

Hy 12  
3/13/67



## APOLLO TRAINING

GUIDANCE AND CONTROL  
SYSTEMS  
BLOCK II

FEBRUARY 10, 1967

FOR TRAINING PURPOSES ONLY



BOX 088-151

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DATA - SED

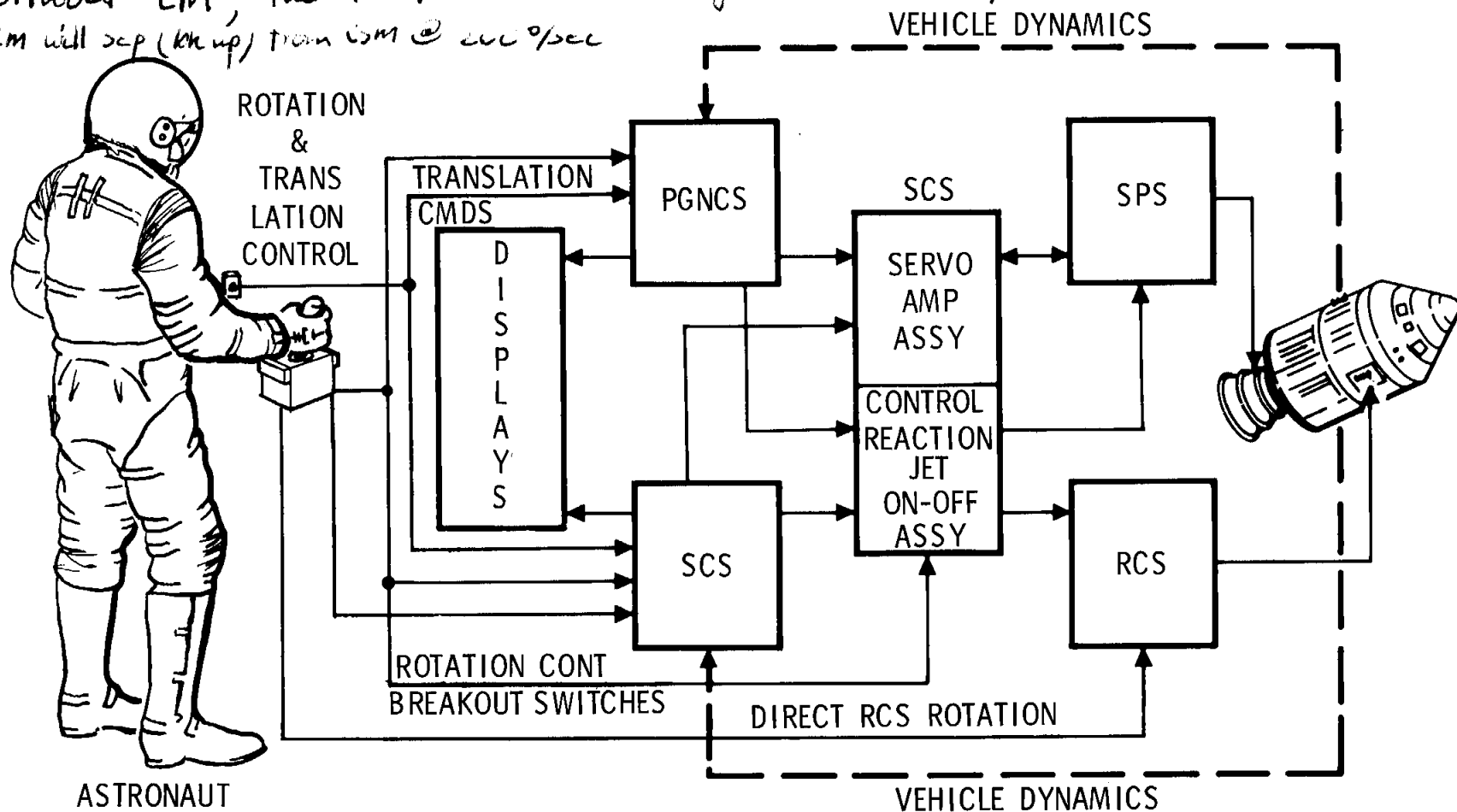
(\*) The study, but the results to be  
given a comprehensive  
picture of the whole (of) it.

- \* If G&N system isn't working
- @ LVI, jett. LM & return to earth.

\* SCS is parallel with PGNCs  
 $\therefore$  it is a back up. control system

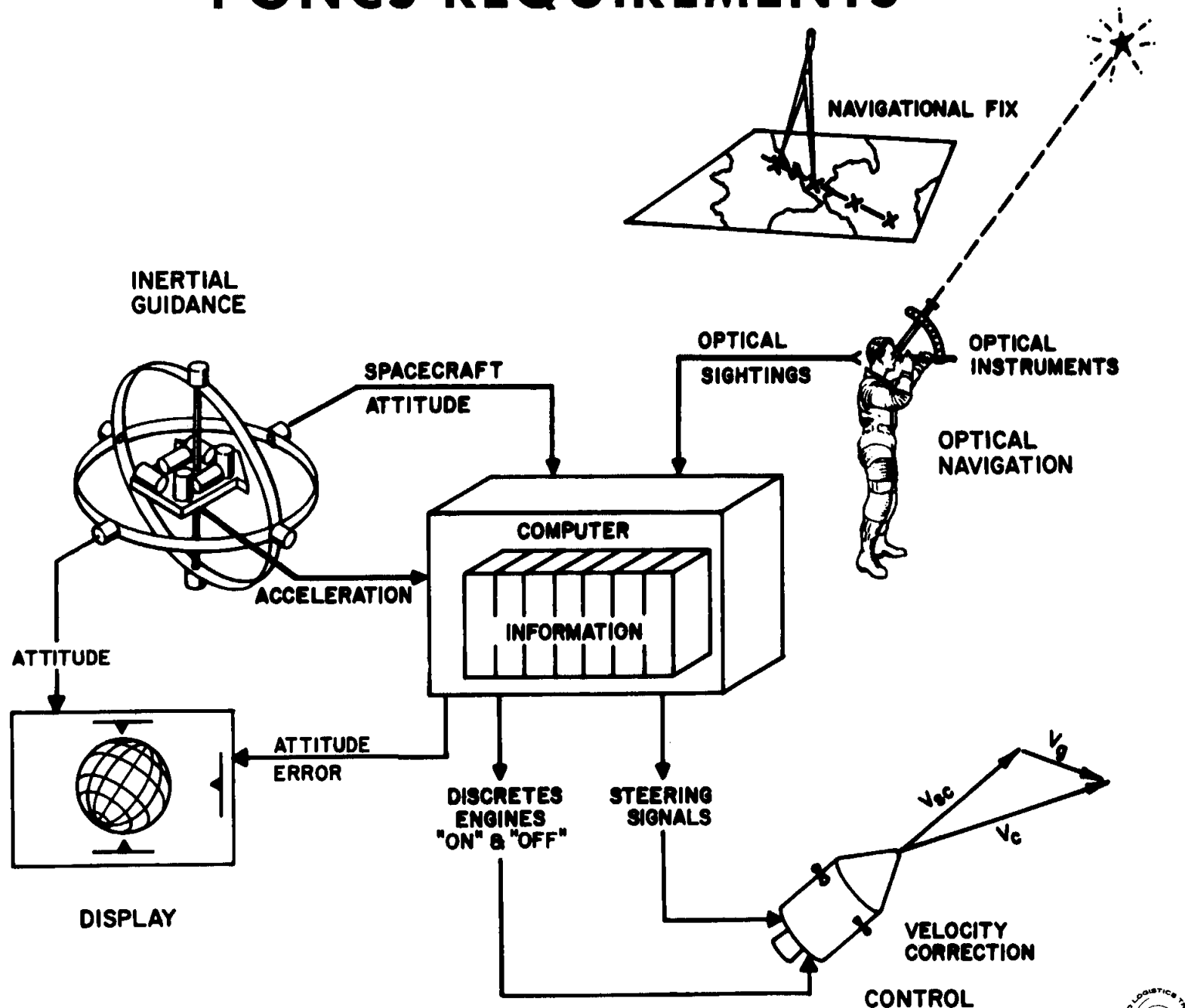
## CSM GUIDANCE & CONTROL

- \* With LM attached cy position is a good cue --- because att. control is sluggish
- \* Without LVI, the limiter in the TVC logic becomes a good rate cue.
- ✓ \* CM will sep (kn up) from CSM @ 200°/sec



Backup actuator  $\therefore$  if you have actuator hardware, 2<sup>nd</sup> one takes over & you can see it & control

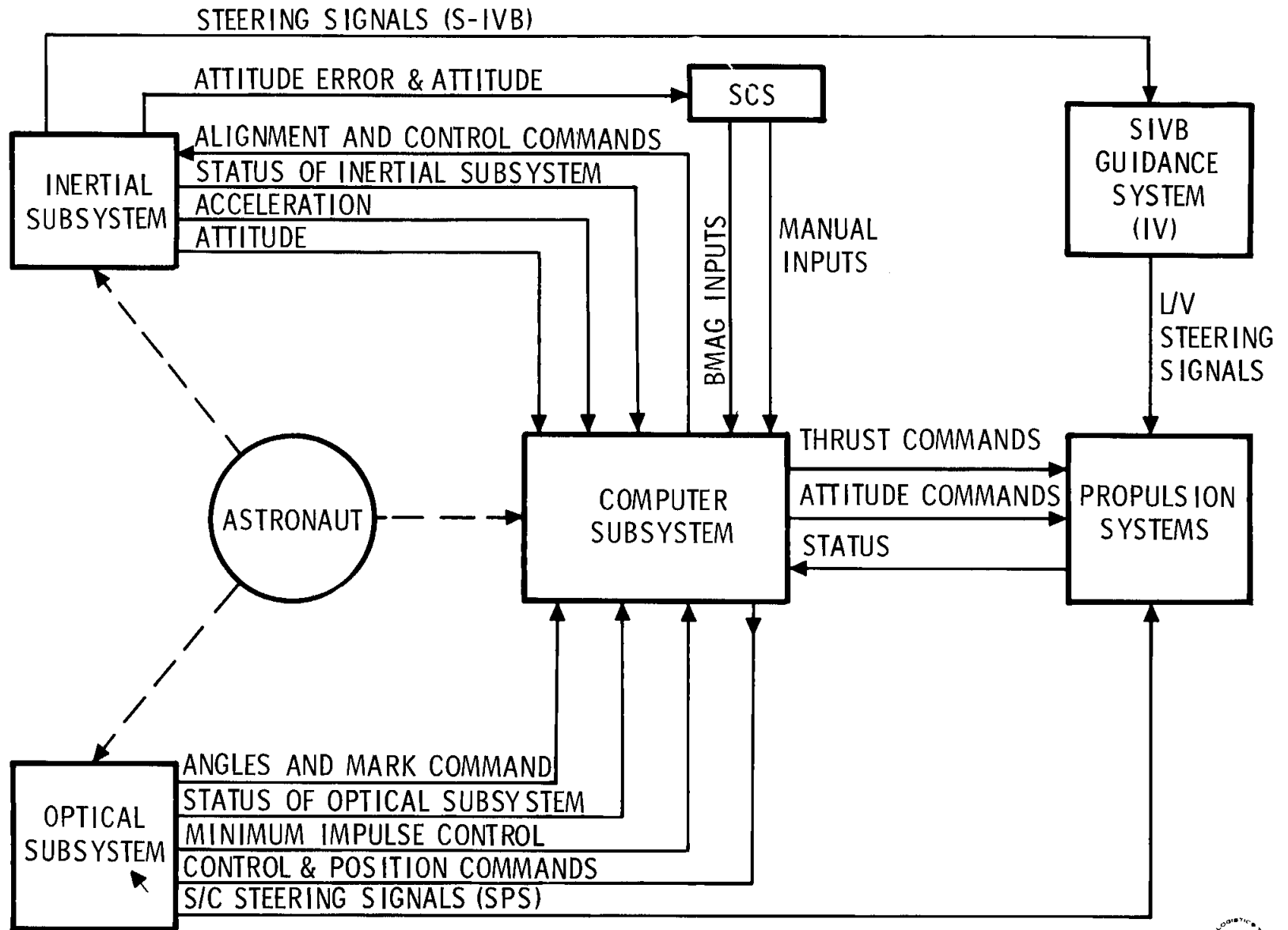
# PGNCS REQUIREMENTS



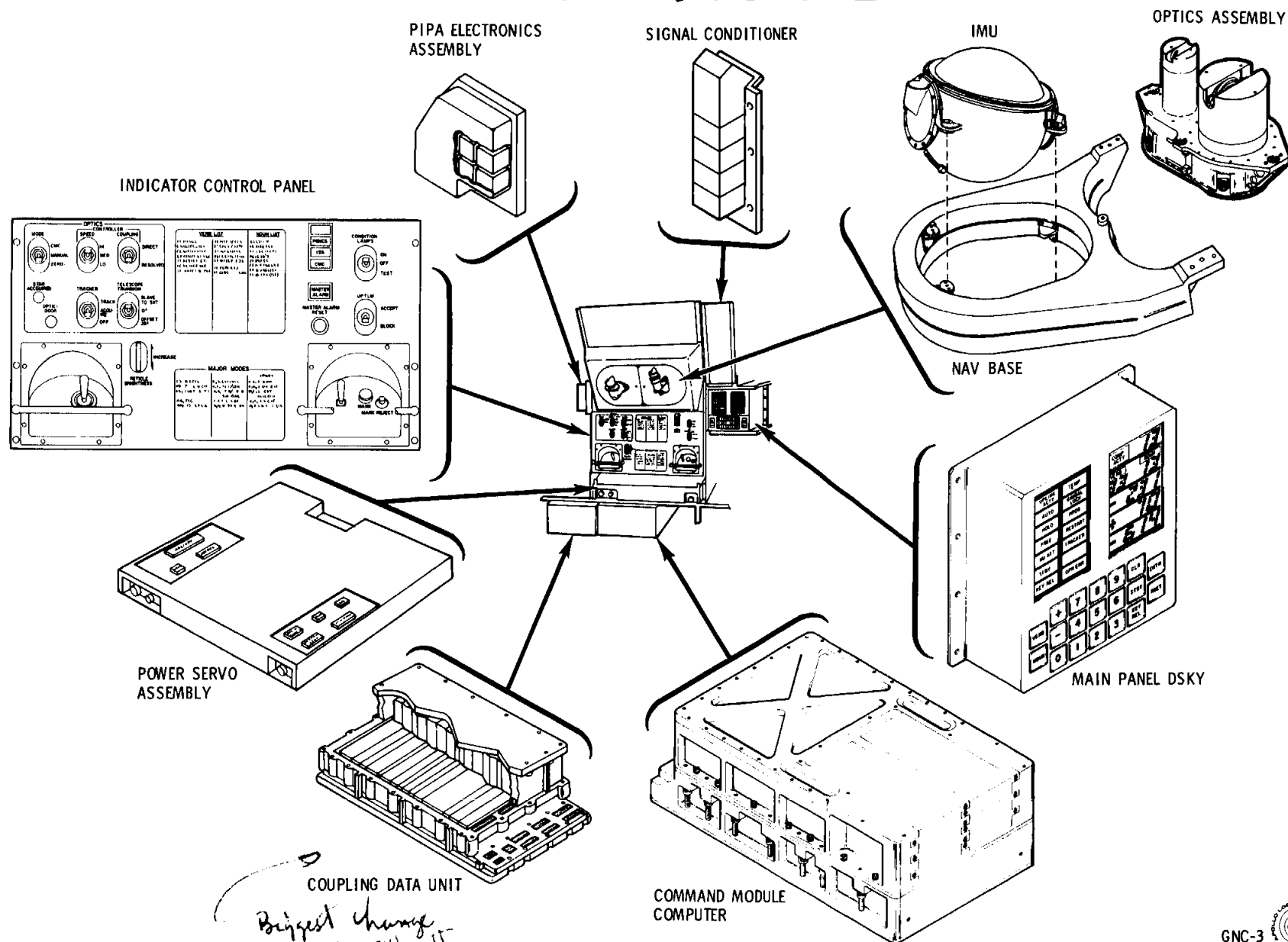
GNC-1



# PGNCS DATA FLOW

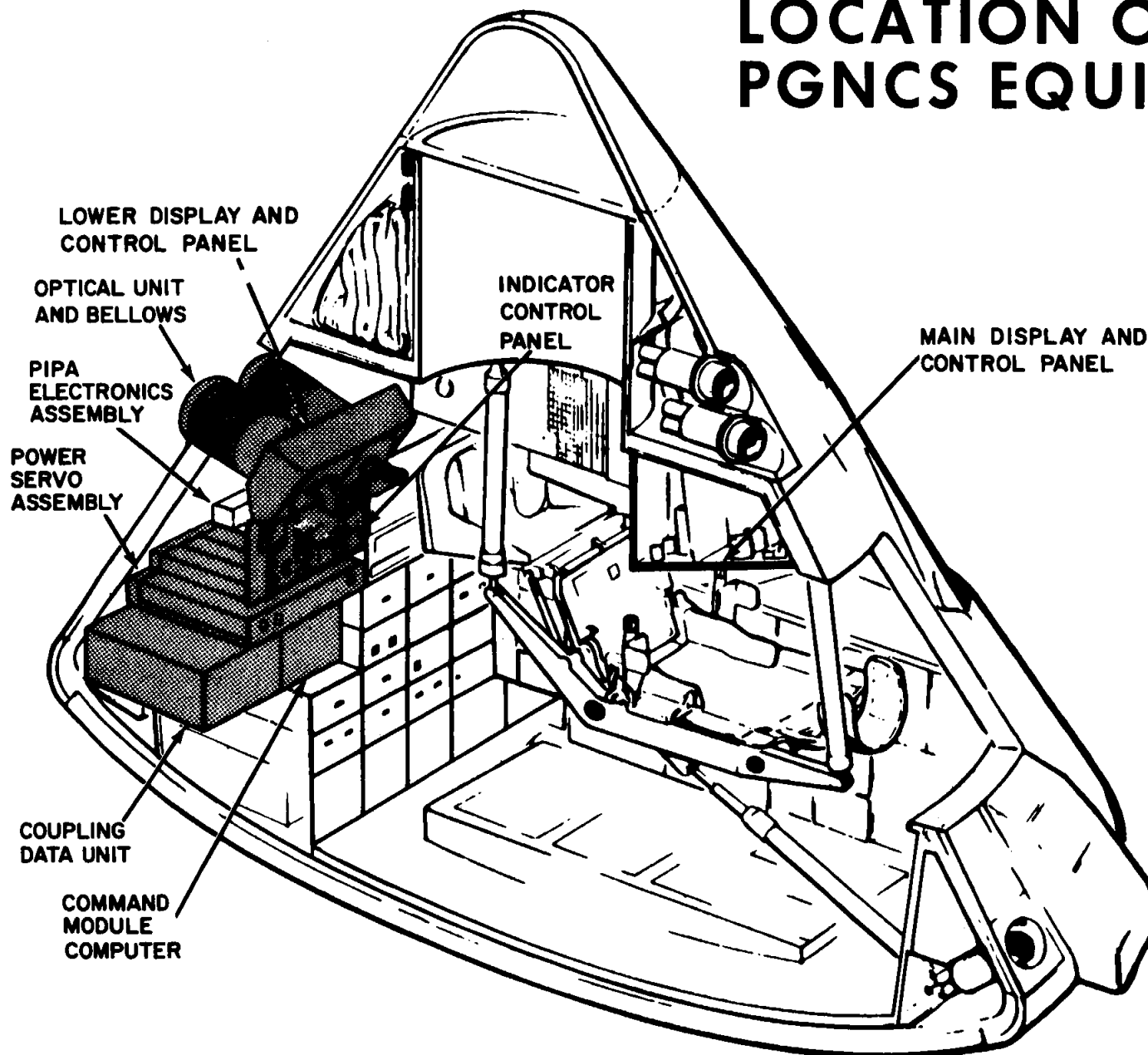


# PGNCS EQUIPMENT



Biggest change  
Blk I to Blk II  
No display in Blk II  
(extension of comp)

# LOCATION OF PGNCS EQUIPMENT

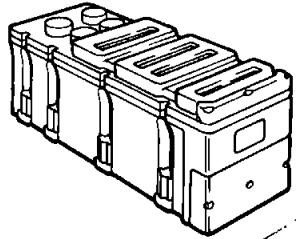


GNC-4

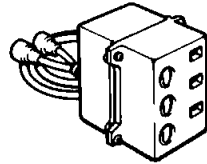


# SCS FLIGHT HARDWARE

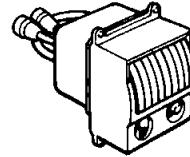
## BLOCK II



ELECTRONIC CONTROL ASSEMBLY



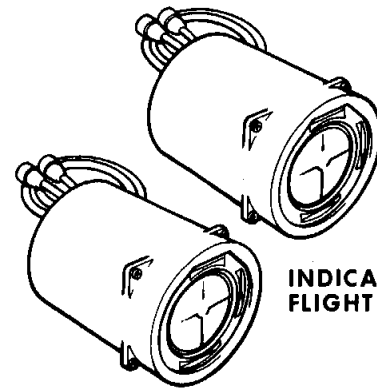
CONTROL PANEL, ATTITUDE SET



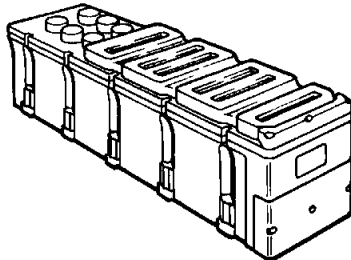
INDICATOR, GIMBAL POSITION AND FUEL PRESSURE

*in SII & SIVB (SAE)*

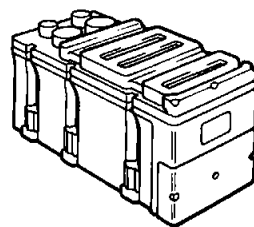
*ox, fuel in SIVB until sep. then SPS eng. gimbal position*



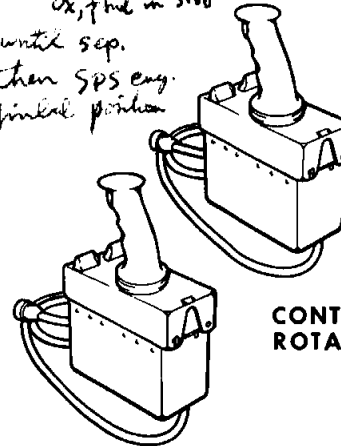
INDICATOR, ATTITUDE, FLIGHT DIRECTOR (2)



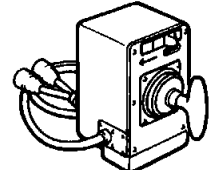
REACTION JET AND ENGINE ON-OFF CONTROL



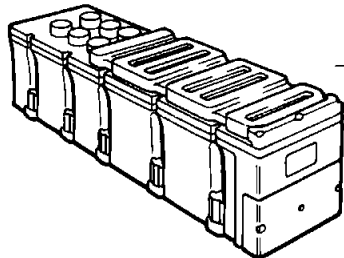
SERVO AMPLIFIER, THRUST VECTOR POSITION



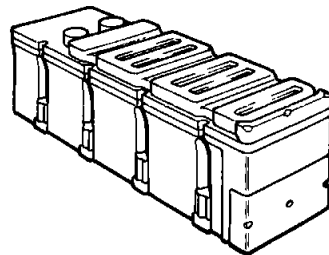
CONTROL, ROTATION (2)



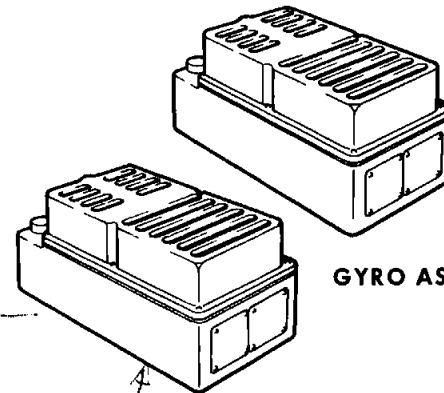
CONTROL, TRANSLATION



ELECTRONIC DISPLAY ASSEMBLY



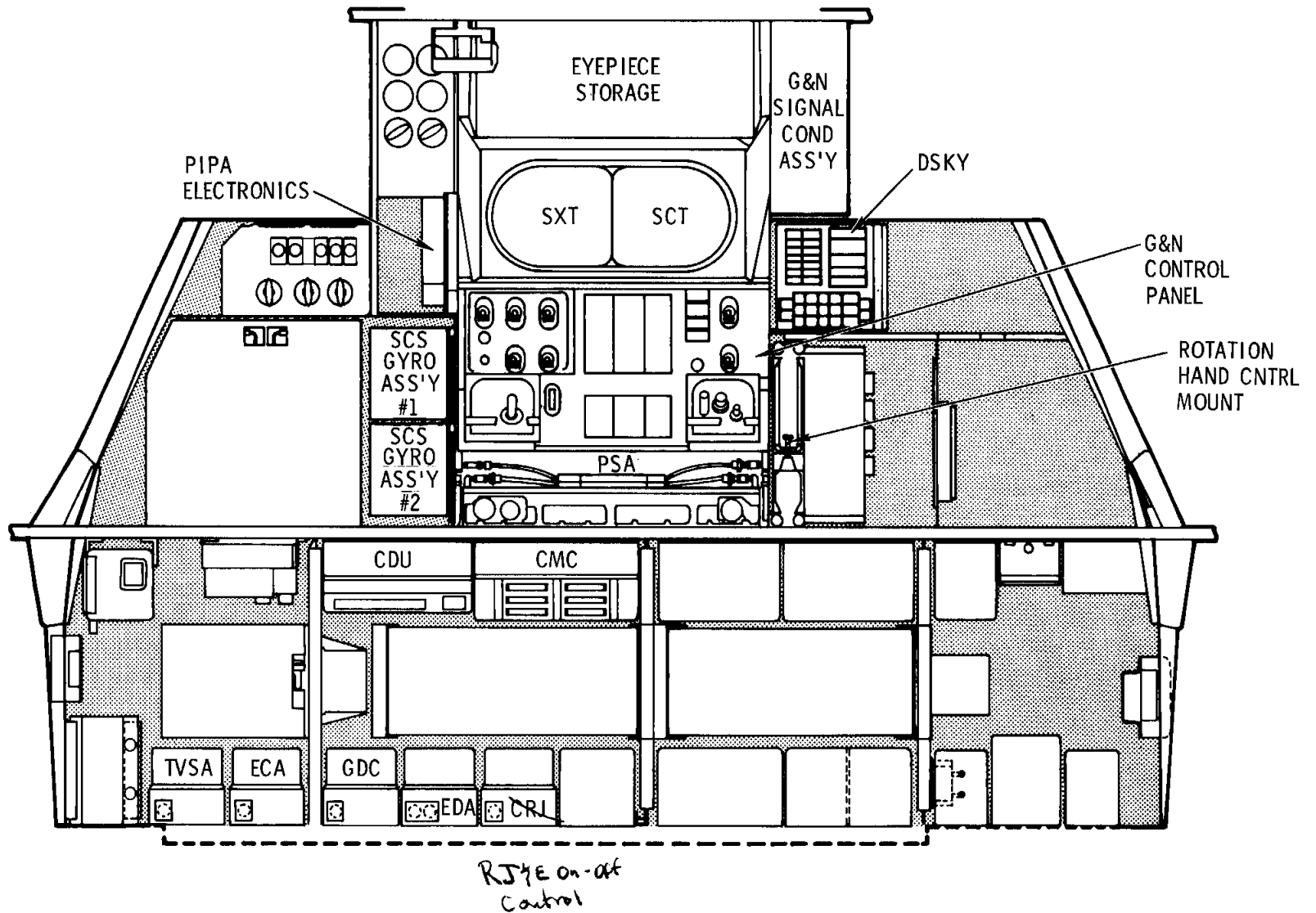
COUPLER, GYRO DISPLAY



GYRO ASSEMBLY (2)

*BMA6s*

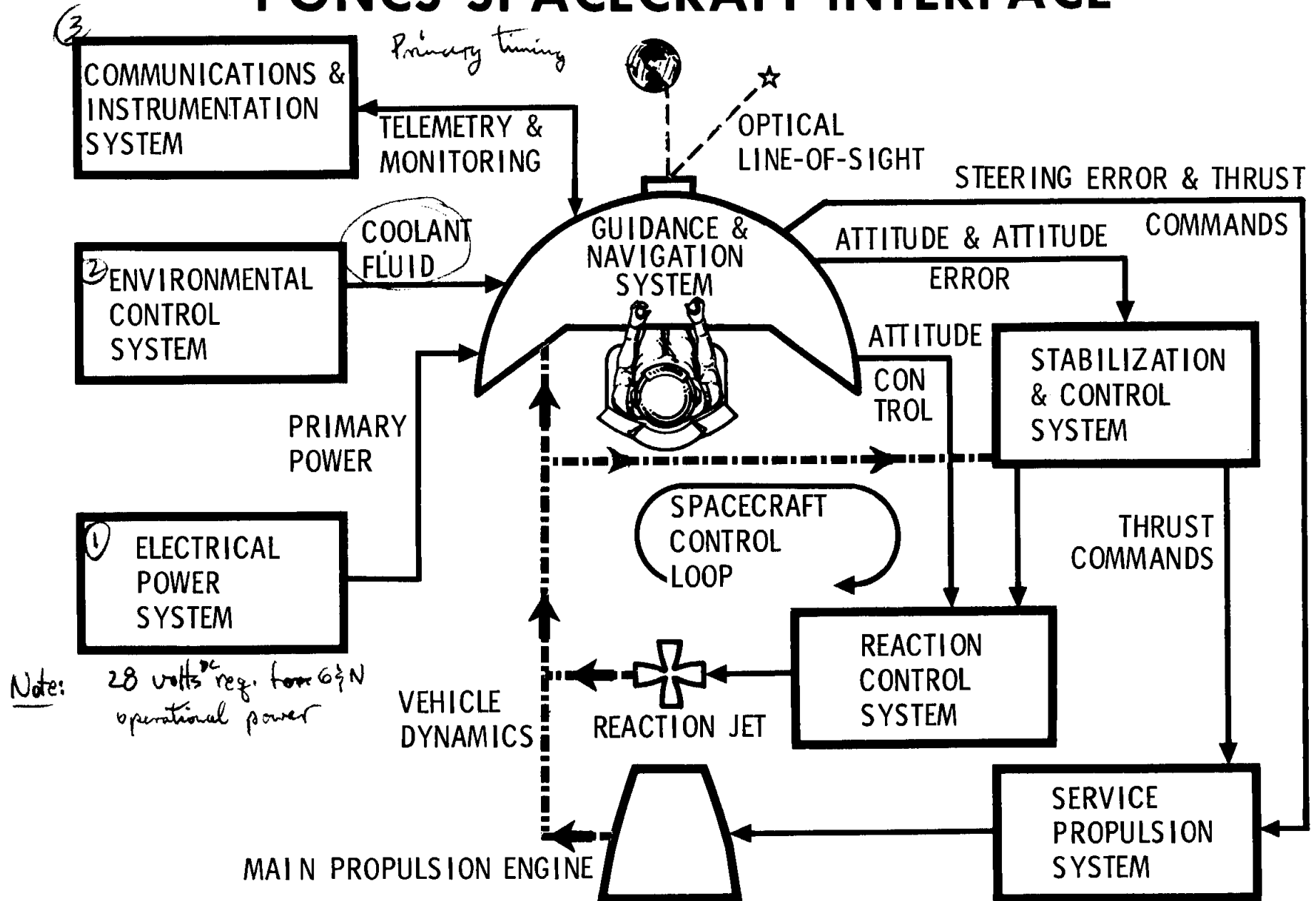
# G&C EQUIPMENT LOCATION

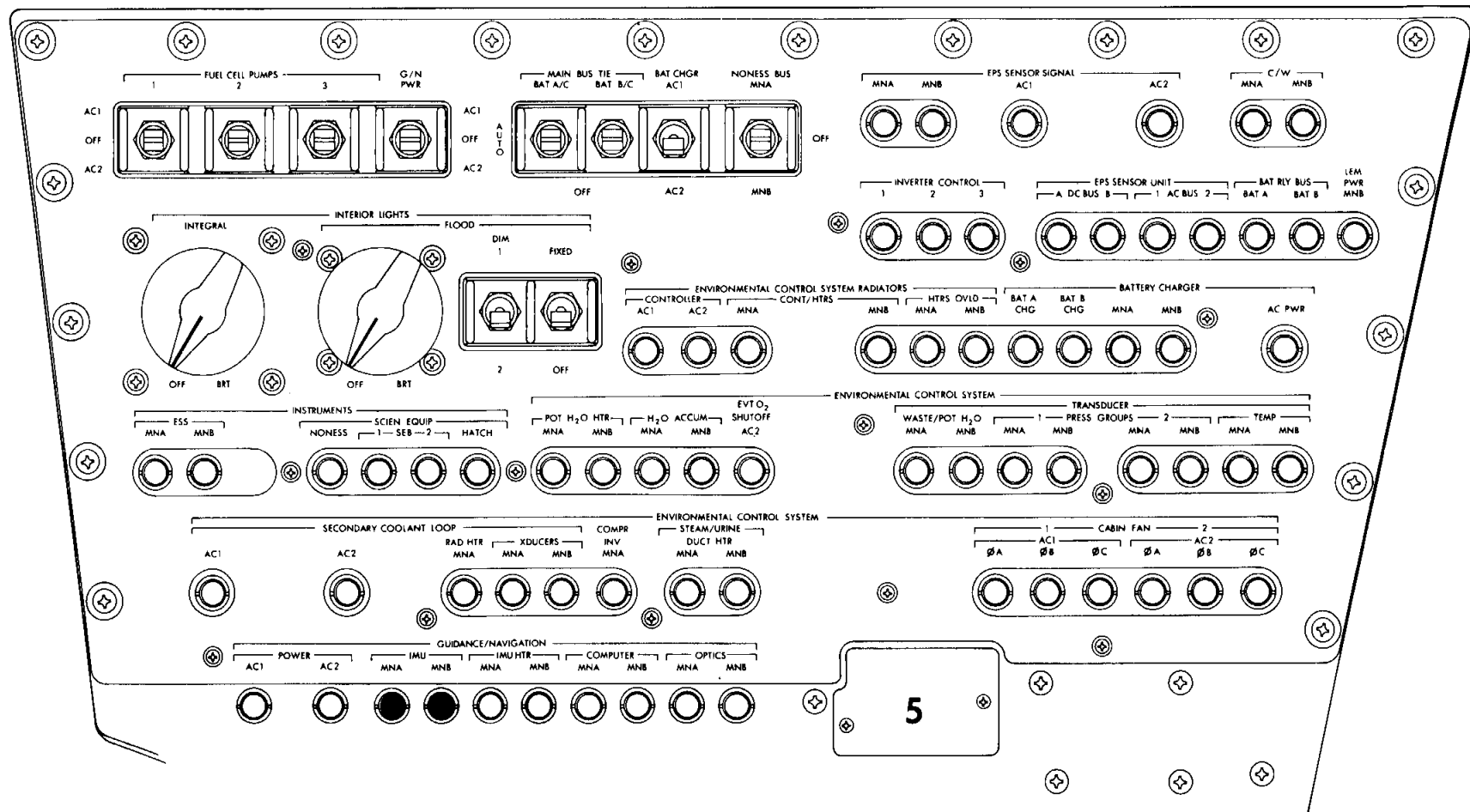


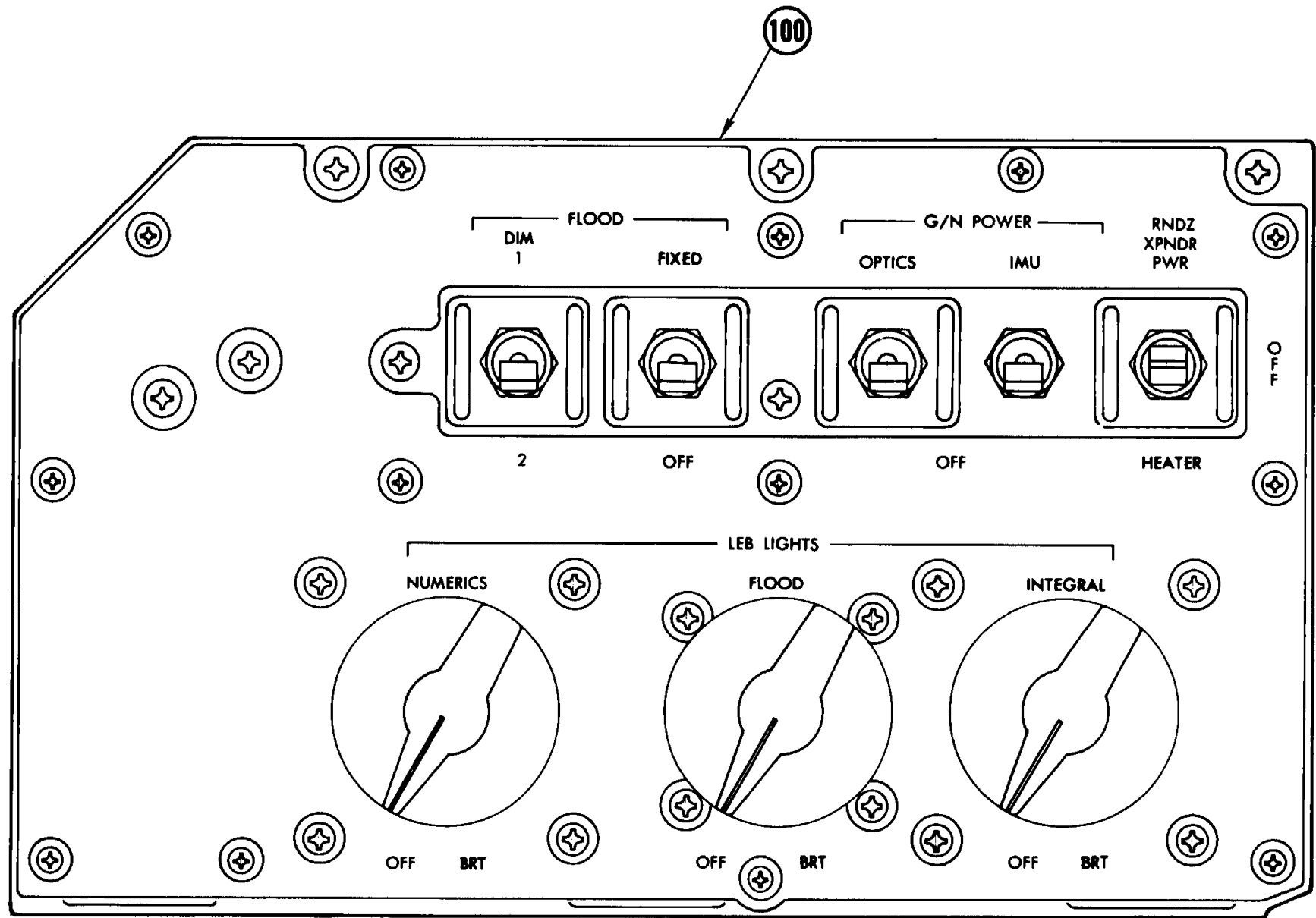
SCS-3004A



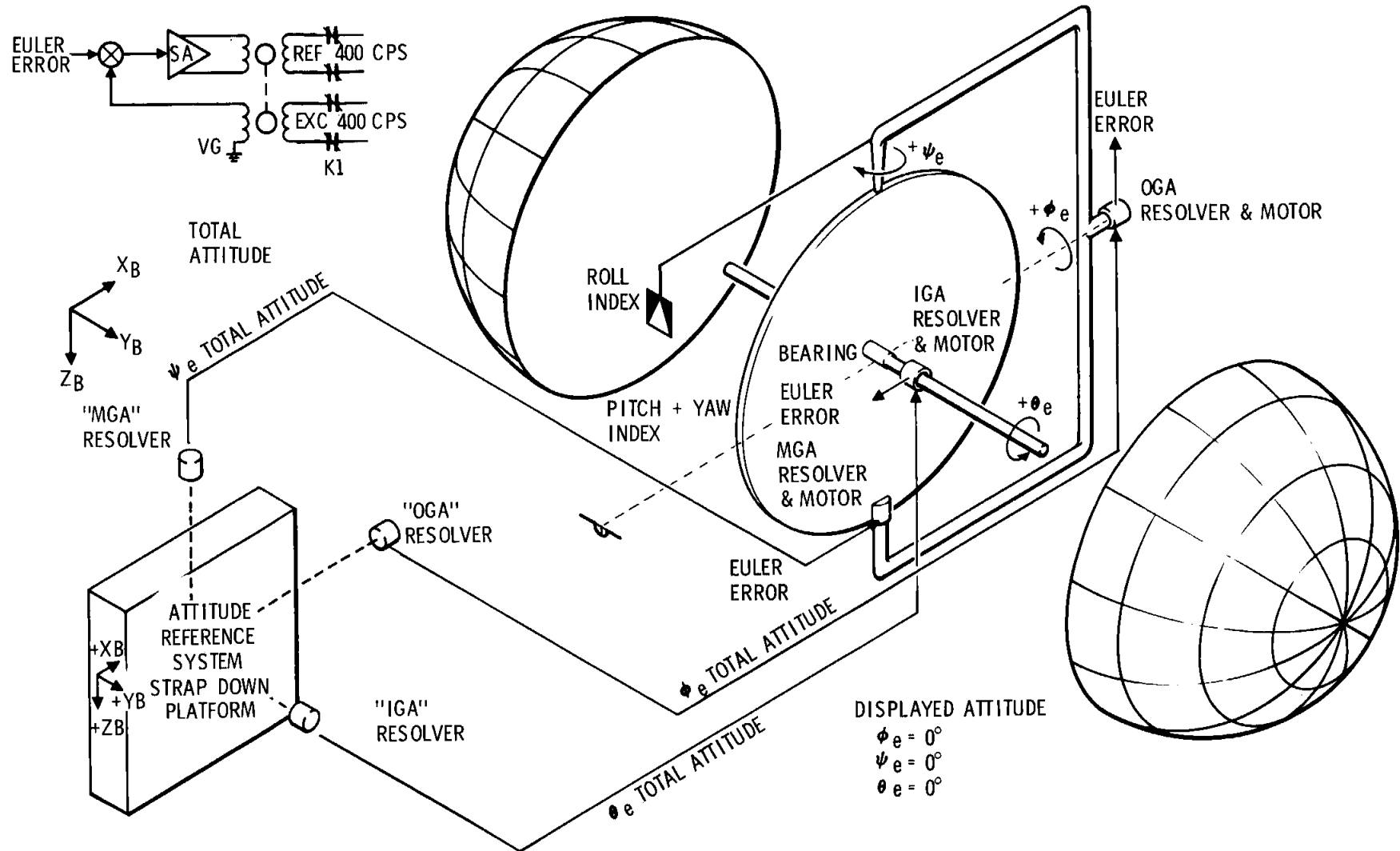
# PGNCS SPACECRAFT INTERFACE







# FDAI/GDC SHAFT RELATIONSHIP



Euler Angles (P, Y, R seq.)

# FLIGHT DIRECTOR ATTITUDE INDICATOR

Inside out system



ROLL  
+ANGULAR VELOCITY-  
+ATTITUDE ERROR-

This shows total att. wrt  
to ball

PITCH & YAW  
INDEX

ROLL INDEX

I) Airplane wings  
& roll only give total  
att. ... wings fixed,  
ball moves

II) Att Error ... 3 st.  
indicators

III) Rates ... Outside  
gates

ATTITUDE  
ERROR

ANGULAR  
VELOCITY

P  
I  
T  
C  
H

+

+

EULER ATTITUDE ON BALL

PITCH -  $\theta$  =  $014^\circ$

YAW -  $\psi$  =  $034^\circ$

ROLL -  $\phi$  =  $330^\circ$

NOTE:

ALL POLARITIES INDICATE  
VEHICLE DYNAMICS

ROLL TOTAL  
ATTITUDE SCALE

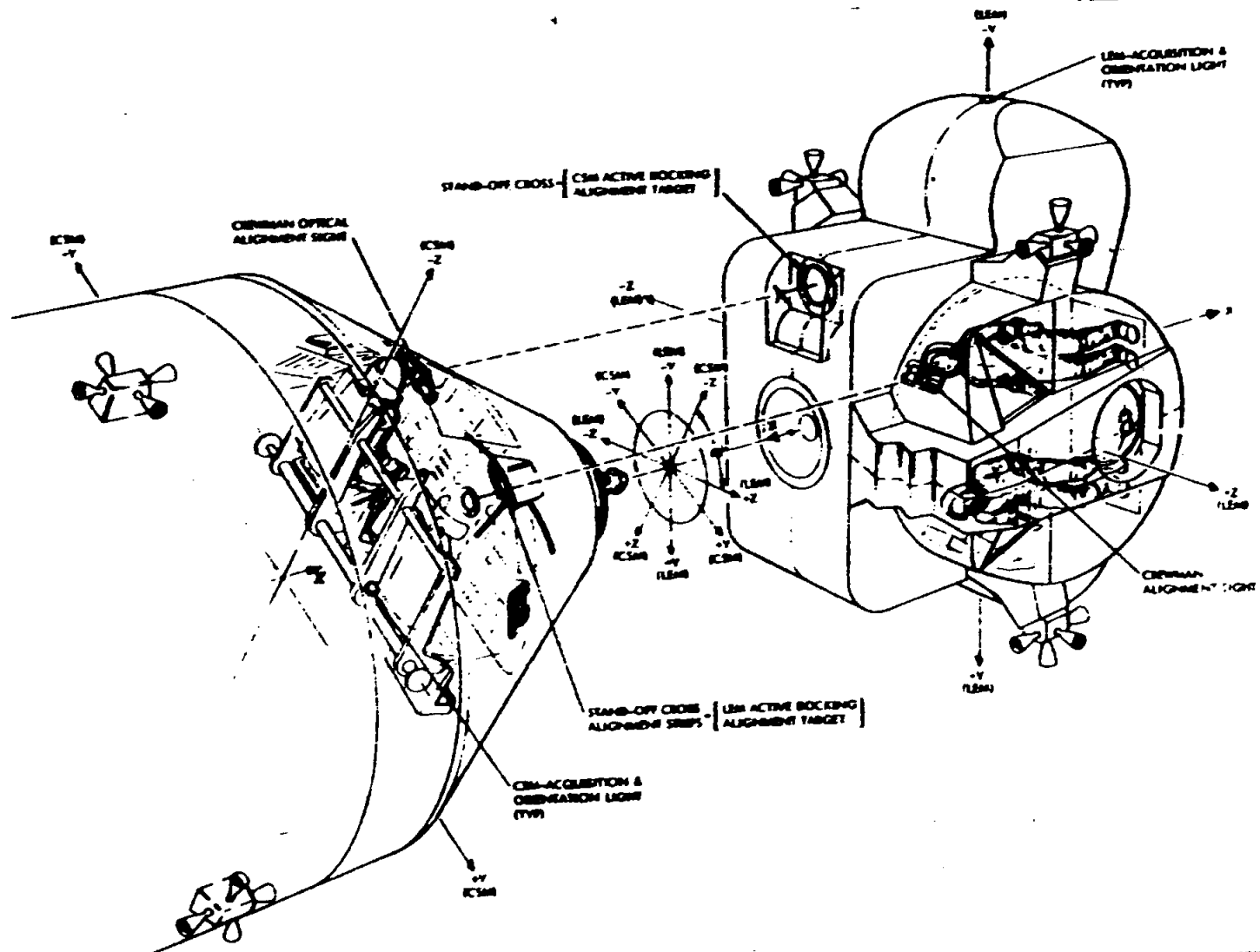
YAW  
+ATTITUDE ERROR-  
+ANGULAR VELOCITY-

Fly to Commands

If sic yaw rty, the yaw rate  
needle moves left. To correct  
pil & move rate into in dir. of  
needle entry, 3 st. timing thumb up fire & rotate sic c.w.

SCS-2100D

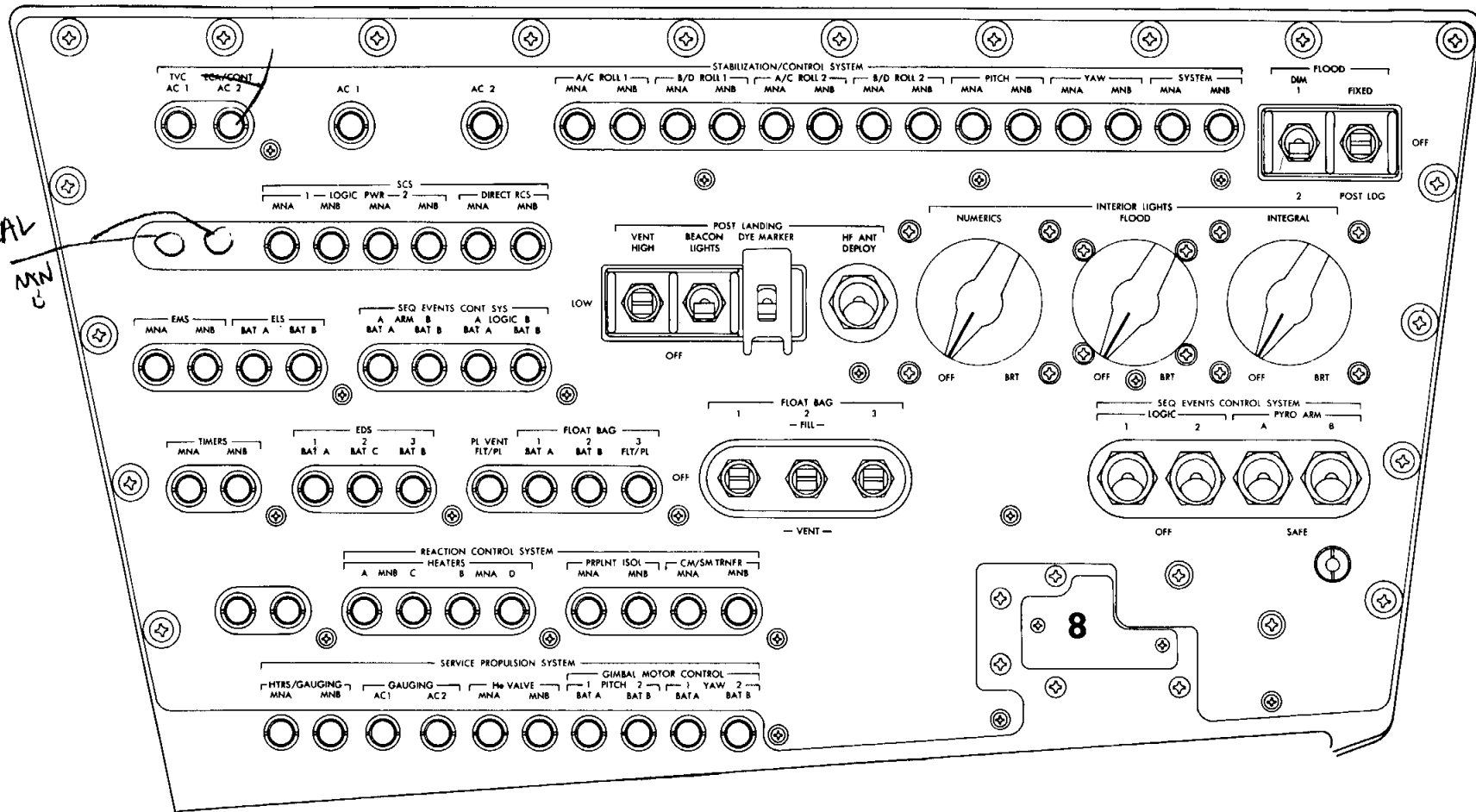




# SCS Panel

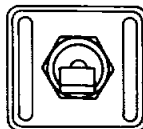
ECA/TVC

ORIGINAL  
AC2  
MNB



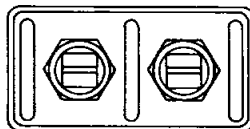
7

EDS POWER



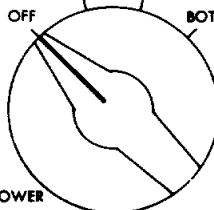
OFF

TVC SERVO POWER  
1-AC1/MNA-2



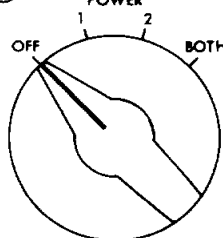
OFF

SCS  
INDICATORS  
POWER

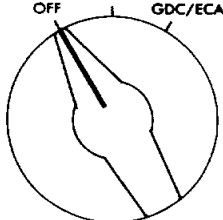


BOTH AC2/MNB

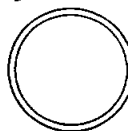
HAND CONTROL  
POWER



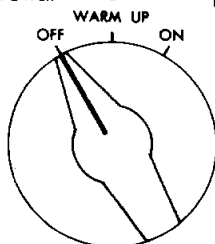
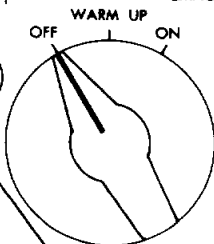
SCS  
ELECTRONICS POWER  
ECA



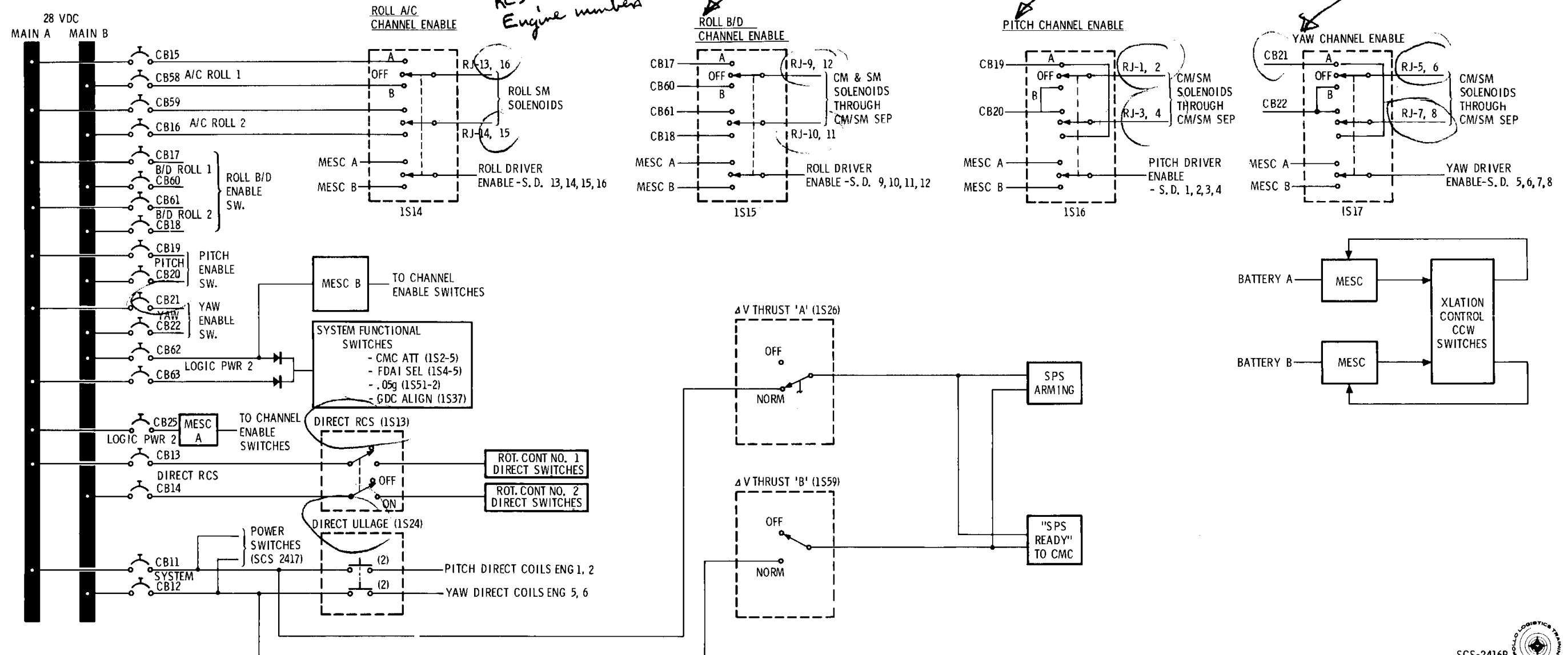
DIRECT O<sub>2</sub>  
OPEN



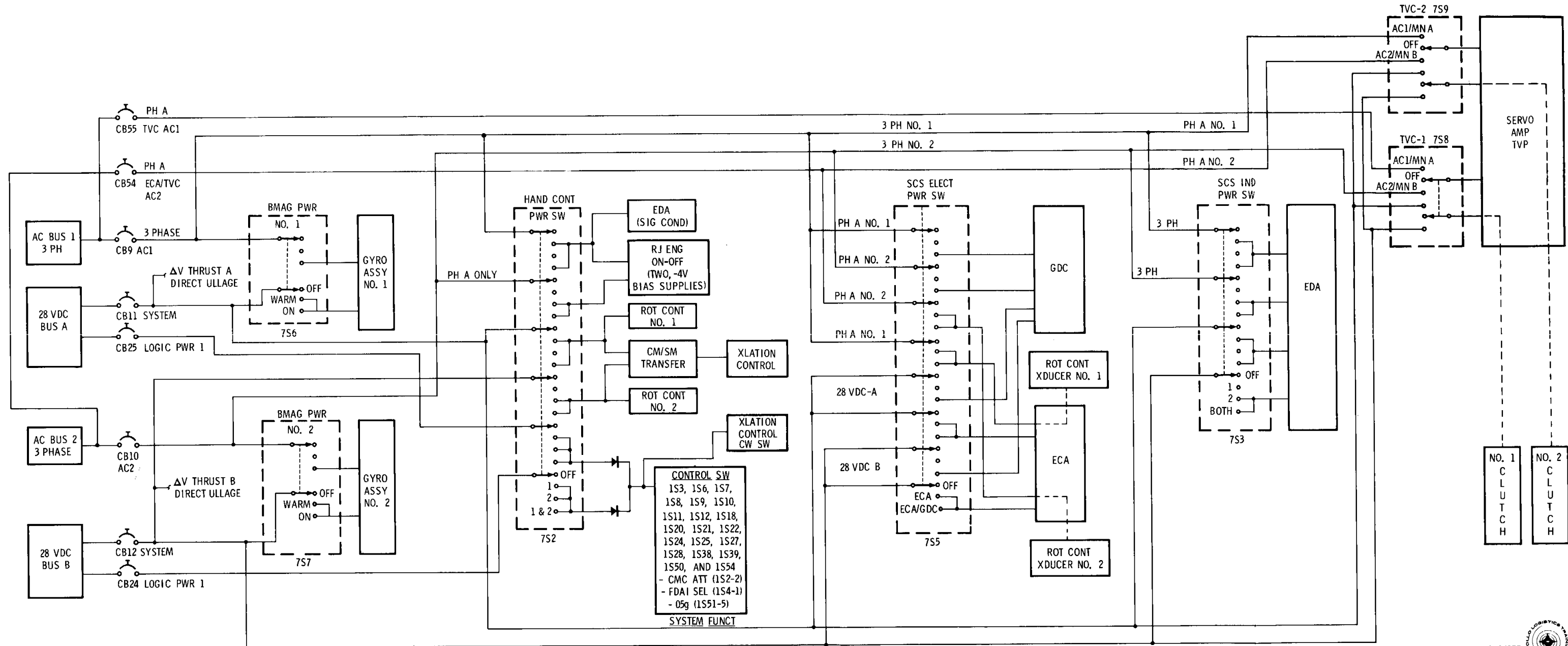
1 — BMAG POWER — 2



# SCS NON SWITCHED POWER



# SCS SWITCHED POWER DISTRIBUTION



(X) TVC

S/C control switch is in CMC

If a  $6\frac{1}{2}$  N burn was initiated and the CMC light came on, the burn could be completed immedi.  
if before starting burn you put SPS TVC into ~~auto~~ <sup>for note and</sup> then when you get CMC light ~~put~~  
<sub>or fixed off.</sub>  
~~sc out switch to SCS.~~  
turn the translation control cw.  
(rotation)?

IMP!

G & N displays no att. rates!  
Ratio from SCS!

8 Bull #1 IMU for att error  
GDC [ att error, att set diff.

FDAI

Total att.  
att. error  
att. rates — from SCS

Scaling

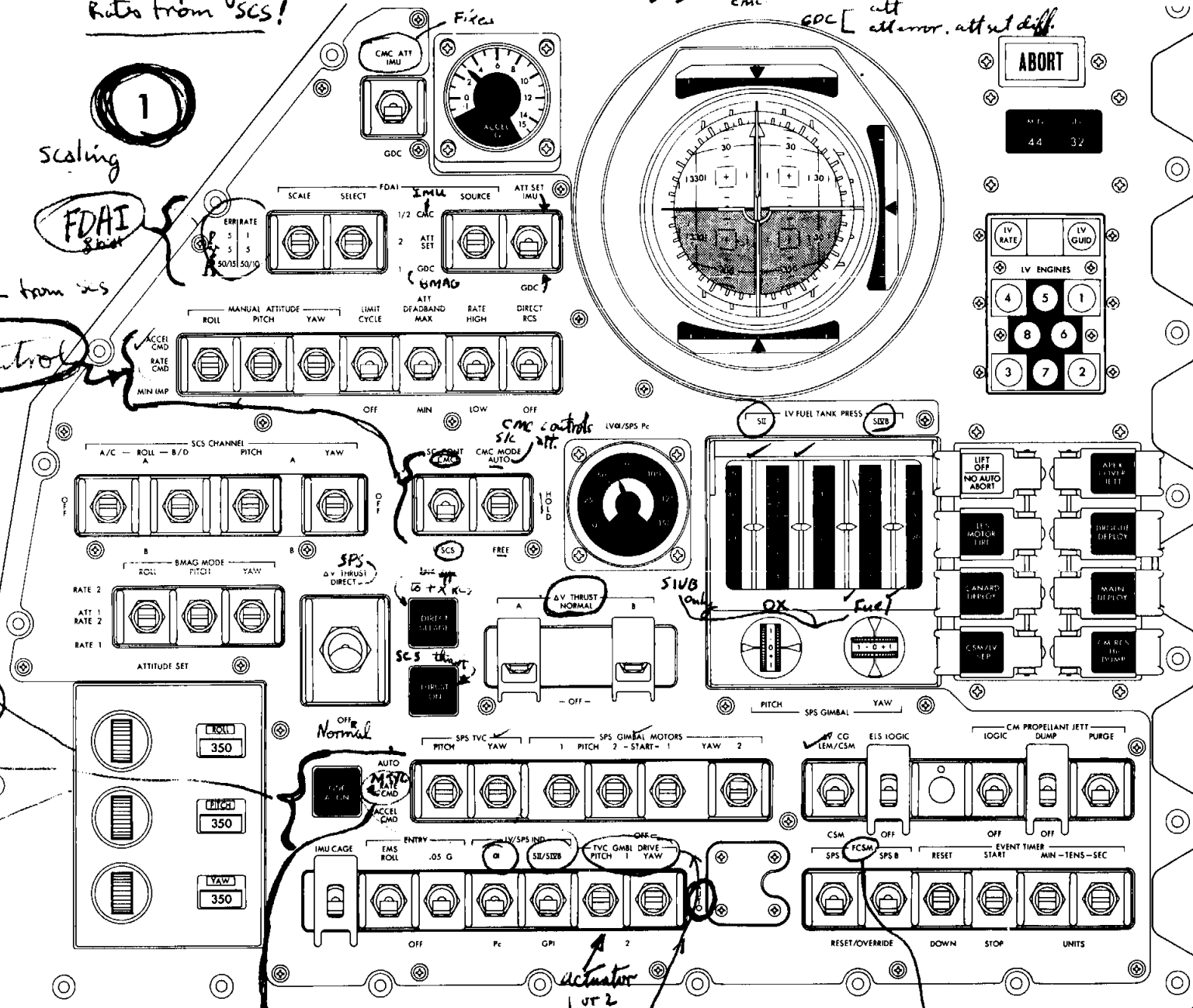
FDAI  
3000

SCS att. control

IMU vs dials  
in Enter upgr

Thrust Vector  
Control

Att. set  
dials  
vs GDC  
compare att.  
error  
Body axes



Rot. control with  
rates damp by gyro  
while doing SPS man.

Same as press. gauge  
if S/C is sep. from L/V.

Rough  
Start!

