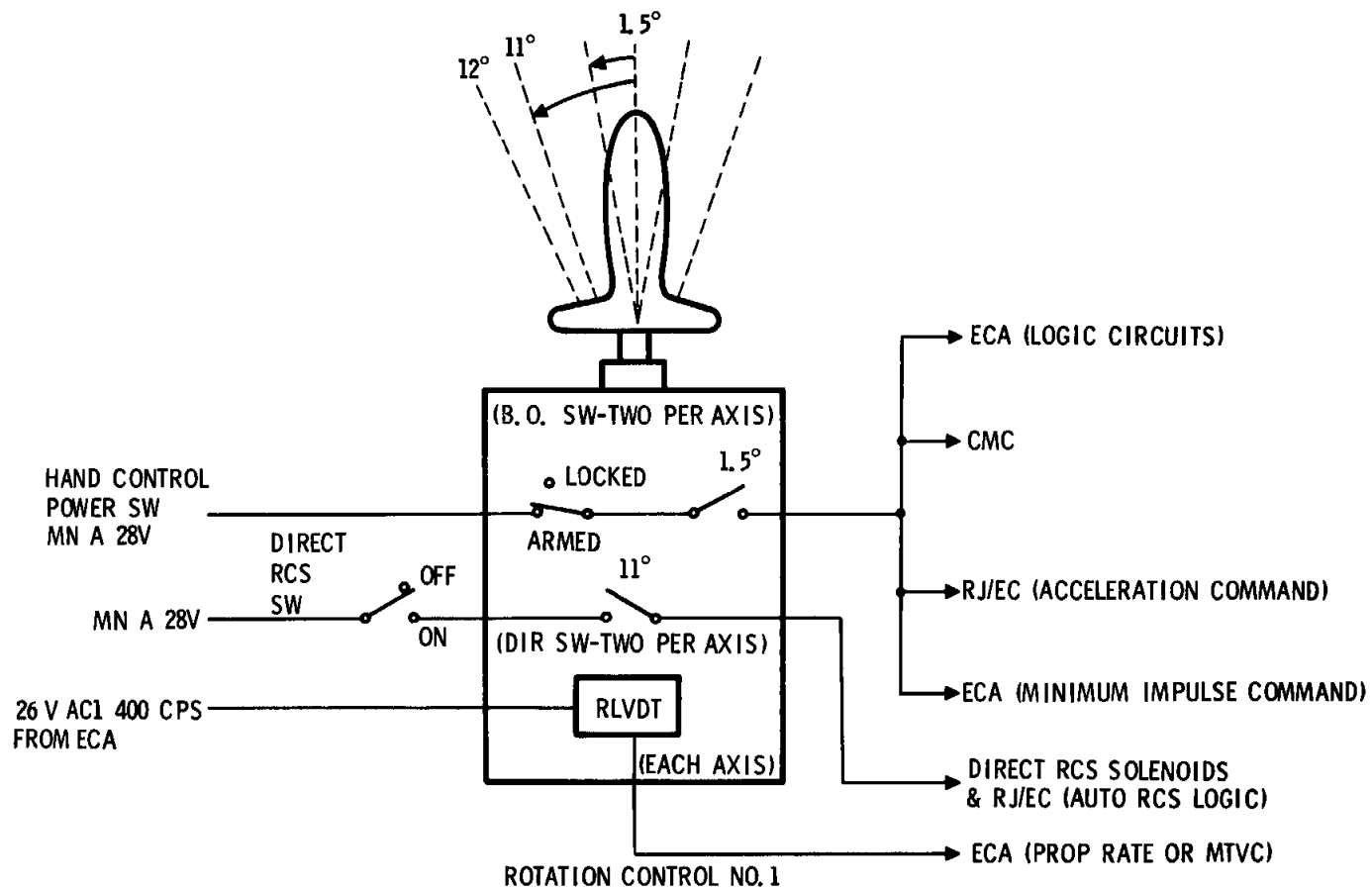
	<u>DISPLACEMENT</u>
HARD STOP	11.5±0.50
DIRECT SWITCH ACTUATION	≈11.0°
SOFT STOP	10±1°
BREAKOUT SWITCH ACTUATION	1.5± 0.5°
CONTROLLER LOCK TO ARM	50.0°



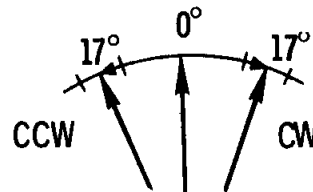
SCS-2002B



ROTATION CONTROL INTERFACES



TRANSLATION CONTROL

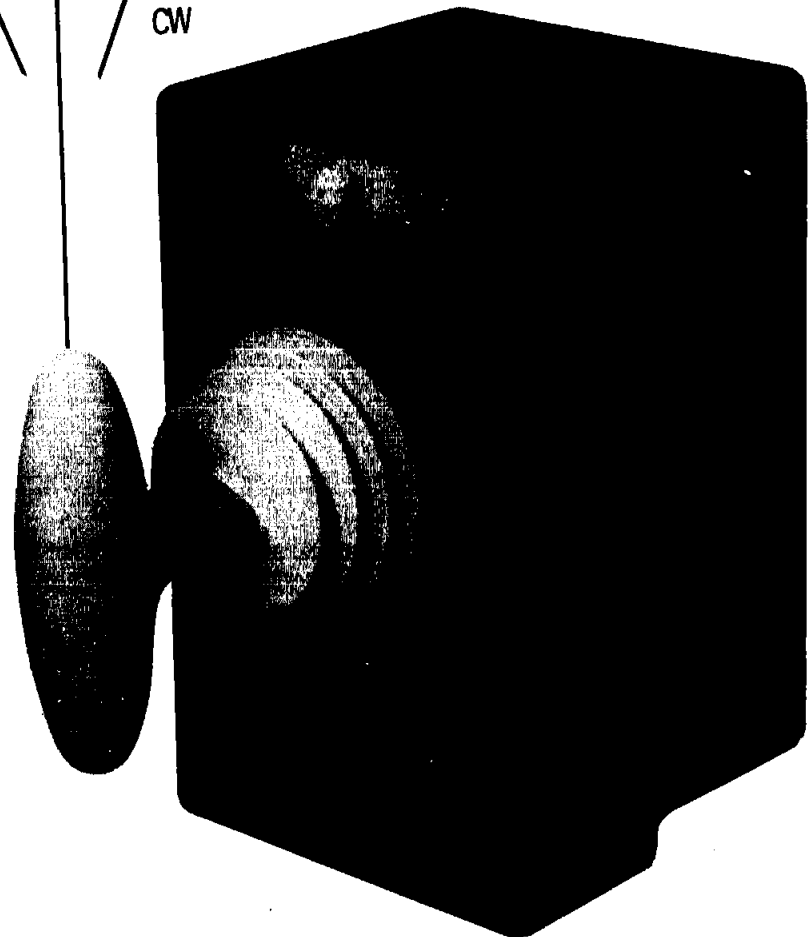
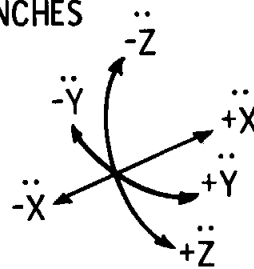


CW & CCW CONTROL MOTION LIMITS

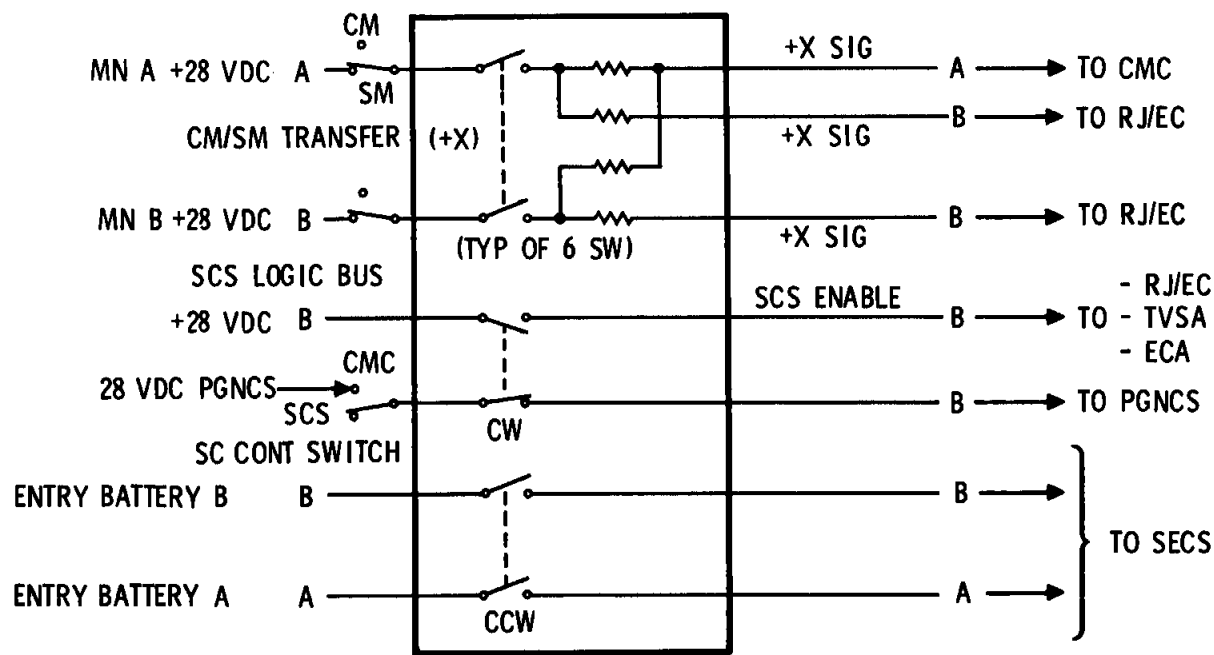
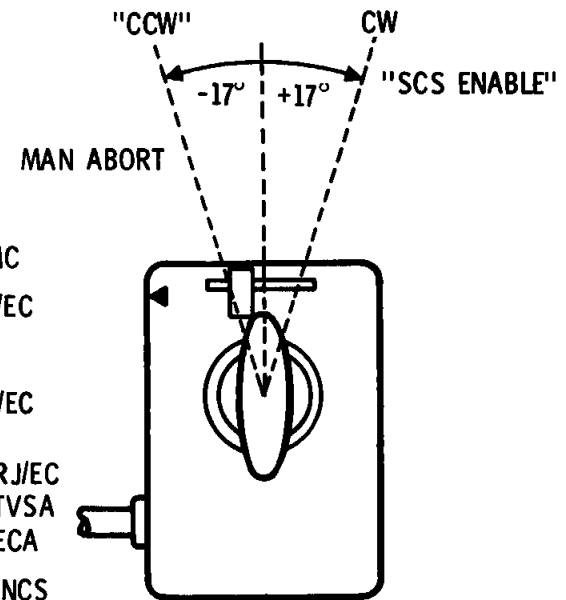
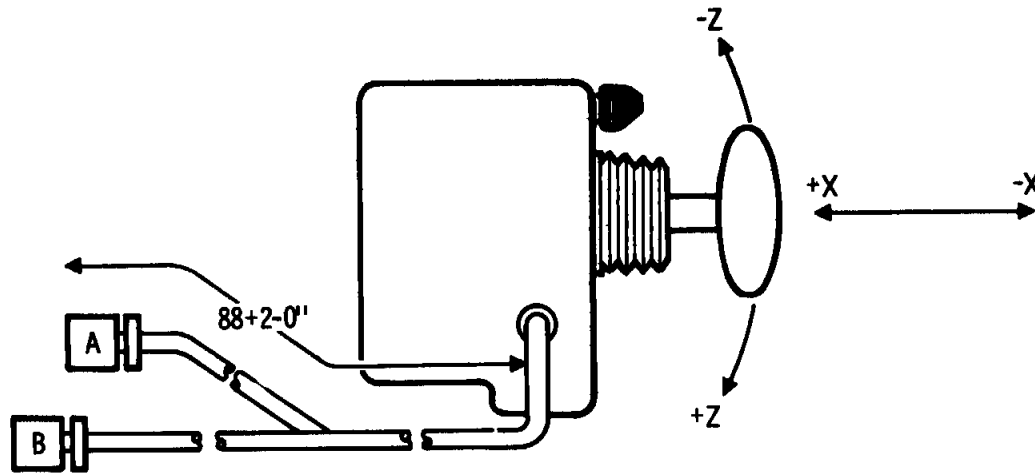
HARD STOP, DETENT & SWITCH CLOSURE	$17^\circ \pm 2^\circ$
FORCE INTO DETENT	15 ± 5.0 LB INCHES
OUT OF DETENT	6 LB INCHES MIN

TRANSLATION CONTROL MOTION LIMITS (+ OR - COMMANDS)

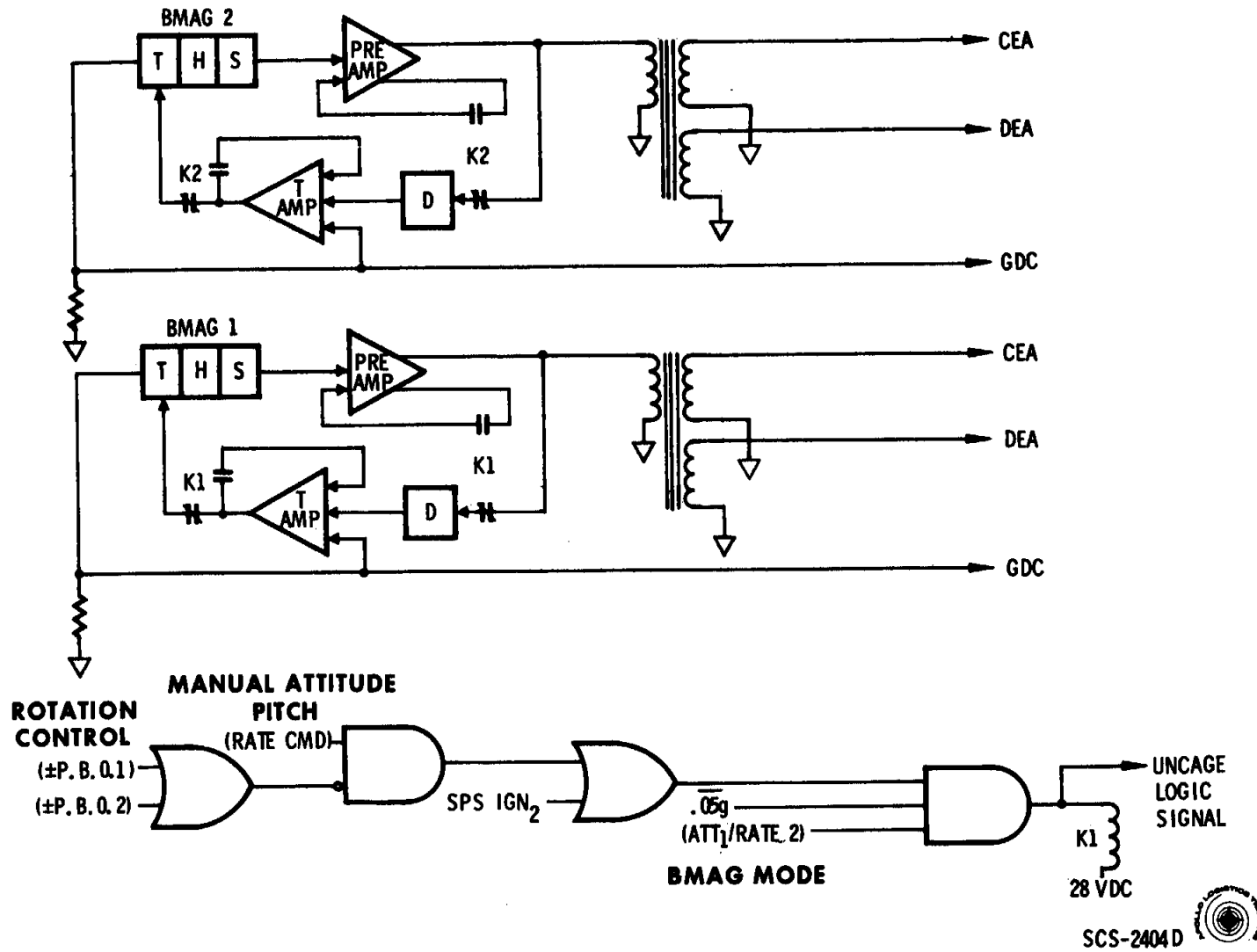
MECHANICAL STOP	-	0.5 ± 0.075 ARC INCHES
SWITCH CLOSURE	-	$0.375 \begin{matrix} +0.025 \\ -0.075 \end{matrix}$ ARC INCHES
FORCE	-	1.5 ± 0.33 POUNDS



TRANSLATION CONTROL INTERFACES

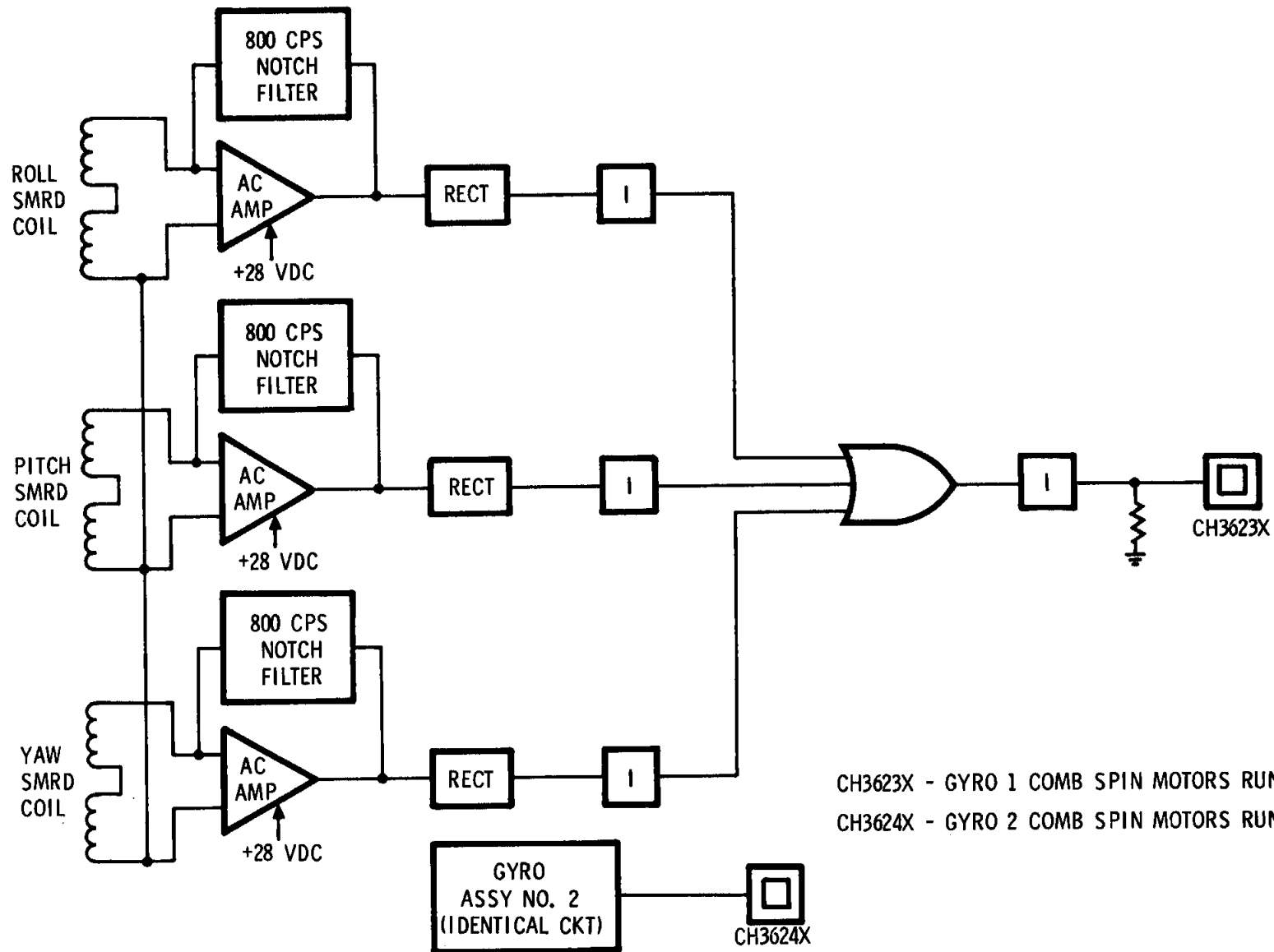


PITCH BMAG LOGIC AND OUTPUTS



SCS GYRO ASSEMBLY NO.1

SMRD TM

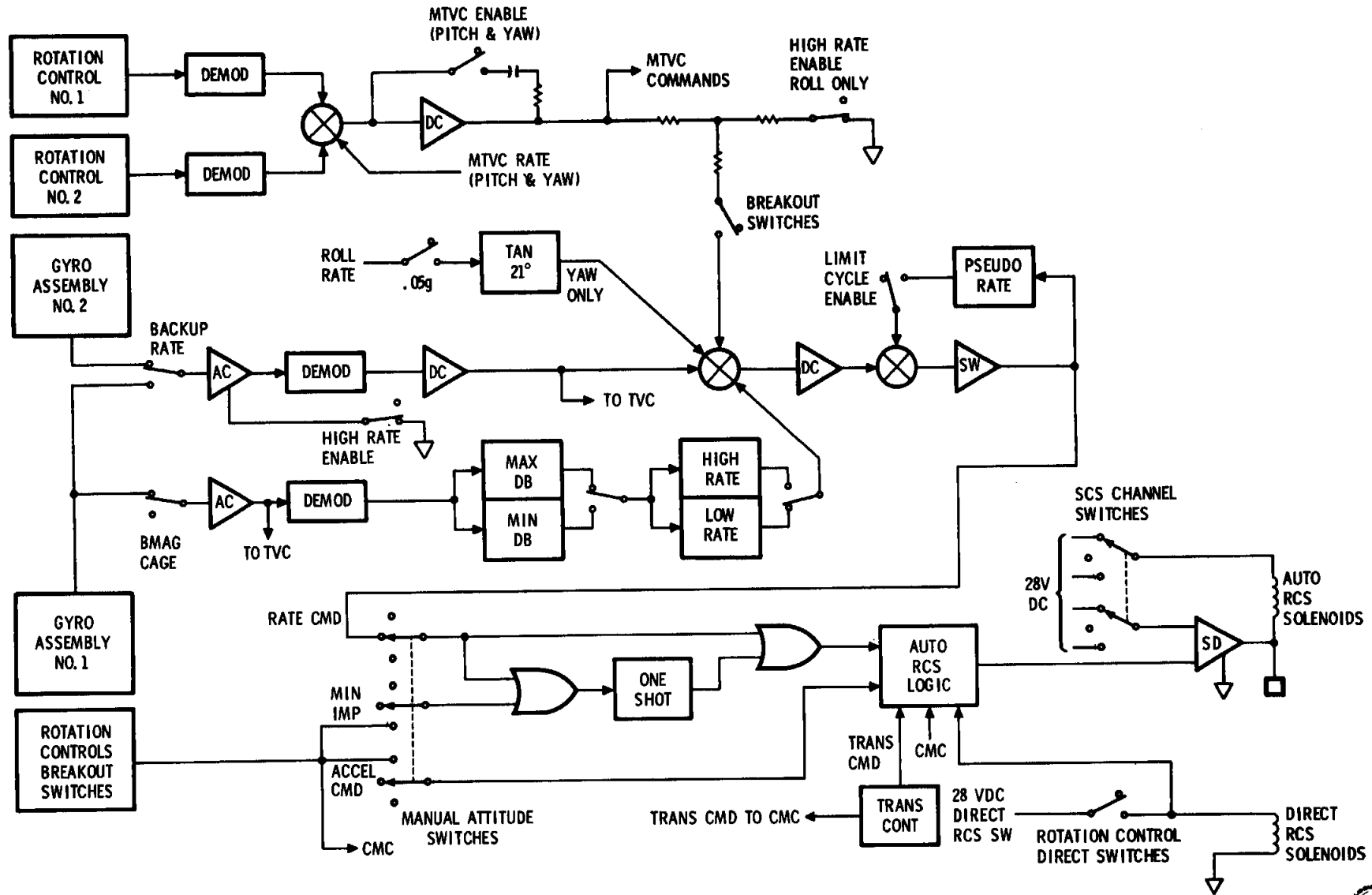



CH3623X - GYRO 1 COMB SPIN MOTORS RUN DET

CH3624X - GYRO 2 COMB SPIN MOTORS RUN DET

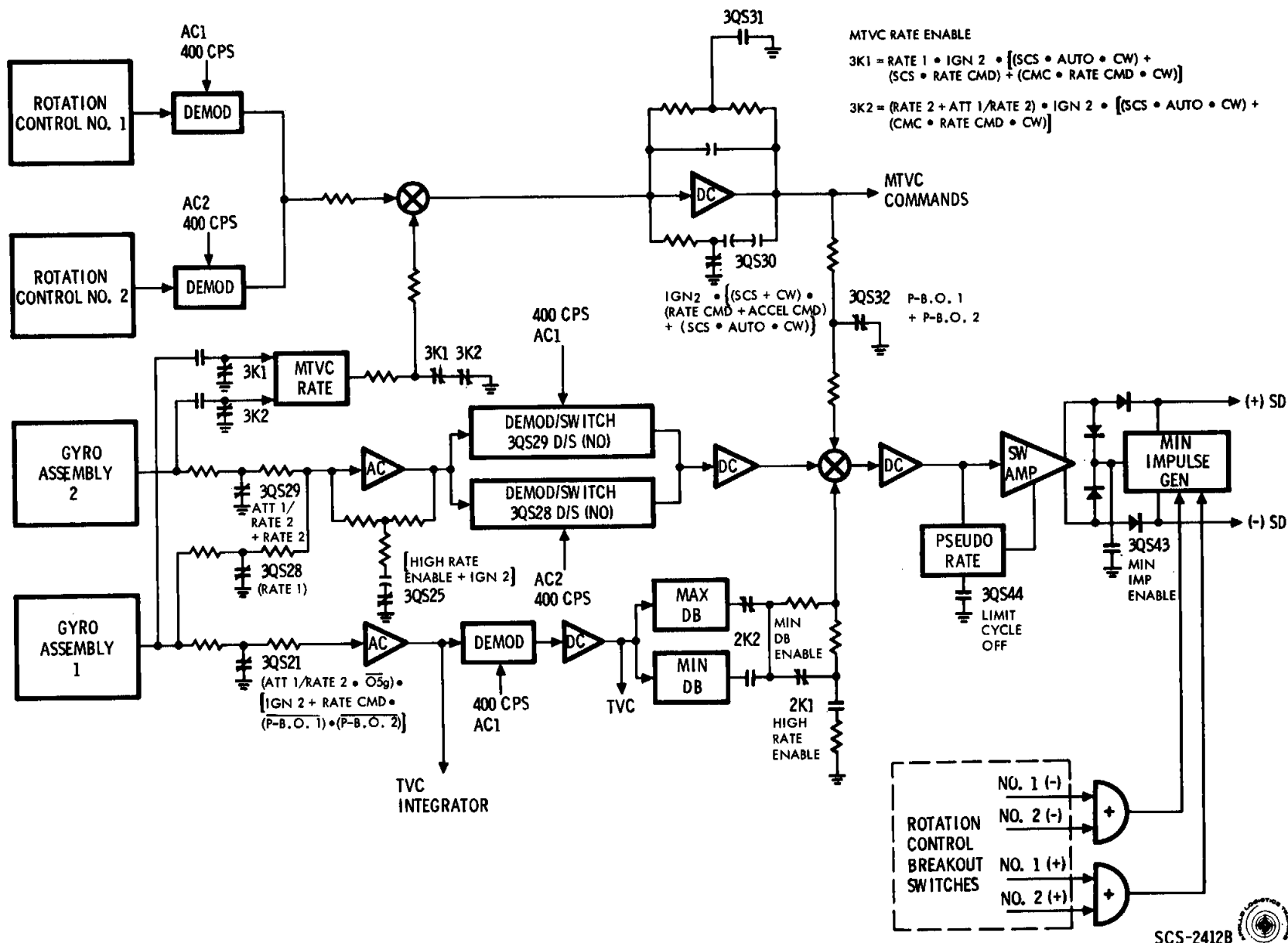
SCS ATTITUDE CONTROL

FUNCTIONAL OPERATION



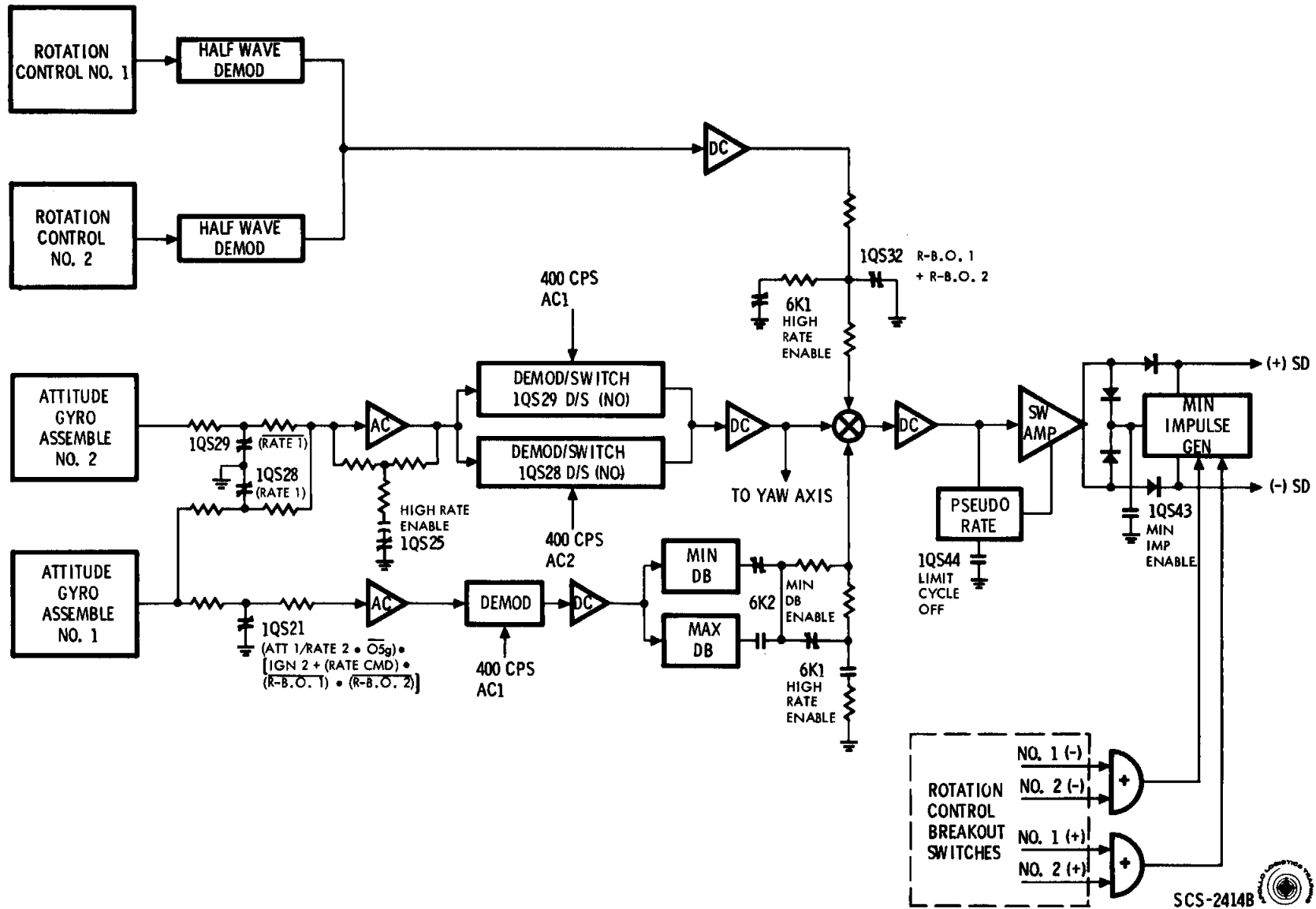
SCS-2410C 

SCS ATTITUDE CONTROL PITCH CHANNEL

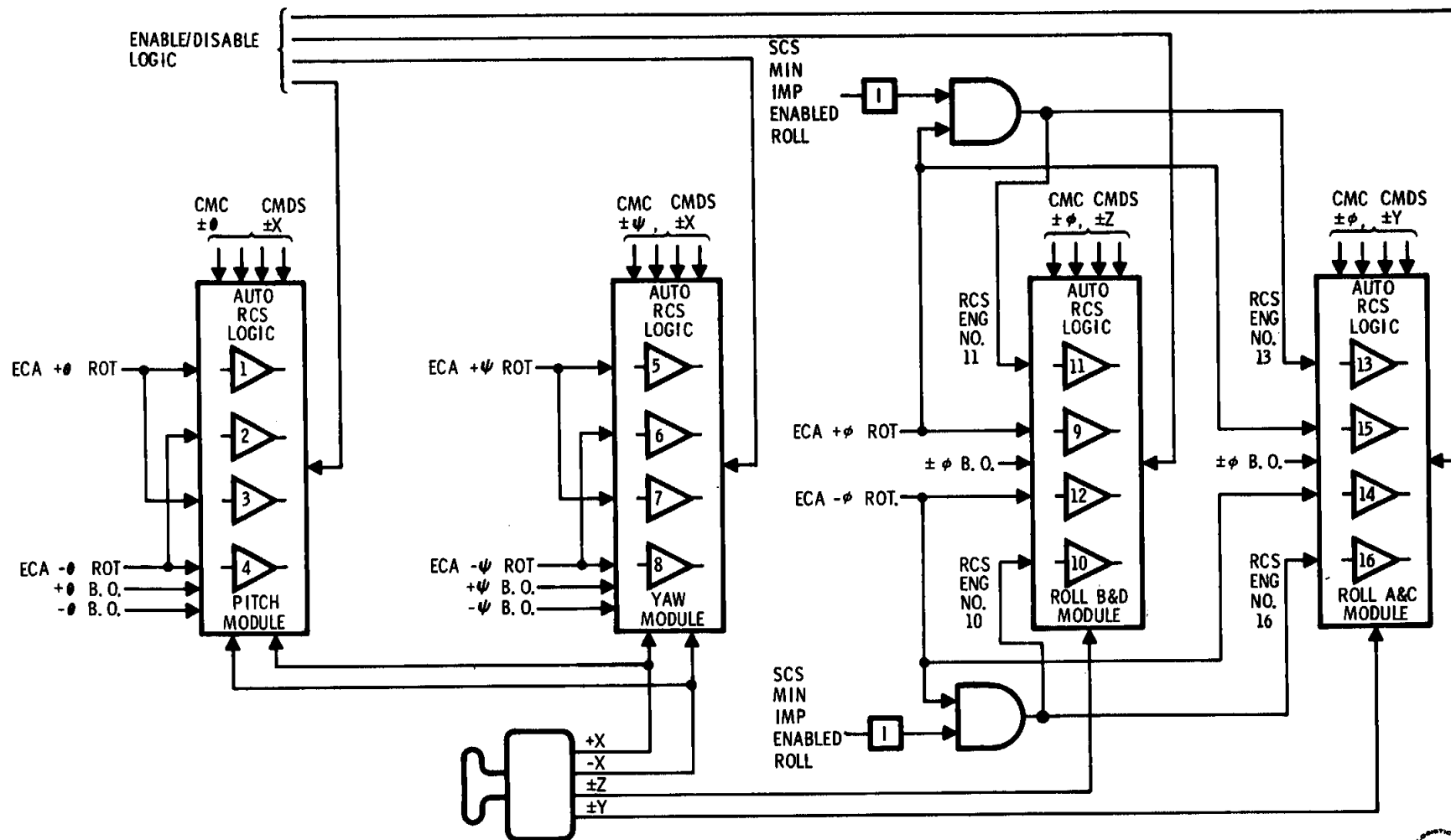



SCS-2412B

SCS ATTITUDE CONTROL ROLL CHANNEL

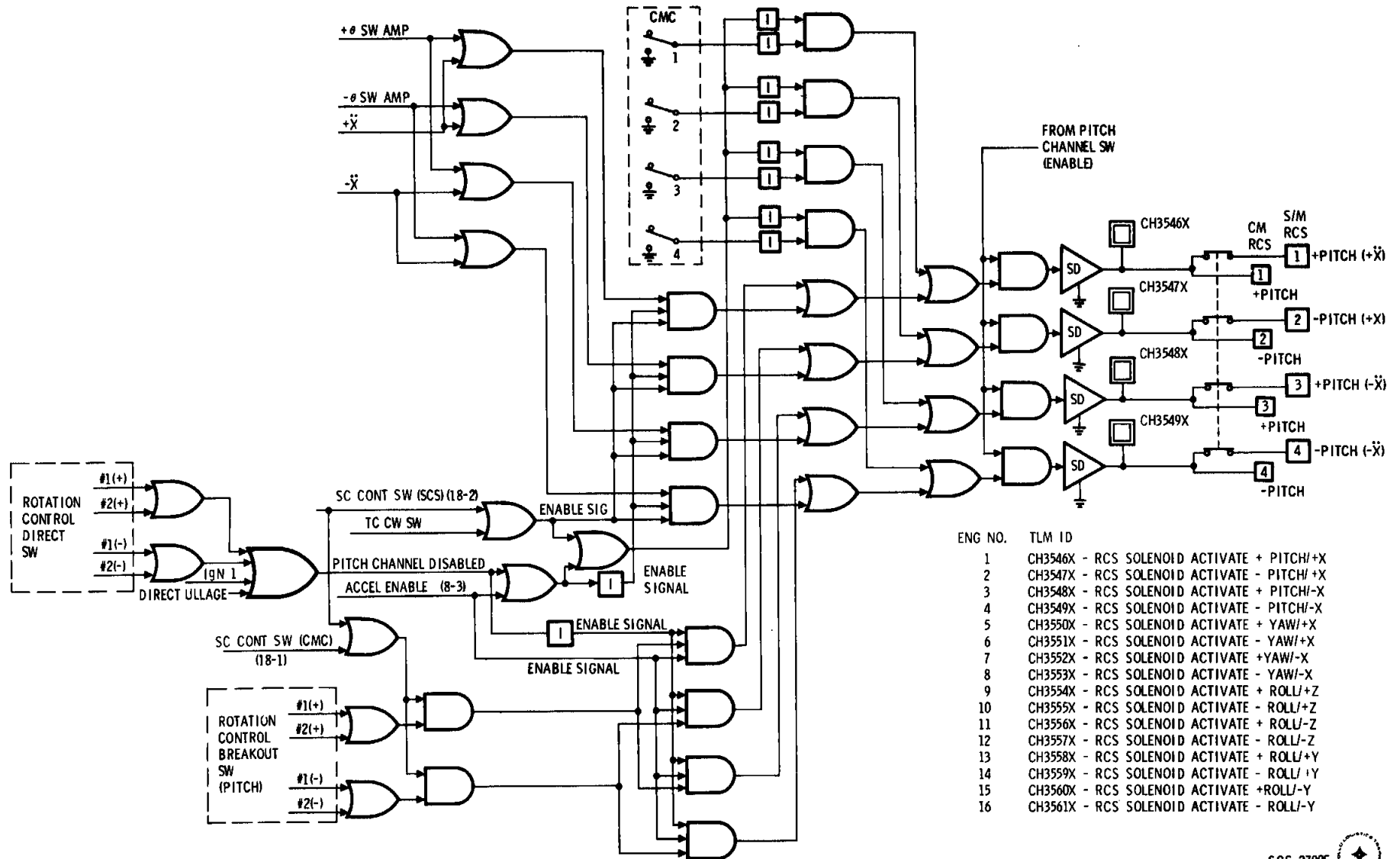


AUTO RCS LOGIC SIG FLOW

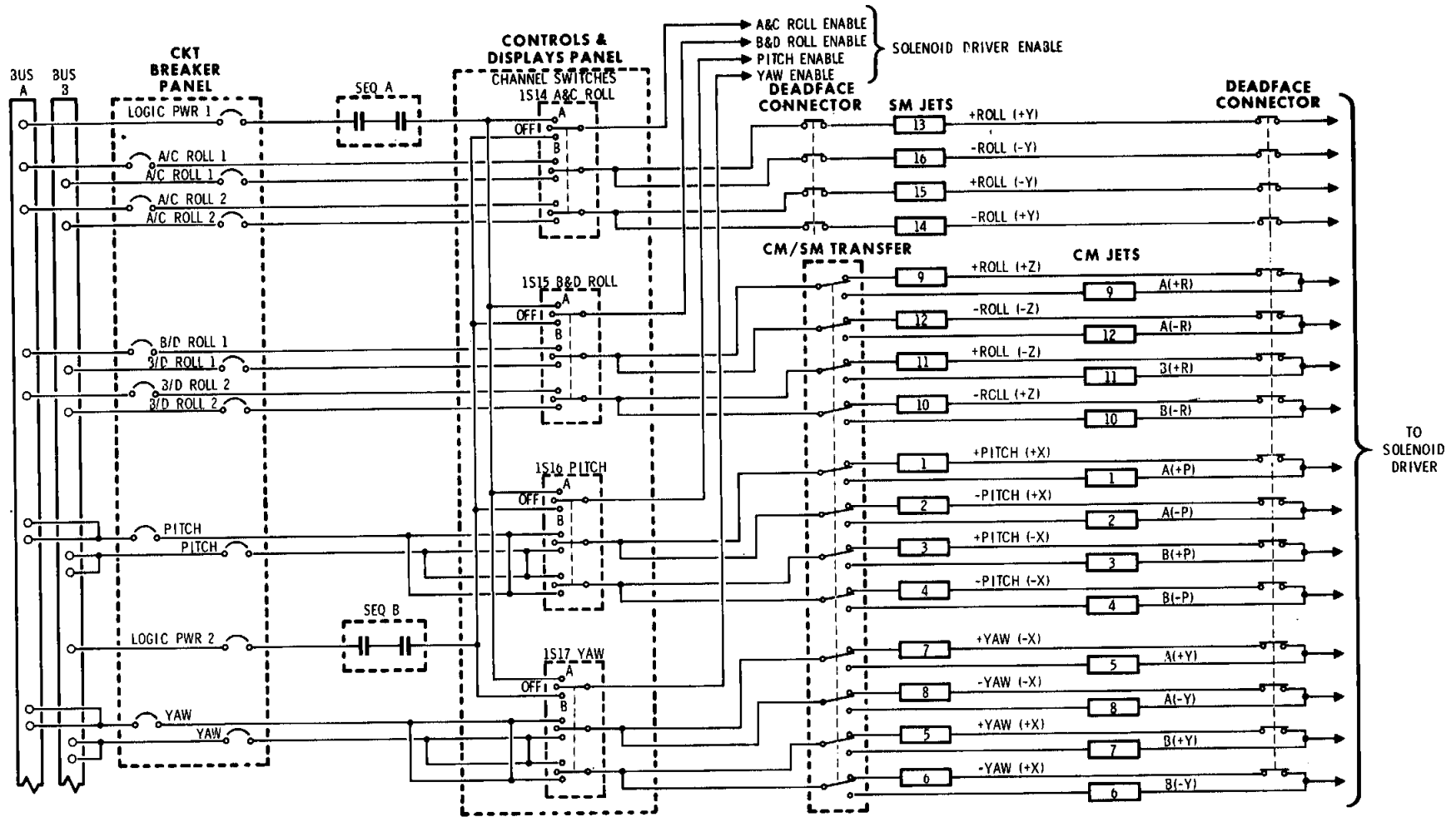


SCS-2415 C 

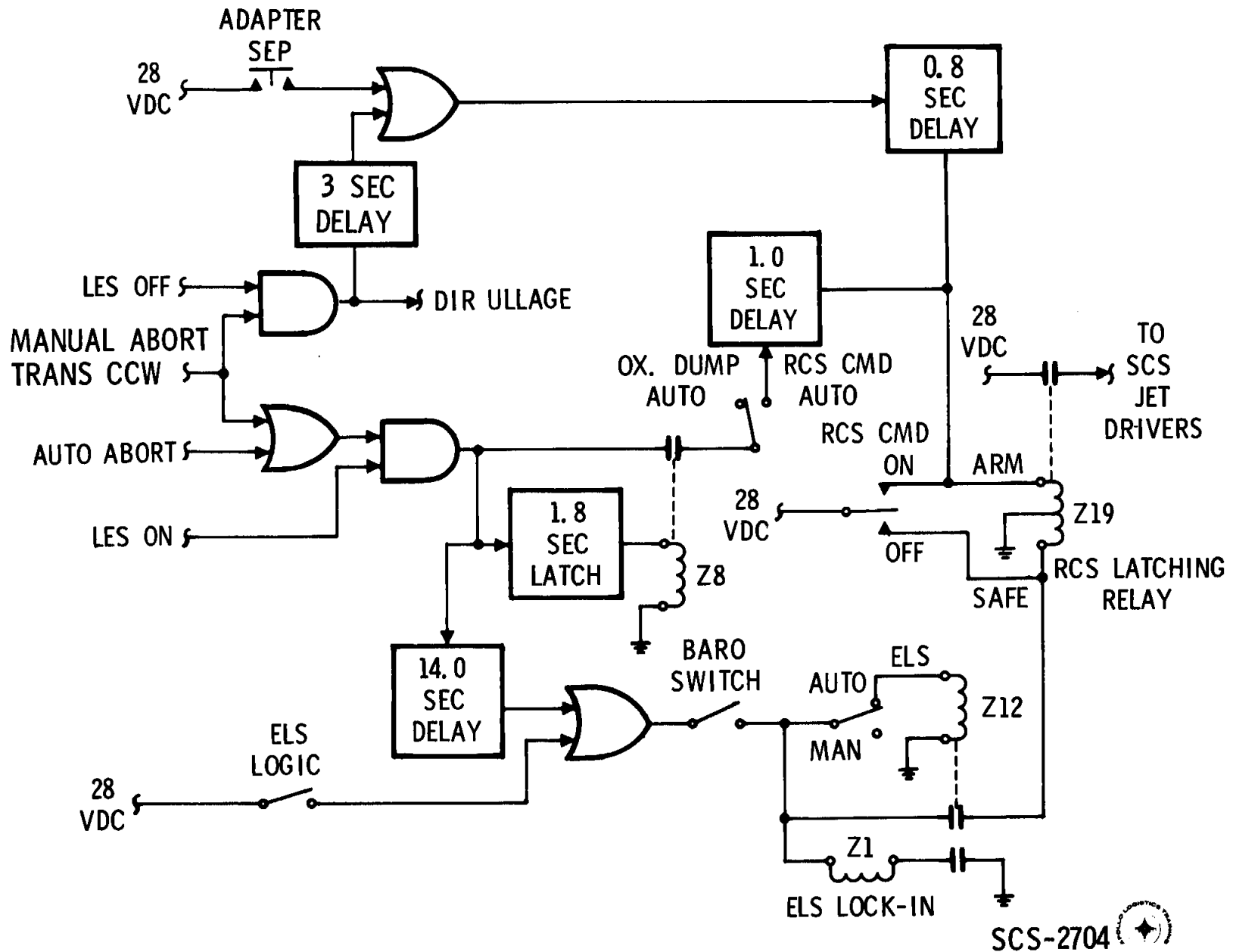
AUTO RCS LOGIC TYPICAL CHANNEL (PITCH)




ENABLING POWER - AUTO RCS

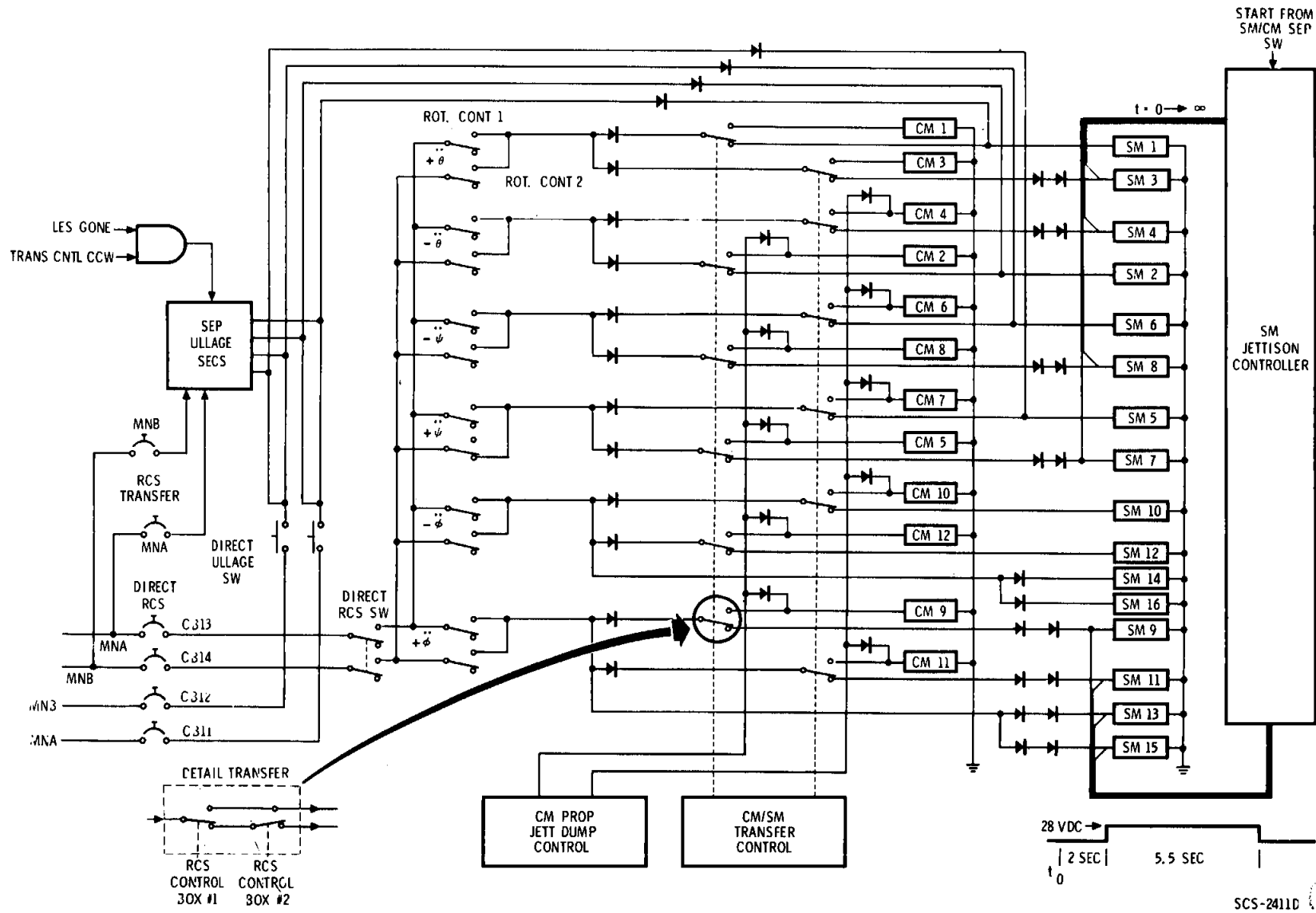


RCS LATCHING RELAY LOGIC



SCS-2704 

DIRECT CONTROL LOOP



SCS-2411D

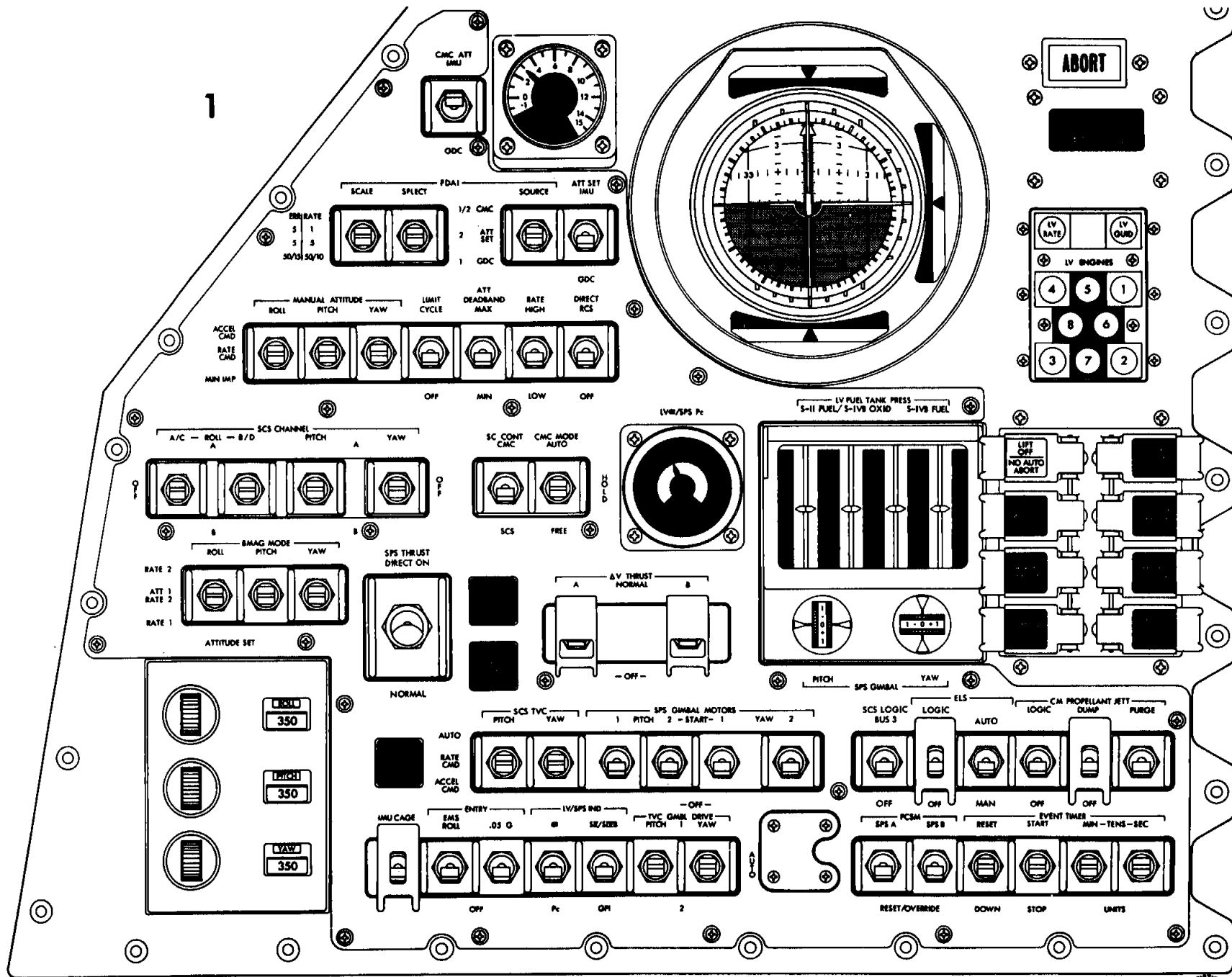
ACS CONTROL CAPABILITIES

		MANUAL					AUTOMATIC		
		DIRECT	ACCELERATION CMD	TRANSLATION	MINIMUM IMPULSE	PROPORTIONAL RATE (4)	RATE DAMPING	ATTITUDE HOLD	
MANUAL ATTITUDE	ROLL	ACCEL CMD	✓						
		RATE CMD		✓		✓	✓	✓	
		MIN IMP		✓	✓				
	PITCH	ACCEL CMD	✓						
		RATE CMD		✓		✓	✓	✓	
		MIN IMP		✓	✓				
	YAW	ACCEL CMD	✓						
		RATE CMD		✓		✓	✓	✓	
		MIN IMP		✓	✓				
BMAG MODE	ROLL	RATE 2					✓		
		ATT 1/RATE 2						✓	
		RATE 1					✓		
	PITCH	RATE 2					✓		
		ATT 1/RATE 2						✓	
		RATE 1					✓		
	YAW	RATE 2					✓		
		ATT 1/RATE 2						✓	
		RATE 1					✓		
SC CONT	CMC			✓	✓	✓	✓		
	SCS		✓	✓	✓	✓	✓		
TRANS CONTROL	CW			✓	✓	✓	✓		
	NEUTRAL			✓	✓	✓	✓		
DIRECT RCS	UP	✓	(3)	(3)	(3)	(3)	(3)		
	OFF								
ROT CONTROL	B. O. SW		CLOSE (2)		CLOSE (2)	CLOSE	OPEN		
	DIRECT SW	CLOSE					OPEN		
LIMIT (1) CYCLE	UP						✓		
	OFF				✓	✓			
ENTRY	05G								
	OFF						✓		

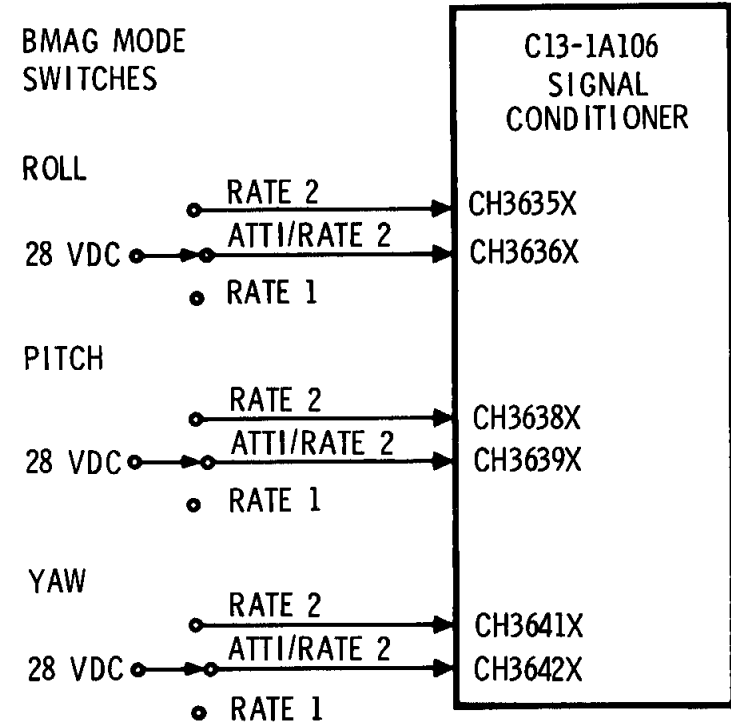
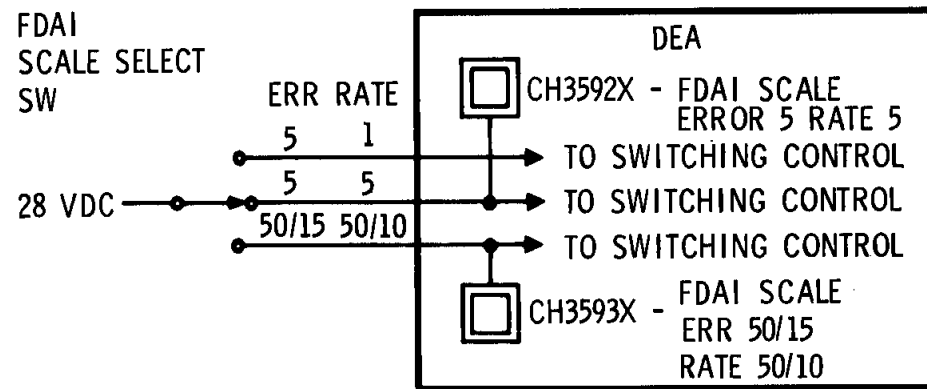
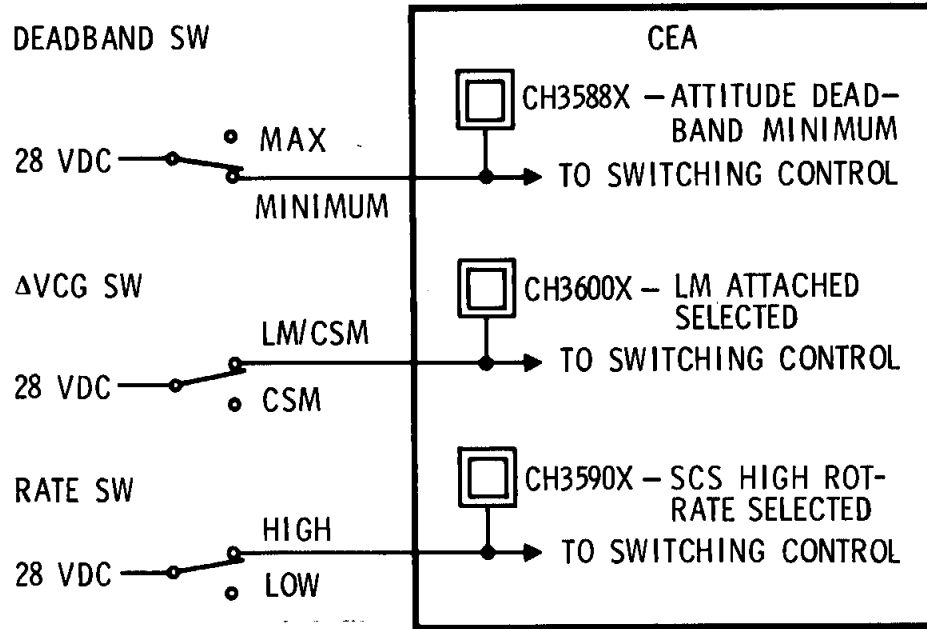
- (1) NOT REQUIRED TO ENABLE A PARTICULAR FUNCTION.
INDICATES DESIRED POSITION FOR RCS PROPELLANT CONSERVATION.
- (2) IF B. O. SW IS OPEN THE S/C WILL BE IN FREE DRIFT.
- (3) IF "ON", DIRECT SW IN ROTATION CONTROL MUST BE "OPEN".
- (4) MAXIMUM RATE ATTAINABLE IS FUNCTION OF RATE-HIGH/LOW SWITCH

GENERAL COMMENTS:

- A. THE CAPABILITIES, IN GENERAL, ARE LISTED IN ORDER OF THEIR PRIORITY.
- B. WHEN MORE THAN ONE SWITCH POSITION IS CHECKED (✓) THE CAPABILITY WILL BE ENABLED IN EITHER POSITION.

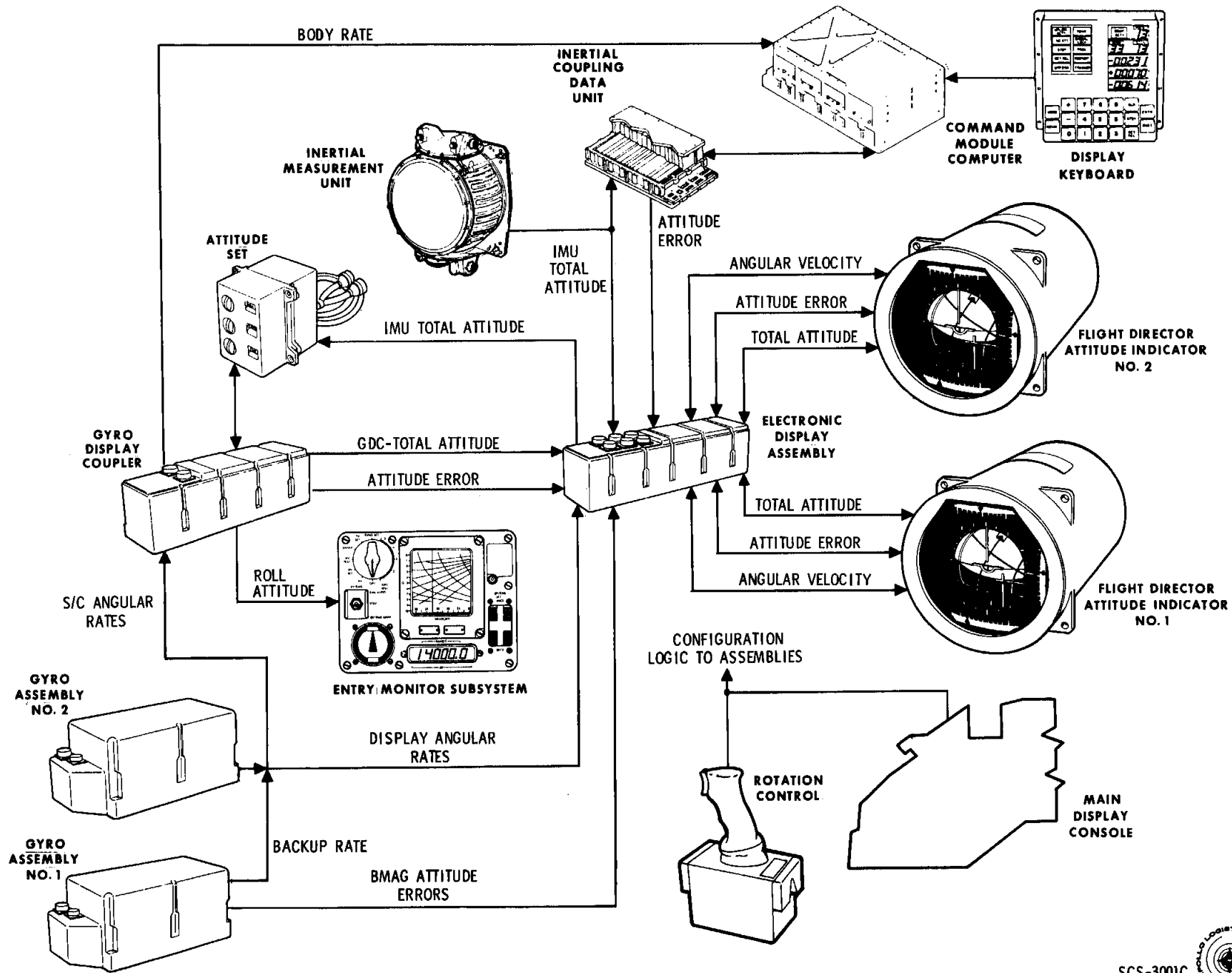


SCS CONTROL PANEL SWITCHING TM



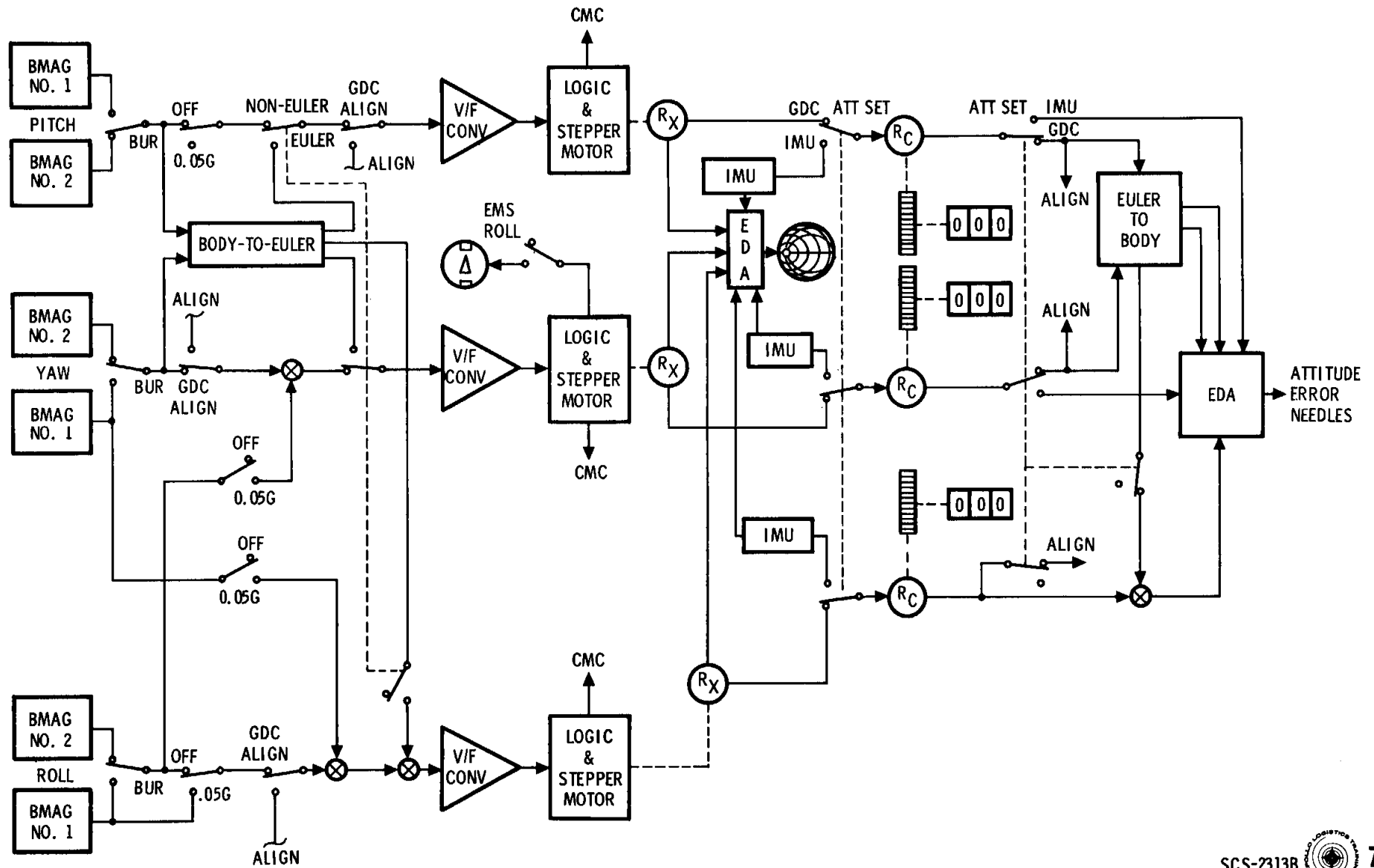
- CH3635X - BMAG MODE SW ROLL ATTI/RATE 2
- CH3636X - BMAG MODE SW - ROLL RATE 2
- CH3638X - BMAG MODE SW - PITCH ATTI/RATE 2
- CH3639X - BMAG MODE SW - PITCH RATE 2
- CH3641X - BMAG MODE SW - YAW ATT 1/RATE 2
- CH3642X - BMAG MODE SW - YAW RATE 2

G & C ATTITUDE REFERENCE

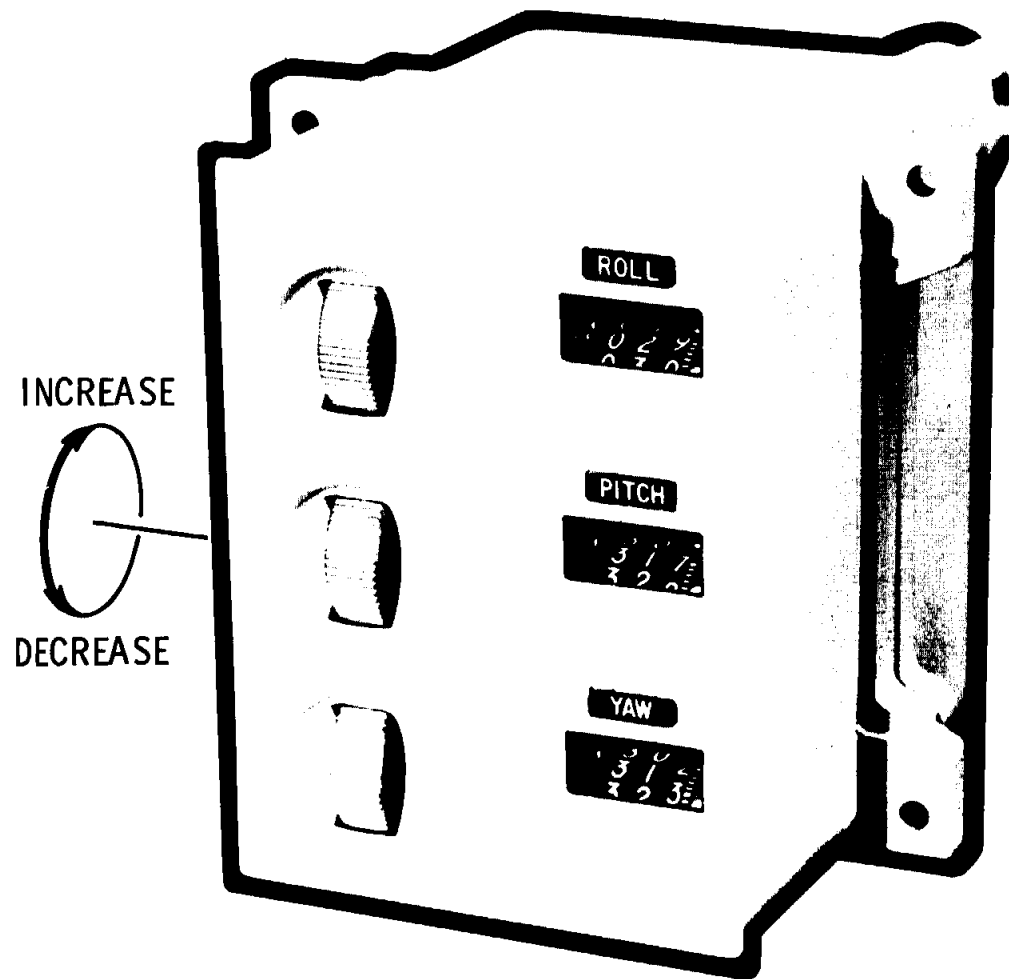


ATTITUDE REFERENCE SUBSYSTEM

FUNCTIONAL OPERATION



ATTITUDE SET DISPLAY

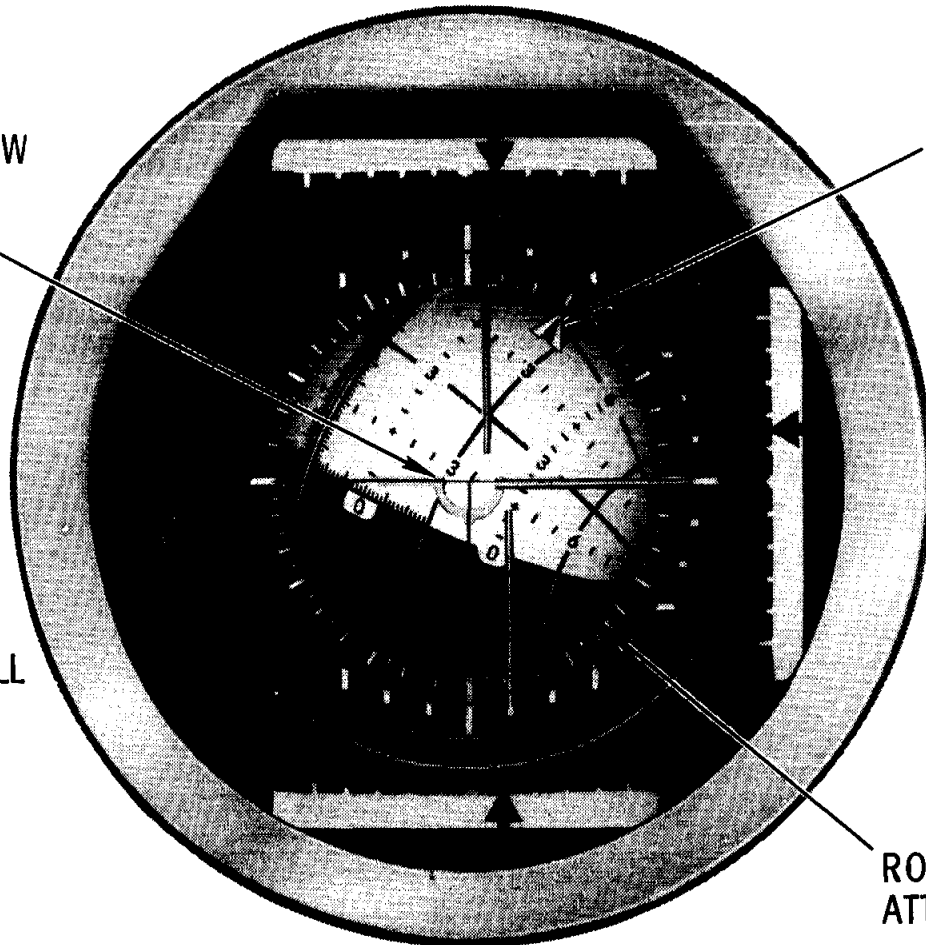


FLIGHT DIRECTOR ATTITUDE INDICATOR

ROLL
 +ANGULAR VELOCITY-
 +ATTITUDE ERROR-

PITCH & YAW
 INDEX

ROLL INDEX



-	P	-
ATTITUDE	I	ANGULAR
ERROR	T	VELOCITY
	C	
+	H	+

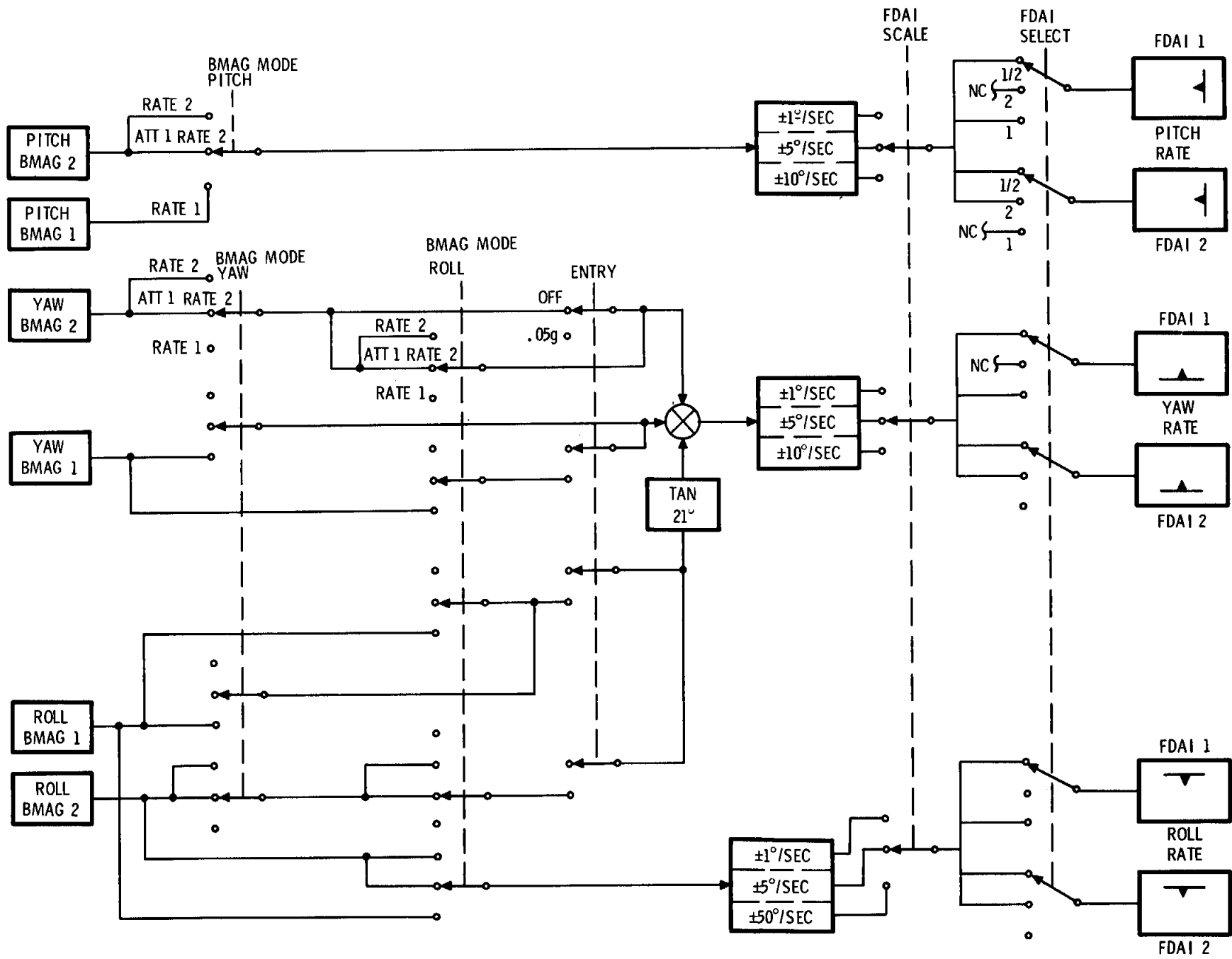
EULER ATTITUDE ON BALL
 PITCH - $\theta = 014^\circ$
 YAW - $\psi = 034^\circ$
 ROLL - $\phi = 330^\circ$