# Entry Monitor Display

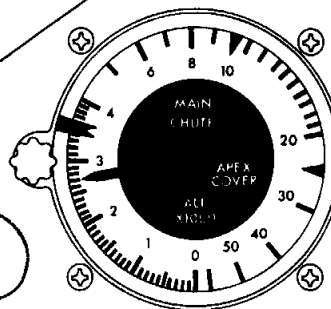
EMS

Top of  
PANEL

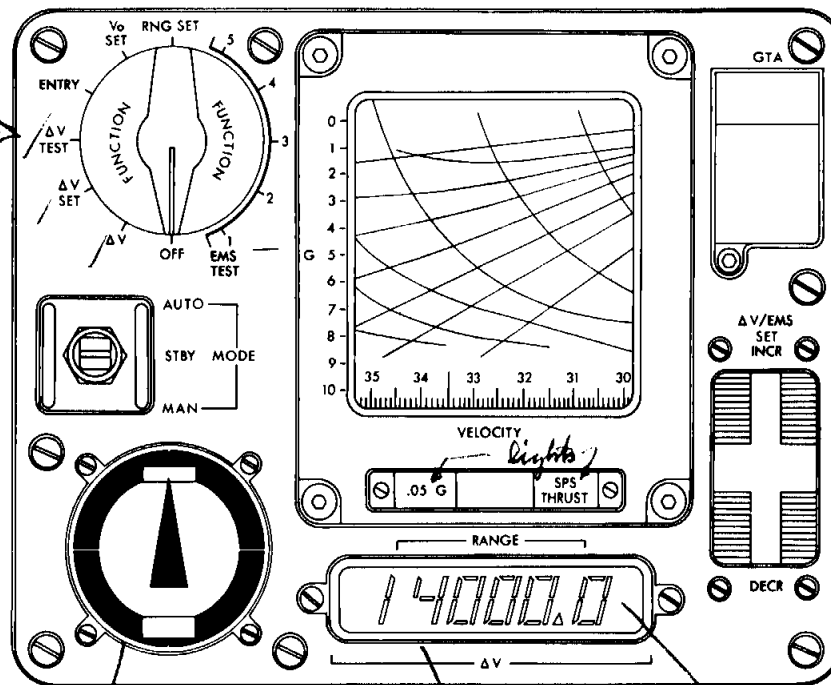
1 cont'd

set  $\Delta V$  counter to 1585.6  
move to test & SPS thrust light comes on  
cont'd from last pg.

verifies circuits



1



roll stab indicator  
From SCS

down to  
-1000

1 per

FAM-6311C



IMU  
(fail)

#2 FDAI

2

Lights

On  
working  
on 8. 1980

|                          |                                       |
|--------------------------|---------------------------------------|
| UPLINK<br>ACTY           | TEMP                                  |
| <del>AUTO</del>          | GIMBAL<br>LOCK                        |
| <del>HOLD</del>          | PROG                                  |
| <del>FREE</del>          | RESTART                               |
| NO ATT<br><i>come up</i> | TRACKER<br><i>opt. type<br/>file.</i> |
| STBY                     | <del>X</del>                          |
| KEY REL                  | OPR ERR                               |

|              |      |
|--------------|------|
| COMP<br>ACTY | PROG |
|              | 77   |
| VERB         | NOUN |
| 31           | 33   |
| ÷ 58944      |      |
| ÷ 35870      |      |
| - 836 14     |      |

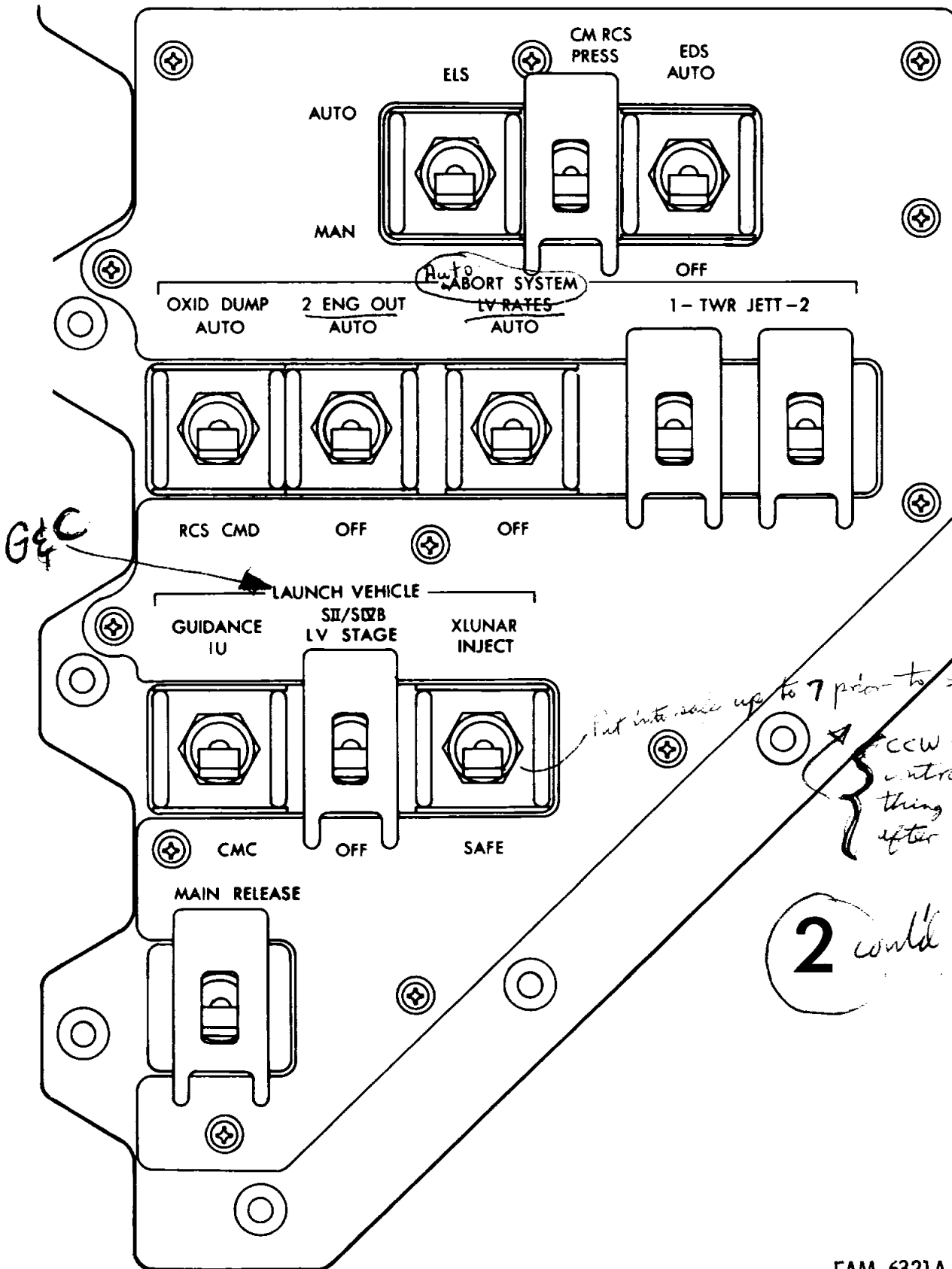
- what you  
do it to.

come up  
to display key

|      |   |   |   |   |             |      |
|------|---|---|---|---|-------------|------|
| VERB | + | 7 | 8 | 9 | CLR         | ENTR |
| NOUN | - | 4 | 5 | 6 | STBY        | RSET |
|      | 0 | 1 | 2 | 3 | KEY<br>RLSE |      |

turns lights  
off



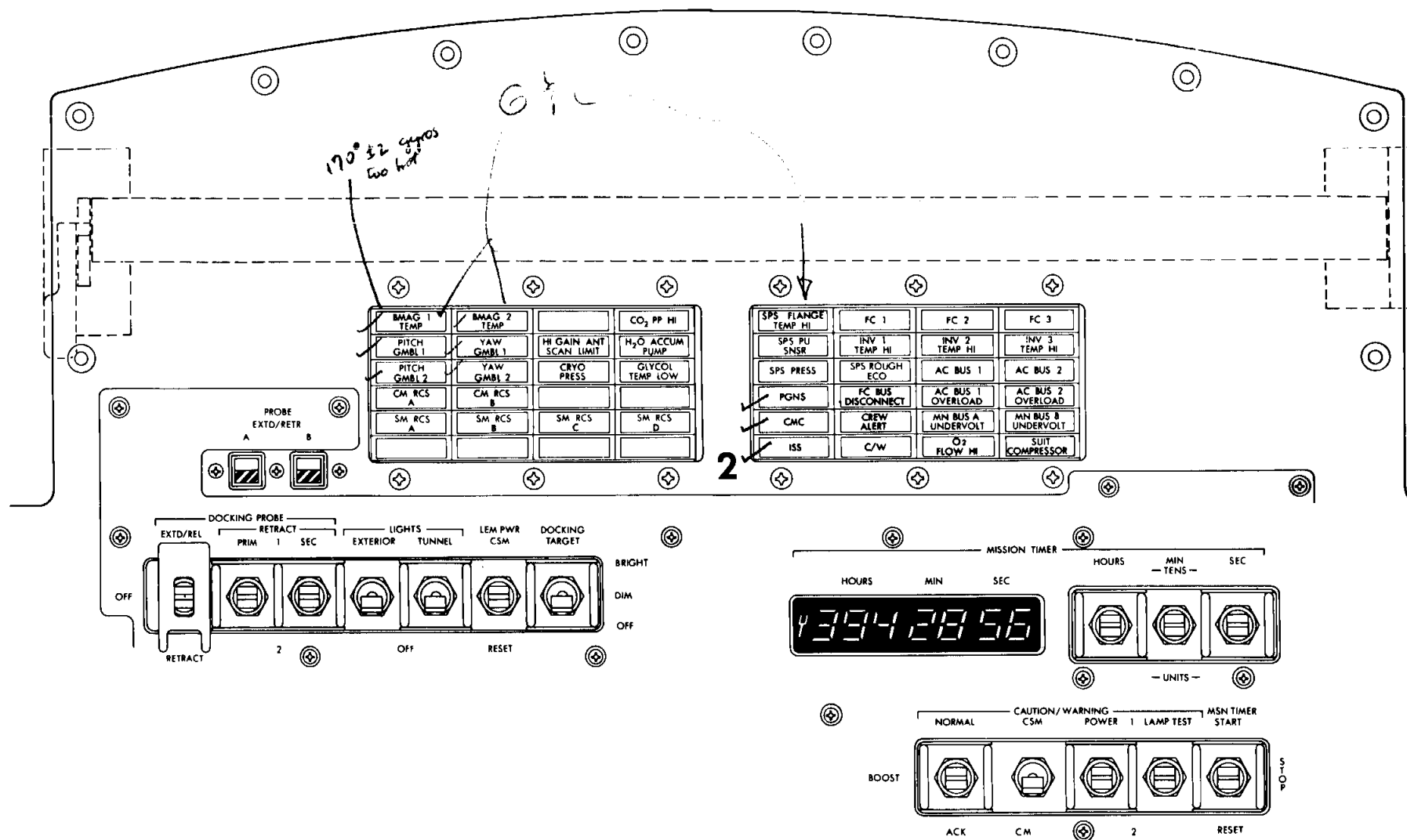


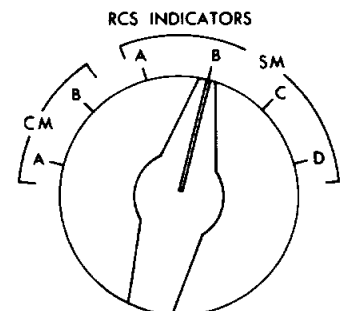
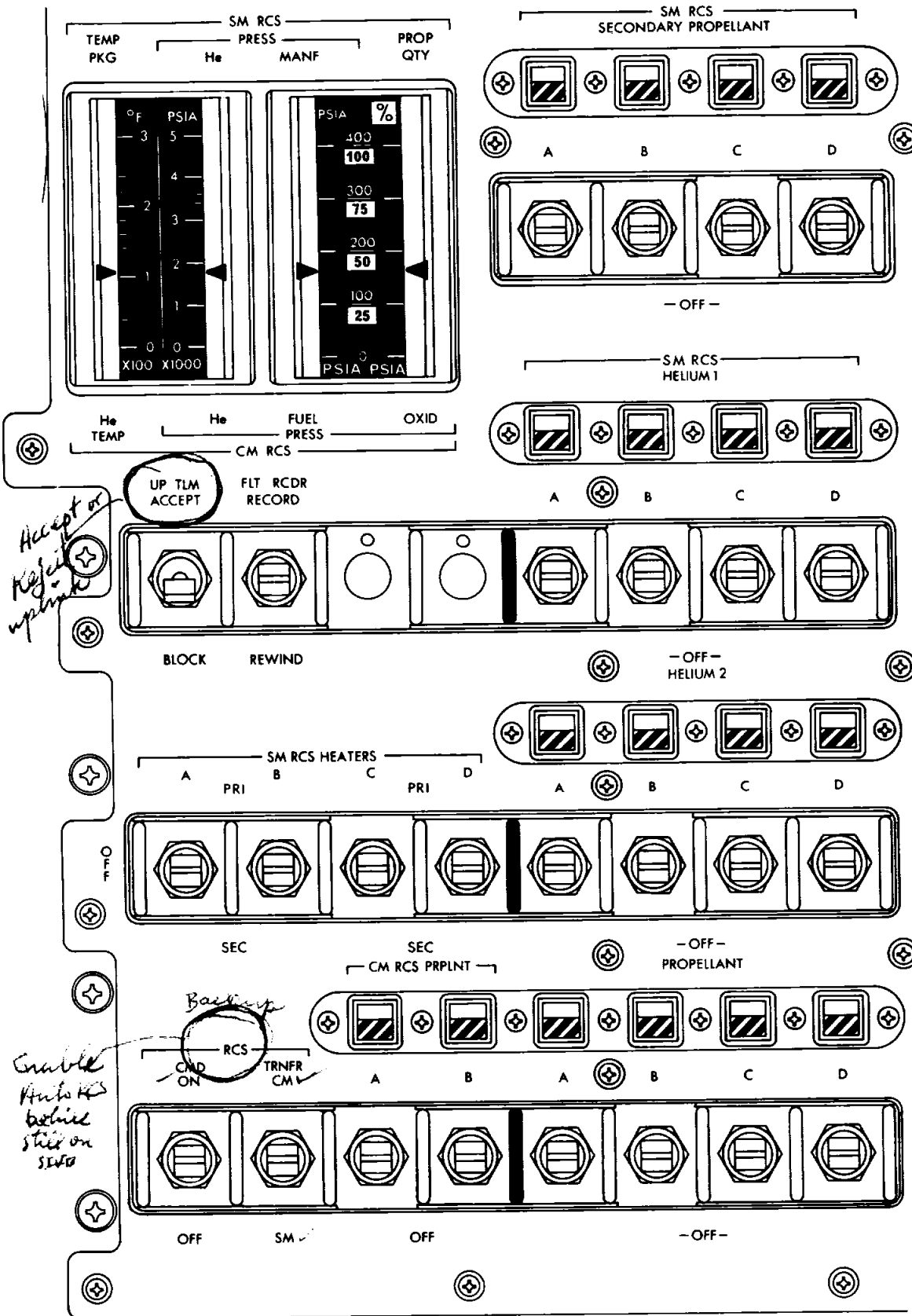
Put into safe up to 7 prior to = IVB 2 min burn  
 ccw translation control is only thing that stops TEL after 7 min

2 could



Caution & Warning Lights

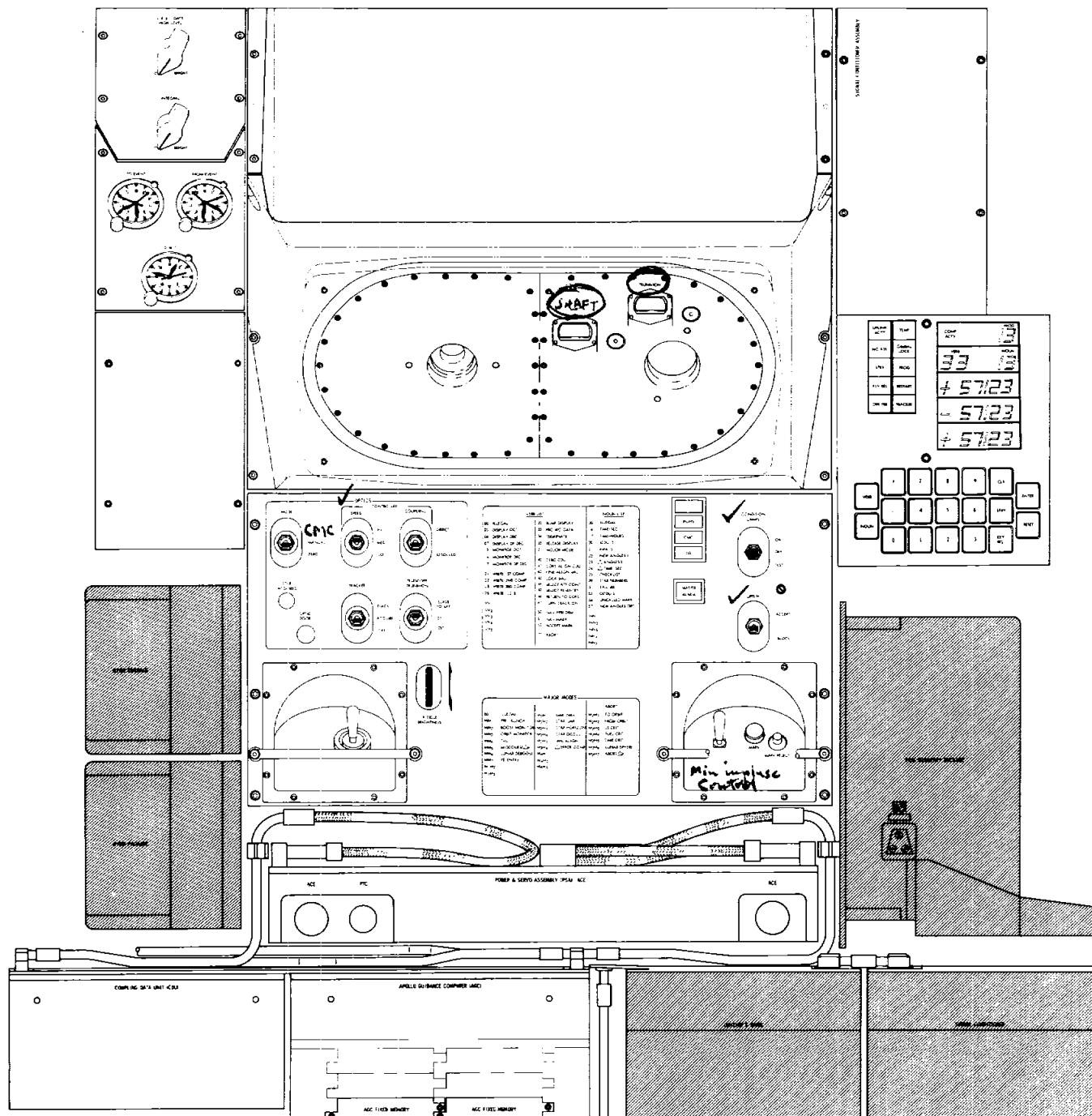




2



## BLOCK II



# G & C ATTITUDE REFERENCE

① Total Attitude Displays

IMU

GDC - Roll  
Entry

② Att. Error

CDUs

Gyro Ass. 1

Source  
IMU / Att. Set Control  
GDC / Att. Set Disb.

③ Att. Rates

GYRO  
DISPLAY  
COUPLER

S/C ANGULAR  
RATES

GYRO  
ASSEMBLY  
NO. 2

GYRO  
ASSEMBLY  
NO. 1

ATTITUDE CHANGES

Iner Ref Frame - Euler Angle?

INERTIAL  
MEASUREMENT  
UNIT

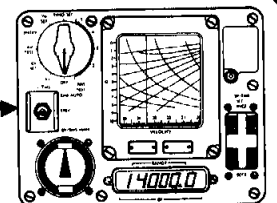
ATTITUDE  
SET

IMU TOTAL ATTITUDE

GDC-TOTAL ATTITUDE

ATTITUDE ERROR

ROLL  
ATTITUDE

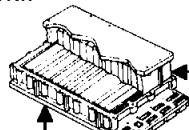


ENTRY MONITOR SUBSYSTEM

DISPLAY ANGULAR  
RATES

BMAG ATTITUDE  
ERRORS

COUPLING  
DATA  
UNIT



ATTITUDE  
ERROR

ANGULAR VELOCITY

ATTITUDE ERROR

TOTAL ATTITUDE

ELECTRONIC  
DISPLAY  
ASSEMBLY

TOTAL ATTITUDE

ATTITUDE ERROR

ANGULAR VELOCITY

CONFIGURATION  
LOGIC TO ASSEMBLIES

ROTATION  
CONTROL

MAIN  
DISPLAY  
CONSOLE

COMMAND  
MODULE  
COMPUTER

DISPLAY  
KEYBOARD

FLIGHT DIRECTOR  
ATTITUDE INDICATOR  
NO. 2

FLIGHT DIRECTOR  
ATTITUDE INDICATOR  
NO. 1

Not normally uncaged - Only for SCS att. control

SCS-3001B

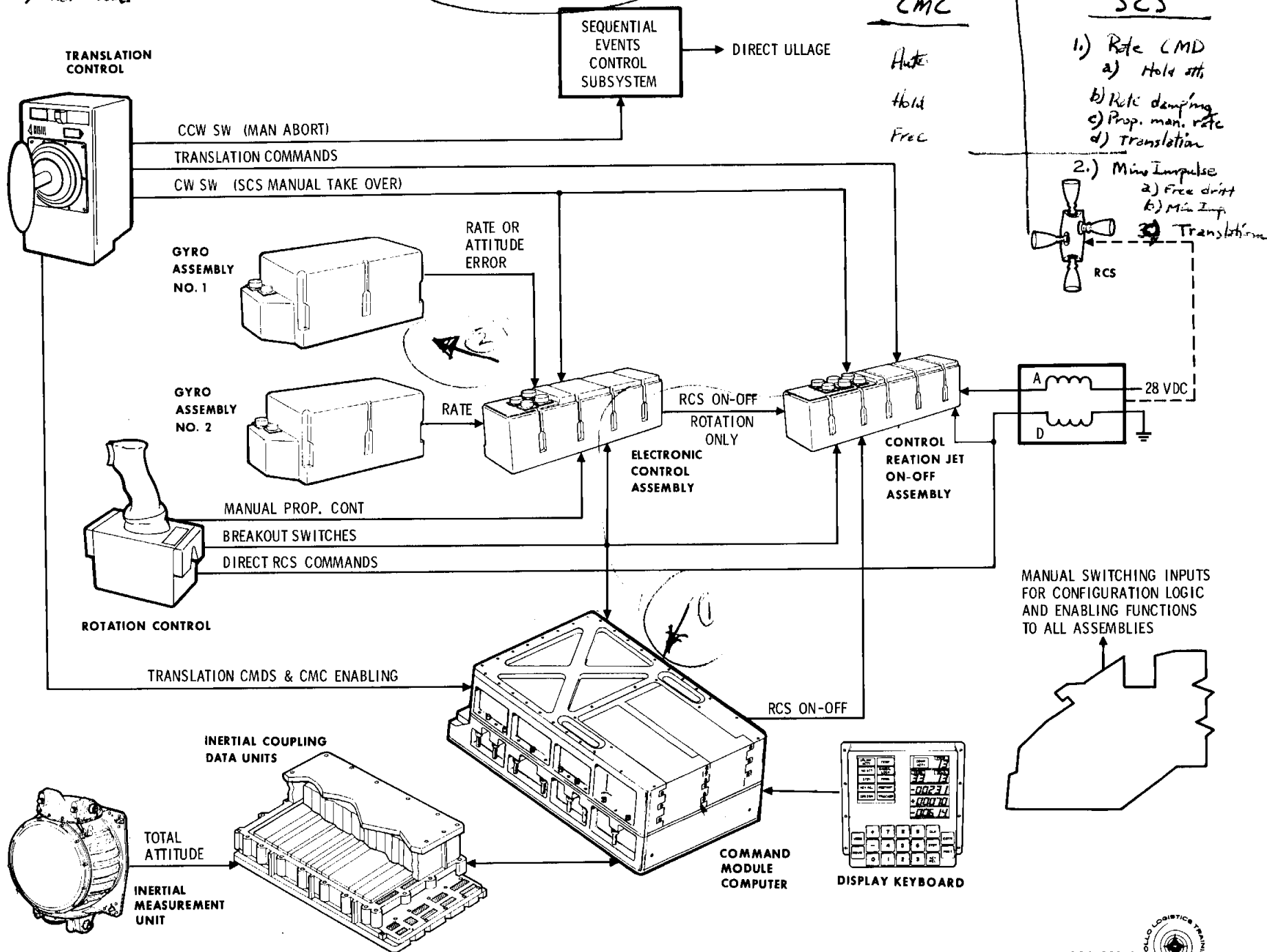


- 3.) Accel. Cmd.  
a) free drift  
b) Rot. accel.

# G&C ATTITUDE CONTROL

CMC

SCS



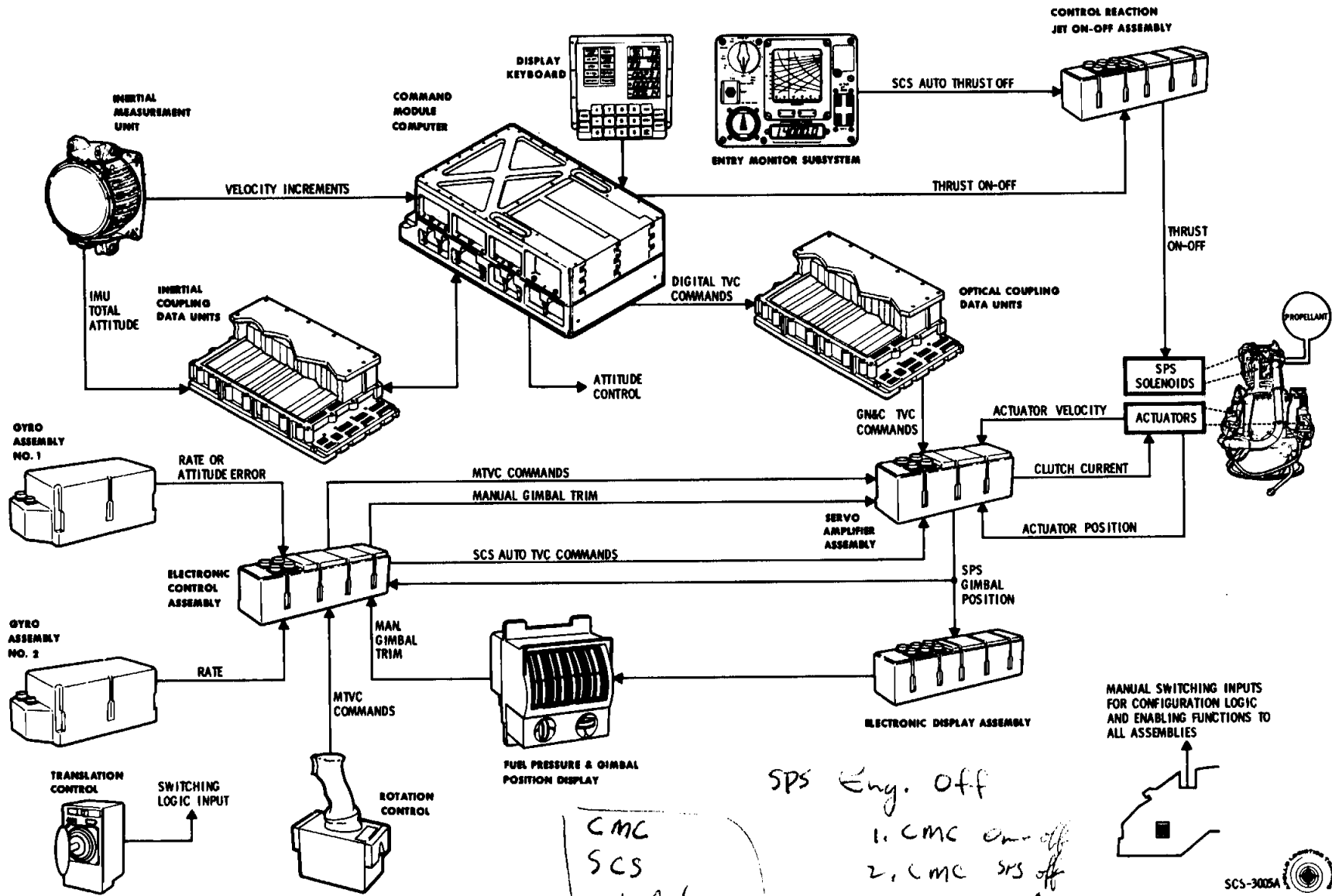
SCS-3006A



TVC  
 Actuator (eng. thrn)  
 SPS on-off

See Panel (1)  
 Display

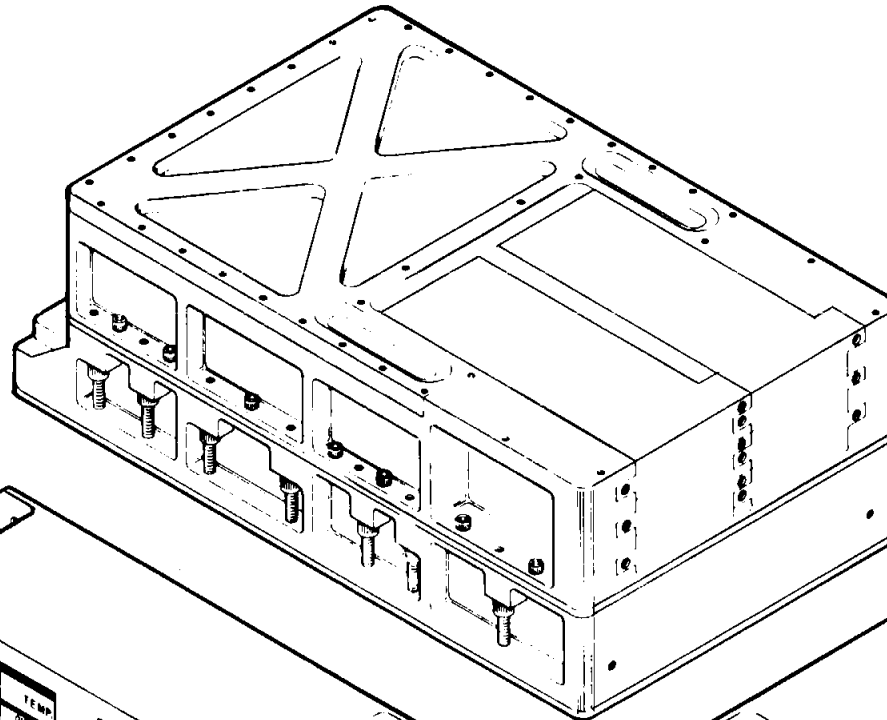
# G & C THRUST VECTOR CONTROL



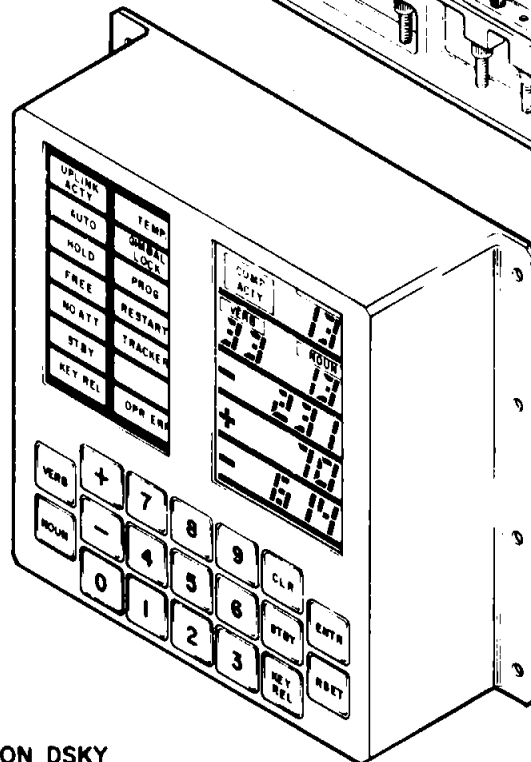
CMC  
 SCS  
 1. Auto  
 2. Rate Cmd  
 3. Heel. Cmd

SPS Eng. Off  
 1. CMC on-off  
 2. CMC SPS off  
 3. SPS on-off  
 4. Direction off

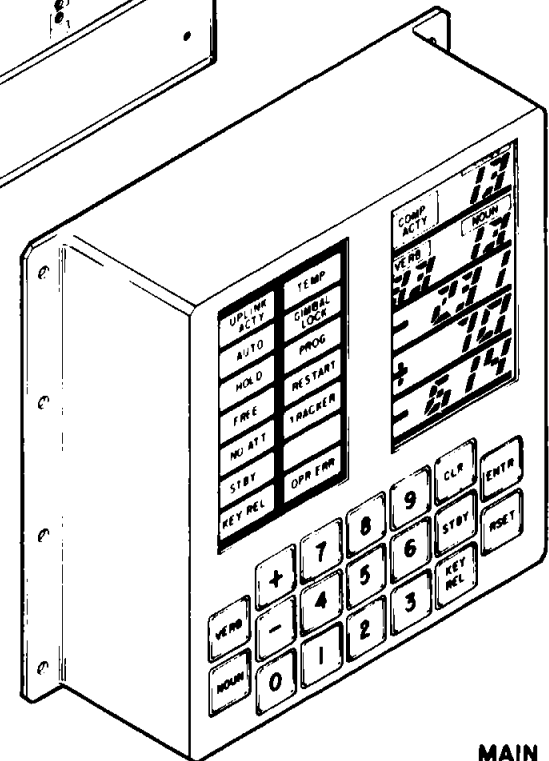
# CSS EQUIPMENT



COMMAND  
MODULE  
COMPUTER

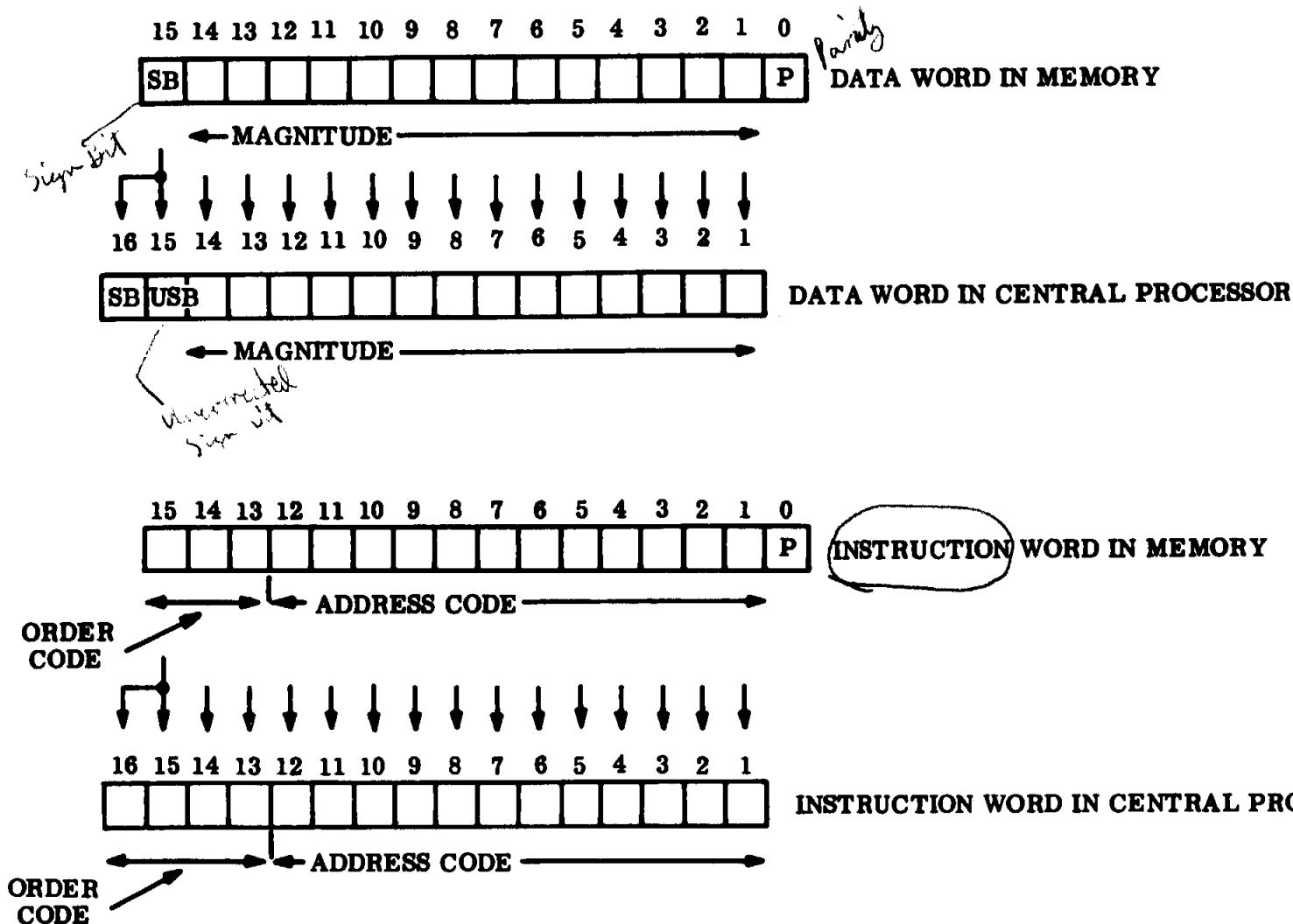


NAVIGATION DSKY



MAIN DSKY

# WORD FORMATS IN MEMORY AND CENTRAL PROCESSOR



$$101 = 5$$

$$1 = 1$$

$$10 = 2$$

$$11 = 3$$

$$100 = 4$$

$$101 = 5$$

$$110 = 6$$

$$111 = 7$$

$$1000 = 8$$

$$1001 = 9$$

$$1010 = 10$$

101

010

KNIN

One's complement

9

Enables comp.  
to subtract

7

-5

111

101

comp

sub

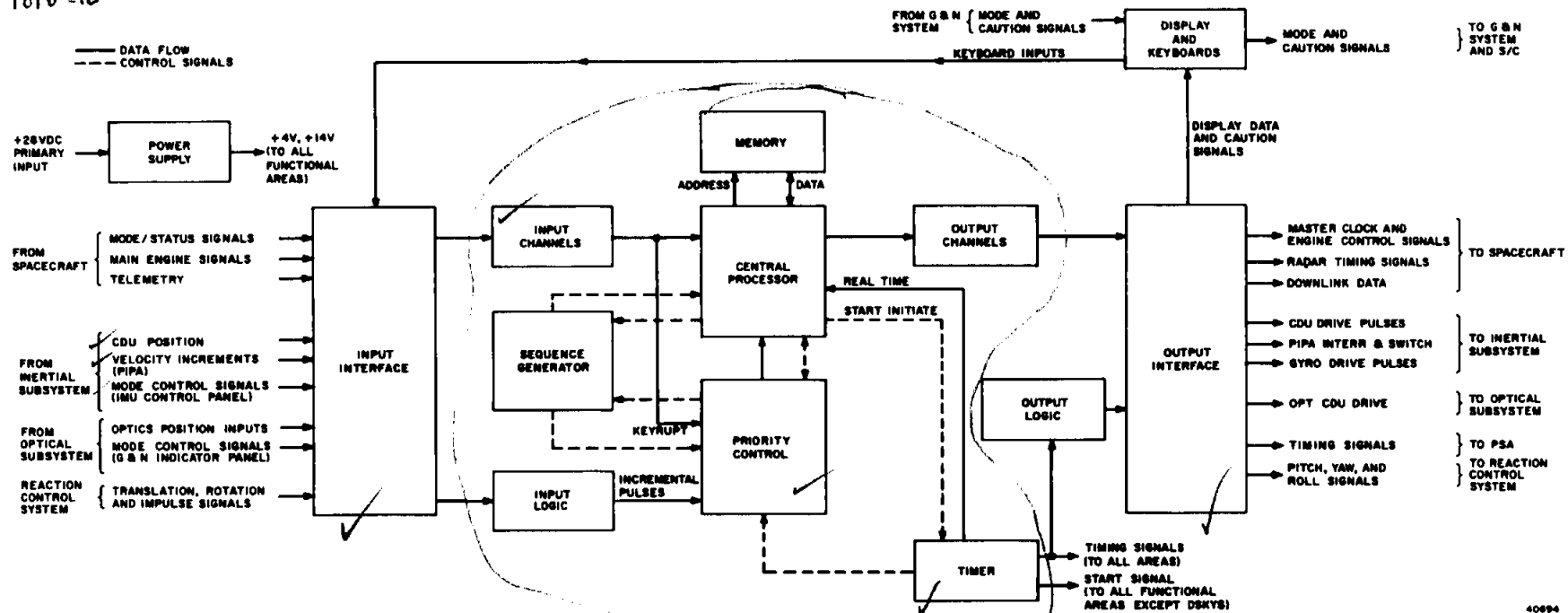
000

010

010 which is = 2.

check

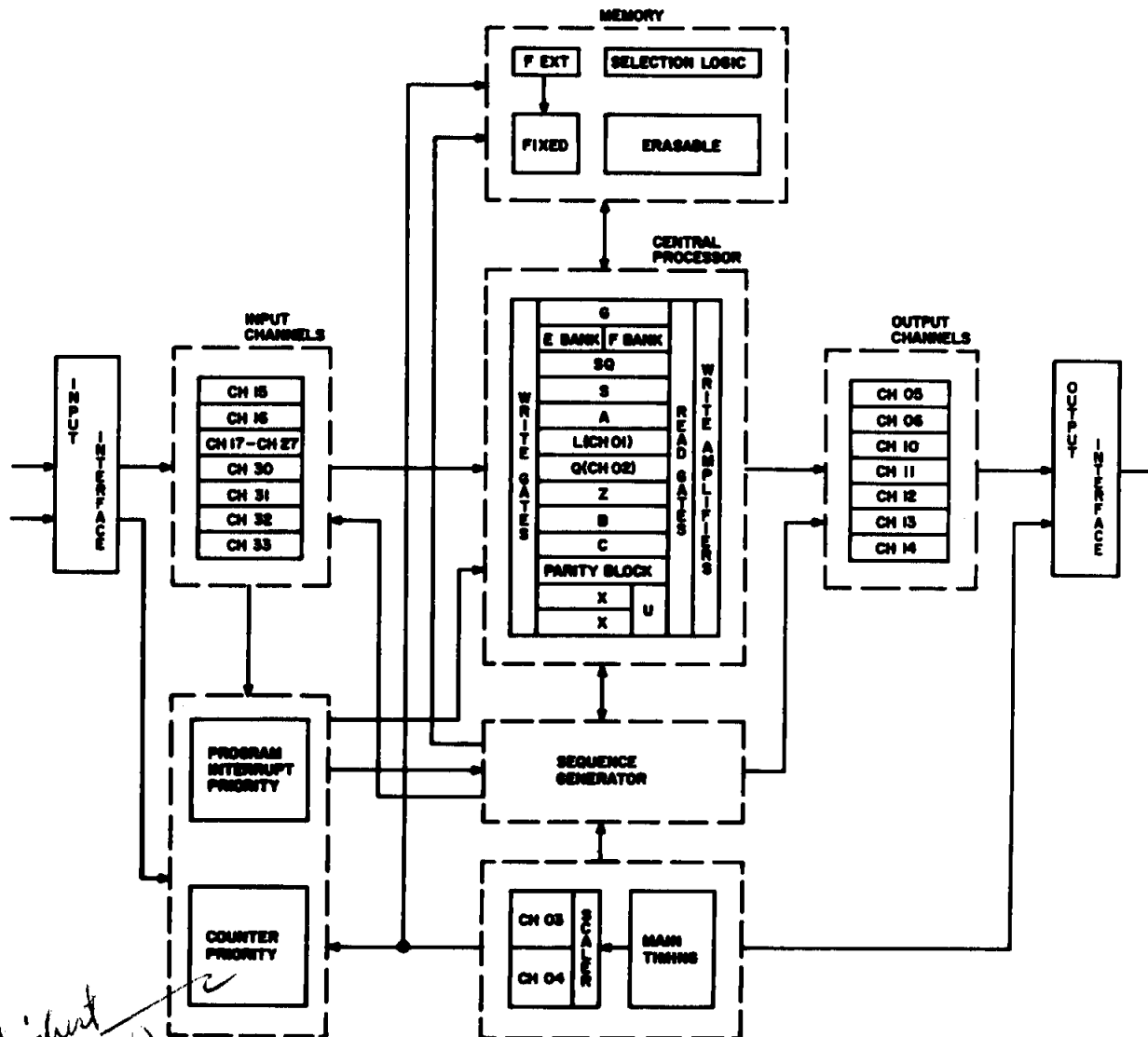
# CSS BASIC FLOW



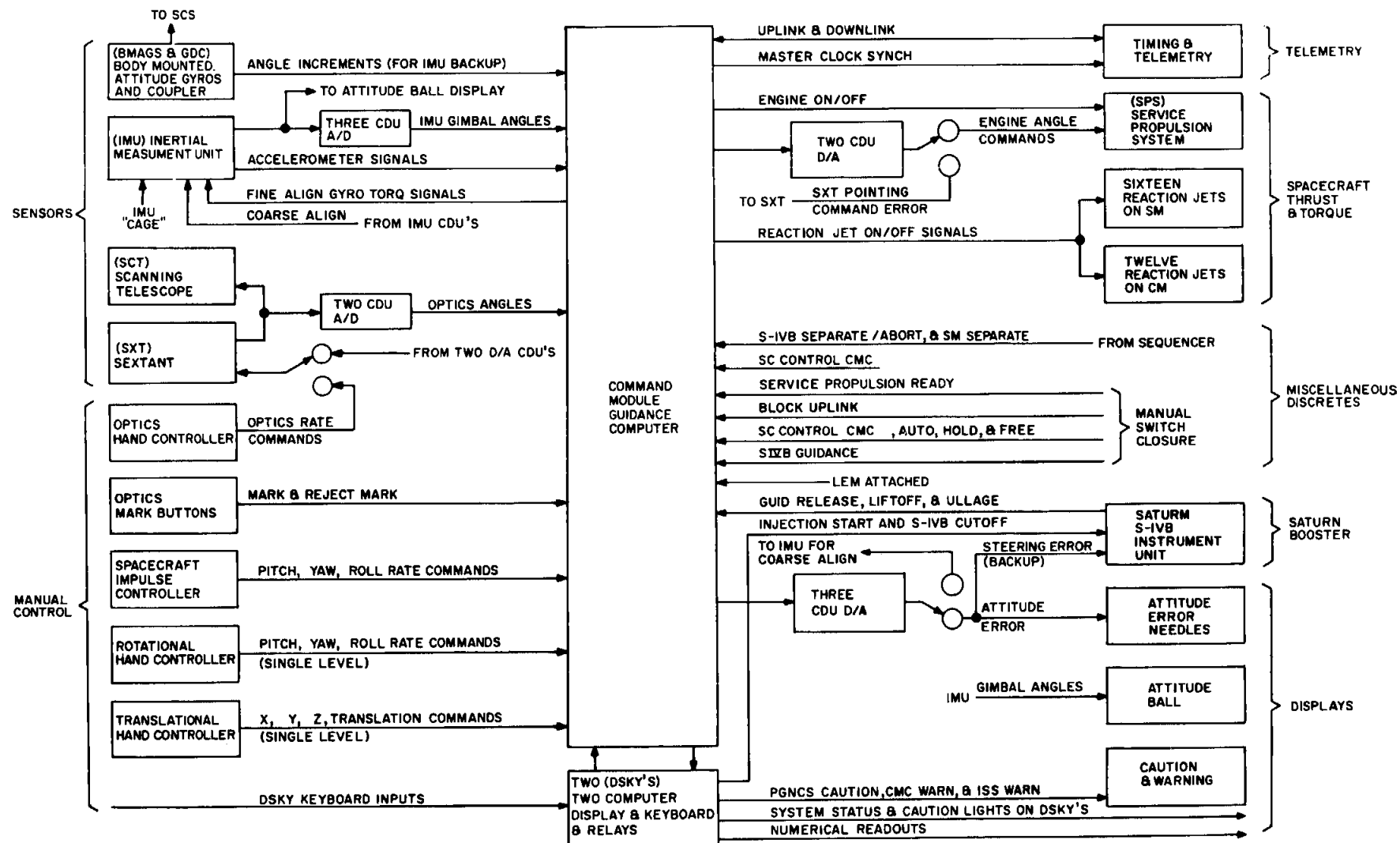
Next page



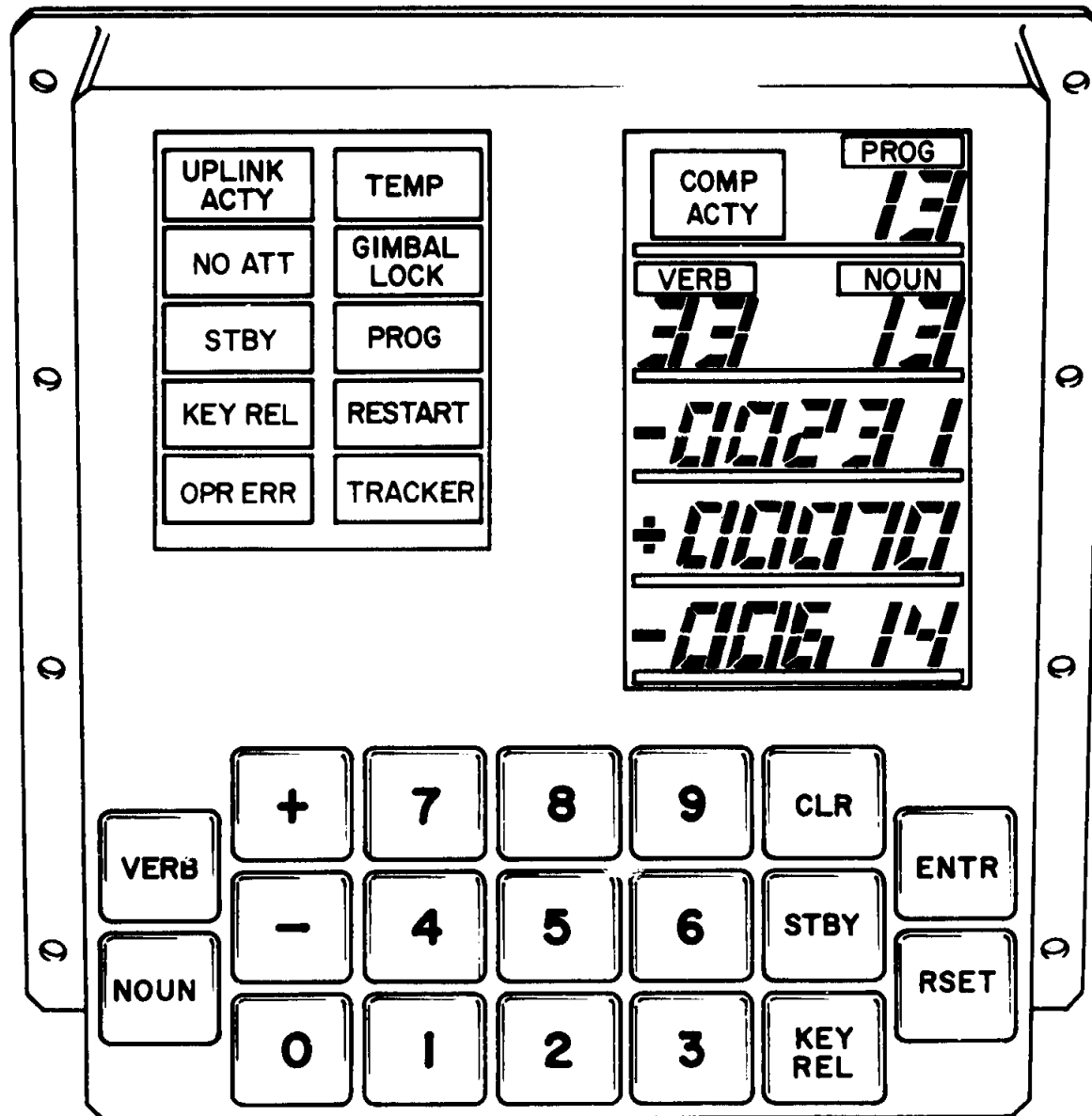
# CSS BASIC FLOW DIAGRAM



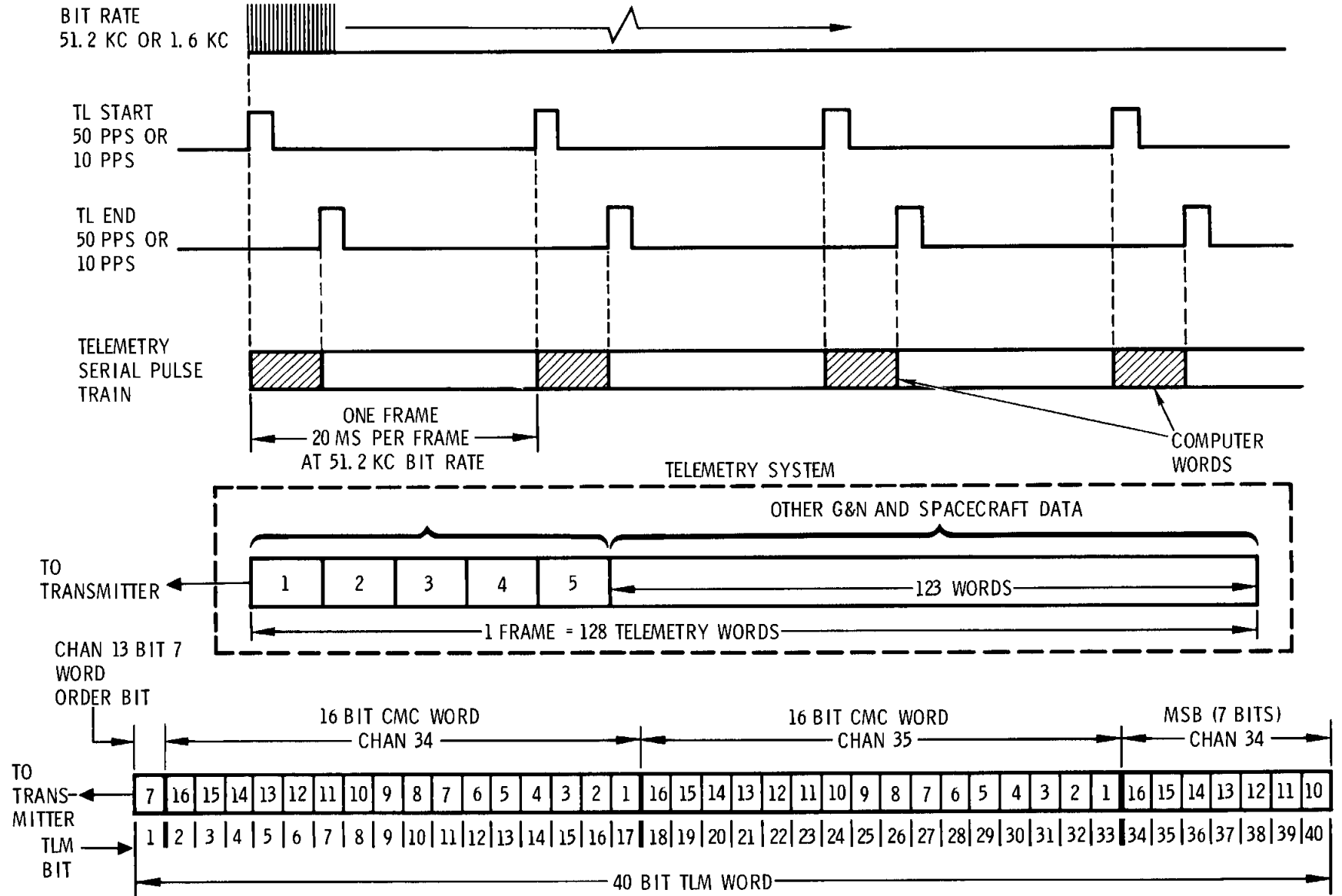
# PGNCS - BLOCK II FUNCTIONAL INTERFACE



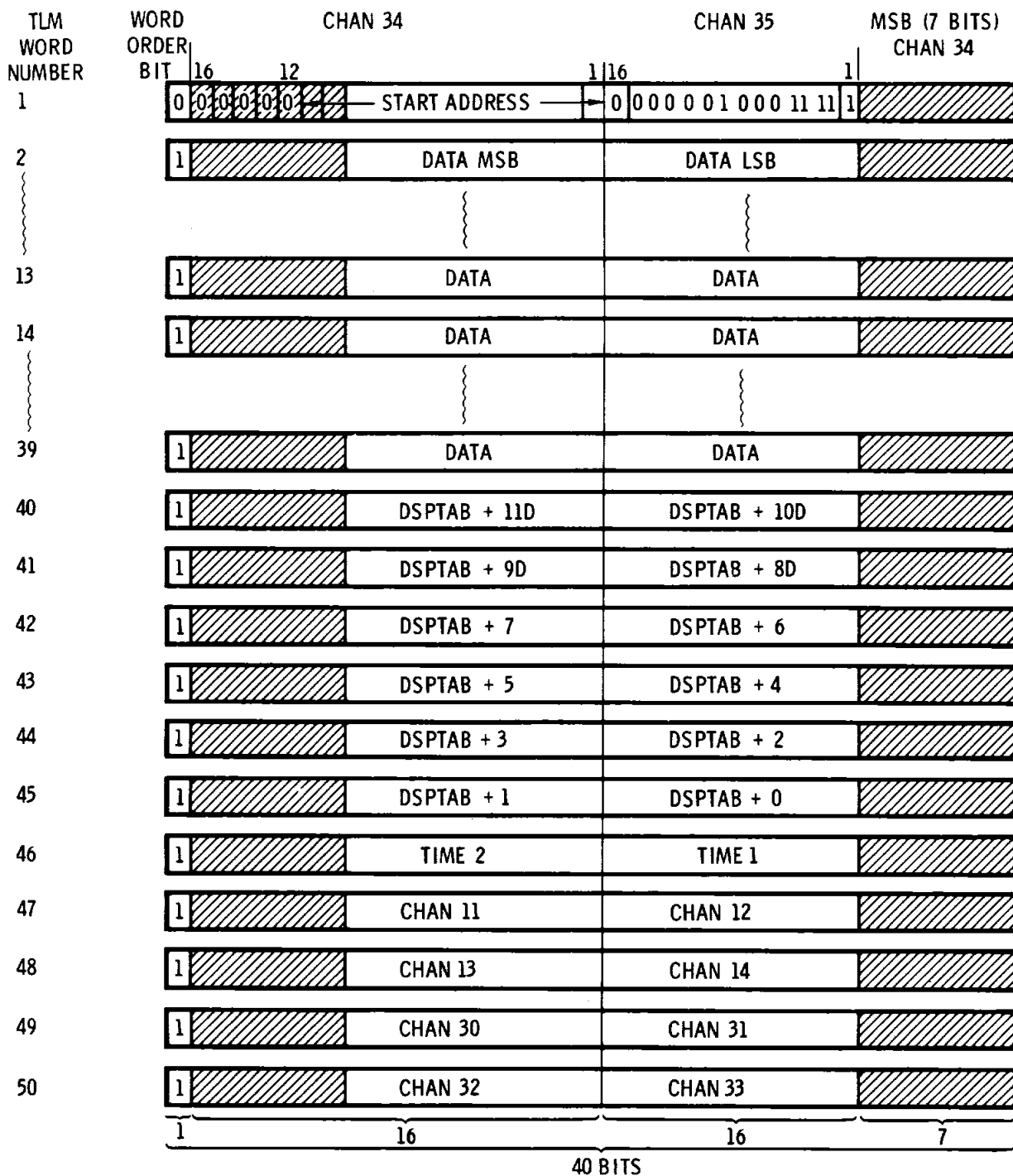
# DISPLAY AND KEYBOARD ( DSKY )



# DWN TLM FORMAT



# 50 WORD DWNTLM LIST



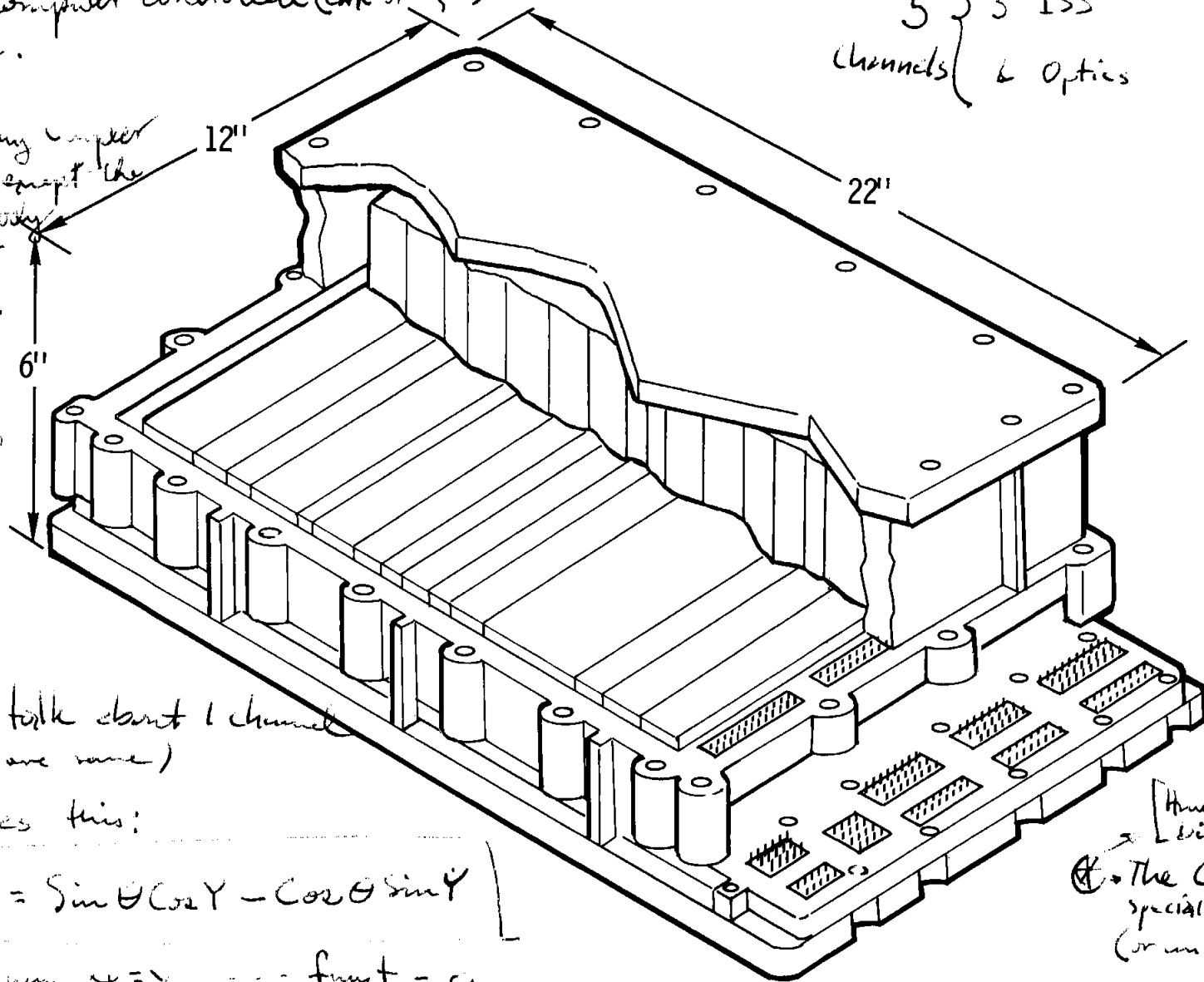
# COUPLING DATA UNIT

Relates s/c attitude to the LMU ret. frame for the computer controlled (can or o/c) operations.

{ Analog to Digital converter  
 { Digital to Analog converter

5 Channels { 3 IDS  
 { 2 Optics

Optic display computer  
 but same except the  
 info. is a video  
 all fixed at  
 the time you  
 initiate the  
 operation. No  
 # goes to  
 CMC



We'll only talk about 1 channel  
 (others are same)

CDU does this:

$$\sin(\theta - \gamma) = \sin \theta \cos \gamma - \cos \theta \sin \gamma$$

where  $\gamma = \gamma$  --- funct = c

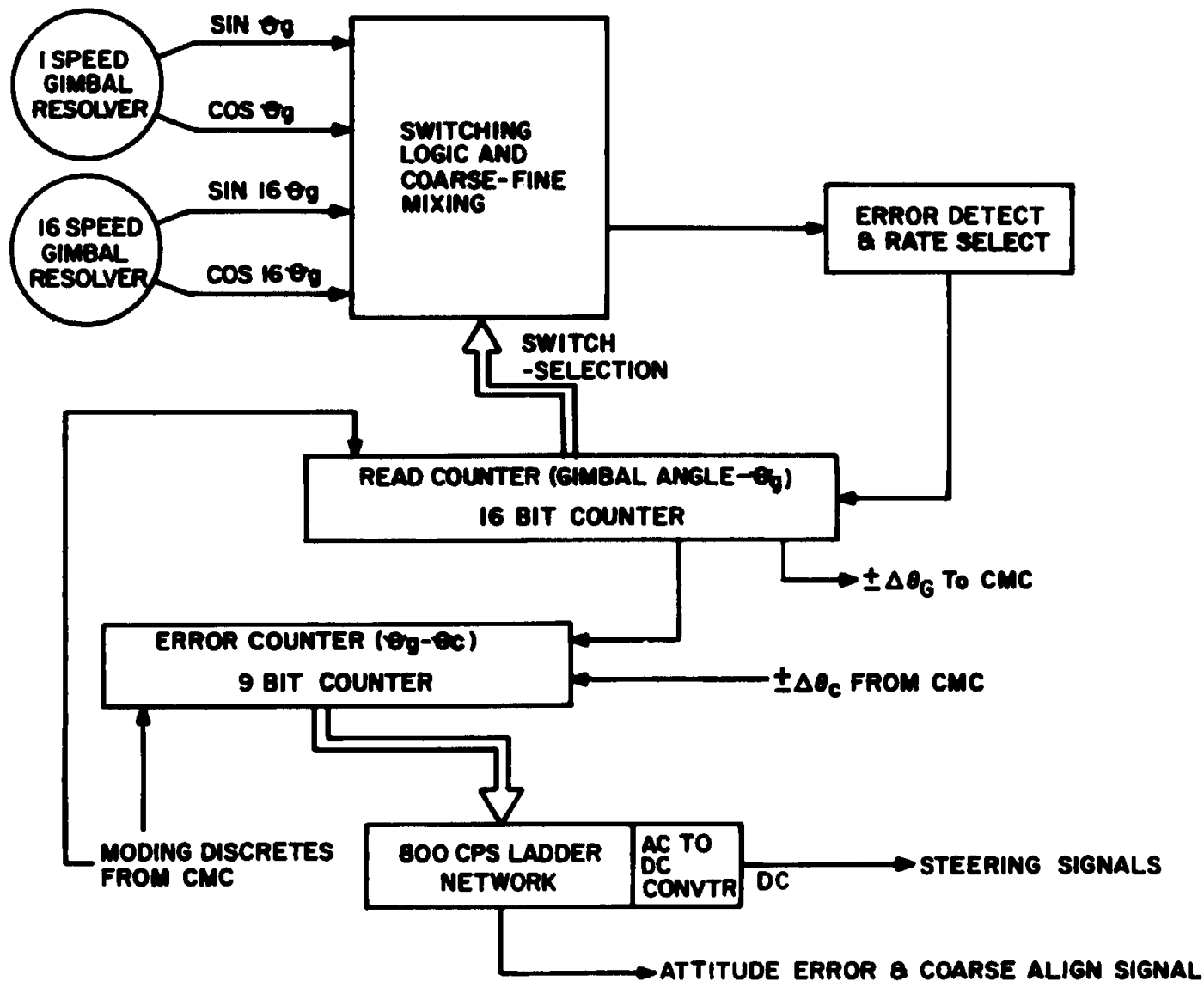
[Analog to Digital]  
 [Digital to Analog]  
 \* The CDU is a  
 special purpose computer  
 (or an extension of the cmc)

GNC-11

CDU



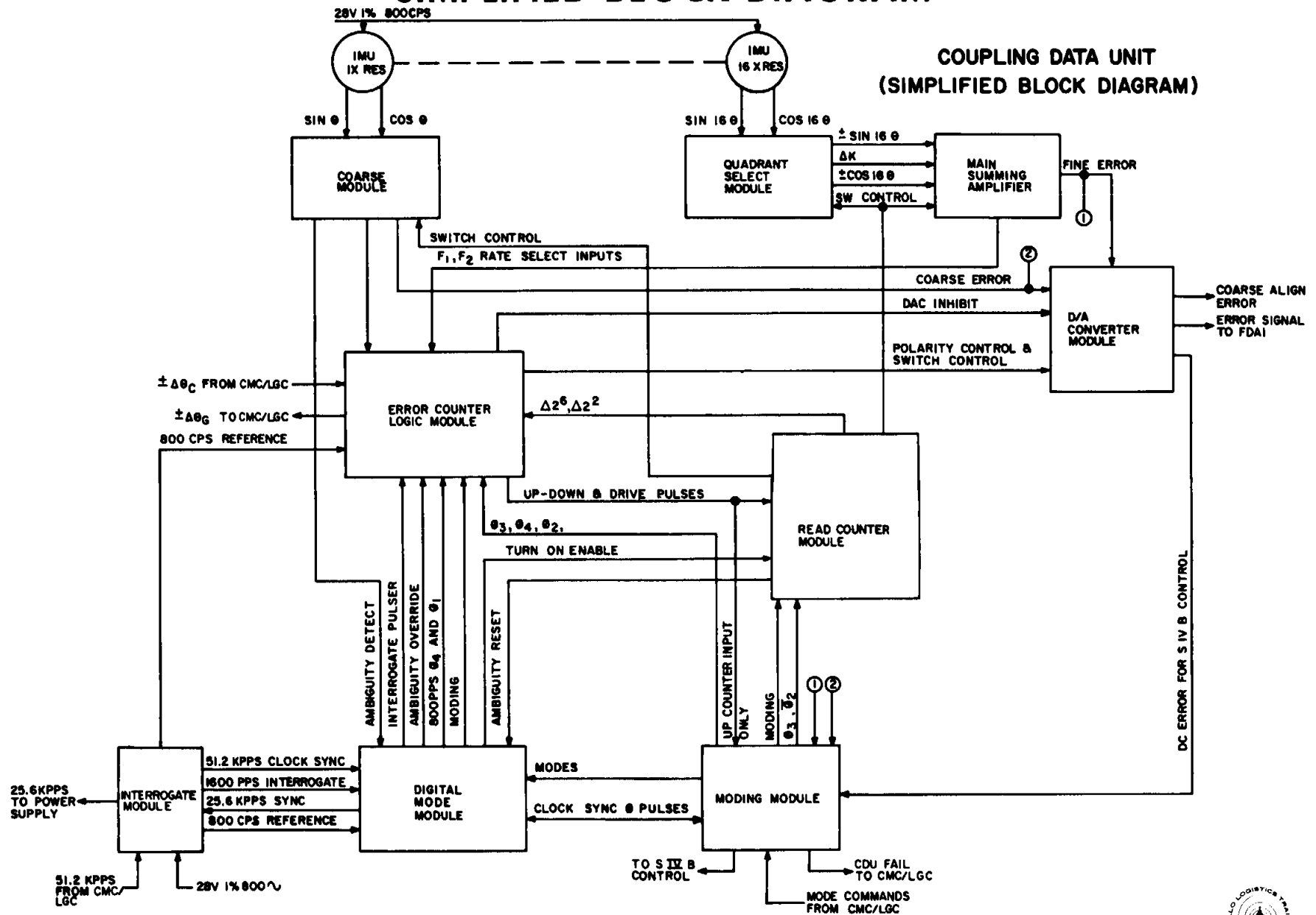
# COUPLING DATA UNIT BLOCK DIAGRAM



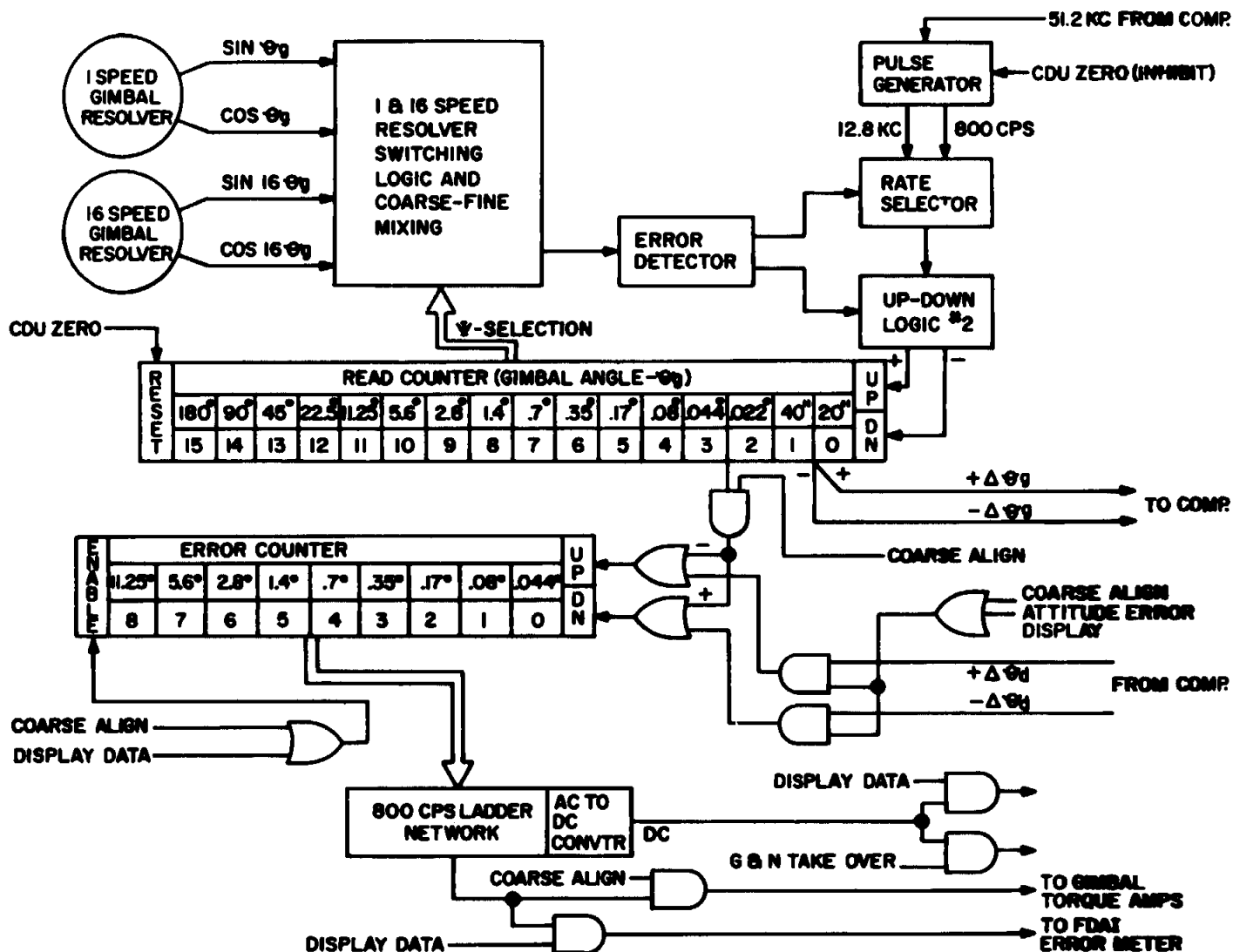
# COUPLING DATA UNIT

## SIMPLIFIED BLOCK DIAGRAM

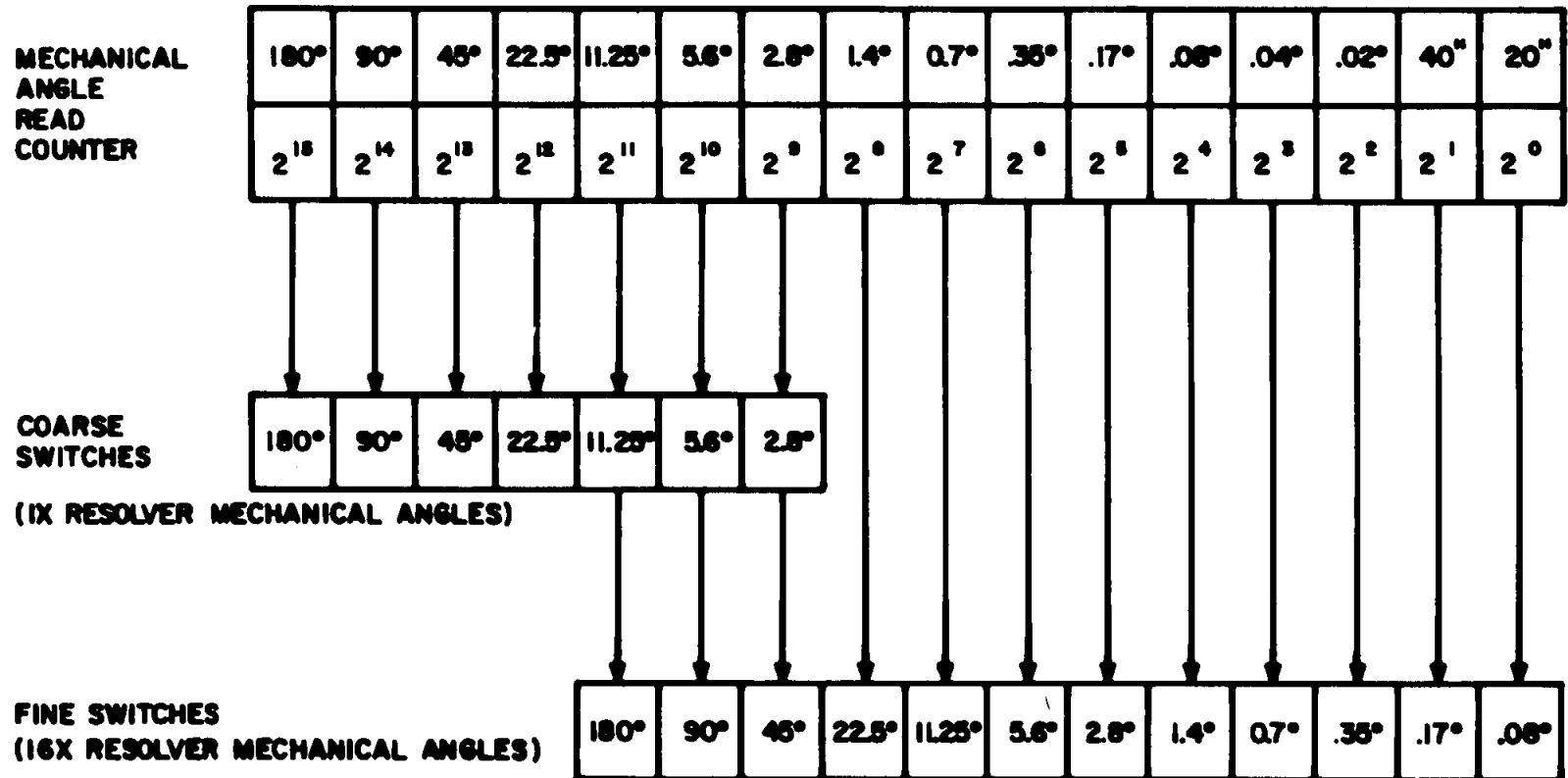
COUPLING DATA UNIT  
(SIMPLIFIED BLOCK DIAGRAM)