ROLL TOTAL
 ATTITUDE SCALE

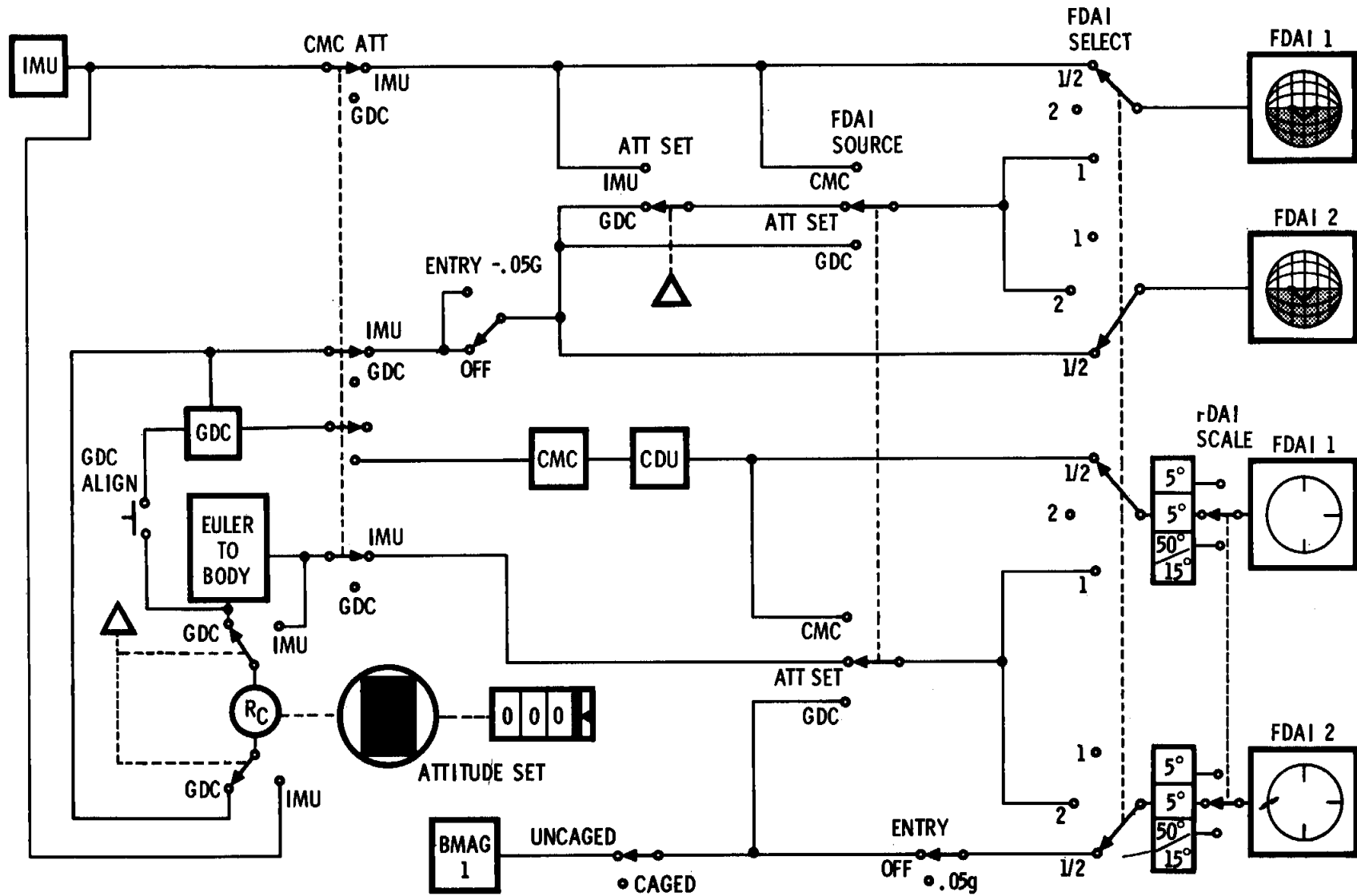
NOTE:
 ALL POLARITIES INDICATE
 VEHICLE DYNAMICS

YAW
 +ATTITUDE ERROR-
 +ANGULAR VELOCITY-

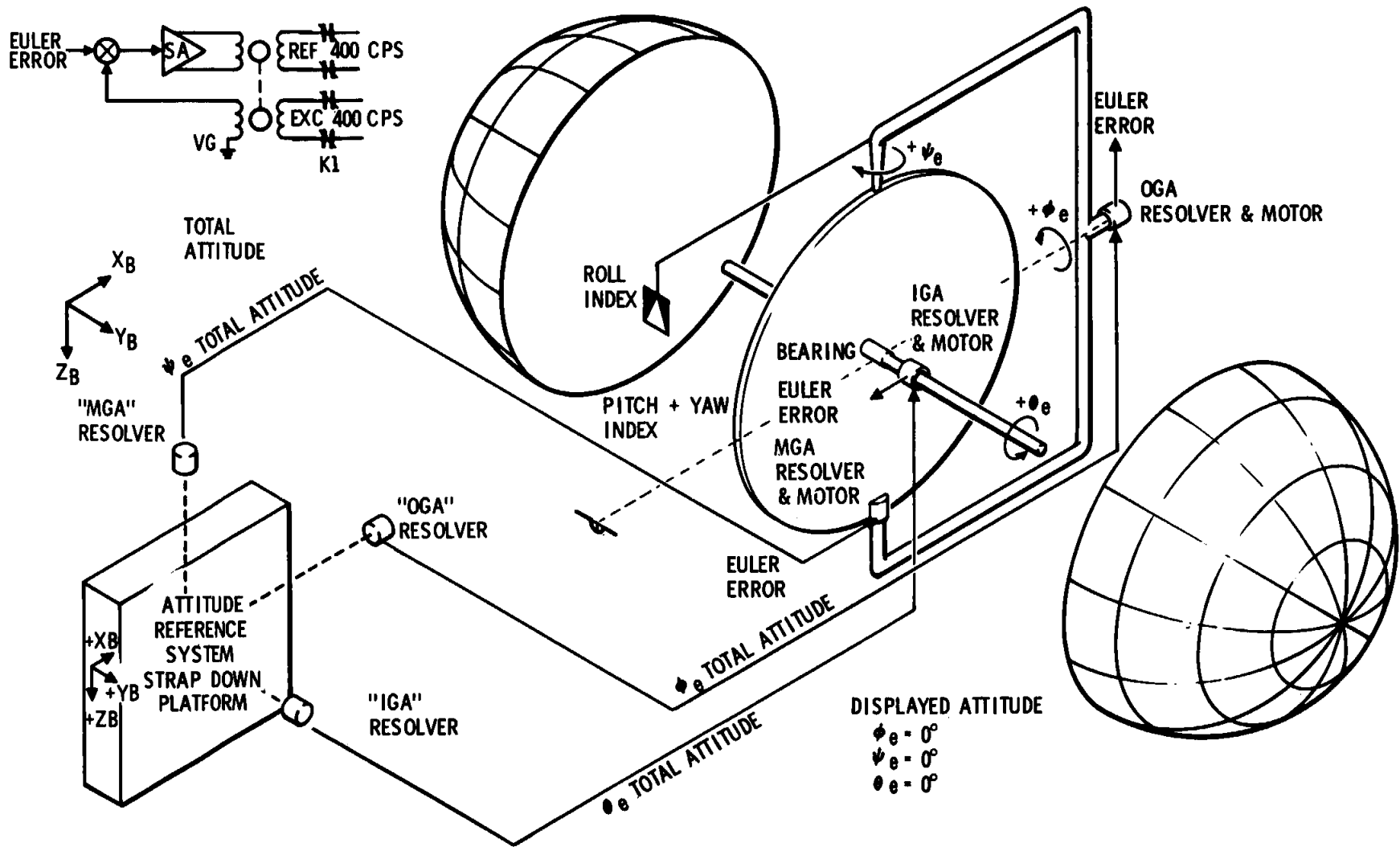
FDAI RATE SELECT LOGIC



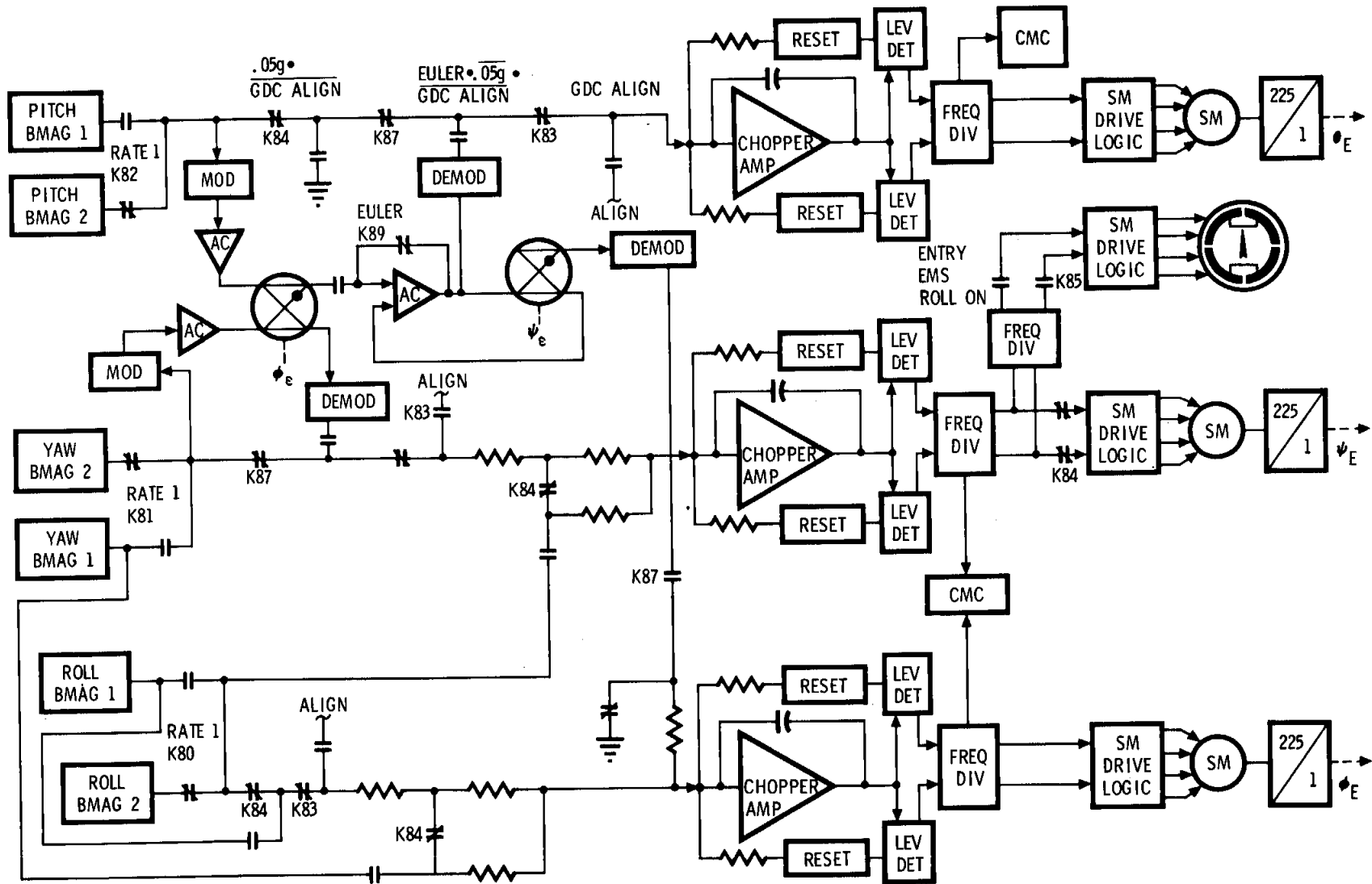
FDAI ATTITUDE SELECT LOGIC



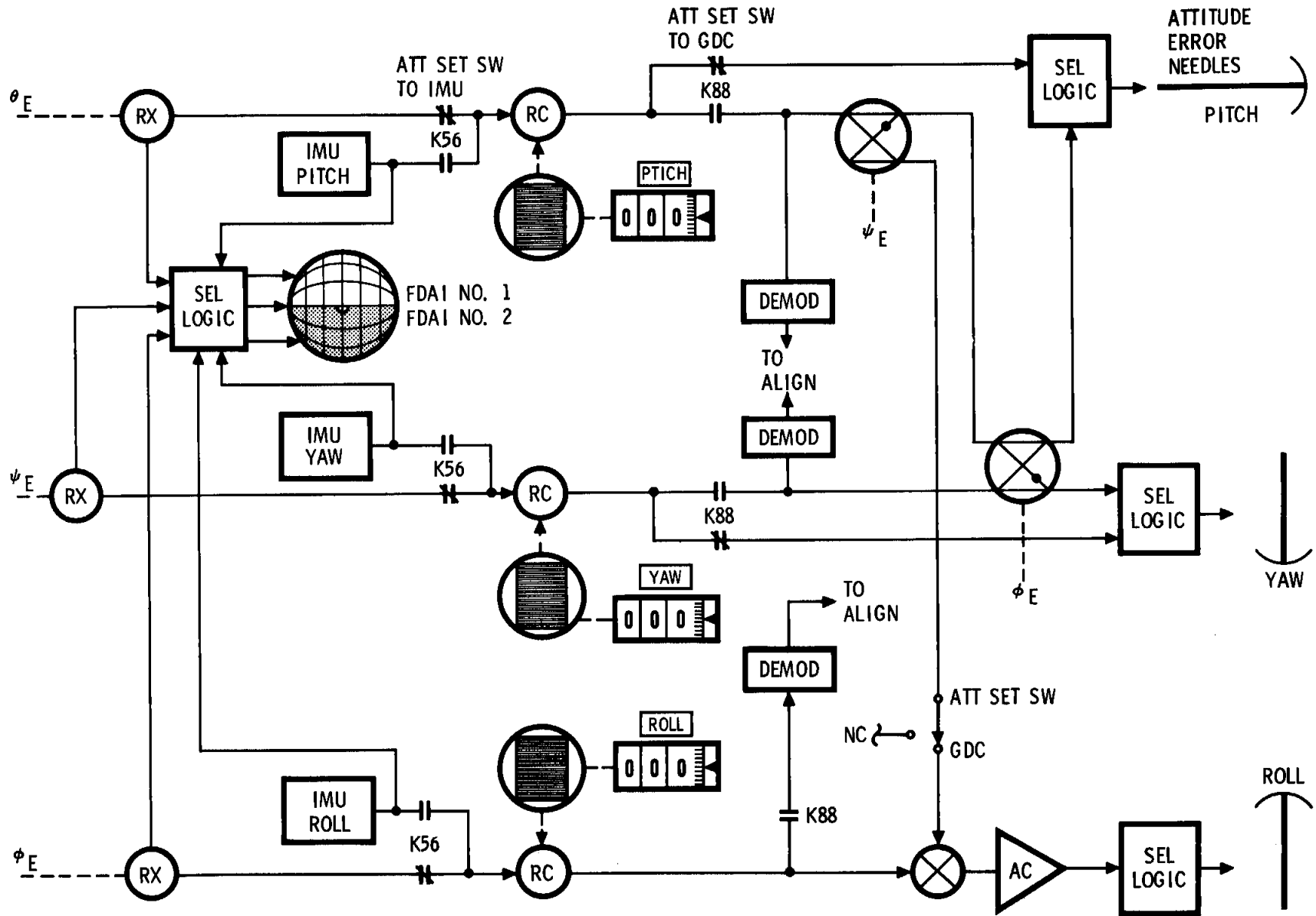
FDAI/GDC SHAFT RELATIONSHIP



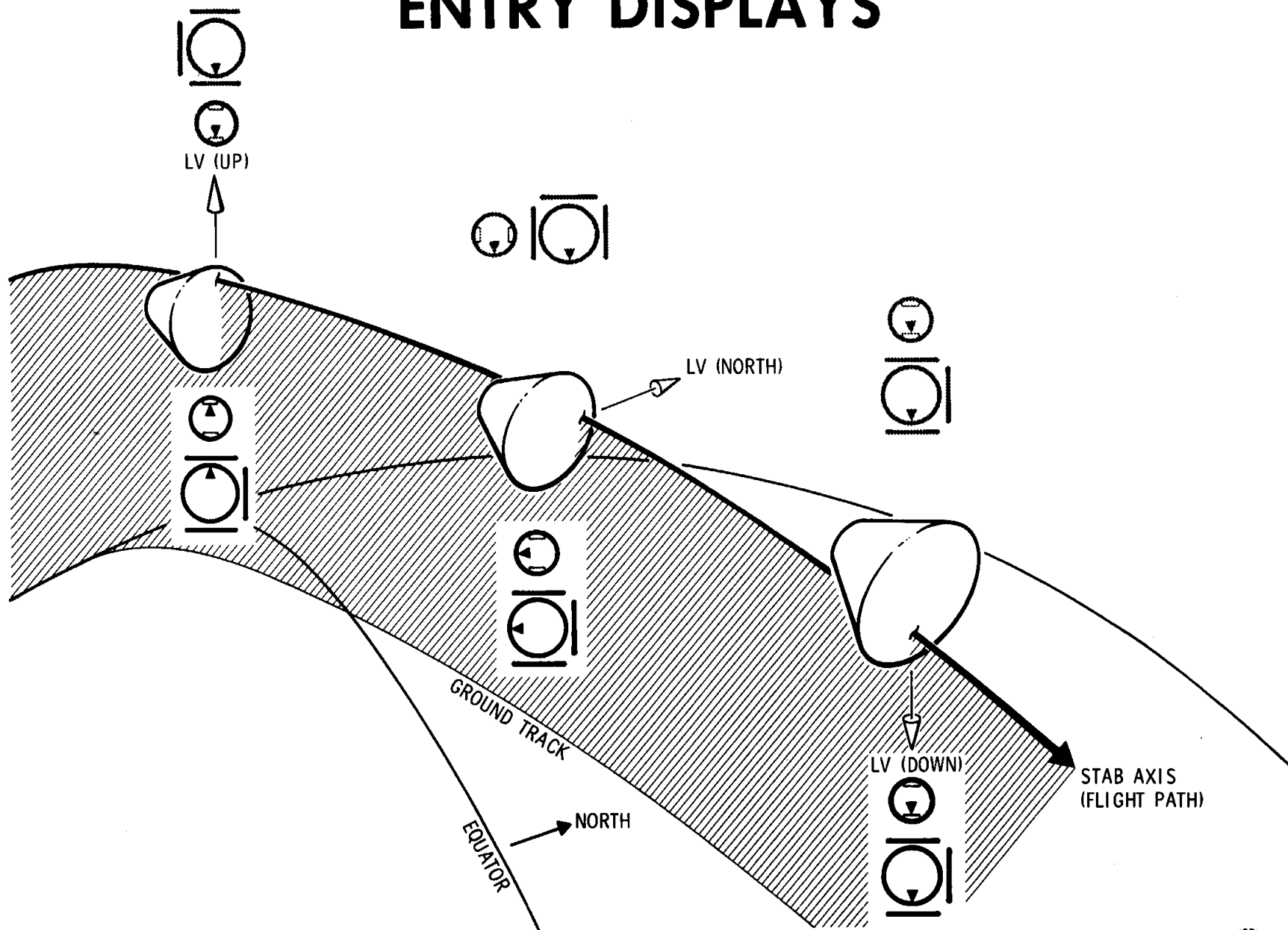
GYRO DISPLAY COUPLER



FDAI SIGNAL FLOW



ENTRY DISPLAYS



ARS SWITCHING

		ARS CONFIGURATIONS					TOTAL ATTITUDE DISP SOURCES			ERROR DISP SOURCES (4)			RATE DISP SOURCES		
		GDC ALIGN	EULER	NON-EULER	ENTRY > .05G	IMU	GDC (2)	BMAG #1 (3)	GDC-ATT SET DIFF	IMU-ATT SET DIFF	CDU	BMAG #2	BMAG #1		
B M	PITCH	RATE 2											✓		
		ATT 1/ RATE 2						✓						✓	
		RATE 1													✓
A G M	YAW	RATE 2											✓		
		ATT 1/ RATE 2						✓						✓	
		RATE 1													✓
O D E	ROLL	RATE 2											✓		
		ATT 1/ RATE 2						✓						✓	
		RATE 1													✓
E N T R Y	.05G	05G			✓		✓ (2)								
		OFF	✓	✓			✓	✓				✓ (4)	✓ (4)		
	EMS ROLL	EMS ROLL					✓ (2)								
		OFF													
	FDAI SELECT	(1) 1/2				✓	✓	✓			✓				
		2				✓	✓	✓	✓		✓	✓			
		1				✓	✓	✓	✓	✓		✓	✓		
	FDAI SOURCE	CMC				✓							✓		
		ATT SET					✓		✓	✓					
		GDC					✓	✓							
	ATT SET	IMU				✓				✓					
		GDC	✓				✓	✓		✓					
	CMC ATT	IMU		✓		✓	✓								
		GDC		✓											
	GDC ALIGN	PRESS	✓												
		OFF		✓	✓	✓									
	ATTITUDE SET CONT PANEL	3 THUMB-WHEELS	✓							✓	✓				

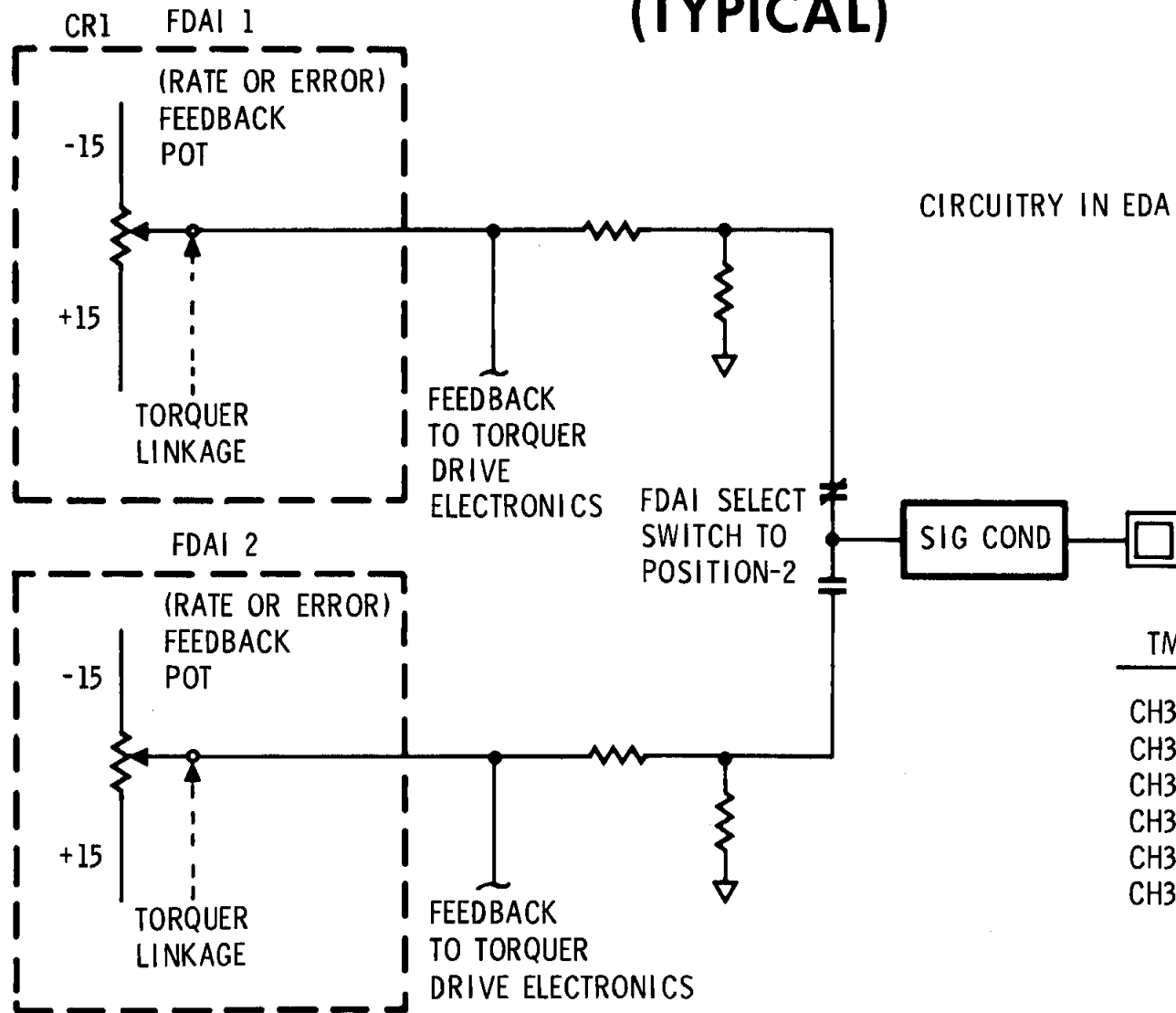
- (1) ATTITUDE AND ATTITUDE ERROR TO FDAI #1 FROM G&N AND TO FDAI #2 FROM THE SCS
- (2) DURING ENTRY, STABILITY ROLL ONLY IS SUPPLIED TO THE FDAI SELECTED AND TO THE ROLL STABILITY INDICATOR ON THE ENTRY MONITOR SYSTEM.
- (3) BMAG UNCAGE LOGIC MUST ALSO BE SATISFIED IN ADDITION TO SWITCHES SHOWN.
- (4) NECESSARY FOR CORRECT YAW DISPLAY DURING NON ENTRY MISSION PHASES.

CHART 1

SCS-2804B



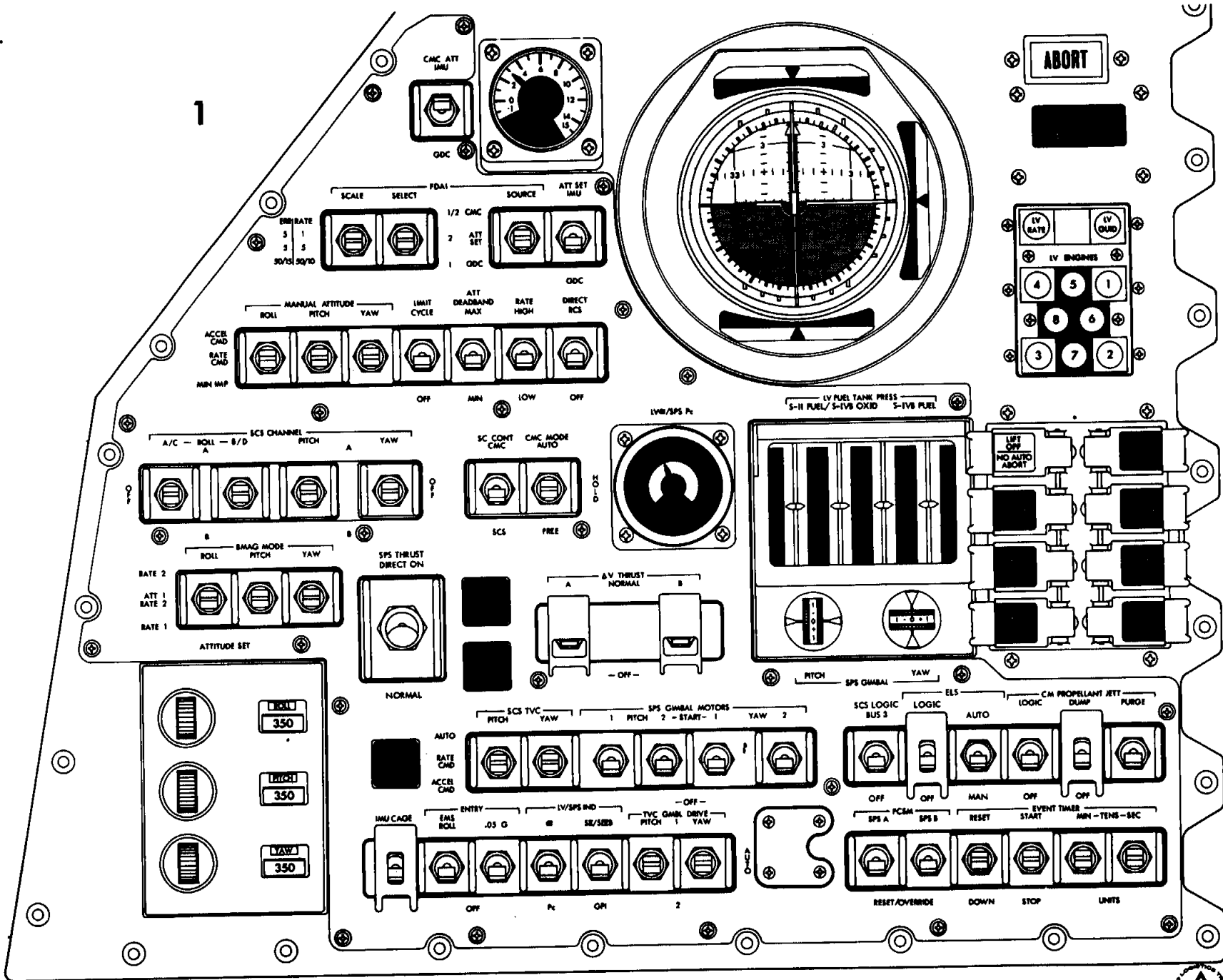
RATE AND ATTITUDE ERROR TELEMETRY PICKOFF (TYPICAL)



TM ID	S/C PARAMETER
CH3500V	ATTITUDE ERROR PITCH
CH3501V	ATTITUDE ERROR YAW
CH3502V	ATTITUDE ERROR ROLL
CH3503R	SCS BODY RATE PITCH
CH3504R	SCS BODY RATE YAW
CH3505R	SCS BODY RATE ROLL