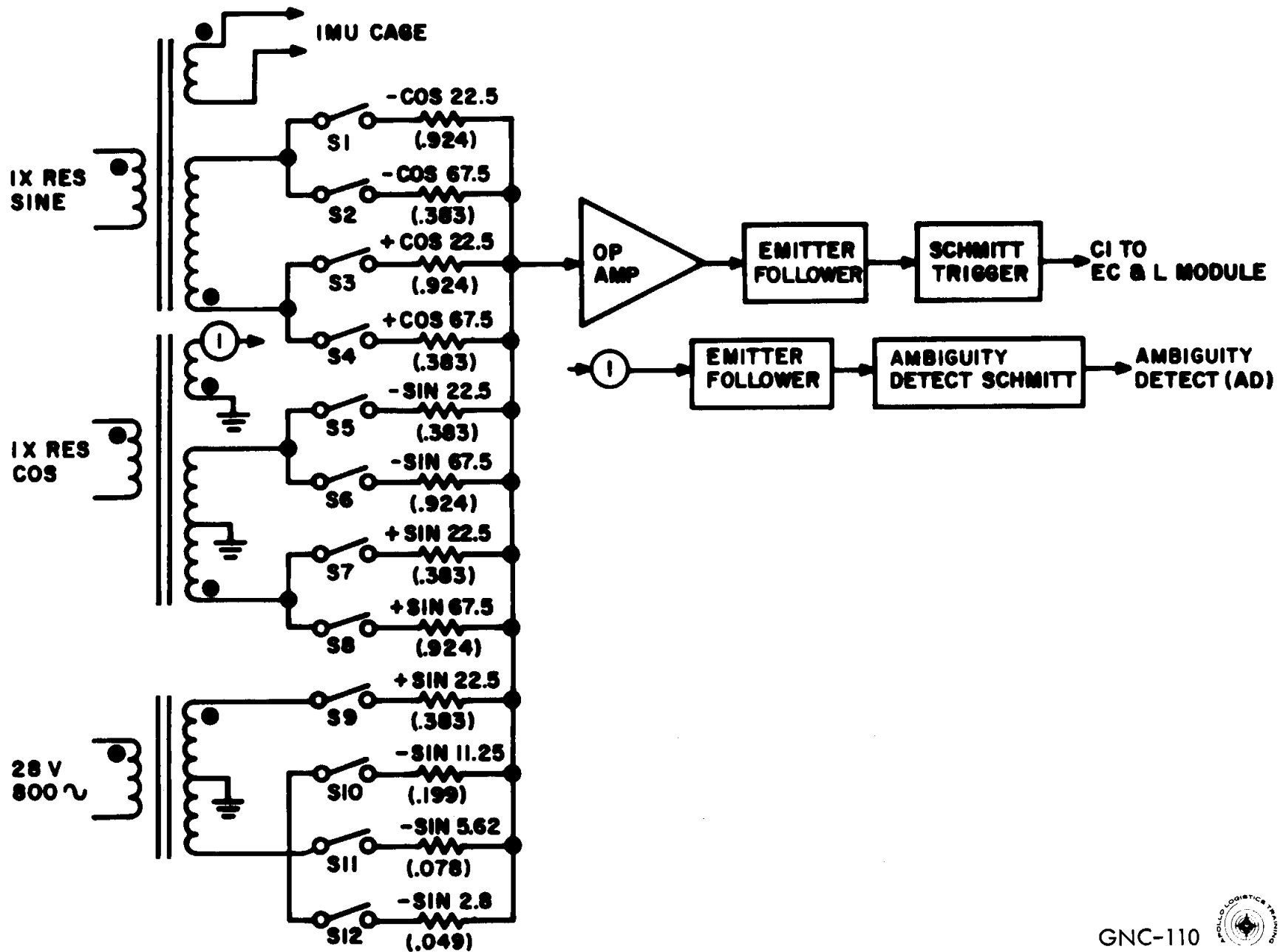
# CDU FUNCTIONAL BLOCK DIAGRAM



# READ COUNTER RELATIONSHIP TO COARSE FINE SWITCHING



# CDU COARSE MODULE BLOCK DIAGRAM



# COARSE SWITCH LOGIC EQUATIONS

$$\text{DC 1} = \overline{2^{15}} 2^{14} 2^{13} + 2^{15} \overline{2^{14}} \overline{2^{13}}$$

$$\text{DC 2} = \overline{2^{15}} 2^{14} \overline{2^{13}} + 2^{15} \overline{2^{14}} 2^{13}$$

$$\text{DC 3} = 2^{15} 2^{14} 2^{13} + \overline{2^{15}} \overline{2^{14}} \overline{2^{13}}$$

$$\text{DC 4} = \overline{2^{15}} \overline{2^{14}} 2^{13} + 2^{15} 2^{14} \overline{2^{13}}$$

$$\text{DC 5} = \overline{2^{15}} (2^{14} 2^{13} + \overline{2^{14}} \overline{2^{13}})$$

$$\text{DC 6} = 2^{15} (\overline{2^{14}} 2^{13} + 2^{14} \overline{2^{13}})$$

$$\text{DC 7} = 2^{15} (2^{14} 2^{13} + \overline{2^{14}} \overline{2^{13}})$$

$$\text{DC 8} = 2^{15} (\overline{2^{14}} 2^{13} + 2^{14} \overline{2^{13}})$$

$$\text{DC 9} = \overline{2^{12}}$$

$$\text{DC 10} = 2^{11}$$

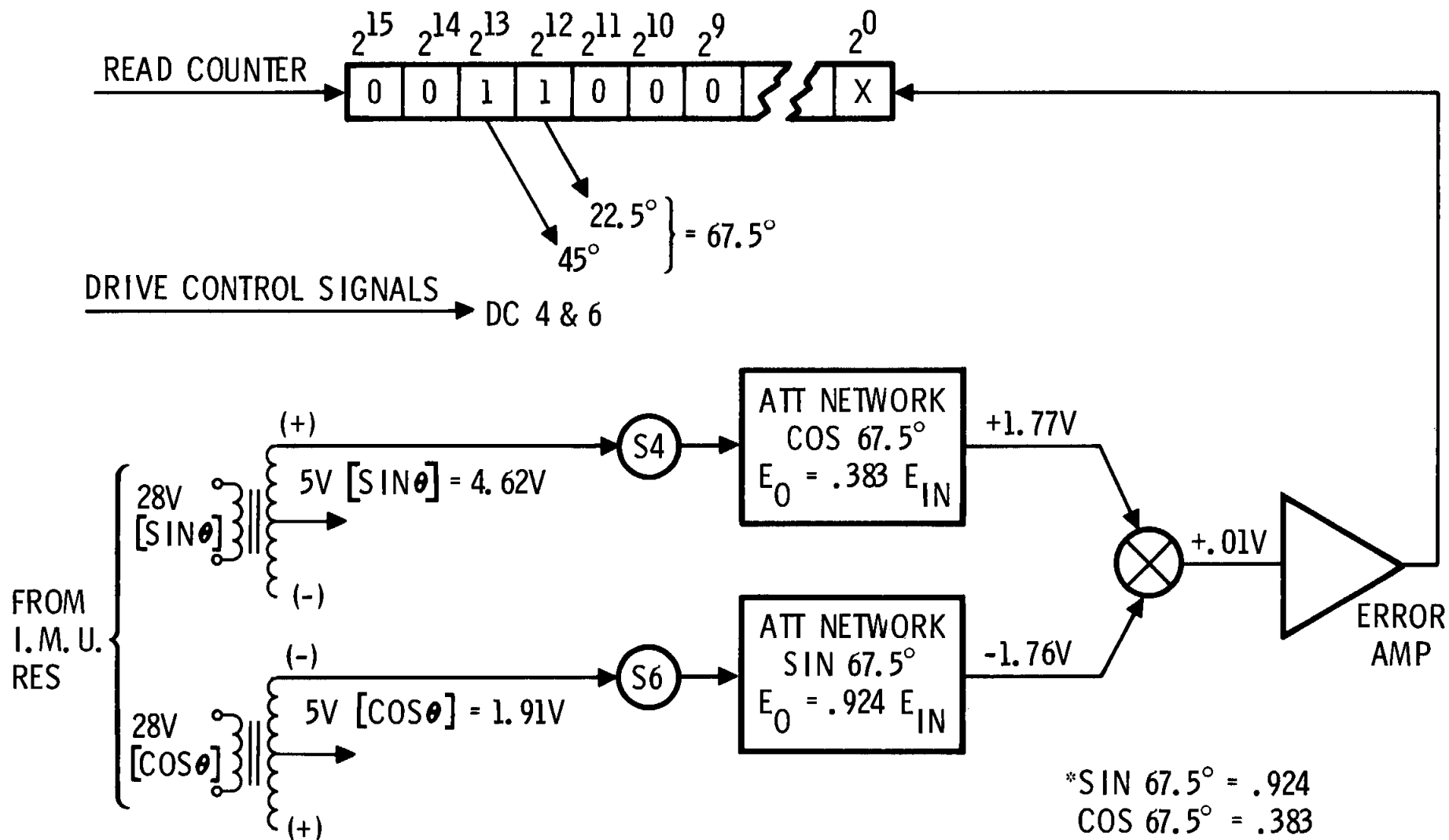
$$\text{DC 11} = 2^{10}$$

$$\text{DC 12} = 2^9$$

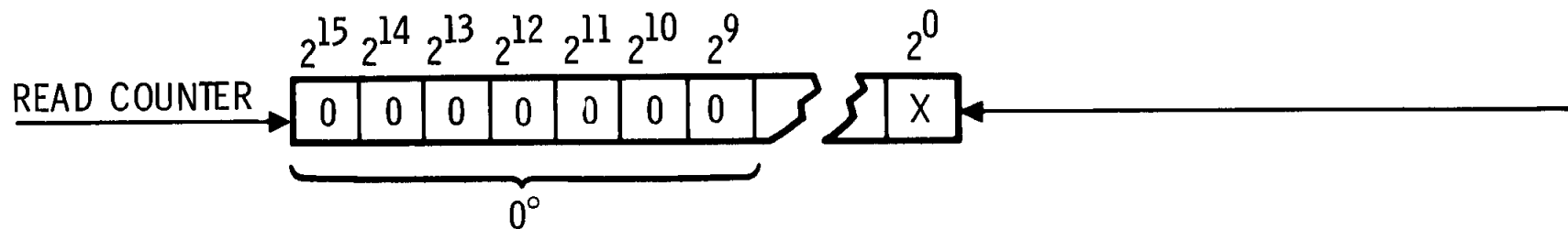
\*  $2^N$  = "N" REFERS TO BIT IN  
THE READ COUNTER

\* DC "X" CLOSES SWITCH "X"

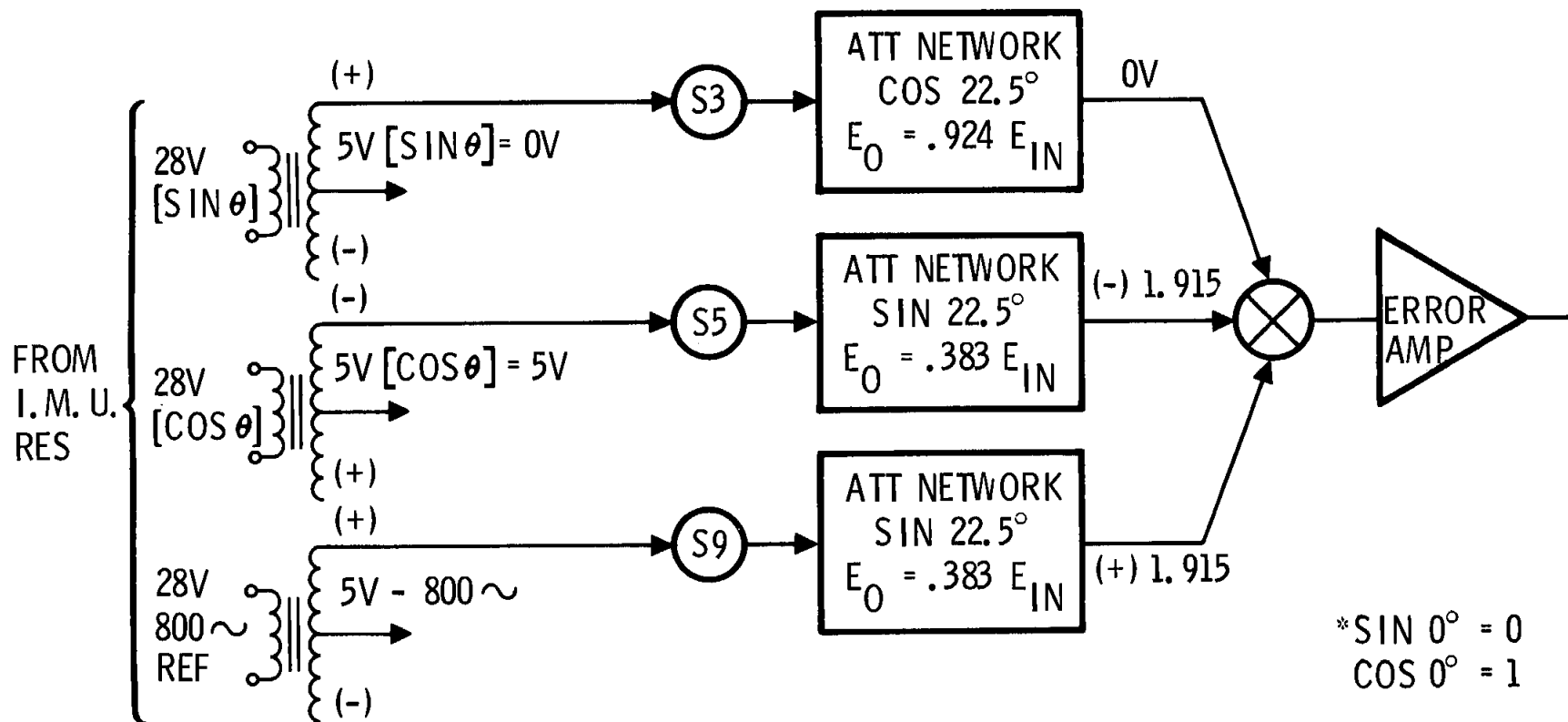
$$\theta = 67.5$$



$$\theta = 0^\circ$$



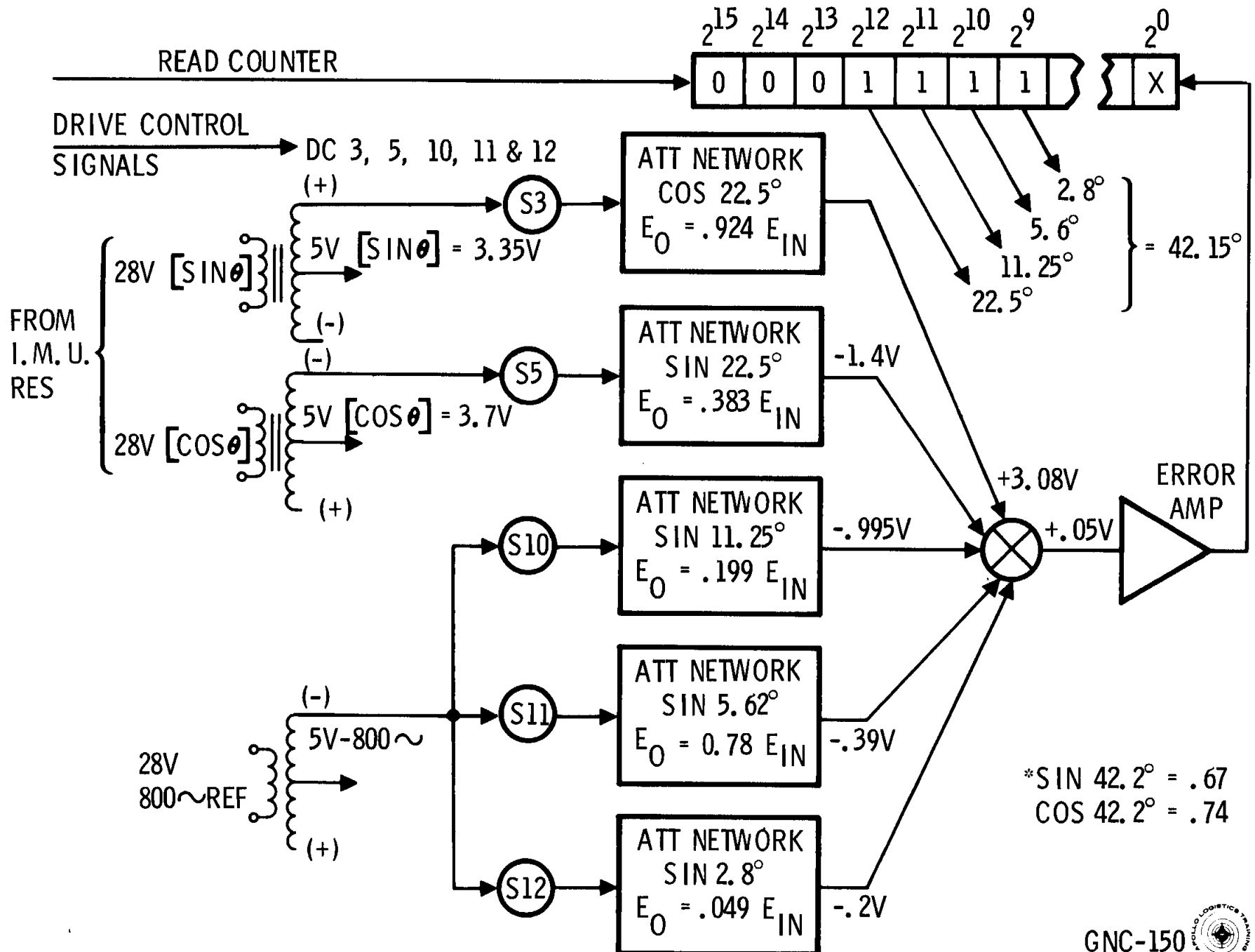
DRIVE CONTROL SIGNALS → DC 3, 5 & 9



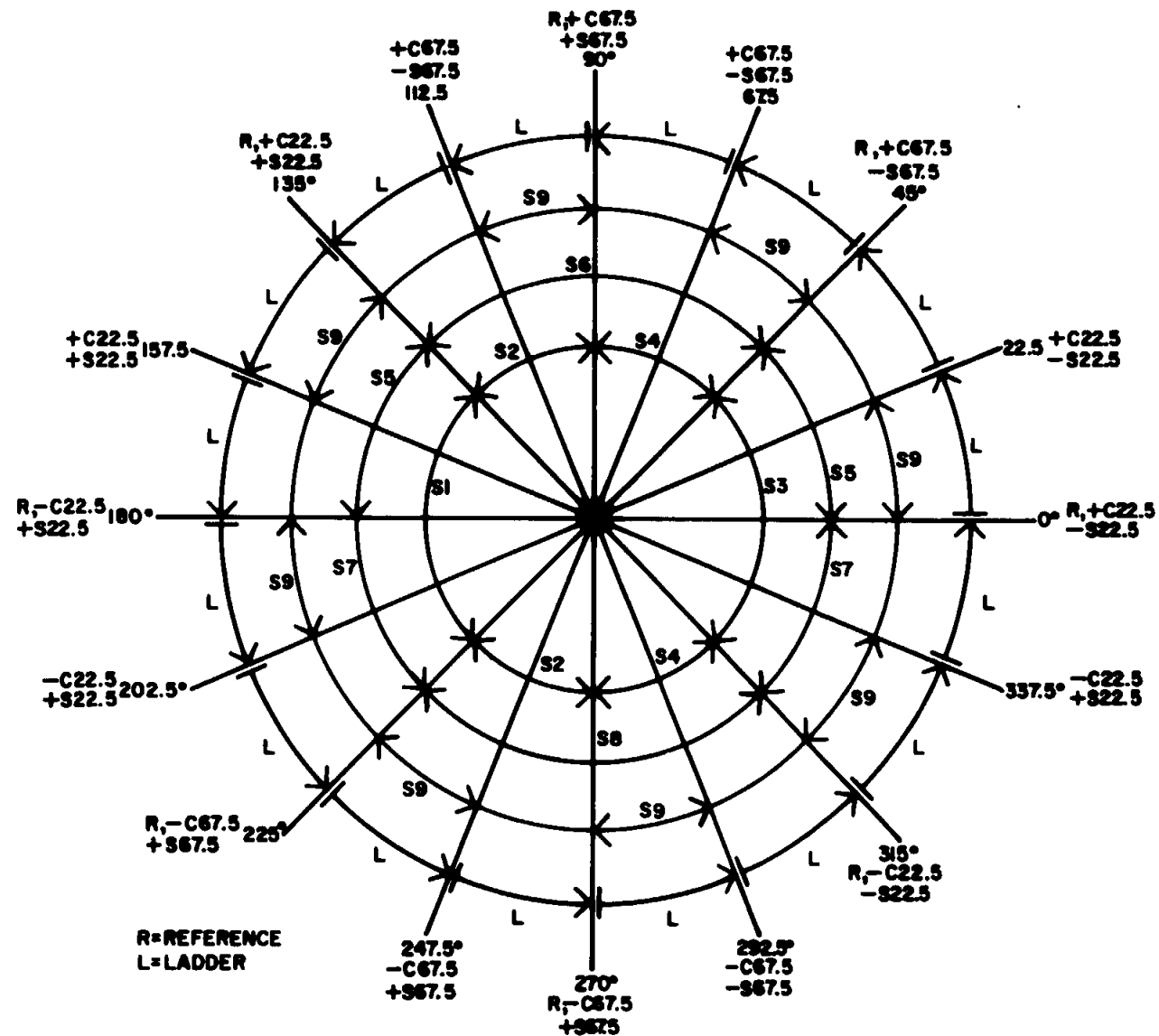
\* SIN  $0^\circ = 0$   
 COS  $0^\circ = 1$

C/U

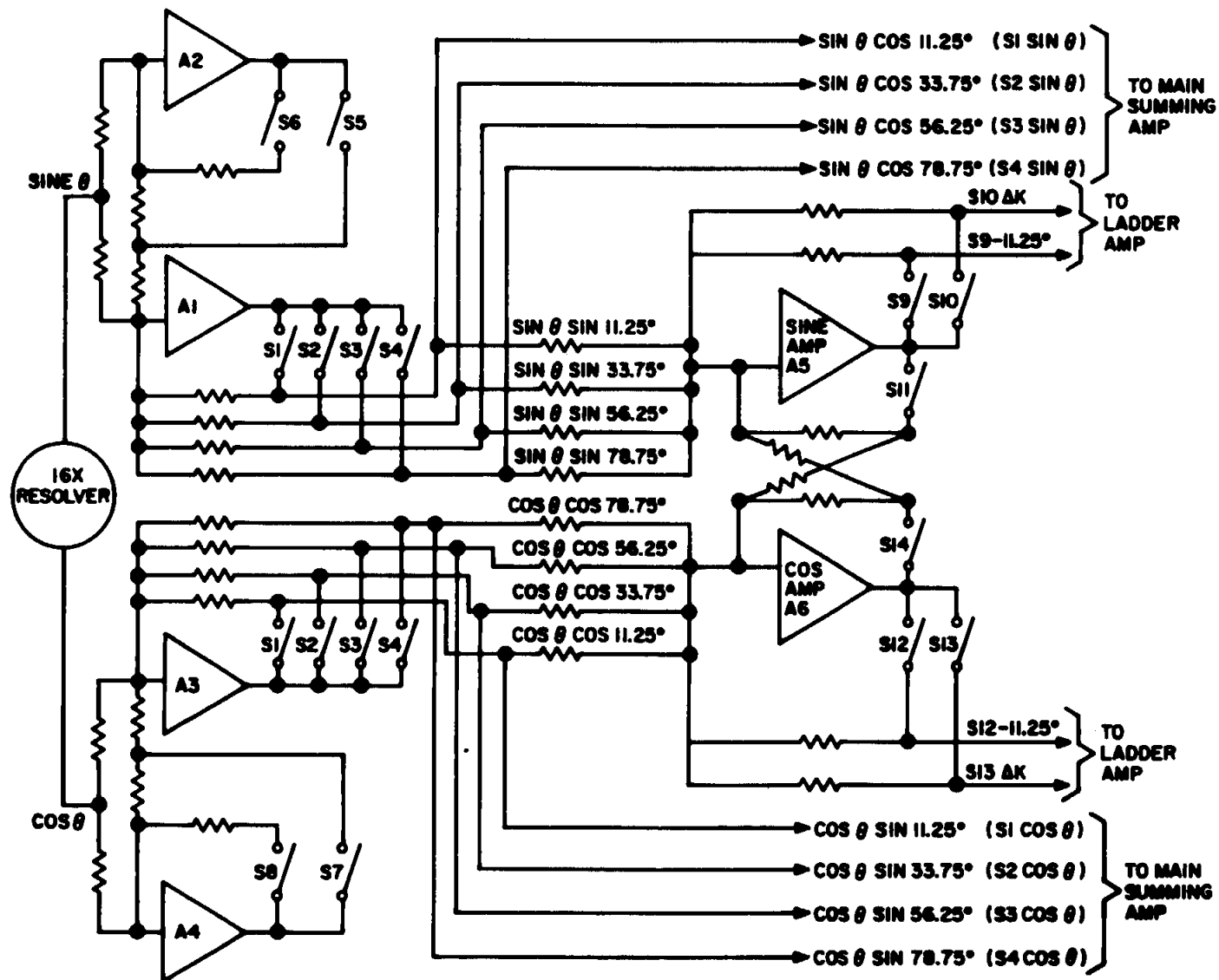
$$\theta = 42.2^\circ$$



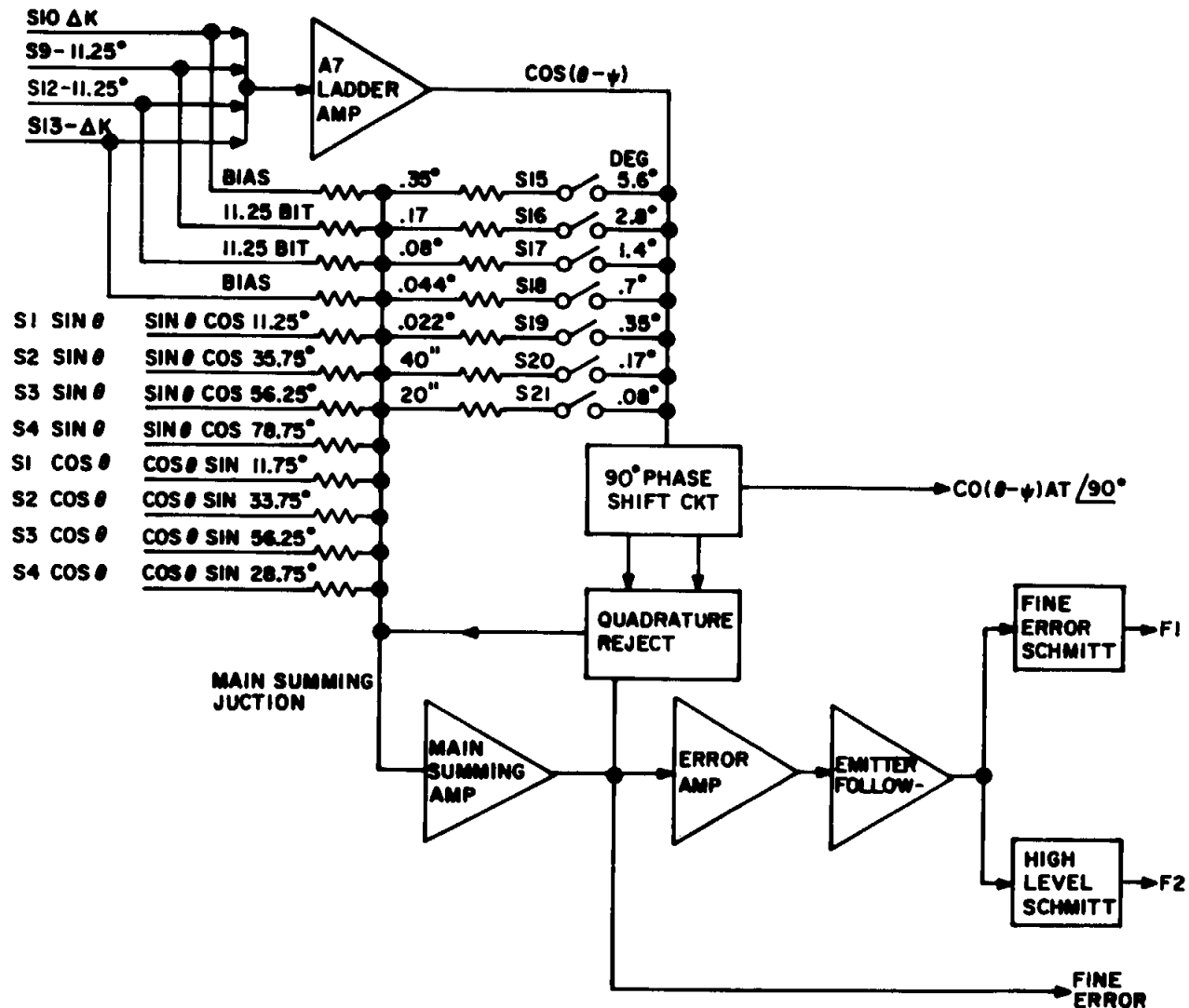
# COARSE SWITCHING DIAGRAM



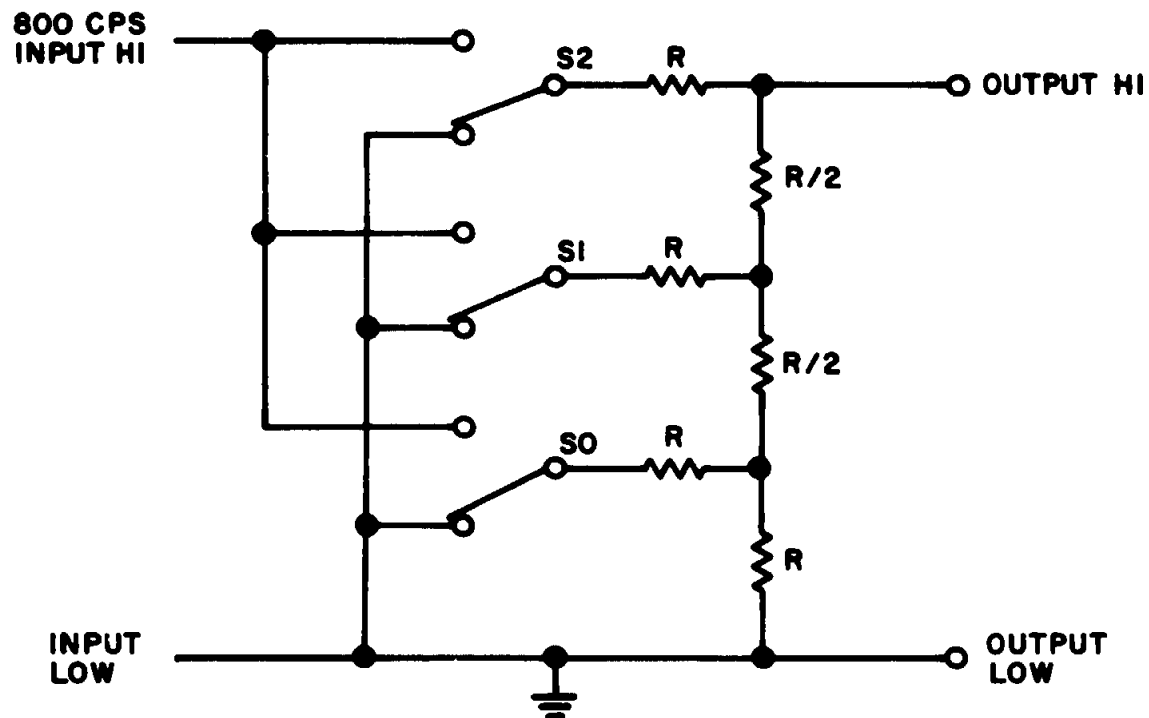
# QUADRANT SELECT MODULE BLOCK DIAGRAM



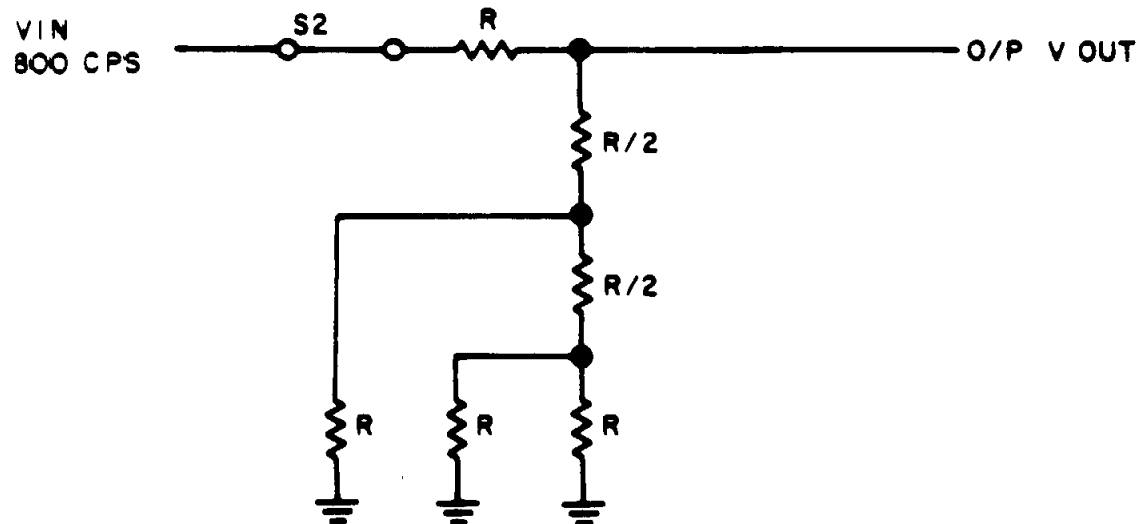
# MAIN SUMMING AMPLIFIER QUADRATURE REJECT MODULE BLOCK DIAGRAM



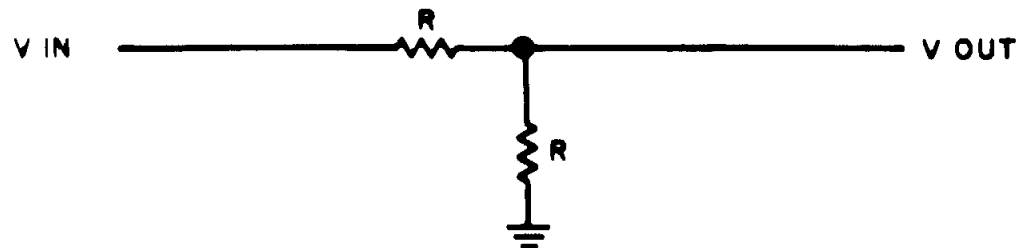
# LADDER DECODER-SIMPLIFIED



# LADDER CIRCUIT WITH S2 CLOSED



(A) CIRCUIT WHEN  $S_2$  ONLY CLOSED

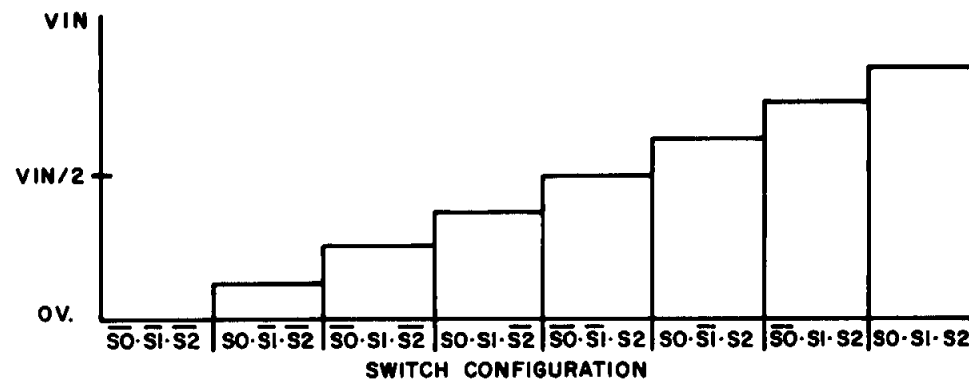


(B) EQUIVALENT CIRCUIT

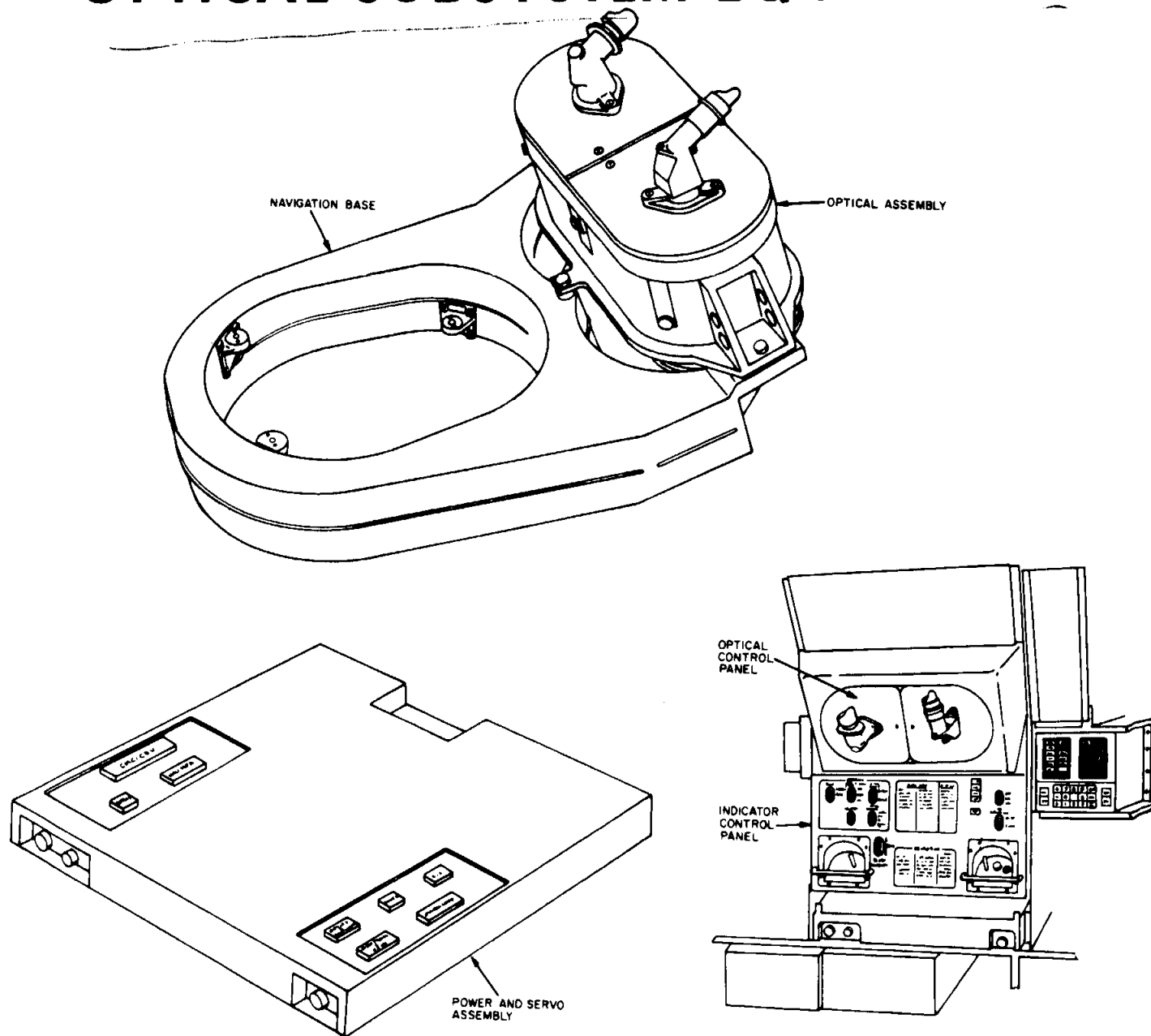
# LADDER OUTPUT VOLTAGE

| S0 | S1 | S2 | V OUT        |
|----|----|----|--------------|
| 0  | 0  | 0  | 0            |
| 1  | 0  | 0  | $V_{IN}/8$   |
| 0  | 1  | 0  | $V_{IN}/4$   |
| 1  | 1  | 0  | $3/8 V_{IN}$ |
| 0  | 0  | 1  | $V_{IN}/2$   |
| 1  | 0  | 1  | $5/8 V_{IN}$ |
| 0  | 1  | 1  | $3/4 V_{IN}$ |
| 1  | 1  | 1  | $7/8 V_{IN}$ |

Table 4-4. Ladder Decoder Truth Table



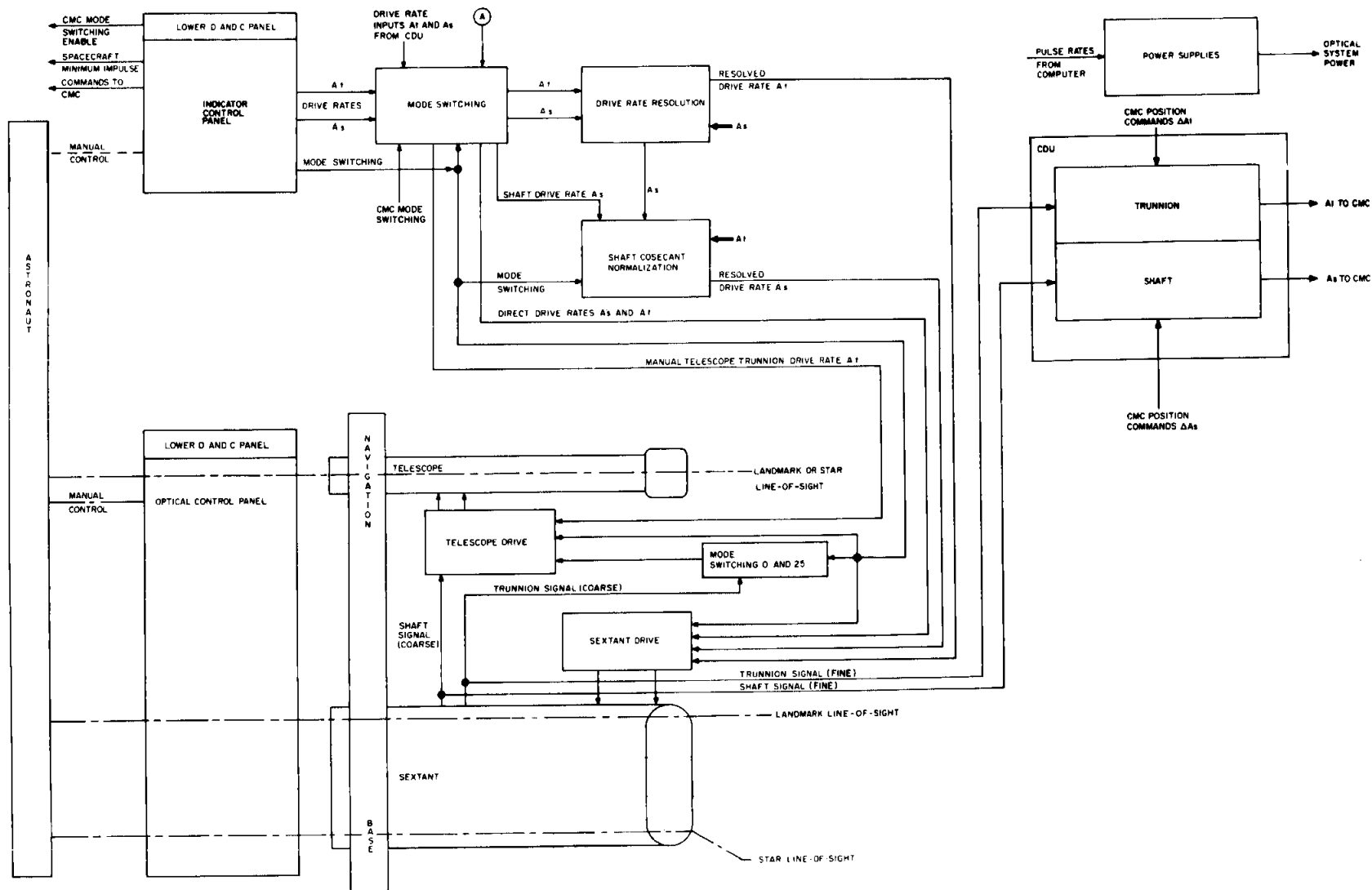
# OPTICAL SUBSYSTEM EQUIPMENT



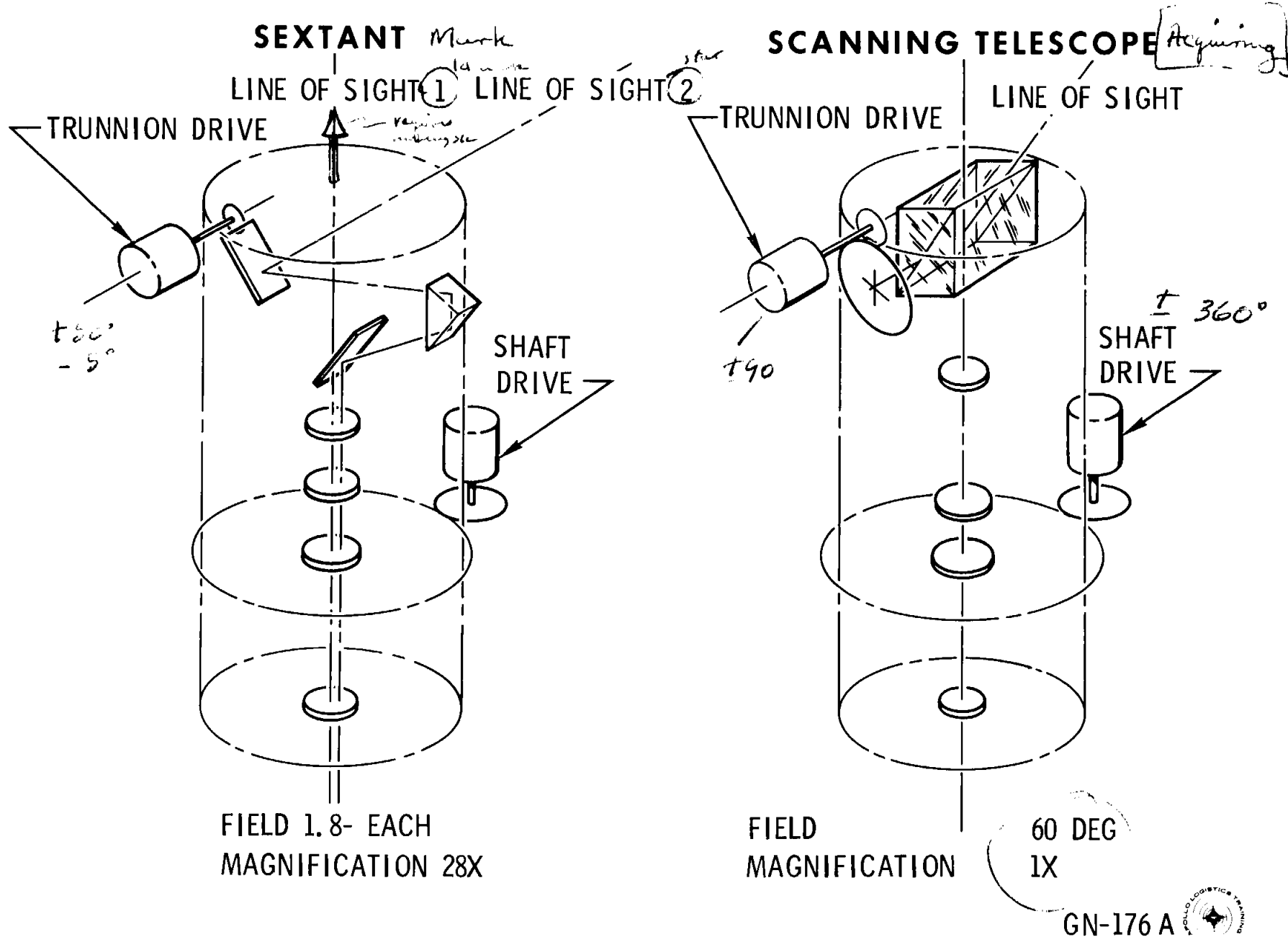
GNC-21



# OPTICAL SUBSYSTEM INTERFACE



# OPTICAL SCHEMATIC

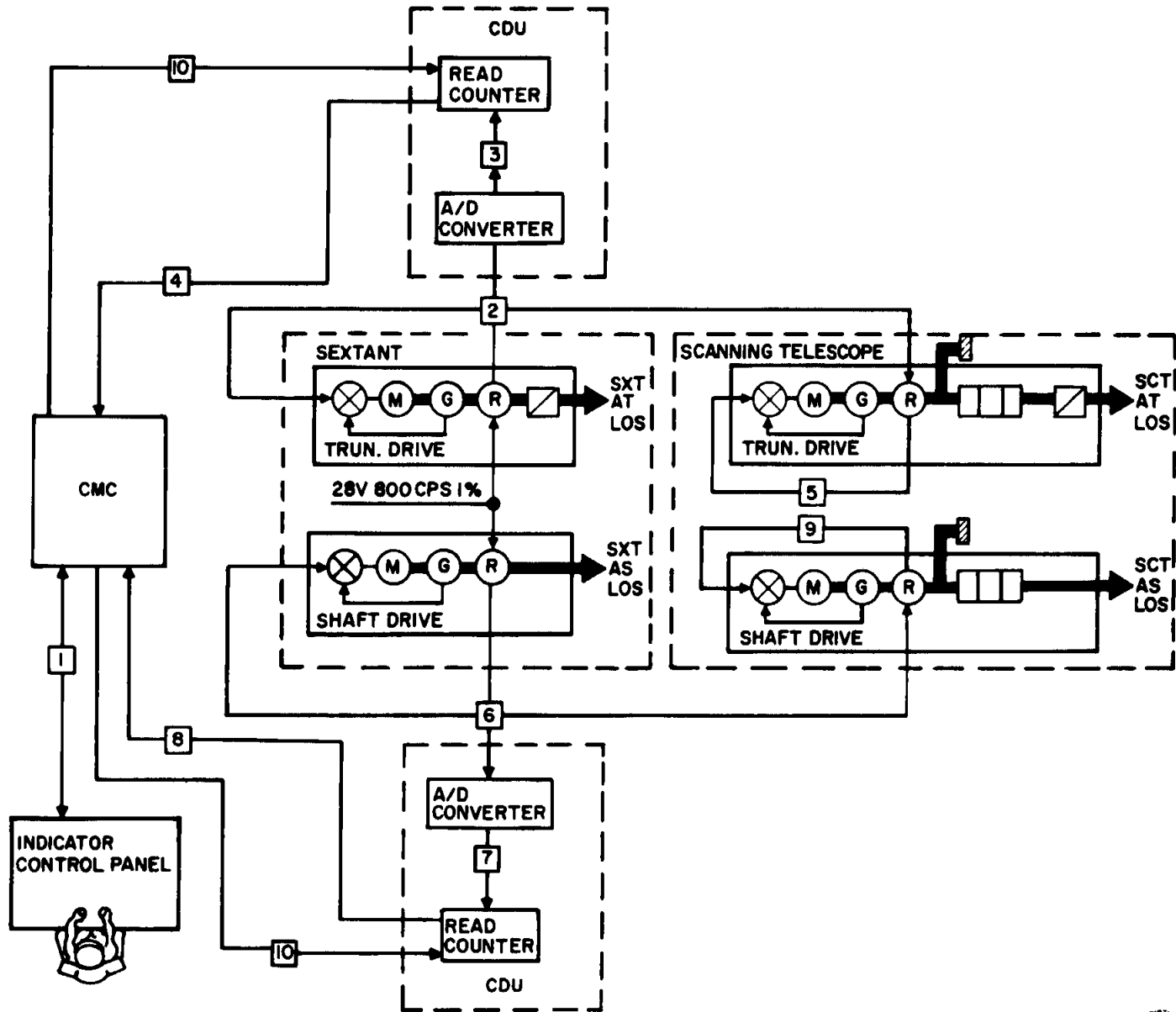




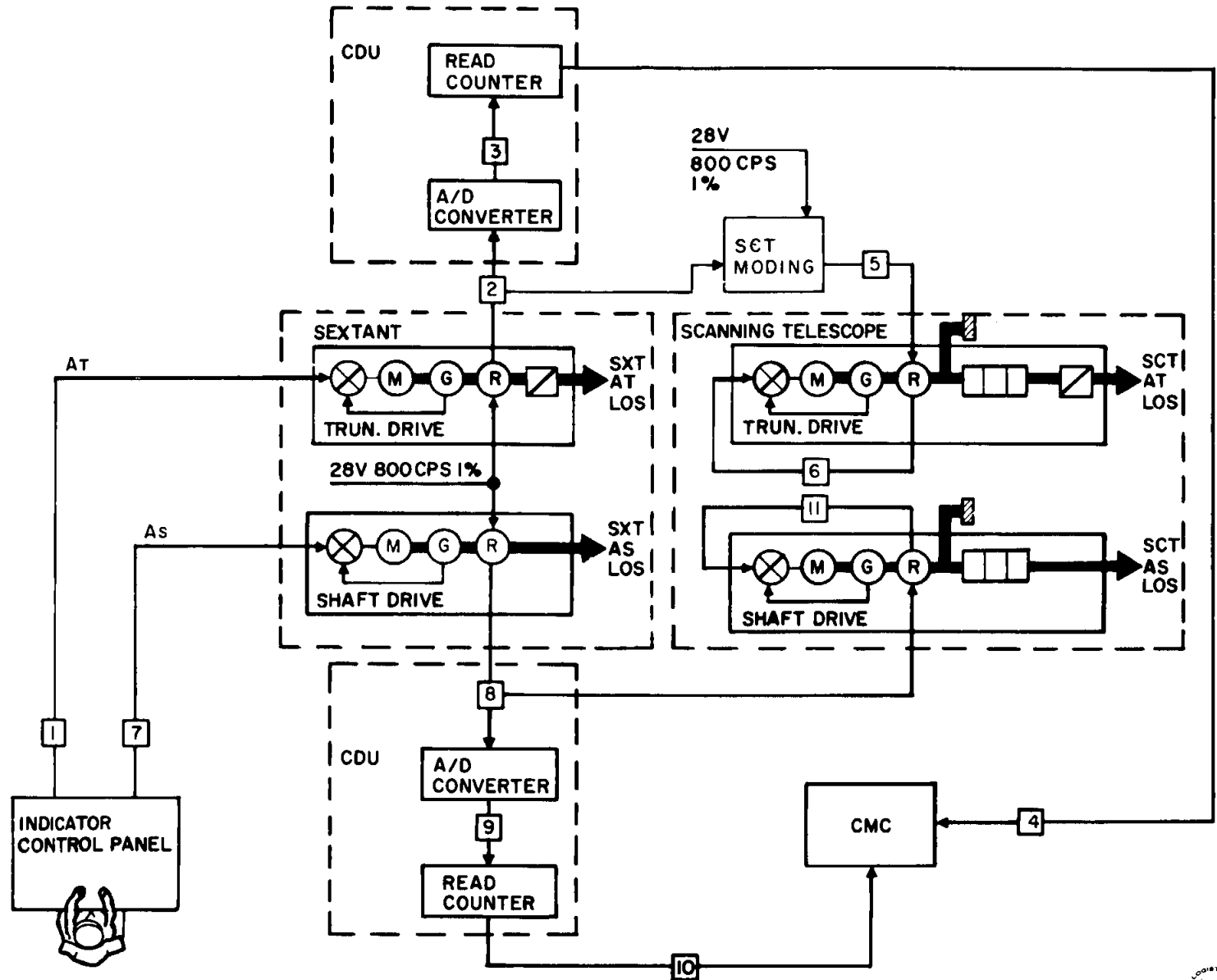
The diagram illustrates the electrical architecture of an optical tracking system. Key components and their interconnections include:

- Optics Controller:** Features various modes (CMC, Manual, Zero, Star Acquired, Tracker, Telescope Trunnion, Slave to SXT) and a detailed inset showing the physical control knobs and their electrical connections to the system.
- Speed Control:** Receives input from the Optics Controller and provides feedback to the Trunnion assembly.
- Anti Creep:** Two units that provide stability and feedback for the Trunnion and SXT assemblies.
- DAC Output Command Channels:** Two channels (Trunnion and SXT) that interface with the CMC and provide command signals to the respective assemblies.
- Trunnion and SXT Assemblies:** The core tracking components, each containing a DAC, a CDU Channel, and a Sin/Cos output stage.
- Power Distribution:** The system is powered by 28VDC and 28V AC (800~ 1% and 800~ 5%) sources, which are distributed to various components and control lines.
- Signal Flow:** The diagram shows the flow of control signals (e.g., MODE, SPEED, COUPLING) and tracking data (e.g., LOS, SLOS, LLOS) throughout the system.

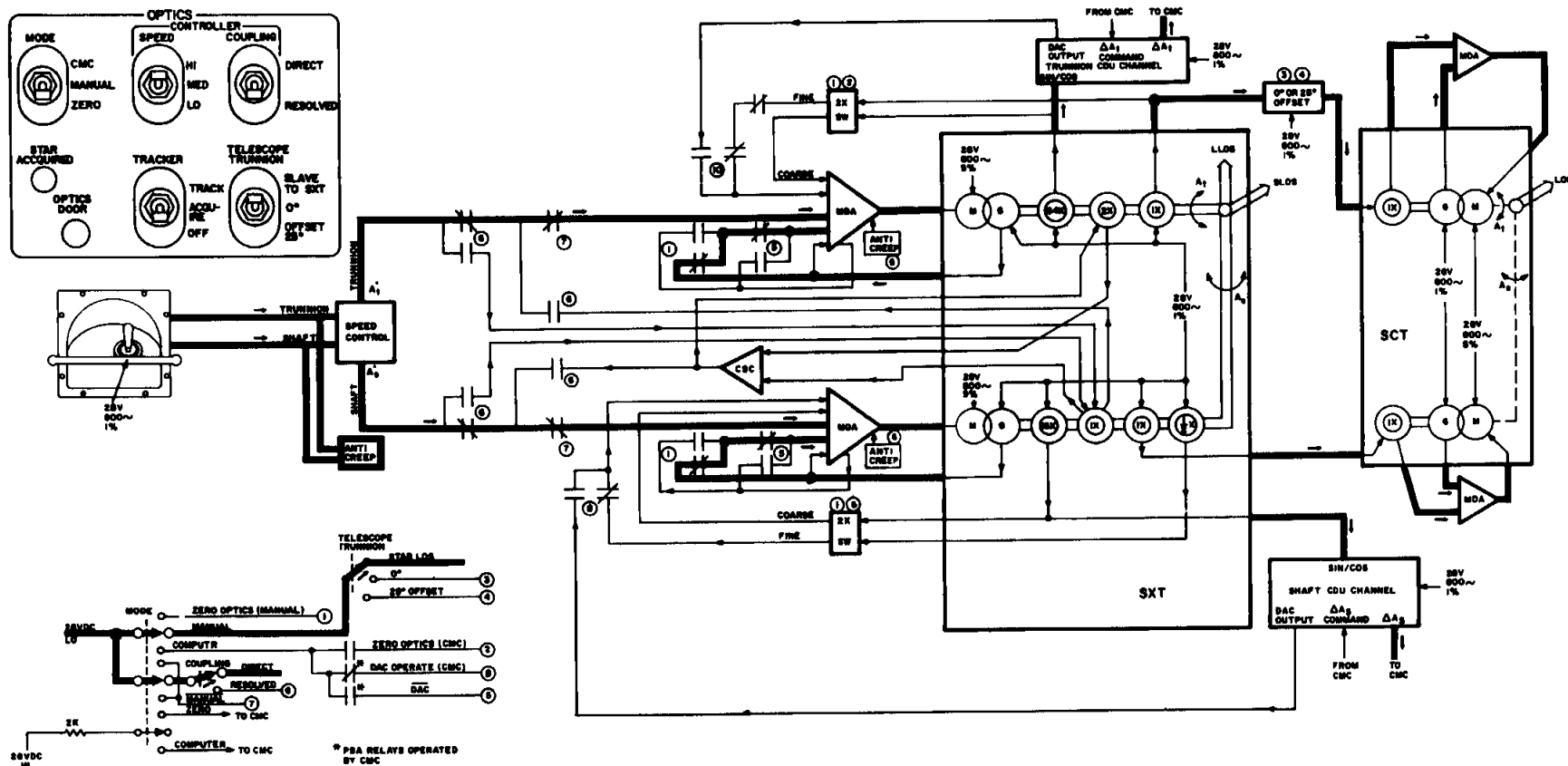
# ZERO OPTICS MODE



# MANUAL DIRECT MODE

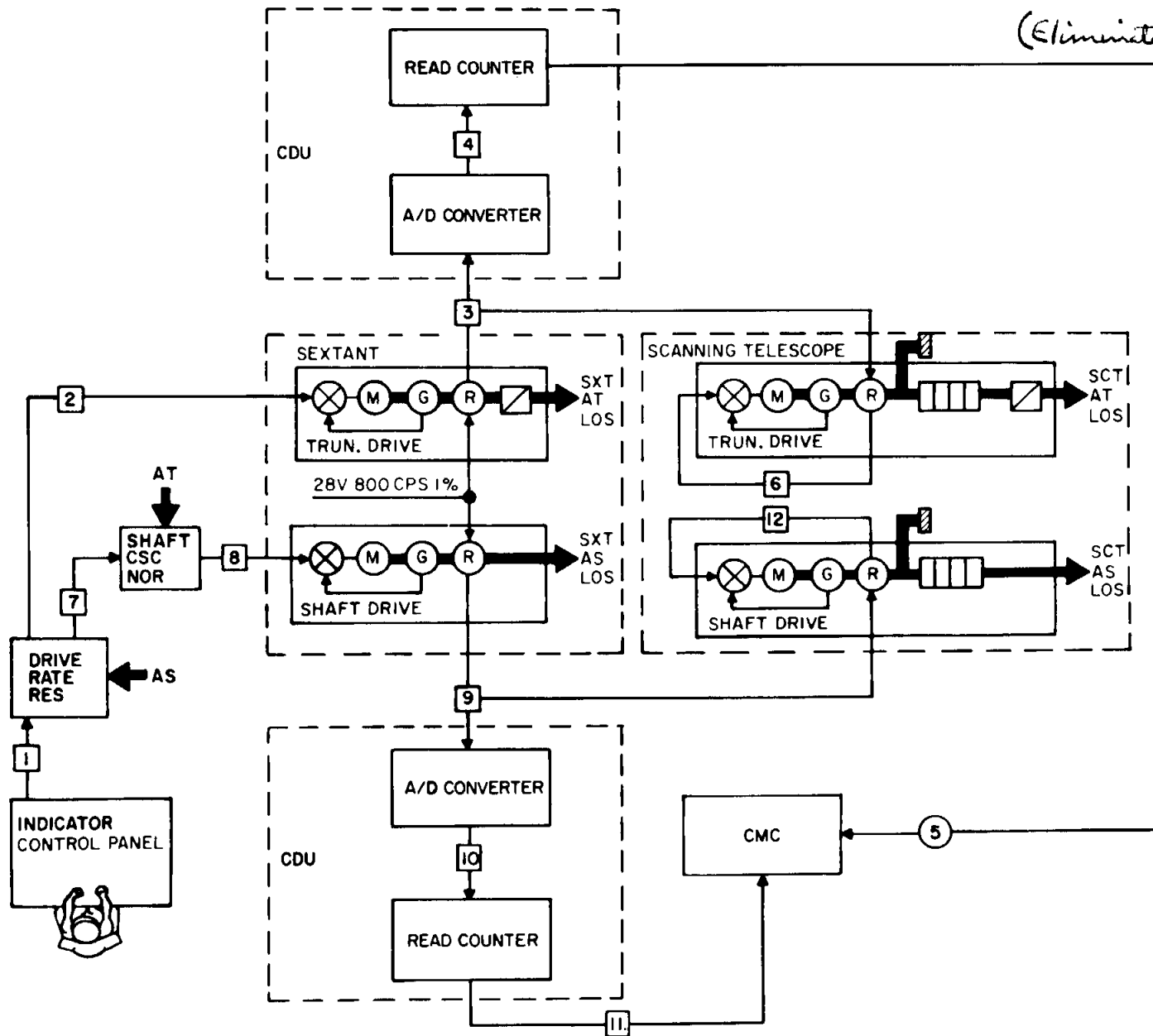


# MANUAL DIRECT MODE

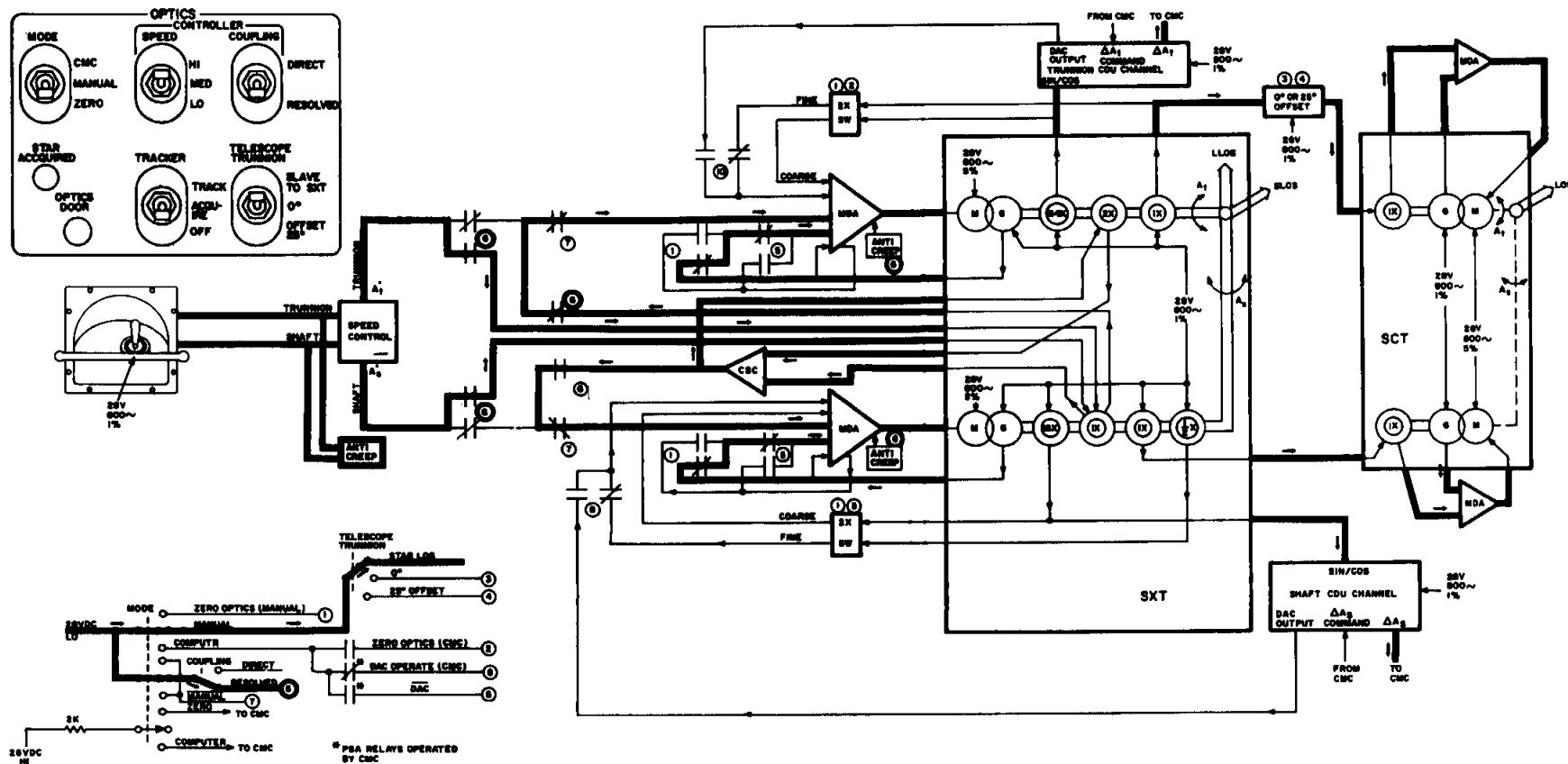


# MANUAL RESOLVED MODE

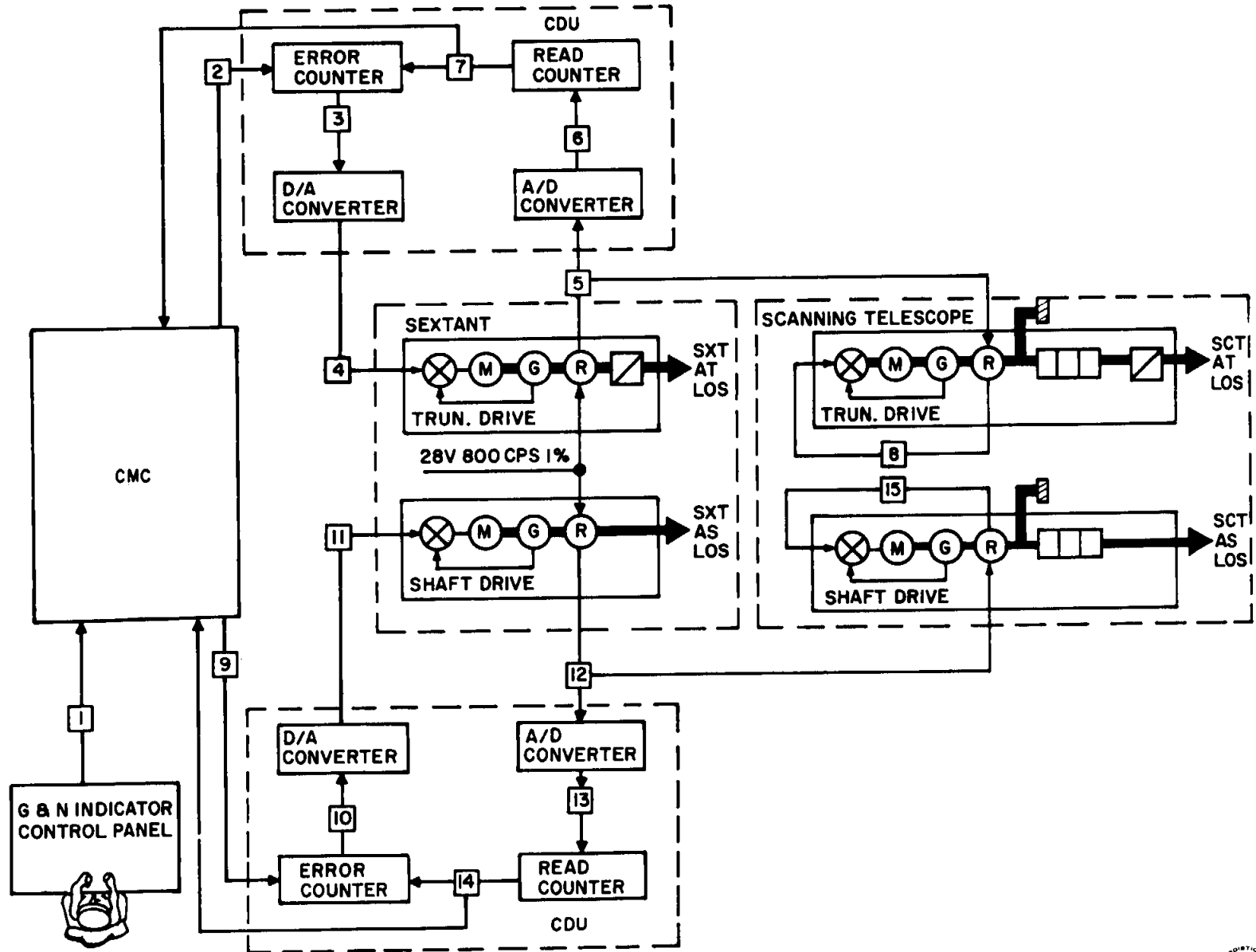
*Object moves wrt viewer  
(Eliminates shaft angle):*



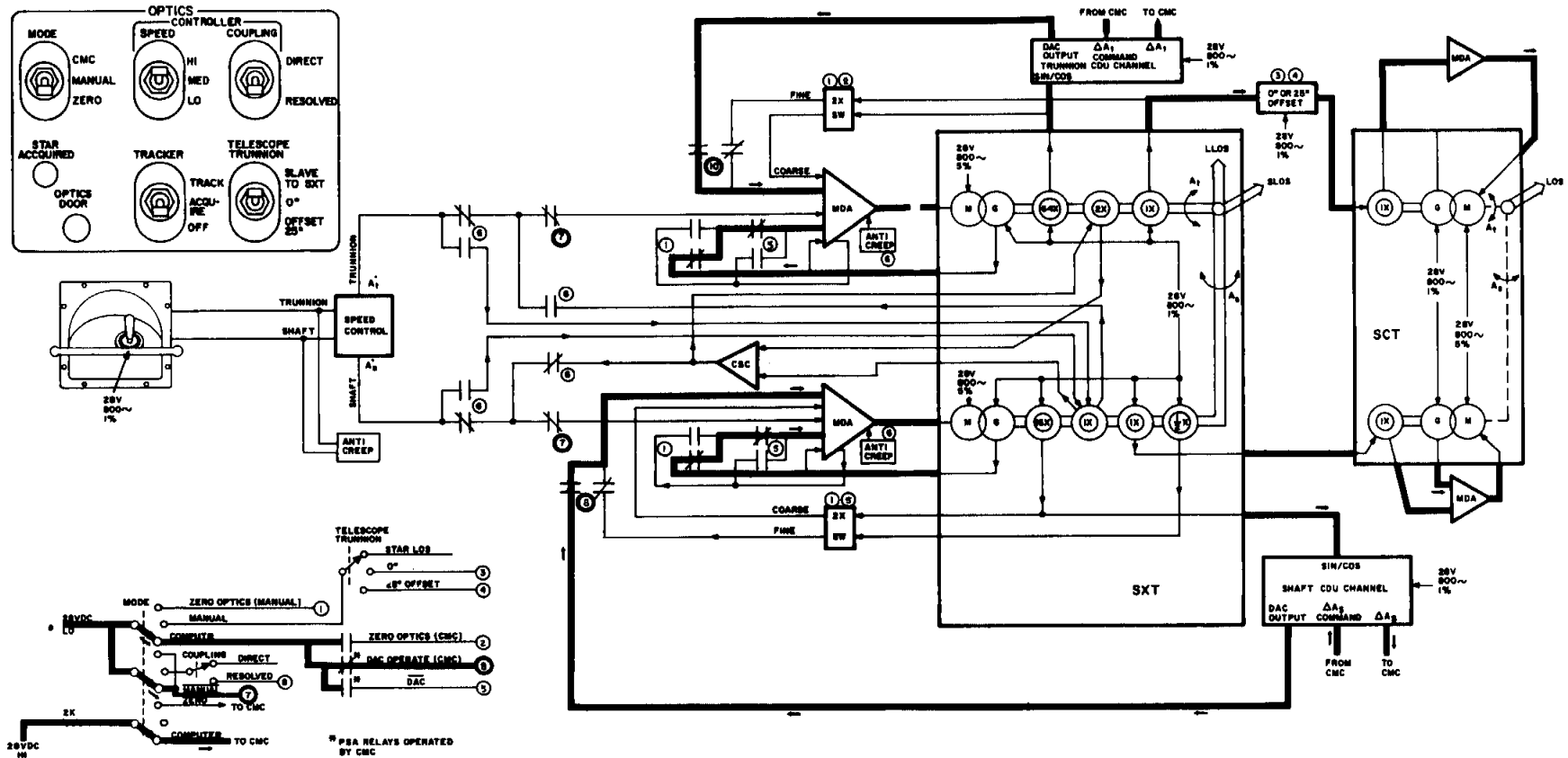
# MANUAL RESOLVED MODE



# COMPUTER MODE



# COMPUTER MODE



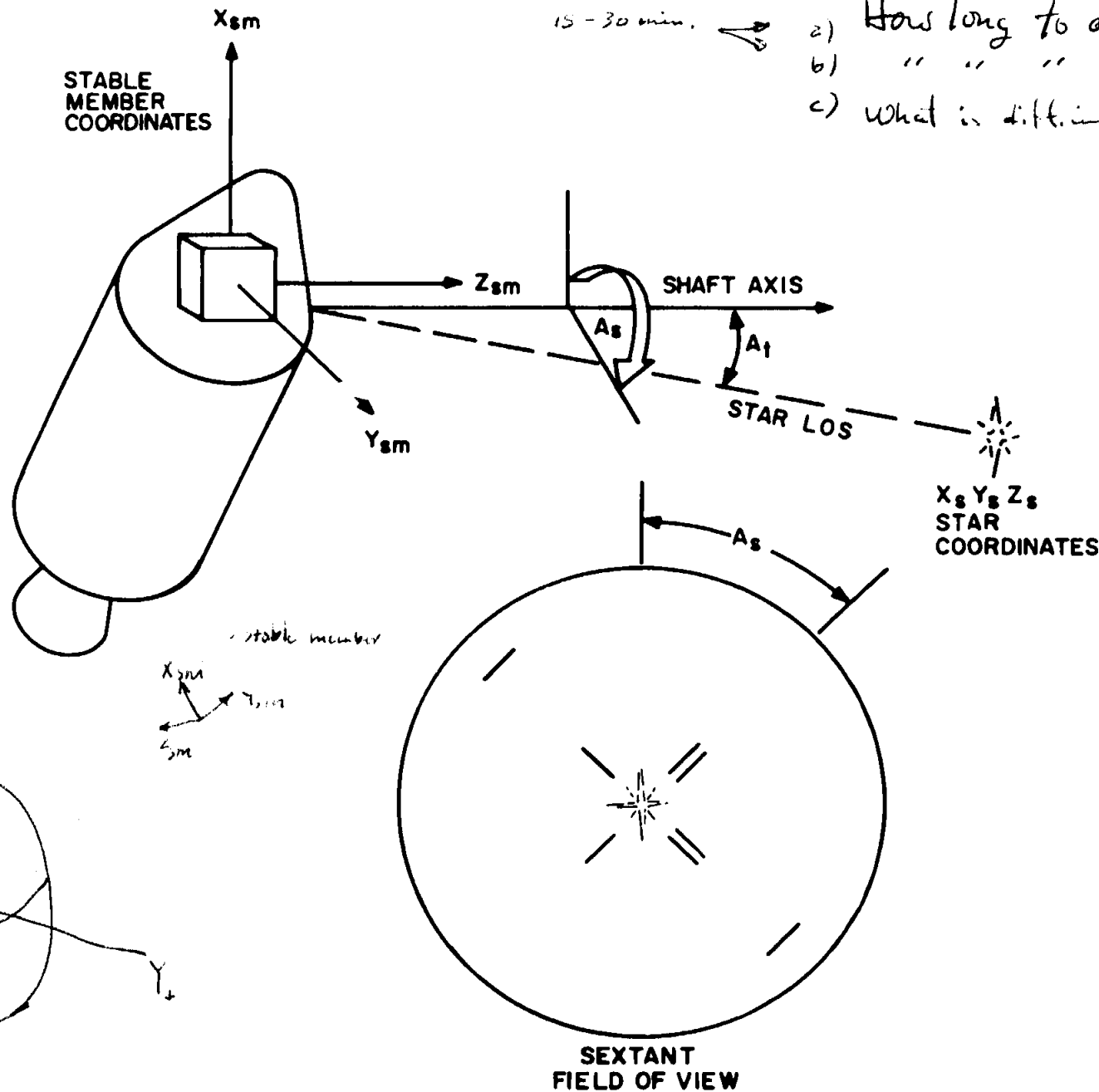
Al Sohler } Instructors (NNA)  
 Martin Murray }

# IMU ALIGNMENT MEASUREMENT

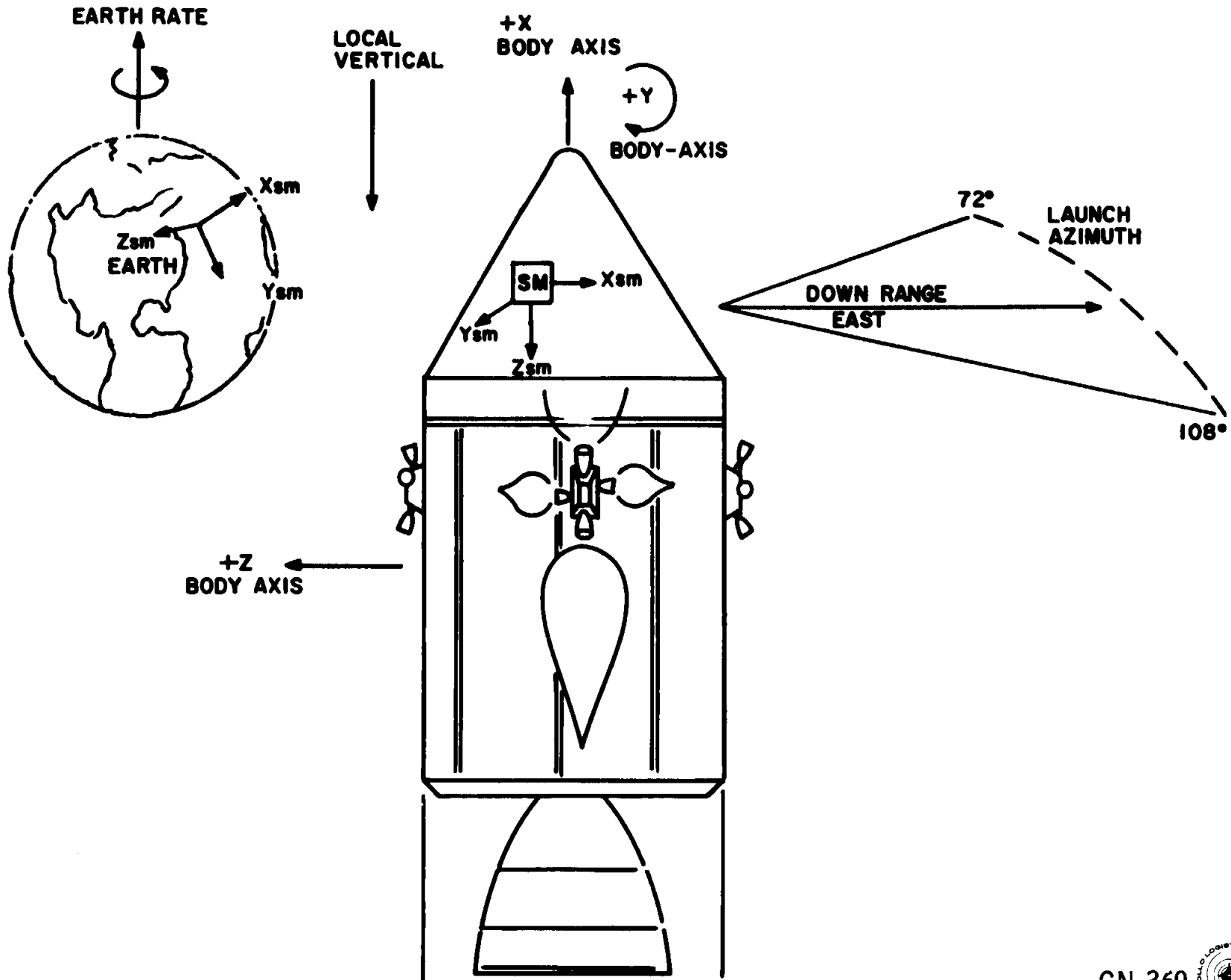
15 - 30 min.

- a) How long to align the platform
- b) " " " Det. R&F/MMA/1
- c) What is diff. in time of course change  
 7-8 min

1. Pos



# PRELAUNCH ALIGNMENT

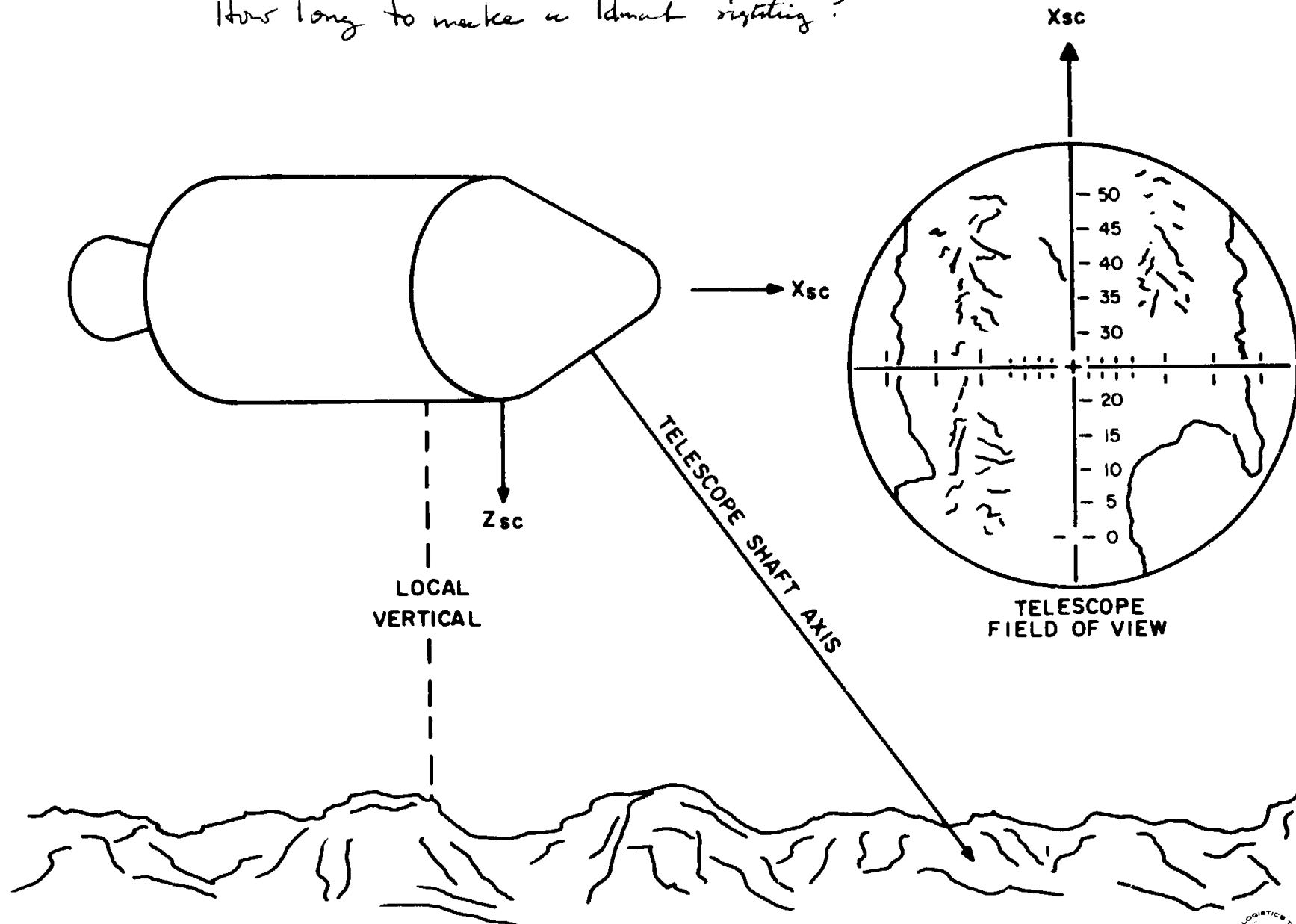


To Update State Vector

# ORBITAL NAVIGATION SIGHTING

Program 21  
22

How long to make a Idmat sighting?



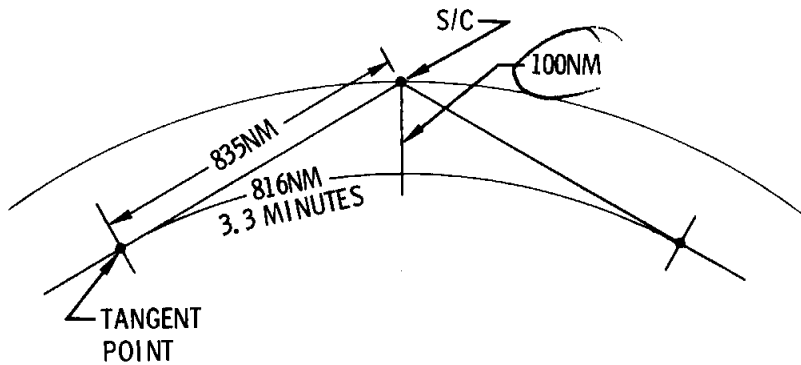
GN-9102B



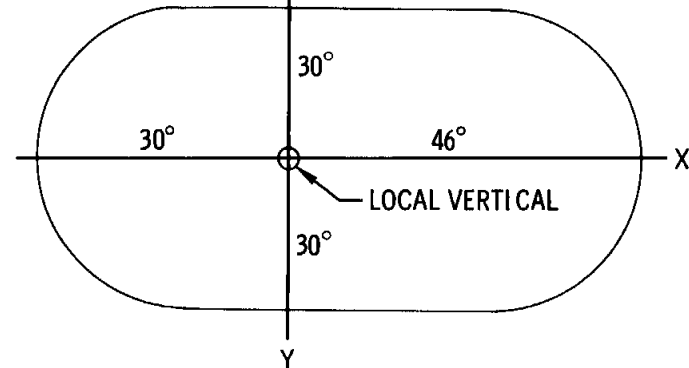
# EARTH ORBIT NAVIGATION

*How do you get valid update data from an unknown landmark?*

P 21  
22

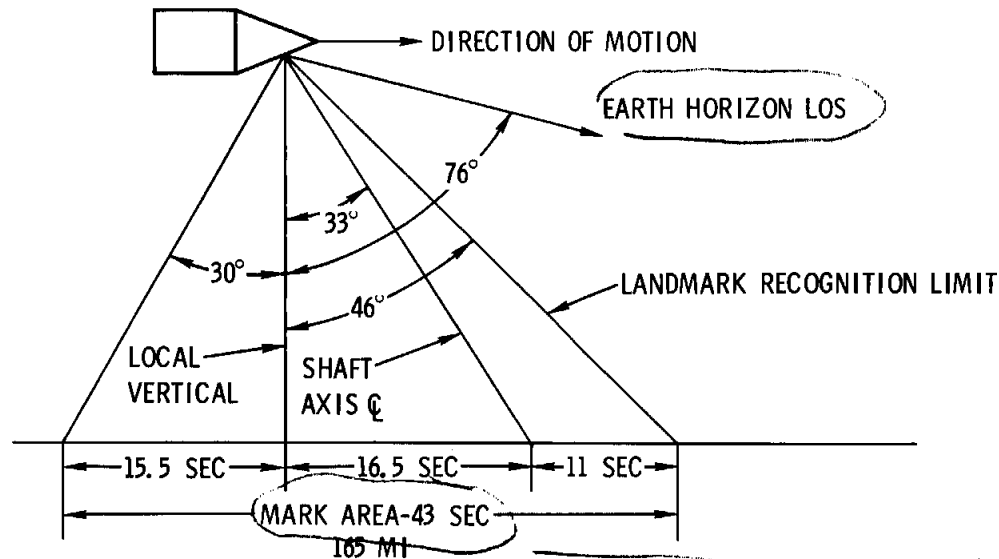


EARTH ORBIT GEOMETRY FIGURE 1



VIEW ON SURFACE FIGURE 3

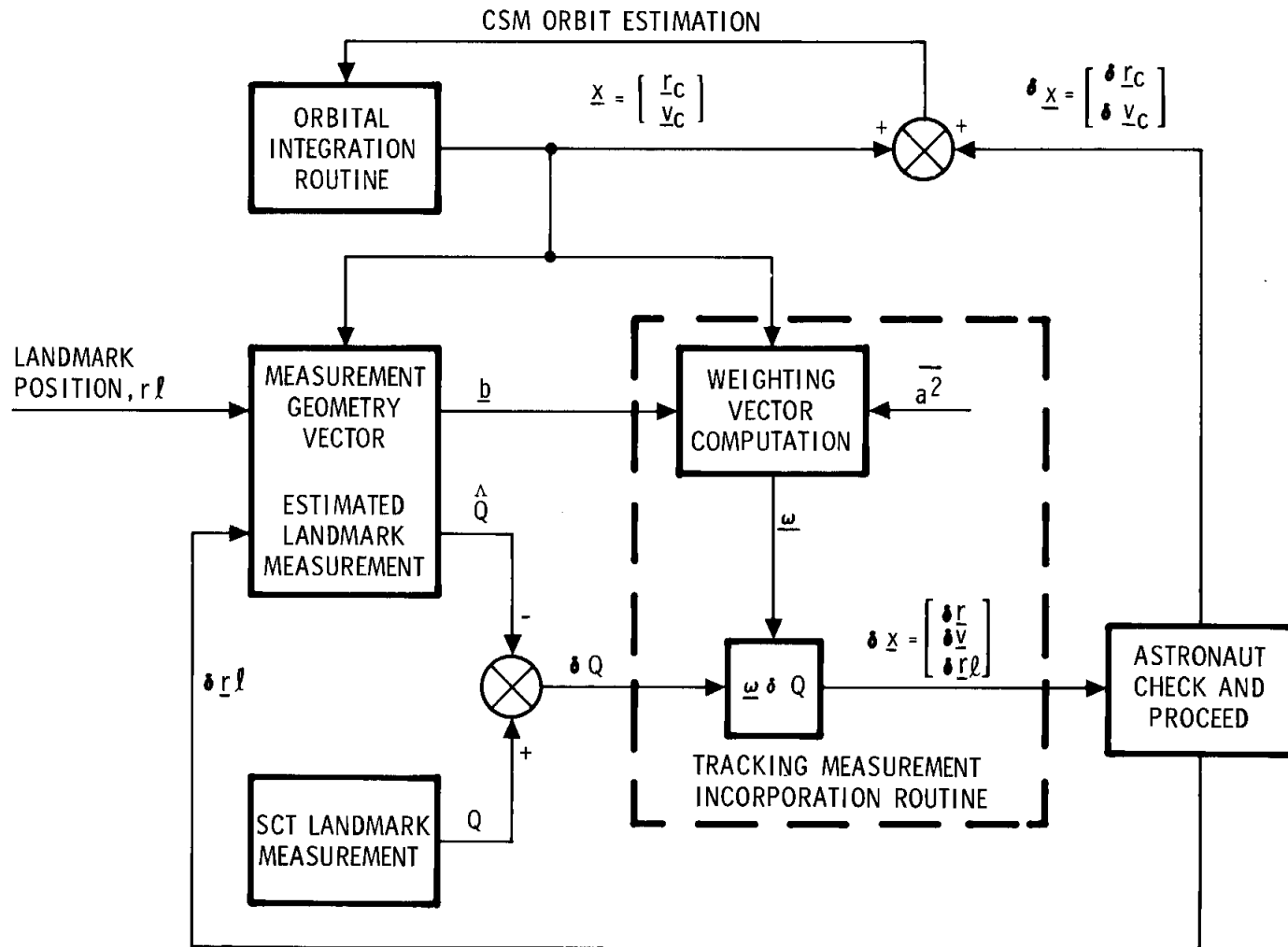
R1  $\Delta P_{02}$  (4 mi)  
R2  $\Delta V$  (5 ft/sec)  
R3 00135  
    /    \  
1 processing 3rd mile



COVERAGE ON SURFACE FIGURE 2

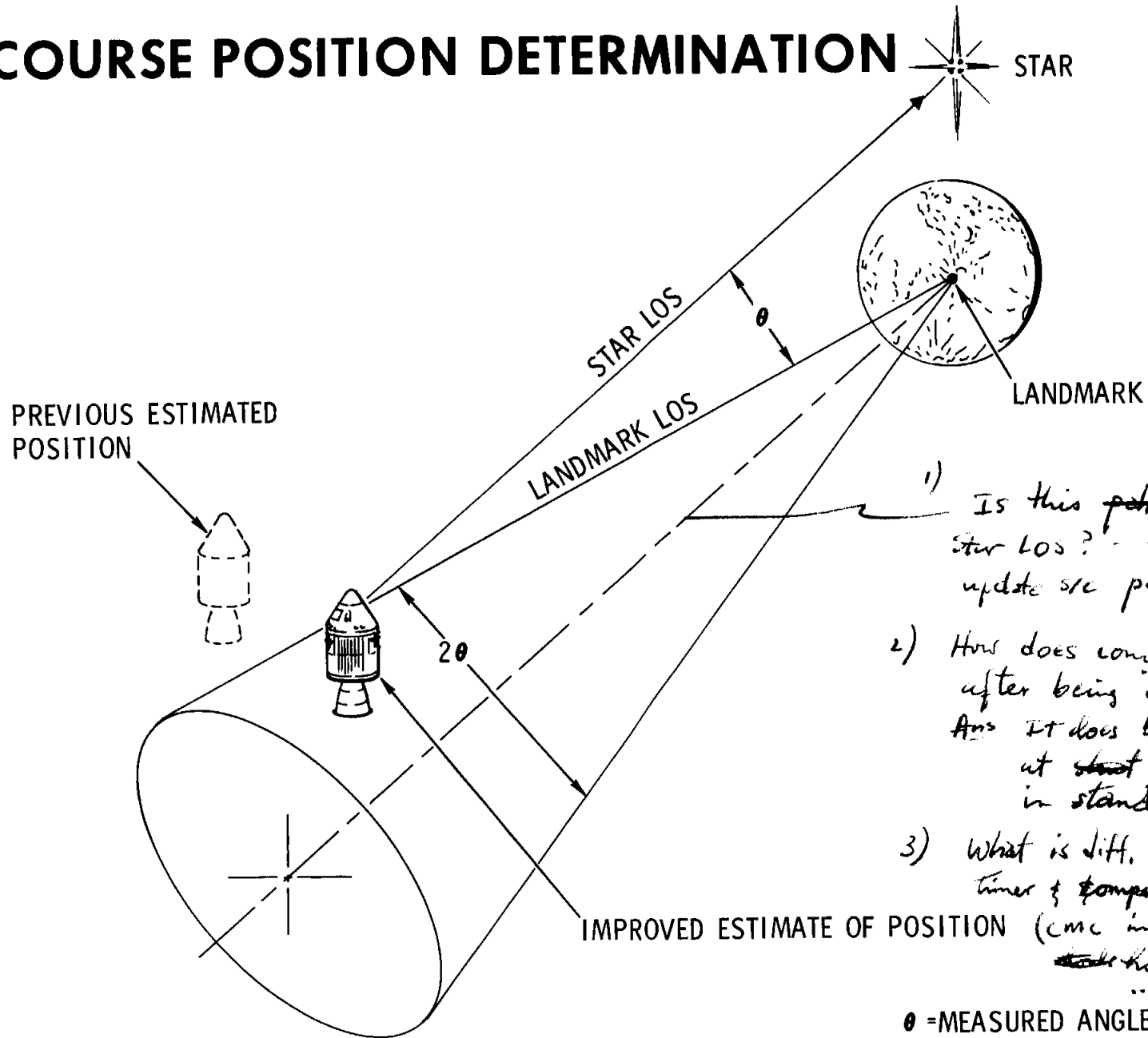
*would like to  
have 5 sightings  
(in 43 sec?)*

# SIMPLIFIED ORBITAL NAVIGATION FUNCTIONAL DIAGRAM



# MIDCOURSE POSITION DETERMINATION

Program 23



1) Is this path parallel to star LOS? - Must be to update src position

2) How does comp. update itself after being in standby?  
 Ans It does based on st. vect at start standby time & time in standby

3) What is diff. in mission event timer & computer time?

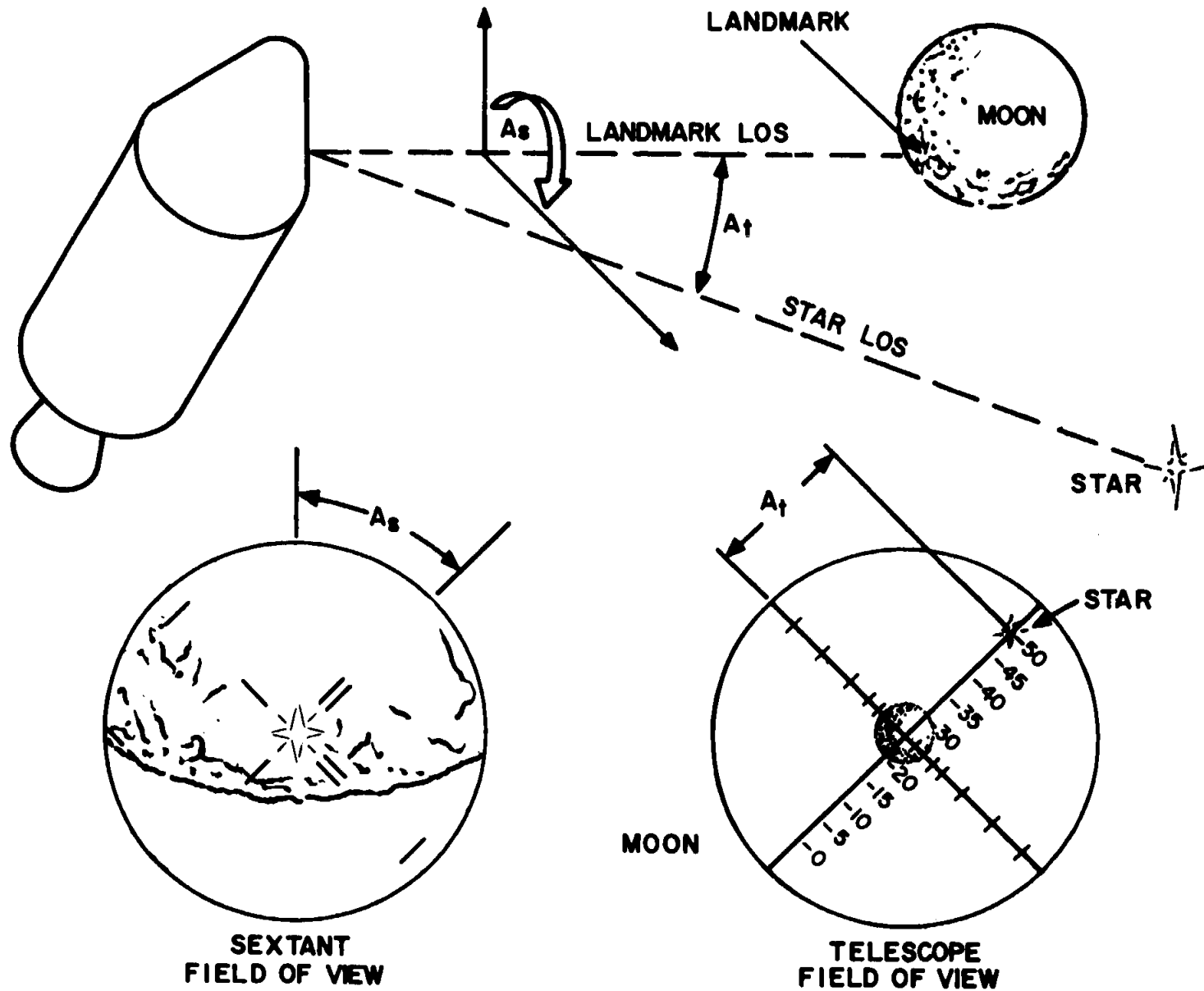
(comp in standby can only ~~hold~~ hold up to 10 min ... it then corrects time  $\therefore$  state of update.)

$\theta$  = MEASURED ANGLE

GN-9101A



# NAVIGATIONAL MEASUREMENT



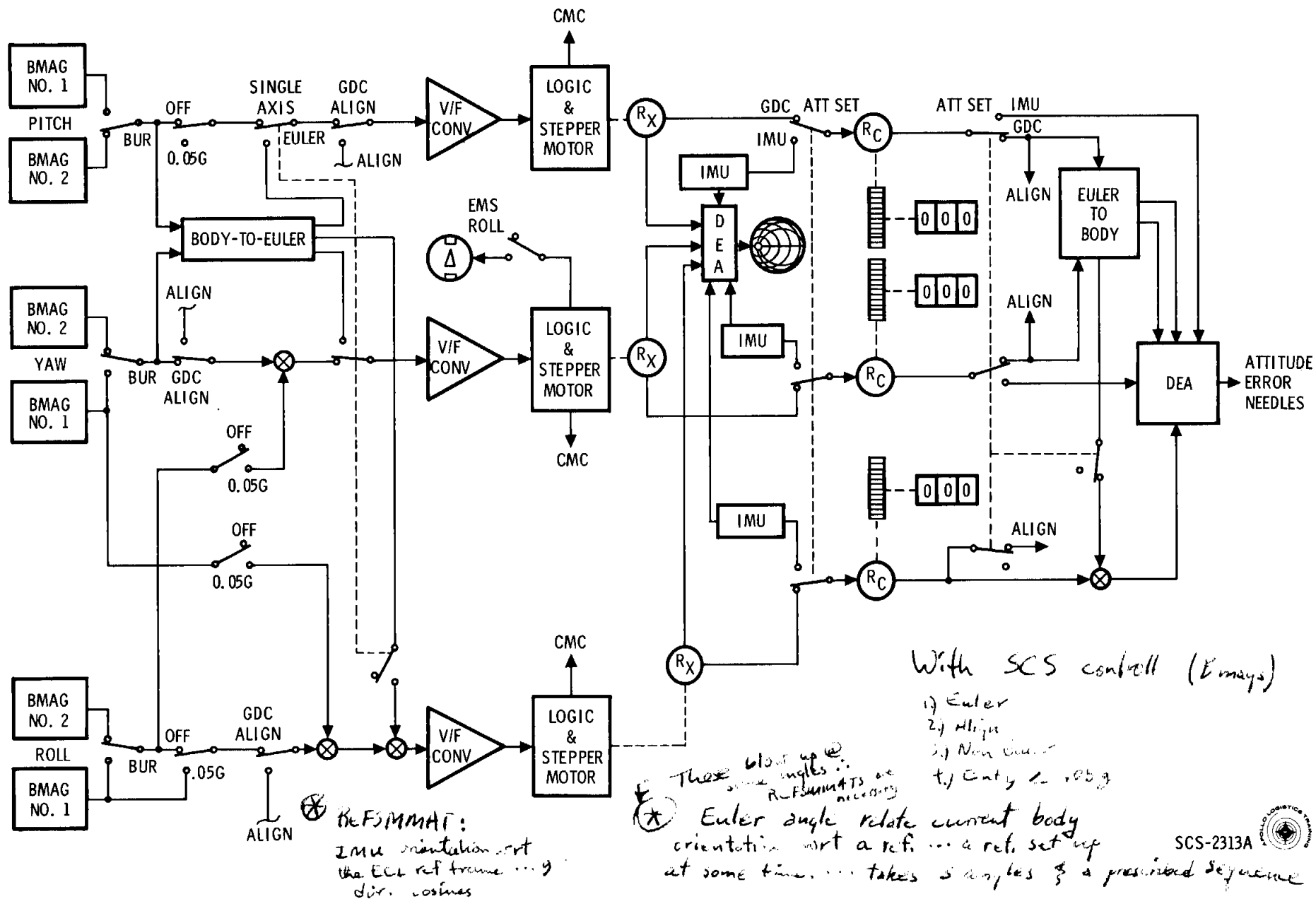
GN-9103B



# ATTITUDE REFERENCE SUBSYSTEM

SCS

## FUNCTIONAL OPERATION

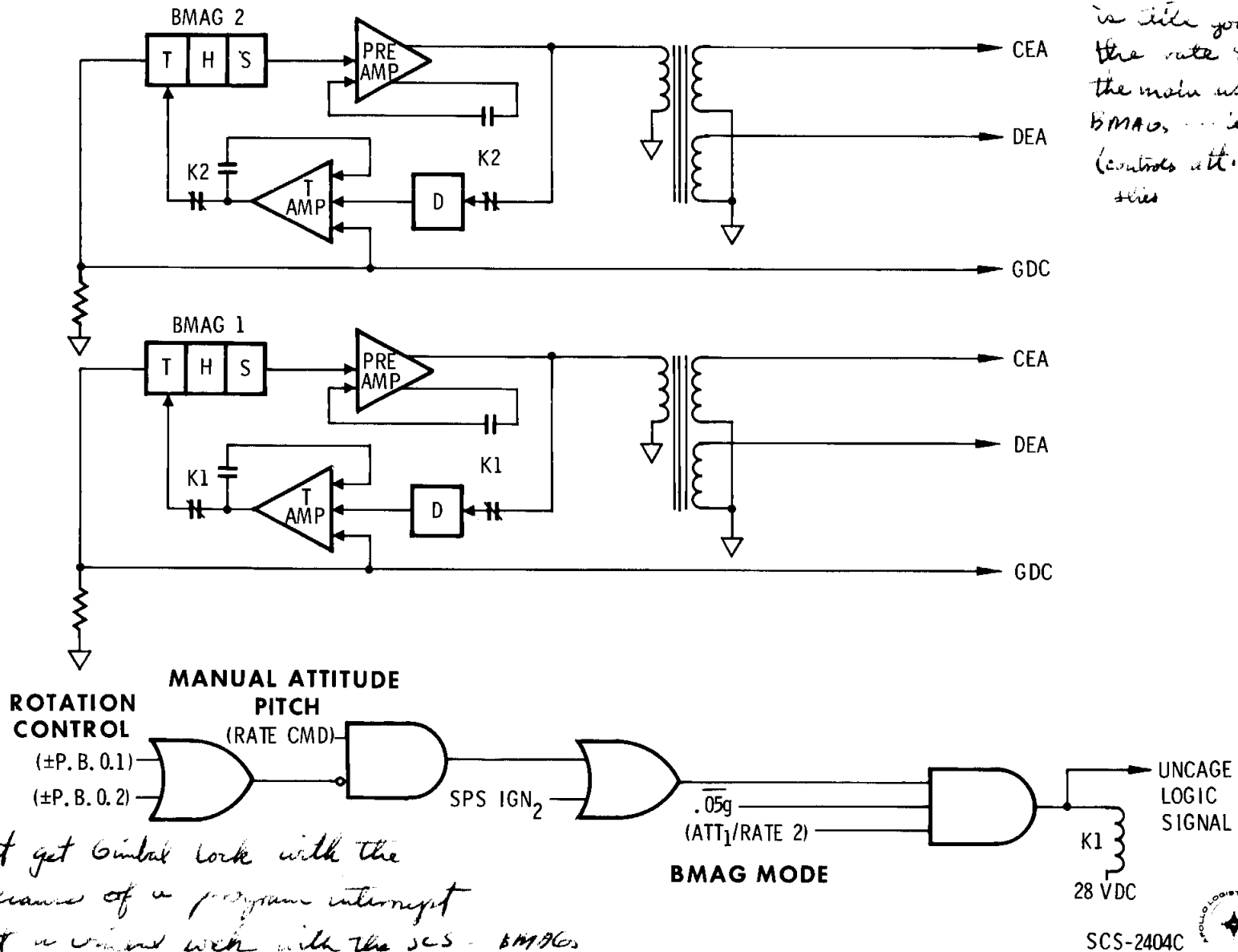


SCS-2313A



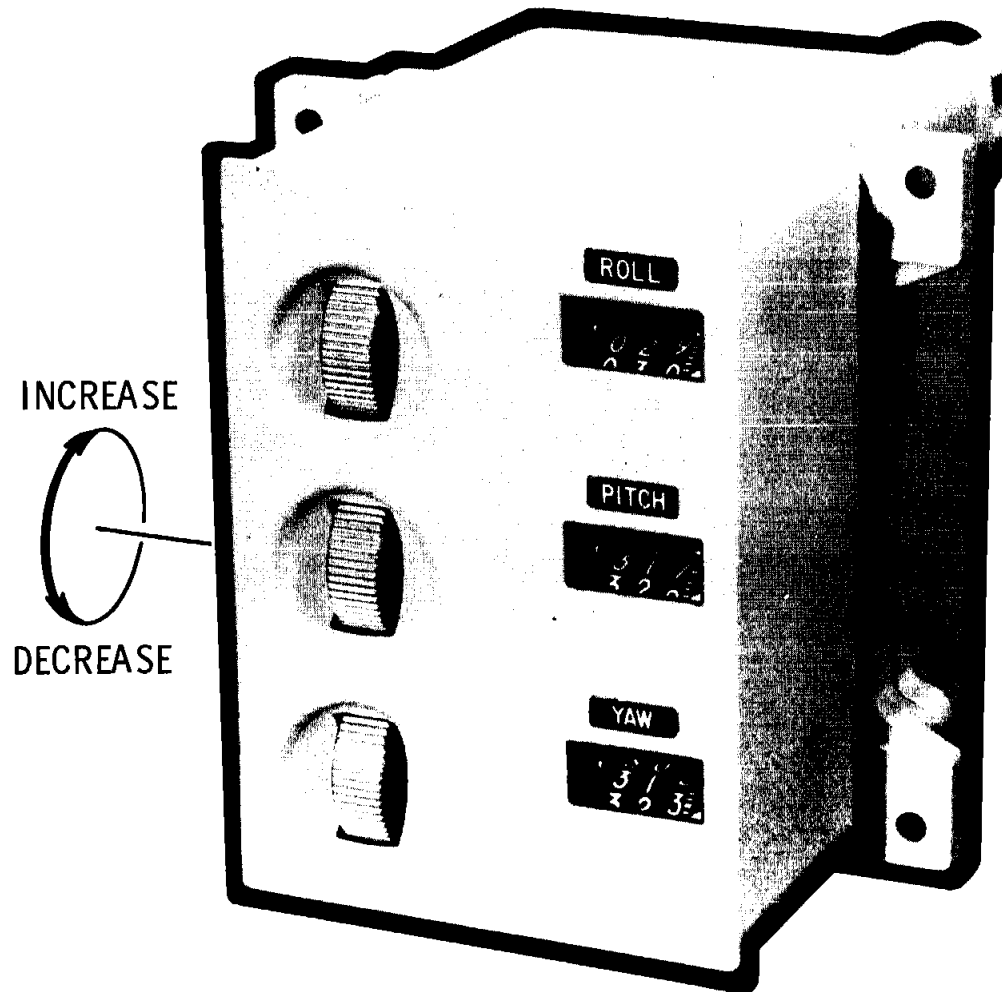
# PITCH BMAG LOGIC AND OUTPUTS

\* Temp. limit of  $170^{\circ} \pm 1^{\circ}$  on BMAGs  
 If Temp. goes up to  $175^{\circ}$  the att. incr goes to pot, but the rate incr. is still good. Also the rate signal is the main use of the BMAGs... i.e. MTVL (controls att. while incr. rates)



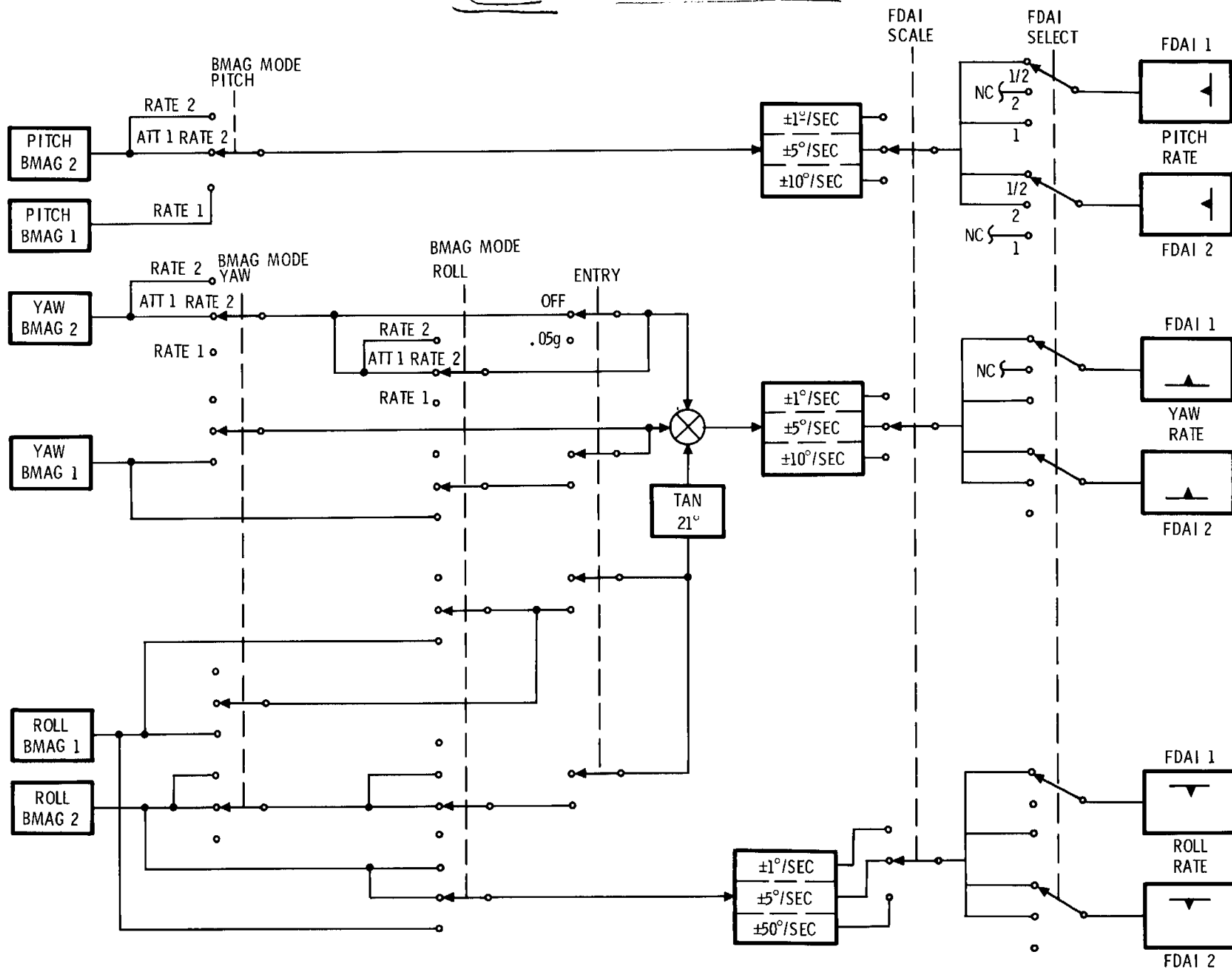
\* You can't get Gimbal lock with the  $3\frac{1}{2}R$  because of a program interrupt. You get a warning with the SES - BMAGs at a yaw of  $45^{\circ}$

# ATTITUDE SET DISPLAY

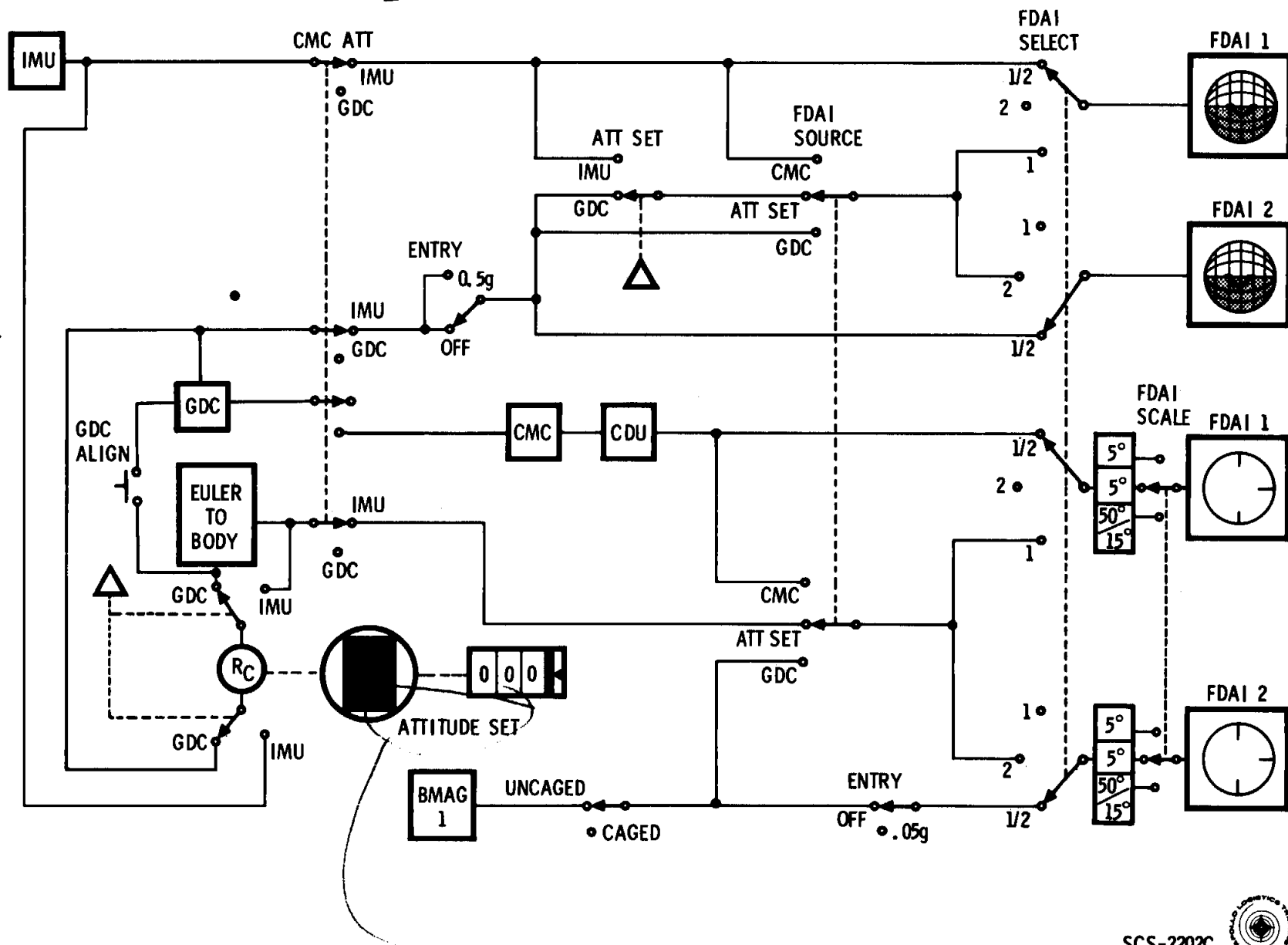


# FDAI RATE SELECT LOGIC

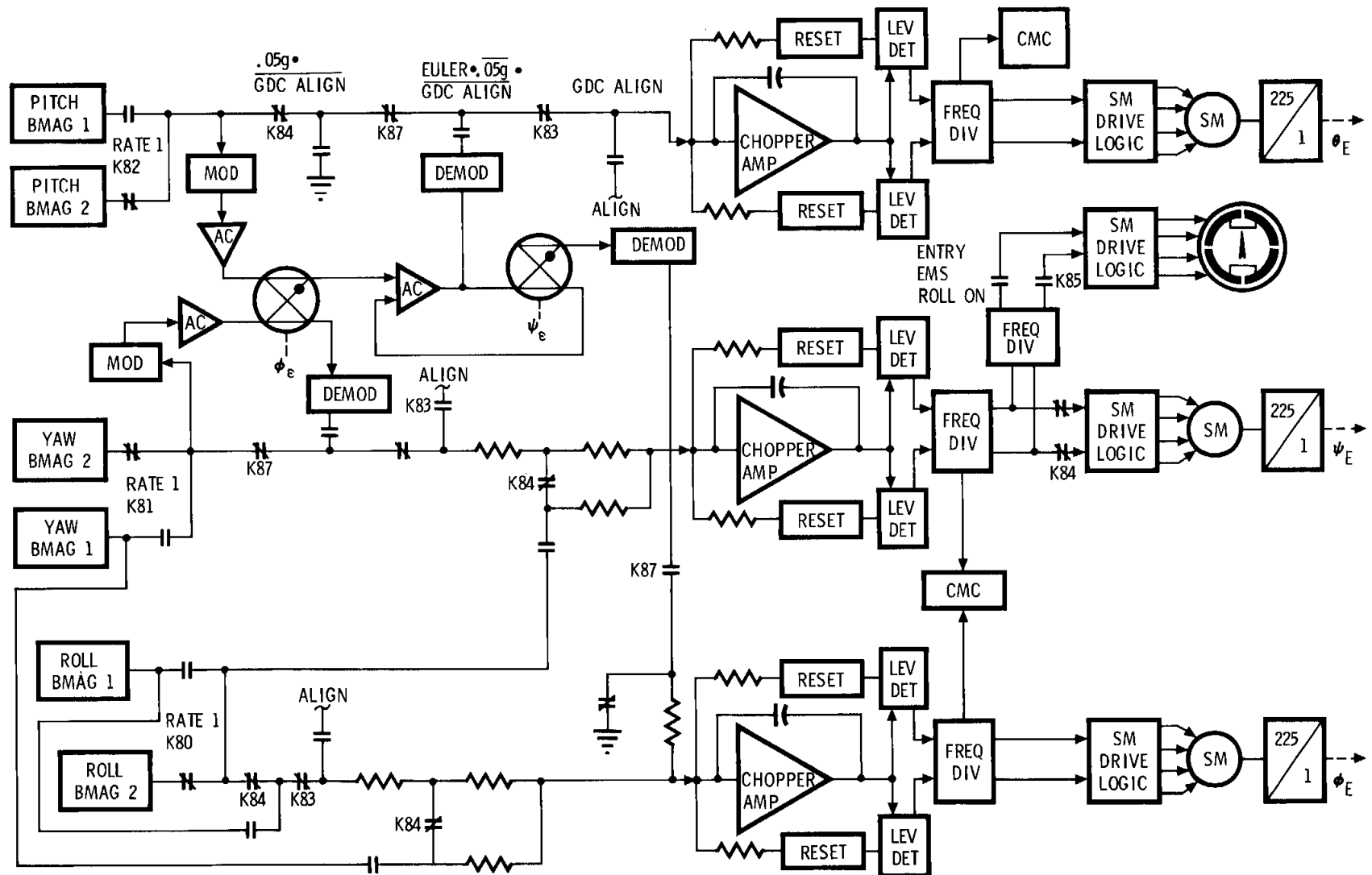
SCS



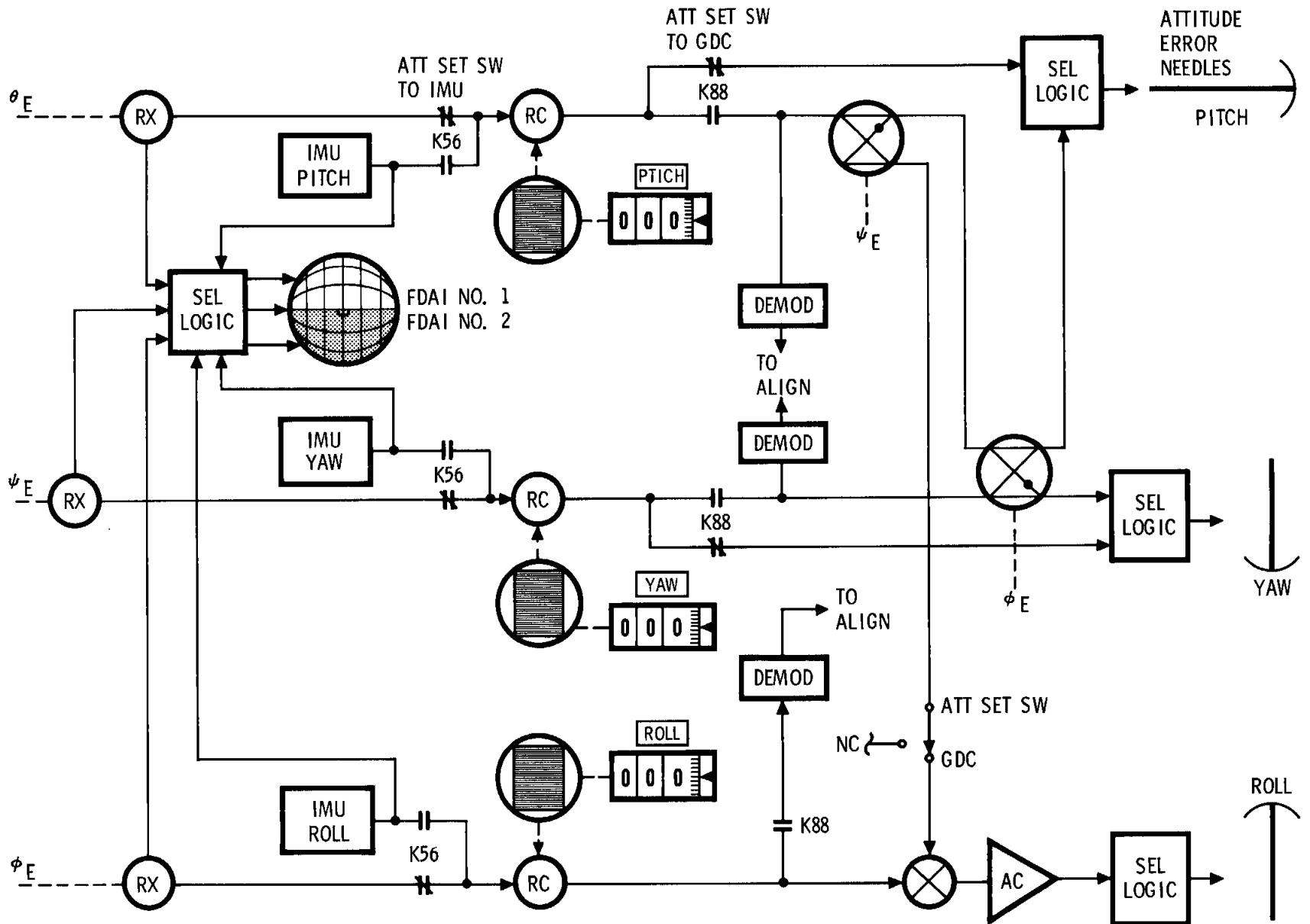
# FDAI ATTITUDE SELECT LOGIC



# GYRO DISPLAY COUPLER



# FDAI SIGNAL FLOW





Att. Ref Sys  
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<br>M<br>A<br>G<br>M<br>O<br>D<br>E | PITCH                      | RATE 2             |       |           |              |     |                             |             |                        |                  | ✓     |                   |         |
|                                      |                            | ATT 1/<br>RATE 2   |       |           |              |     | ✓                           |             |                        |                  | ✓     |                   |         |
|                                      |                            | RATE 1             |       |           |              |     |                             |             |                        |                  |       | ✓                 |         |
|                                      | YAW                        | RATE 2             |       |           |              |     |                             |             |                        |                  | ✓     |                   |         |
|                                      |                            | ATT 1/<br>RATE 2   |       |           |              |     | ✓                           |             |                        |                  | ✓     |                   |         |
|                                      |                            | RATE 1             |       |           |              |     |                             |             |                        |                  |       | ✓                 |         |
|                                      | ROLL                       | RATE 2             |       |           |              |     |                             |             |                        |                  | ✓     |                   |         |
|                                      |                            | ATT 1/<br>RATE 2   |       |           |              |     | ✓                           |             |                        |                  | ✓     |                   |         |
|                                      |                            | RATE 1             |       |           |              |     |                             |             |                        |                  |       | ✓                 |         |
| E<br>N<br>T<br>R<br>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<br>CONT PANEL | 3 THUMB-<br>WHEELS | ✓     |           |              |     |                             | ✓           | ✓                      |                  |       |                   |         |

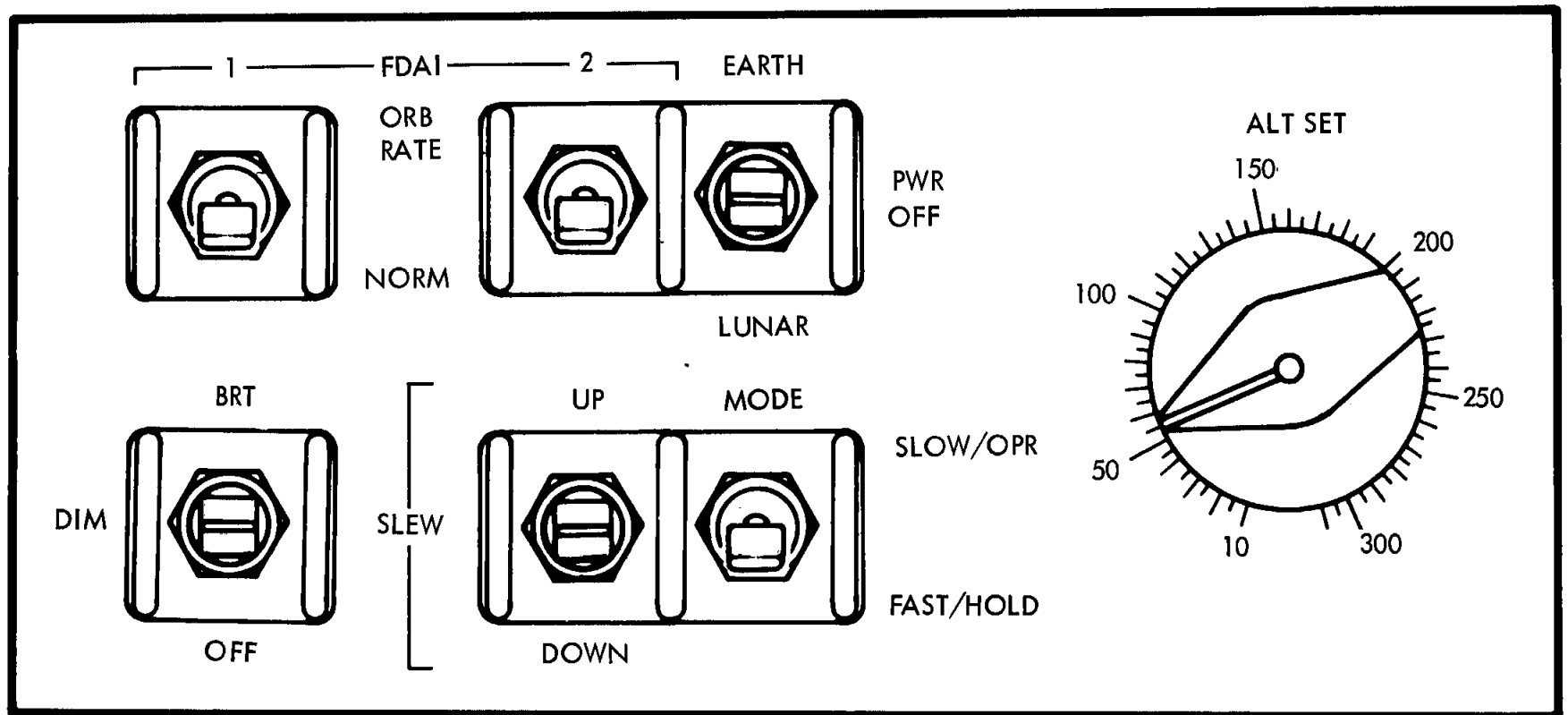
- (1) ATTITUDE AND ATTITUDE ERROR TO FDAI #1 FROM G&N AND TO FDAI #2 FROM THE SCS
- (2) DURING ENTRY, STABILITY ROLL ONLY IS SUPPLIED TO THE FDAI SELECTED AND TO THE ROLL STABILITY INDICATOR ON THE ENTRY MONITOR SYSTEM.
- (3) BMAG UNCAGE LOGIC MUST ALSO BE SATISFIED IN ADDITION TO SWITCHES SHOWN.
- (4)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