SCS-2212A

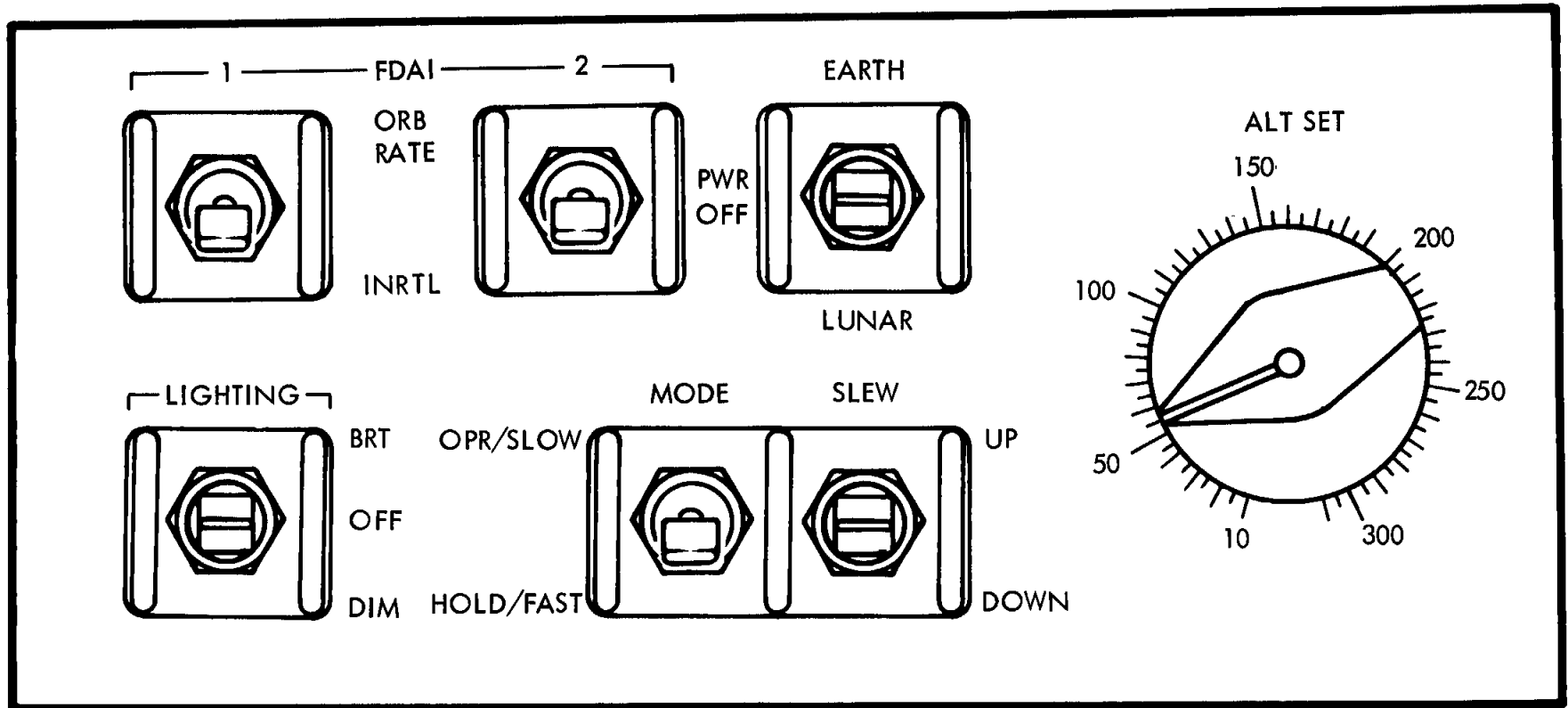




1

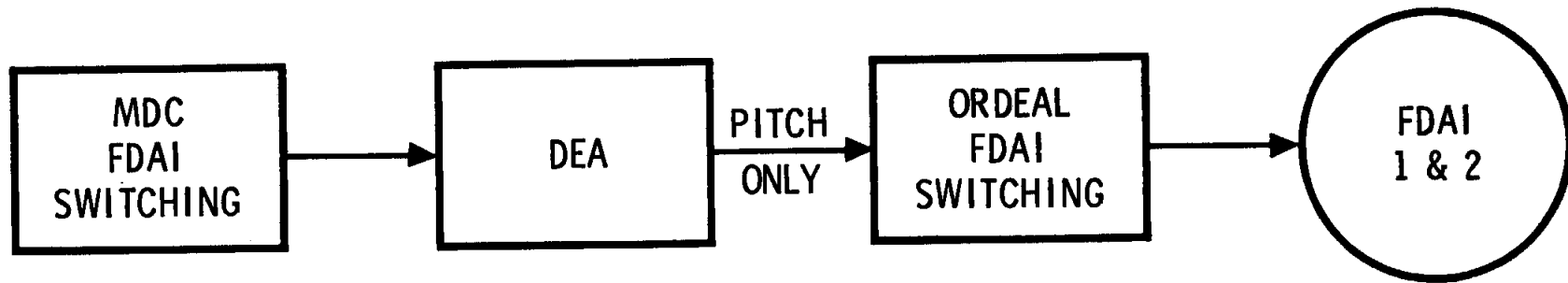


ORDEAL PANEL



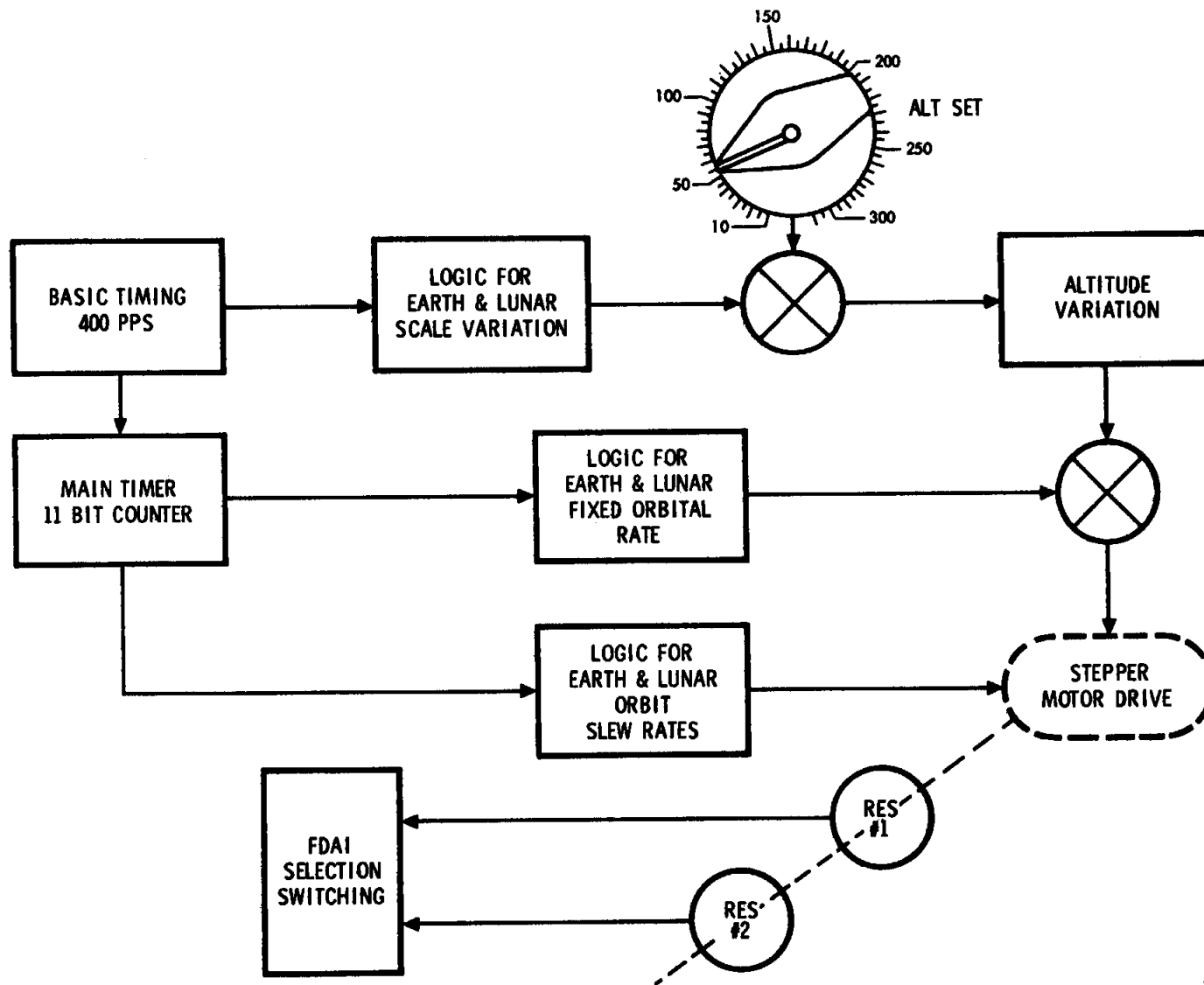
SCS-4000A

ORDEAL INTERFACE

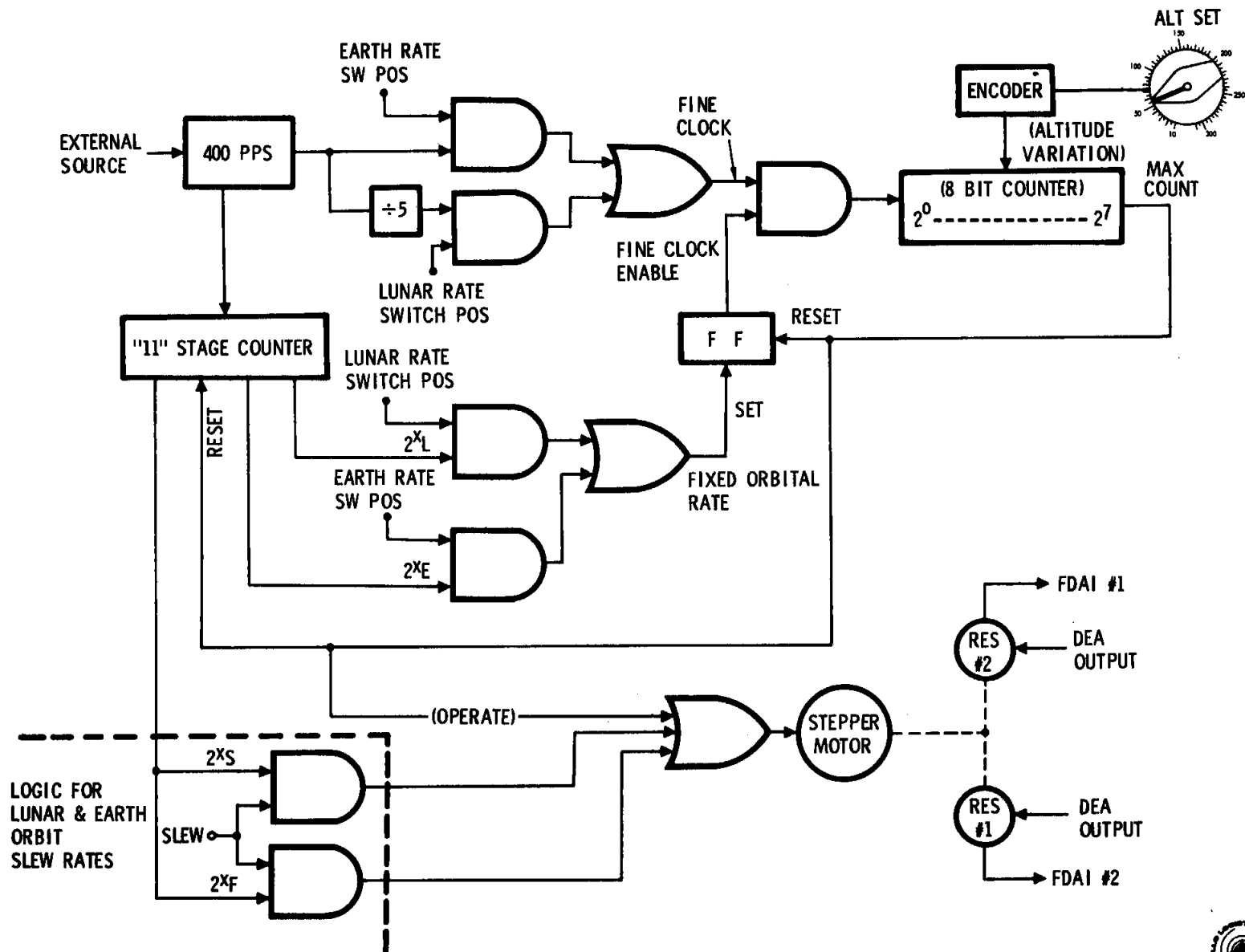


SCS-4001 

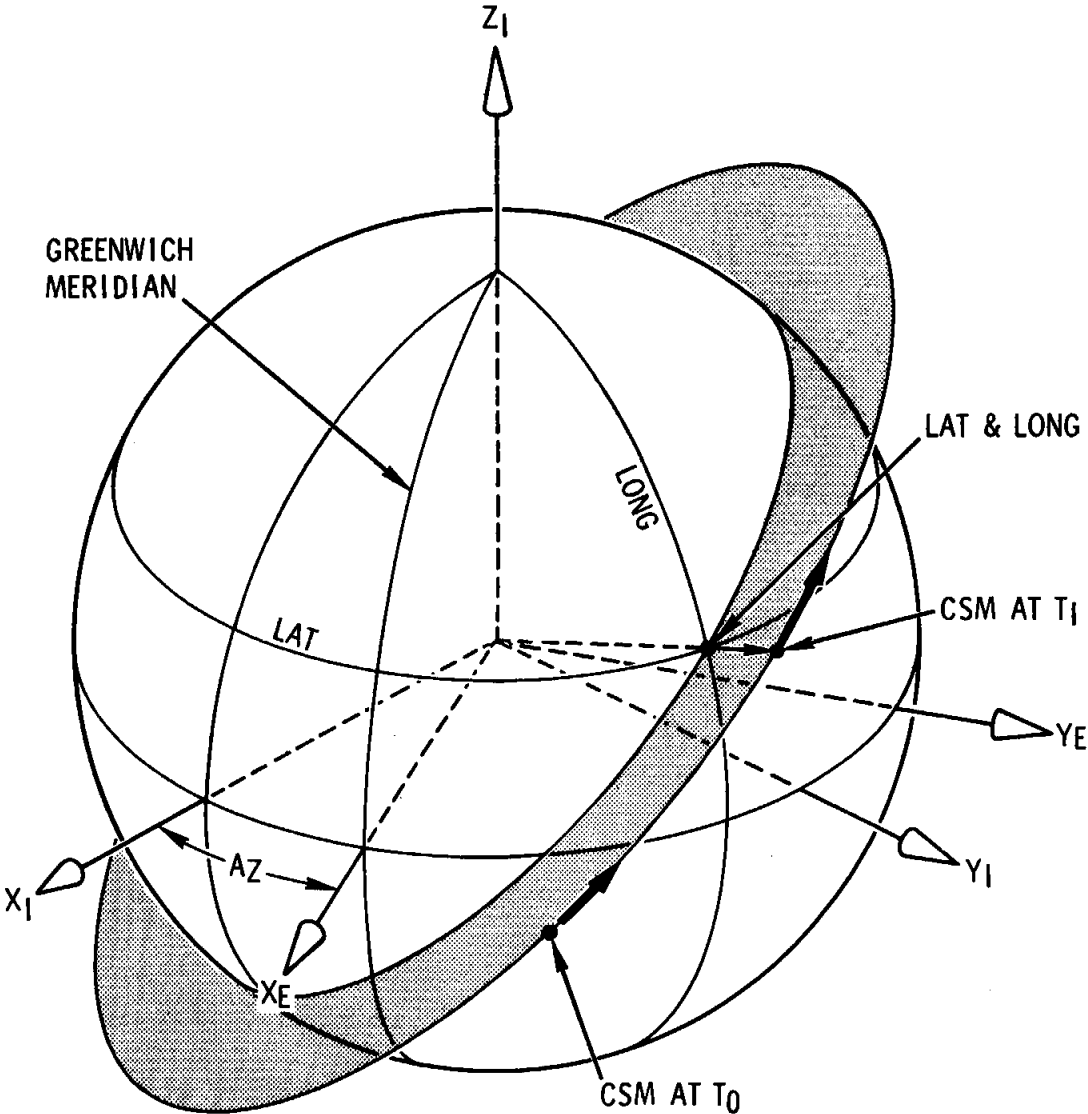
ORDEAL FUNCTIONAL BLOCK DIAGRAM



ORDEAL SIGNAL FLOW DIAGRAM

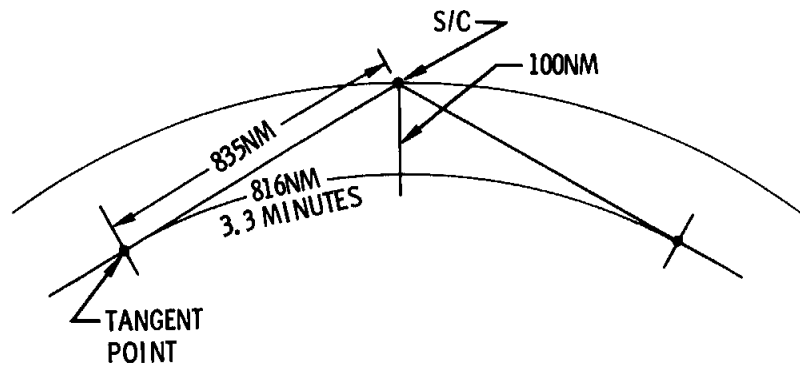


LONGITUDE-LATITUDE DETERMINATION

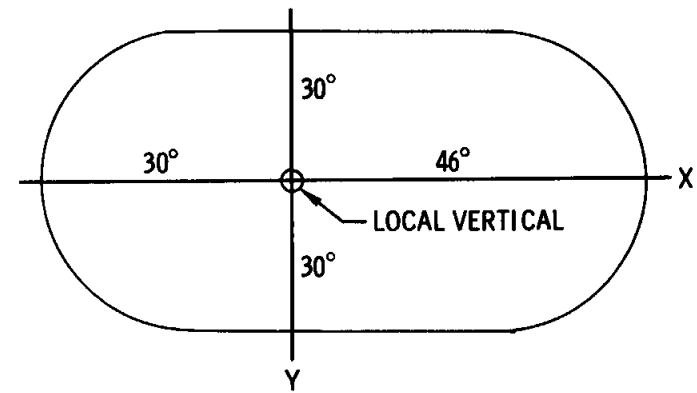


$$AZ = AZ_0 + \omega(t + t \text{ ephem})$$

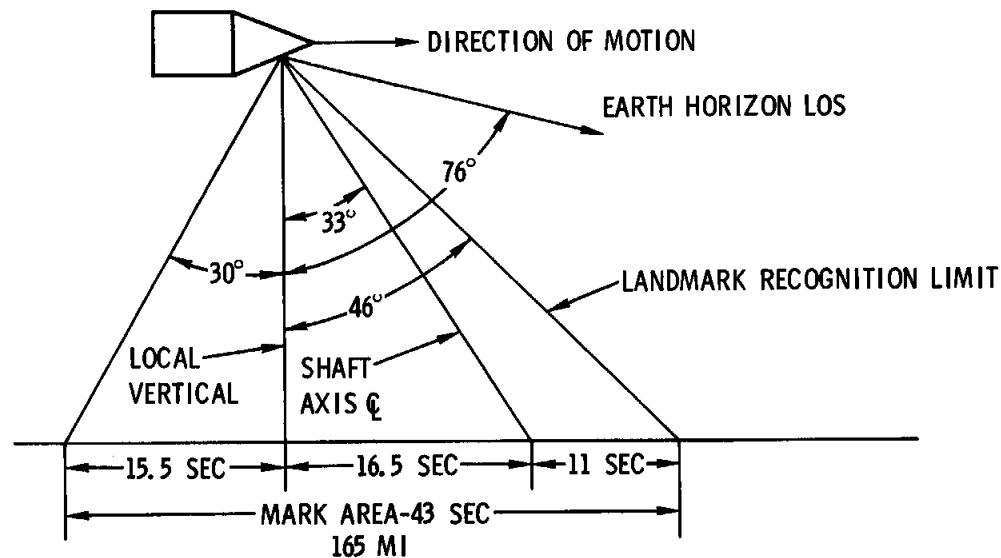
EARTH ORBIT NAVIGATION



EARTH ORBIT GEOMETRY FIGURE 1

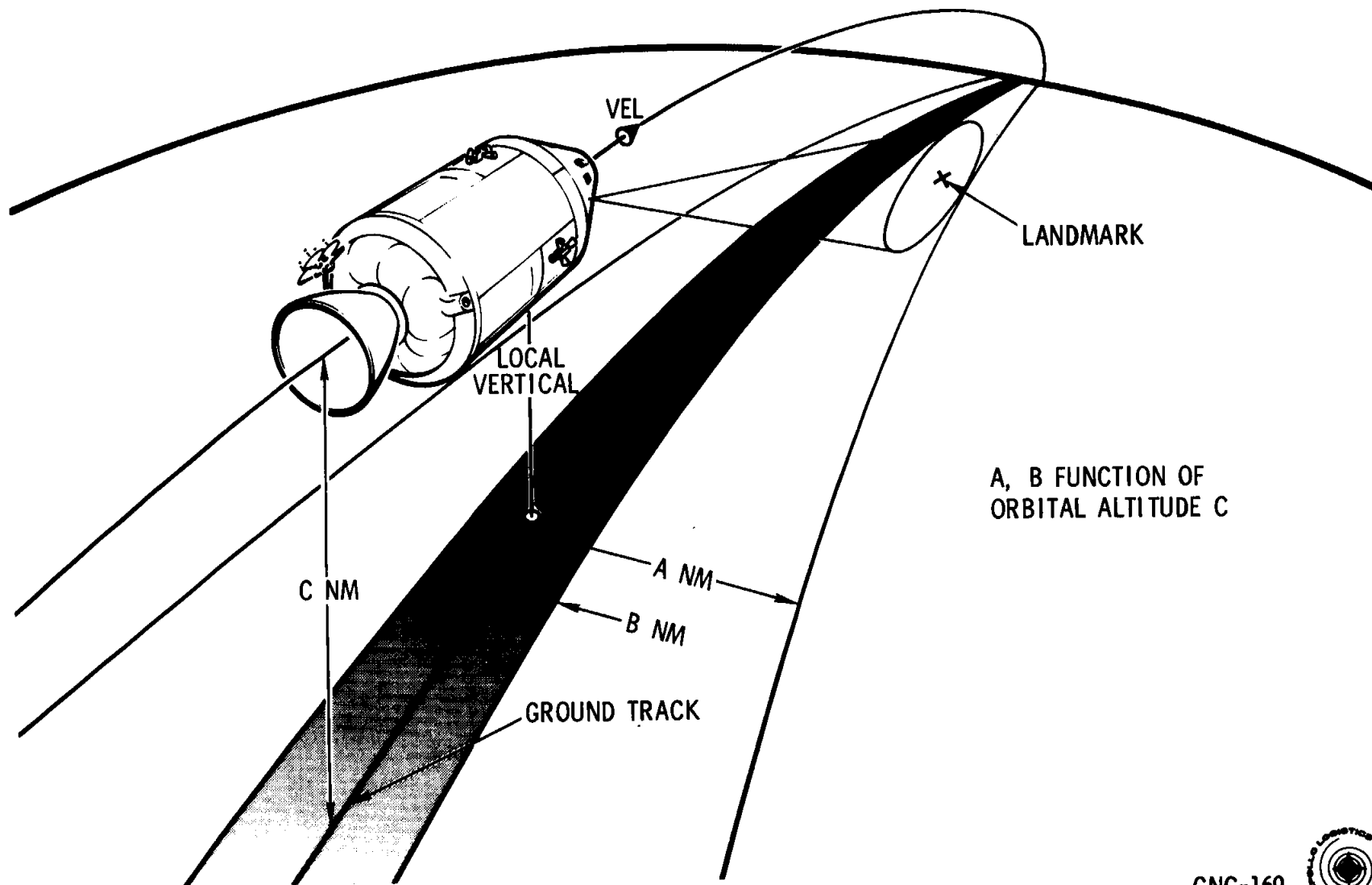


VIEW ON SURFACE FIGURE 3



COVERAGE ON SURFACE FIGURE 2

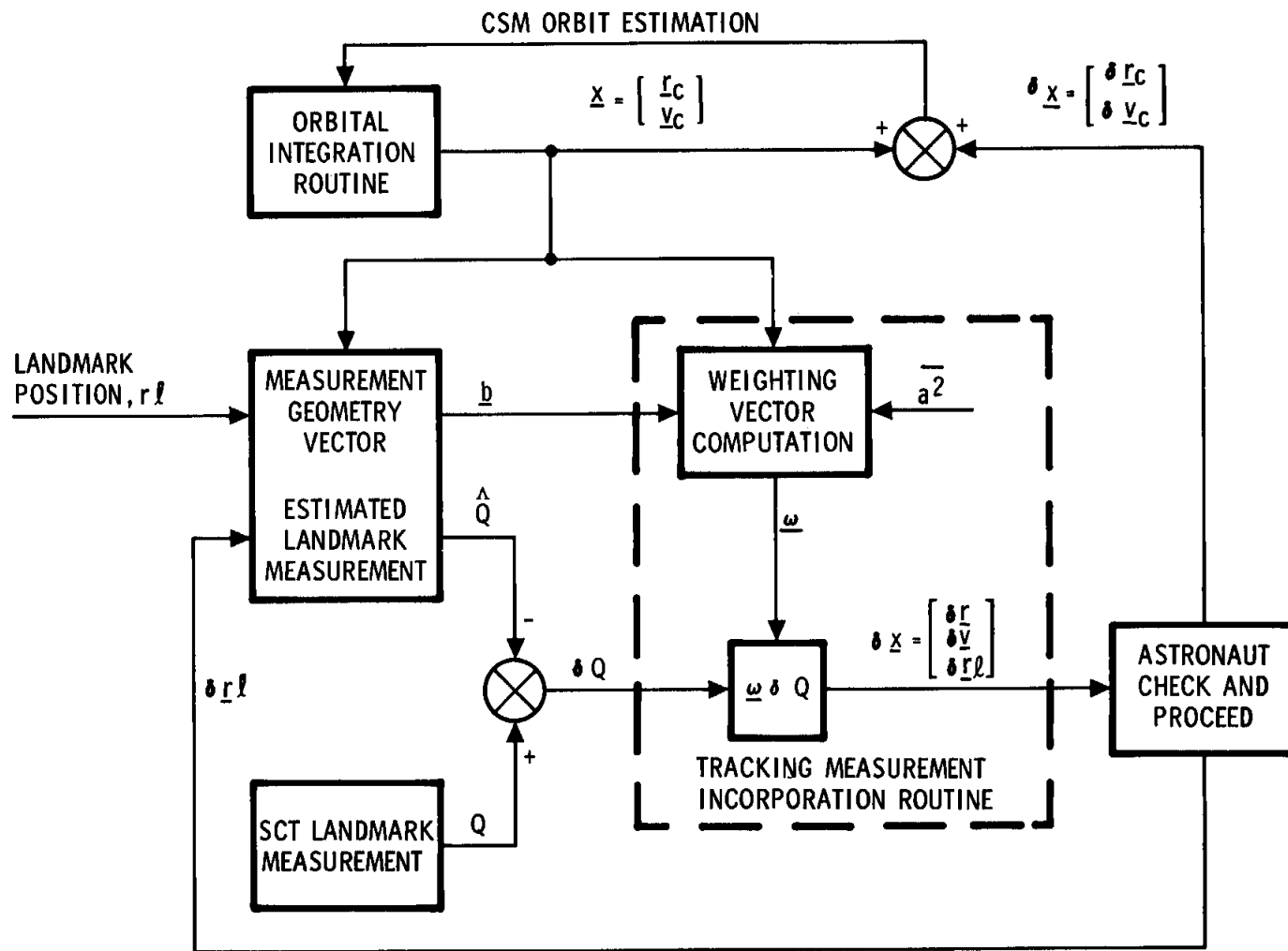
ORBITAL LANDMARK TRACKING



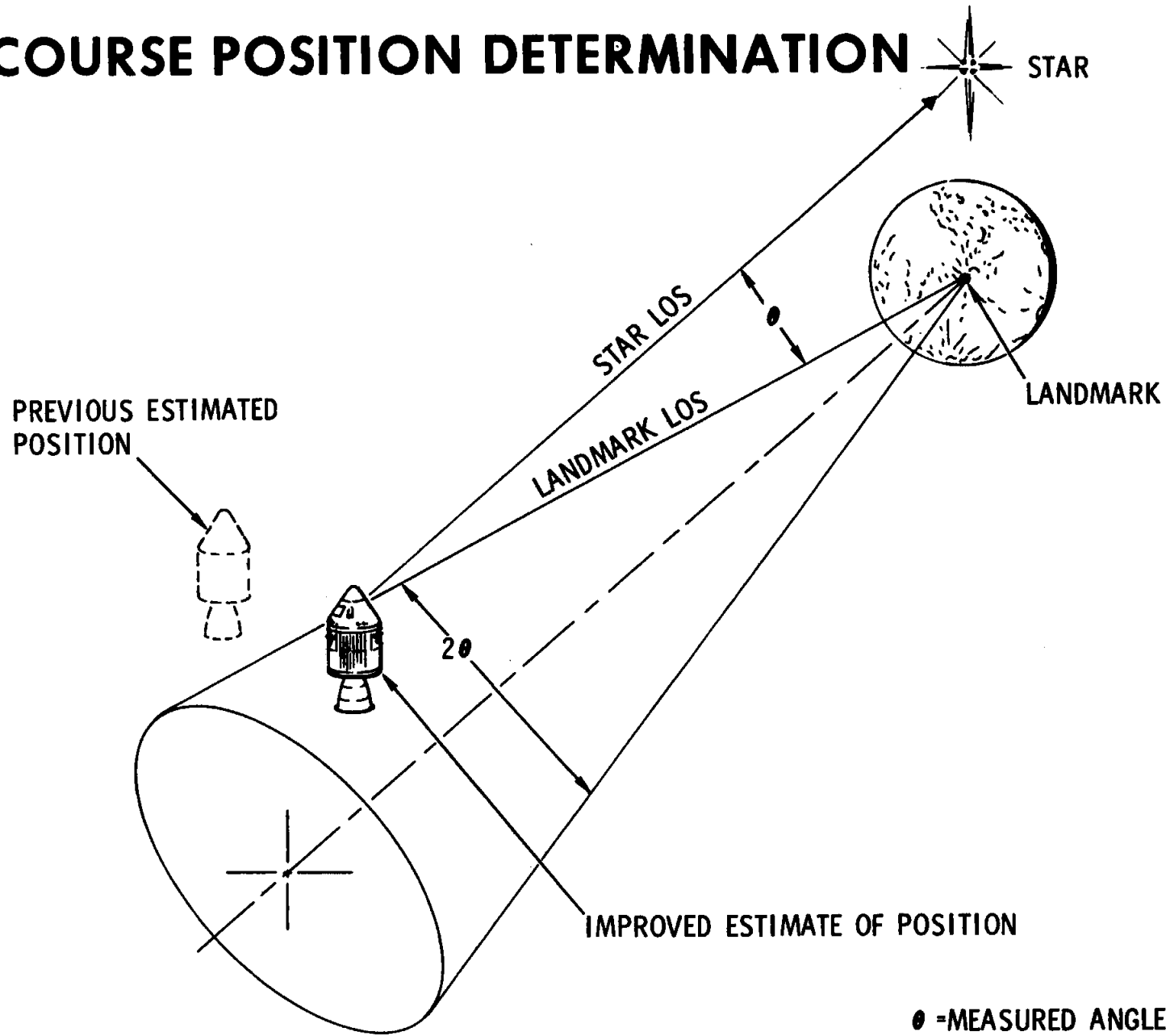
GNC-169



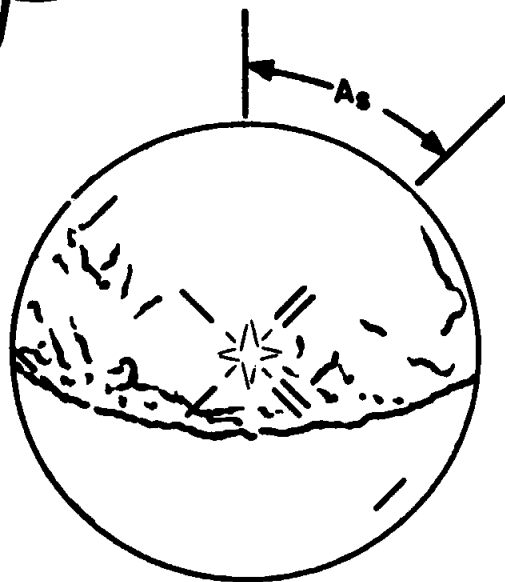
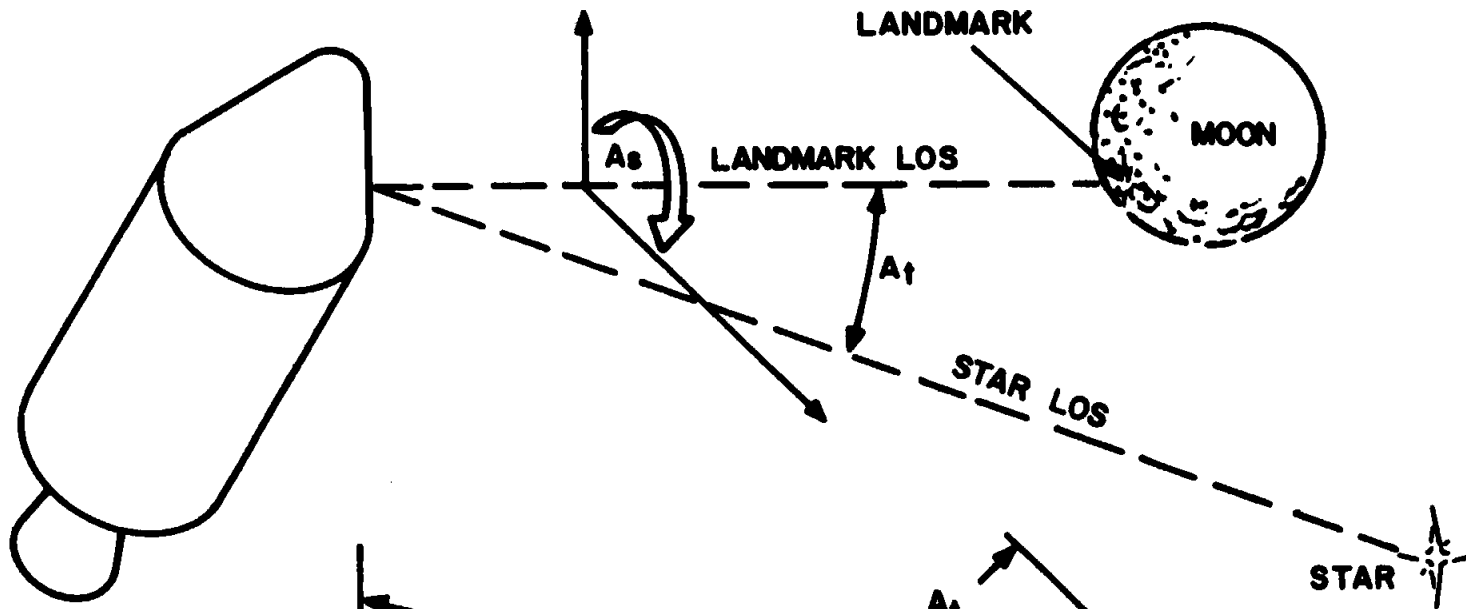
SIMPLIFIED ORBITAL NAVIGATION FUNCTIONAL DIAGRAM



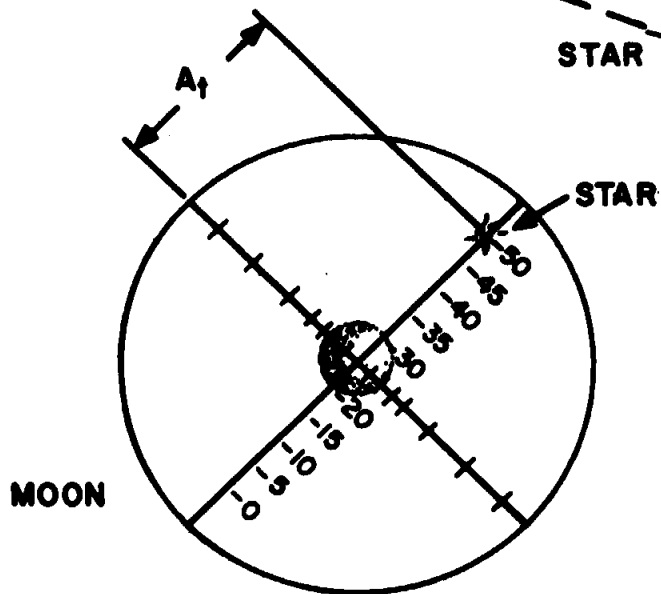
MIDCOURSE POSITION DETERMINATION




NAVIGATIONAL MEASUREMENT



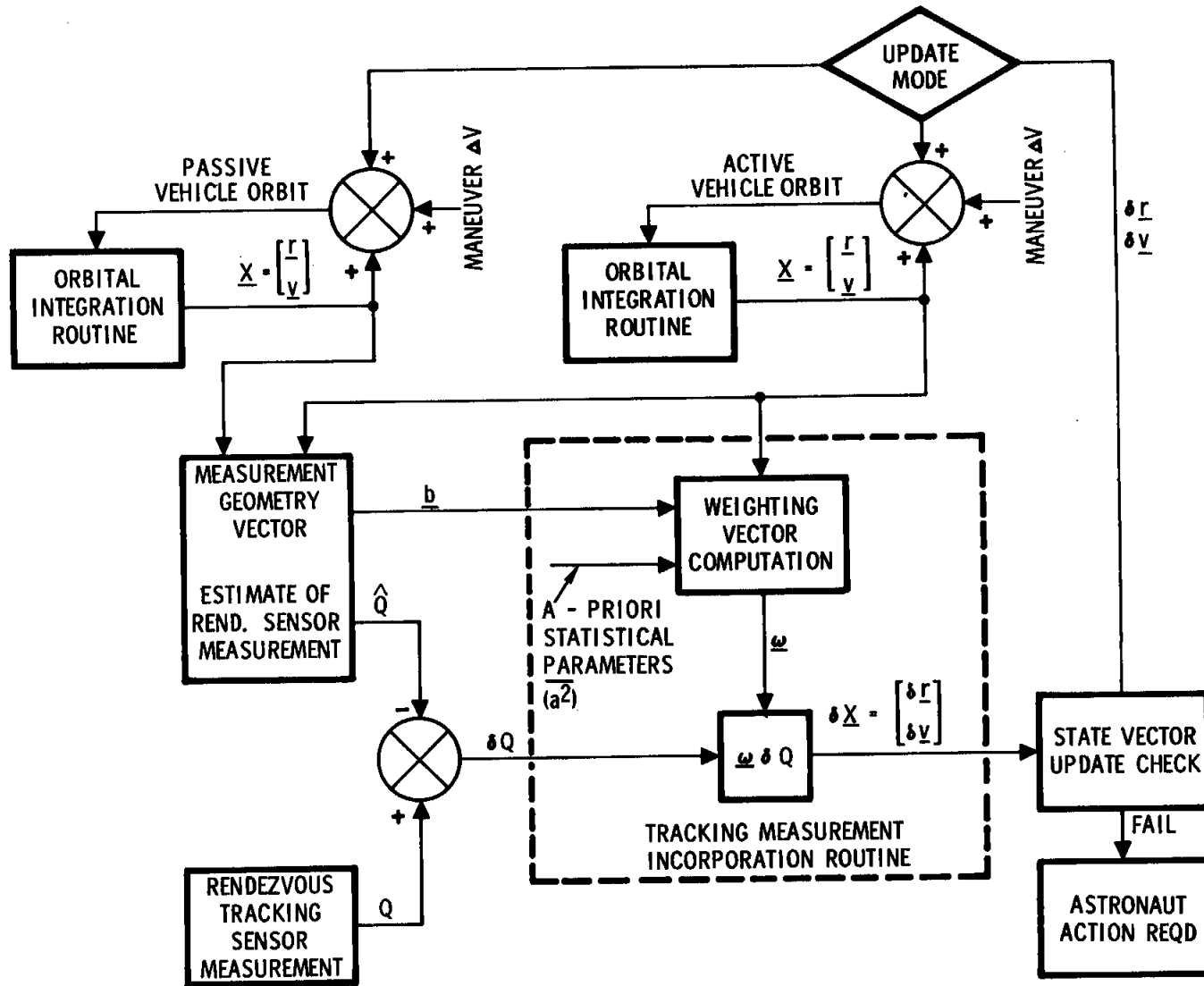
SEXTANT
FIELD OF VIEW



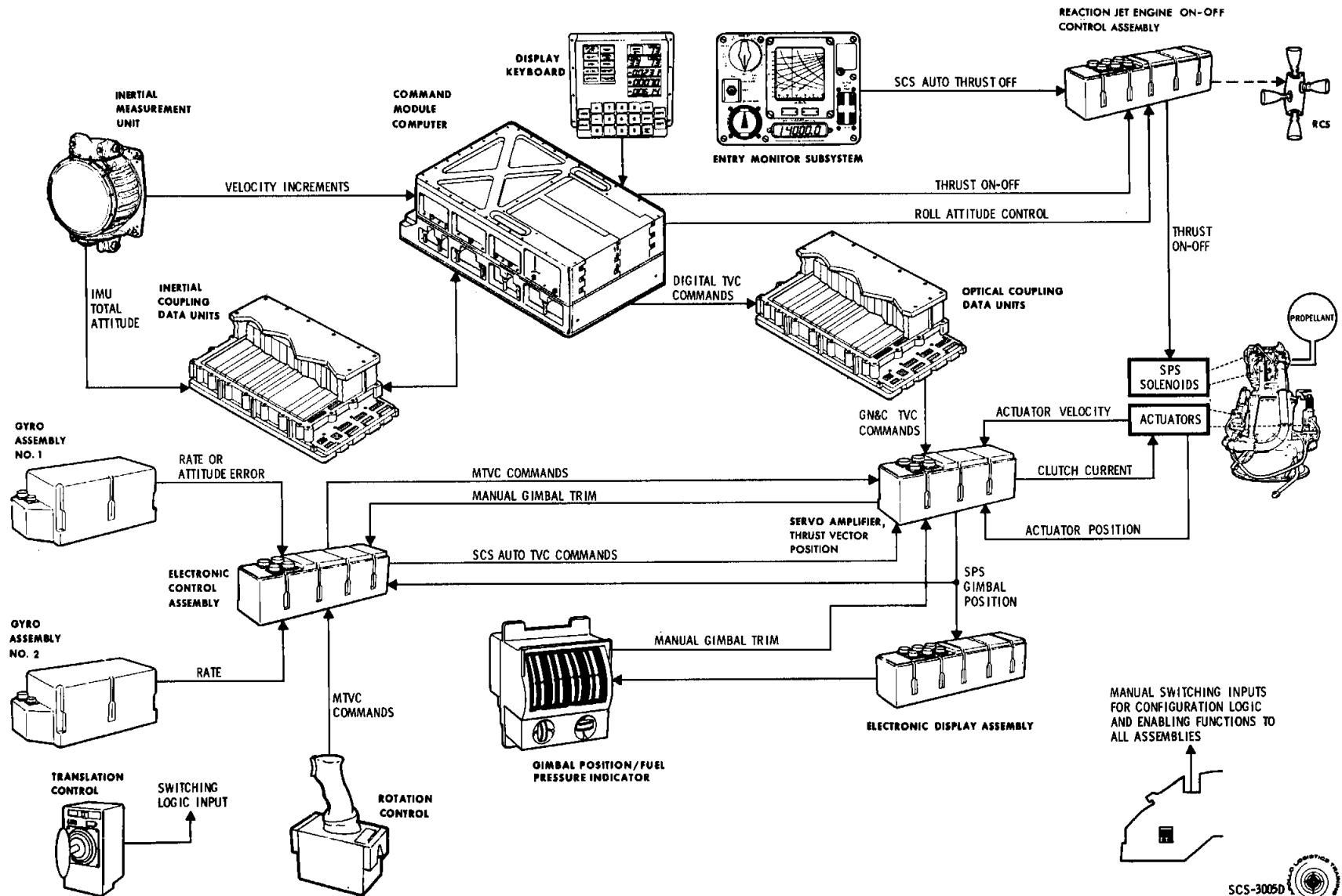
TELESCOPE
FIELD OF VIEW

GN-9103B 

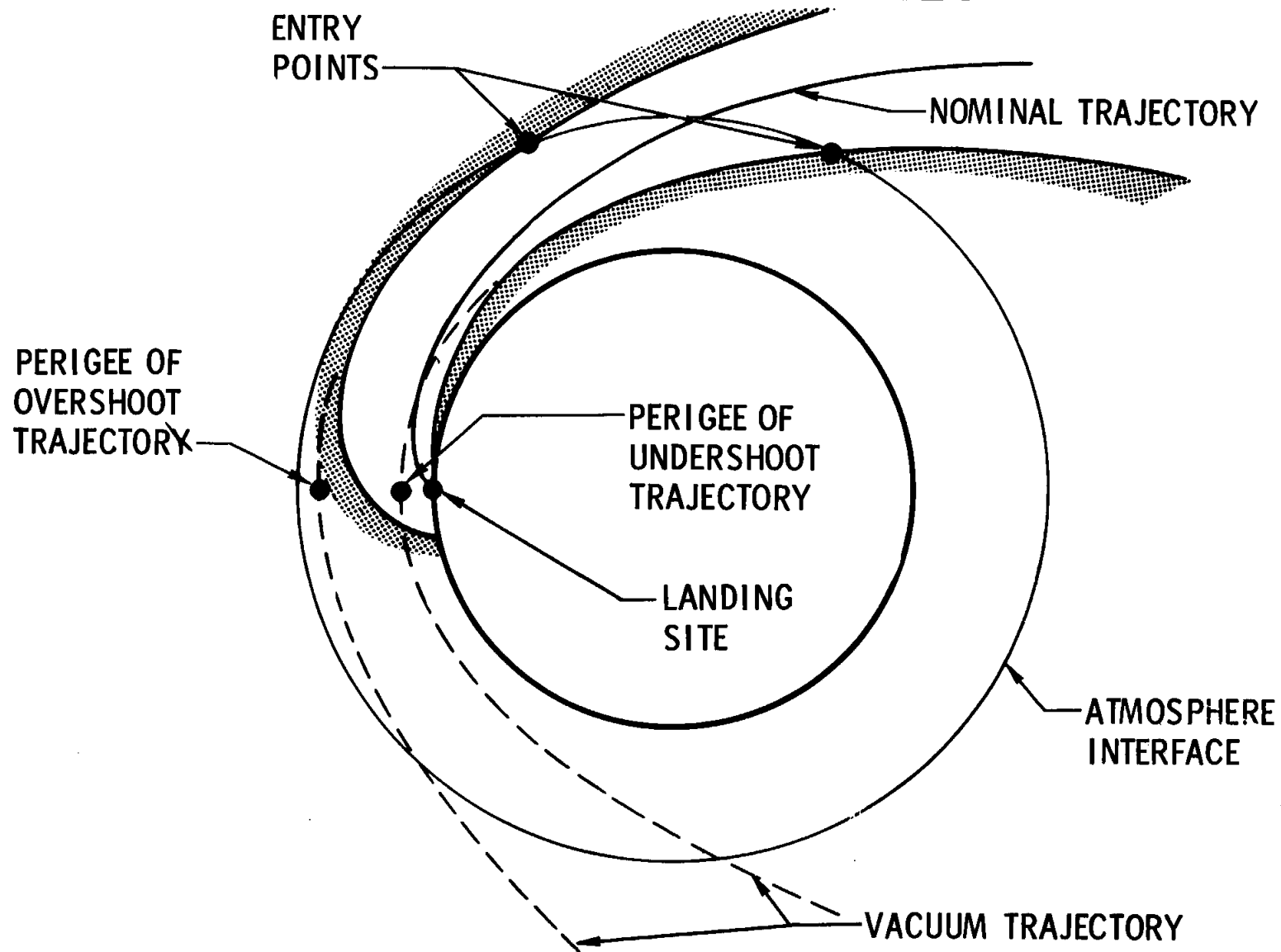
SIMPLIFIED CMC RENDEZVOUS NAVIGATIONAL FUNCTIONAL DIAGRAM



G & C THRUST VECTOR CONTROL

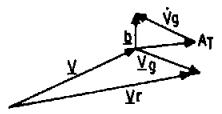
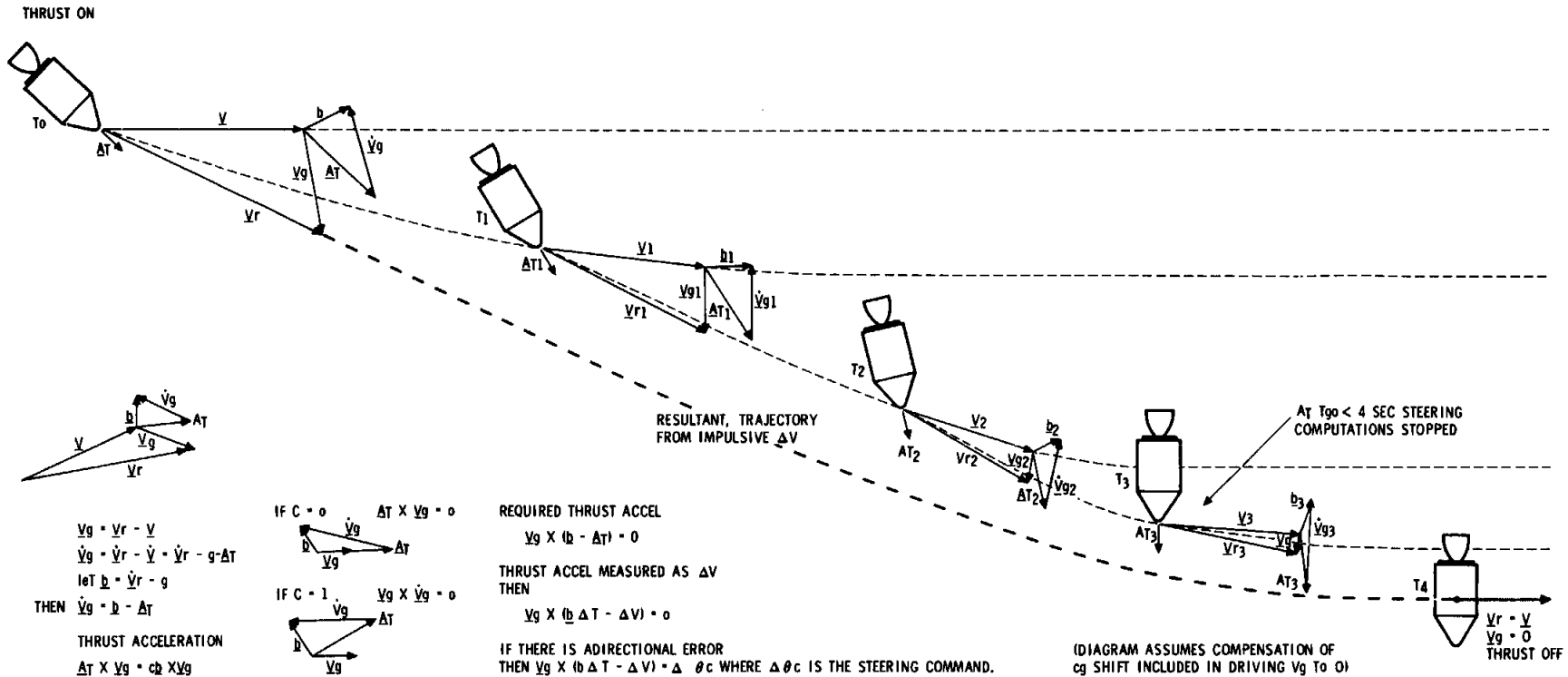


ENTRY BOUNDARIES

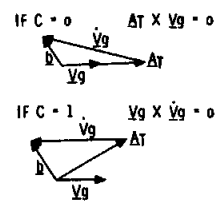


GN-205 A 

STEERING FOR ORBITAL MANUEVERS



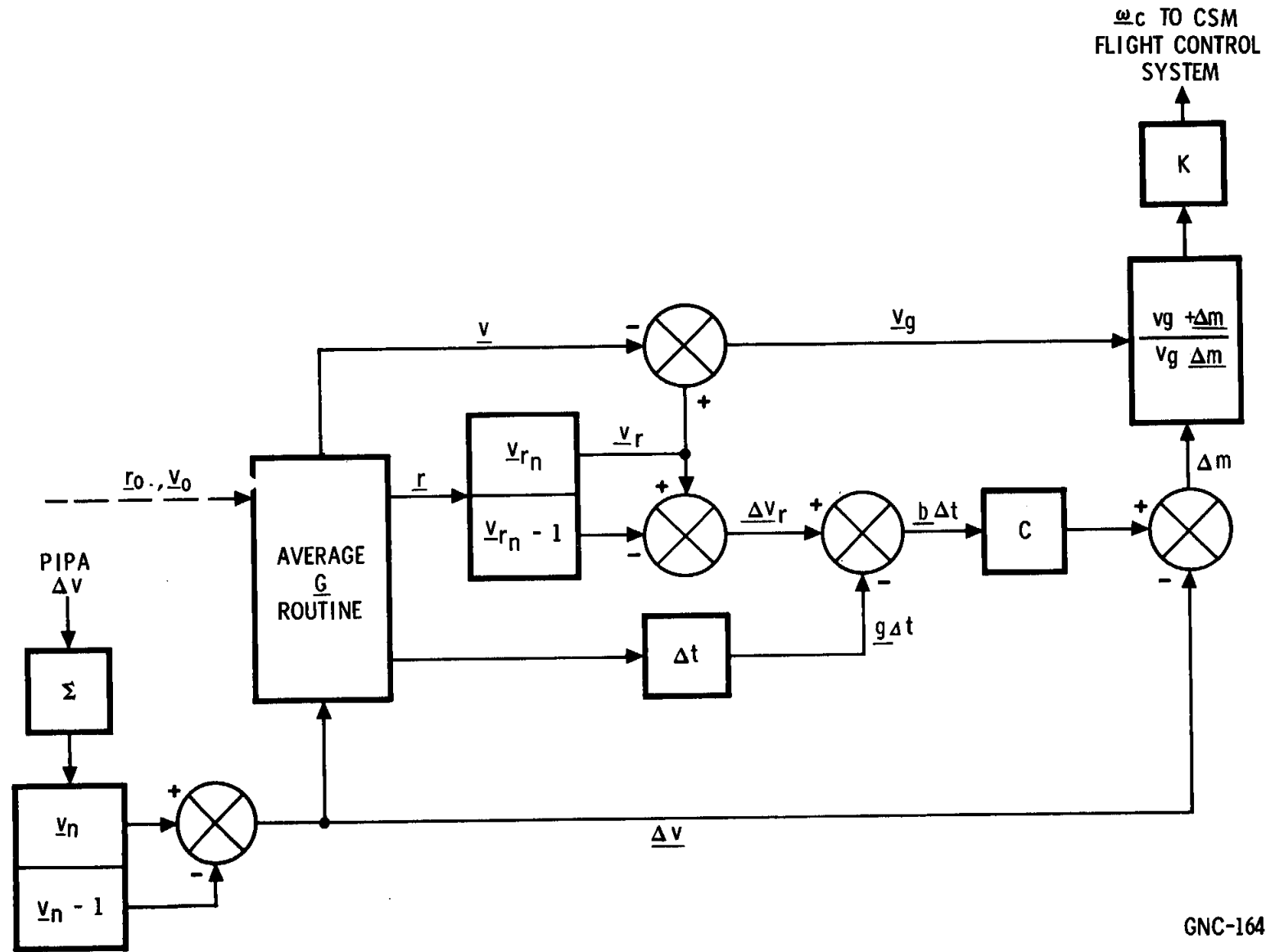
$V_g = V_r - \dot{V}$
 $\dot{V}_g = \dot{V}_r - \ddot{V} - \dot{V}_r - g - \Delta T$
 let $b = \dot{V}_r - g$
 THEN $\dot{V}_g = b - \Delta T$
 THRUST ACCELERATION
 $\Delta T \times V_g = c_b \times V_g$



REQUIRED THRUST ACCEL
 $V_g \times (b - \Delta T) = 0$
 THRUST ACCEL MEASURED AS ΔV
 THEN
 $V_g \times (b \Delta T - \Delta V) = 0$
 IF THERE IS A DIRECTIONAL ERROR
 THEN $V_g \times (b \Delta T - \Delta V) = \Delta \theta c$ WHERE $\Delta \theta c$ IS THE STEERING COMMAND.

(DIAGRAM ASSUMES COMPENSATION OF cg SHIFT INCLUDED IN DRIVING V_g TO 0)

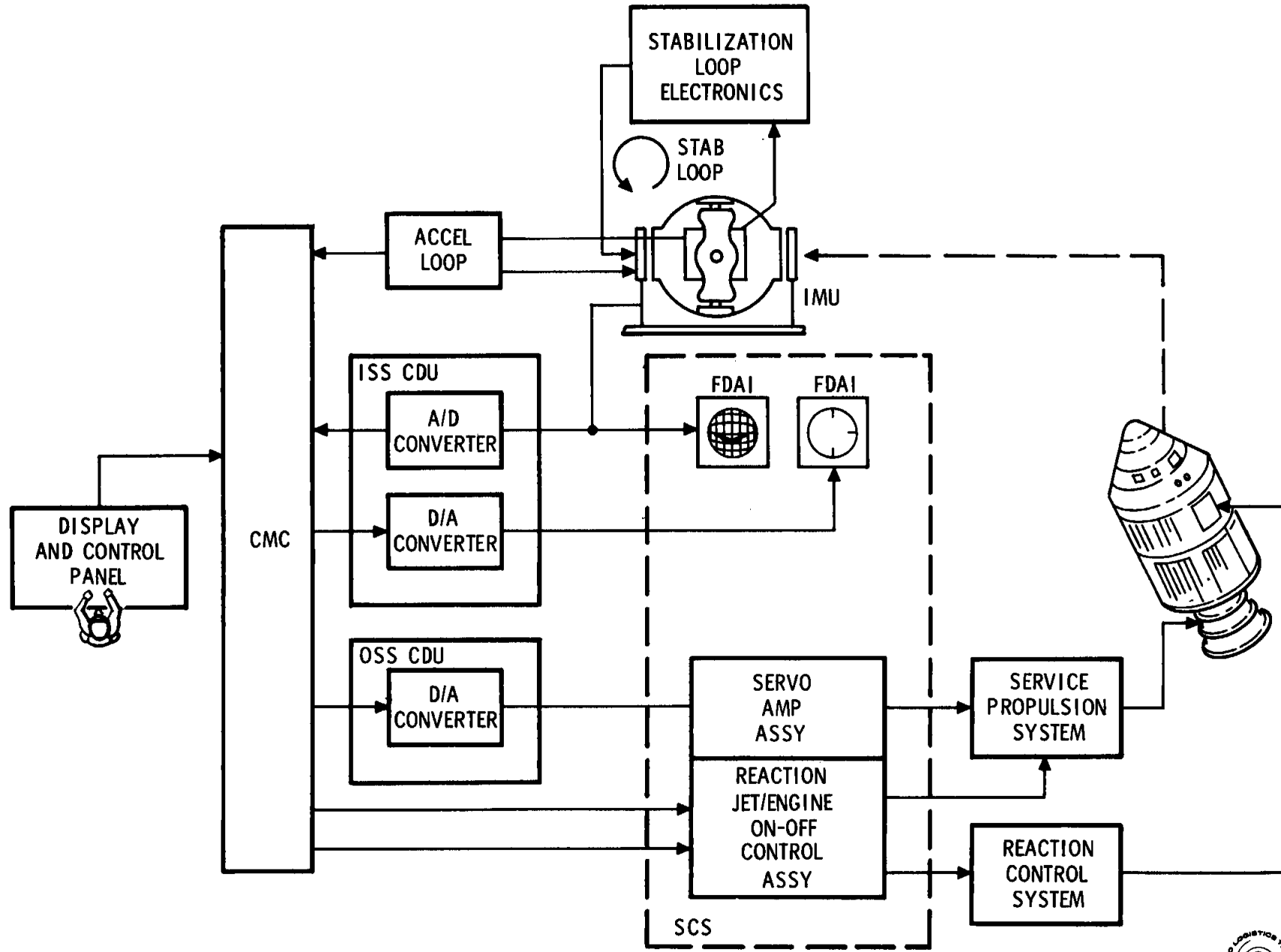
CMC POWERED FLIGHT STEERING BLOCK DIAGRAM



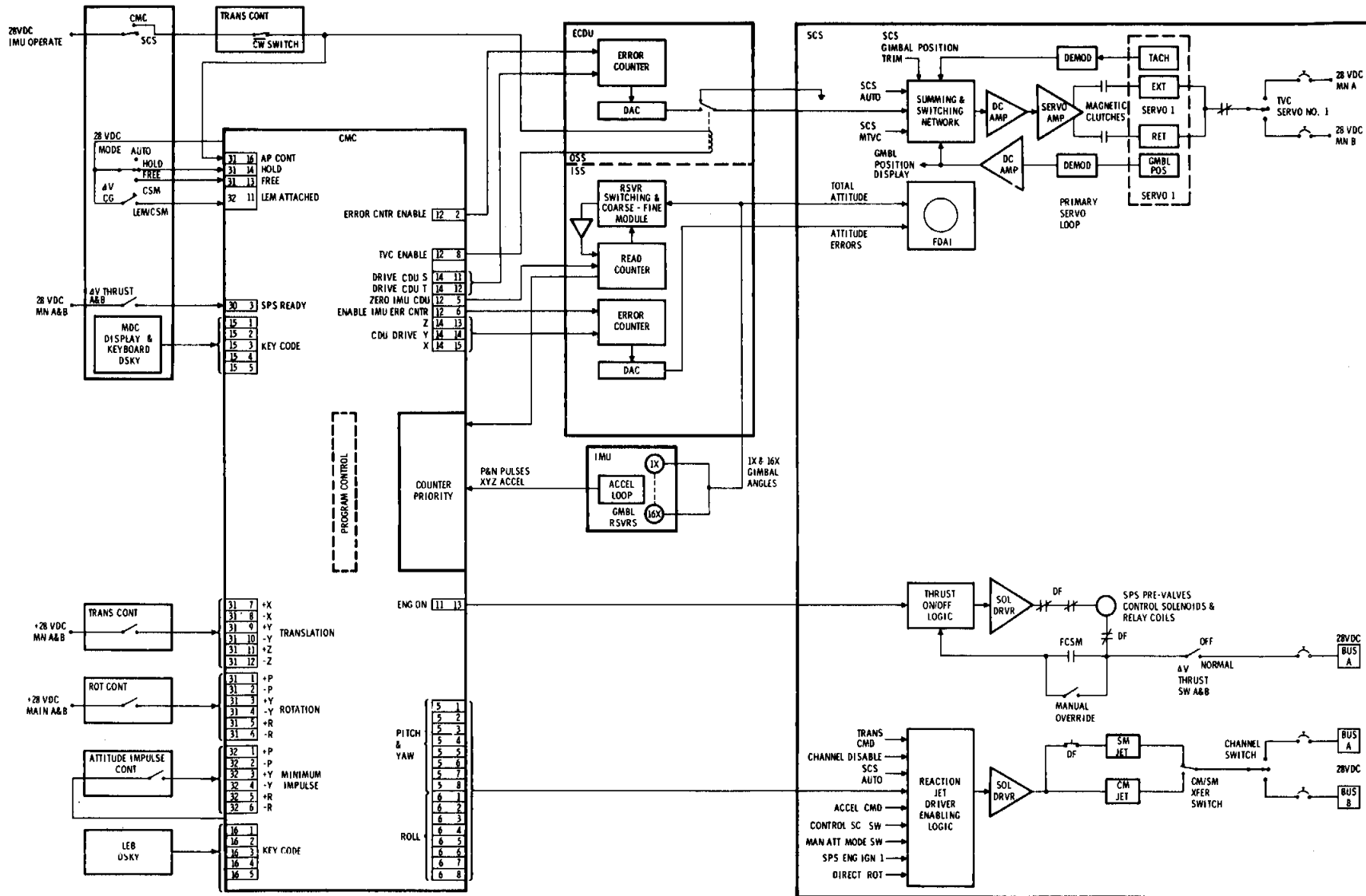
GNC-164



THRUST VECTOR CONTROL

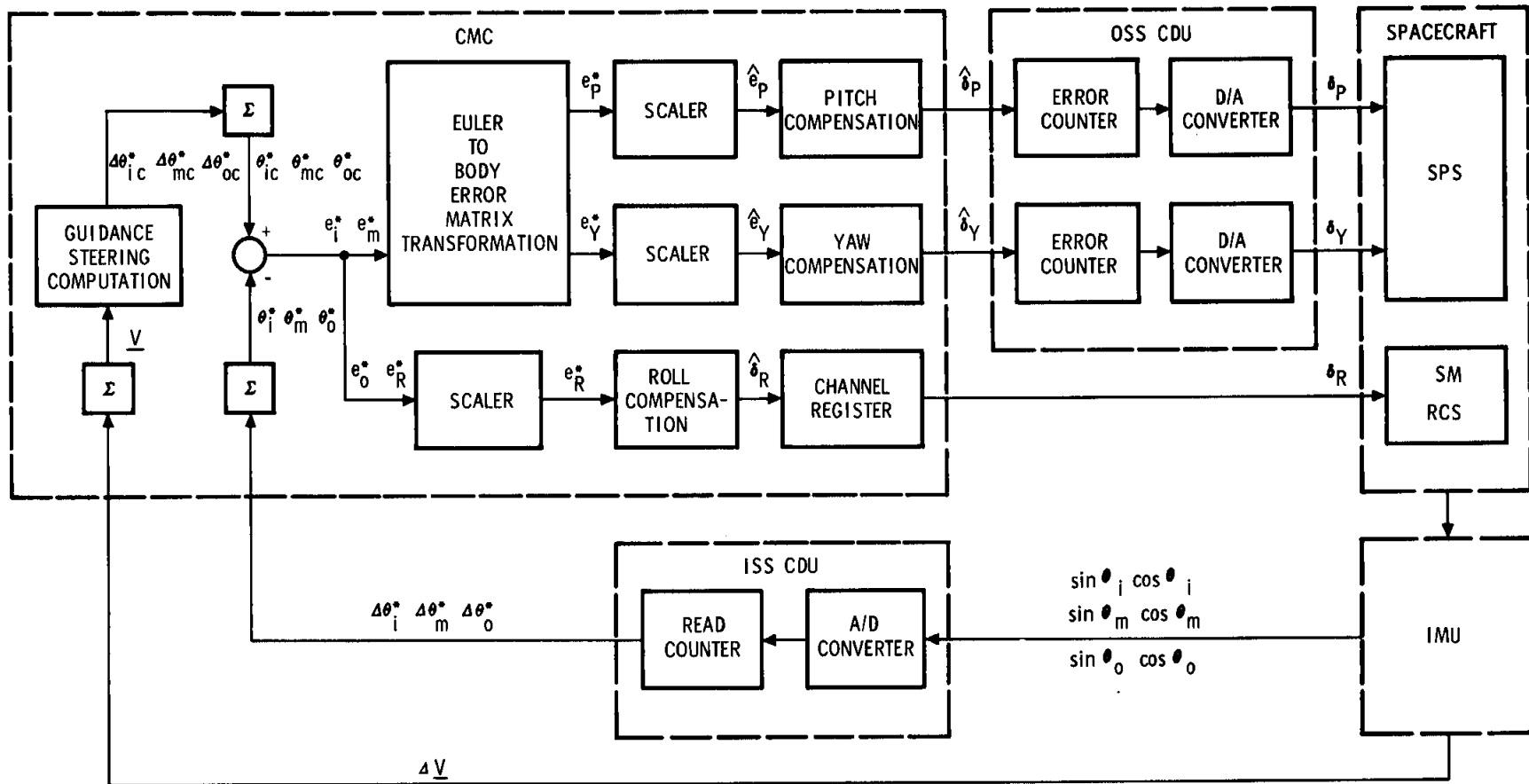


TVC FUNCTIONAL BLOCK DIAGRAM



TVC DAP

SIMPLIFIED BLOCK DIAGRAM

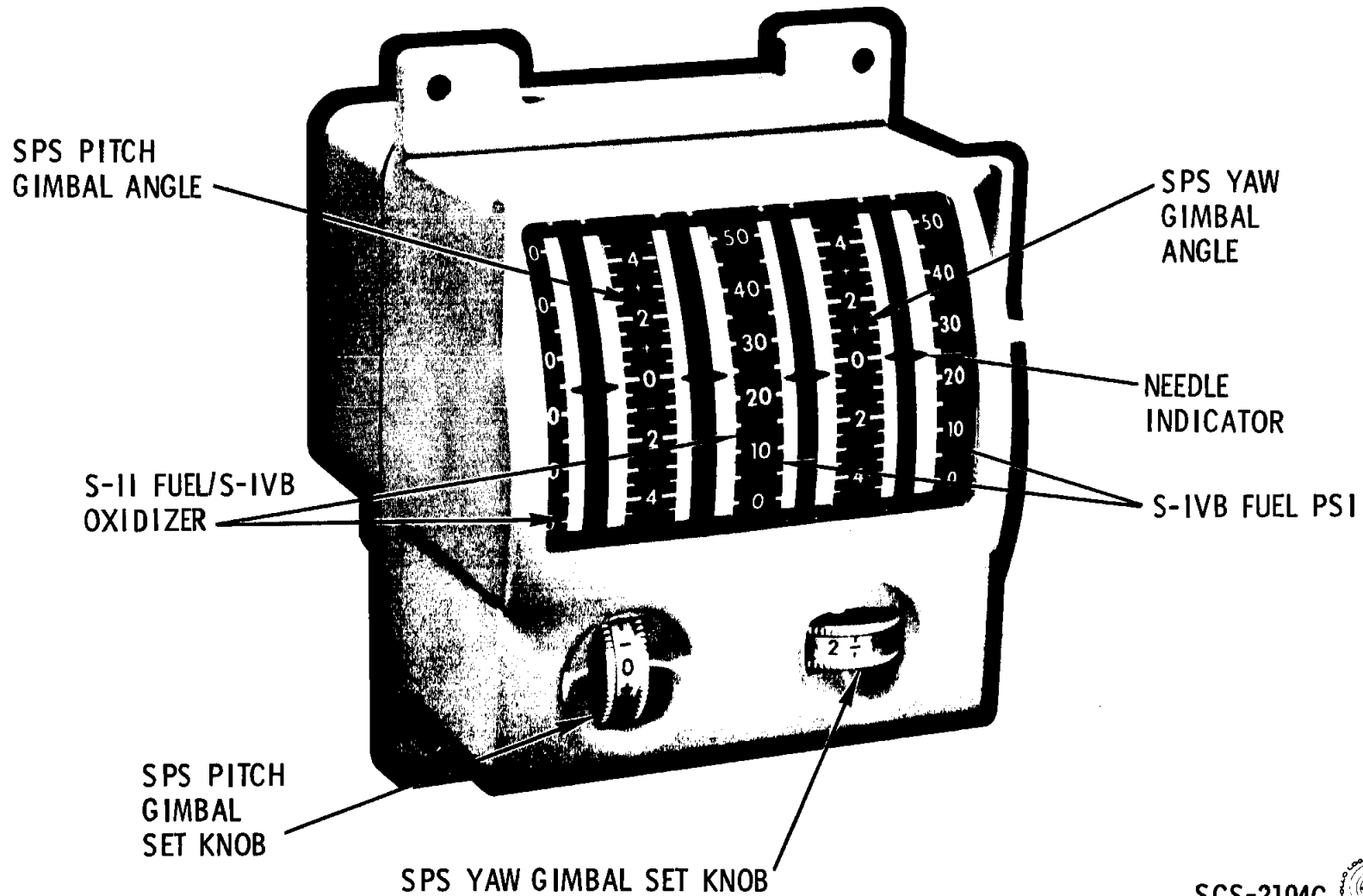



LEGEND:

θ_i θ_m θ_o IMU GIMBAL ANGLES: INNER, MIDDLE AND OUTER.
 θ_{ic} θ_{mc} θ_{oc} IMU GIMBAL-ANGLE COMMANDS: INNER, MIDDLE AND OUTER.
 e_i e_m e_o GIMBAL-ANGLE ERRORS: INNER, MIDDLE AND OUTER.

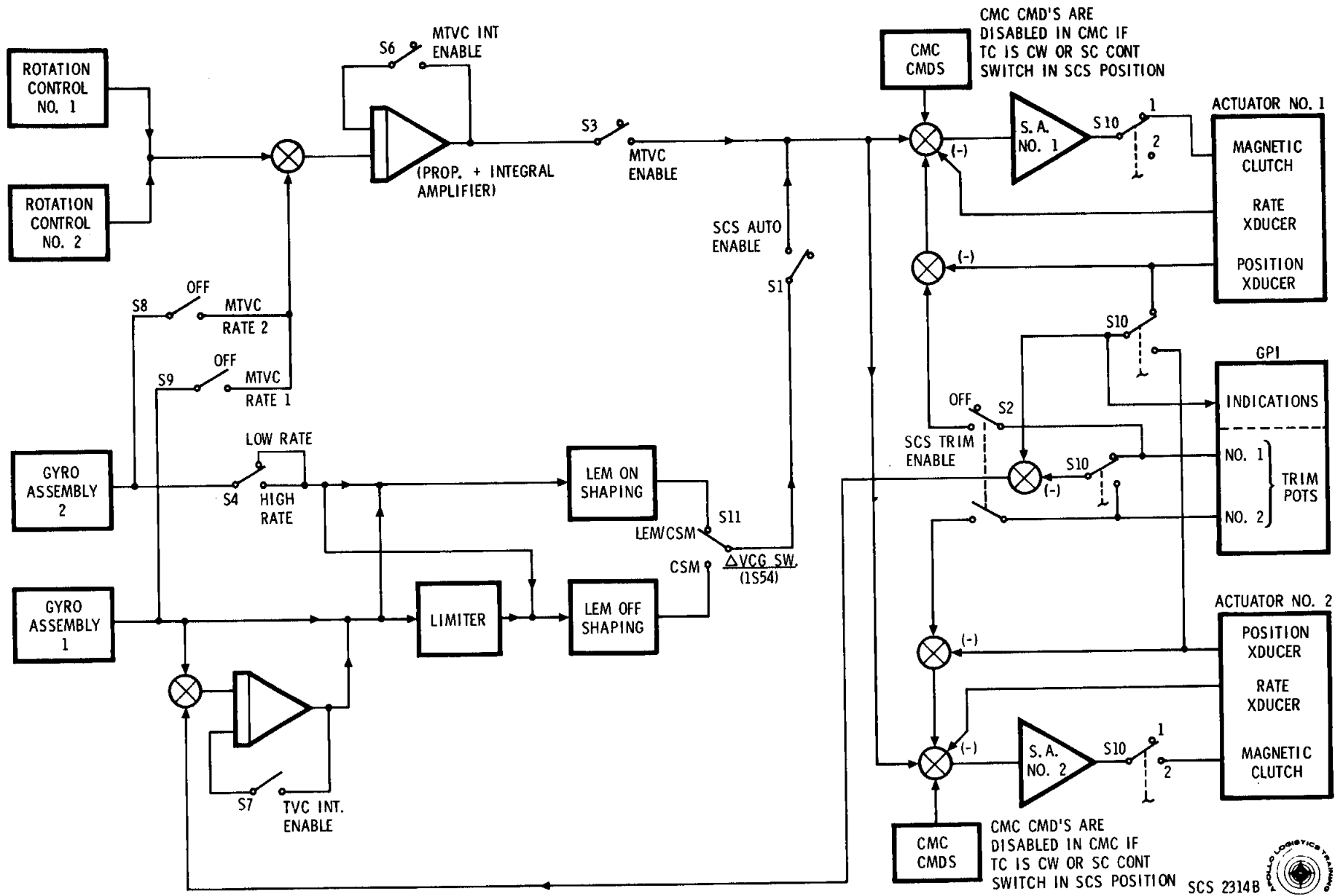
e_p e_y e_R SPACECRAFT ATTITUDE ERRORS: PITCH, YAW AND ROLL.
 δ_P δ_Y PITCH-AND YAW-CHANNEL SPS GIMBAL-ANGLE COMMANDS.
 δ_R ROLL-CHANNEL SM RCS ENGINE "ON-OFF" COMMANDS.

FUEL PRESSURE/GIMBAL POSITION INDICATOR



SCS-2104C 

THRUST VECTOR CONTROL-SIGNAL FLOW



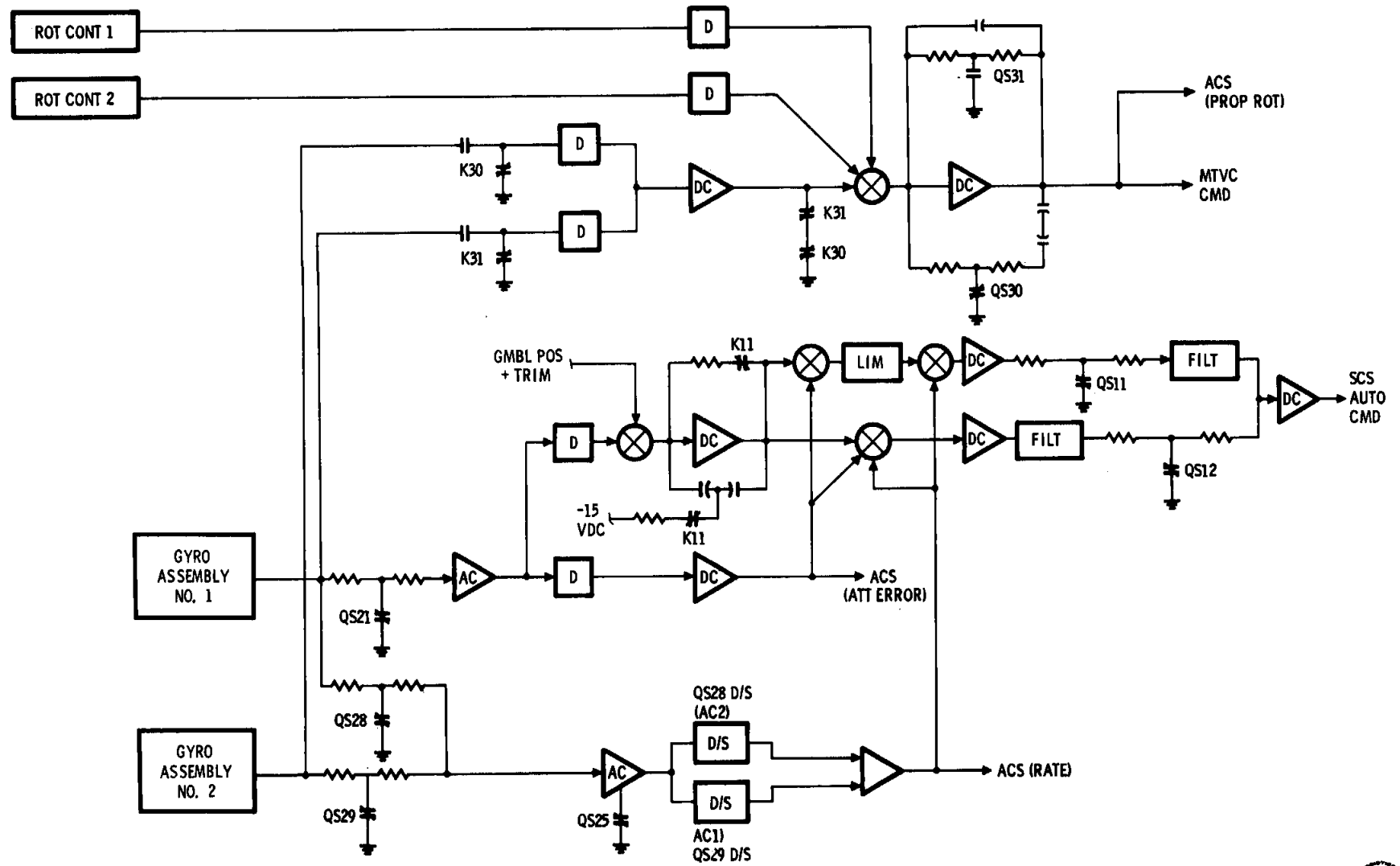
TVC FUNCTION ENABLING LOGIC

SYSTEM CONFIGURATION	FUNCT SW. / POSITION SWITCH POS.		PANEL SWITCHING AND LOGIC FOR ENABLING FUNCTIONAL SWITCH POSITION															
			SC CONT (1S18)		BMAG MODE (1S21 OR 1S22)			SPSTVC (1S38 OR 1S39)			TVC GMBL DR (1S27 OR 1S28)			XLATION CONTROL		FAIL SENSE (P OR Y)		
			SCS	CMC	RATE 2	ATT 1/ RATE 2	RATE 1	AUTO	RATE CMD	ACCEL CMD	1	AUTO	2	\overline{CW}	CW	\overline{FS}	FS	IGN 2
SCS AUTO TVC (1)	S1	SCS AUTO ENABLE	X			(2)		X						X				X
		SCS TRIM ENABLE		X				X						X				X
	S4 (3)	HIGH RATE																X(3)
		TVC INT. ENABLE	X												X			X
COMMON FUNCTION	S3	MTVC ENABLE	X						X OR X									
			X					X						X				
M T V C RATE CMD	S6	MTVC INT. ENABLE	SWITCH POSITIONS ARE SAME AS FOR S3 BUT LOGIC REQUIRES 'IGN 2' SIGNAL															
			X			X OR X			X									
	S8	MTVC RATE 2	X			X OR X		X							X			
			X		X OR X			X						X				X
ACCEL CMD	S9	MTVC RATE 1	SWITCH POSITIONS ARE SAME AS FOR S8 EXCEPT BMAG MODE SWITCH MUST BE IN RATE 1 POSITION															
SERVO NO. 1	S10	1										X						
															X		X	
SERVO NO. 2	S10	2																
															X			X

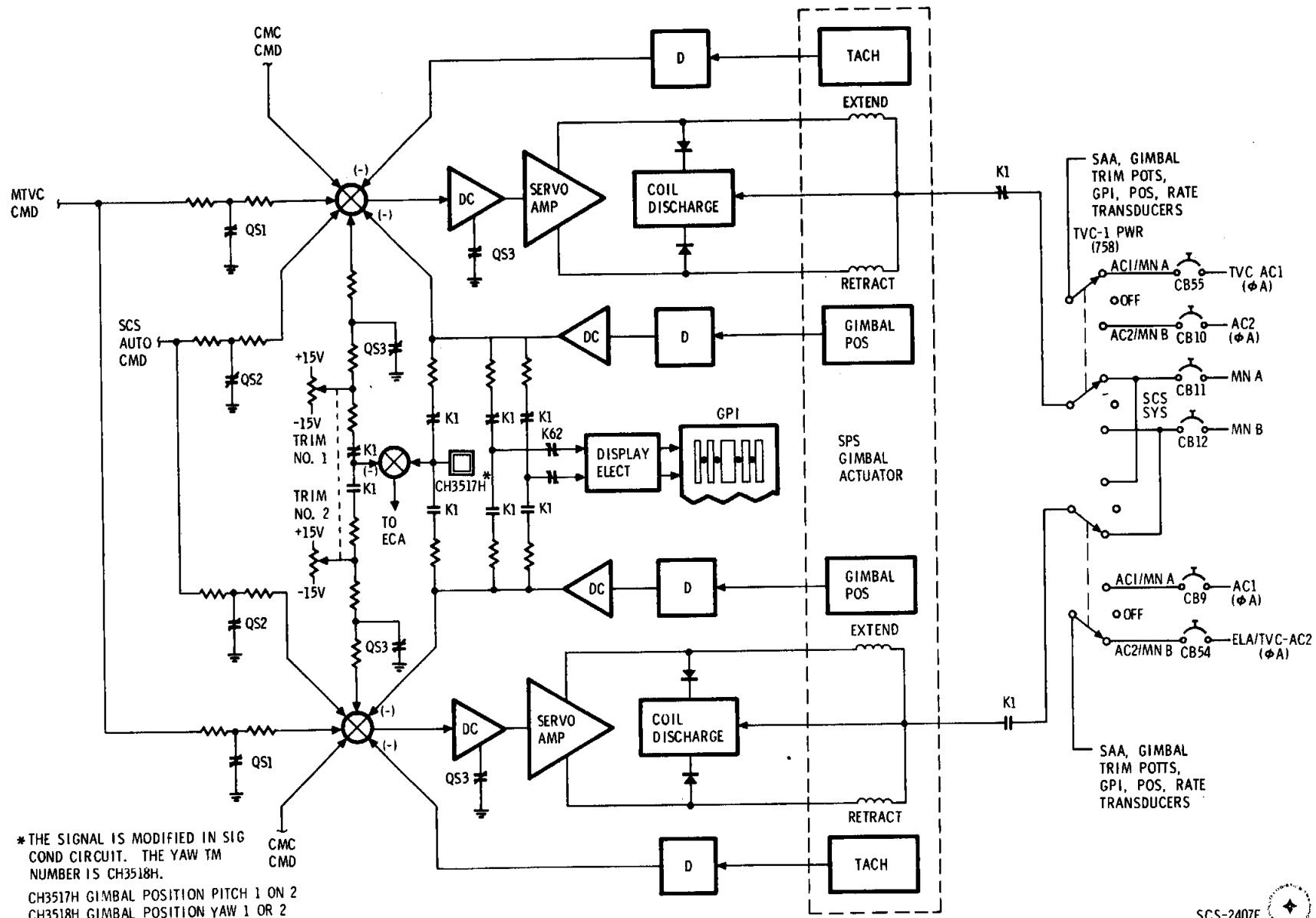
- (1). FUNCTIONAL SWITCH -S11- REPRESENTS Δ VCG SW. (1S54). SELECTS LEM ON OR LEM OFF SHAPING CIRCUITS.
- (2). FOR SCS AUTO BMAG MODE SWITCH MUST BE IN ATT 1/RATE 2 POSITION, HOWEVER, ENABLING LOGIC DOES NOT REQUIRE THIS.
- (3). SWITCH S4 POSITION IS ALSO CONTROLLED BY RATE SWITCH (1S12). IF (1S12) IS IN "LOW" POSITION, THEN, PRIOR TO IGN 2 RATE SIGNALS ARE SHAPED THROUGH HIGH GAIN CIRCUITRY, (THIS IS NOT SHOWN IN SCS 2314 DWG BECAUSE THE SIGNALS ARE NOT SWITCHED (FCT SW S1) INTO SERVO AMP UNTIL IGN 2).