CHART 1

SCS-2804B



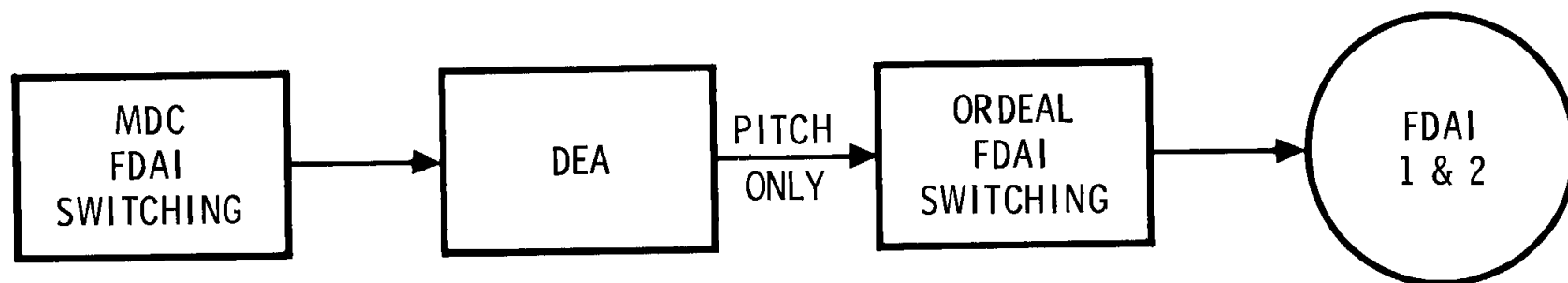
# ORDEAL PANEL



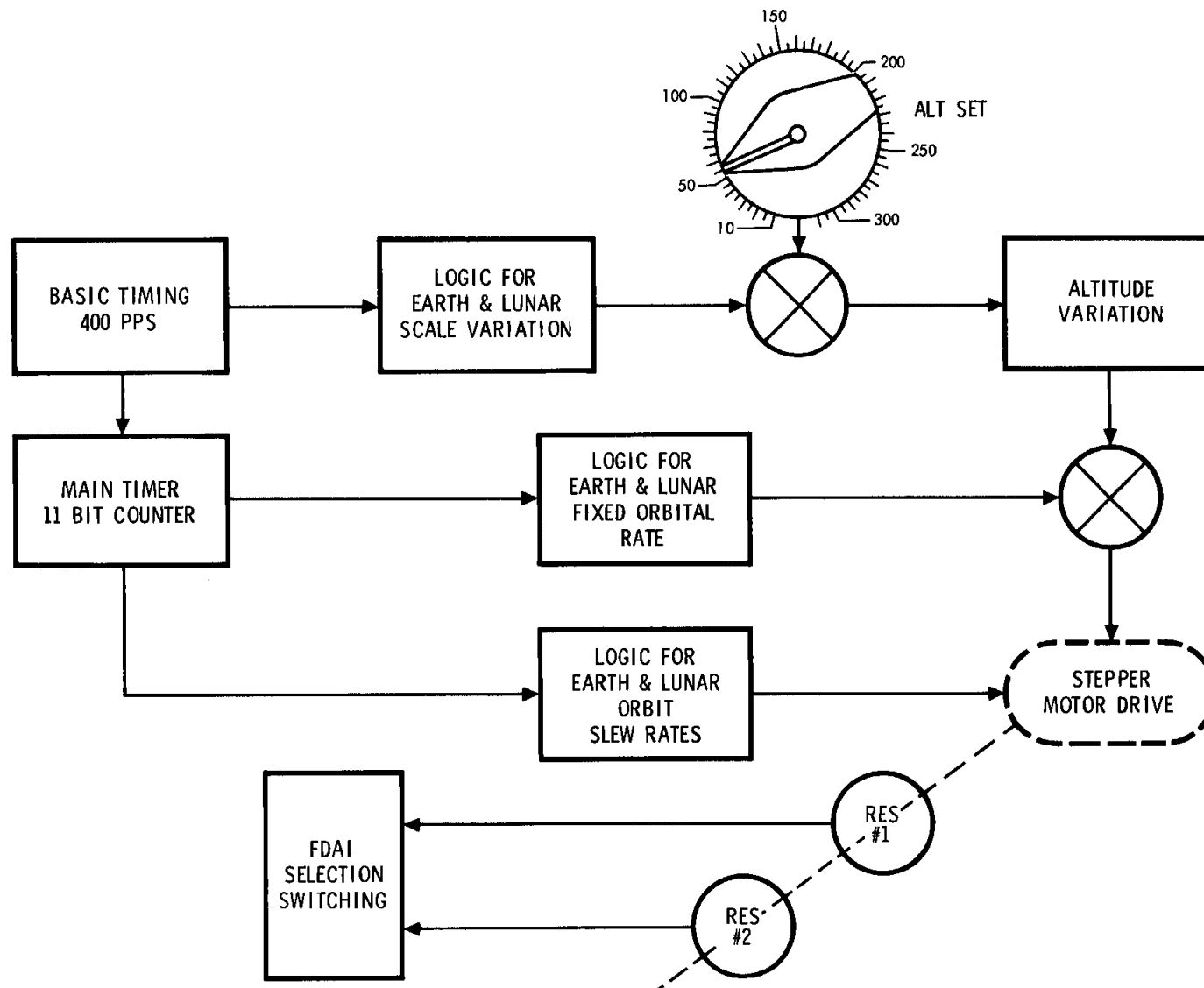
*Orbital  
Route  
Drive Electronics  
Apollo  
LM*

# ORDEAL INTERFACE

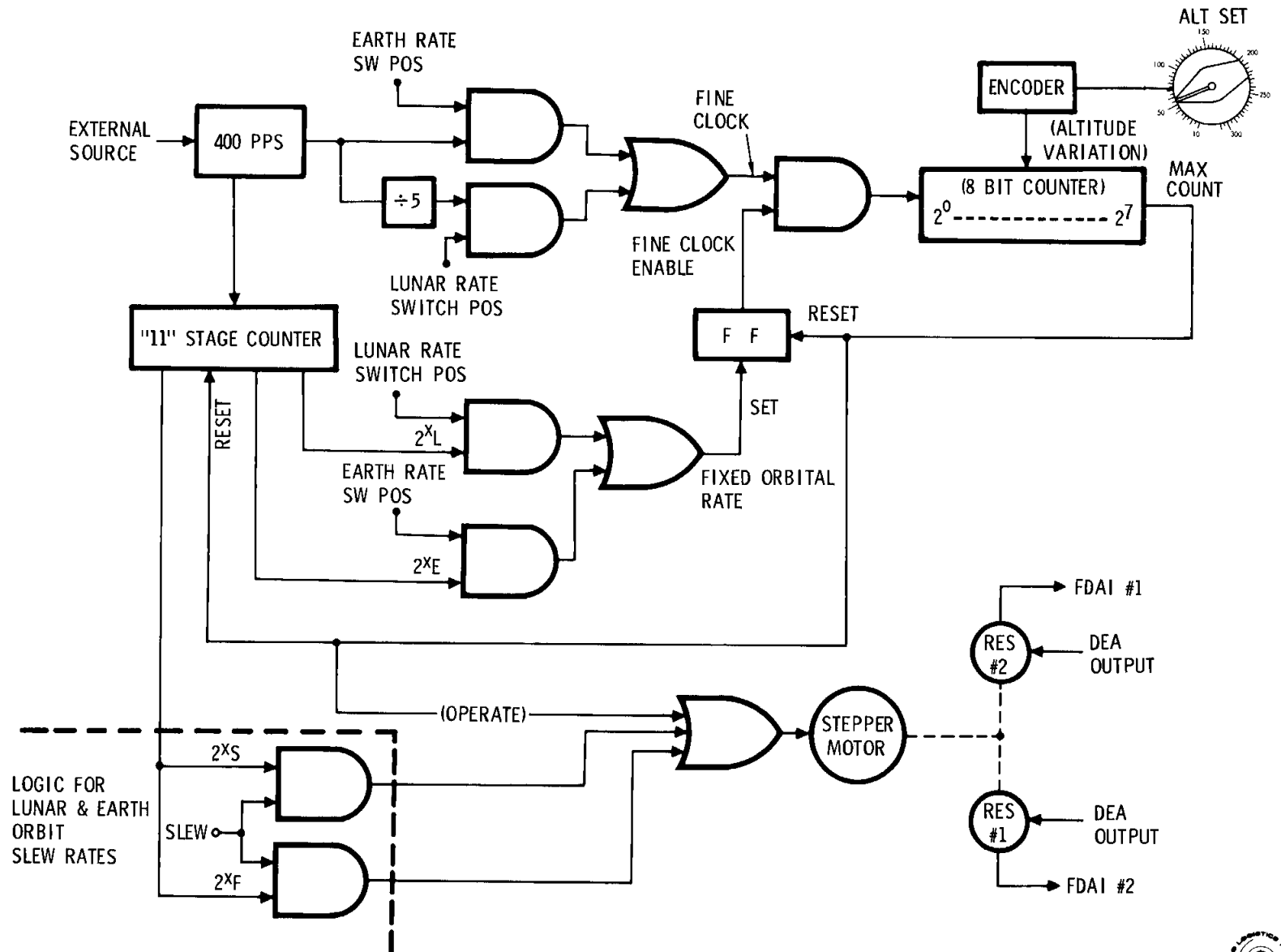
Provide Astro. with visual  
indication of local vertical  
(pitch only) in plane  
1°



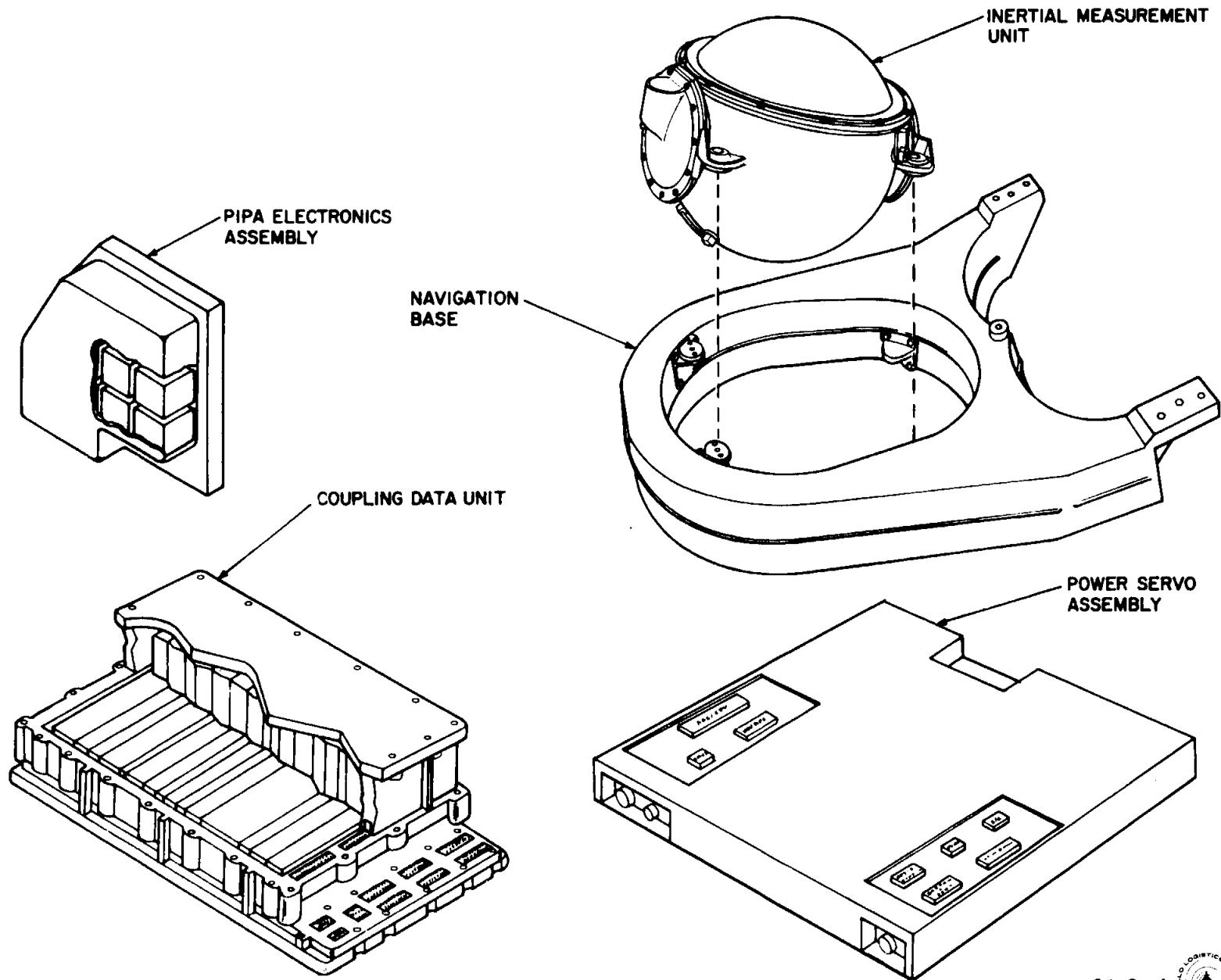
# ORDEAL FUNCTIONAL BLOCK DIAGRAM



# ORDEAL SIGNAL FLOW DIAGRAM



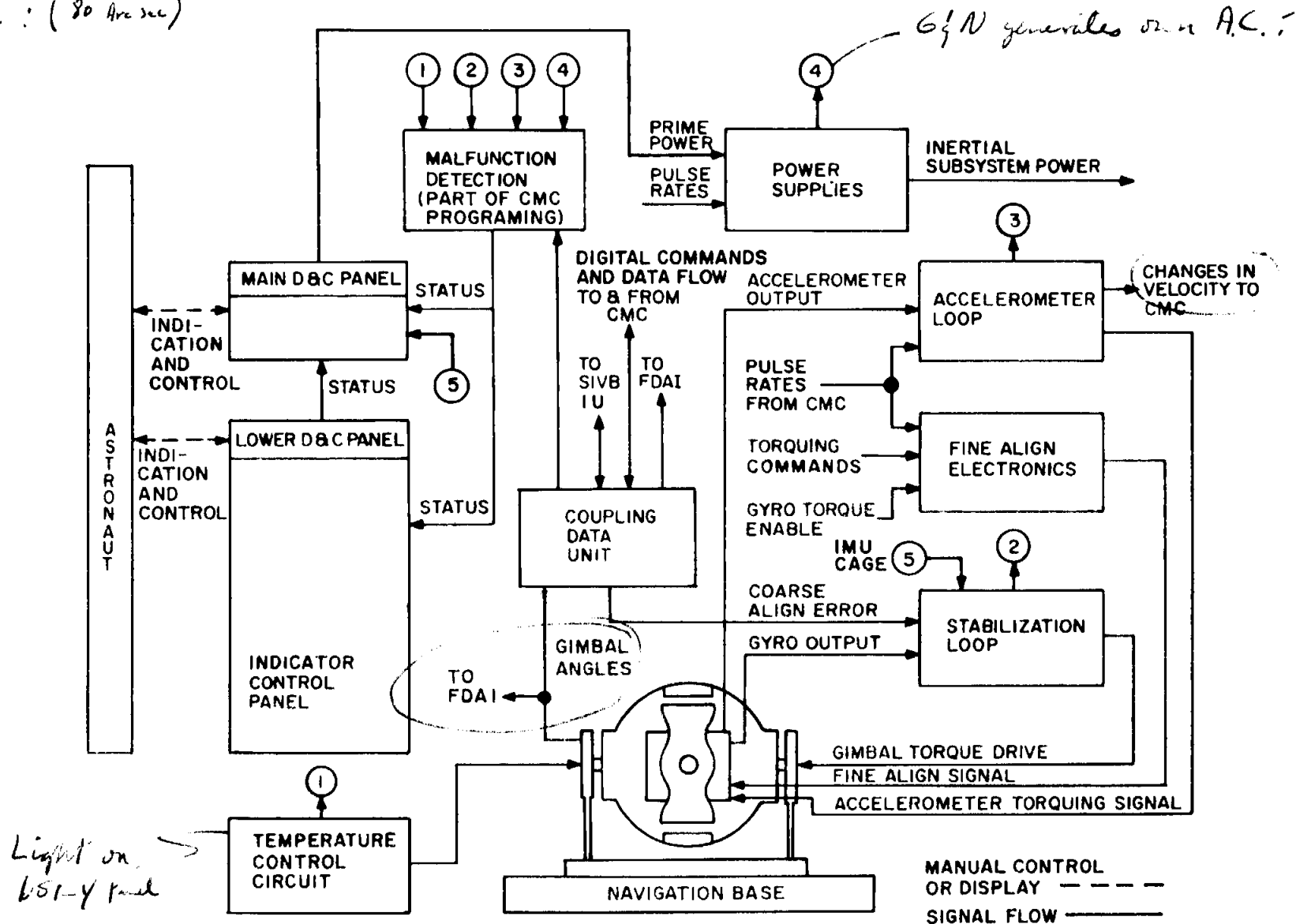
# ISS EQUIPMENT



Course Align: ( $1^\circ - 1.5^\circ$ )

Fine Align: (80 Arc sec)

# INERTIAL SUBSYSTEM INTERFACE

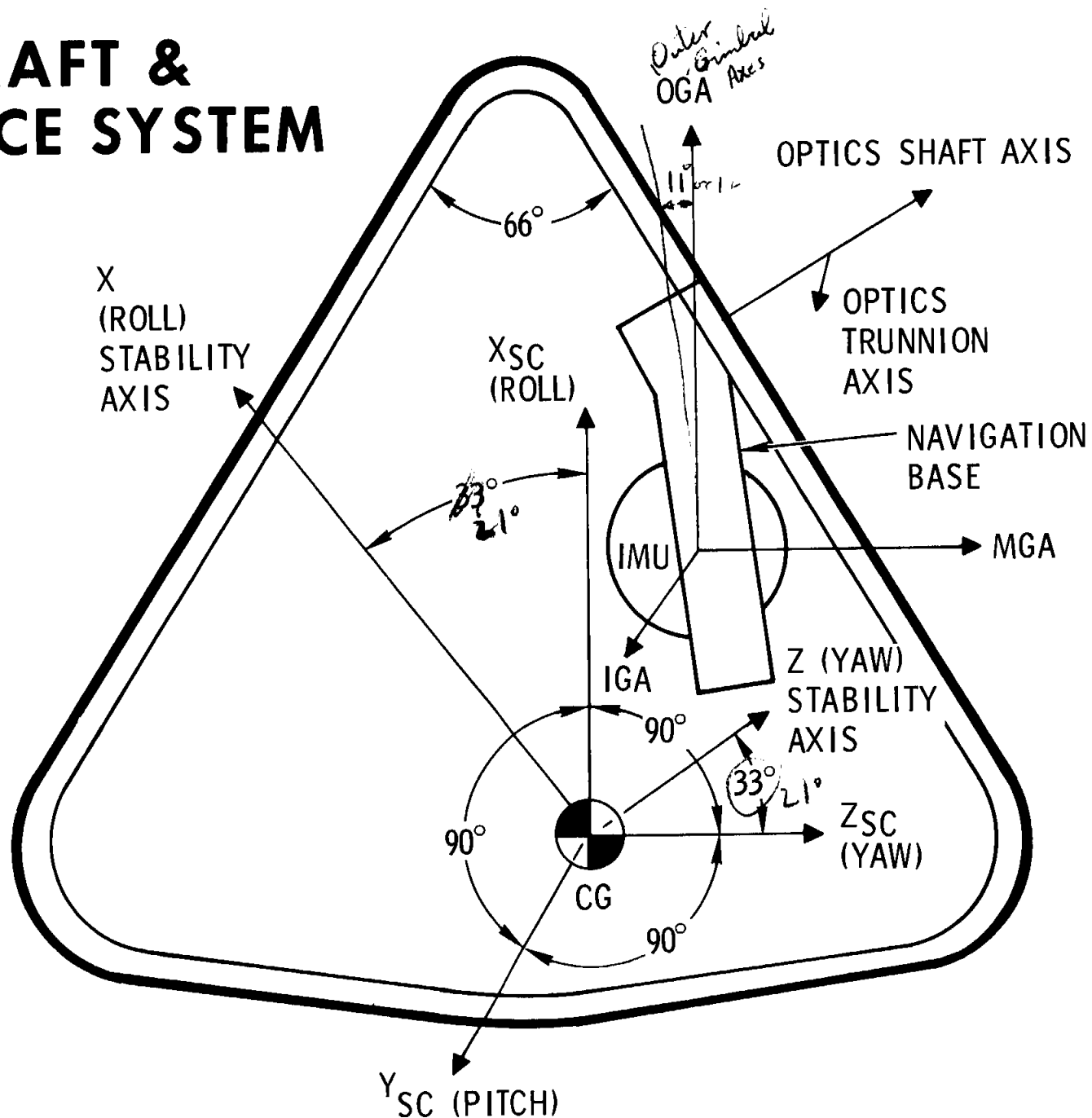


Uncaged means platform is providing an inertial ref. frame & measures s/c motion w/ this ref.  
 Caged means moving etc doesn't get input from 205 --- Gimbal angle driven to zero.

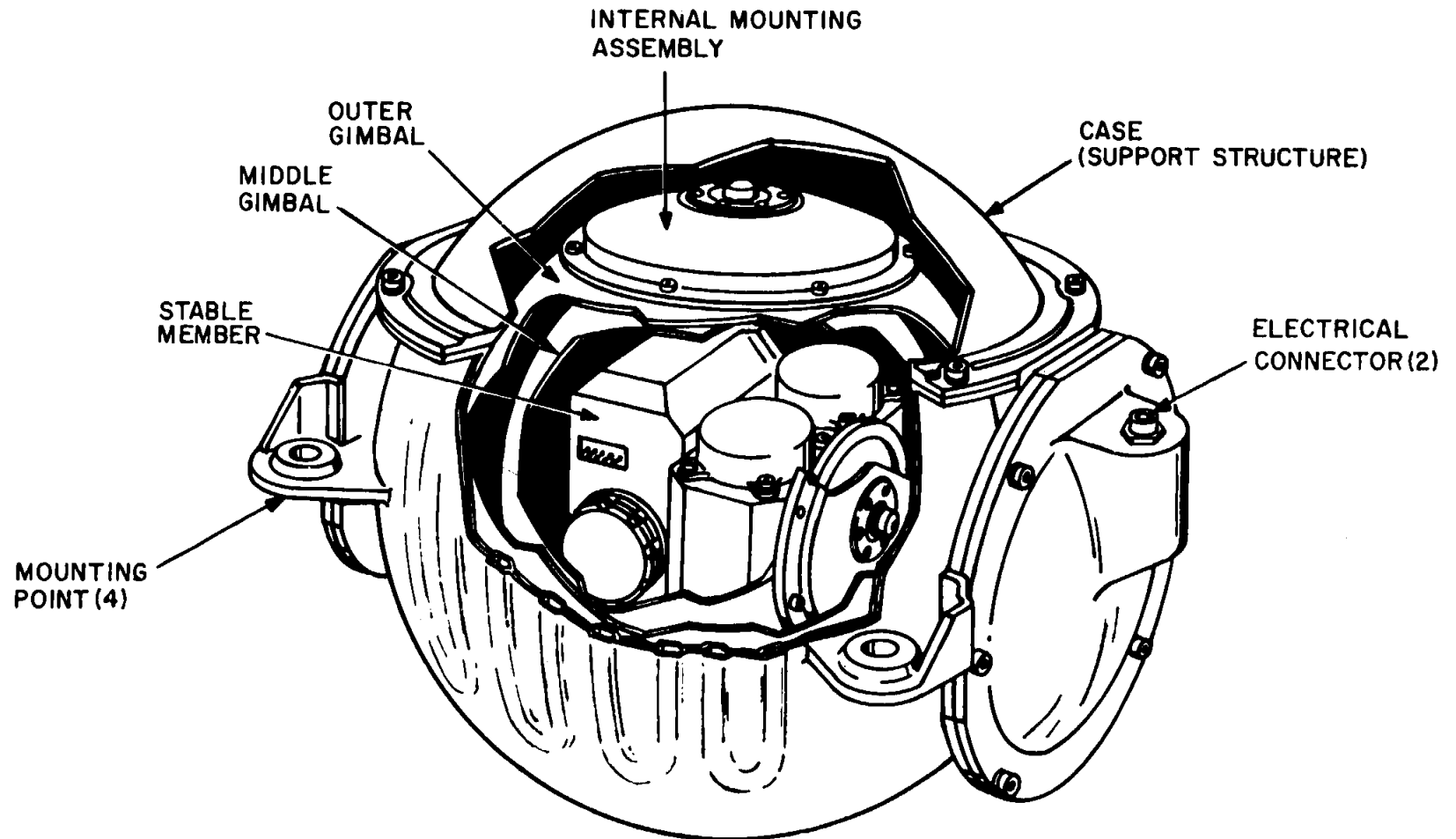
GNC-8



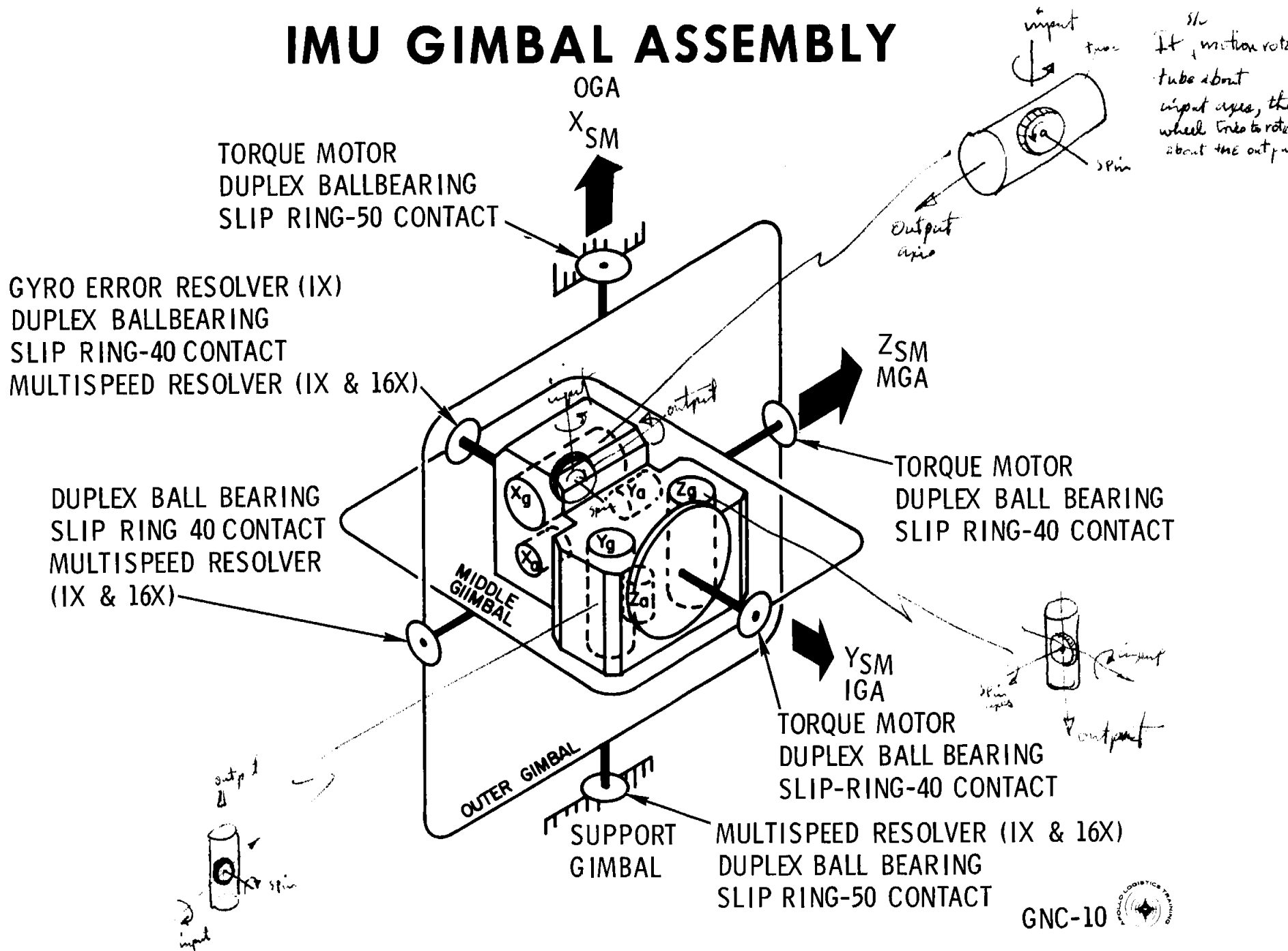
# SPACECRAFT & GUIDANCE SYSTEM AXES



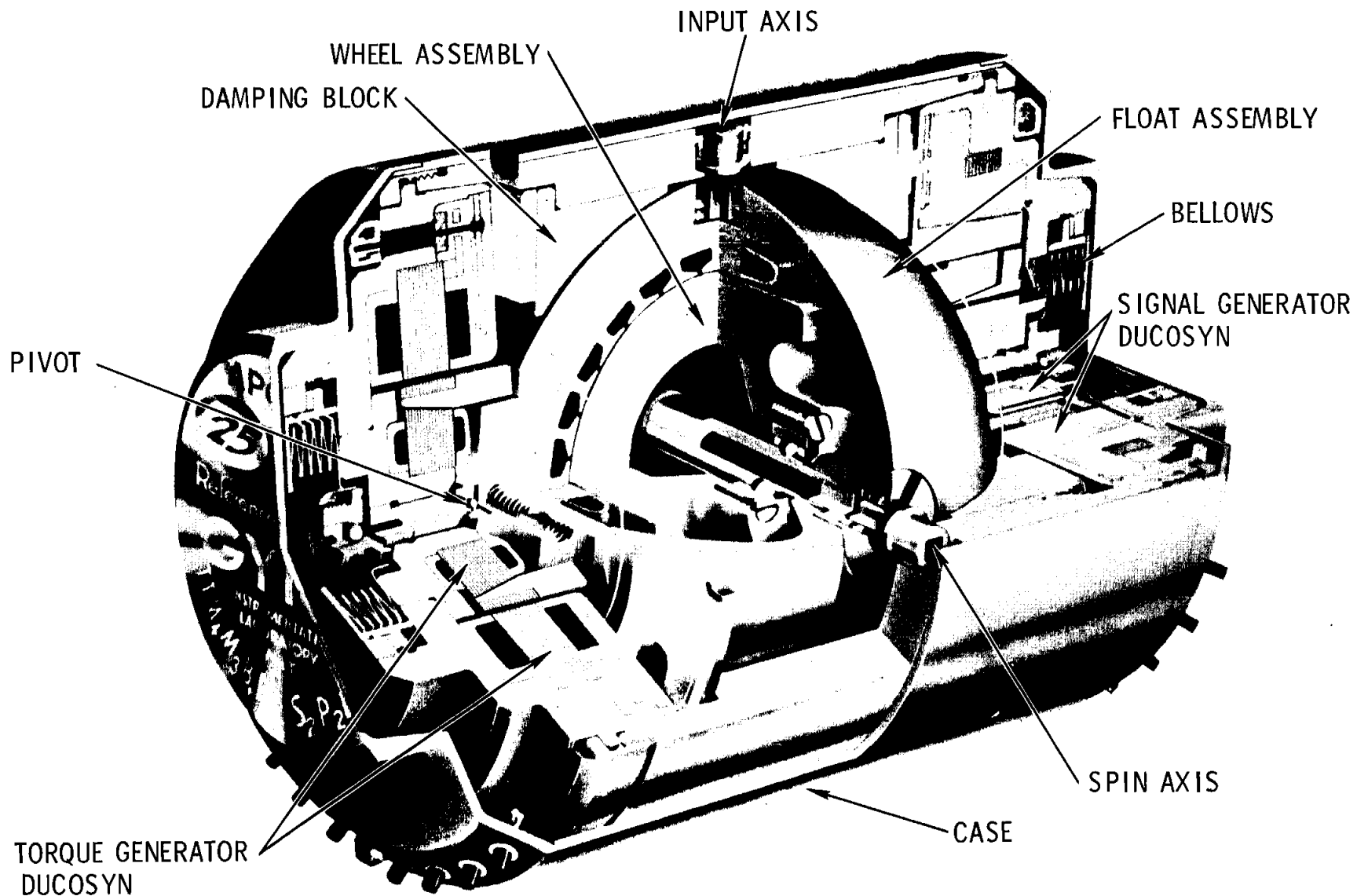
# INERTIAL MEASUREMENT UNIT



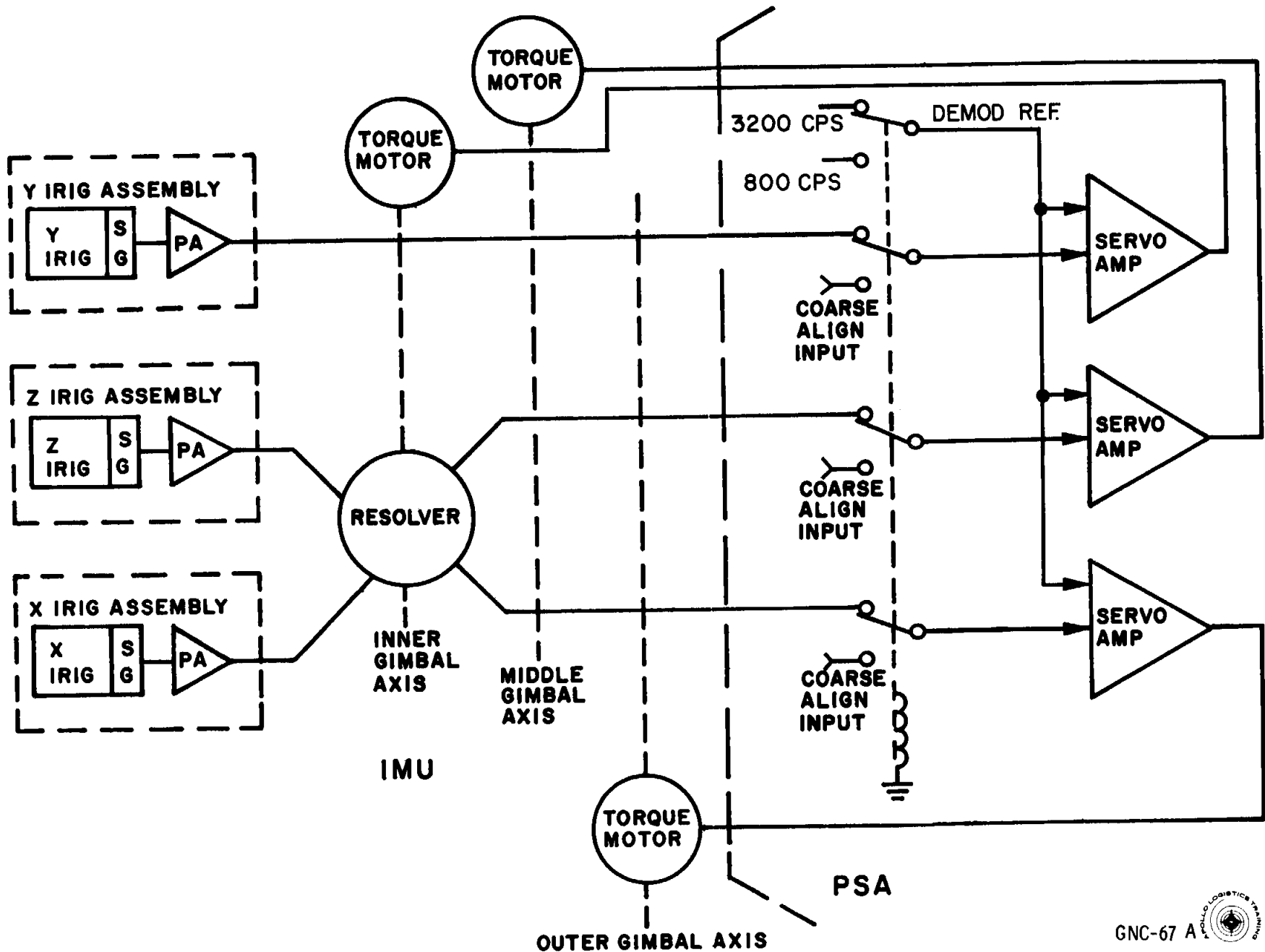
# IMU GIMBAL ASSEMBLY



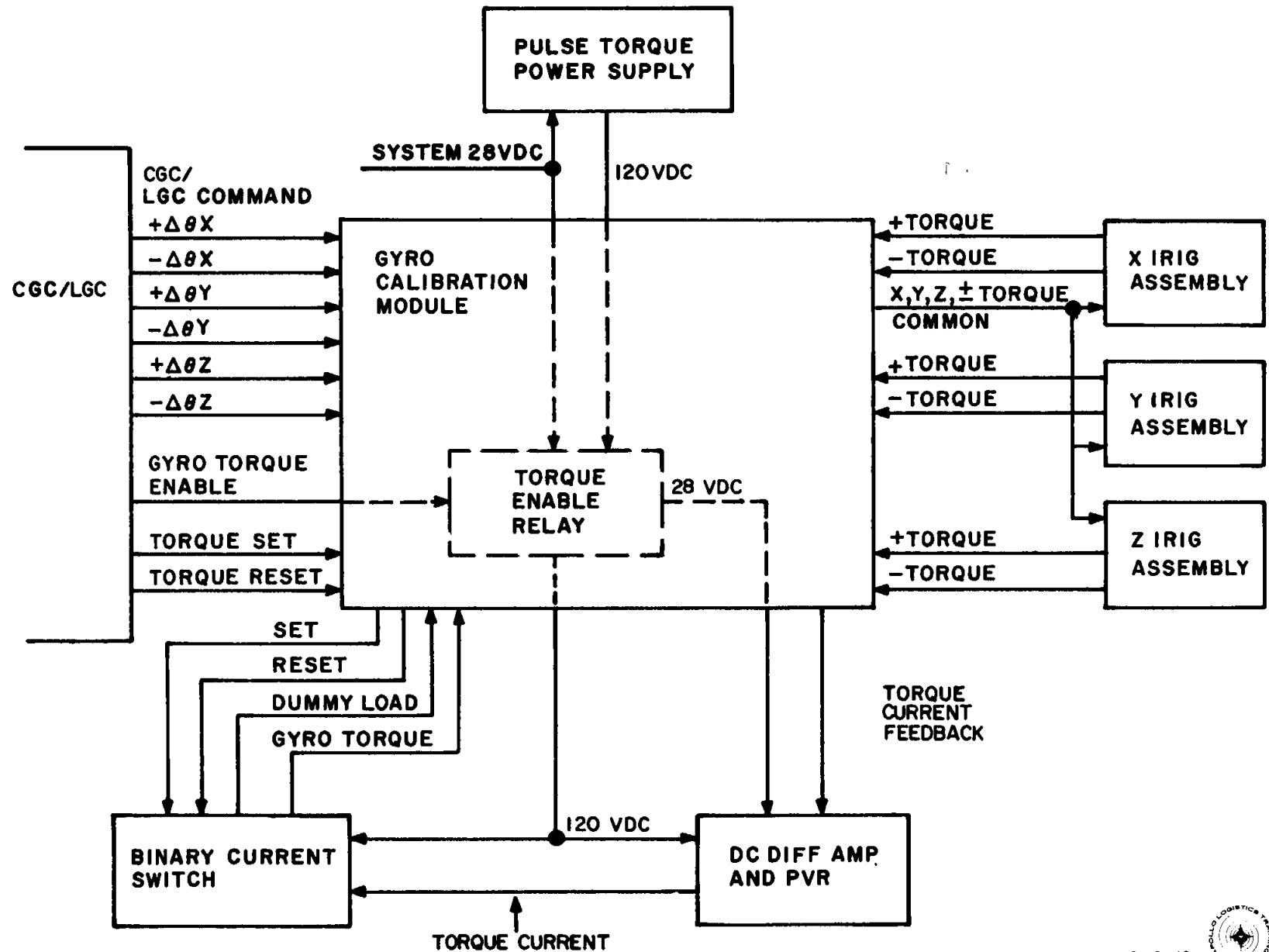
# 25 IRIG



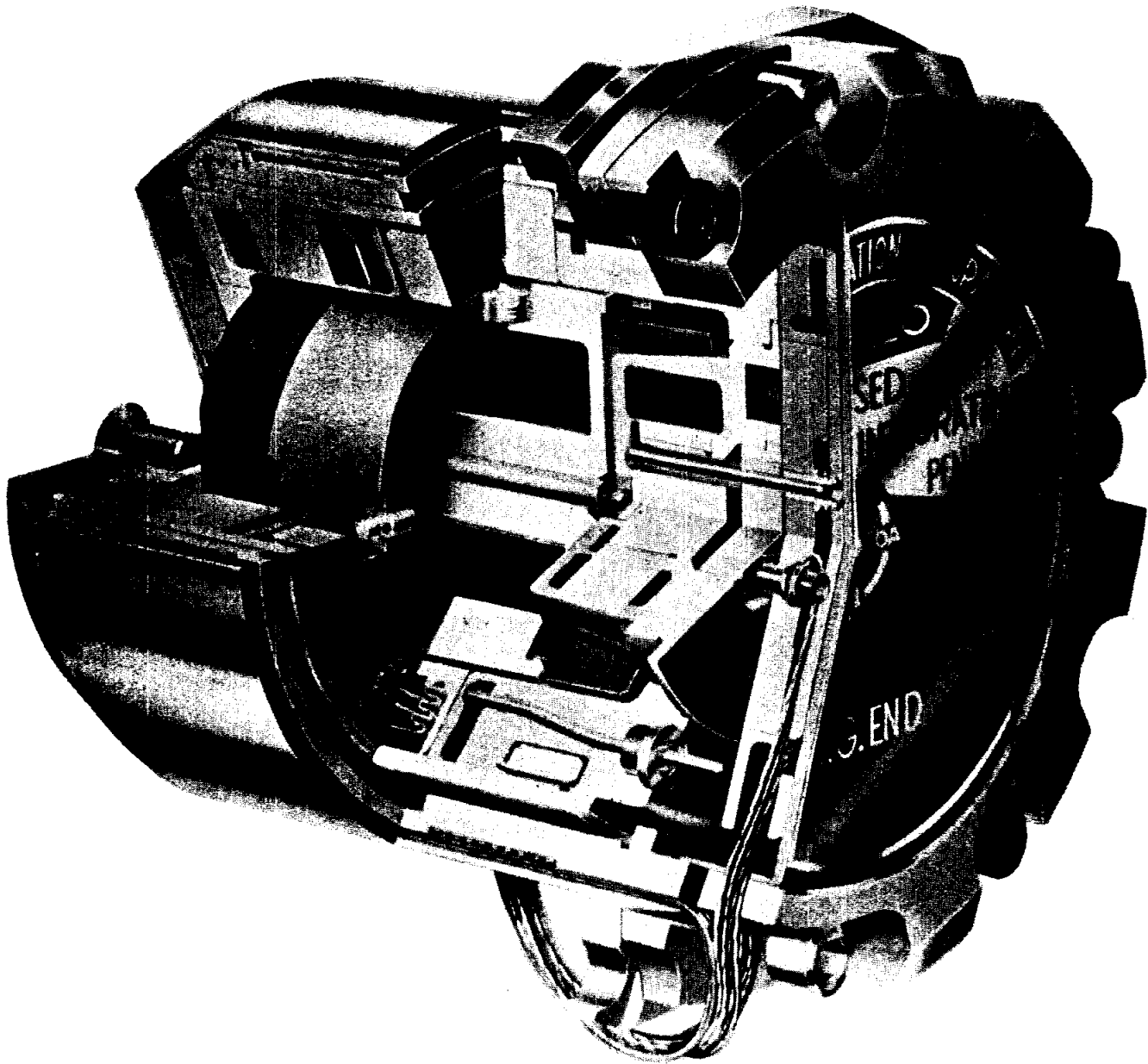
# BLOCK II STABILIZATION LOOPS



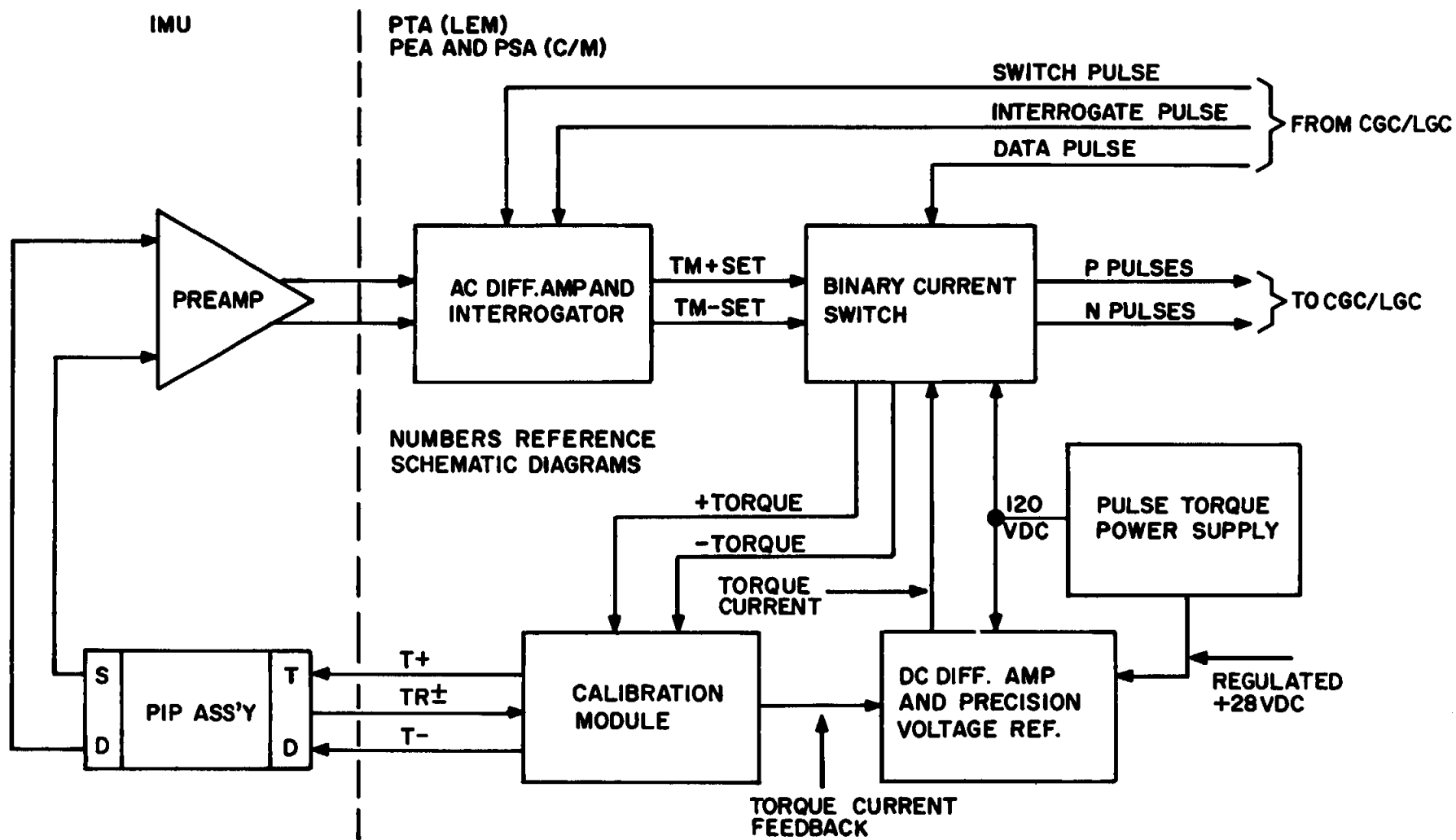
# FINE ALIGN ELECTRONICS



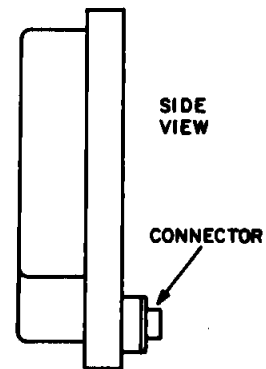
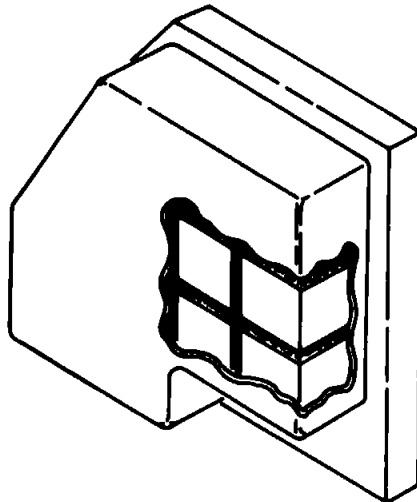
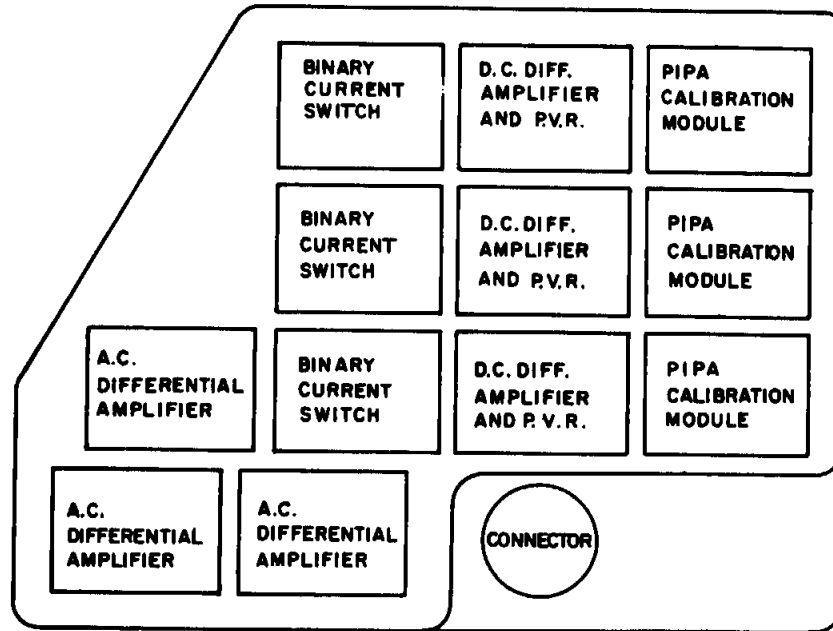
# PIP



# BLOCK II ACCELEROMETER LOOP



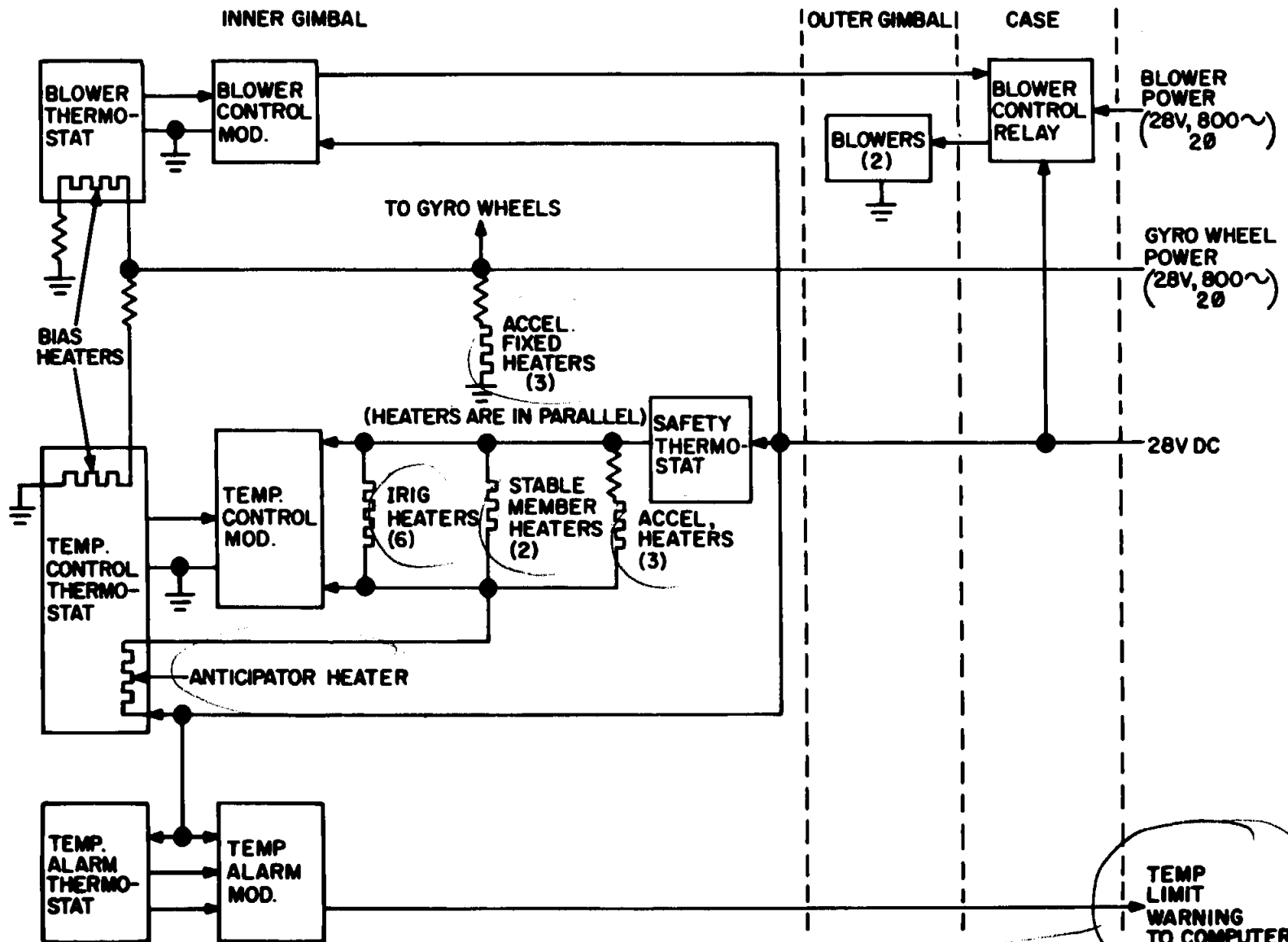
# PIP. ELECTRONICS ASSEMBLY



6 heaters

# TEMPERATURE CONTROL SYSTEM

located on IMU



⊗ Normal temp 158°

Heater/amplifier deteriorates with temp.

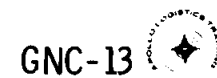
⊗ What limits (temp) before you wouldn't use much?

No control over this.

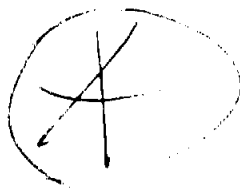
GNC-81



⊛ See Iss Modes  
on Addendum



P05 on  
P06 off



except in L.I. Mode

ISS Modes

1. IMU - Turn On P05 P06
2. IMU - cage
3. Coarse Align } P05
4. Fine Align }
5. Inert. Ref.
6. Htt. Error Display

CMC Standby:  
bit operates & then

# IMU TURN-ON MODE

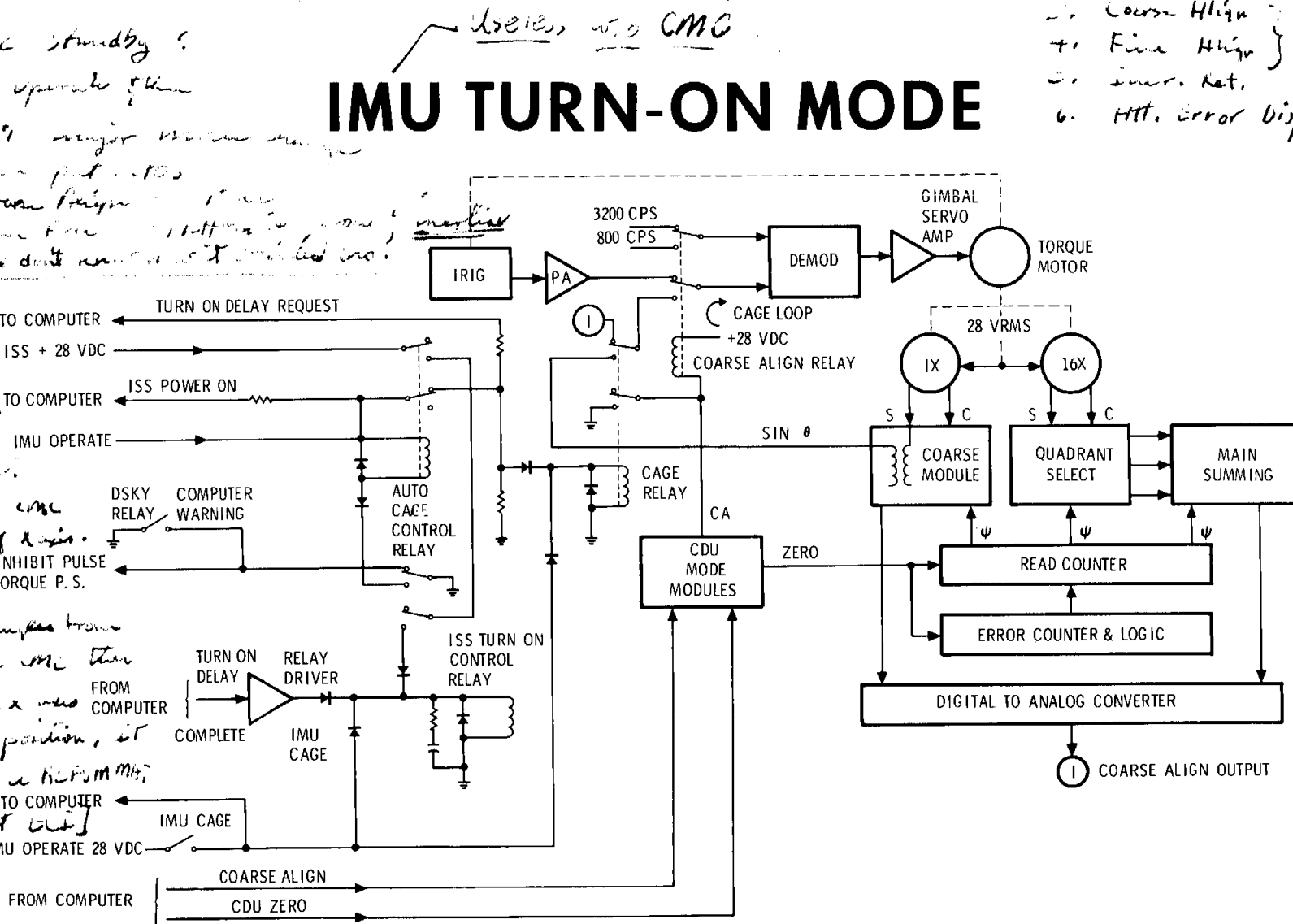
1. V29 major machine change  
and put into

Coarse Align - Inertial  
time from 1st turn on to 1st inertial  
we don't know if it's inhibited or not.

like -  
it's signals  
the X, Y  
points to start.

and gives CMC  
direction of axis.

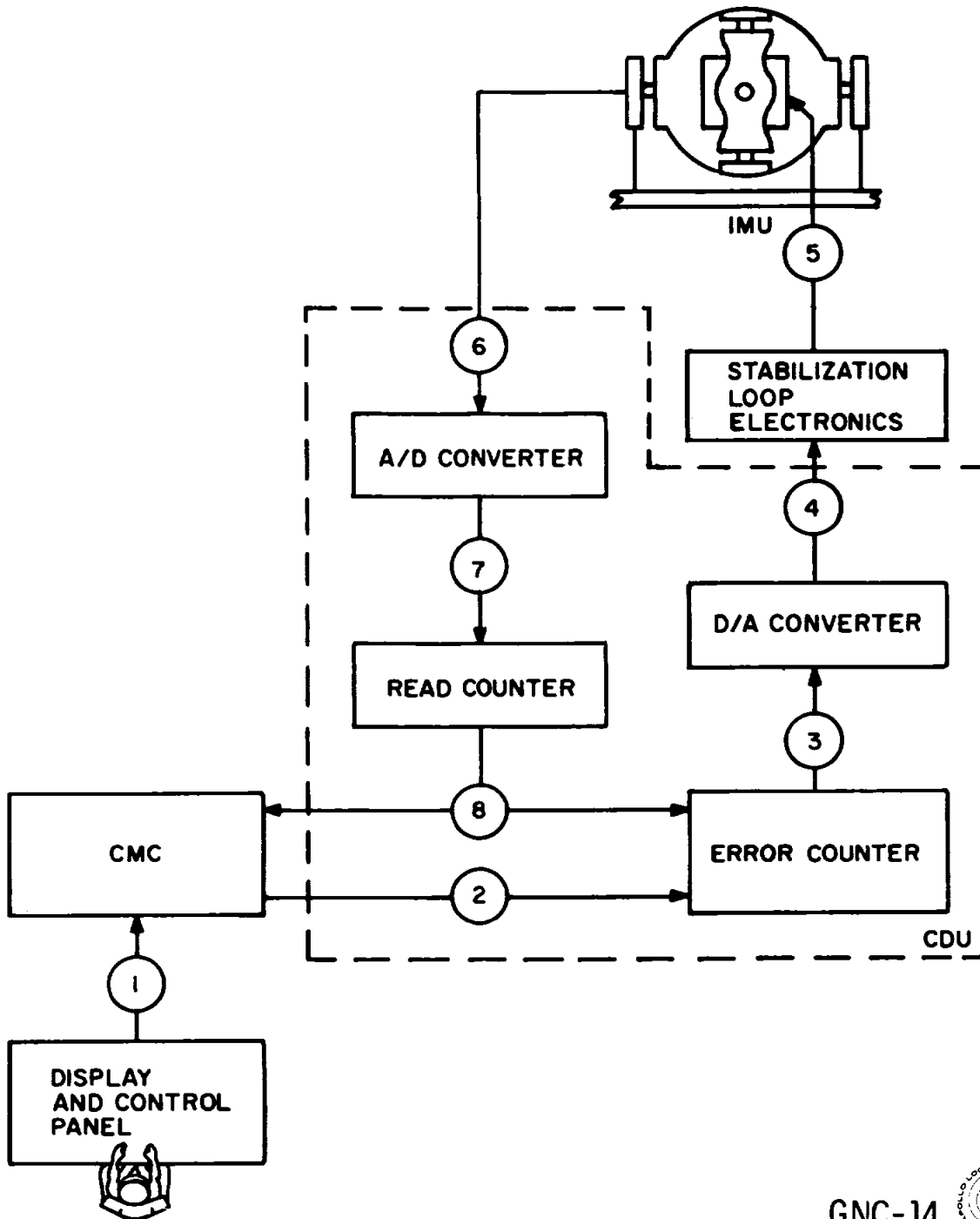
turning  
the star angles from  
45 deg, the CMC then  
moves the axis  
to 0 deg position, it  
then moves a bit from 0 deg  
to 1 deg and back to 0 deg.