SCS TVC ELECTRONICS (PITCH)



SPS SERVO ELECTRONICS (PITCH)

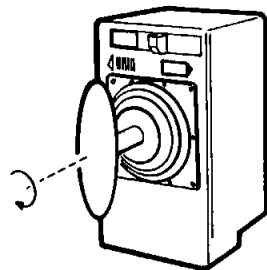
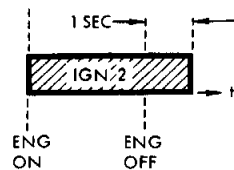
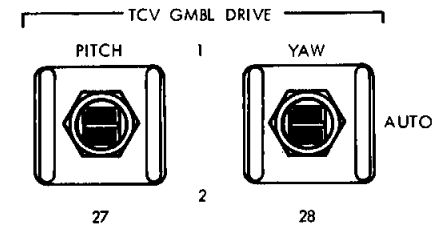
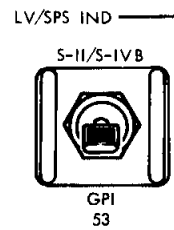
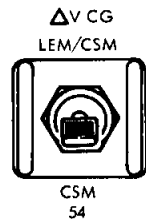
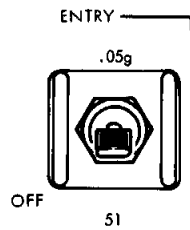
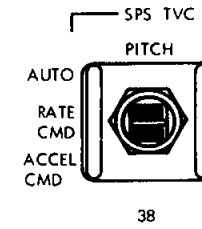
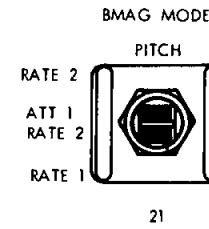
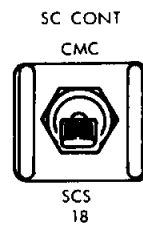
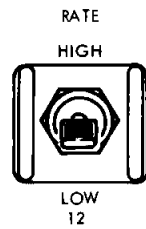
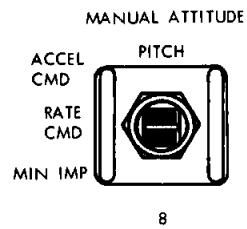


* THE SIGNAL IS MODIFIED IN SIG COND CIRCUIT. THE YAW TM NUMBER IS CH3518H.
 CH3517H GIMBAL POSITION PITCH 1 ON 2
 CH3518H GIMBAL POSITION YAW 1 OR 2

SCS-2407E

TVC LOGIC

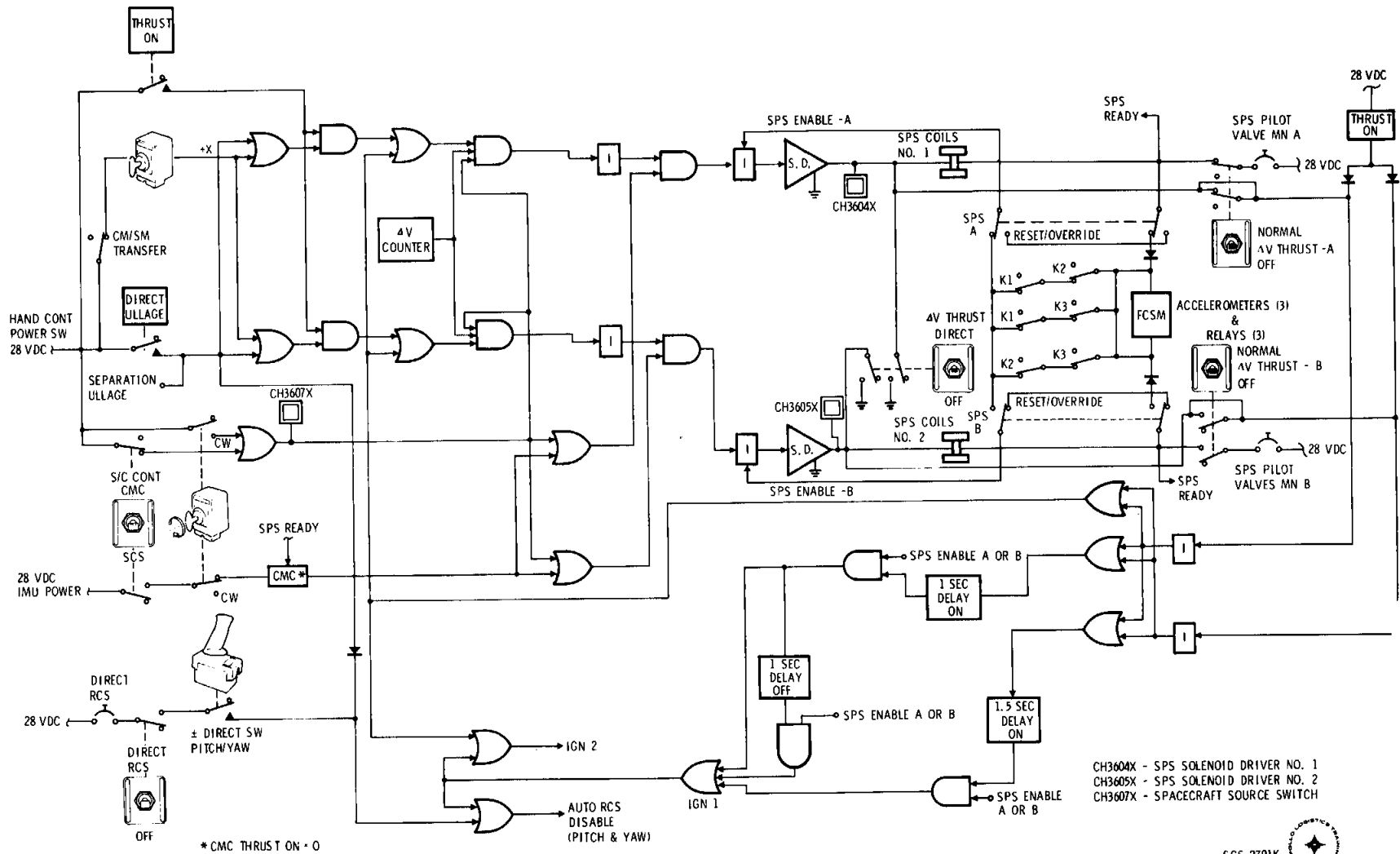
(SCS TVC ELECTRONICS)




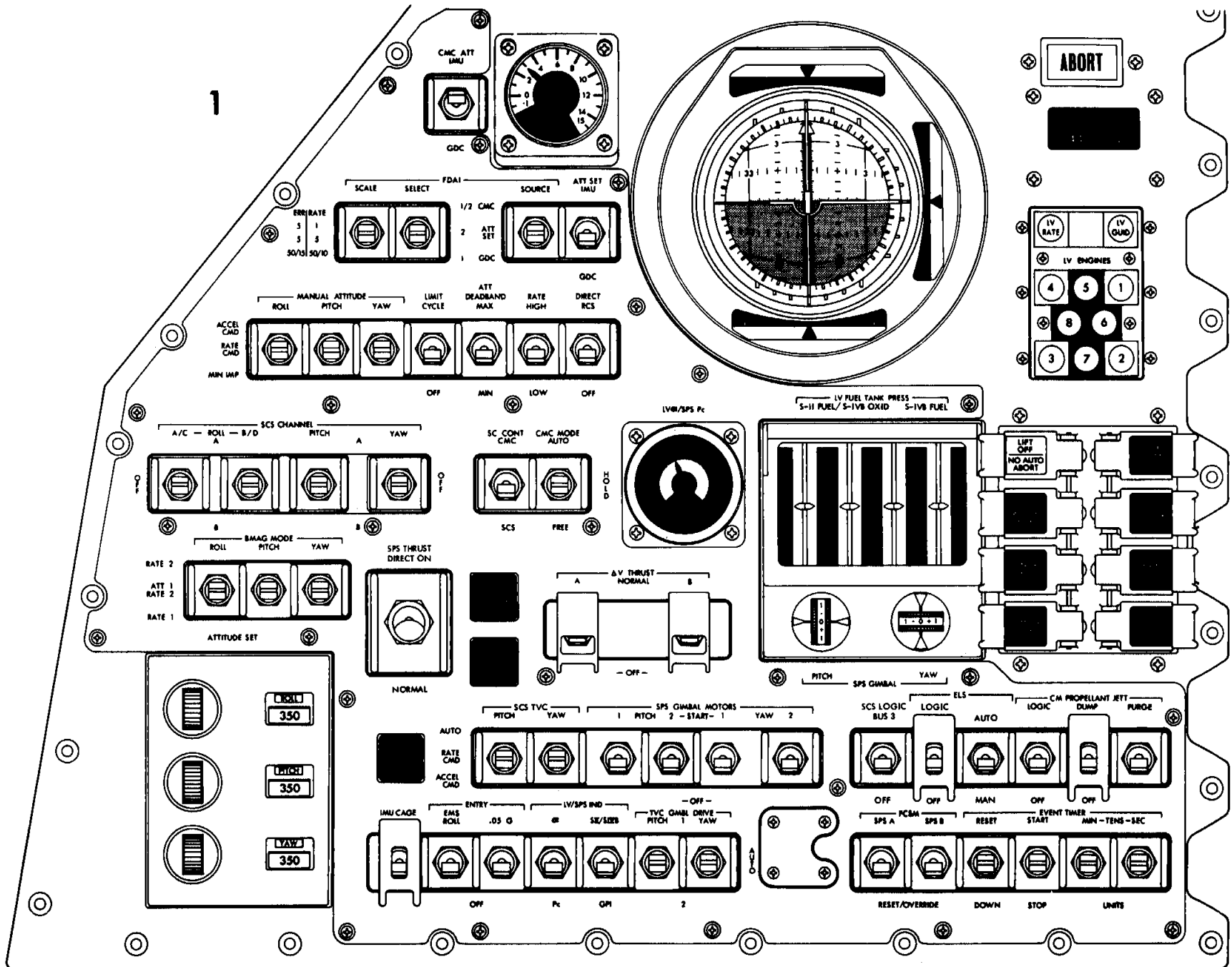
TC

- 3QS28 = RATE 1
- 3QS29 = (RATE 2) + (ATT 1/RATE 2)
- 3QS25 = (HIGH RATE) + IGN 2
- 3QS11 = LEM OFF
- 3QS12 = LEM ON
- 3QS31 = $\{ \text{IGN}_2 [(\text{SCS} + \text{CW}) \cdot (\text{RATE CMD} + \text{ACCEL}) + \text{SCS} \cdot \text{AUTO} \cdot \text{CW}] \}$
- 3K11 = (IGN 2) (SCS + CW)
- 121A5K1 = (ATT 1/RATE 2) (0.05g)' [IGN 2 + (RATE CMD MAN. ATT) (± BO P)']
- 3QS21 = 121A5K1
- 3QS30 = $\text{IGN}_2 [(\text{SCS} + \text{CW}) \cdot (\text{RATE CMD} + \text{ACCEL}) + \text{SCS} \cdot \text{AUTO} \cdot \text{CW}]$
- 3K30 = $[(\text{RATE 2}) + (\text{ATT 1/RATE 2})]$ (RATE DAMPED MTVC)
- 3K31 = (RATE 1) (RATE DAMPED MTVC)
- 3QS1 = $\text{SCS} \cdot (\text{SCS AUTO})' + \text{CW} \cdot (\text{SCS AUTO})' + \text{CW} \cdot \text{SCS}$
- 3QS2 = (SCS AUTO) (IGN 2) $[\text{SCS} \cdot \overline{\text{CW}} + \text{CMC} \cdot \text{CW}]$
- 3QS3 = SCS + CW
- K1 = GIM DR 2 + GIM DR AUTO (F. S. + CW)
- K62 = GPI

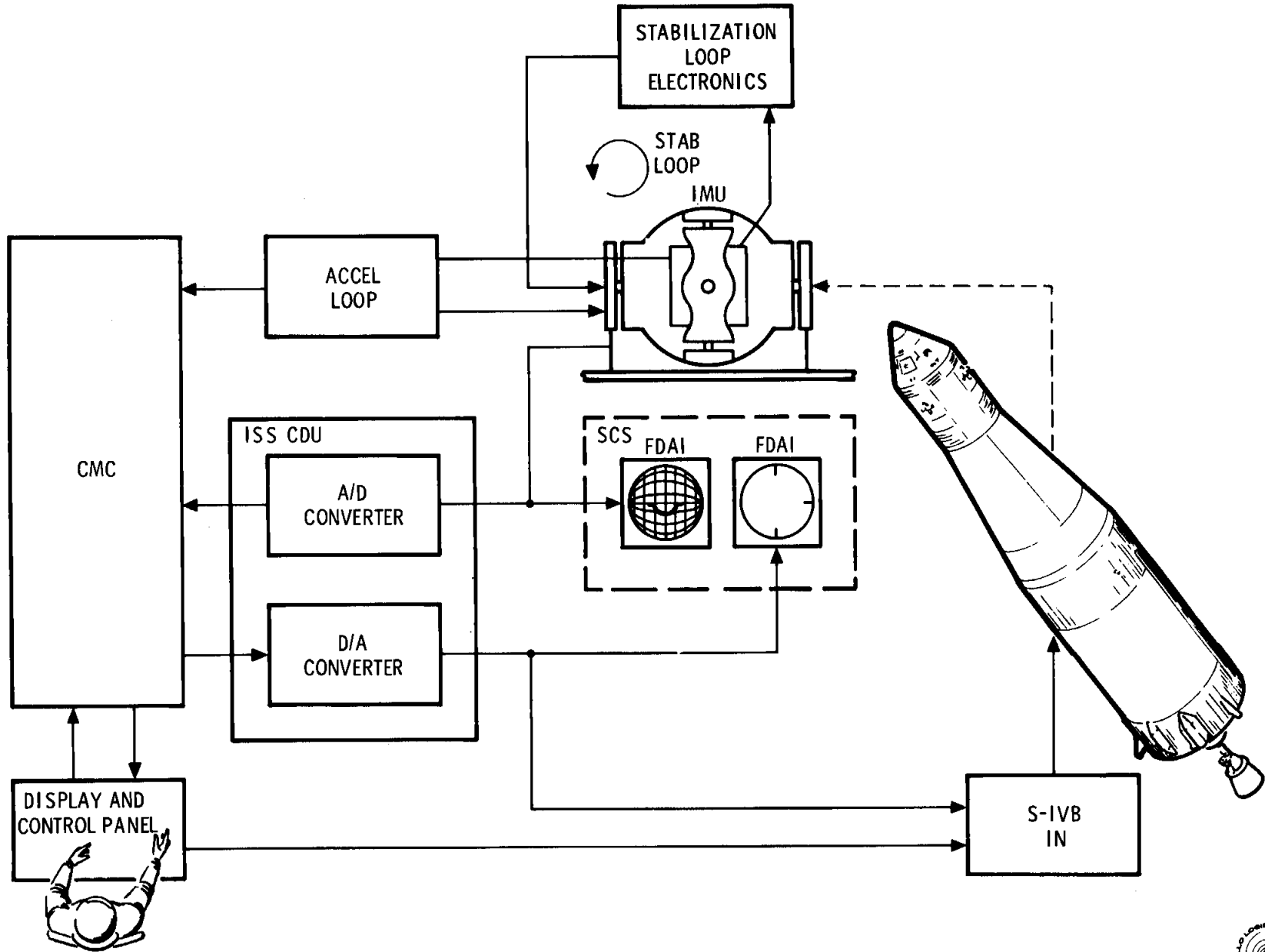
SPS ENGINE ON-OFF LOGIC



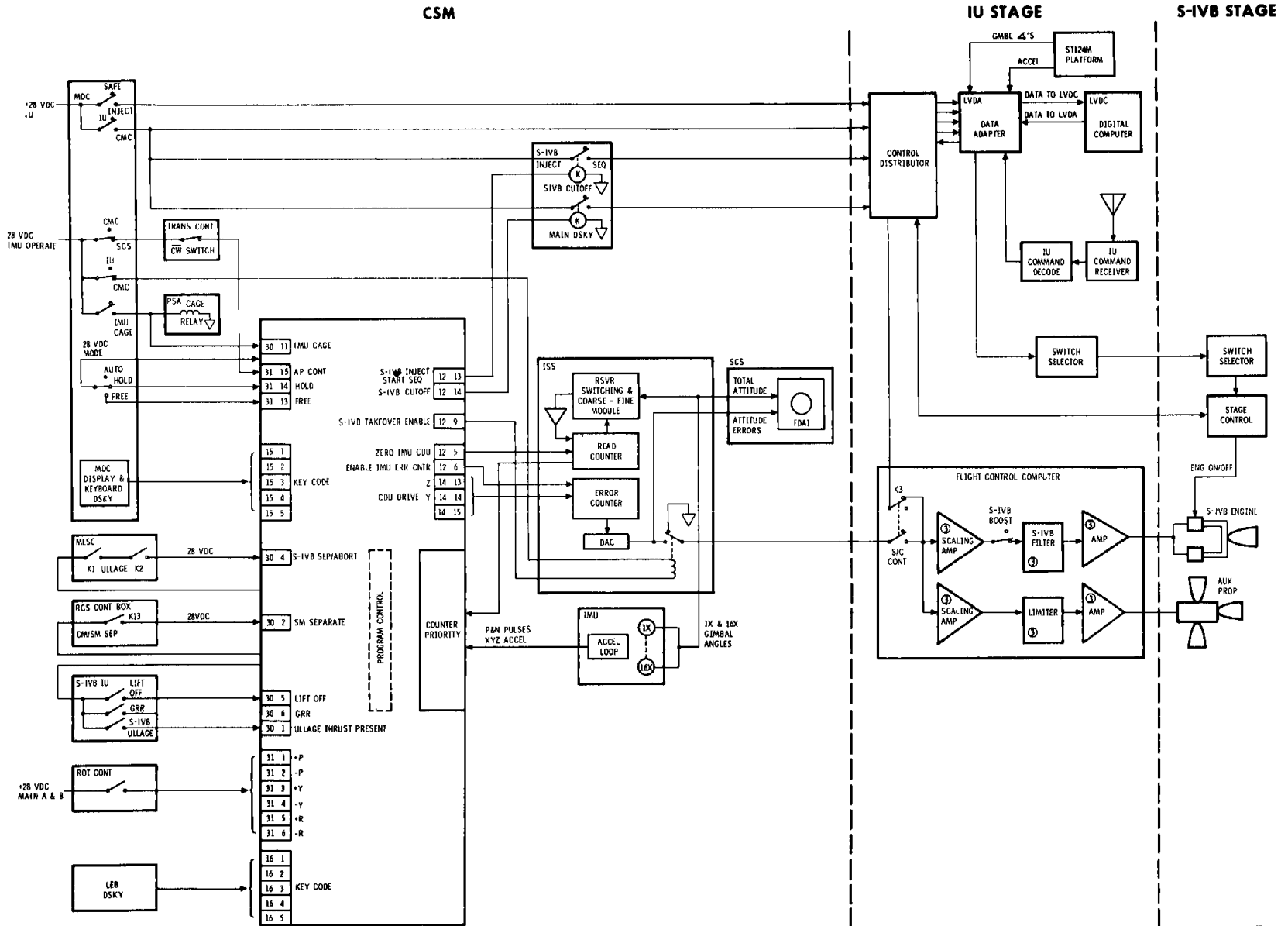
SCS-2701K 

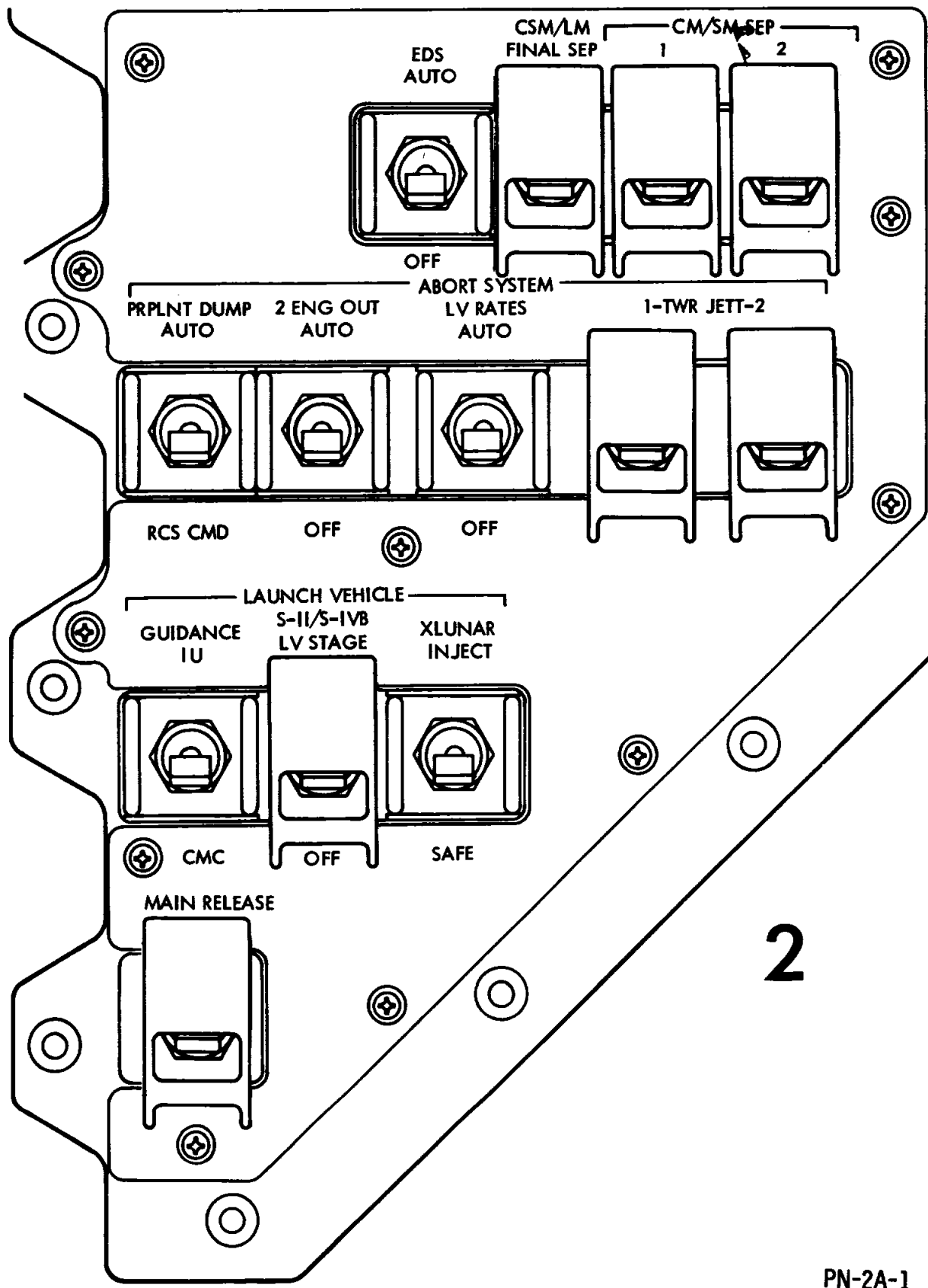


SC CONTROL OF SATURN

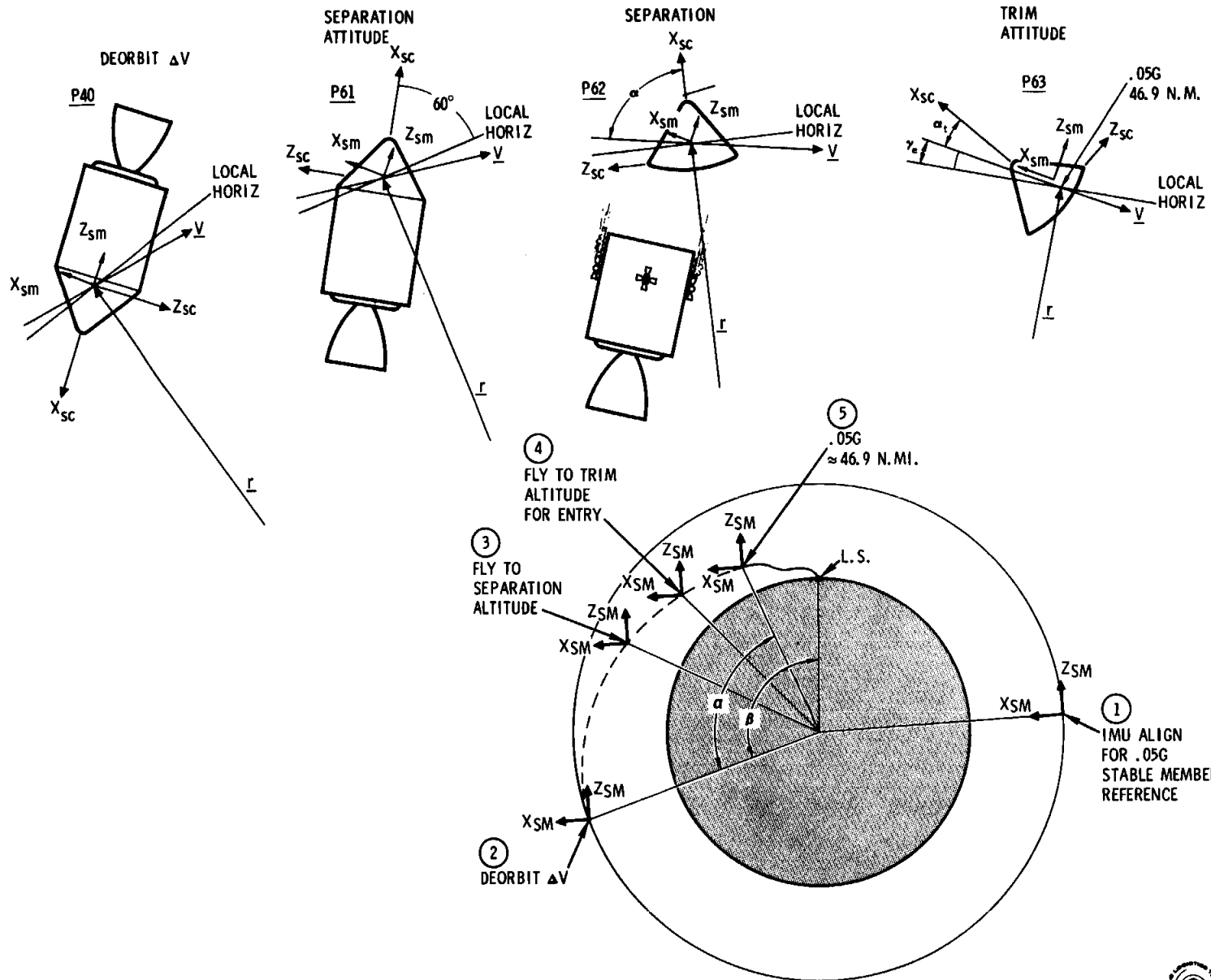


S-IVB CONTROL

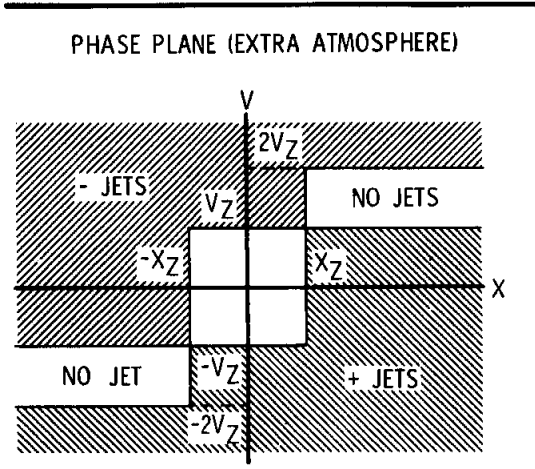
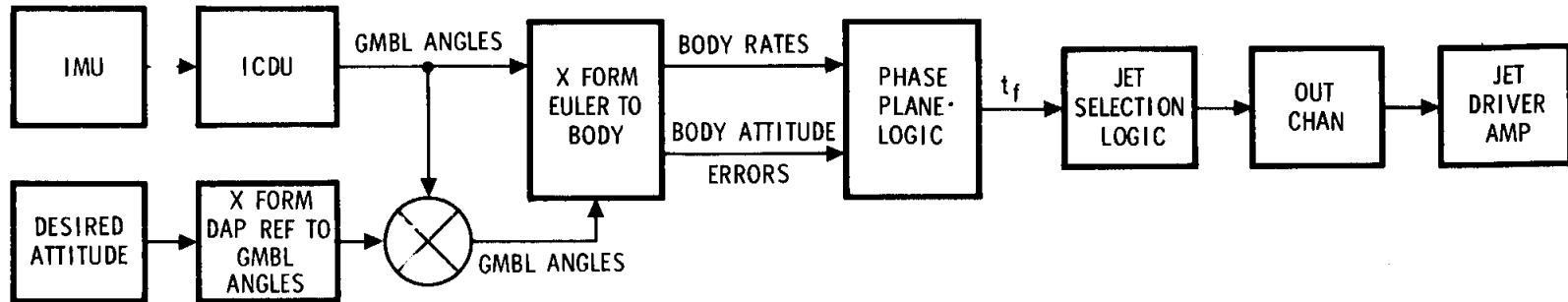




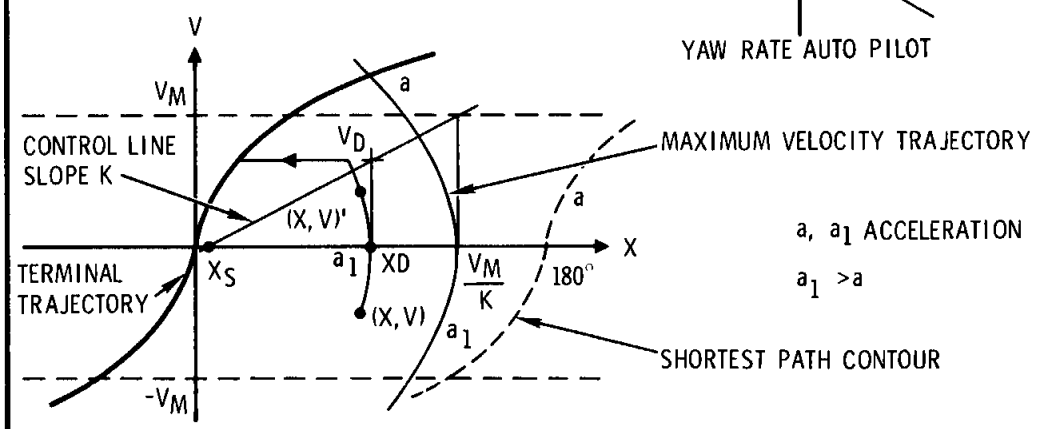
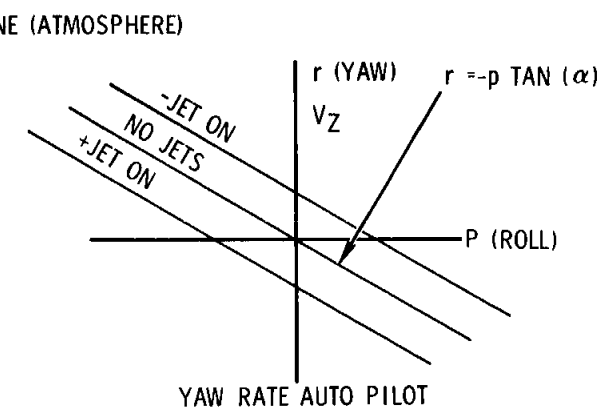
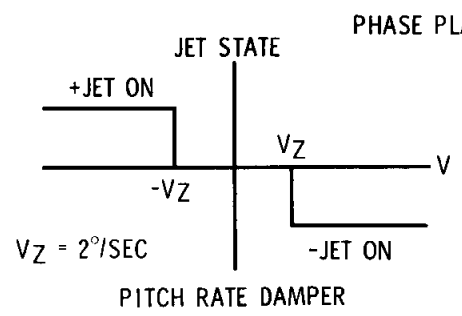
PREPARATION FOR ENTRY



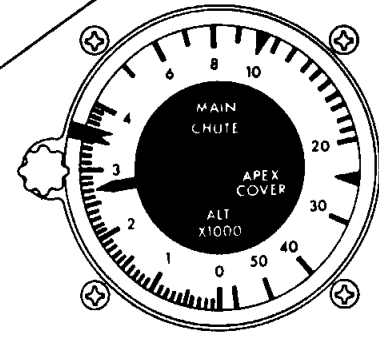
ENTRY DAP



$Xz = 3^\circ$
 $Vz = 2^\circ/\text{SEC}$
 ATTITUDE CONTROL



DUAL GAIN ROLL ATTITUDE PHASE PLANE WITH CONTROL LINE

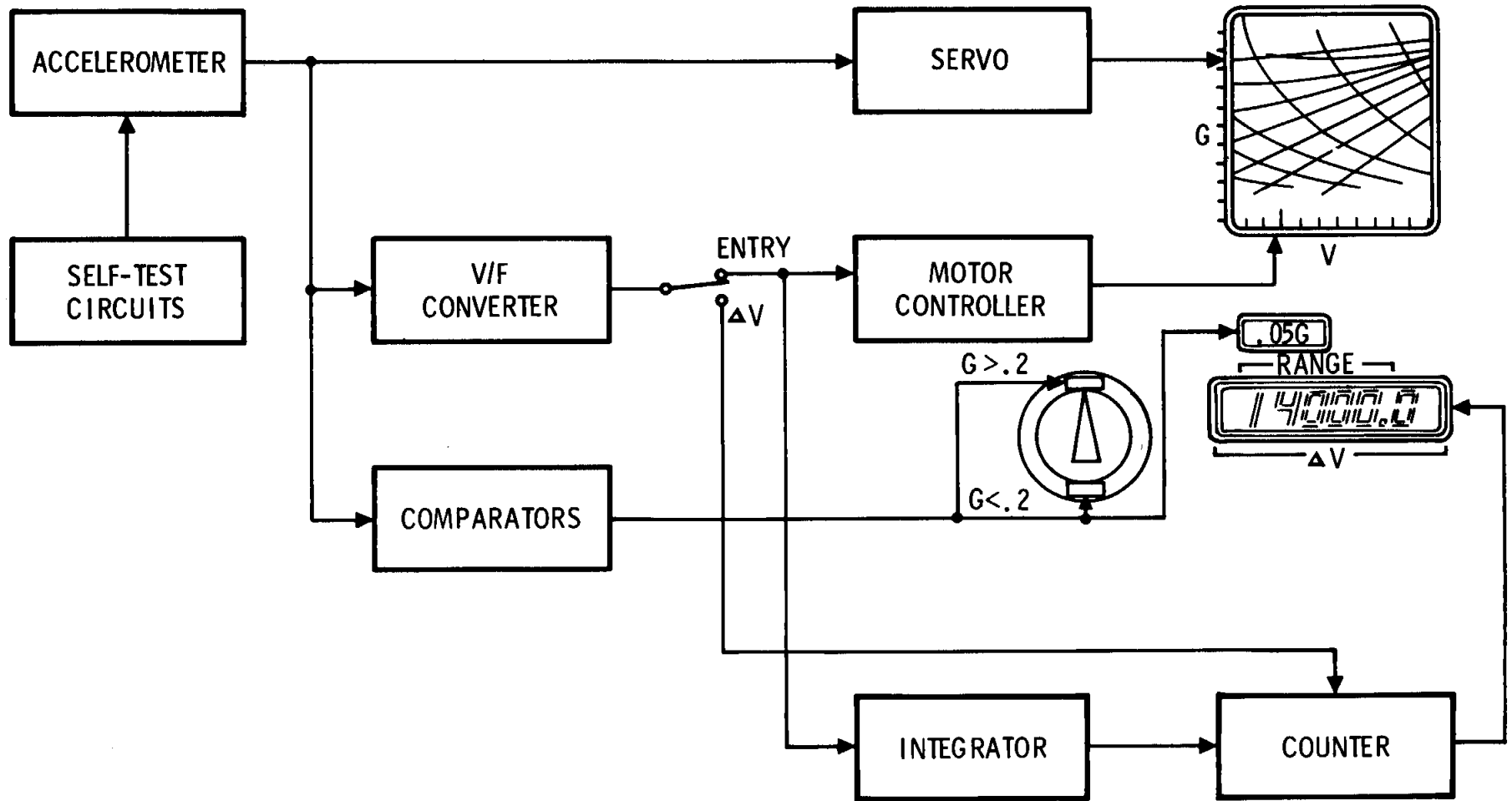


The main instrument panel includes the following components:

- Top Left:** A circular gauge with a needle and scale. Labels include V_0 SET, RNG SET, ENTRY, ΔV TEST, ΔV SET, ΔV , OFF, EMS TEST, and FUNCTION.
- Center:** A graph with a vertical axis labeled 'G' (0 to 10) and a horizontal axis labeled 'VELOCITY' (35 to 30). A needle points to approximately 33.5 on the velocity scale.
- Bottom Center:** A digital display showing '14000.0' with 'RANGE' and ' ΔV ' labels.
- Right Side:** A vertical panel with a 'GTA' label at the top, a 'DECR' button at the bottom, and a central section labeled ' ΔV /EMS SET INCR'.
- Bottom Left:** A circular gauge with a needle pointing to the top, labeled 'MASTER ALARM'.
- Bottom Center:** A control section with 'AUTO', 'STBY', 'MODE', and 'MAN' labels.
- Bottom Right:** A control section with ' ΔV TEST', ' ΔV SET', and 'OFF' labels.



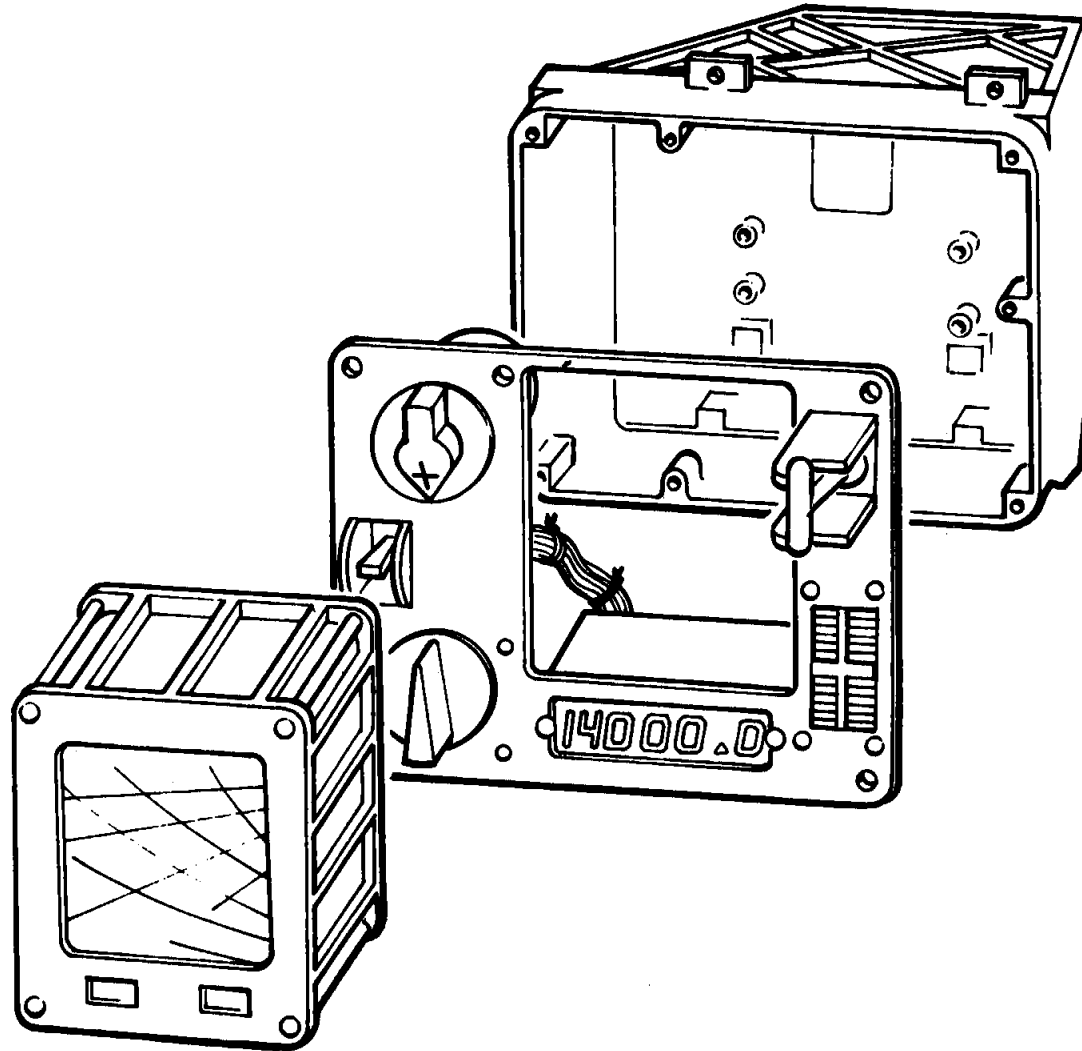
EMS BLOCK DIAGRAM



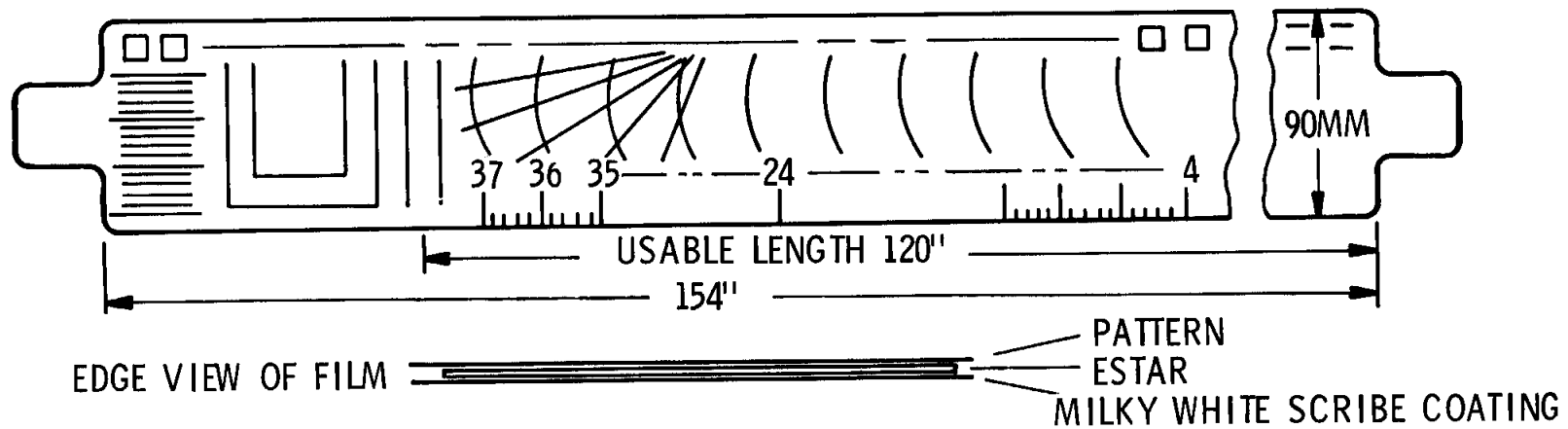
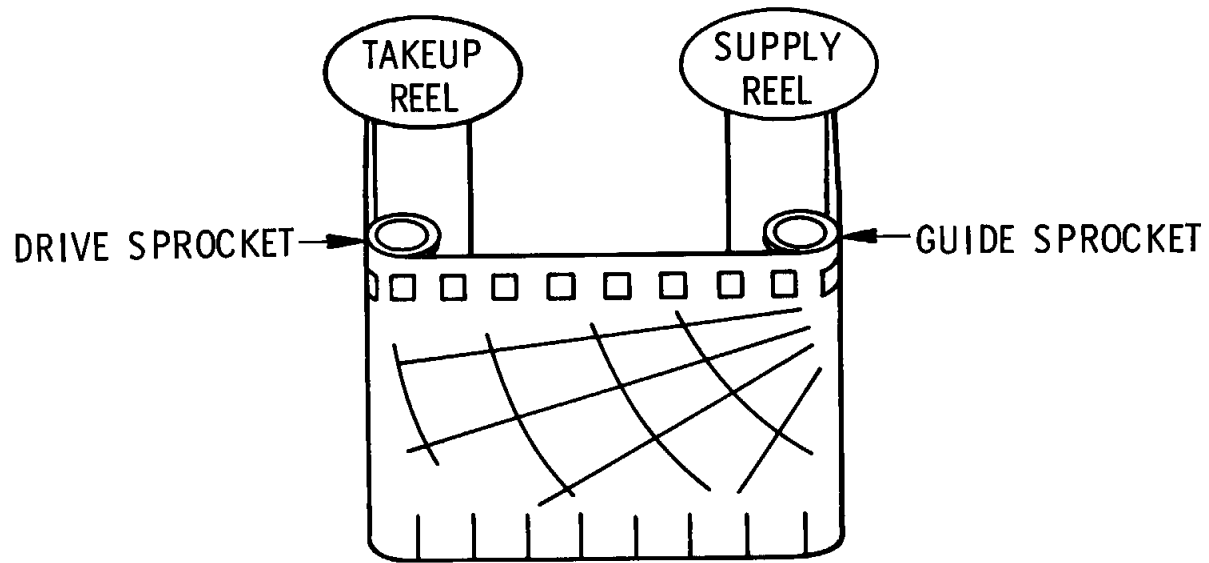
SCS-2205



EMS HOUSING FRONT PANEL



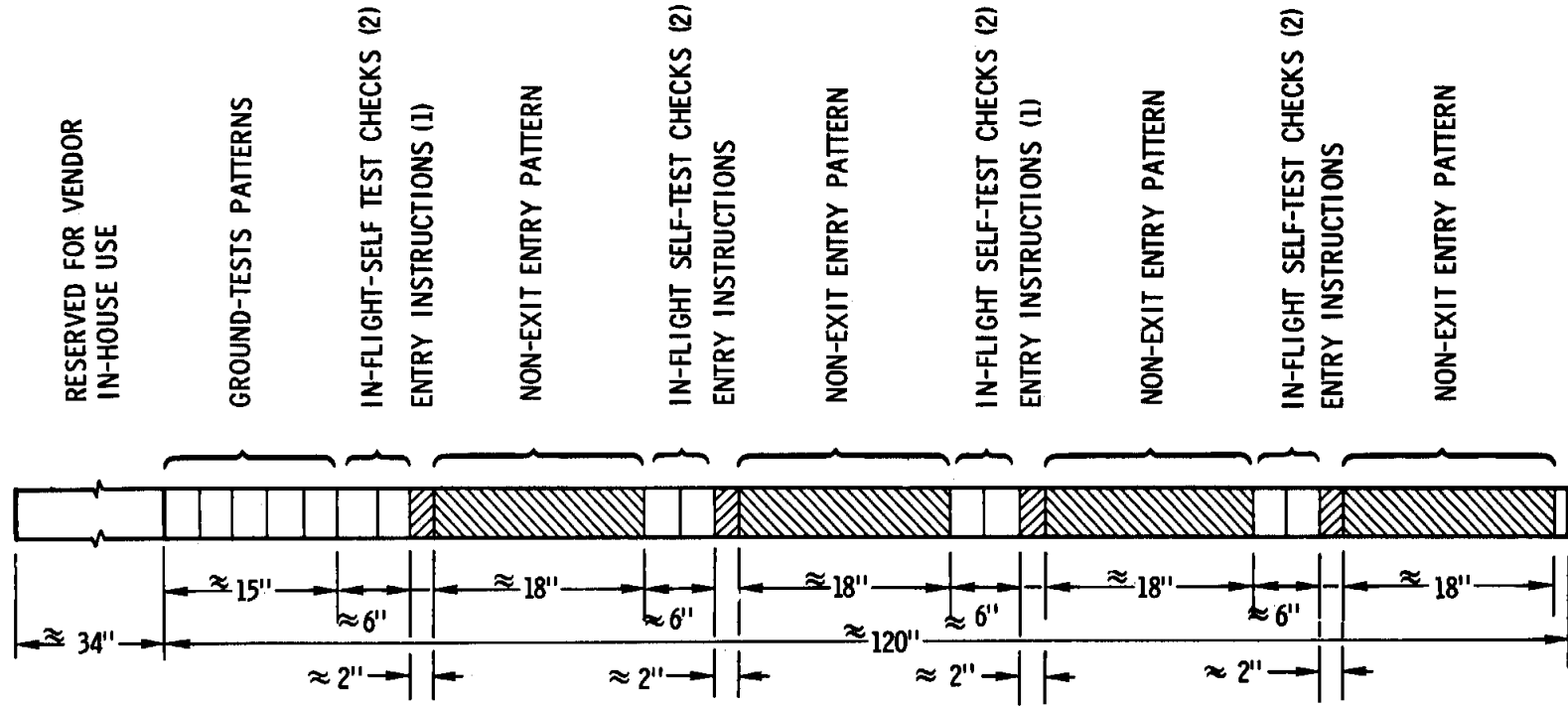
EMS SCROLL & SCRIBE



SCS-2014

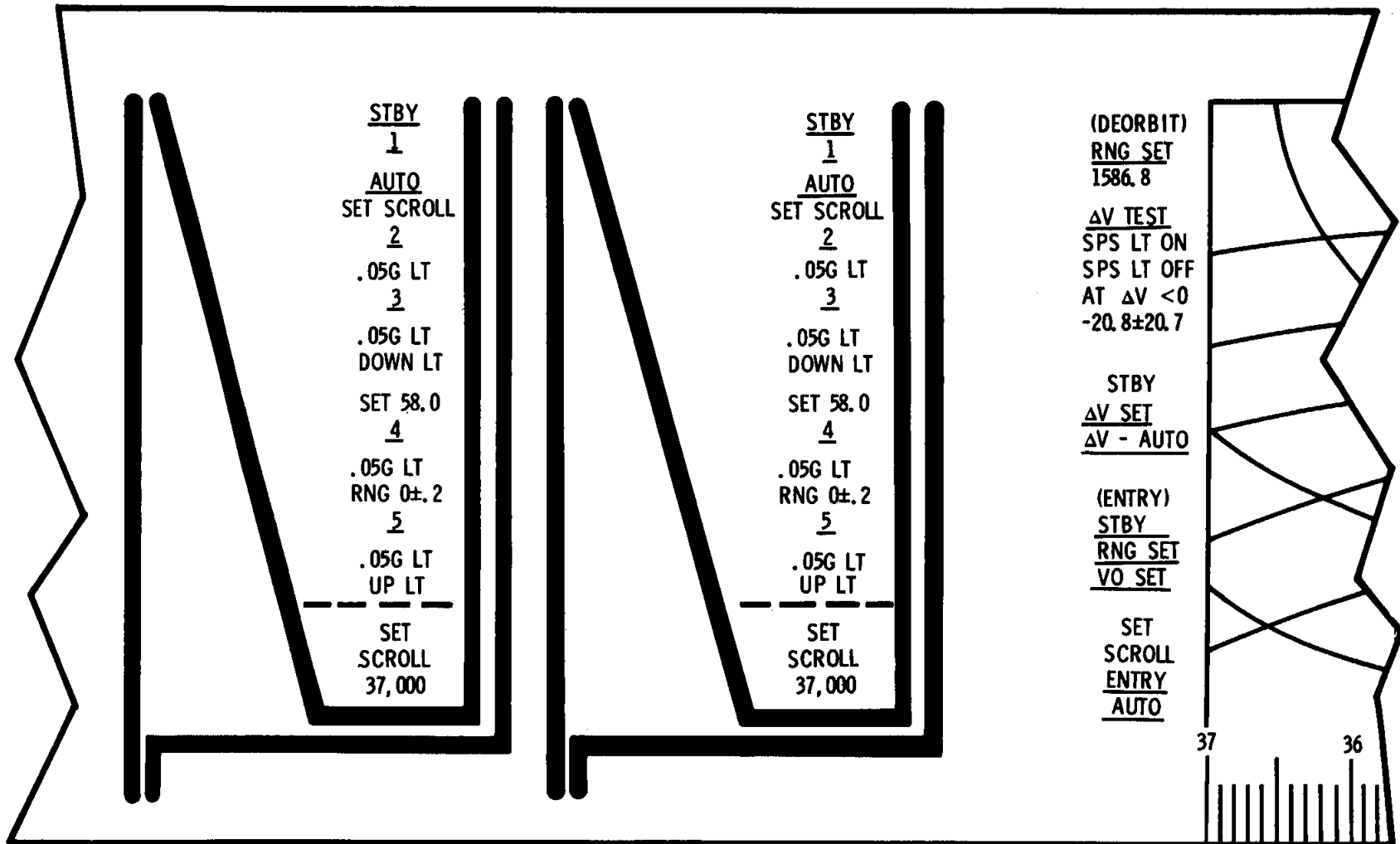


EMS SCROLL FORMAT



EMS FLIGHT SCROLL

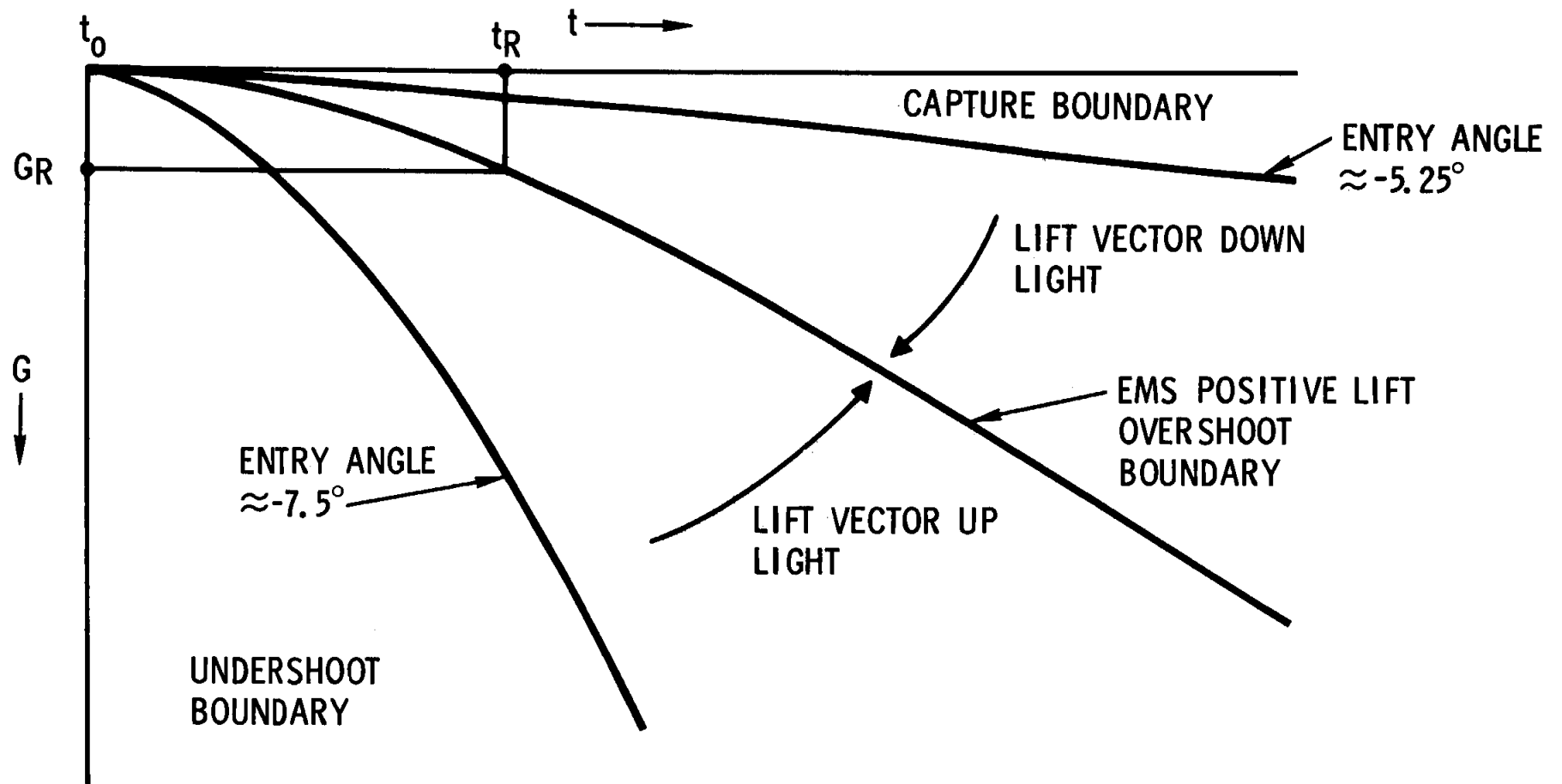
SELF TEST & ENTRY PREPARATION



SCS-2209



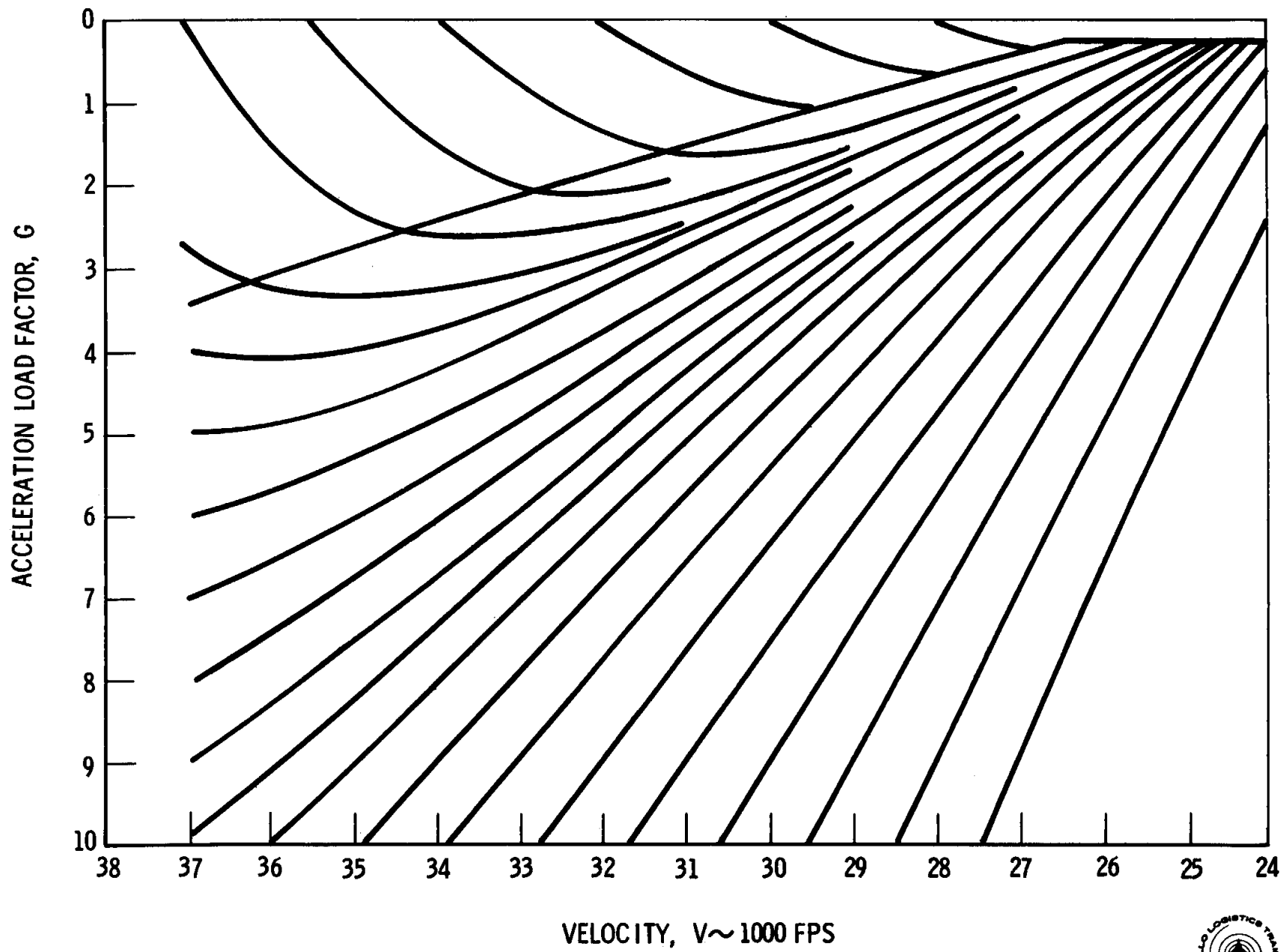
EMS CORRIDOR EVALUATION



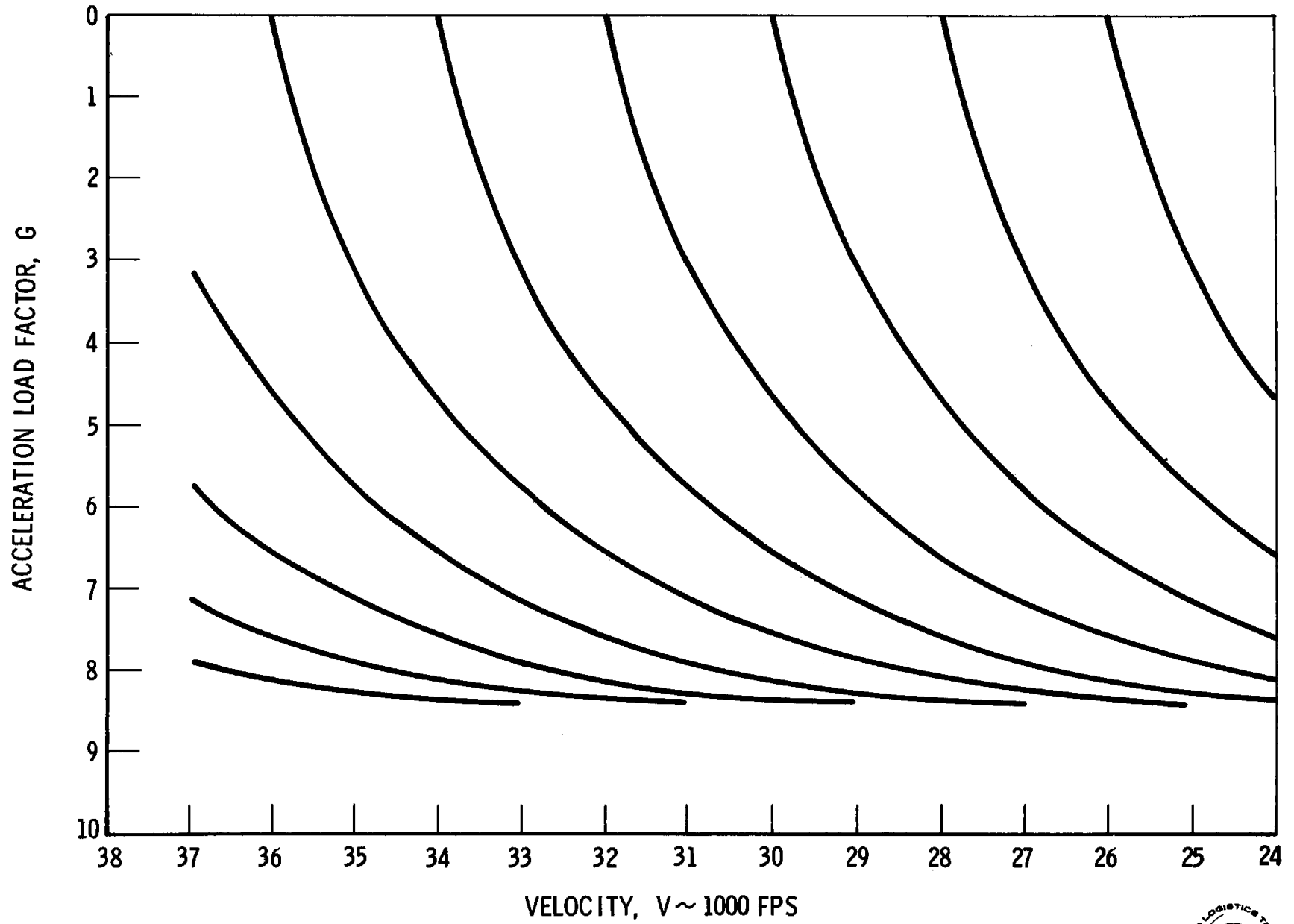
$GR = .2G$
 $t_R = 10 \text{ SEC AFTER } t_0$
 $t_0 = \text{TIME AT } .05G$

FOR LUNAR
 ENTRY VELOCITY
 AND ENTRY ANGLES ONLY

OFF-SET FLIGHT LIMITS



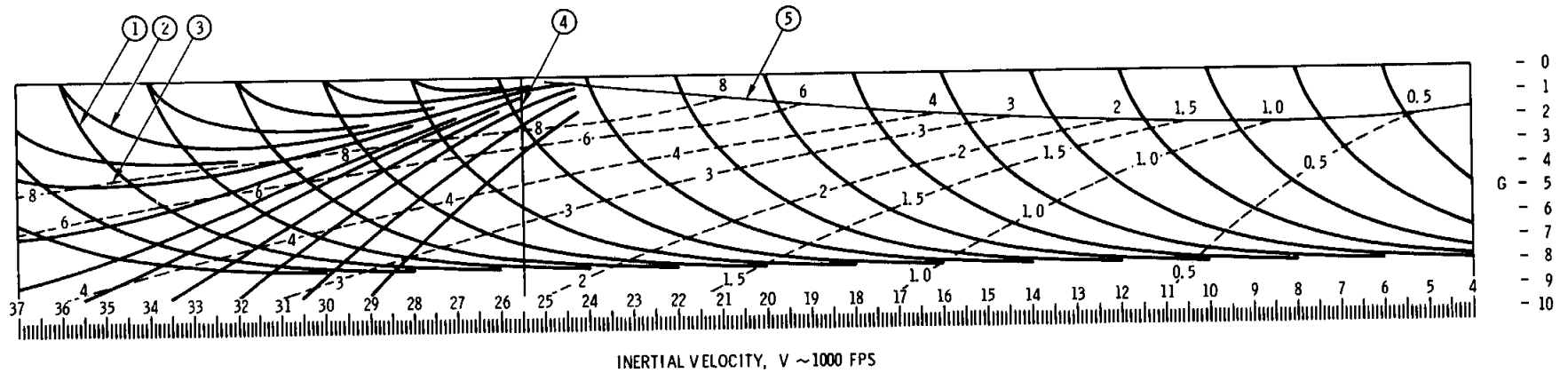
ON-SET FLIGHT LIMITS



SCS-2312



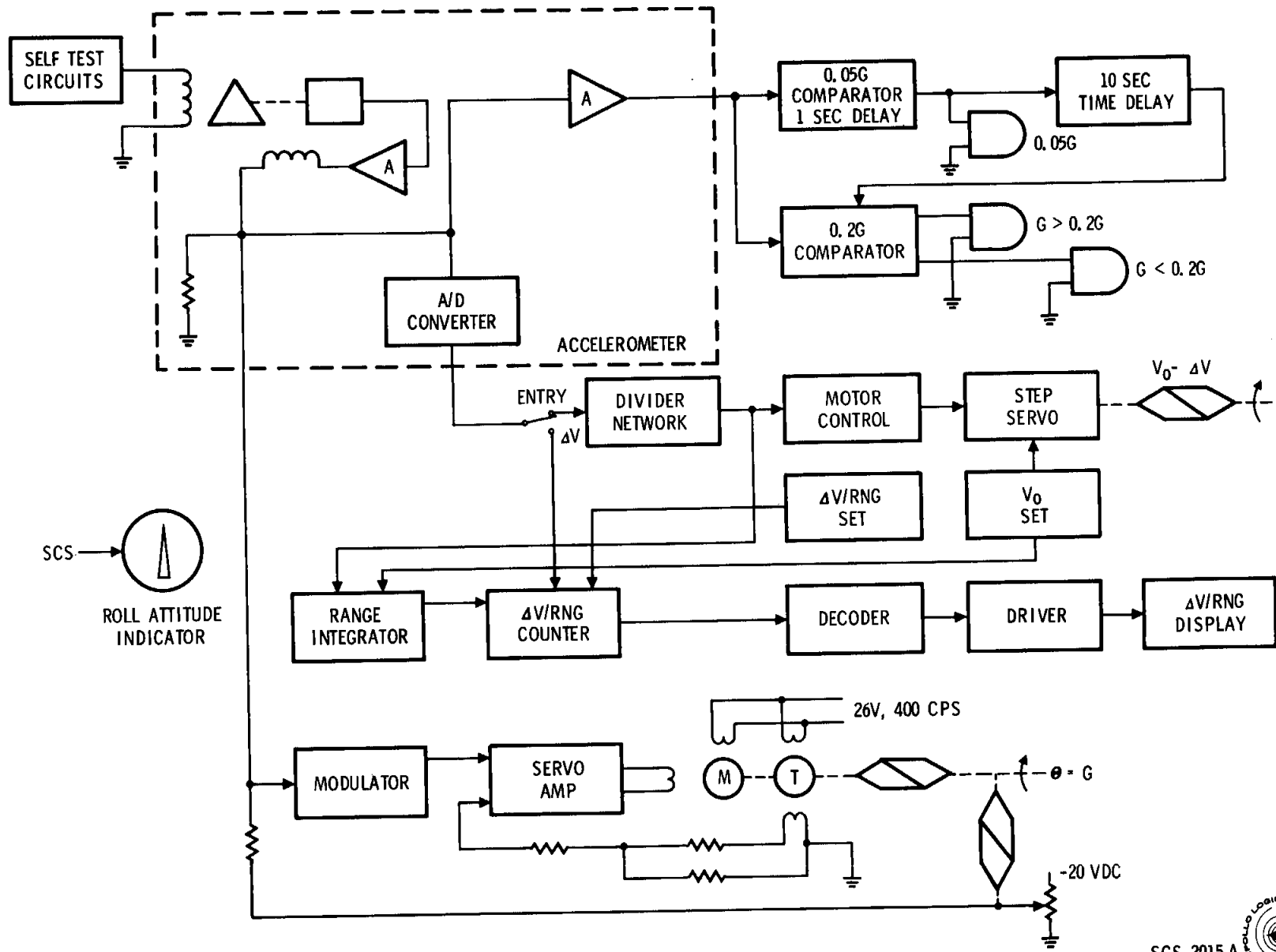
NON-EXIT ENTRY PATTERN FOR EMS ORBITAL MISSION

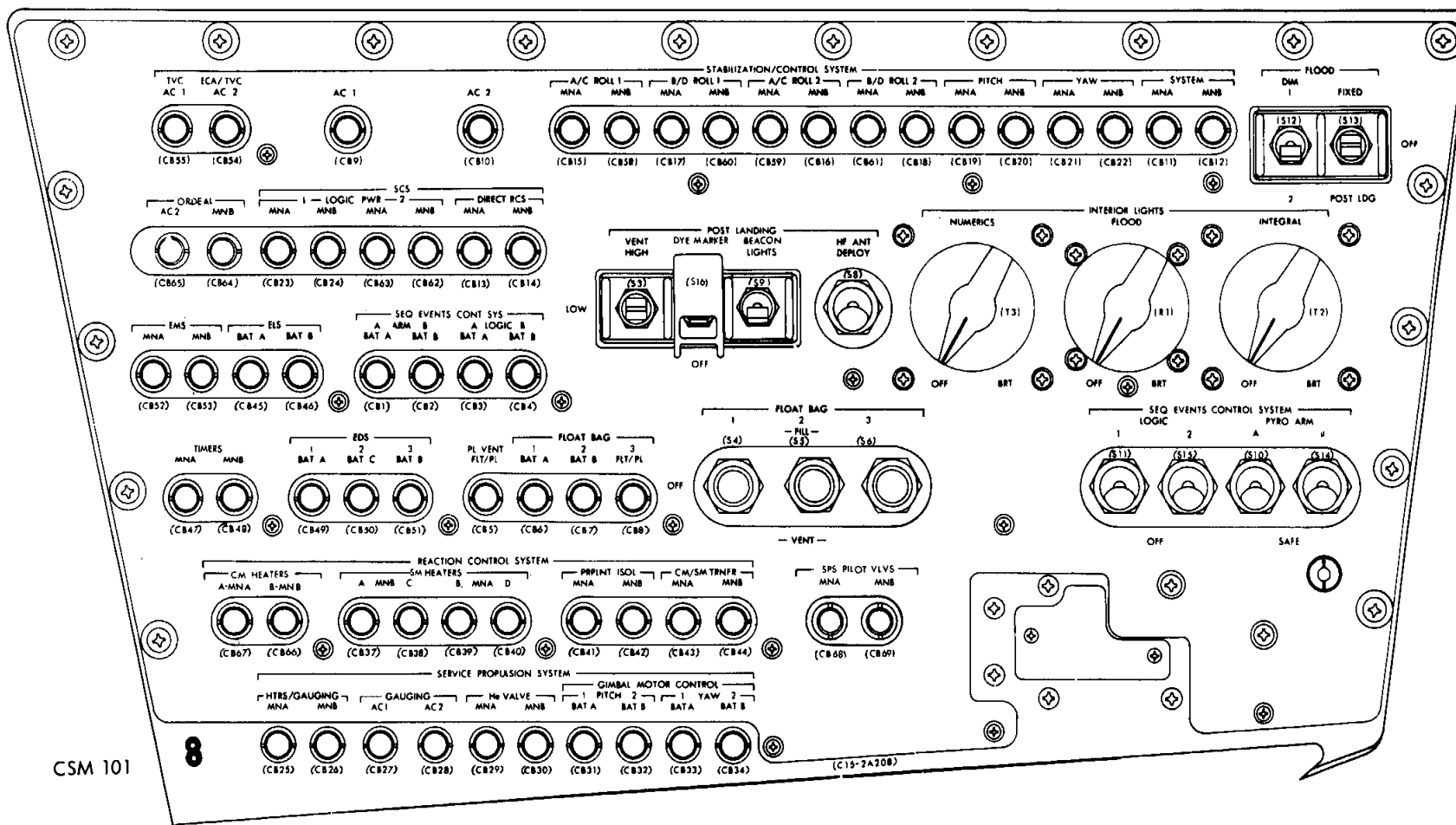


- ① ON-SET GUIDE LINE
- ② OFF-SET GUIDE LINE
- ③ RANGE POTENTIAL GUIDE LINE
- ④ SATELLITIC VELOCITY INDICATOR
- ⑤ FULL LIFT PROFILE

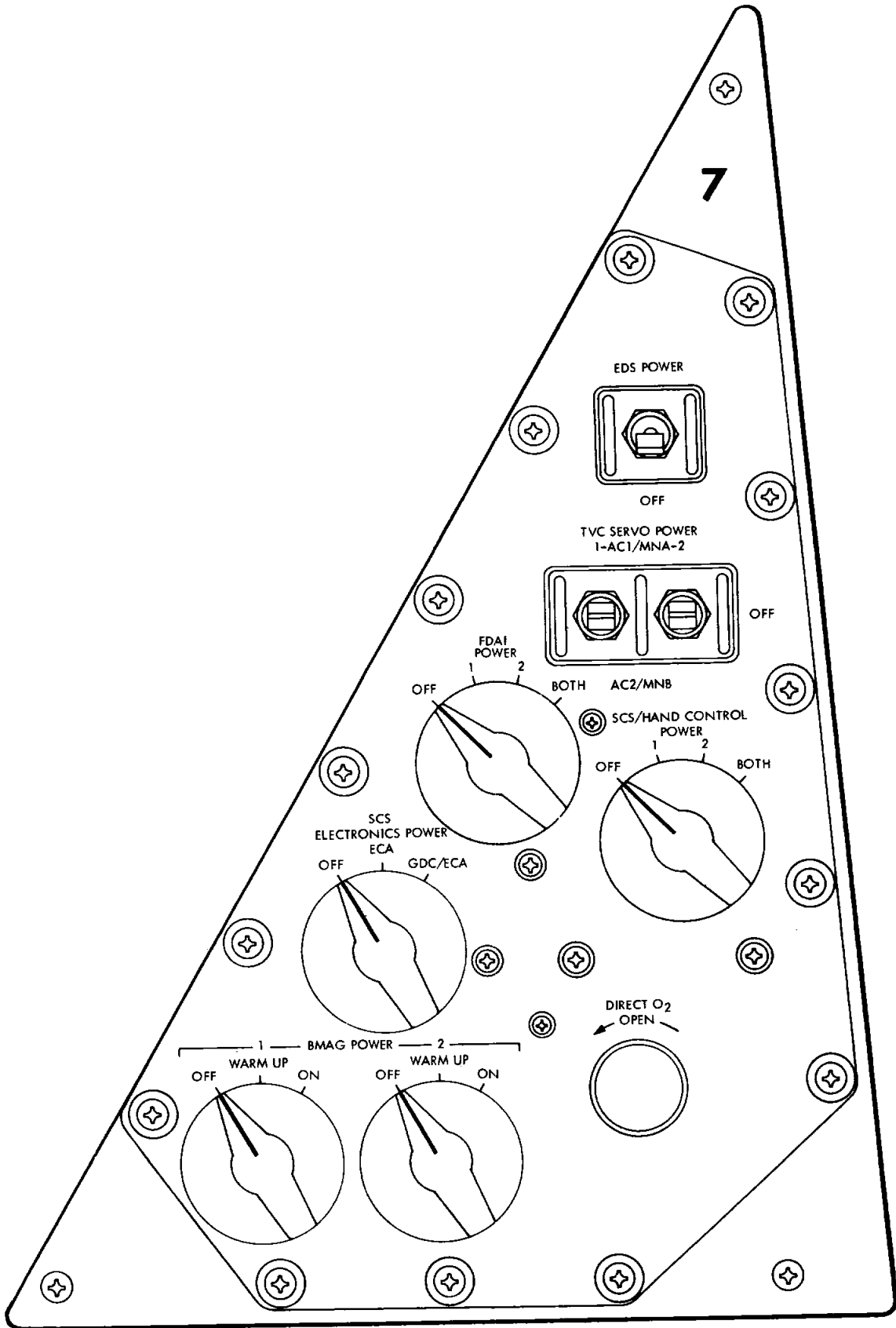
SCS-2211 (◆)