F51  
Find IMU  
not CMC

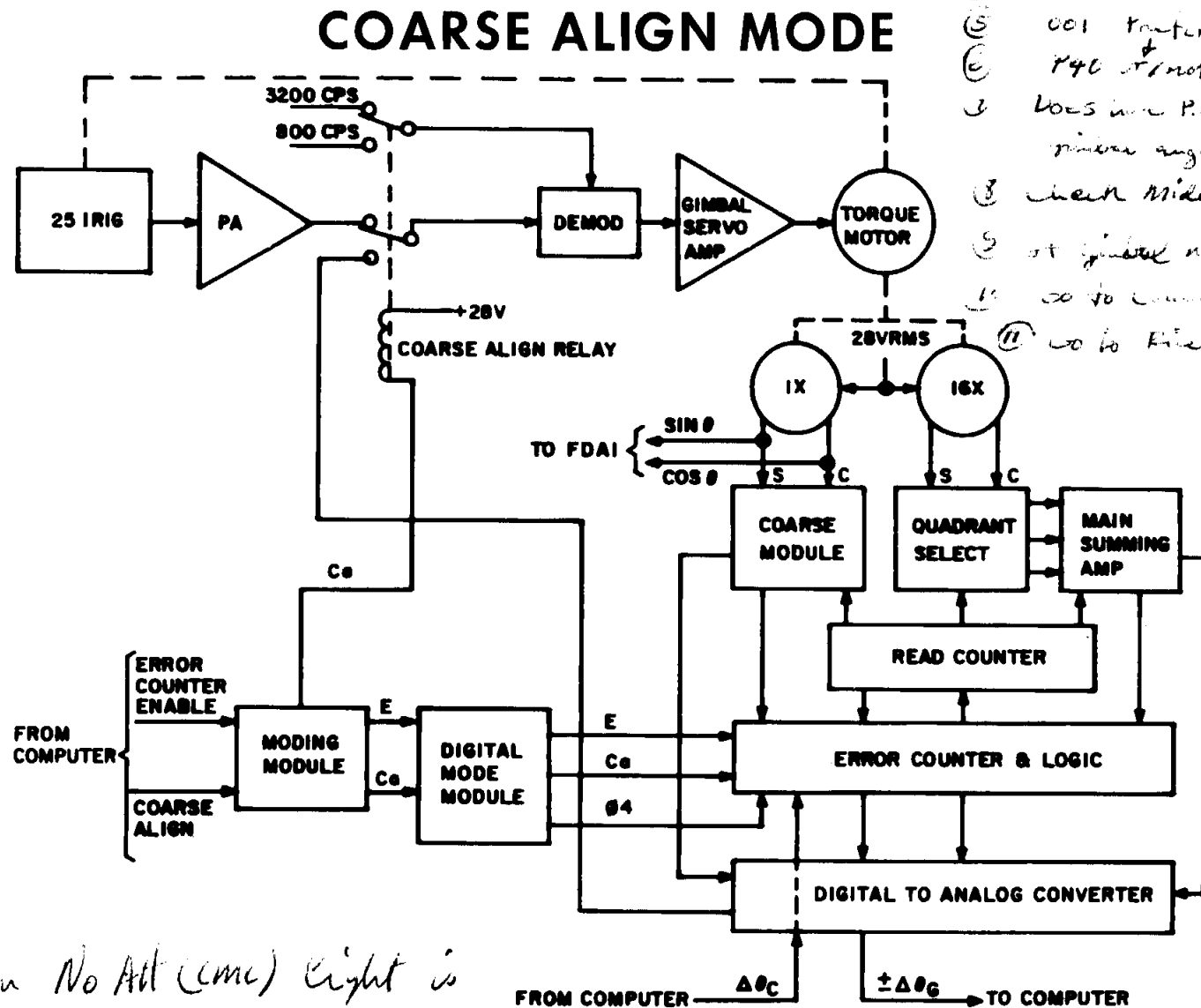
\* Need start here like  
to get out of state. Start in CMC

# COARSE ALIGN MODE



Mod. 1118 High Platform  
① VSI → P52

- ② Turn on 200 CS
- ③ P51 Fide 2nd int 6 sec
- ④ 001 Performance Unimpaired
- ⑤ P40 1st int 10 sec
- ⑥ Does have P.O. Flag for angle
- ⑦ Check Middle point 60°
- ⑧ 1st gimbal move 20 sec
- ⑨ 20 to 30 sec delay
- ⑩ 20 to 30 sec delay

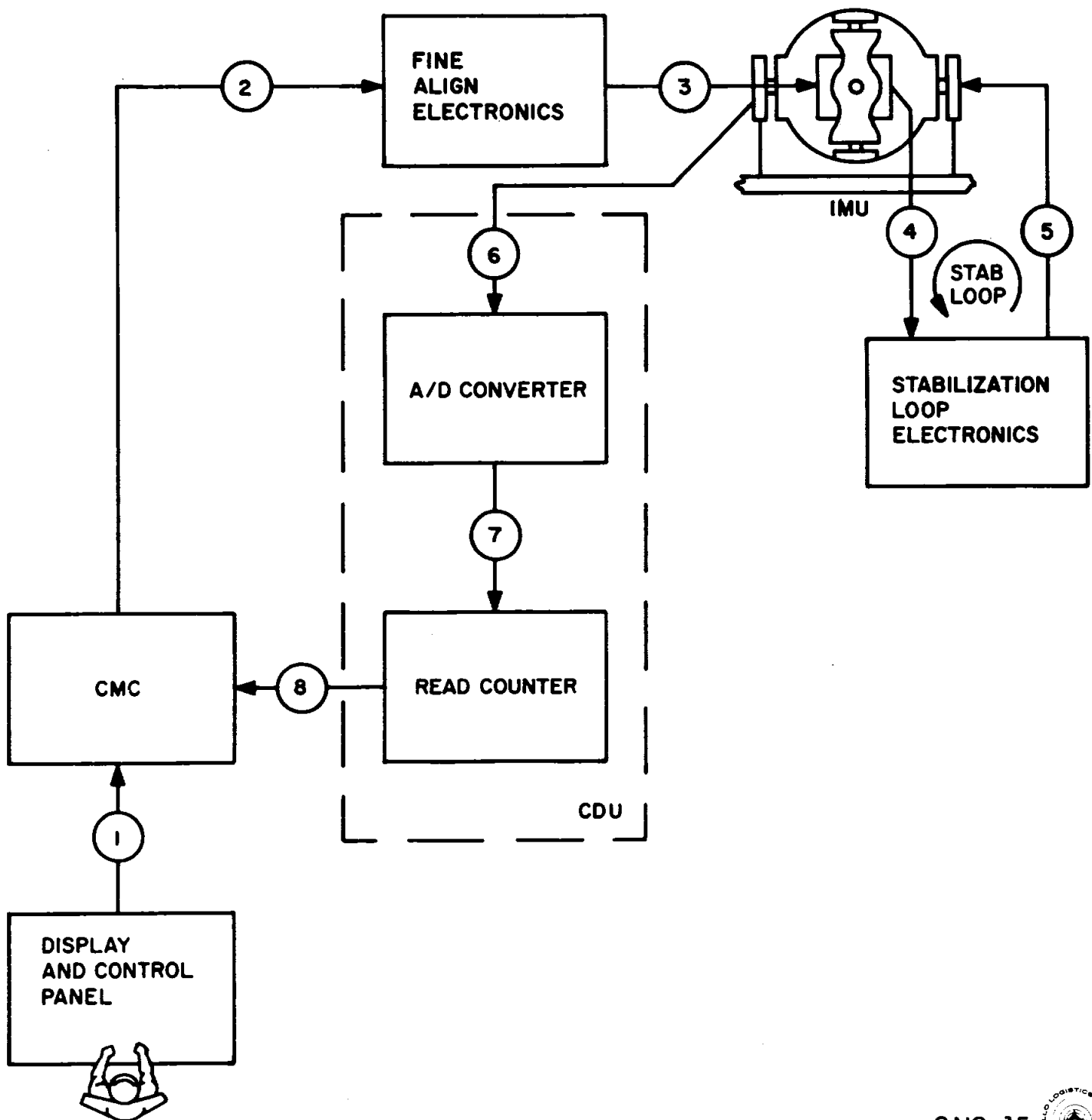


⊗ When No Att (cmc) light is on --- Coarse Align too

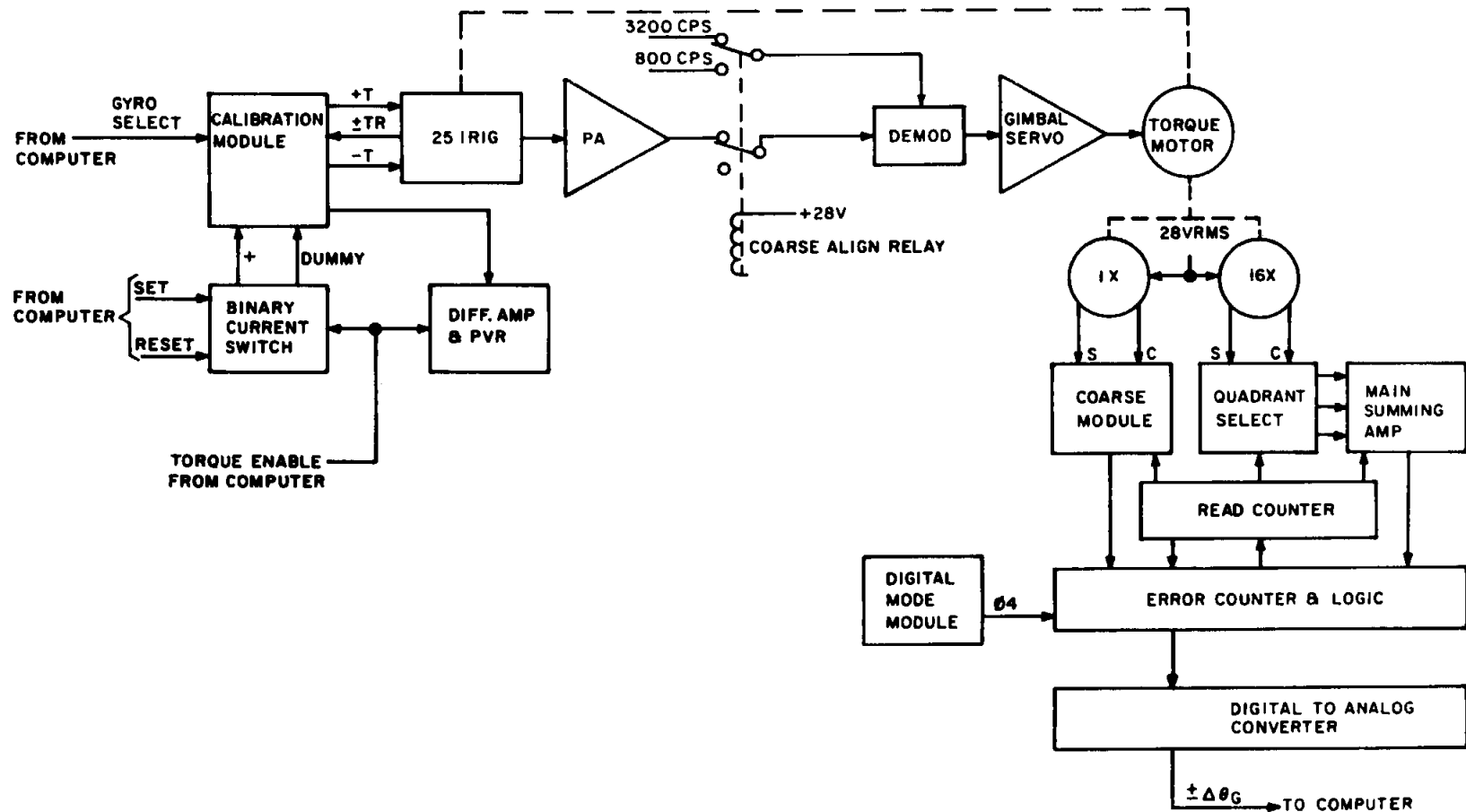
⊗ V&K Y Plankes when coarse align



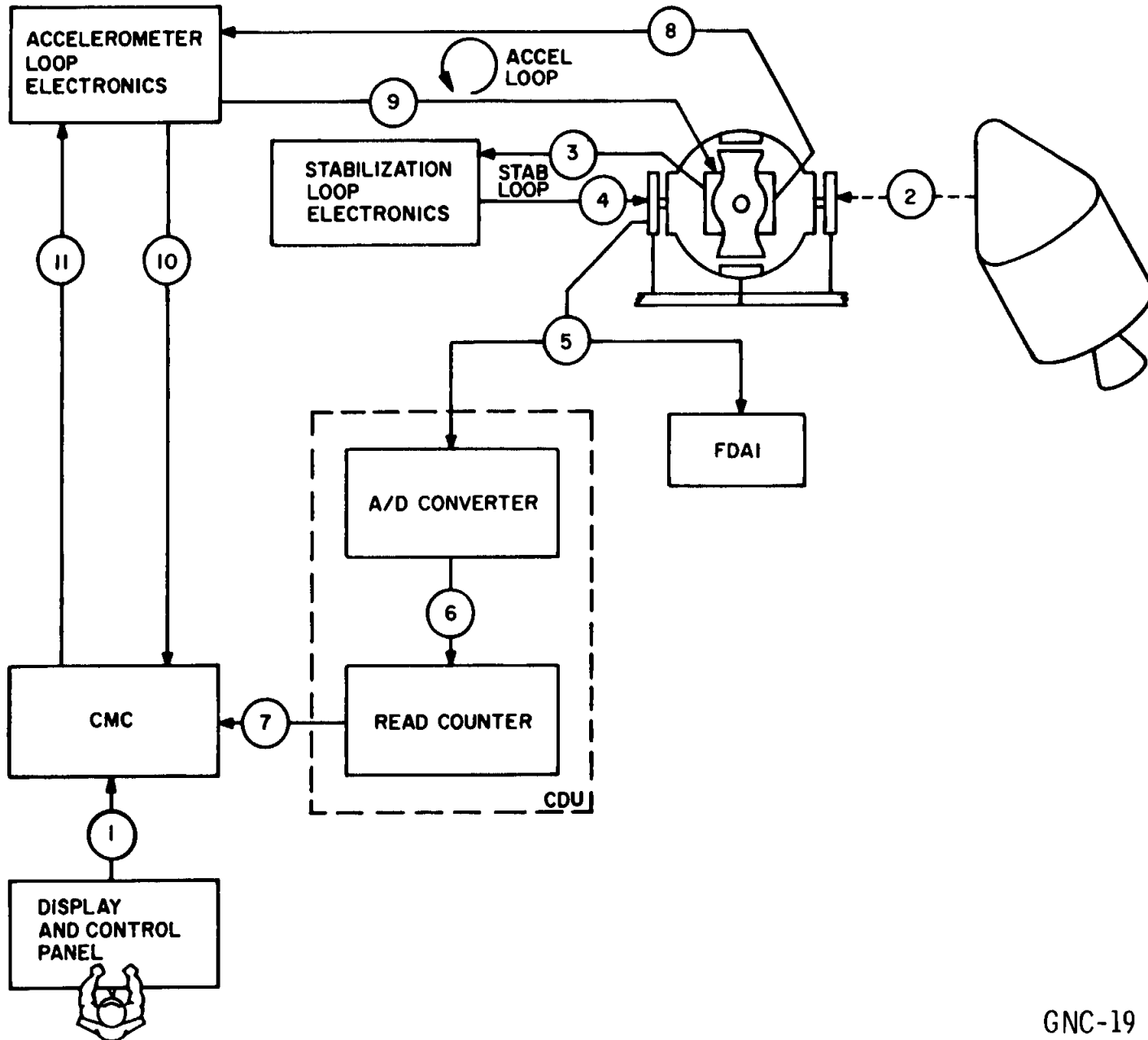
# FINE ALIGN



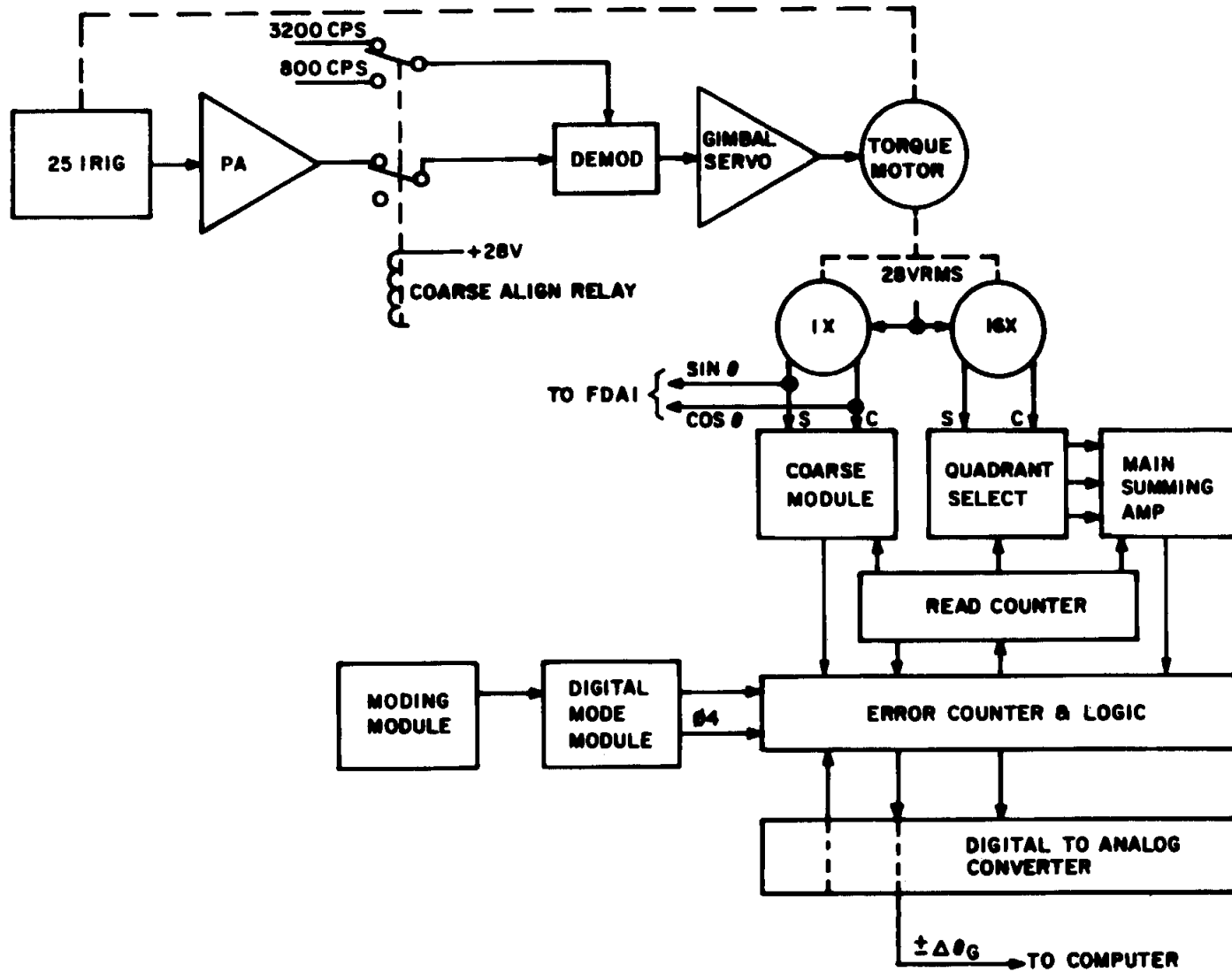
# FINE ALIGN MODE



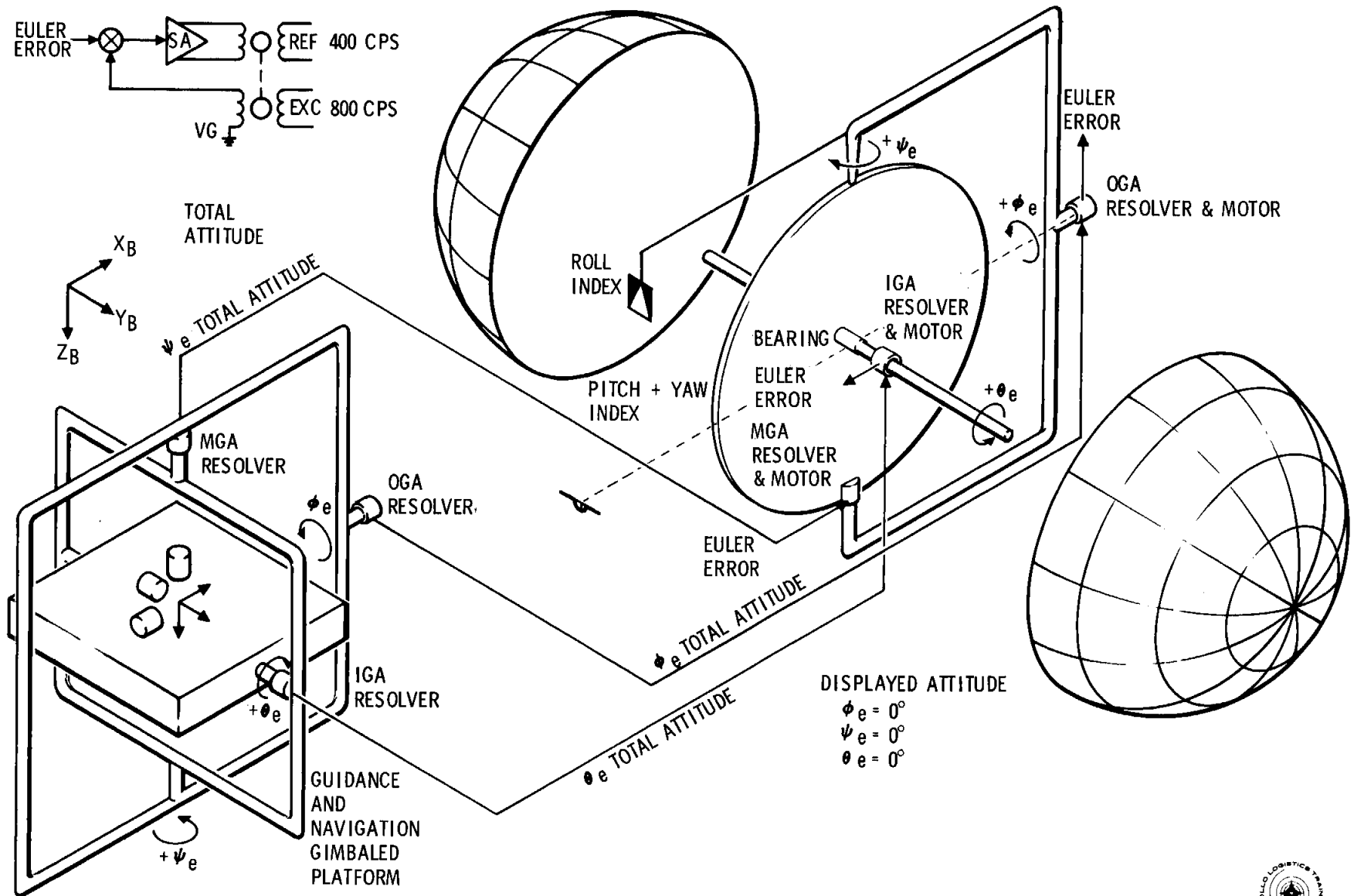
# INERTIAL REFERENCE MODE



# INERTIAL REFERENCE MODE



# FDAI/IMU GIMBAL RELATIONSHIP



Encl 5

PREPARED BY: TFW

NORTH AMERICAN AVIATION, INC.  
SPACE AND INFORMATION SYSTEMS DIVISION

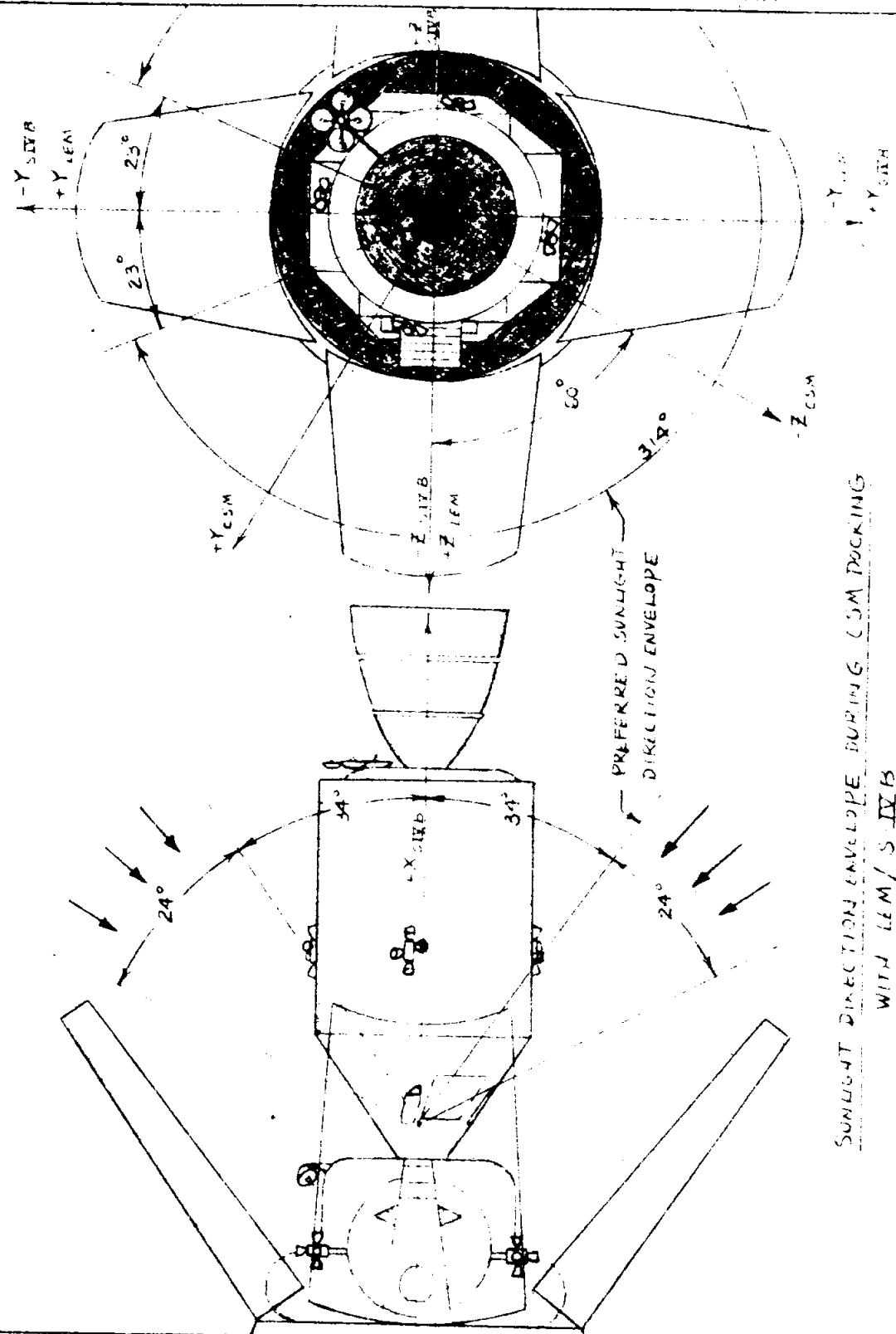
PAGE NO 2-8

CHECKED BY:

REPORT NO.

DATE: 5-17-67

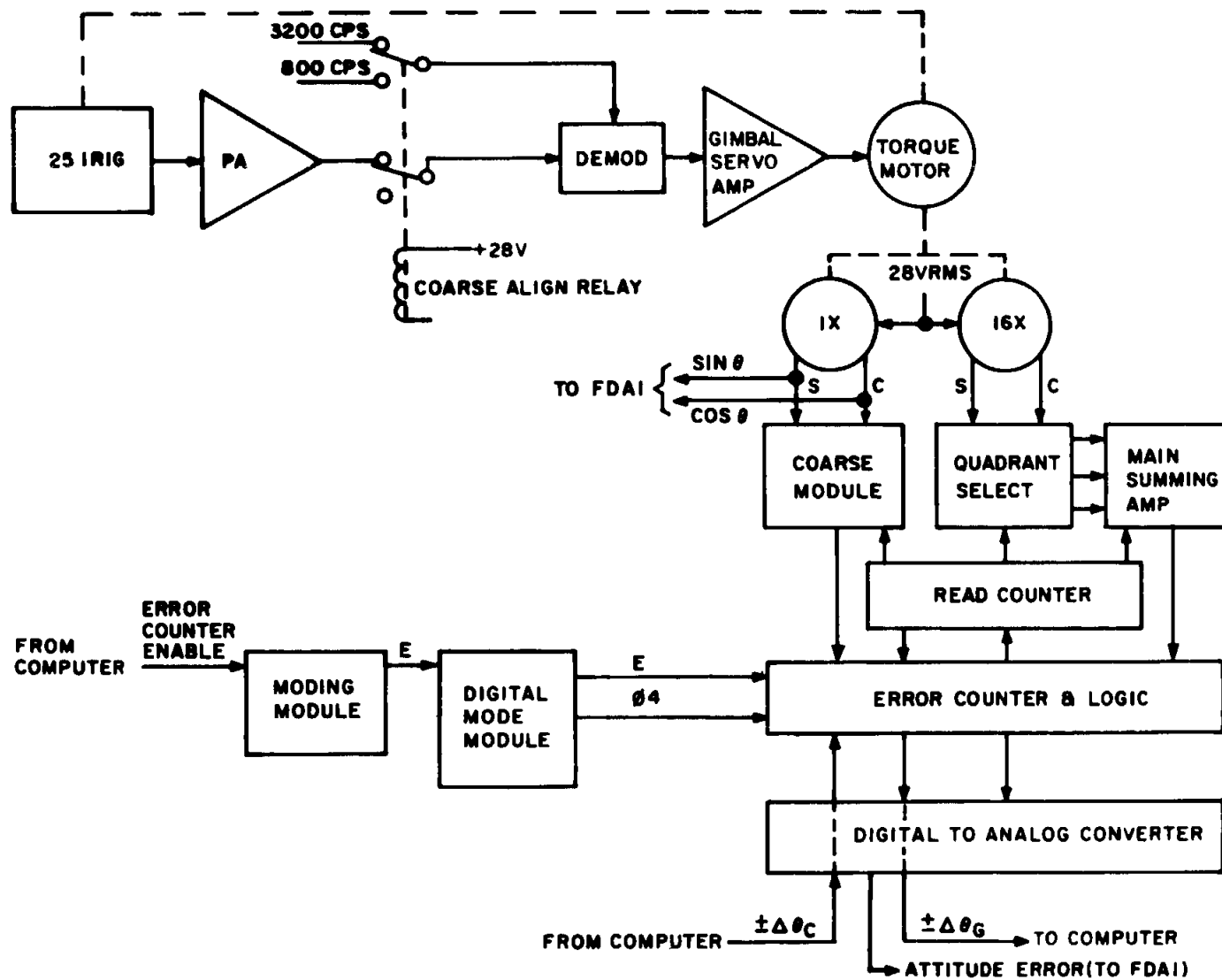
MODEL NO



SUNLIGHT DIRECTION ENVELOPE DURING CSM DOCKING  
WITH LEM/S-IVB

FIGURE 1

# ATTITUDE ERROR DISPLAY



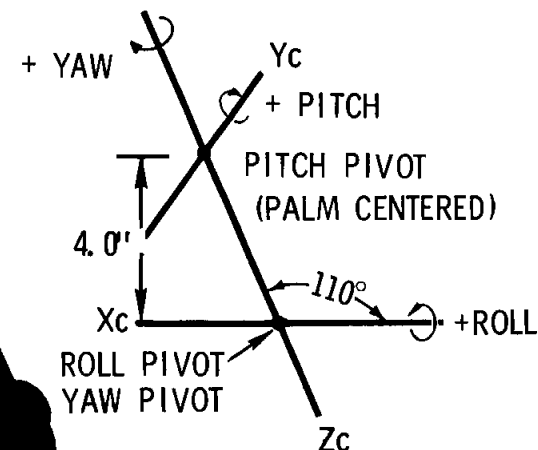
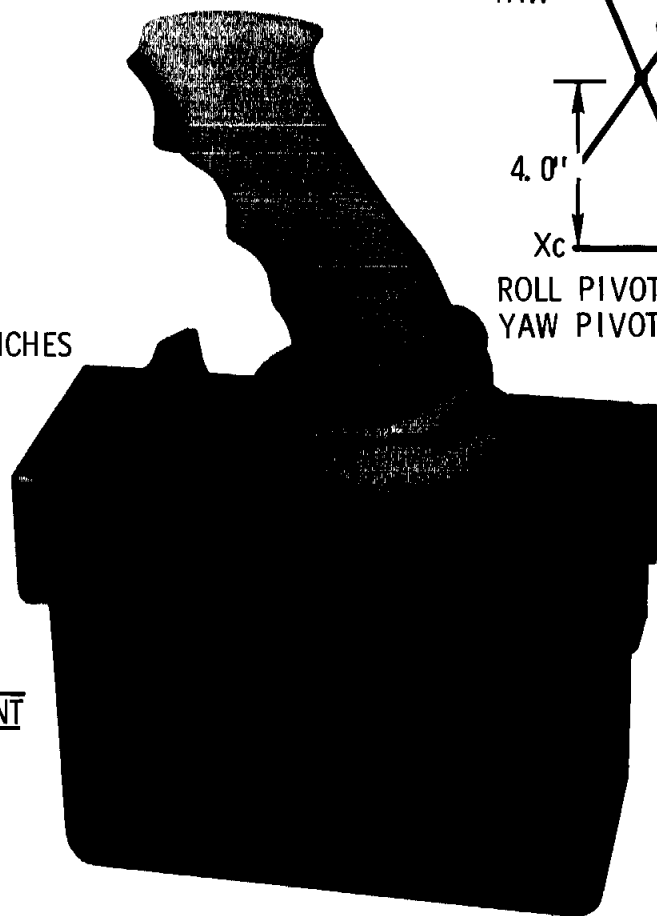
# ROTATION CONTROL

## 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

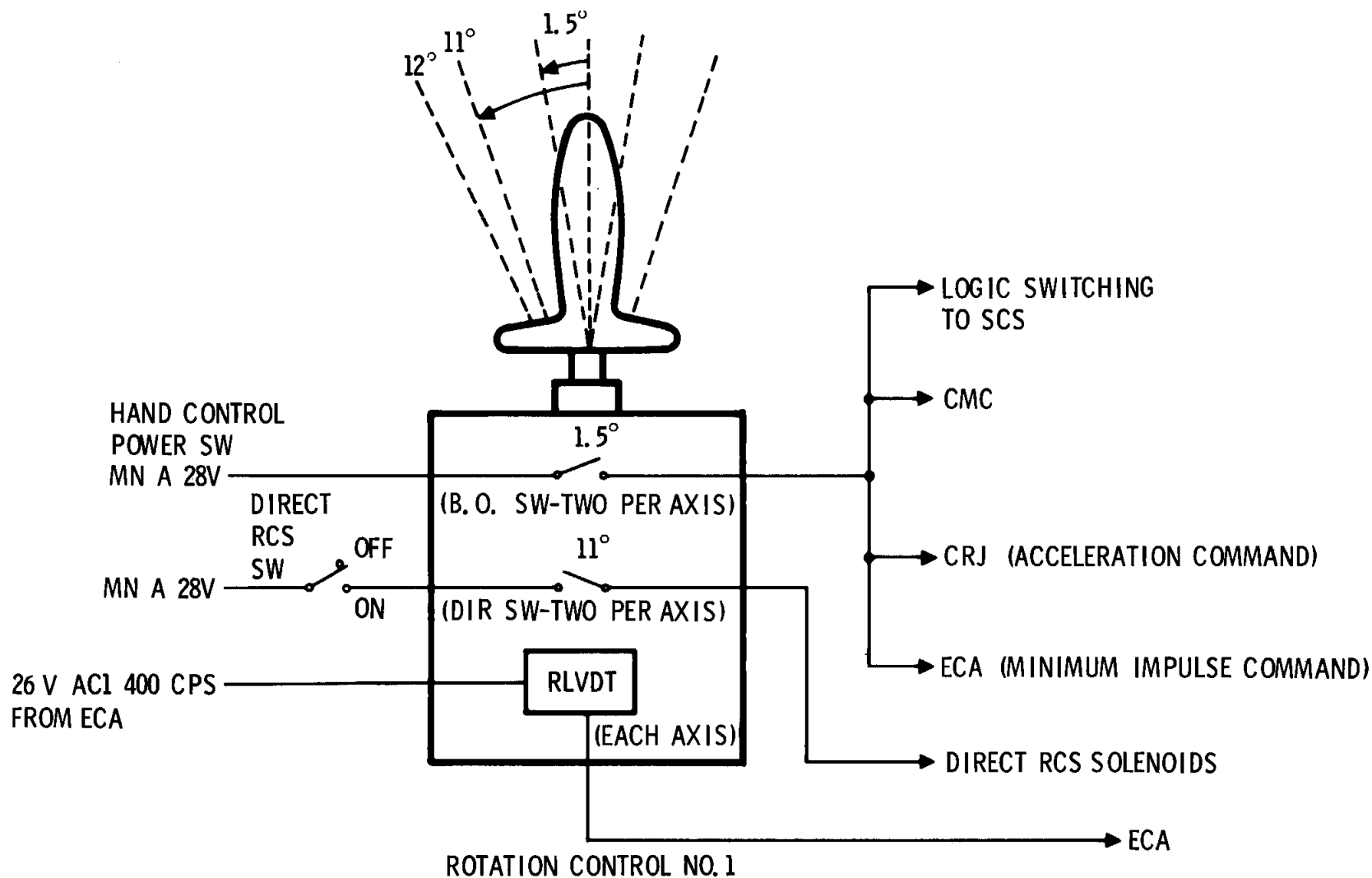
|                           | <u>DISPLACEMENT</u> |
|---------------------------|---------------------|
| HARD STOP                 | 11.5 ± 0.50         |
| DIRECT SWITCH ACTUATION   | ≈ 11.0°             |
| SOFT STOP                 | 10 ± 1°             |
| BREAKOUT SWITCH ACTUATION | 1.5 ± 0.5°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



SCS-2002B



# ROTATION CONTROL INTERFACES



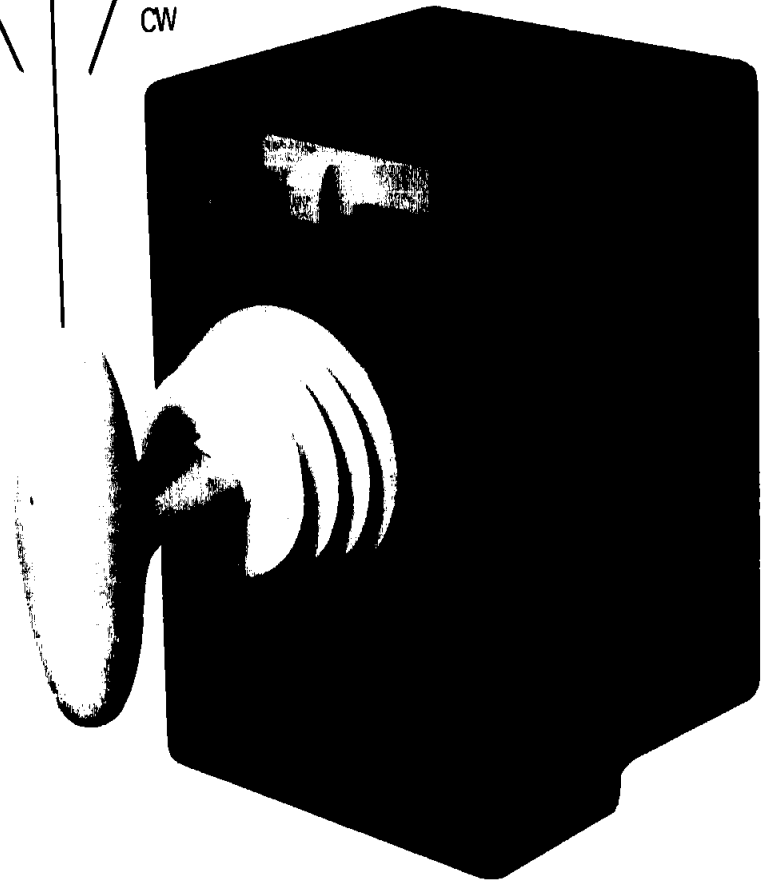
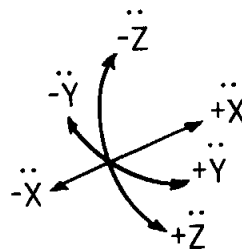
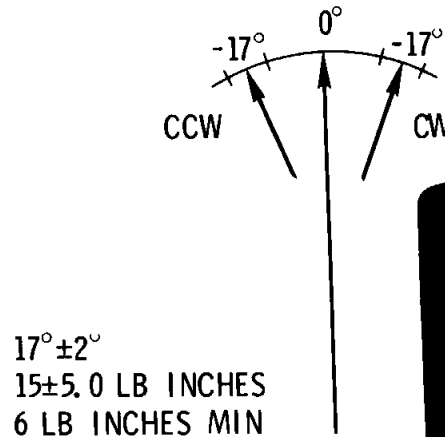
# TRANSLATION CONTROL

## CW & CCW CONTROL MOTION LIMITS

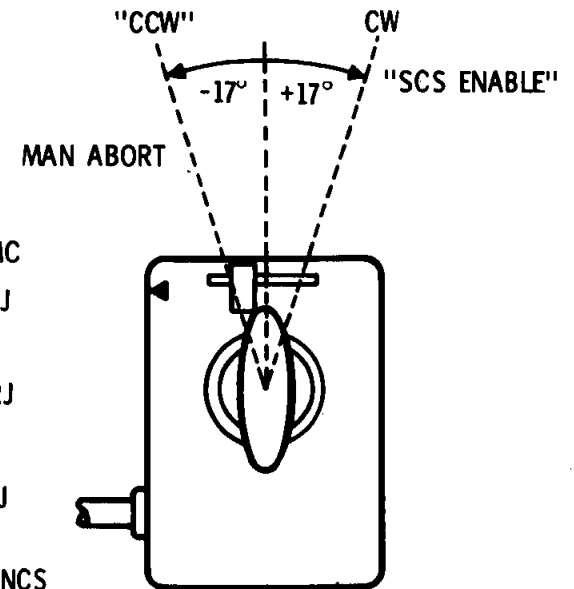
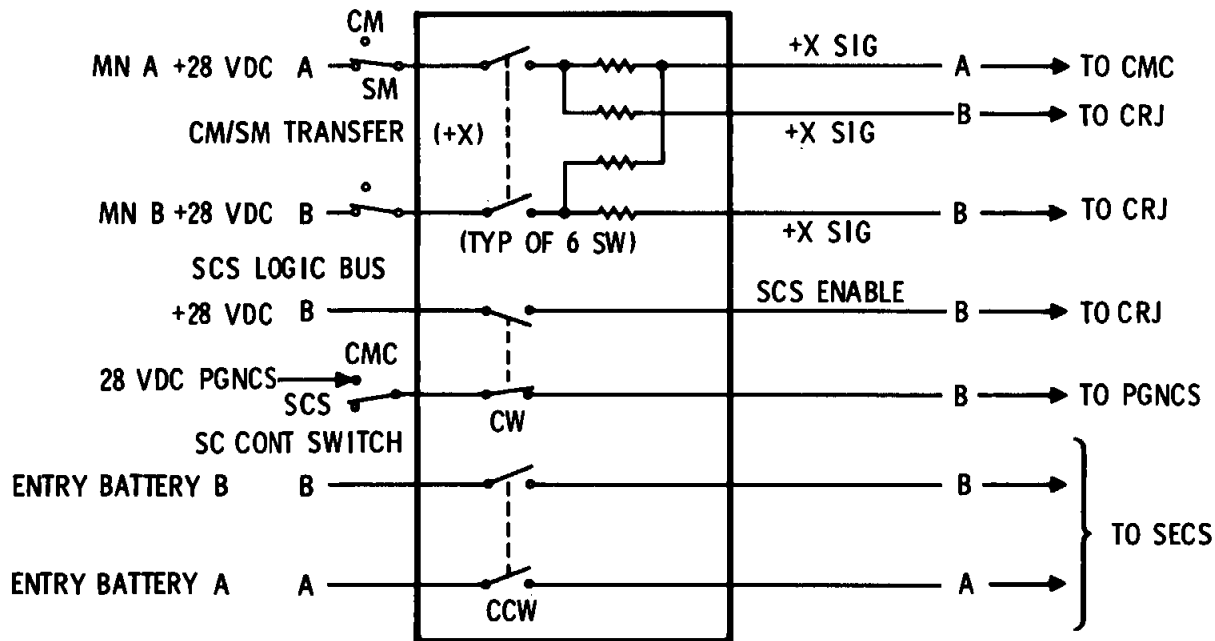
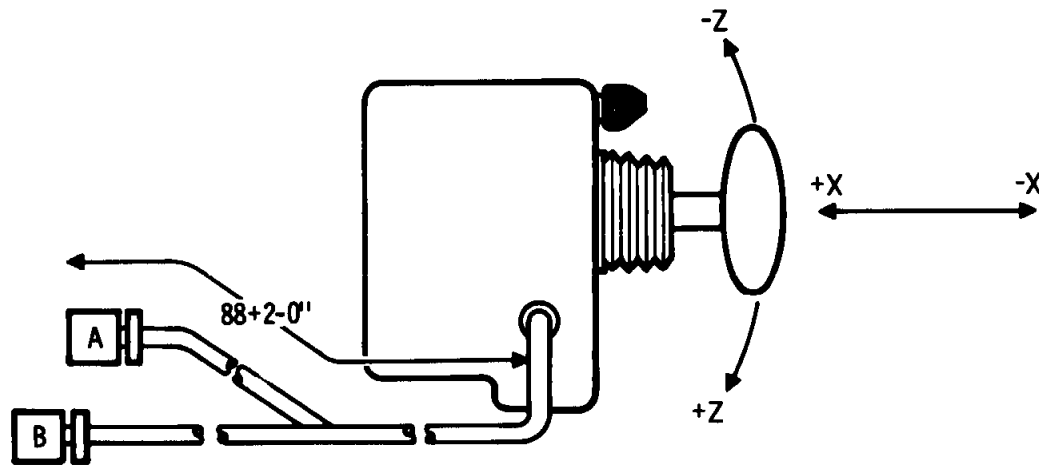
HARD STOP, DETENT & SWITCH CLOSURE  
FORCE INTO DETENT  
OUT OF DETENT

## TRANSLATION CONTROL MOTION LIMITS

|         |                                                            |
|---------|------------------------------------------------------------|
| MAXIMUM | $\pm 0.5$ INCHES                                           |
| SWITCH  | $\pm 0.375$ $\begin{matrix} +0.025 \\ -0.075 \end{matrix}$ |
| CLOSURE |                                                            |
| FORCE   | $2.1 \pm 0.3$ POUNDS                                       |

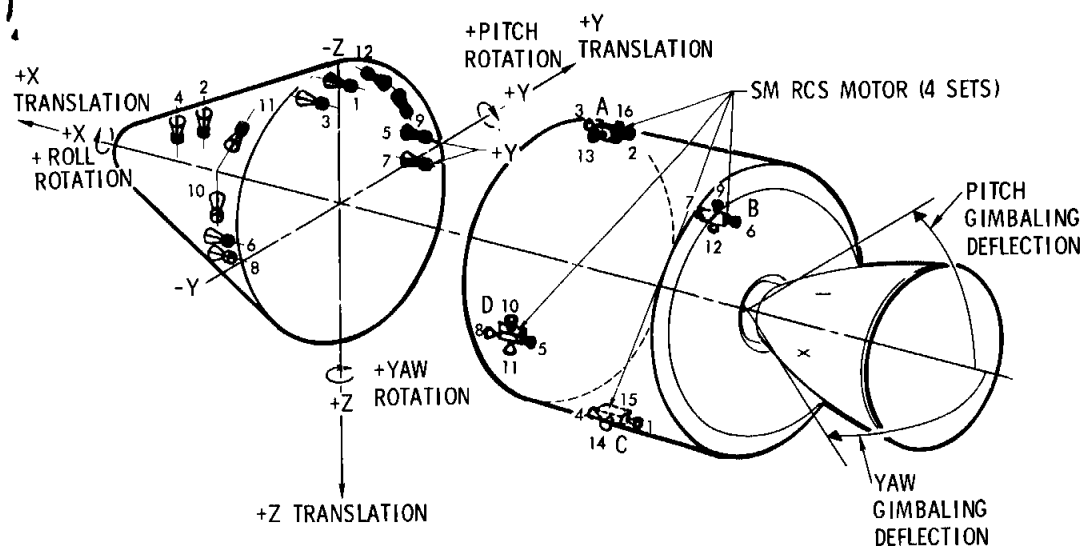


# TRANSLATION CONTROL INTERFACES



✳️  
Could do orbit with the  
cm RCS only!

# SM JET FUNCTIONS



| RCS ENG NO. | COMMANDS      | QUAD | CHANNEL | CHANNEL SWITCH<br>A POSITION B |
|-------------|---------------|------|---------|--------------------------------|
| 1           | +X + $\theta$ | C    | PITCH   | A CB'S B                       |
| 2           | +X - $\theta$ | A    | PITCH   | A CB'S B                       |
| 3           | -X + $\theta$ | A    | PITCH   | B CB'S A                       |
| 4           | -X - $\theta$ | C    | PITCH   | B CB'S A                       |
| 5*          | +X + $\psi$   | D    | YAW     | B CB'S A                       |
| 6           | +X - $\psi$   | B    | YAW     | B CB'S A                       |
| 7*          | -X + $\psi$   | B    | YAW     | A CB'S B                       |
| 8           | -X - $\psi$   | D    | YAW     | A CB'S B                       |
| 9           | +Z + $\phi$   | B    | ROLL    | A BD ROLL 1 CB'S B             |

| RCS ENG NO. | COMMANDS    | QUAD | CHANNEL | CHANNEL SWITCH<br>A POSITION B |
|-------------|-------------|------|---------|--------------------------------|
| 10          | +Z - $\phi$ | D    | ROLL    | A B<br>BD ROLL 2 CB'S          |
| 11          | -Z + $\phi$ | D    | ROLL    | A B<br>BD ROLL 2 CB'S          |
| 12          | -Z - $\phi$ | B    | ROLL    | A B<br>BD ROLL 1 CB'S          |
| 13          | +Y + $\phi$ | A    | ROLL    | A B<br>AC ROLL 1 CB'S          |
| 14          | +Y - $\phi$ | C    | ROLL    | A B<br>AC ROLL 2 CB'S          |
| 15          | -Y + $\phi$ | C    | ROLL    | A B<br>AC ROLL 2 CB'S          |
| 16          | -Y - $\phi$ | A    | ROLL    | A B<br>AC ROLL 1 CB'S          |

\*SM ONLY

# SCS ATTITUDE CONTROL

## FUNCTIONAL OPERATION

SCS Att. Control

Auto

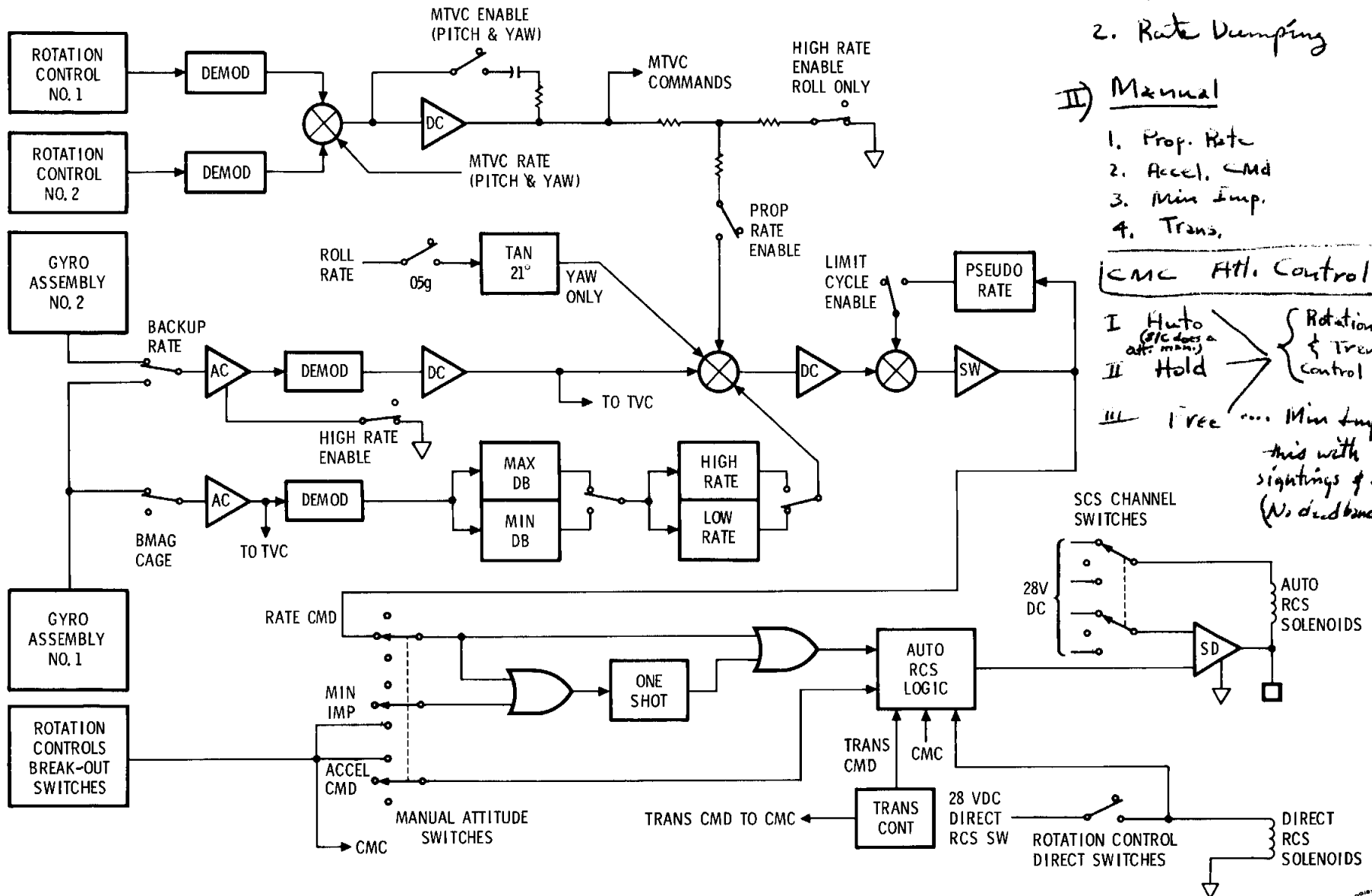
1. Att. hold
2. Rate Dumping

II) Manual

1. Prop. Rate
2. Accel. Cmd
3. Min Imp.
4. Trans.

CMC Att. Control (GjN)

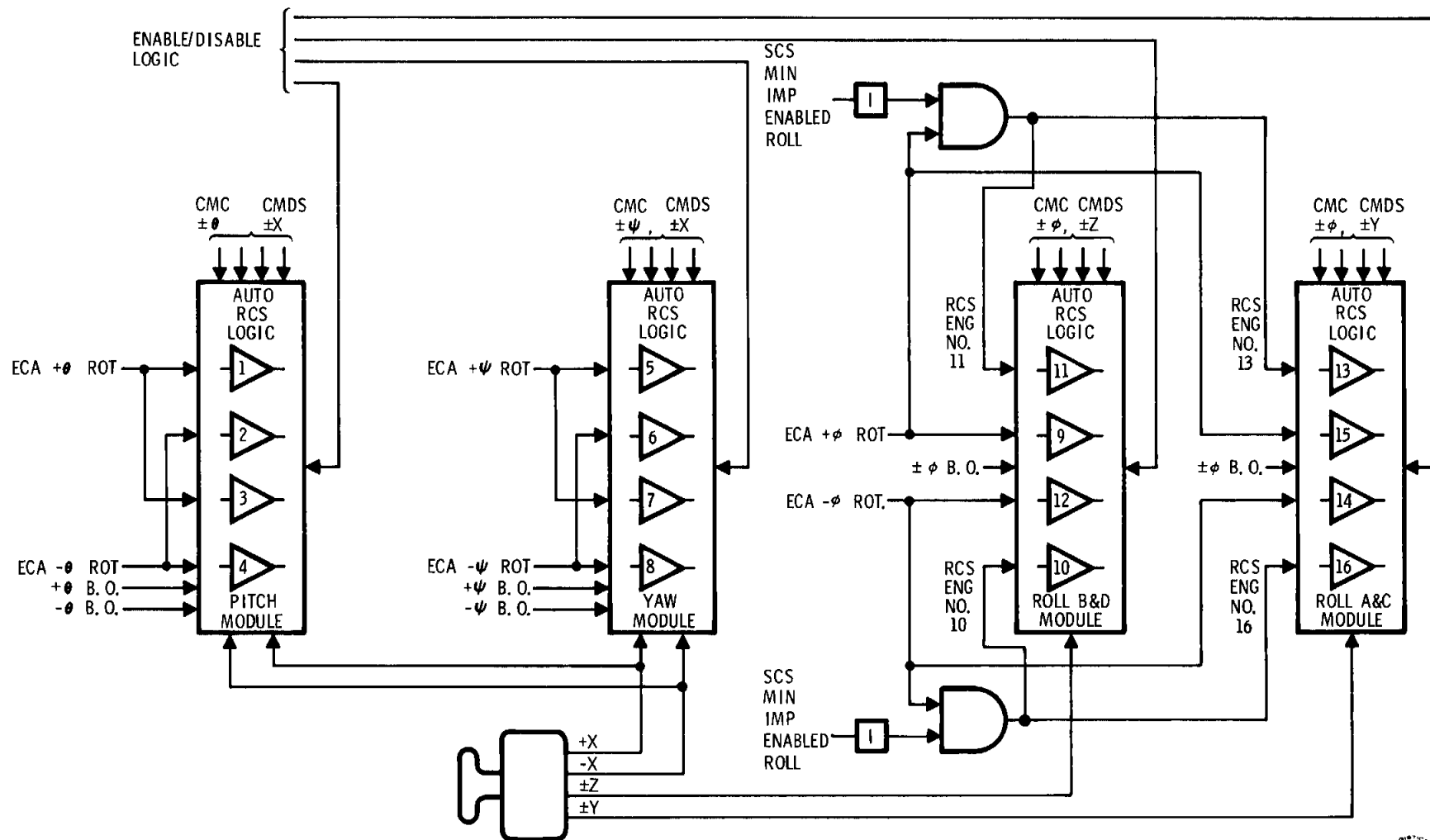
I Auto (PIC does a att. main)  
 II Hold  
 III Free ... Min Imp. - usc  
 this with star sightings & alignments (No deadband firings)



SCS-2410B

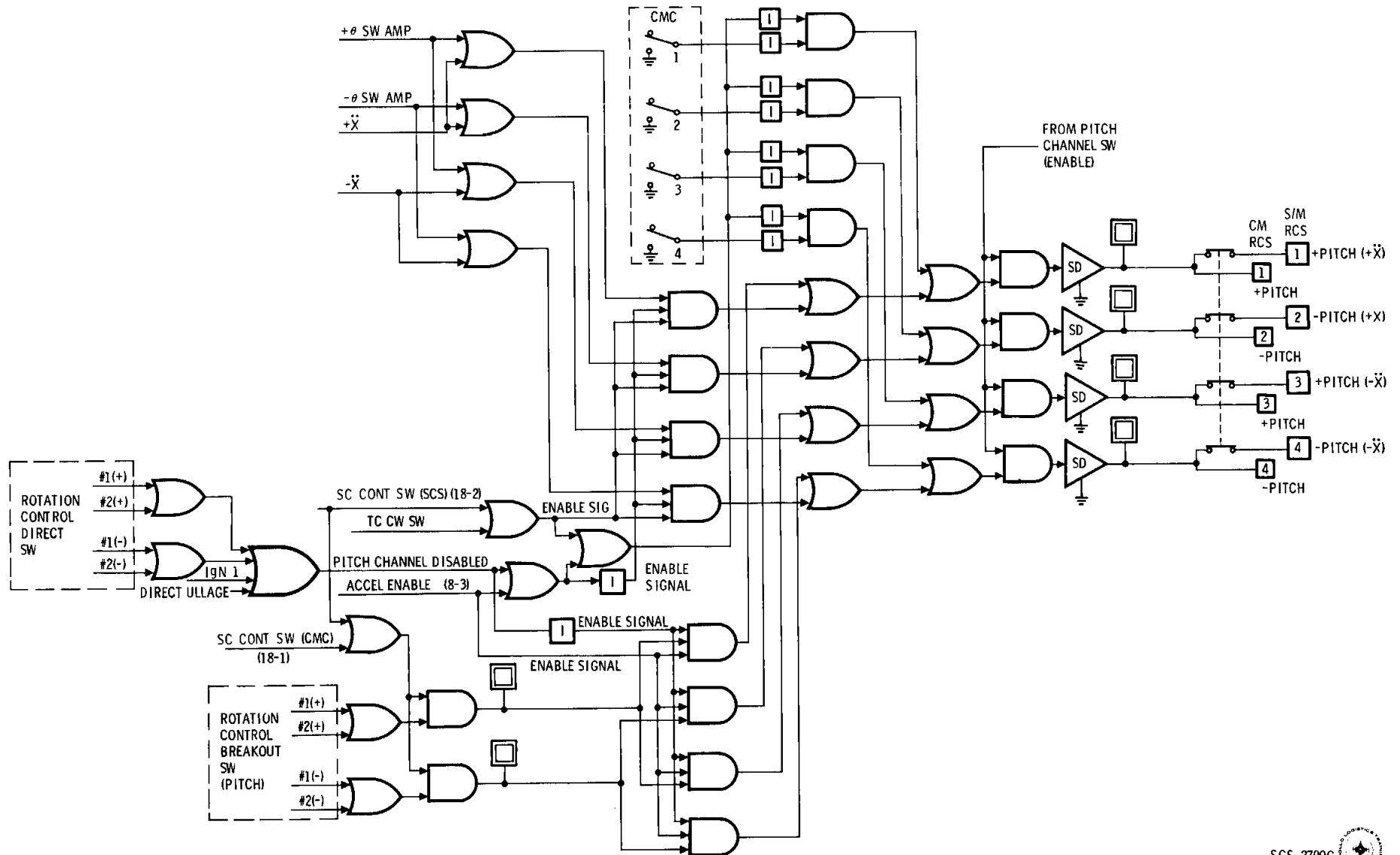


# AUTO RCS LOGIC SIG FLOW

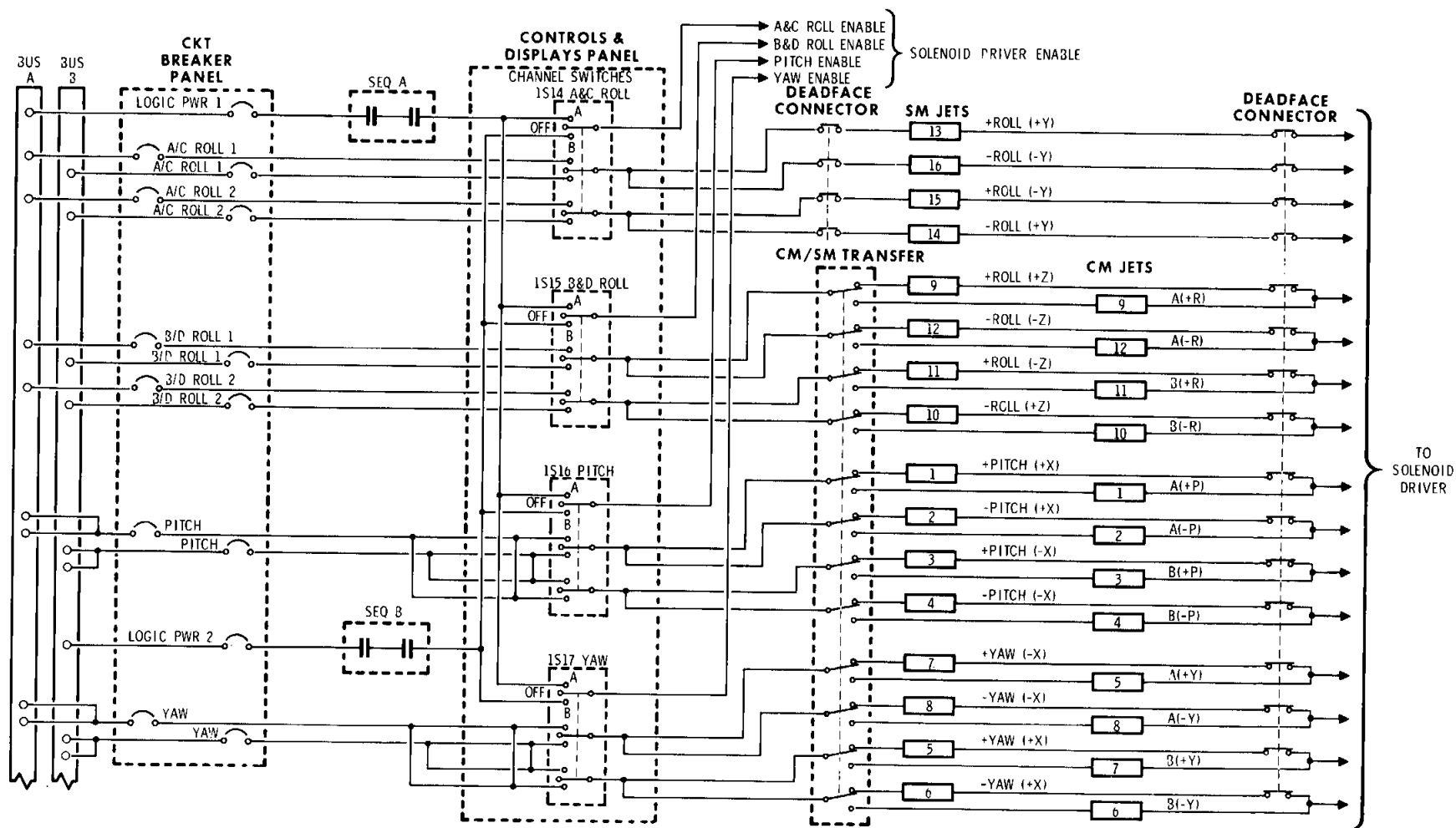


# AUTO RCS LOGIC

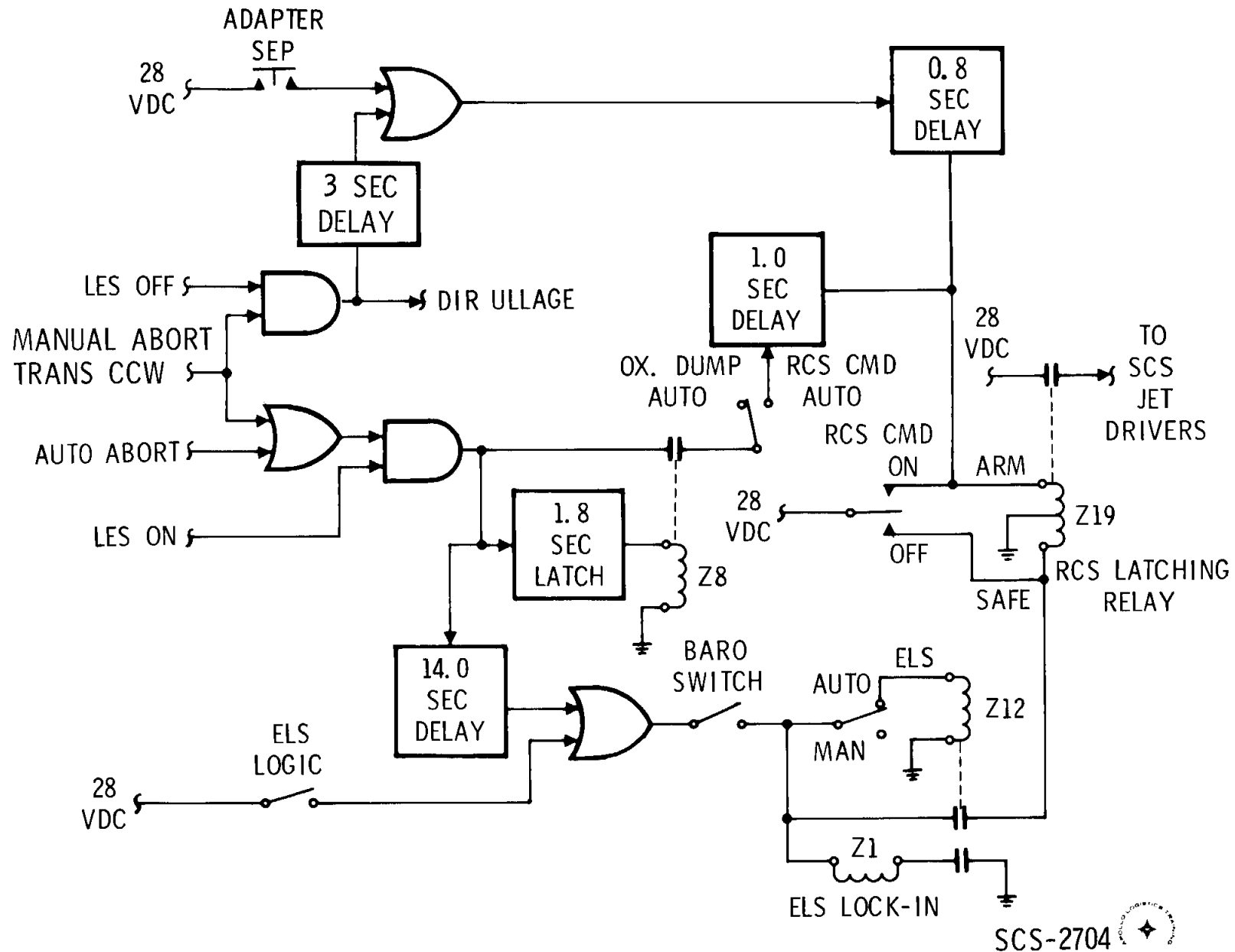
## TYPICAL CHANNEL (PITCH)



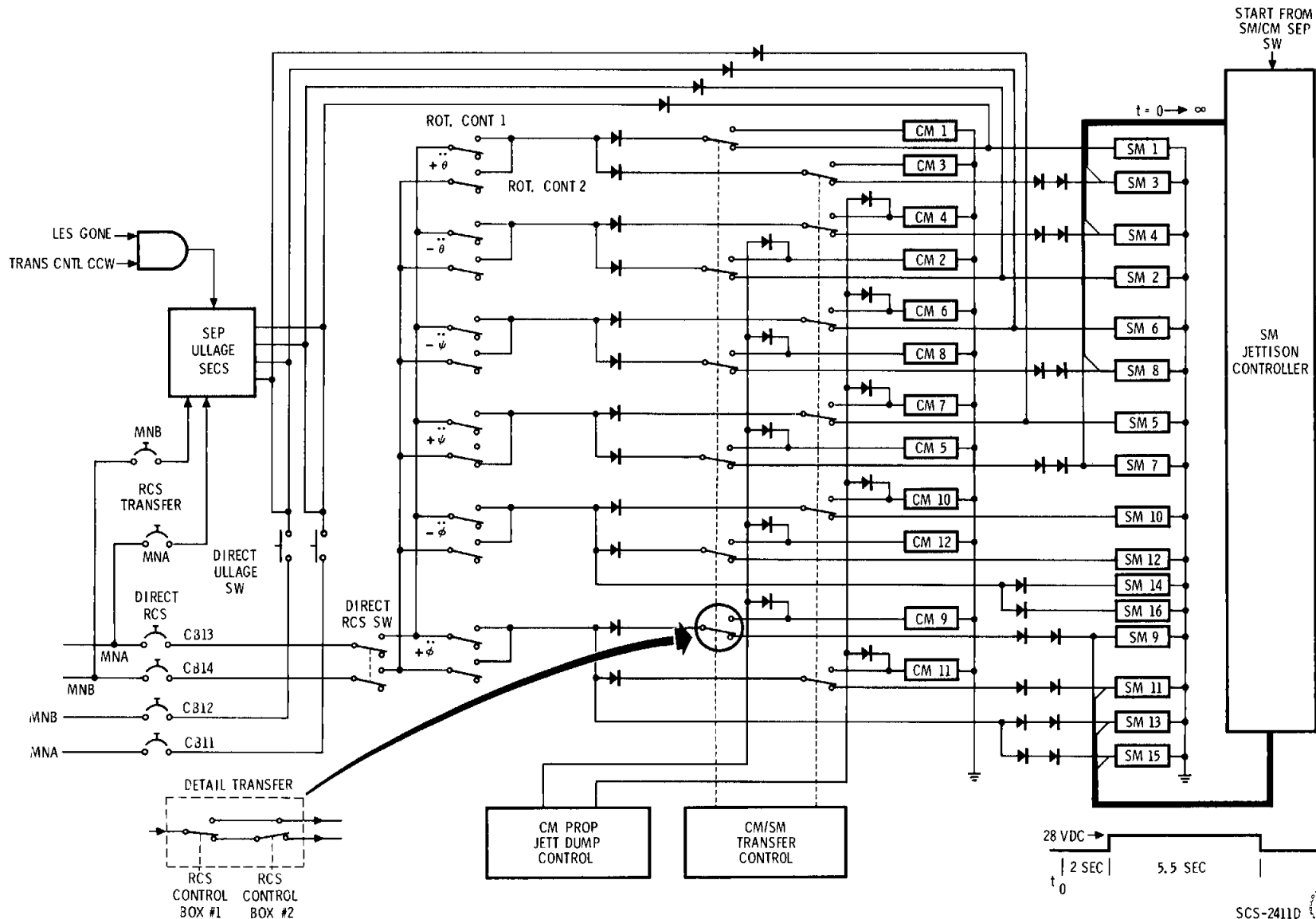
# ENABLING POWER - AUTO RCS



# RCS LATCHING RELAY LOGIC



# DIRECT CONTROL LOOP



# ACS CONTROL CAPABILITIES

|                    |       |              | MANUAL |                     |             |                    |                          | AUTOMATIC       |                  |
|--------------------|-------|--------------|--------|---------------------|-------------|--------------------|--------------------------|-----------------|------------------|
|                    |       |              | DIRECT | ACCELERATION<br>CMD | TRANSLATION | MINIMUM<br>IMPULSE | PROPORTIONAL<br>RATE (4) | RATE<br>DAMPING | ATTITUDE<br>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)             | (3)              |
|                    |       | OFF          |        |                     |             |                    |                          |                 |                  |
| ROT CONTROL        |       | B.O. SW      |        | CLOSE (2)           |             | CLOSE (2)          | CLOSE                    | OPEN            | OPEN             |
|                    |       | DIRECT SW    | CLOSE  |                     |             |                    |                          |                 |                  |
| LIMIT (1)<br>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:

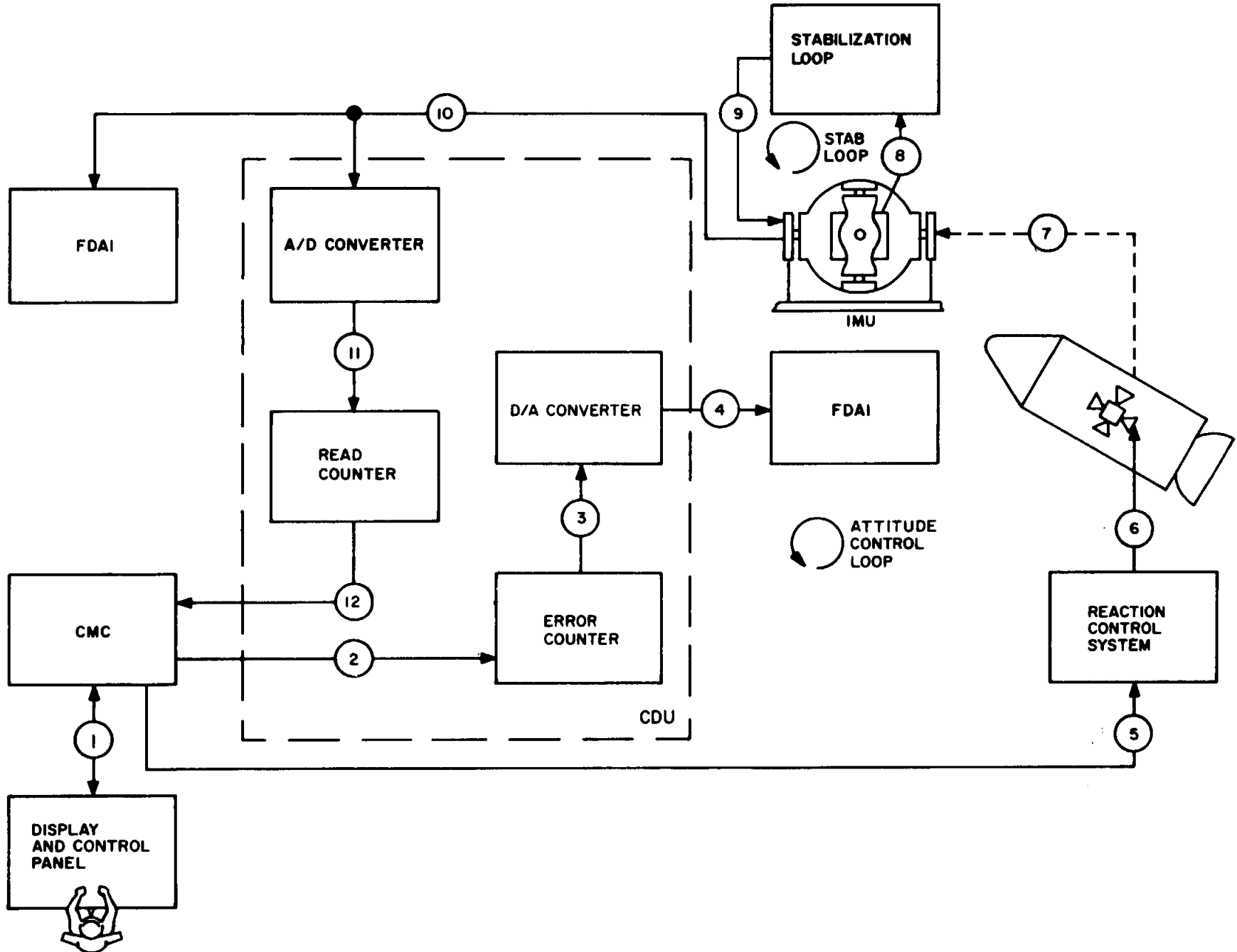
A. THE CAPABILITIES, IN GENERAL, ARE LISTED IN ORDER OF THEIR PRIORITY.