EMS FUNCTIONAL BLOCK DIAGRAM

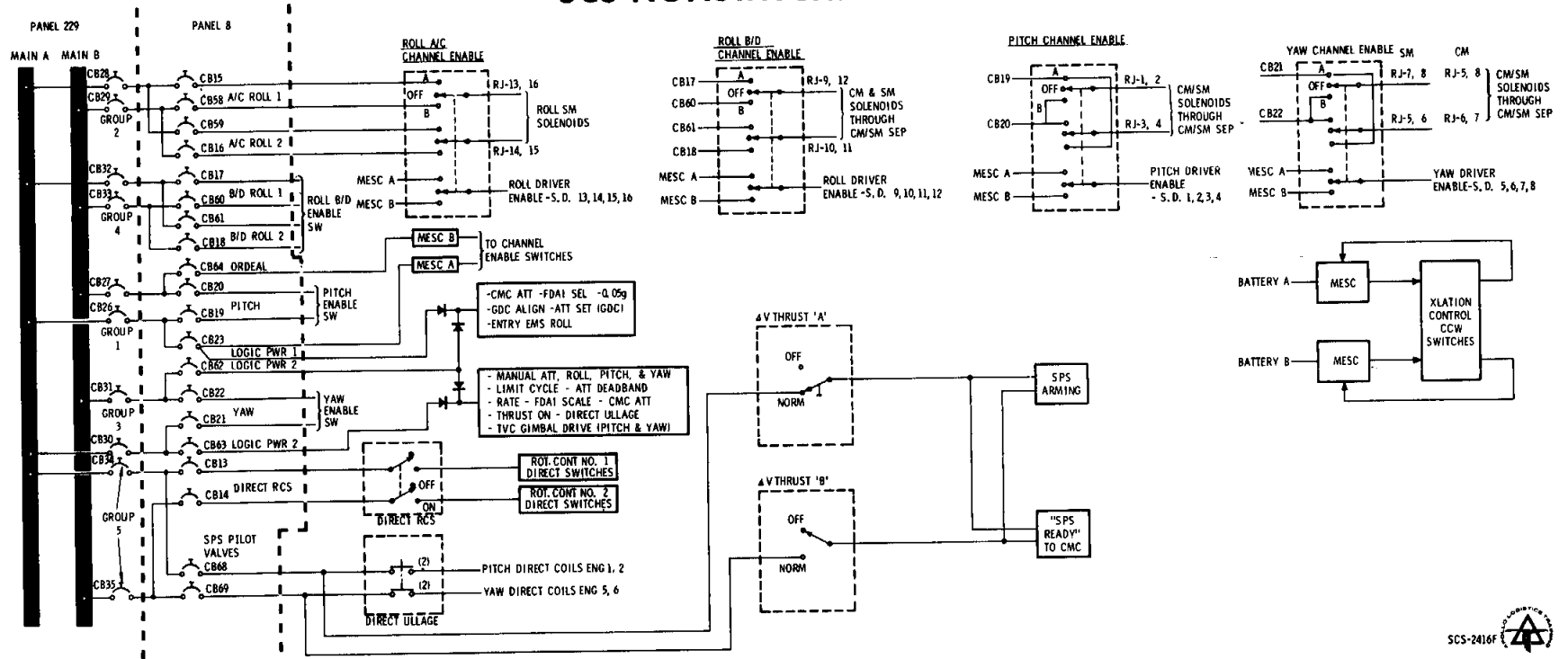




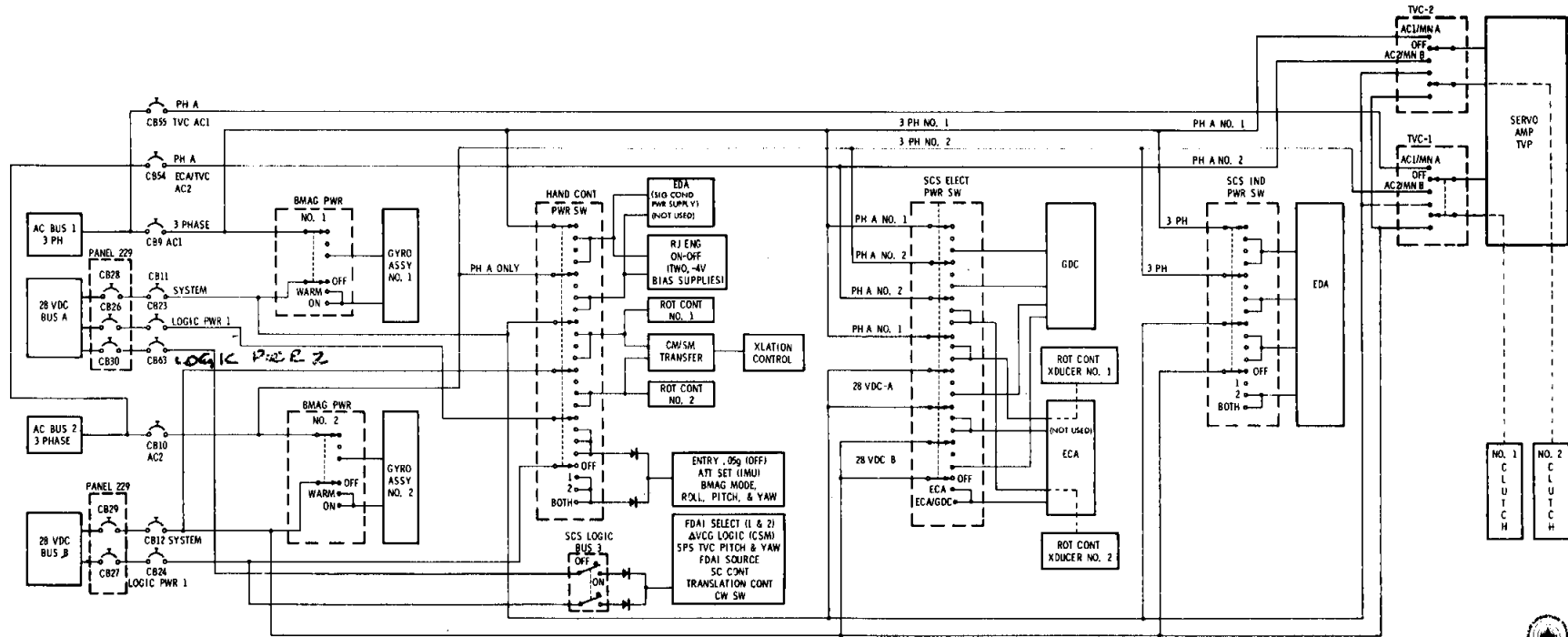
CSM 101



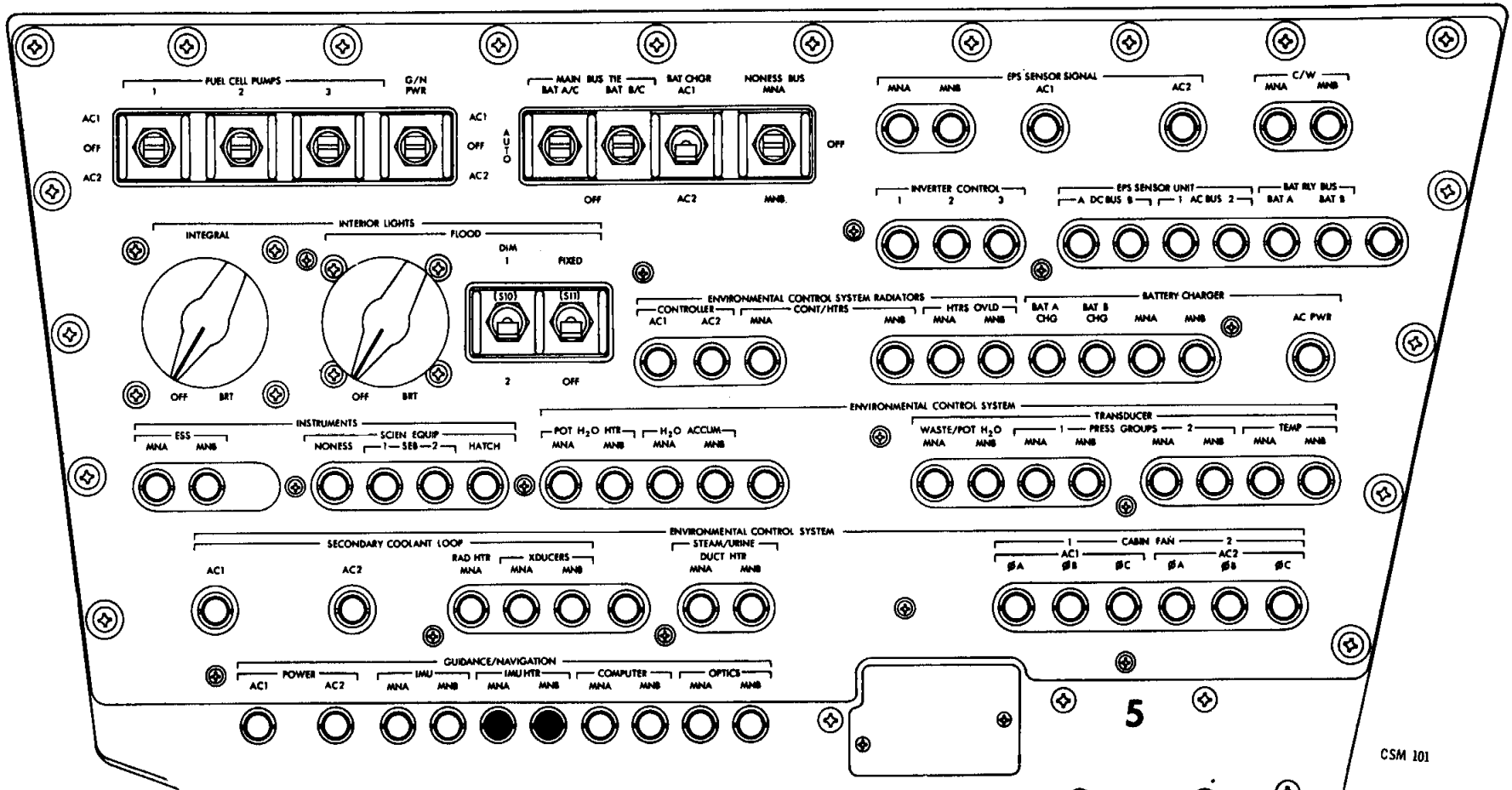
SCS NONSWITCHED POWER



SCS SWITCHED POWER DISTRIBUTION



SCS-24171

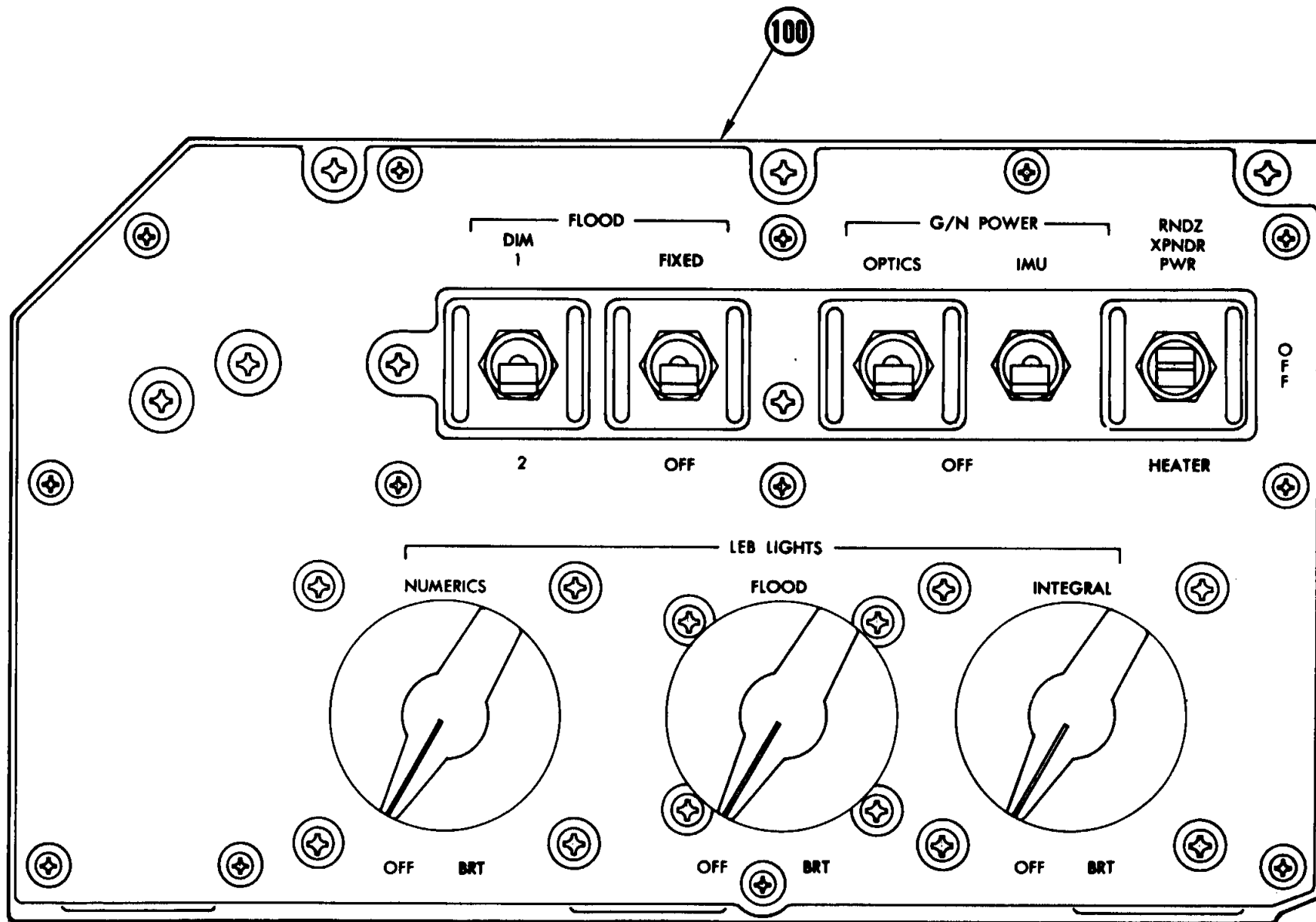


5

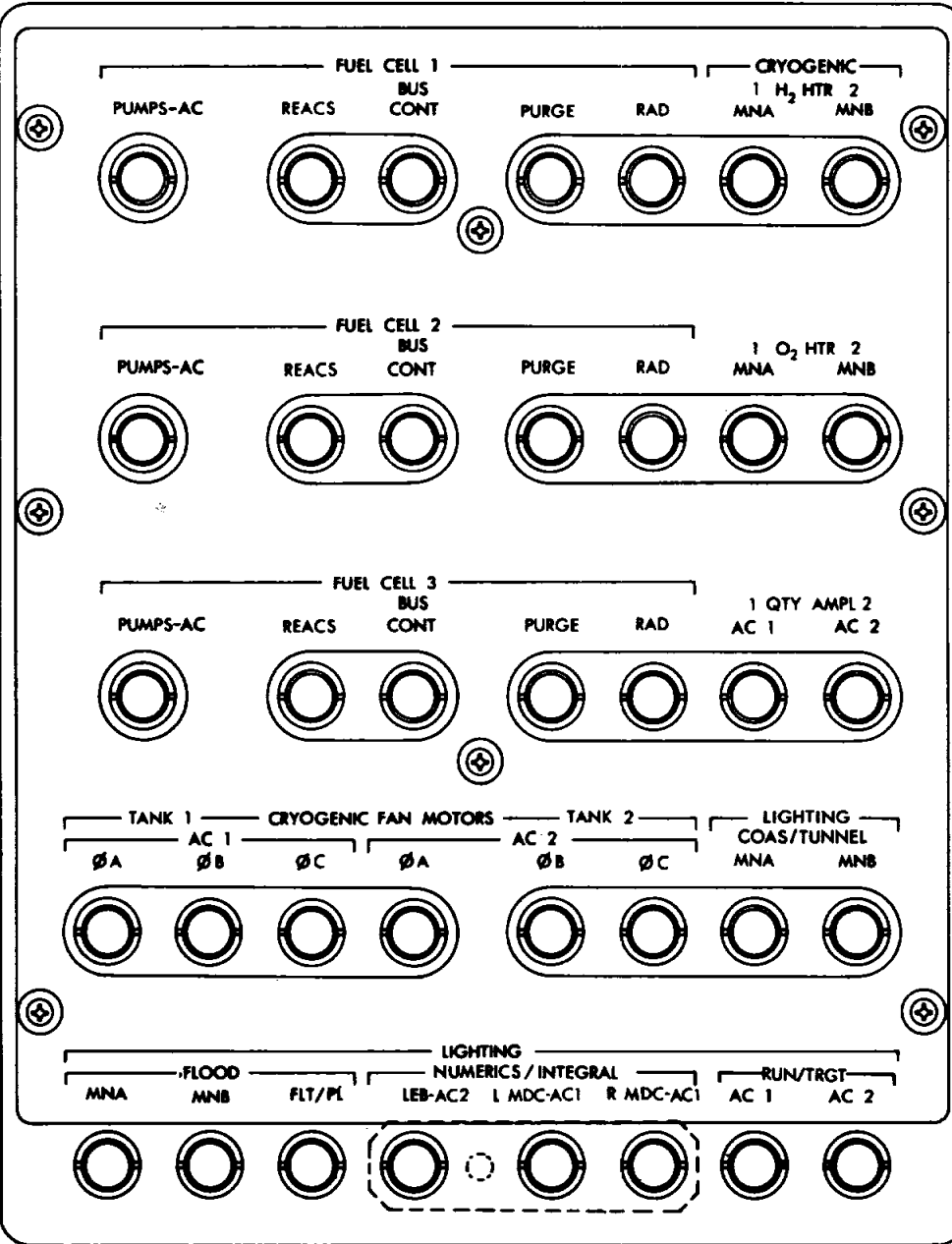
CSM 101



PN-5-1



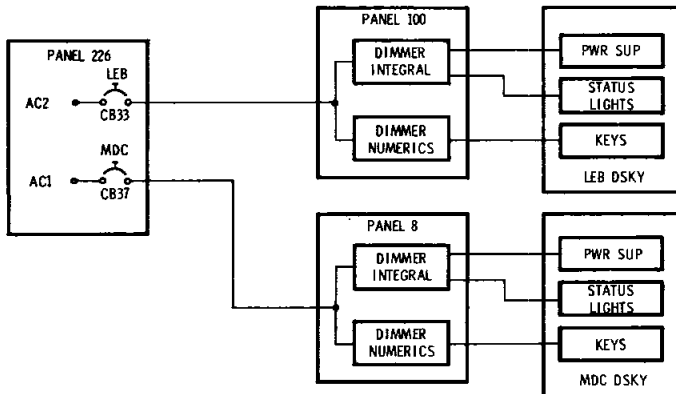
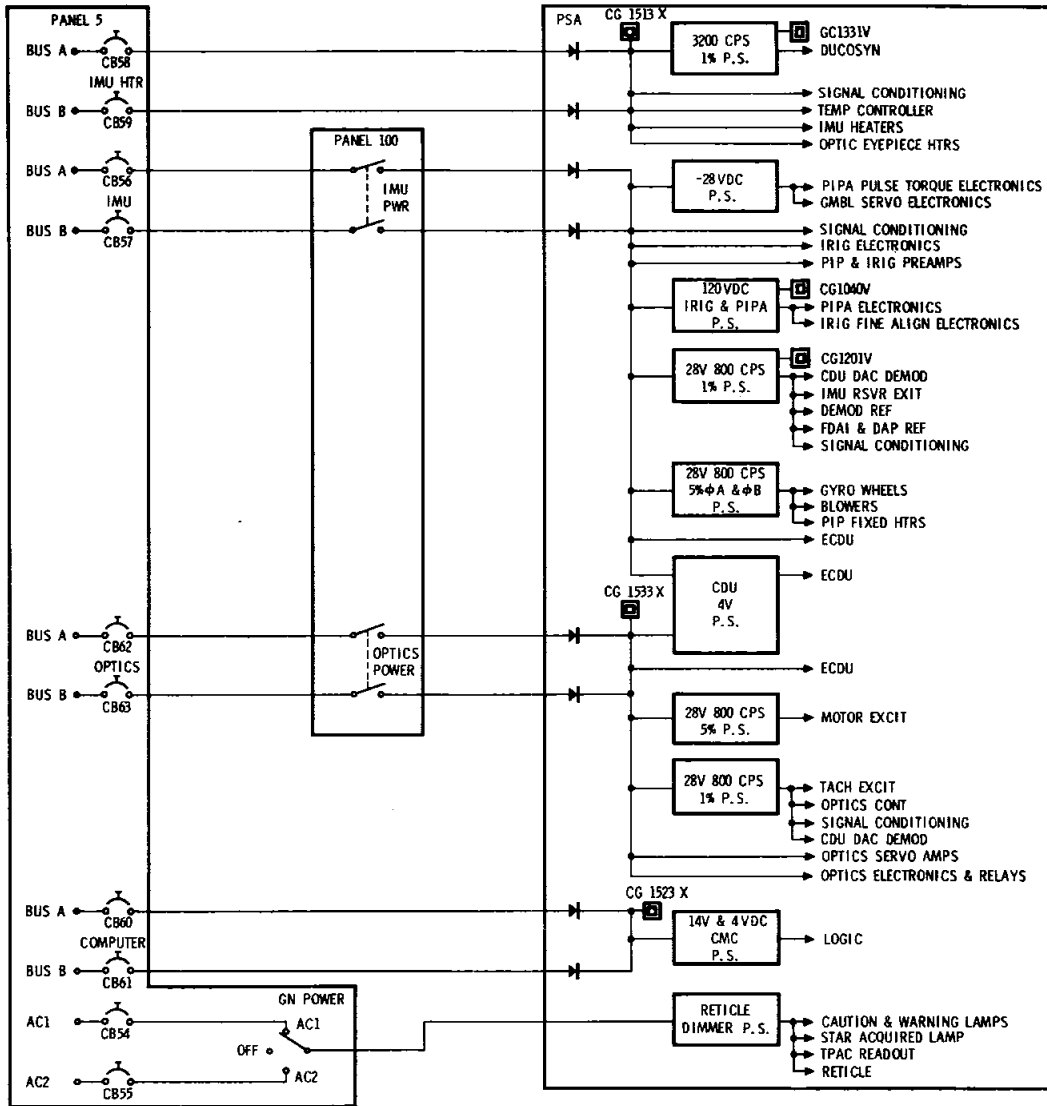
226



PN-226-1



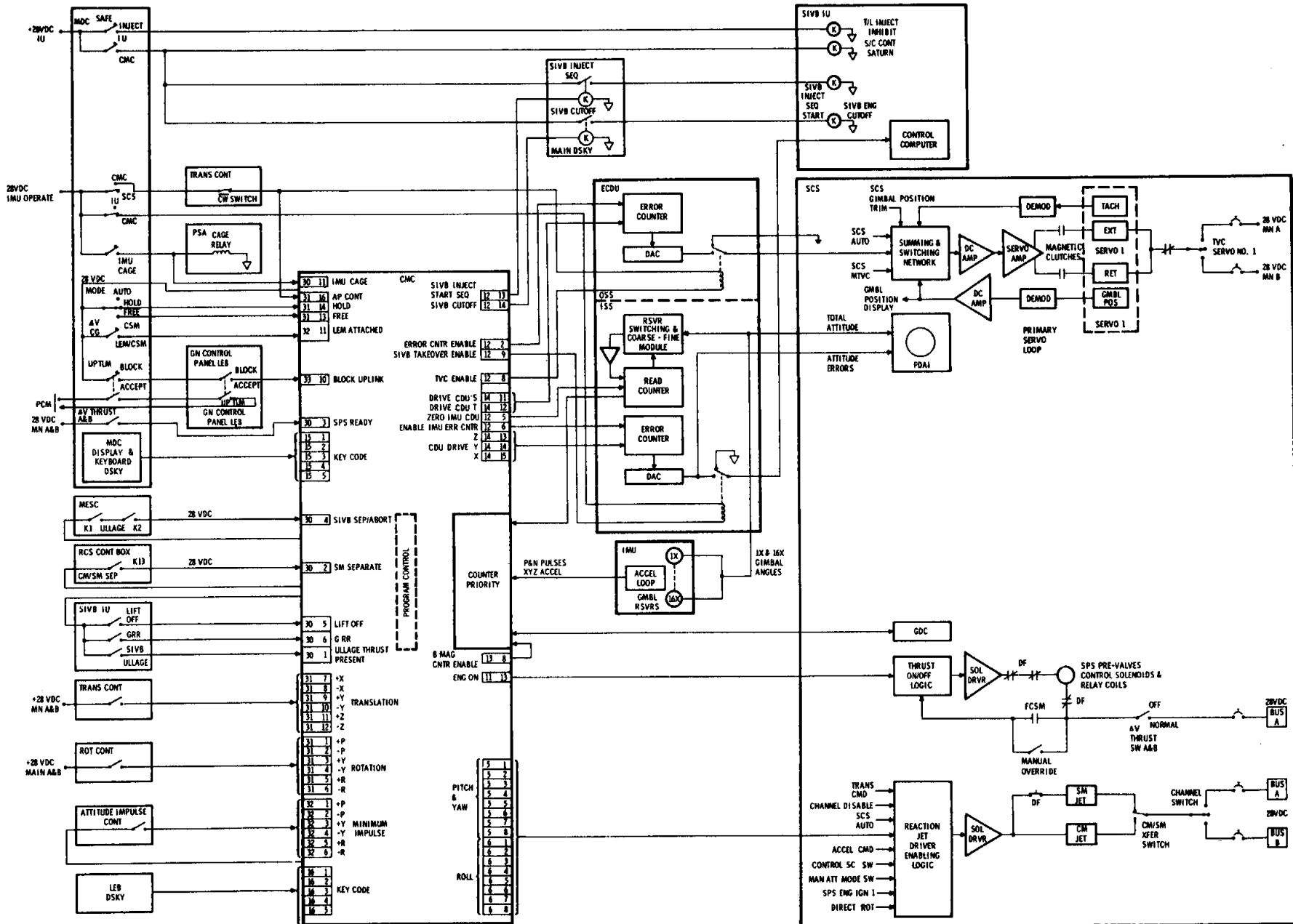
GNC POWER DISTRIBUTION



CG1513X - IMU +28 VDC STANDBY
 CG1331V - 3.2KC 28V SUPPLY
 CG1040V - 120 VDC PIPA SUPPLY DC LEVEL
 CG1201V - IMU 28V .8KC 1 PCT °DEG SUP RMS
 CG1533X - OPTICS OPERATE +28 VDC
 CG1523X - +28 V CMC OPERATE



G & C FUNCTIONAL FLOW



PCM

<u>Measurement No.</u>	<u>Measurement Description</u>	<u>Channel Code</u>	<u>S/S</u>
CG 0001V	COMPUTER DIGITAL DATA 40 BITS	51DS1	50
CG 1040V	+120 VDC PIPA SUPPLY DC LEVEL	10A83	1
CG 1110V	2.5 VDC TM BIAS	10A138	1
CG 1201V	IMU 28V .8KC 1 PCT 0 DEG SUP RMS	10A91	1
CG 1211V	OPTX 28V .8KC 1 PCT 0 DEG RMS	10A146	1
CG 1331V	3.2KC 28V SUPPLY	10A85	1
CG 1513X	IMU +28 VDC STANDBY	11E15-2	10
CG 1523X	+28V CMC OPERATE	11E15-3	10
CG 1533X	OPTX OPERATE +28 VDC	11E15-4	10
CG 2001V	X PIPA SG OUTPUT IN PHASE	51A2	50
CG 2021V	Y PIPA SG OUTPUT IN PHASE	51A3	50
CG 2041V	Z PIPA SG OUTPUT IN PHASE	51A4	50
CG 2112V	IG IX RESOLVER OUTPUT SIN	11A54	10
CG 2113V	IG IX RESOLVER OUTPUT COS	11A59	10
CG 2117V	IGA SERVO ERROR IN PHASE	12A2	100
CG 2142V	MG IX RESOLVER OUTPUT SIN	11A60	10
CG 2143V	MG IX RESOLVER OUTPUT COS	11A61	10
CG 2147V	MGA SERVO ERROR IN PHASE	12A1	100
CG 2172V	OG IX RESOLVER OUTPUT SIN	11A62	10
CG 2173V	OG IX RESOLVER OUTPUT COS	11A63	10
CG 2177V	OGA SERVO ERROR IN PHASE	12A3	100
CG 2219V	PITCH ATT ERROR - CDU DAC OUT	11A64	10
CG 2249V	YAW ATT ERROR - CDU DAC OUT	11A65	10
CG 2279V	ROLL ATT ERROR - CDU DAC OUT	11A16	10
CG 2300T	PIPA TEMPERATURE	10A96	1
CG 2301T	IRIG TEMPERATURE	10A1	1
CG 2302X	IMU HEATER CURRENT	10A5	1
CG 2303X	IMU BLOWER CURRENT	10A7	1
CG 3011V	TRUNNION CDU FINE ERROR	11A171	10
CG 3021V	SHAFT CDU FINE ERROR	11A180	10

PGNCS A/B TLM LIST

PCM

<u>Measurement No.</u>	<u>Measurement Description</u>	<u>Channel Code</u>	<u>S/S</u>
CG 3140V	SXT SHAFT TACHOMETER OUTPUT	11A172	10
CG 3150V	SXT TRUNNION TACHOMETER OUTPUT	11A173	10
CG 3160V	SCT SHAFT TACHOMETER OUTPUT	10A13	1
CG 3170V	SCT TRUNNION TACHOMETER OUTPUT	10A14	1
CG 3721V	SHAFT CDU DAC OUTPUT	11A52	10
CG 3722V	TRUNNION CDU DAC OUTPUT	11A53	10
CG 5040X	CMC WARNING	11E19-1	10

SCS TM List

<u>Measurement ID</u>	<u>Measurement Description</u>	<u>Response Rate</u>	<u>Sensor Range</u>		<u>Display Readout</u>	<u>Channel Code</u>
			<u>Low</u>	<u>High</u>		
CH3500V	Attitude Error Pitch	50 S/S	-5/5/15	+5/5/15 Deg	FDAI	51A5
CH3501V	Attitude Error Yaw	50 S/S	-5/5/15	+5/5/15 Deg	FDAI	51A6
CH3502V	Attitude Error Roll	100 S/S	-5/5/50	+5/5/50 Deg	FDAI	12A4
CH3503R	SCS Body Rate Pitch	100 S/S	-1/5/10	+1/5/10 Deg/sec	FDAI	12A5
CH3504R	SCS Body Rate Yaw	100 S/S	-1/5/10	+1/5/10 Deg/sec	FDAI	12A6
CH3505R	SCS Body Rate Roll	100 S/S	-1/5/50	+1/5/50 Deg/sec	FDAI	12A7
CH3517H	GIMBAL POSITION Pitch 1 or 2	100 S/S	-5	+5 Deg	FP/GPI	12A8
CH3518H	GIMBAL POSITION Yaw 1 or 2	100 S/S	-5	+5 Deg	FP/GPI	12A10
CH3546X	RCS Solenoid Activate +Pitch/+X	200 S/S		Event	None	22E1-1
CH3547X	RCS Solenoid Activate -Pitch/+X	200 S/S		Event	None	22E2-2
CH3548X	RCS Solenoid Activate +Pitch/-X	200 S/S		Event	None	22E3-3
CH3549X	RCS Solenoid Activate -Pitch/-X	200 S/S		Event	None	22E4-4
CH3550X	RCS Solenoid Activate +Yaw/+X	200 S/S		Event	None	22E5-5
CH3551X	RCS Solenoid Activate -Yaw/+X	200 S/S		Event	None	22E6-6
CH3552X	RCS Solenoid Activate +Yaw/-X	200 S/S		Event	None	22E7-7
CH3553X	RCS Solenoid Activate -Yaw/-X	200 S/S		Event	None	22E8-8
CH3554X	RCS Solenoid Activate +Roll/+Z	200 S/S		Event	None	22E9-1
CH3555X	RCS Solenoid Activate -Roll/+Z	200 S/S		Event	None	22E13-5
CH3556X	RCS Solenoid Activate +Roll/-Z	200 S/S		Event	None	22E14-6
CH3557X	RCS Solenoid Activate -Roll/-Z	200 S/S		Event	None	22E10-2

SCS TM List

<u>Measurement ID</u>	<u>Measurement Description</u>	<u>Response Rate</u>	<u>Sensor Range</u>		<u>Display Readout</u>	<u>Channel Code</u>
			<u>Low</u>	<u>High</u>		
CH3558X	RCS Solenoid Activate +Roll/+Y	200 S/S	Event		None	22E15-7
CH3559X	RCS Solenoid Activate -Roll/+Y	200 S/S	Event		None	22E11-3
CH3560X	RCS Solenoid Activate +Roll/-Y	200 S/S	Event		None	22E12-4
CH3561X	RCS Solenoid Activate -Roll/-Y	200 S/S	Event		None	22E16-8
CH3588X	Attitude Deadband Minimum	10 S/S	Event		Panel Switch	11E8-2
CH3590X	SCS High Rot-Rate Selected	10 S/S	Event		Panel Switch	11E8-4
CH3592X	FDAI Scale Error 5, Rates 5	10 S/S	Event		Panel Switch	11E8-5
CH3593X	FDAI Scale ERR50/15, Rate 50/10	10 S/S	Event		Panel Switch	11E8-6
CH3600X	LM ATTACHED Selected	10 S/S	Event		Panel Switch	11E9-3
CH3604X	SPS Solenoid Driver No. 1	10 S/S	Event		EMS	11E4-4
CH3605X	SPS Solenoid Driver No. 2	10 S/S	Event		EMS	11E9-4
CH3607X	Spacecraft Control Source Switch	10 S/S	Event		Panel Switch	11E9-5
CH3623X	Gyro 1 Comb. SPIN MOTORS Run Det	10 S/S	Event		None	11E8-7
CH3624X	Gyro 2 Comb. SPIN MOTORS Run Det	10 S/S	Event		None	11E8-8
CH3635X	BMAG Mode SW-Roll Att 1/Rate 2	10 S/S	Event		Panel Switch	11E33-1
CH3636X	BMAG Mode Sw-Roll Rate 2	10 S/S	Event		Panel Switch	11E33-2
CH3638X	BMAG Mode Sw-Pitch Att 1/ Rate 2	10 S/S	Event		Panel Switch	11E33-3

SCS TM List

<u>Measurement ID</u>	<u>Measurement Description</u>	<u>Response Rate</u>	<u>Sensor</u>	<u>Range</u> <u>Low</u> <u>High</u>	<u>Display Readout</u>	<u>Channel Code</u>
CH3639X	BMAG Mode SW - Pitch Rate 2	10 S/S	Event		Panel Switch	11E33-4
CH3641X	BMAG Mode Sw-Yaw Att 1/ Rate 2	10 S/S	Event		Panel Switch	11E33-5
CH3642X	BMAG Mode Sw - Yaw Rate 2	10 S/S	Event		Panel Switch	11E33-6

ACCEL	Accelerometer/Acceleration
ACS	Attitude Control Subsystem
AC	Alternating Current
A/C	RCS Quads A and C
A/D	Analog to Digital
ALT	Attitude
AMP	Amplifier
ARS	Attitude Reference Subsystem
ASCP	Attitude Set Control Panel
ATT	Attitude/Attenuation
ATT SET	Attitude Set
AUTO	Automatic
B/D	RCS Quads B and D
BMAG	Body Mounted Attitude Gyro
B.O.	Break Out Switch
bps	Bits Per Second
BUR	Backup Rate
BURR	Backup Rate Roll
BURP	Backup Rate Pitch
BURY	Backup Rate Yaw
CB	Circuit Breaker
CCW	Counterclockwise
C&D	Controls and Displays
CDH	Constant Delta Height
CDU	Coupling Data Unit
CFP	Concentric Flight Plan
CG	Center of Gravity
CHAN	Channel
CM	Command Module
CMC	Command Module Computer
CMD	Command
COAS	Crew Optical Alignment Sight
CONT	Control
CPS	Cycles Per Second
CSC	Cosecant Computing Amplifier

CSM	Command and Service Module
CSS	Computer Subsystem
CTE	Central Timing Equipment
CW	Clockwise/Continuous Wave
CW	Not Clockwise
C/W	Caution and Warning
D/A	Digital - to - Analog
DAC	Digital to Analog Converter
DAP	Digital Autopilot
DB or	Deadband
d.b.	Decrease
DECR	Decrease
DC	Direct Current
DEM0D	Demodulator
DSKY	Display and Keyboard
E	Elevation Angle
ECA	Electronic Control Assembly
ECO	Engine Combustion/Engine Cut OFF
EDA	Electronic Display Assembly
ELECT	Electronic
ELS	Earth Landing System
EMS	Entry Monitor System
ENC	Encode
ENG	Engine
ERR	Error
FCSD	Flight Crew Support Division (MSC)
FCSM	Flight Combustion Stability Monitor
FDAI	Flight Director Attitude Indicator
FUNCT	Functional
GA	Gyro Assembly
G&C	Guidance and Control
GET	Ground Elapse Time
G&N	Guidance and Navigation

GNCS Guidance Navigation and Control System
 GDC Gyro Display Coupler
 GMBL Gimbal
 GP/FPI Gimbal Position and Fuel Pressure Indicator
 GPI Gimbal Position Display
 GSOP Guidance System Operations Plan

ha Apogee Altitude
 HI High/Hello
 hp Perigee Altitude
 HTRS Heaters

ICDU Inertial Coupling Data Unit
 IGA Inner Gimbal Angle
 IGN Ignition
 IND Indicator
 IMP Impulse
 IMU Inertial Measurement Unit
 INCR Increase
 IRIG Inertial Rate Integrating Gyro
 ISS Inertial Subsystem
 IU Instrument Unit

KC Kilo Cycles

LAT Latitude
 LEB Lower Equipment Bay
 LES Launch Escape System
 LET Launch Escape Tower
 LM Lunar Module
 LMK Landmark
 LOR Lunar Orbit Rendezvous
 LOS Line of Sight
 LV Launch Vehicle/Lift Vector

MAN Manual
 MAX Maximum
 MDC Main Display Console
 MERU Milli Earth Rate Unit
 MESC Mission Events Sequence Control
 MIN Minimum
 MGA Middle Gimbal Angle
 MMH Monomethylhydrozene
 MNA Main Buss A
 MNB Main Buss B
 MSB Most Significant Bit
 MTVC Manual Thrust Vector Control

NAV Navigation
 NB Navigation Base
 NORM Normal
 NRZ Non-return to Zero

OCDU Optics Coupling Data Unit
 OGA Outer Gimbal Angle
 OPT Optics
 OSS Optics Subsystem
 ORDEAL Orbit Rate Drive Electronics Apollo LM
 OXID Oxidizer

P Pitch Axis of Control/Program
 PA Power Amplifier
 PB Push Button
 PCM Pulse Code Modulation
 PGNCS Primary Guidance, Navigation and Control System
 PH Phase
 PIPA Pulsed Integrating Pendulous Accelerometer
 PSA Power Servo Assembly
 PPS Pulse Per Second
 PTT Push to Talk

PWR	Power	TIGN	Time of Ignition
R	Roll Axis of Control/Routine or DSKY Display Register	TLC	Translunar Coast
RC	Rotation Control	TM	Telemetry
RCS	Reaction Control System	TPAC	Telescope Pointing Angle Counter
REL	Release	TFF	Time of Freefall
REV	Reverse	TPF	Transfer Phase Final
RGA	Rate Gyro Assembly	TPI	Transfer Phase Initiation
RJD	Reaction Jet Driver	TTINT	Time to Intercept
RJ/EC	Reaction Jet and Engine ON-OFF Control	TRNFR	Transfer
RLVDT	Rotary Linear Variable Differential Transformer	TTE	Time - to Events
RNG	Range	TVC	Thrust Vector Control
ROT	Rotation	TVSA	Thrust Vector Position Servo Amplifier
RSI	Roll Stability Indicator	UDL	Up Data Link
RTC	Real Time Commands	UPTLM	Up-Link Telemetry
RUPT	Interrupt	V	Velocity
S/C	Spacecraft	VM	Velocity Measured
SCT	Scanning Telescope	Vc	Circular Velocity
SCS	Stabilization and Control System	Vo	Initial Velocity at .05g
SIG	Signal	XLATION	Translation
SLOS	Star Line of Sight	XLUNAR	Translunar
SM	Service Module	ΔV	Differential Velocity
SMJC	Service Module Jettison Controller	ϕ	Roll Control Axis Designation/Phase
SMRD	Spin Motor Rotation Detector	ψ	Yaw Control Axis Designation
SPS	Service Propulsion System/Samples per Second	θ	Pitch Control Axis Designation
STBY	Standby		
SW	Switch		
SXT	Sextant		
SYNC	Synchronize		
SYS	System		
TC	Translation Control		
TEC	Tranearth Coast		
TEMP	Temperature		
TFL	Time - From - Launch		