B. WHEN MORE THAN ONE SWITCH POSITION IS CHECKED (✓) THE CAPABILITY WILL BE ENABLED IN EITHER POSITION.

SCS-2803C

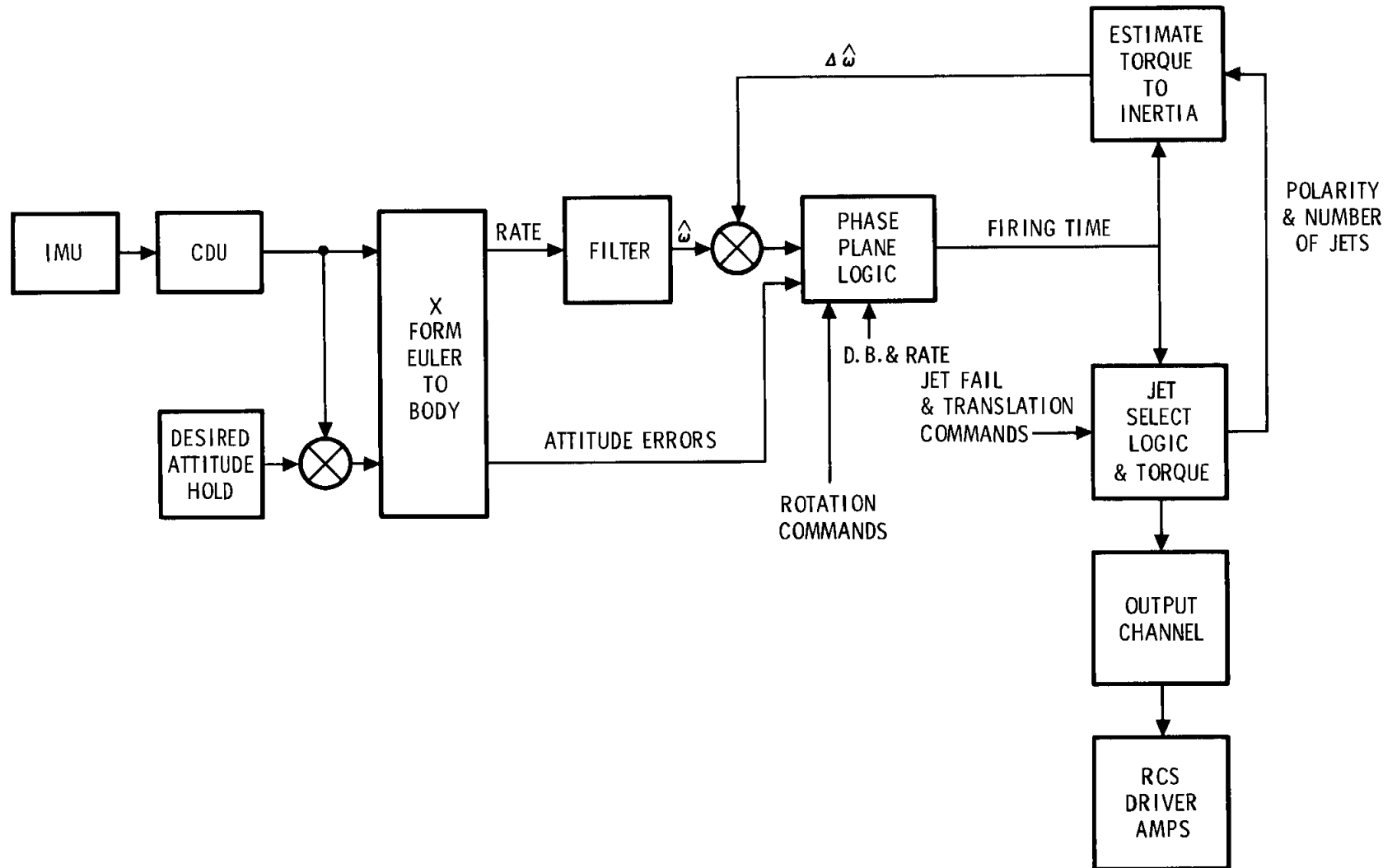


# ATTITUDE CONTROL MODE

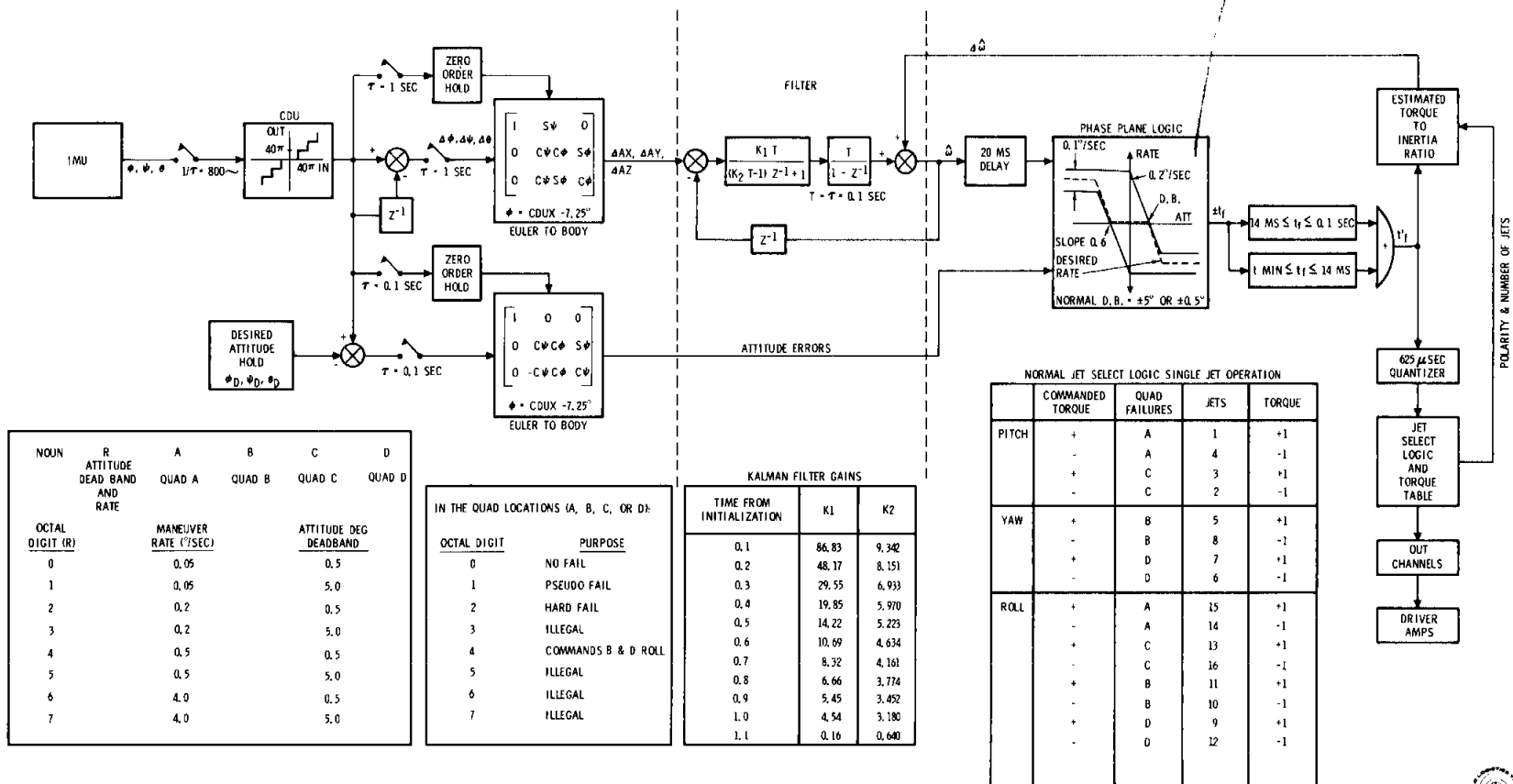


# RCS DAP

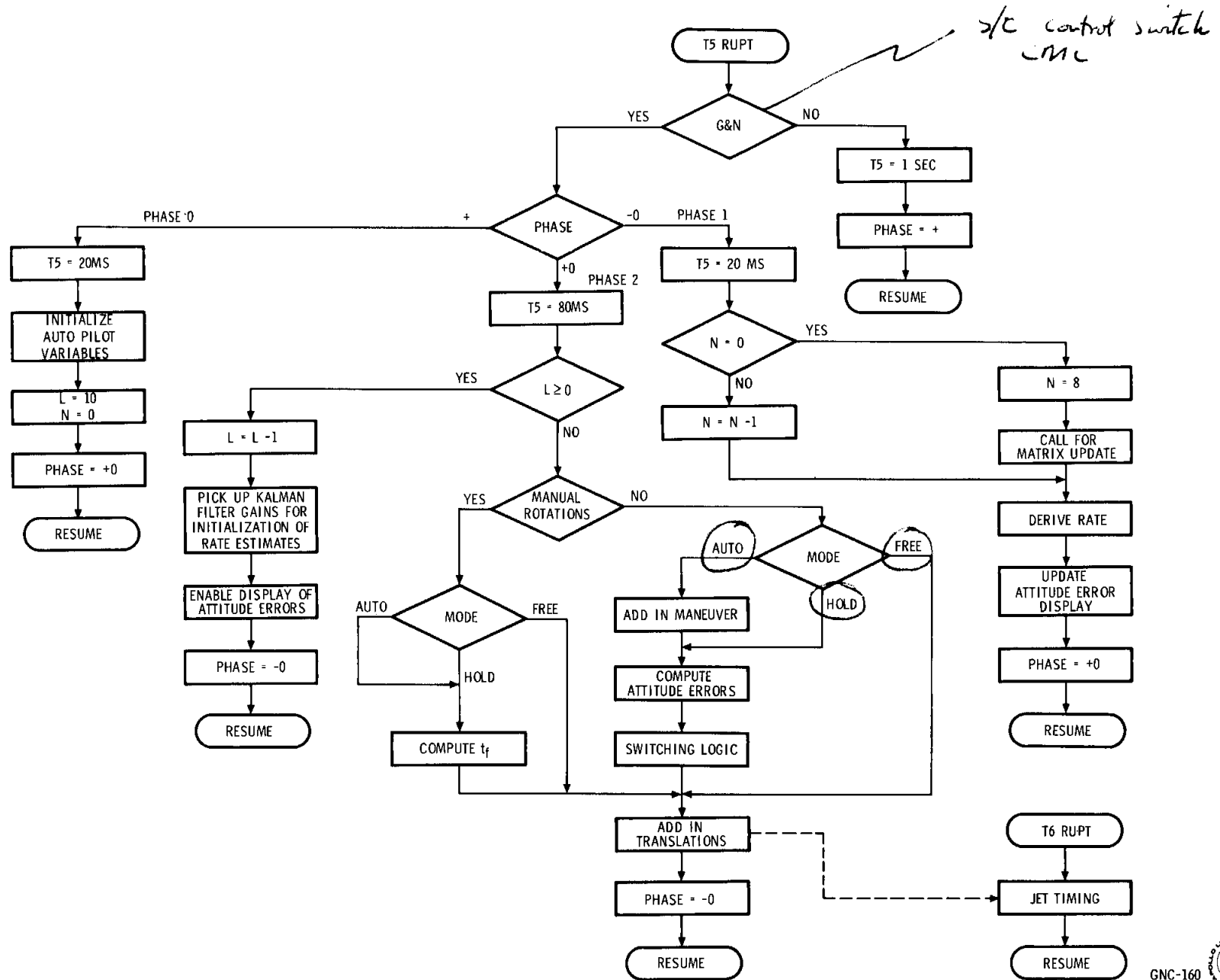
## SIMPLIFIED BLOCK DIAGRAM



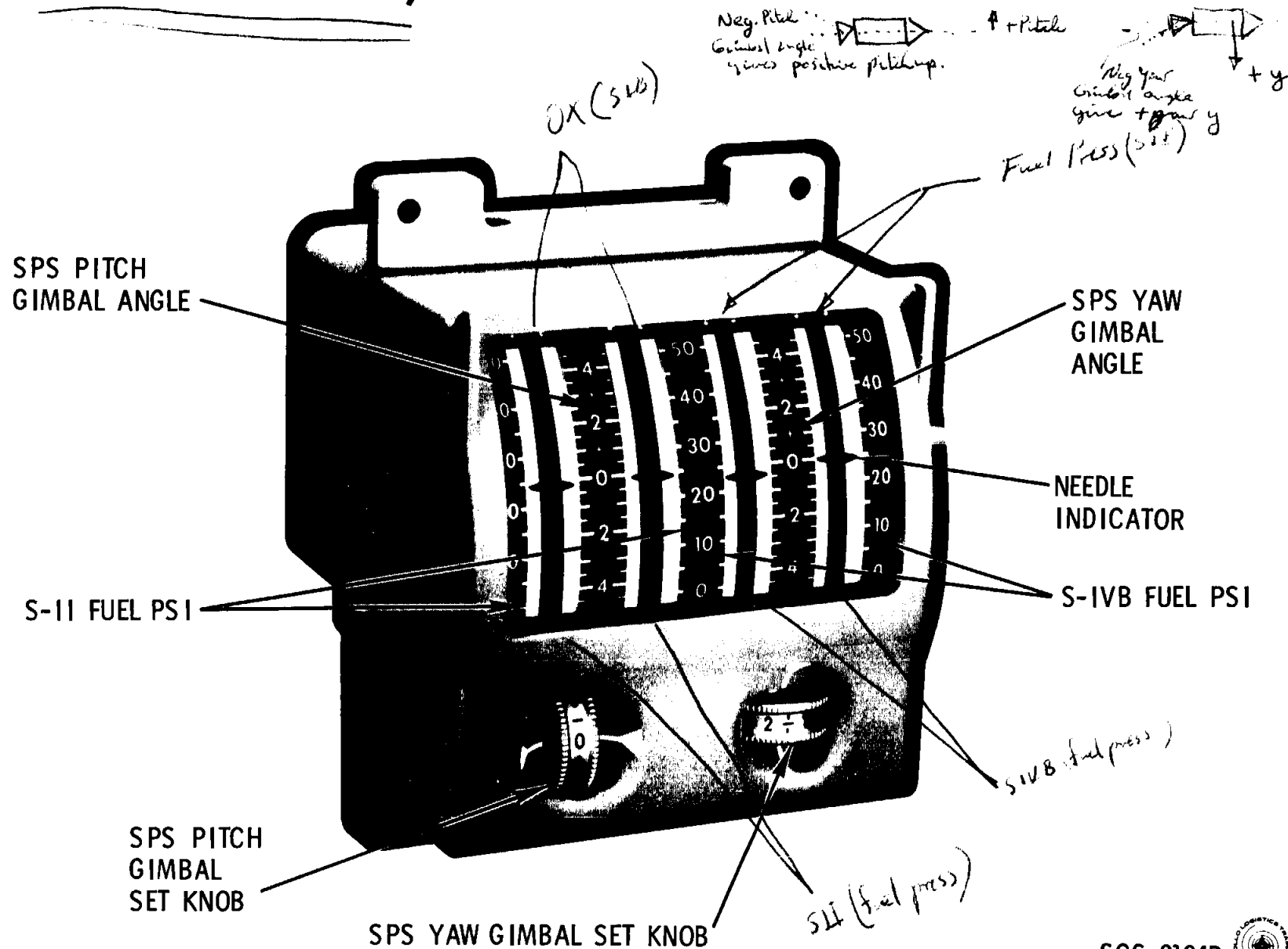
# RCS DAP MODEL



# PROGRAM LOGIC FLOW RCS DAP



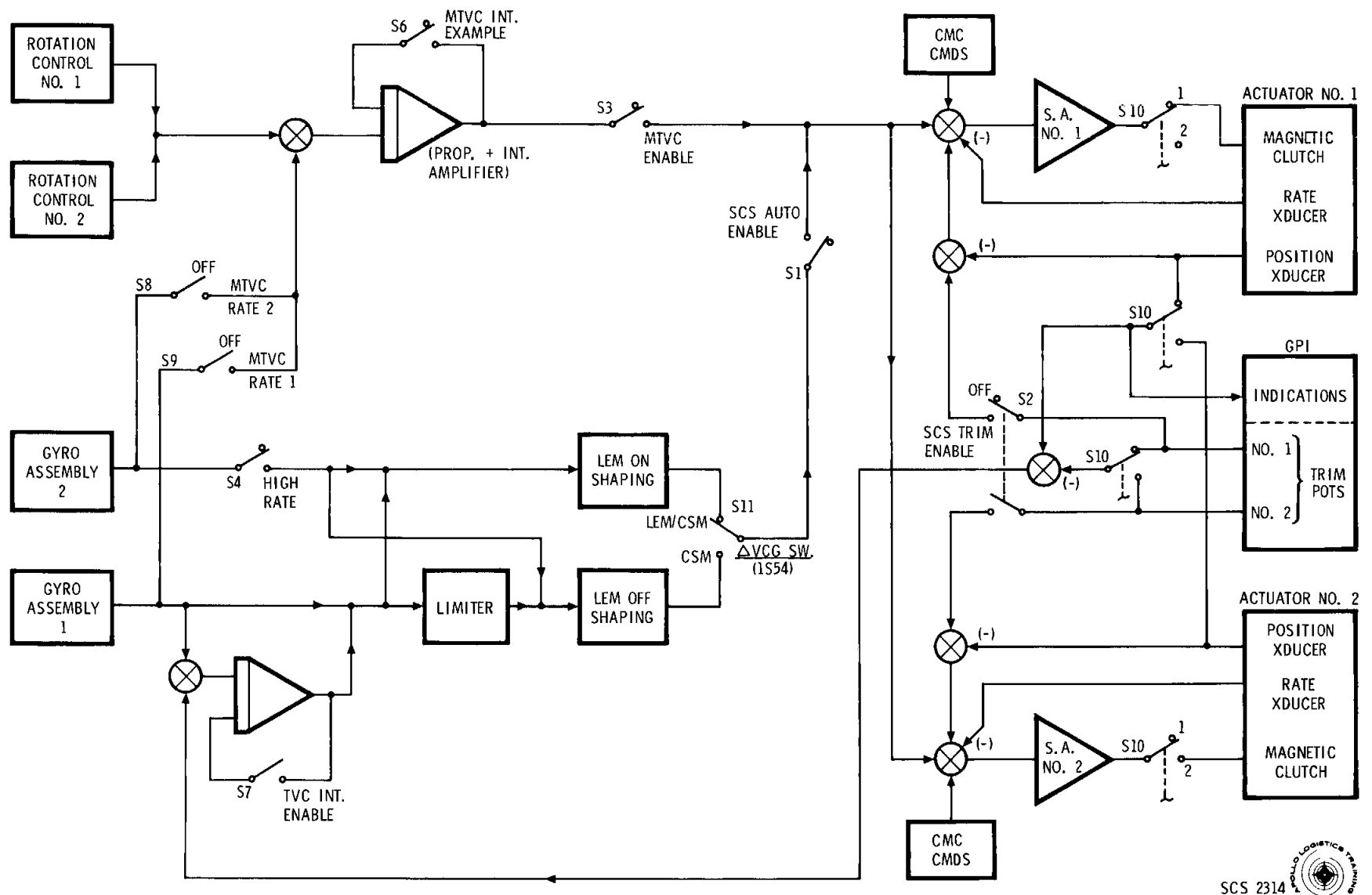
# FUEL PRESSURE/GIMBAL POSITION INDICATOR



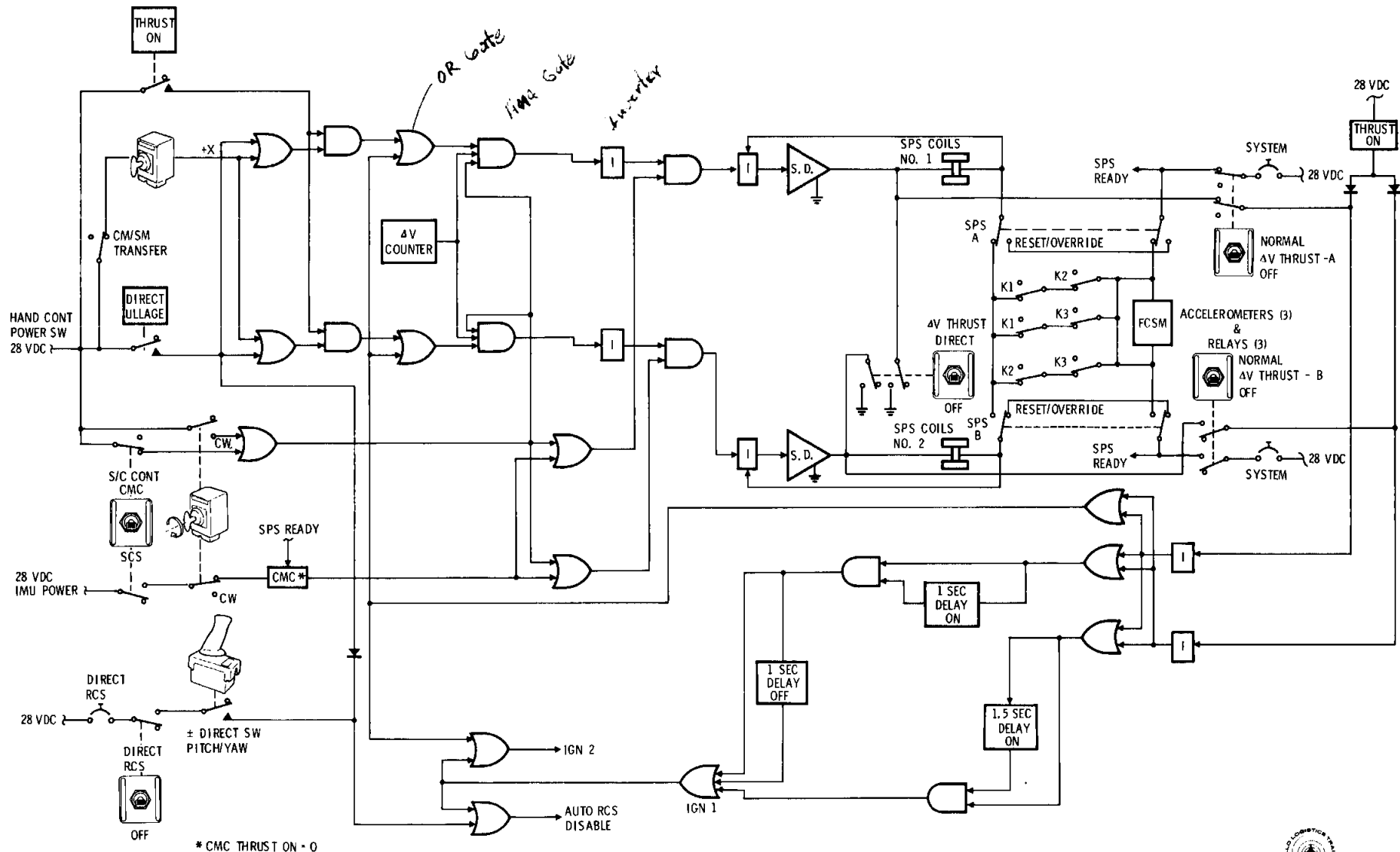
SCS 2104B



# THRUST VECTOR CONTROL-SIGNAL FLOW



# SPS ENGINE ON-OFF LOGIC



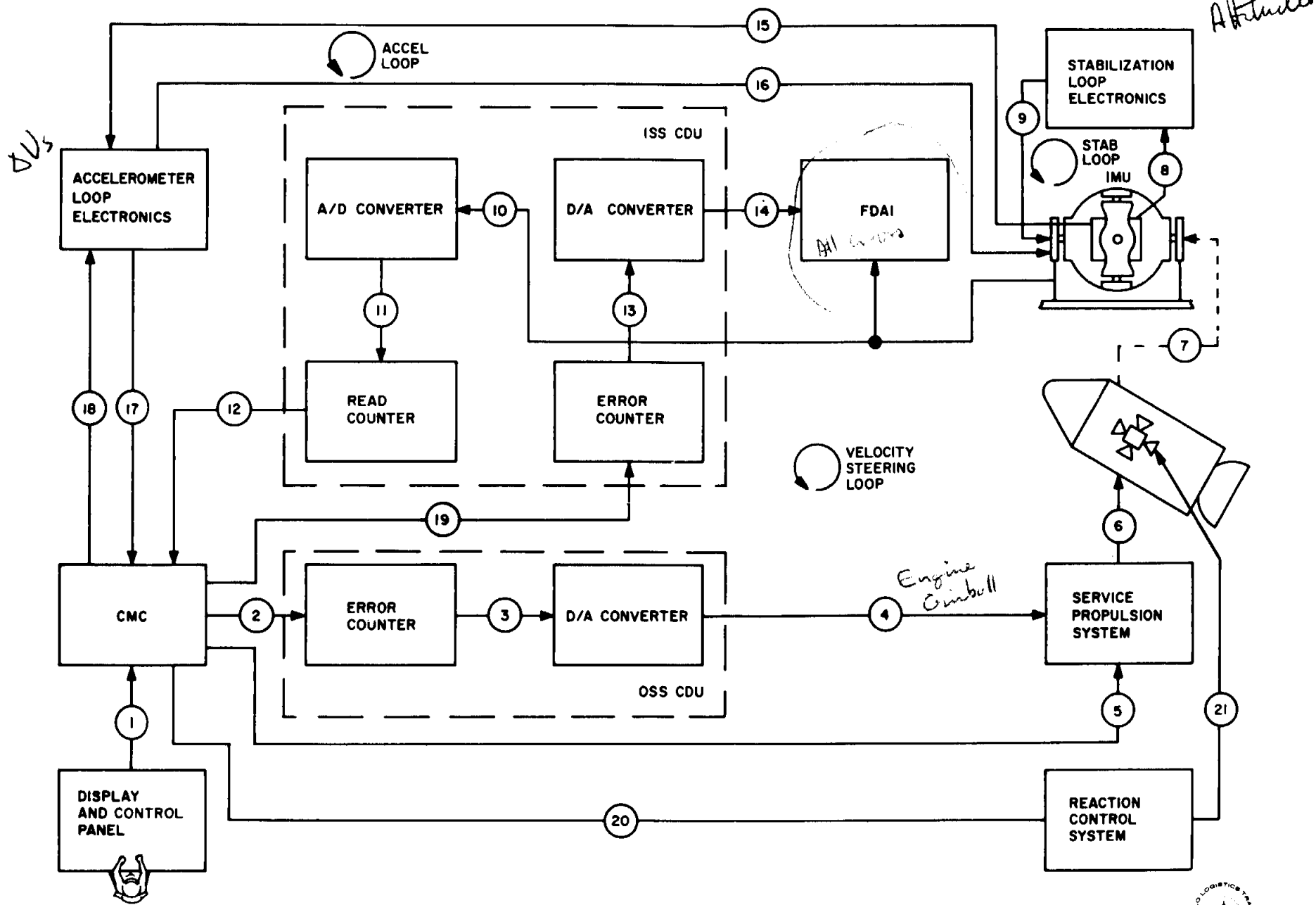
\* CMC THRUST ON - 0

# TVC FUNCTION ENABLING LOGIC

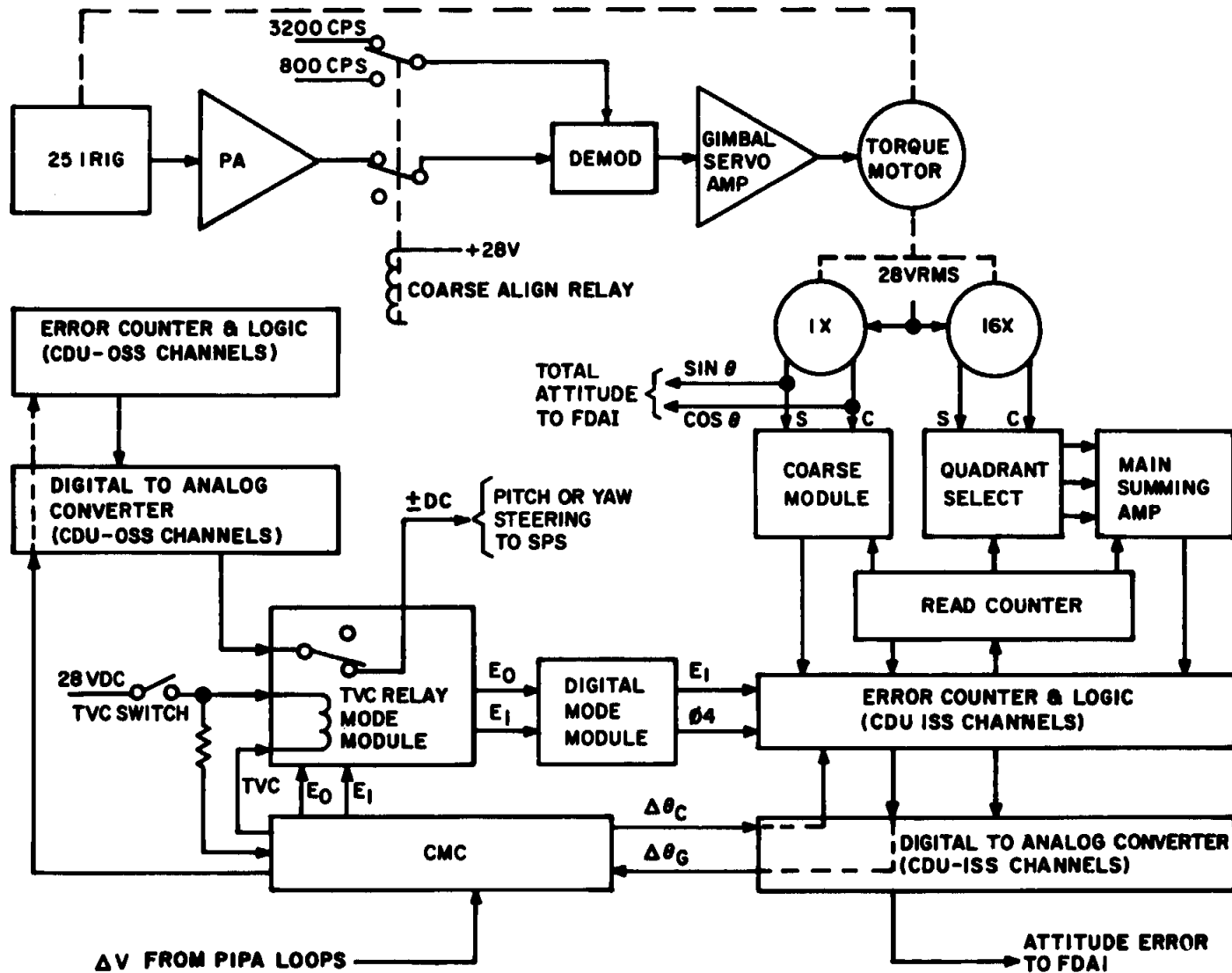
| SYSTEM CONFIGURATION | FUNCT SW. / POSITION SWITCH POS. |                  | PANEL SWITCHING AND LOGIC FOR ENABLING FUNCTIONAL SWITCH POSITION                      |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    |       |
|----------------------|----------------------------------|------------------|----------------------------------------------------------------------------------------|-----|--------------------------|---------------|--------|-----------------------|----------|-----------|----------------------------|------|---|-----------------|----|---------------------|----|-------|
|                      |                                  |                  | 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 | CW              | CW | FS                  | FS | IGN 2 |
| SCS AUTO TVC (1)     | S1                               | SCS AUTO ENABLE  | X                                                                                      |     |                          | (2)           |        | X                     |          |           |                            |      |   | X               |    |                     |    | X     |
|                      |                                  |                  |                                                                                        | X   |                          |               |        | X                     |          |           |                            |      |   | X               |    |                     | X  |       |
|                      | S2                               | SCS TRIM ENABLE  | X                                                                                      |     |                          |               |        |                       |          |           |                            |      |   | X               |    |                     |    |       |
|                      |                                  |                  |                                                                                        | X   |                          |               |        |                       |          |           |                            |      |   | X               |    |                     |    |       |
|                      | S4 (3)                           | HIGH RATE        |                                                                                        |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    | X(3)  |
| COMMON FUNCTION      | S3                               | MTVC ENABLE      | X                                                                                      |     |                          |               |        |                       | X OR X   |           |                            |      |   |                 |    |                     |    |       |
|                      |                                  |                  | X                                                                                      |     |                          |               |        | X                     |          |           |                            |      | X |                 |    |                     |    |       |
|                      |                                  |                  |                                                                                        | X   |                          |               |        |                       | X OR X   |           |                            |      |   | X               |    |                     |    |       |
|                      | S6                               | MTVC INT. ENABLE | SWITCH POSITIONS ARE SAME AS FOR S3 BUT LOGIC REQUIRES 'IGN 2' SIGNAL                  |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    |       |
|                      |                                  |                  |                                                                                        |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    |       |
| M T V C RATE CMD     | S8 OR S9                         | MTVC RATE 2      | X                                                                                      |     |                          | X OR X        |        |                       | X        |           |                            |      |   |                 |    |                     |    | X     |
|                      |                                  |                  | X                                                                                      |     |                          | X OR X        |        | X                     |          |           |                            |      |   | X               |    |                     | X  |       |
|                      |                                  |                  |                                                                                        | X   |                          | X OR X        |        |                       | X        |           |                            |      |   | X               |    |                     | X  |       |
|                      | S9                               | MTVC RATE 1      | SWITCH POSITIONS ARE SAME AS FOR S8 EXCEPT BMAG MODE SWITCH MUST BE IN RATE 1 POSITION |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    |       |
|                      |                                  |                  |                                                                                        |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    |       |
| ACCEL CMD            | S8 AND S9 OFF                    |                  |                                                                                        |     |                          |               |        |                       |          | X         |                            |      |   |                 |    |                     |    |       |
| SERVO NO. 1          | S10                              | 1                |                                                                                        |     |                          |               |        |                       |          |           | X                          |      |   |                 |    |                     |    |       |
|                      |                                  |                  |                                                                                        |     |                          |               |        |                       |          |           |                            | X    |   | X               |    | X                   |    |       |
| SERVO NO. 2          | S10                              | 2                |                                                                                        |     |                          |               |        |                       |          |           |                            |      | X |                 | X  |                     |    |       |
|                      |                                  |                  |                                                                                        |     |                          |               |        |                       |          |           |                            | X    |   |                 |    |                     | X  |       |
|                      |                                  |                  |                                                                                        |     |                          |               |        |                       |          |           |                            |      |   |                 |    |                     |    | X     |

- (1). FUNCTIONAL SWITCH -S11- REPRESENTS ΔVCG 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).

# *G4N* → **THRUST VECTOR CONTROL**



# THRUST VECTOR CONTROL



P40 - SPS thrusting program

$t_{ig} \rightarrow t_B$  1st

$V_G$  1st

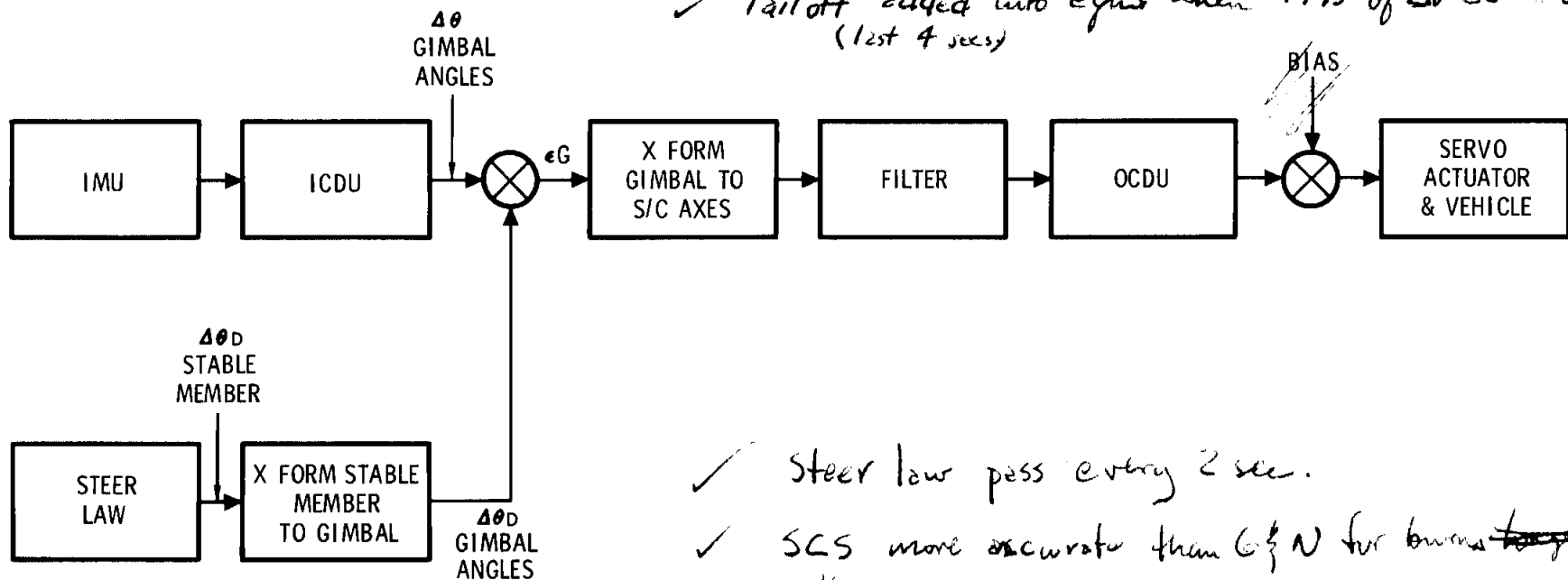
$V_m$  vel. add so far

Sundisc program

## TVC DAP

### SIMPLIFIED BLOCK DIAGRAM

- ⊗ No steering cmds until after 4 sec of burn
- ✓ If burn is less than 4 sec - no steering.
- ✓ No steering in last 4 sec --- cutoff based on predicted cutoff time.
- ✓ Tailoff added into eqns when .995 of  $\Delta V$  achieved (last 4 sec)



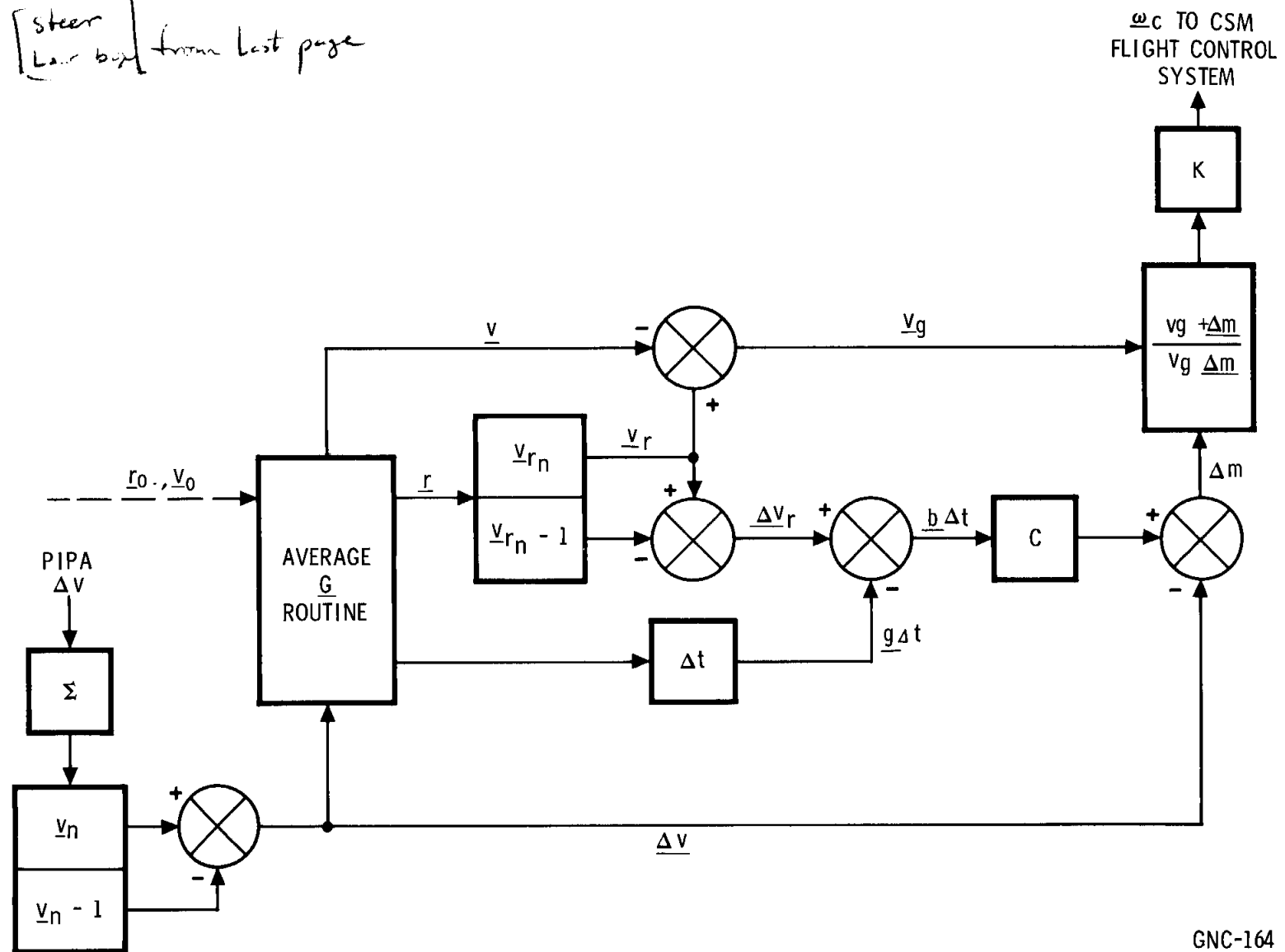
- ✓ Steer law pass every 2 sec.
- ✓ SCS more accurate than G<sub>1</sub>N for burns ~~longer~~ shorter than 20 sec.

G<sub>1</sub>N only (?) can do a "straight" burn (fixed inner H.) - SPS backup - - T.E.R.  
~~SCS~~ can't do the more efficient (fuel) curved burn

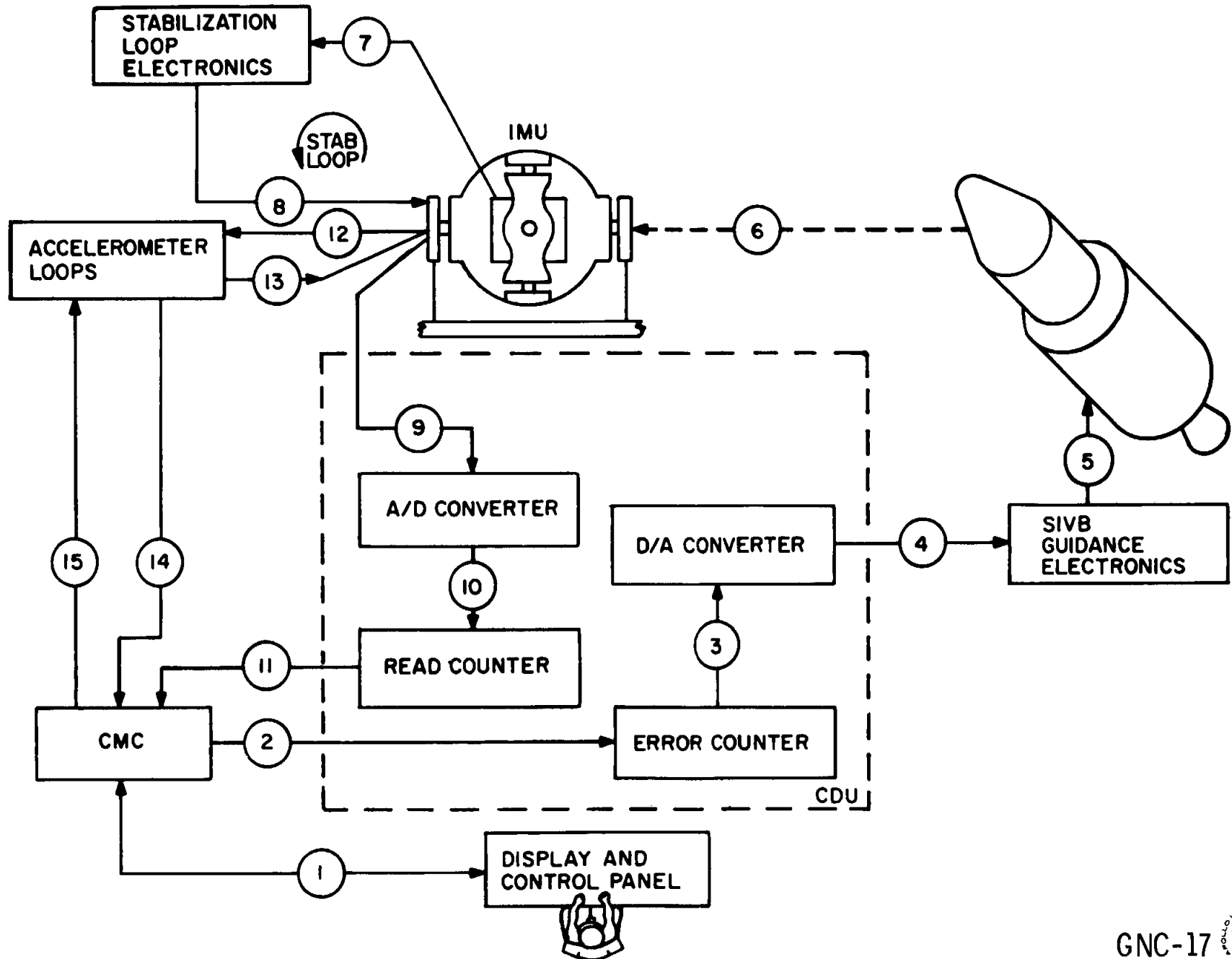


# CMC POWERED FLIGHT STEERING BLOCK DIAGRAM

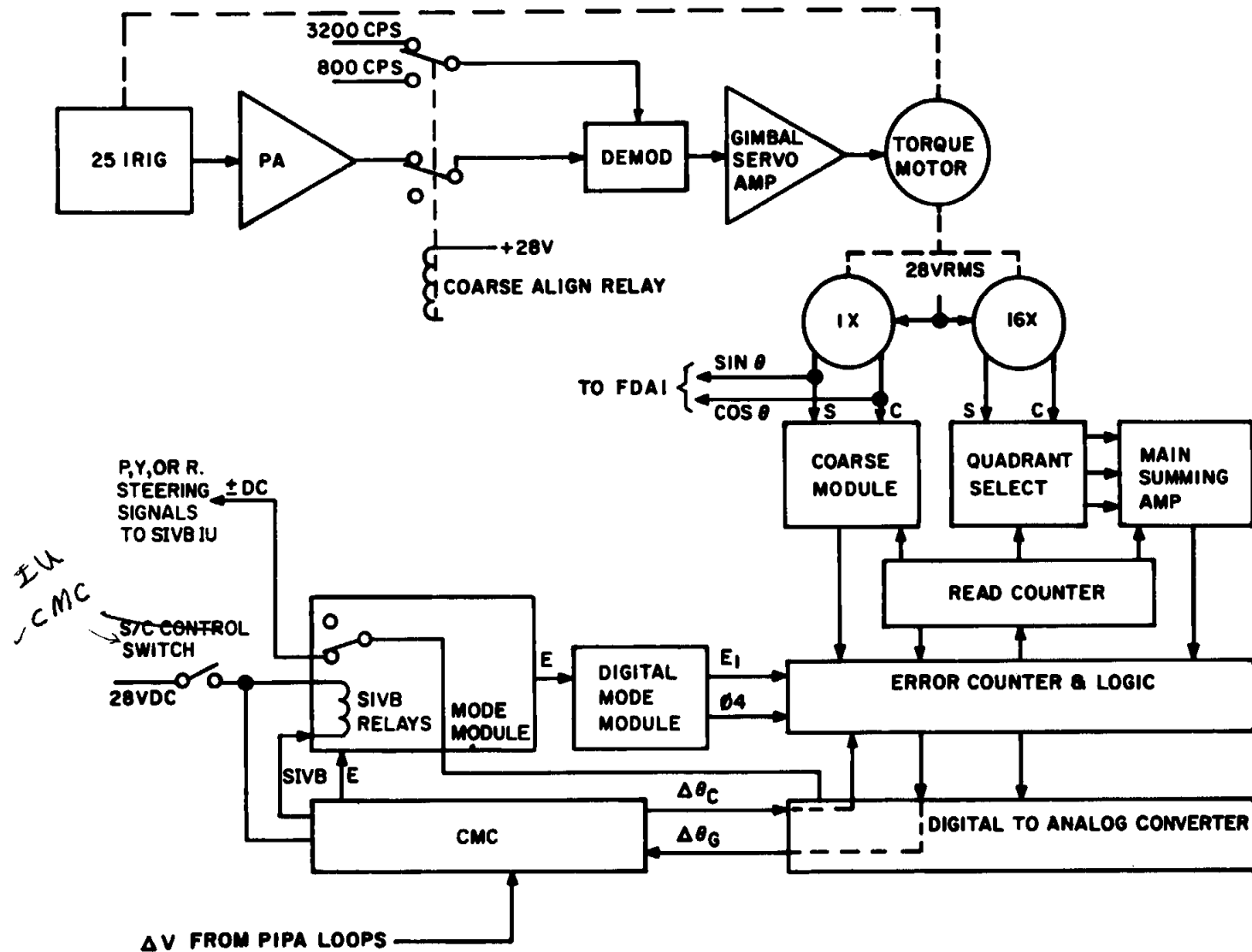
*[steer  
law by] from last page*



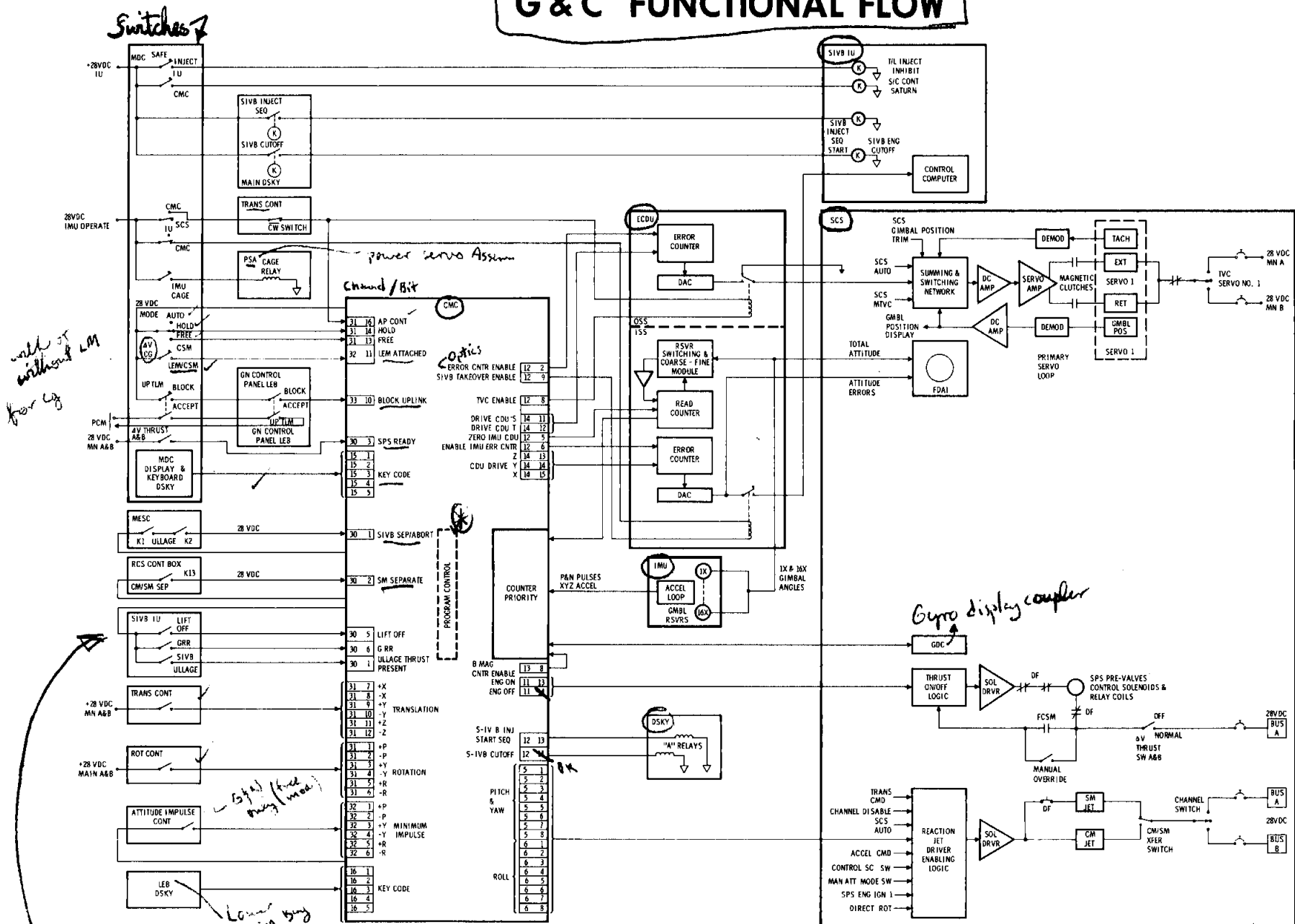
# S/C CONTROL OF SATURN MODE



# SIV B TAKEOVER



## G & C FUNCTIONAL FLOW

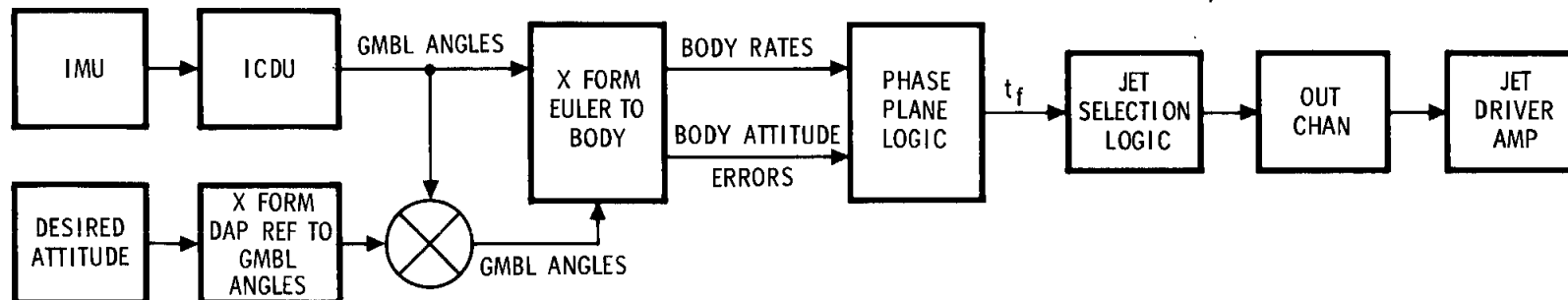


✗ S/C platform goes inertial at 20 Lift Off signal (L/V sends L.V. to computer & platform)   
L/V platform goes inertial @ 6th.

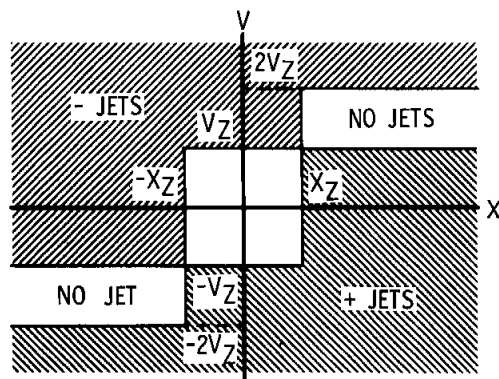
During Program 62  
the Entry DAP is entered

# ENTRY DAP

SCS has rate dump  
No eff. hold.  
(you can hold diff vector  
with ROT control)  
G/N has att hold

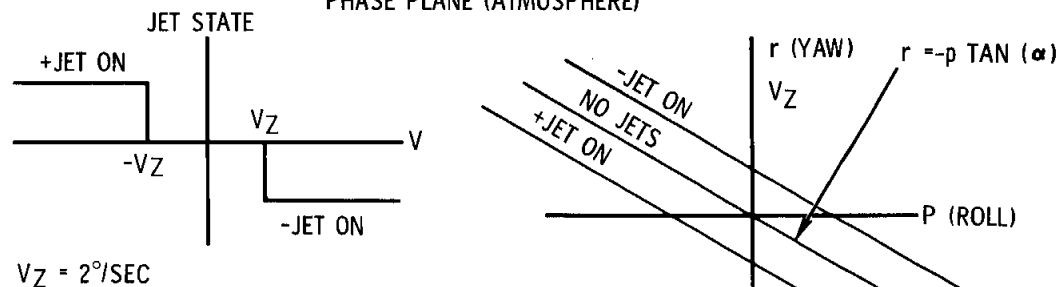


PHASE PLANE (EXTRA ATMOSPHERE)



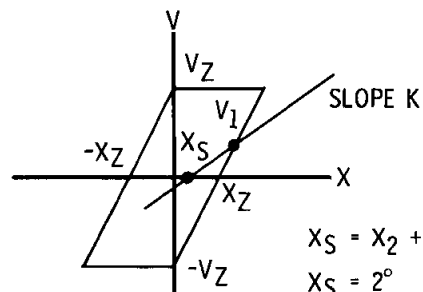
$X_Z = 3^\circ$   
 $V_Z = 2^\circ/\text{SEC}$   
ATTITUDE CONTROL

PHASE PLANE (ATMOSPHERE)



$V_Z = 2^\circ/\text{SEC}$

PITCH RATE DAMPER



ROLL DEAD ZONE

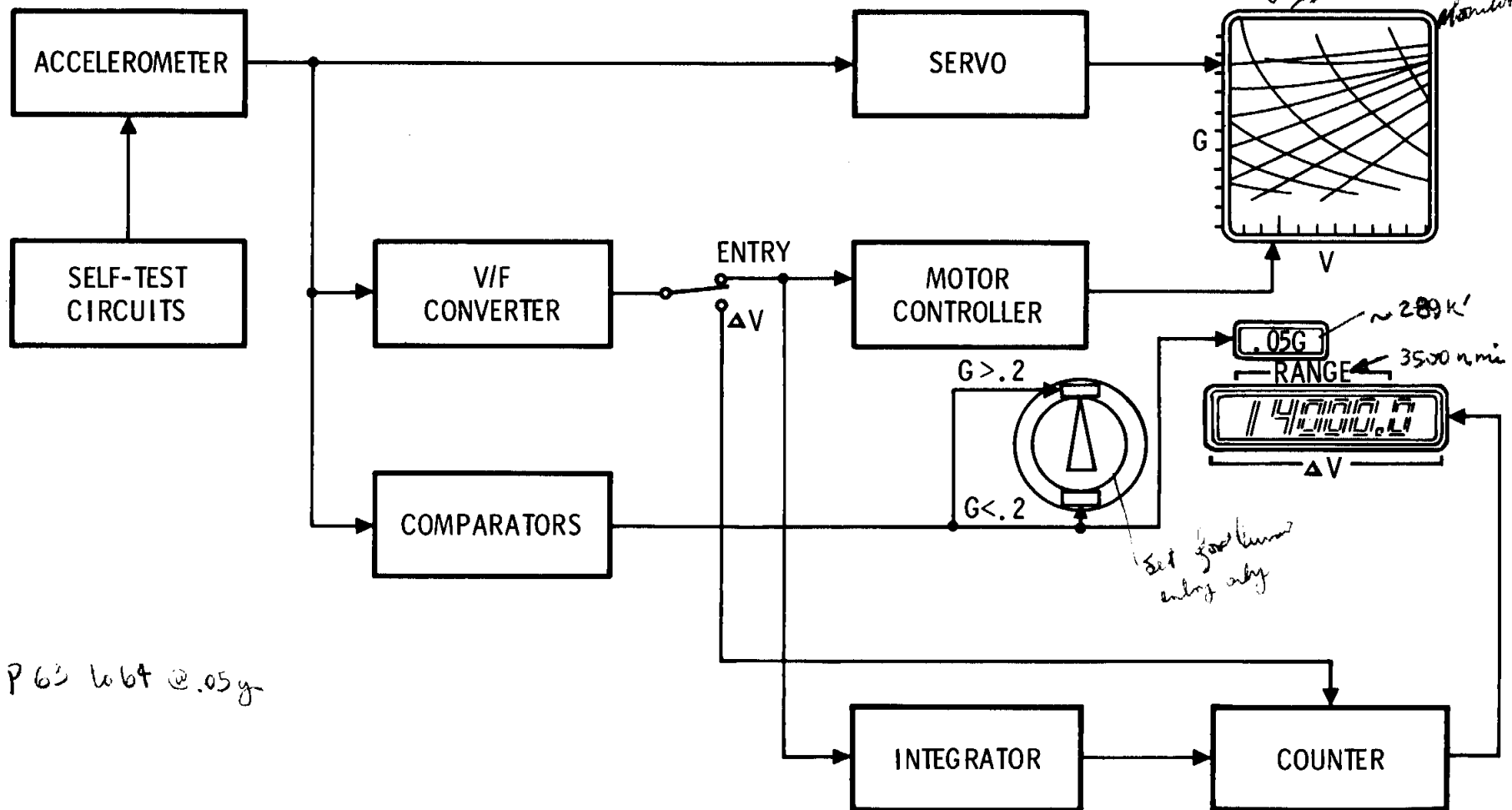
$X_S = X_Z + V_1$   
 $X_S = 2^\circ$   
 $X_Z = 4^\circ$   
 $V_Z = 2^\circ/\text{SEC}$

YAW RATE AUTO PILOT



— Independent of  $G \pm N$   
and  $SCS$

# EMS BLOCK DIAGRAM



P 63 to 64 @ .05 g

SCS-2205



P40 Deorbit  $\Delta V$   
 P61 sep alt.  
 P62 sep to VAF  
 P63

# EMS HOUSING FRONT PANEL

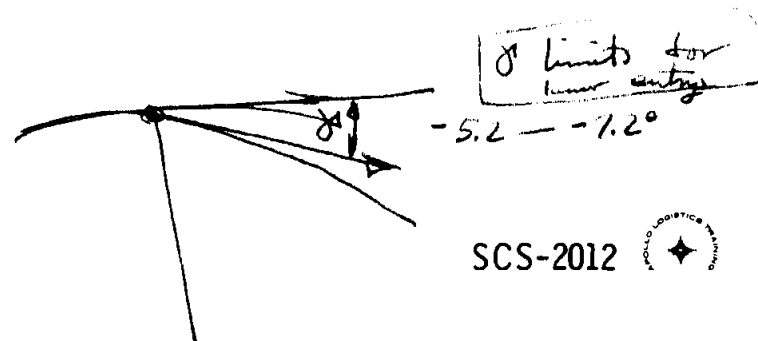
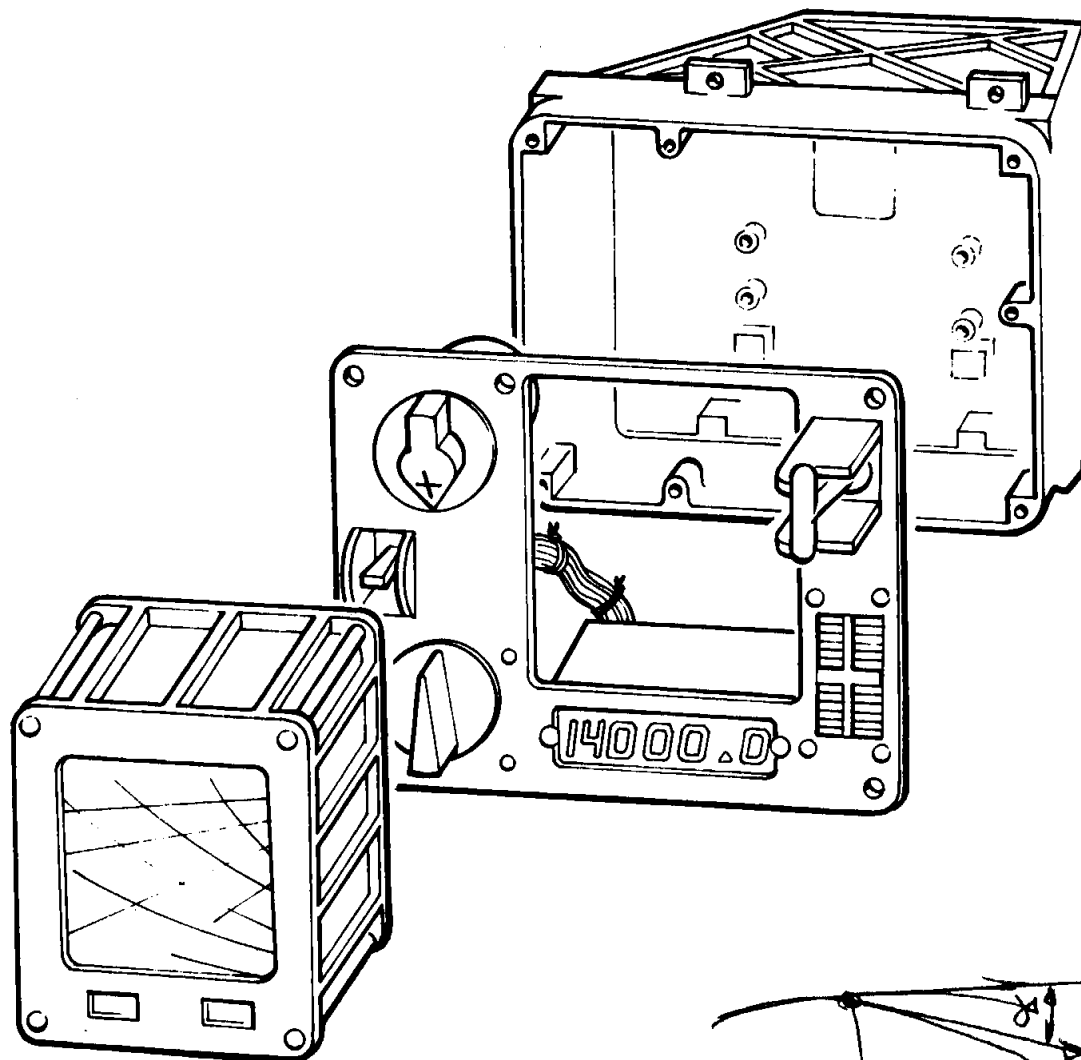
$C_{max}$   
 ?  
 1.8  
 4000L  
 $R_{To60}$   
 $V_s$   
 $t_{lossy}$

$\phi$   
 $\alpha$   
 lift vert. wheel

$G_s$   
 $V$   
 $h$

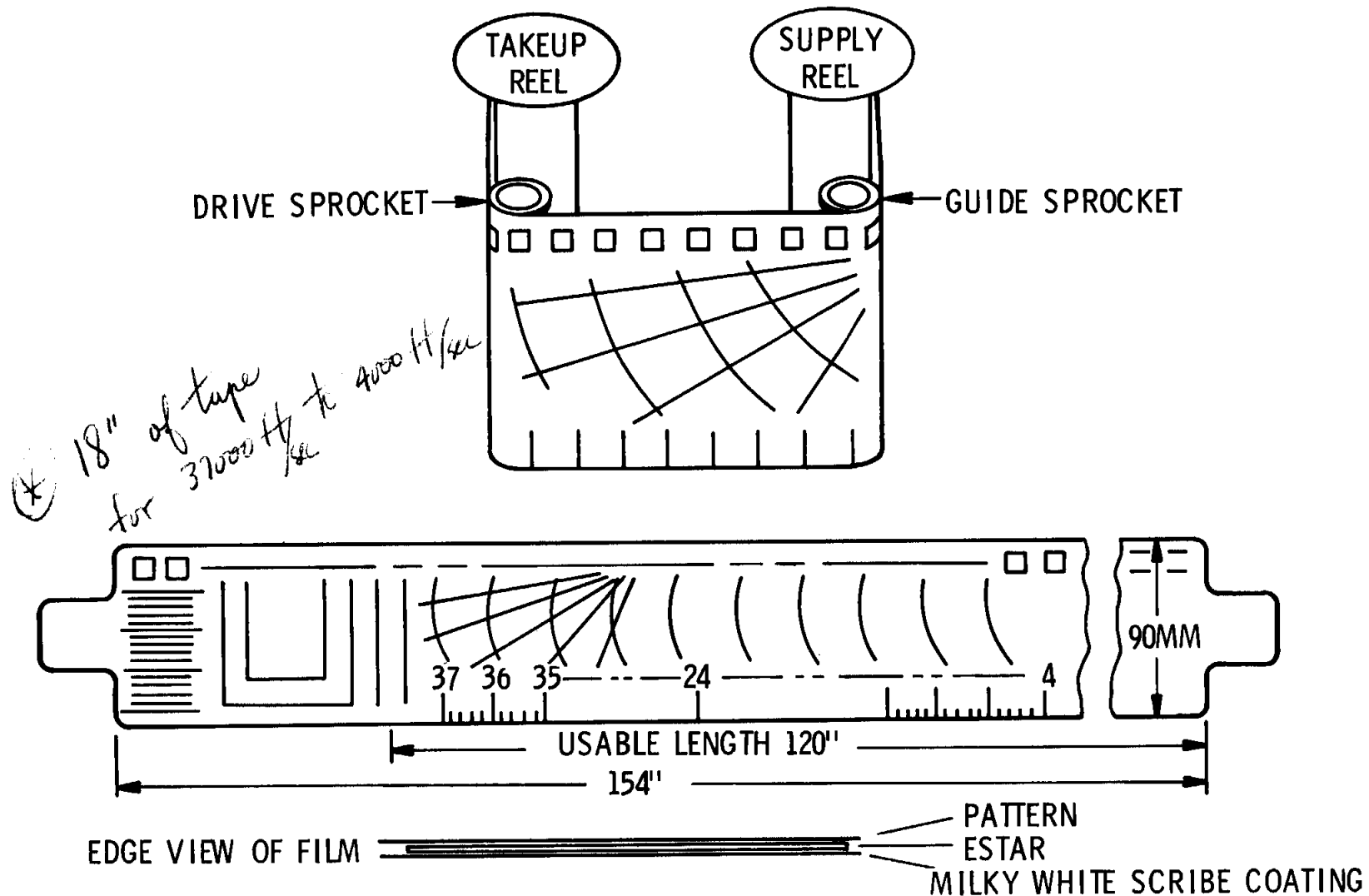
$C_{max}$   
 known range  
 known range

miss range to target  
 $\phi$  present  
 $\alpha$

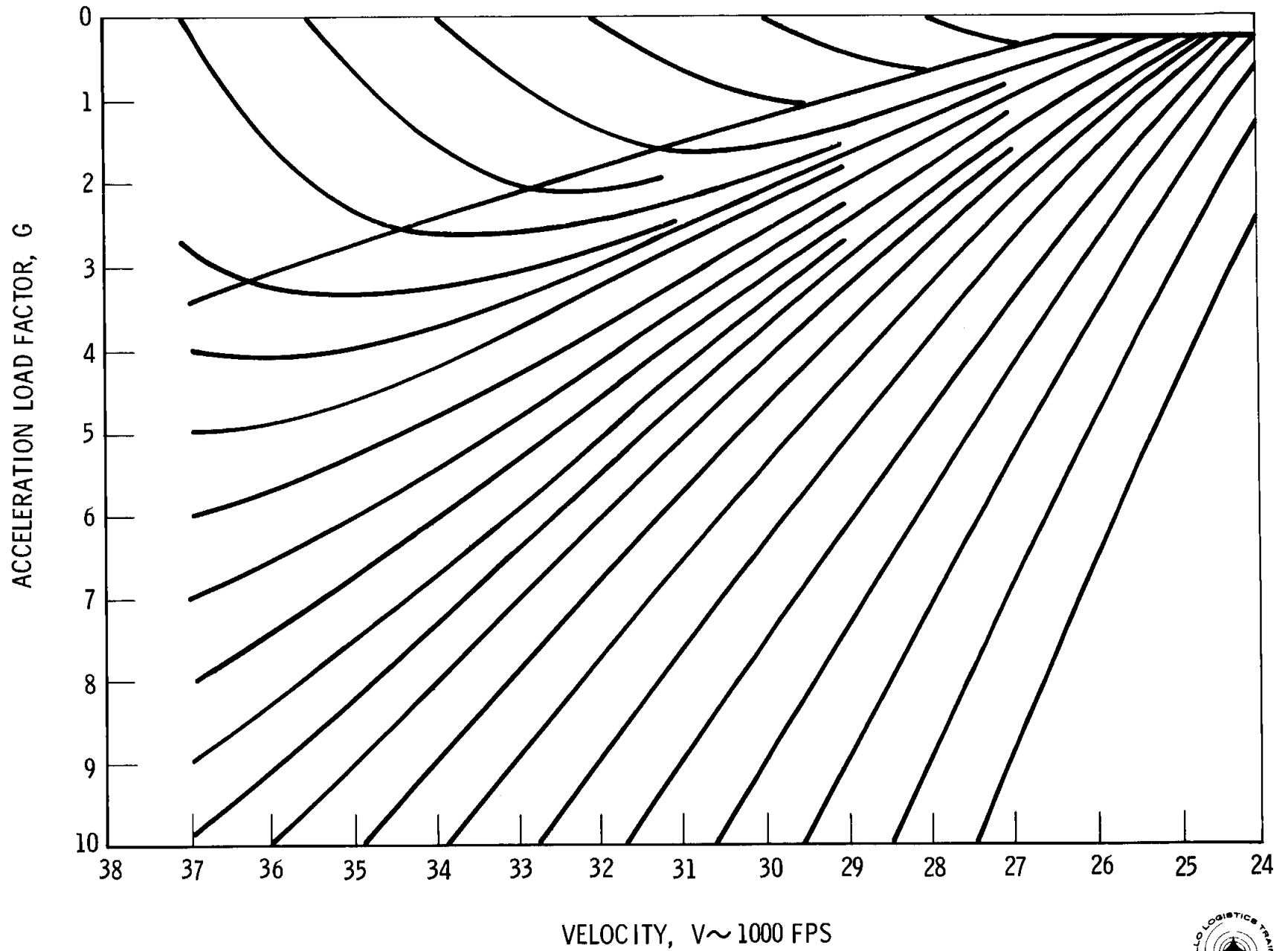


SCS-2012

# EMS SCROLL & SCRIBE



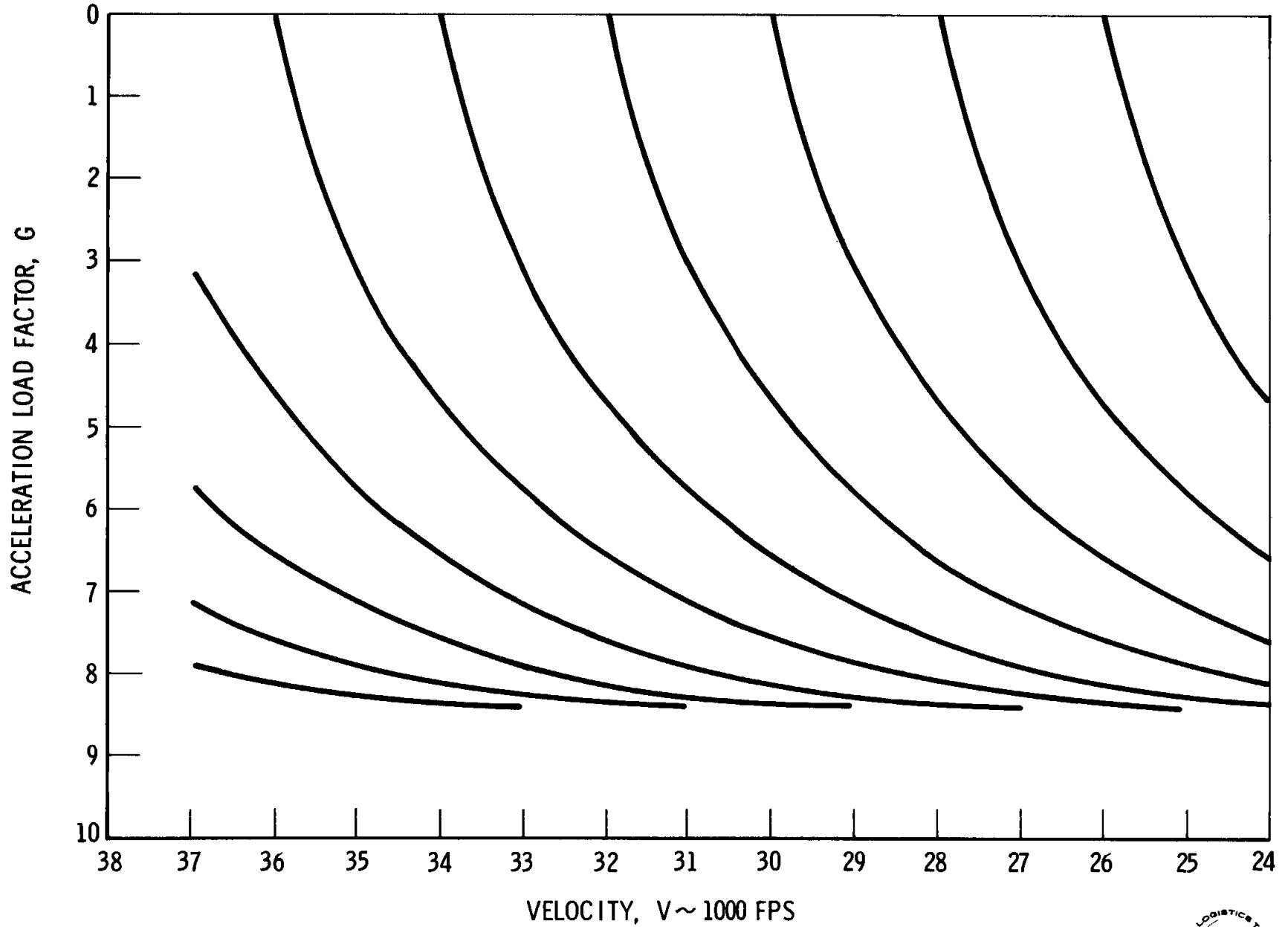
# OFF-SET FLIGHT LIMITS



SCS-2309

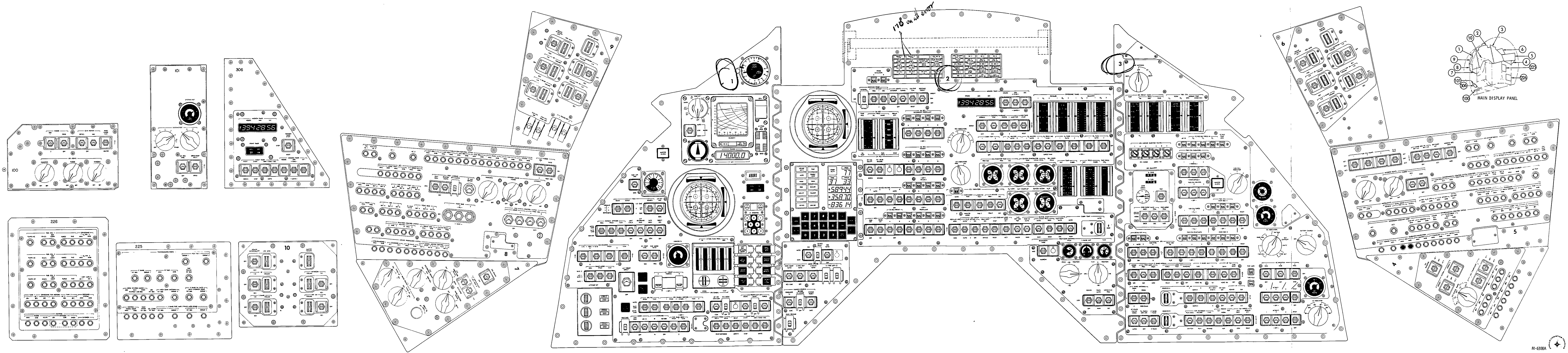


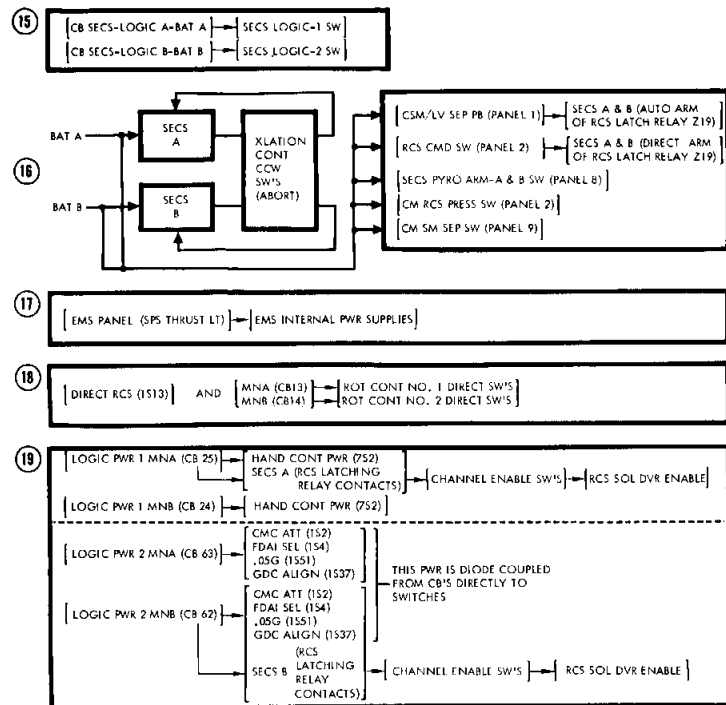
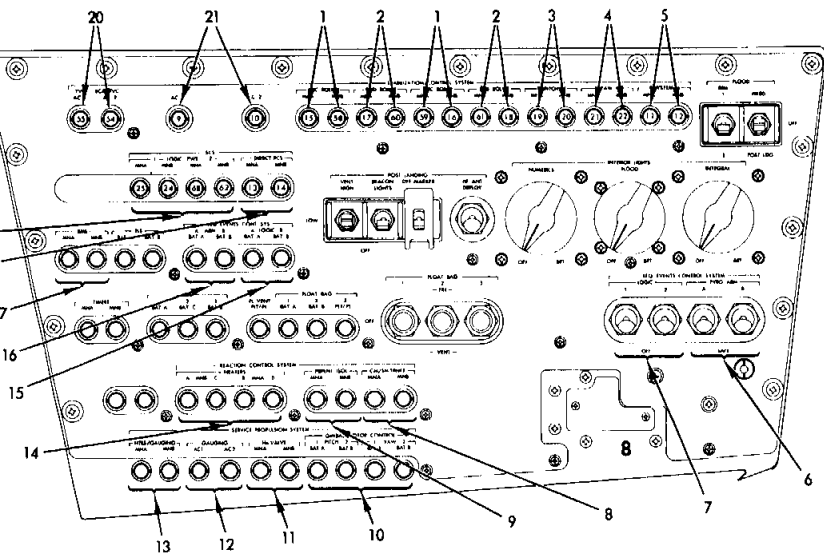
# ON-SET FLIGHT LIMITS



SCS-2312

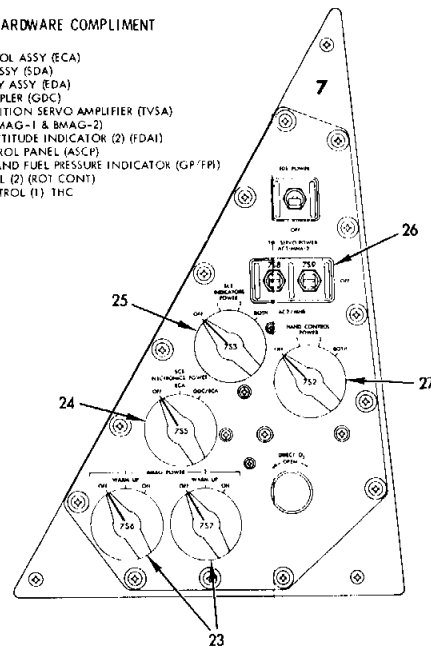




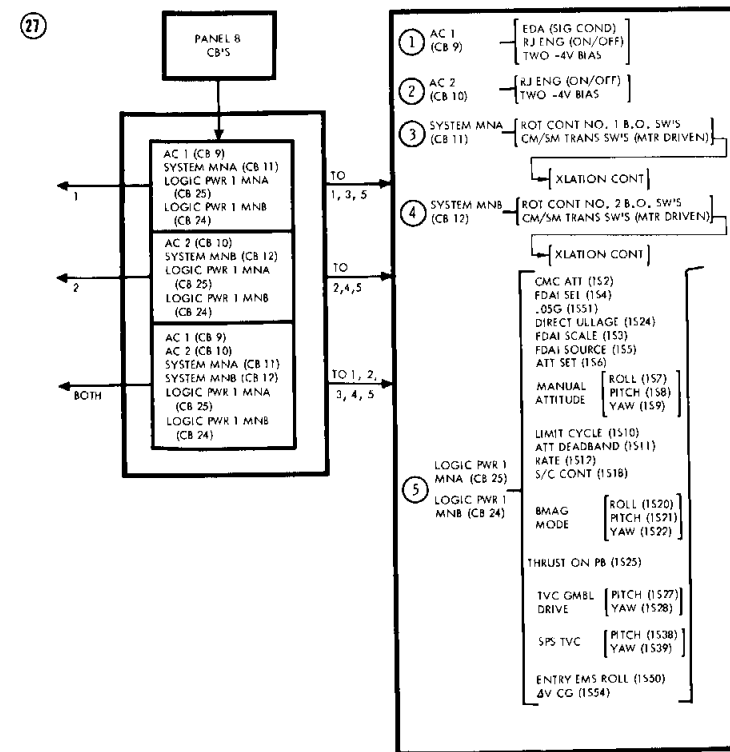
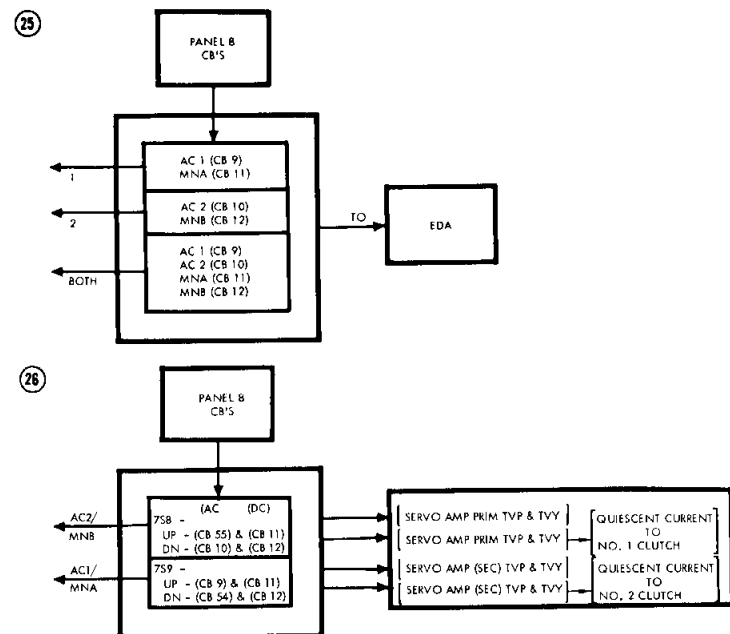


# SCS HARDWARE COMPLIMENT

ELECTRONIC CONTROL ASSY (ECA)  
SOLENOID DRIVER ASSY (SDA)  
ELECTRONIC DISPLAY ASSY (EDA)  
GYRO DISPLAY COUPLER (GDC)  
THRUST VECTOR POSITION SERVO AMPLIFIER (TVSA)  
GYRO ASSY'S (2) (BMAG-1 & BMAG-2)  
FLIGHT DIRECTOR ATTITUDE INDICATOR (2) (FDAI)  
ATTITUDE SET CONTROL PANEL (ASCP)  
GIMBAL POSITION AND FUEL PRESSURE INDICATOR (GP/FPI)  
ROTATION CONTROL (2) (ROT CONT)  
TRANSLATION CONTROL (1) (THC)



NOTE: KEEP BMAG PWR SW'S AT WARM UP UNTIL BMAG TEMP LIT'S (PANEL 2) ARE OUT - (NO INTERLOCK TO KEEP MOTORS FROM SPINNING UP AND DAMAGING GYRO'S)  
C/W CB MNA &/OR MNB ON PANELS 5 ARE CLOSED



GUIDANCE AND CONTROL FUNCTIONAL SWITCHING DIAGRAM (SHEET 1 OF 4)

SCS-3008





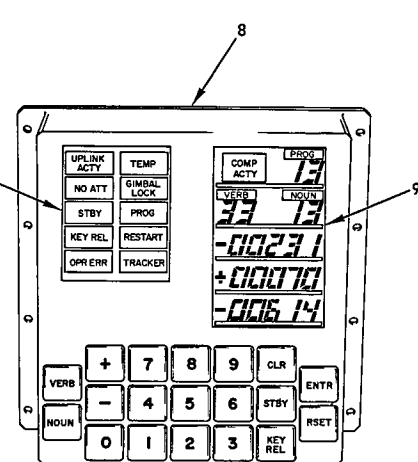
Diagram of the LEB Panel 322. The panel features a top section with two sets of controls, each including a rotary switch and a push button. Below these is a central display area with a large circular gauge and a smaller circular gauge. To the right of the central display is a vertical column of seven push buttons. The diagram is labeled with various callouts: '1' points to the top left control, '2' points to the top right control, '3' points to the central display area, '4' points to the bottom left control, and '5' points to the bottom right control. The text 'LEB PANEL 322' is printed in the center of the diagram.

|                  |                   |                    |                    |
|------------------|-------------------|--------------------|--------------------|
| SFS WALL TEMP HI | FC1               | FC2                | FC3                |
| SFS PU SNGR FAIL | INV 1 TEMP HI     | INV 2 TEMP HI      | INV 3 TEMP HI      |
| SFS PRESS        | LEM               | AC BUS 1 FAIL      | AC BUS 2 FAIL      |
| POMS             | FC BUS DISCONNECT | AC BUS 1 OVERLOAD  | AC BUS 2 OVERLOAD  |
| CMC              |                   | MN BUS A UNDERVOLT | MN BUS B UNDERVOLT |
| ISS              | C/W               | O2 FLOW HI         |                    |

| ① | DISPLAY IND                                                                | FUNCTION                                                                                                                       |
|---|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
|   | PROGRAM INPS                                                               | INDICATE PROGRAM BEING PROCESSED BY CNC                                                                                        |
|   | VER INPS                                                                   | INDICATE VER CODE ENTERED AT KEYBOARD OR COMMANDS BY CNC                                                                       |
|   | NOUN INPS                                                                  | INDICATE NOUN CODE ENTERED AT KEYBOARD OR COMMANDS BY CNC                                                                      |
|   | DATA DISPLAY INPS<br>REGISTER 1 (R1)<br>REGISTER 2 (R2)<br>REGISTER 3 (R3) | INSPECT NUMERICAL DATA ENTERED AT KEYBOARD OR COMMANDS BY CNC AND SIGN ASSOCIATED WITH THIS NUMERICAL DATA IF IT IS IN DECIMAL |

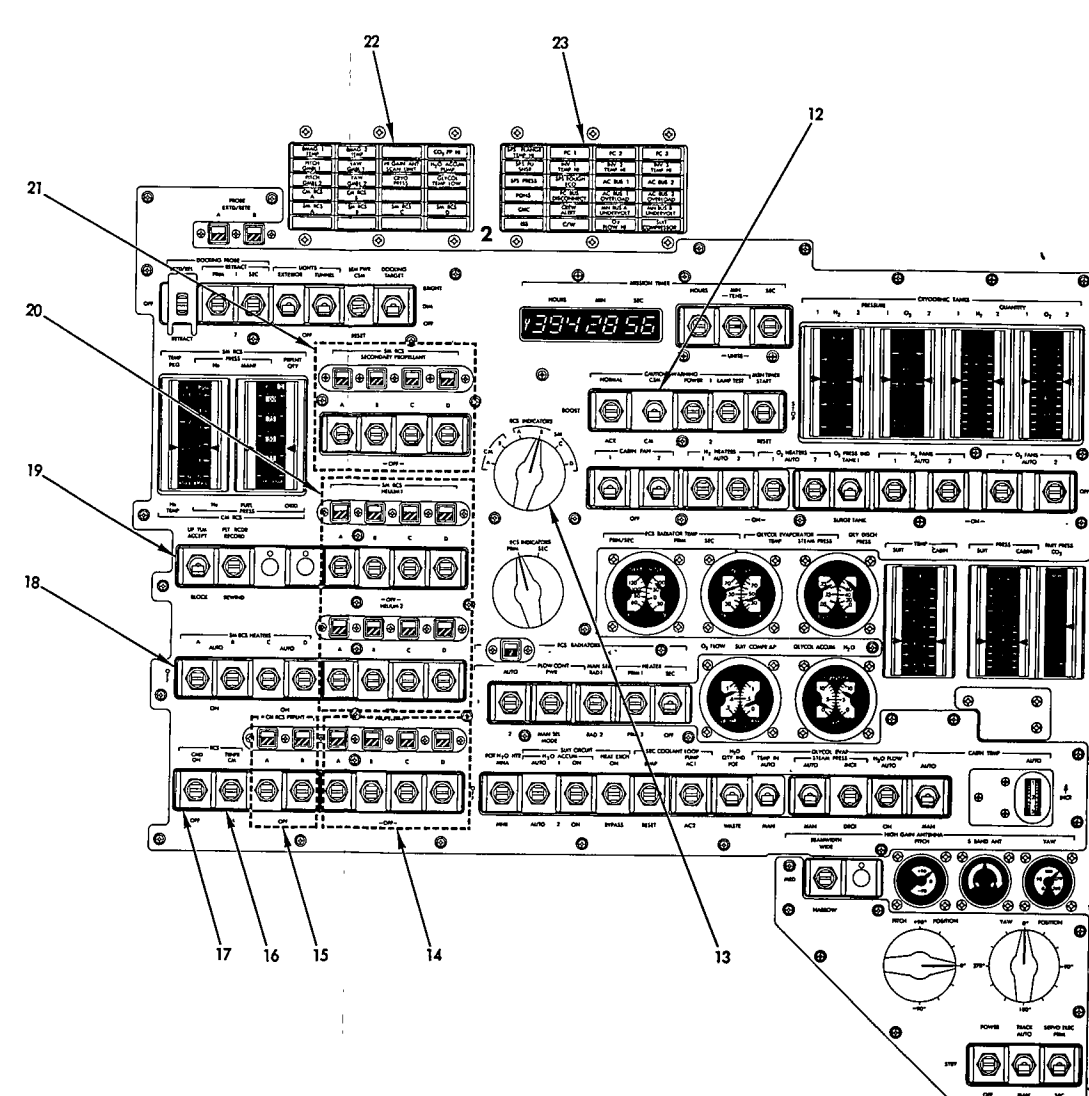
[illegible]

| KEY         | FUNCTION                                                                                                                                                                           |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ENTER       | ENTER NUMERICAL DATA, HOUR CODES AND VIB CODES INTO THE DATA FIELD                                                                                                                 |
| 1 - 9 AND 0 | FROM THE KEY THAT FOLLOWING NUMERICAL DATA IS ENTERED INTO THE DATA FIELD                                                                                                          |
| NUM KEY     | CHARACTERS CODE TO INTERPRET NEXT TWO NUMERICAL DATA AS HOUR CODE AND VIB CODE. HOUR CODE DISPLAY TO BE FORMED                                                                     |
| NUM KEY     | CHARACTERS CODE TO INTERPRET NEXT TWO NUMERICAL DATA AS HOUR CODE AND CAUSE HOUR DISPLAY TO BE FORMED                                                                              |
| CLR KEY     | CLEAR DATA CONTAINED IN DATA FIELD, RESETTING HOUR CODE AND VIB CODE TO ZERO. IF HOUR CODE SUCCESSFUL DEPRESSIONS CLEAR OTHER TWO DATA DEBITS                                      |
| STRT KEY    | COMMANDS CODE TO TRANSFER MORE - AFTER CAC DEPRESSIONS HOUR CODE AND VIB CODE ARE FORMED FOR STANDARD, AN ADDITIONAL DEPRESSION COMMANDS THE CODE TO BE REPEATED REGULAR DIRECTION |
| RELAY       | RELAY RELAY DEPRESSION INTERPRETS BY EXTENSION ACTIONS TO THAT INFORMATION SUPPLIED BY RELAY CODE MAY BE ESTABLISHED                                                               |
| ENR         | INFORMS CODE THAT ADDRESS DATA IS CONTAINS AND THAT THE INQUIRY FUNCTION IS TO BE EXECUTED                                                                                         |
| END         | TERMINATES RELAY DEPRESSIONS OF THE DATA FIELD                                                                                                                                     |

[illegible]

|                                                                                                                                   |                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>EMAG 1 &amp; 2 TEMP</p> <p>FITCH GMBL 1 &amp; 2</p> <p>YAW GMBL 1 &amp; 2</p> <p>CH RCS A &amp; B</p> <p>SM RCS A, B, C, D</p> | <p>INDICATES BHADS ARE NOT WITHIN TEMP LIMITS</p> <p>INDICATES GMBAL MOTORS FAILED<br/>BECAUSE OF OVERCURRENT</p> <p>INDICATES CH RCS OVERUNDER PRESS</p> <p>INDICATES SM RCS Hw OVERUNDER PRESS</p> |
|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                    |                                                                     |                               |
|--------------------|---------------------------------------------------------------------|-------------------------------|
| SPS FLANGE TEMP #4 | LIGHTS WHEN TEMP <50°F                                              | } SEE<br>FAILURE<br>SECTION ⑦ |
| SPS PS INGR        | INDICATES MALFUNCTION OR TRUE UNBALANCE                             |                               |
| SPS PRESS          | SPS OVERUNDER PRESS 200 PSIA = OVER PRESS<br>140 PSIA = UNDER PRESS |                               |
| PGINS              | INDICATES PROBLEM WITHIN PGINS                                      | }                             |
| CHMC               | INDICATES PROBLEM WITHIN CHMC                                       |                               |
| ISS                | INDICATES PROBLEM WITHIN ISS                                        |                               |
| SPS ROUGH ECO      | LIGHTS WHEN PGINS SENSORS ROUGH COMMUTATION                         |                               |



GUIDANCE AND CONTROL FUNCTIONAL SWITCHING DIAGRAM UNIT 3 OF 6

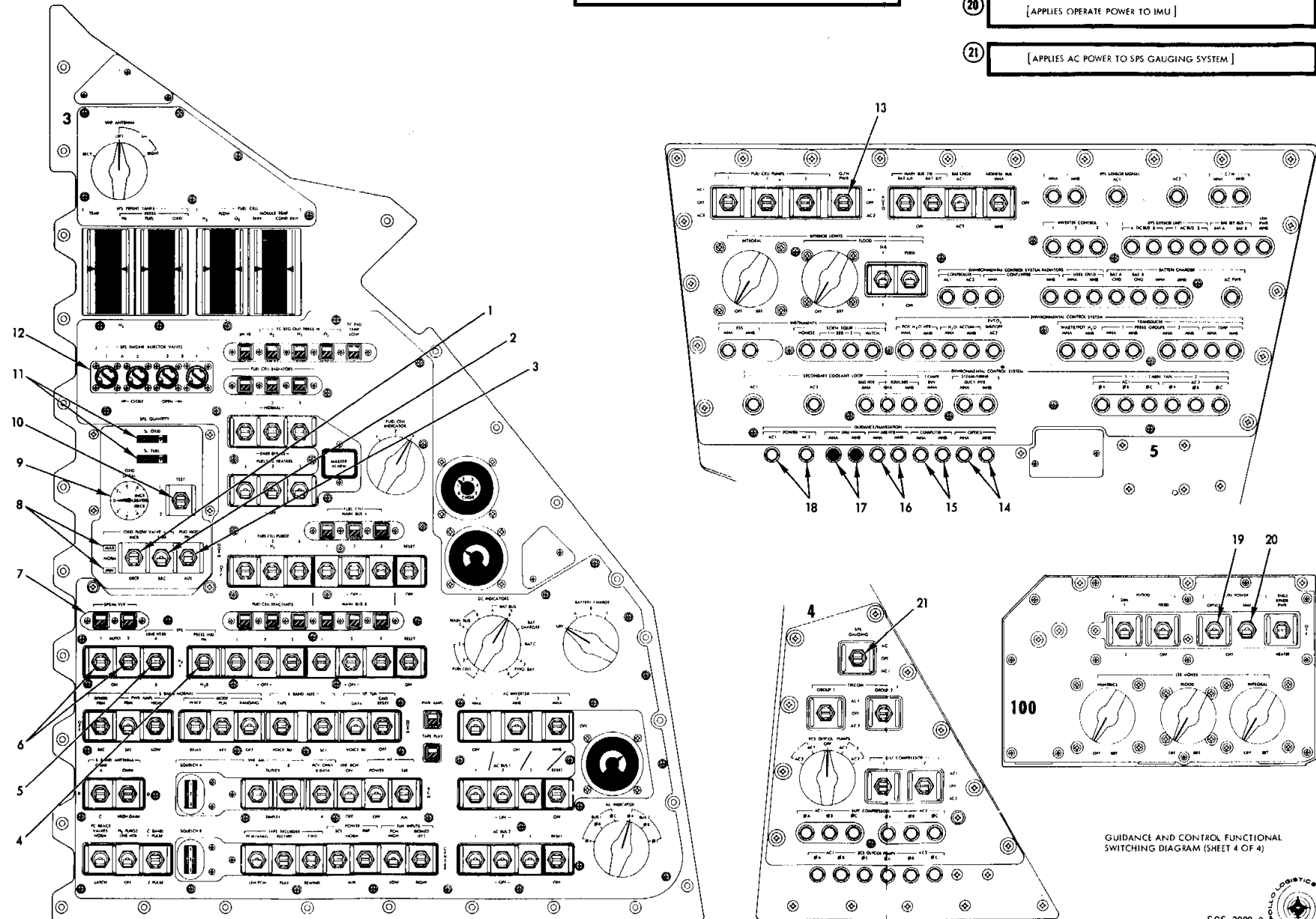
|    |                             |                                           |                                                                                                                                                                                                                                                   |
|----|-----------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | OXID FLOW VALVE-FLOW SW     | INCR                                      | INCREASES VALVE AREA OF PU VALVE SELECTED (PRIM OR SEC) THEREFORE INCREASING OXIDIZER FLOW RATE                                                                                                                                                   |
|    |                             | NORM                                      | NORMAL POSITION - ASSUMES NOMINAL PU VALVE AREA FOR CORRECT OXIDIZER FLOW TO MAINTAIN BALANCE (PROPER FUEL AND OXIDIZER RATIO)                                                                                                                    |
|    |                             | DECR                                      | DECREASES VALVE AREA OF PU VALVE SELECTED, THEREBY DECREASING OXIDIZER FLOW RATE                                                                                                                                                                  |
| 2  | OXID FLOW VALVE-PRIM/SEC SW | PRIM                                      | SELECTS PRIMARY PU VALVE FOR ADJUSTING FLOW                                                                                                                                                                                                       |
|    |                             | SEC                                       | SELECTS SECONDARY PU VALVE FOR ADJUSTING FLOW                                                                                                                                                                                                     |
| 3  | PUG MODE SW                 | PRIM                                      | SELECTS PRIMARY PUG SYSTEM FOR MONITORING                                                                                                                                                                                                         |
|    |                             | NORMAL                                    | SELECTS PRIMARY PUGS SYSTEM AND IS THE NORMAL MONITORING POSITION                                                                                                                                                                                 |
|    |                             | AUX                                       | SELECTS AUXILIARY PUG SYSTEM FOR MONITORING                                                                                                                                                                                                       |
| 4  | SPS-PRESS IND SW            |                                           | THIS SWITCH TIME-SHARES SPS PRPLNT TANKS-PRESS INDICATOR BETWEEN $H_2$ PRESSURE AND $N_2$ PRESSURE                                                                                                                                                |
|    |                             | $H_2$                                     | SELECTS $H_2$ PRESS PORTION OF PRESSURE INDICATOR                                                                                                                                                                                                 |
|    |                             | $N_2$                                     | A OR B SELECTS $N_2$ PRESS PORTION OF PRESSURE INDICATOR                                                                                                                                                                                          |
| 5  | SPS-LINE HTRS SW            | A                                         | SELECTS AND POWERS SPS A SYSTEM HEATER ELEMENTS (12) ONLY                                                                                                                                                                                         |
|    |                             | AB                                        | SELECTS AND POWERS ALL SPS A & B SYSTEM HEATER ELEMENTS (24)                                                                                                                                                                                      |
| 6  | SPS $H_2$ VLV-1 & 2 SW      | AUTO                                      | NORMAL POSITION FOR THRUSTING; $H_2$ PRESSURIZING SW'S FOR SPS $H_2$ ISOLATION VALVES. APPLIES POWER TO CONTACTS OF SPS THRUST ON/OFF RELAYS. AT THRUST ON, POWER IS DIRECTED TO SPS $H_2$ ISOLATION VALVES 1 & 2 PRESSURIZING PROP SYSTEMS A & B |
|    |                             | ON                                        | BYPASSES AUTOMATIC FUNCTION AND ENERGIZES SPS $H_2$ ISOLATION VALVES DIRECT, THEREBY PRESSURIZING THE PROP SYSTEMS                                                                                                                                |
|    |                             | OFF                                       | INHIBITS OPERATE POWER TO $H_2$ ISOLATION VALVES.                                                                                                                                                                                                 |
| 7  | SPS $H_2$ VLV-1 & 2 TB      | STRIPED                                   | INDICATES SPS $H_2$ ISOLATION VALVES CLOSED; PROPELLANTS NOT PRESSURIZED                                                                                                                                                                          |
|    |                             | GRAY                                      | INDICATES SPS $H_2$ ISOLATION VALVES OPEN (PROPELLANTS PRESSURIZED) BY AUTOMATIC OR DIRECT THRUST ON                                                                                                                                              |
| 8  | OXID FLOW VALVE-MAX-MIN TB  | MAX                                       | INDICATES PU VALVE AT MAX FLOW POSITION                                                                                                                                                                                                           |
|    |                             | MIN                                       | INDICATES PU VALVE AT MIN FLOW POSITION                                                                                                                                                                                                           |
|    |                             | GRAY                                      | INDICATES OXID FLOW VALVE-FLOW SW IS AT NORM POSITION AND HAVE NOMINAL FLOW                                                                                                                                                                       |
| 9  | OXID UNBAL IND              | 0                                         | INDICATES BALANCED FUEL/OXID FLOW                                                                                                                                                                                                                 |
|    |                             | INCR                                      | INDICATES OXIDIZER FLOW SHOULD BE INCREASED                                                                                                                                                                                                       |
|    |                             | DECR                                      | INDICATES OXIDIZER FLOW SHOULD BE DECREASED                                                                                                                                                                                                       |
| 10 | PUGS TEST SW                | ENABLES TEST OF PUGS                      |                                                                                                                                                                                                                                                   |
| 11 | % OXID, % FUEL IND          | INDICATES % QUANTITY OF FUEL AND OXIDIZER |                                                                                                                                                                                                                                                   |

|    |                                       |   |                                                                                  |
|----|---------------------------------------|---|----------------------------------------------------------------------------------|
| 12 | SPS ENGINE INJECTOR VALVES INDICATORS | A | IF OPEN, INDICATES (A) PORTION OF SPS BI-PROPELLANT VALVE IS OPEN TO PROPELLANTS |
|    |                                       | B | IF OPEN, INDICATES (B) PORTION OF SPS BI-PROPELLANT VALVE IS OPEN TO PROPELLANTS |

NOTE-(A) WOULD NORMALLY BE SET, THEN (B) IF (A) FAILS

|    |                                                         |
|----|---------------------------------------------------------|
| 13 | [ SUPPLIES PWR FOR G/N LIGHTING ]                       |
| 14 | [ G/N POWER-OPTICS SW (PANEL 100) ] → [ OPTICS SYSTEM ] |
| 15 | [ COMPUTER (CMC) & INTERNAL PWR SUPPLIES ]              |
| 16 | [ IMU & HEATER CKTS ]                                   |

|    |                                             |
|----|---------------------------------------------|
| 17 | [ G/N POWER-IMU SW (PANEL 100) ] → [ IMU ]  |
|    | [ SC CONT SW (1518) CMC POSITION CONTACT ]  |
| 18 | [ G/N PWR SW (PANEL 5) ] → [ G/N LIGHTING ] |
| 19 | [ APPLIES DC POWER TO OPTICS SYSTEM ]       |
| 20 | [ APPLIES OPERATE POWER TO IMU ]            |
| 21 | [ APPLIES AC POWER TO SPS GAUGING SYSTEM ]  |



GUIDANCE AND CONTROL FUNCTIONAL SWITCHING DIAGRAM (SHEET 4 OF 4)

## Block II Computer Programs

### Idling

P00 --- housekeeping (orbital data, clocks)

### Prelaunch Servicing

P05 Power up  
P06 " down

### Boost

P11 boost monitor  
(alt & ullerror)

### Coast

P20 Rendezvous  
P21 Ground Track Det.  
P22 Orbital Nav. --- check state vector  
P23 Midcourse NAV.  
P27 CMC update --- targeting for ext. DV  
CM state  
LM state  
CMC Time } 4 types of updates

### Pre Thrusting

P30 External DV (DV required & big)  
P34 Transfer Phase Initiation (TPI)   
P35 TPI - Midcourse --- rendezvous  
P36 TPI Final

### Thrusting

P40 SPS burn (both fired off & curved burn)  
P41 RCS burn

### Entry

P61 Fly to cm/srv sep. off.  
P62 sep & fly to trim  
P64 .20  
P67 1.0

| BIT<br>CHANNEL                | 16 | 15 | 14               | 13                           | 12     | 11 | 10 | 9   | 8     | 7 | 6 | 5 | 4 | 3 | 2 | 1          |
|-------------------------------|----|----|------------------|------------------------------|--------|----|----|-----|-------|---|---|---|---|---|---|------------|
| 0<br>(VACANT)                 |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| 1                             |    |    |                  | IDENTICAL TO REGISTER #1 (L) |        |    |    |     |       |   |   |   |   |   |   |            |
| 2                             |    |    |                  | IDENTICAL TO REGISTER #2 (Q) |        |    |    |     |       |   |   |   |   |   |   |            |
| 3                             |    |    | HIGH<br>23.3 HRS | ORDER                        | SCALER |    | 14 | BIT | POS # |   |   |   |   |   |   | 5.12 SEC   |
| 4                             |    |    | LOW<br>5.12 SEC  | ORDER                        | SCALER |    | 14 | BIT | POS # |   |   |   |   |   |   | 1/3200 SEC |
| OUTBITS<br>5<br>RCS (P&Y)     |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>6<br>RCS (ROLL)    |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| FMA<br>7                      |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>10<br>"R" RELAYS   |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>11<br>"A" RELAYS   |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>12<br>GN&C         |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>13<br>RADAR & AGC  |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| OUTBITS<br>14<br>IMU          |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>15<br>MAIN KEYBOARD |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>16<br>NAV KEYBOARD  |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| 17 &<br>20 THRU 27<br>VACANT  |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>30<br>GN&C          |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>31<br>TRANS & ROT   |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>32<br>IMPULSE       |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| INBITS<br>33<br>OPTICS & AGC  |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| 34                            |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |
| 35                            |    |    |                  |                              |        |    |    |     |       |   |   |   |   |   |   |            |

| RADAR SELECTION |   |   | 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      |

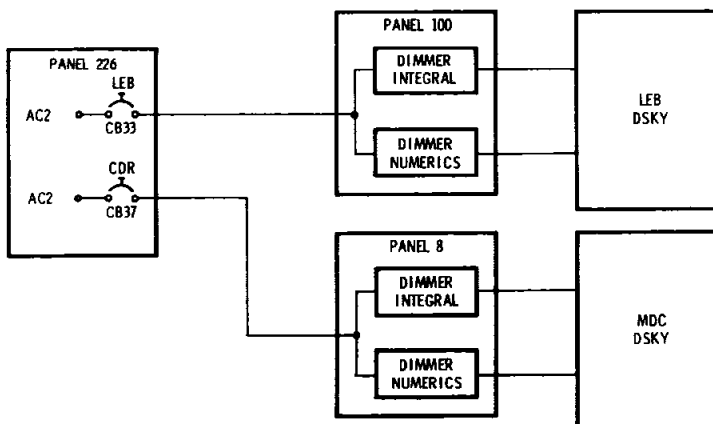
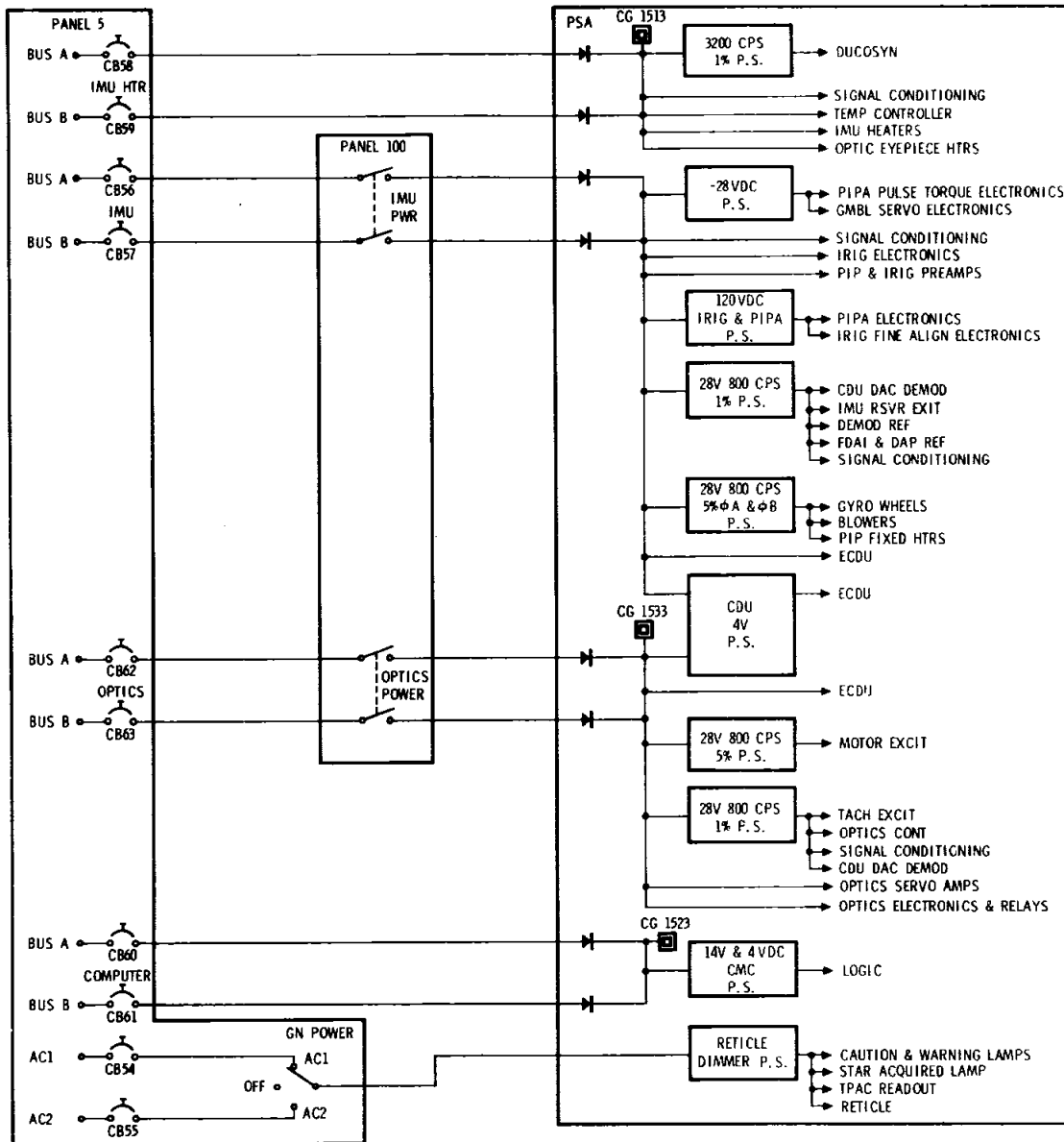
| GYRO SELECT |   |   | GYRO |
|-------------|---|---|------|
| 0           | 0 | 0 | —    |
| 0           | 1 | 0 | X    |
| 1           | 0 | 0 | Y    |
| 1           | 1 | 0 | Z    |

| FE7 | FE6 | FE5 | HIGH BANKS |
|-----|-----|-----|------------|
| 0   | X   | X   | 30-37      |
| 1   | 0   | 0   | 40-43      |
| 1   | 1   | 0   | EMPTY      |
| 1   | 1   | 1   | EMPTY      |

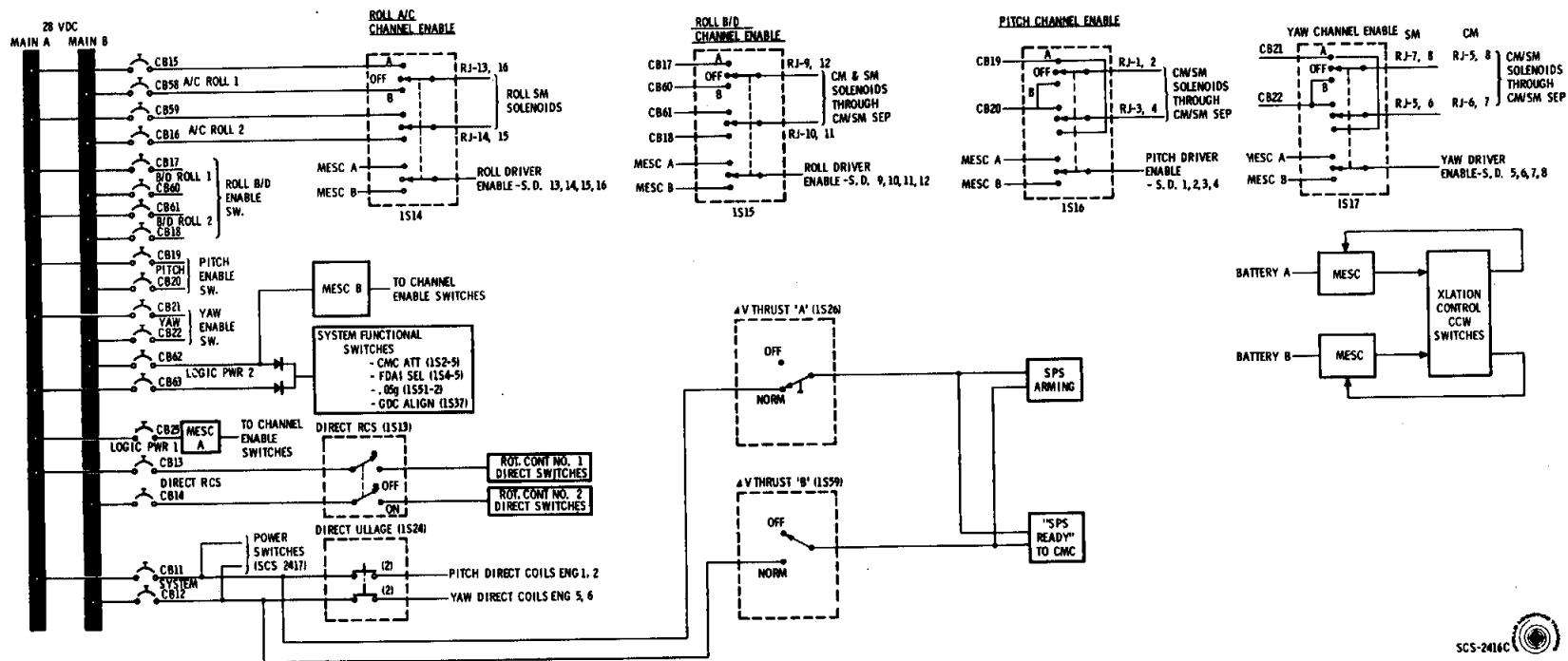
## BLOCK II CMC & LGC CHANNEL-BIT ASSIGNMENTS



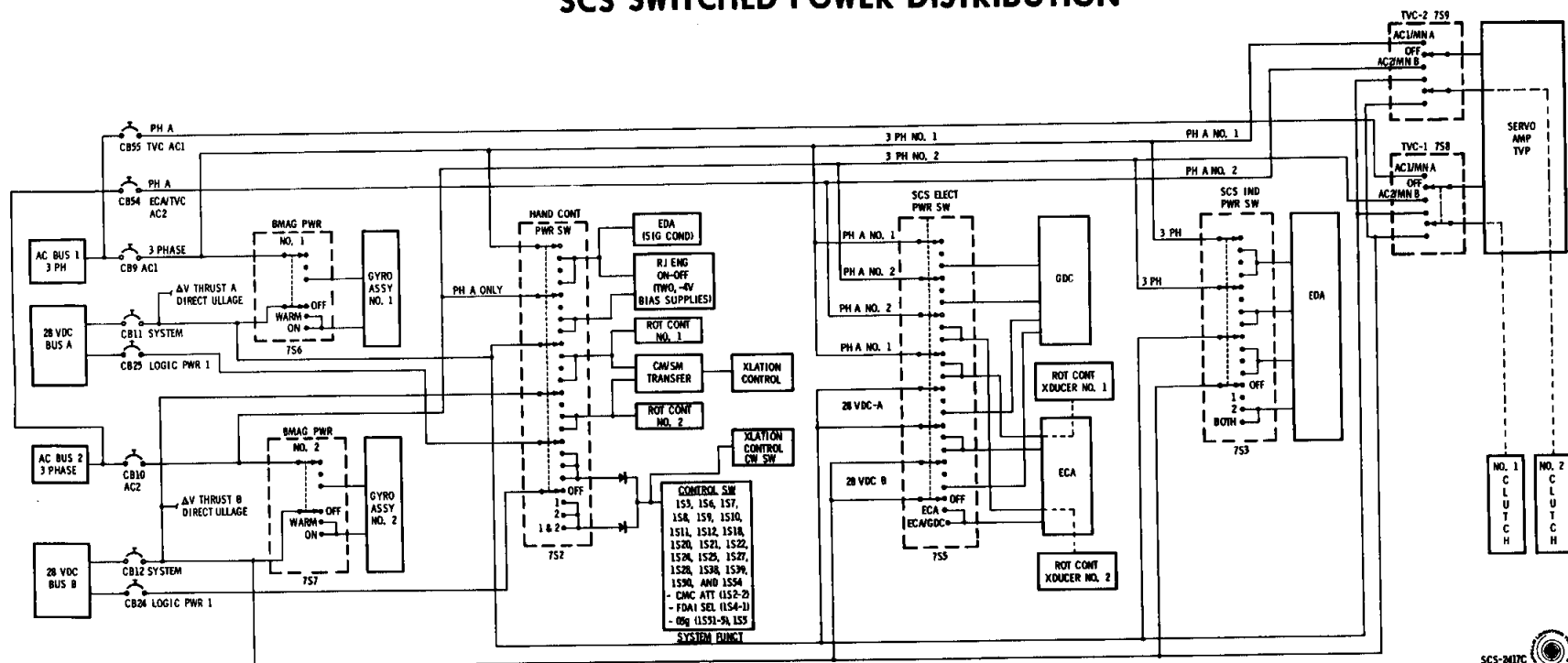
# GNC POWER DISTRIBUTION



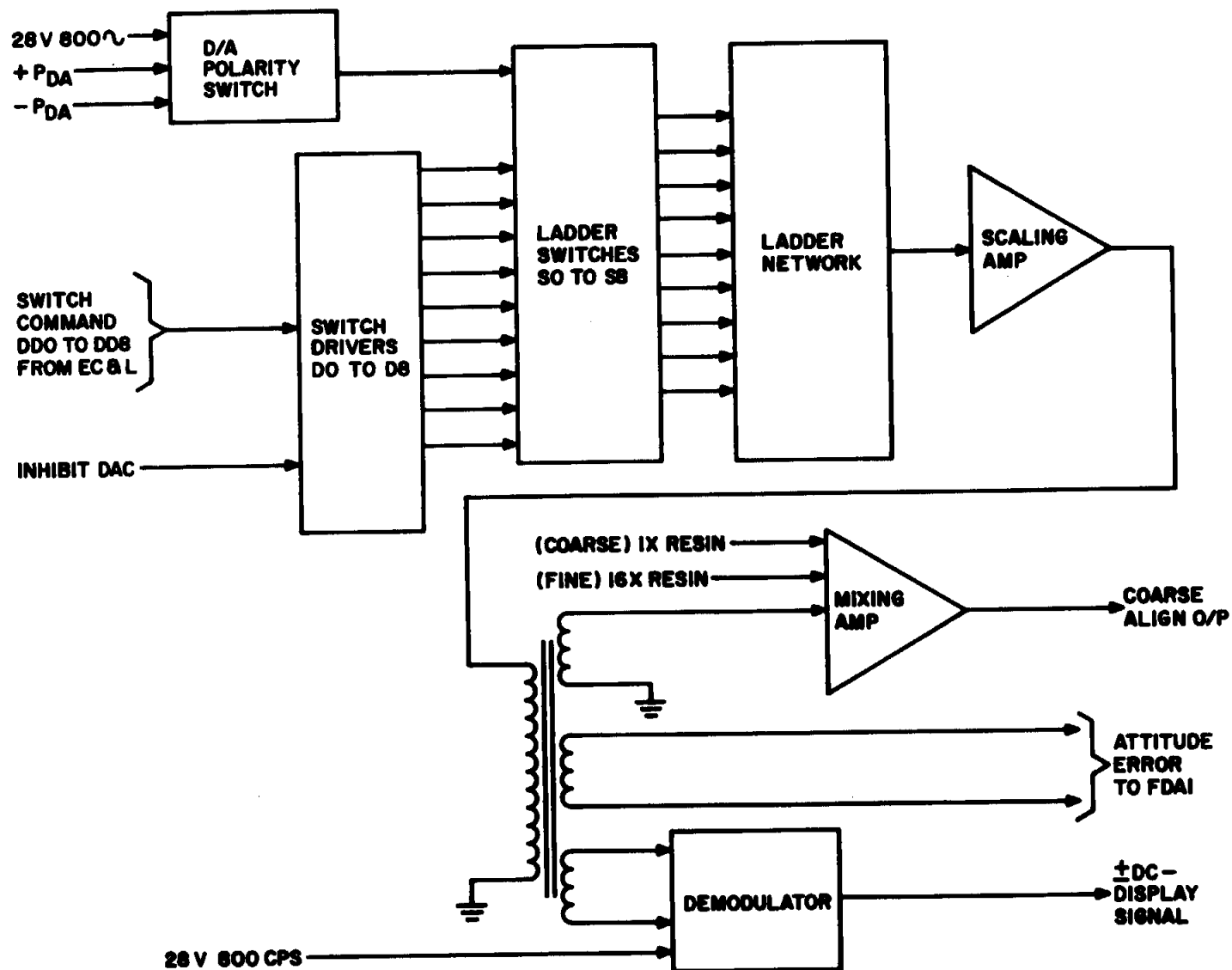
## SCS NON SWITCHED POWER



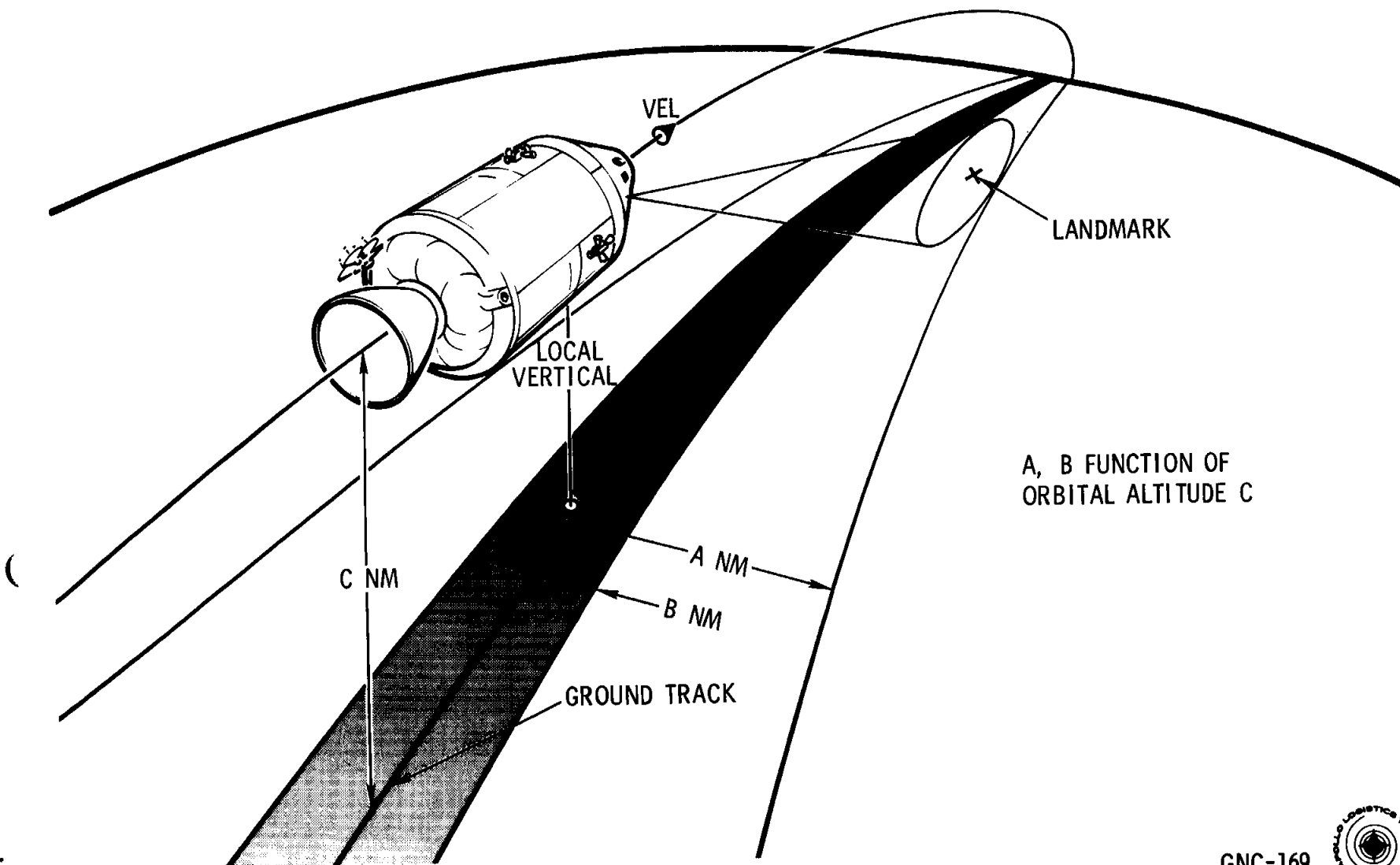
## SCS SWITCHED POWER DISTRIBUTION



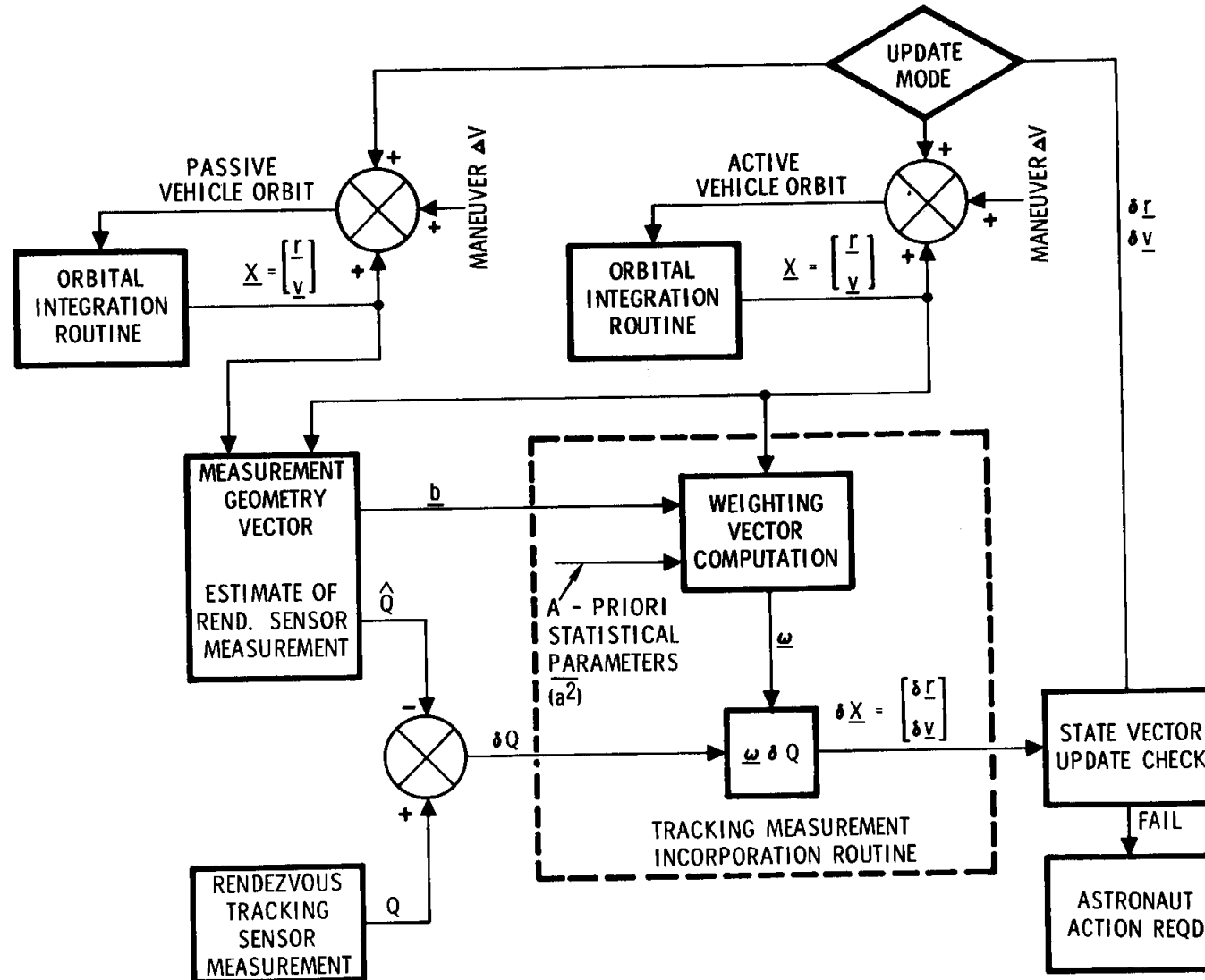
# DIGITAL TO ANALOG CONVERTER MODULE BLOCK DIAGRAM



# ORBITAL LANDMARK TRACKING



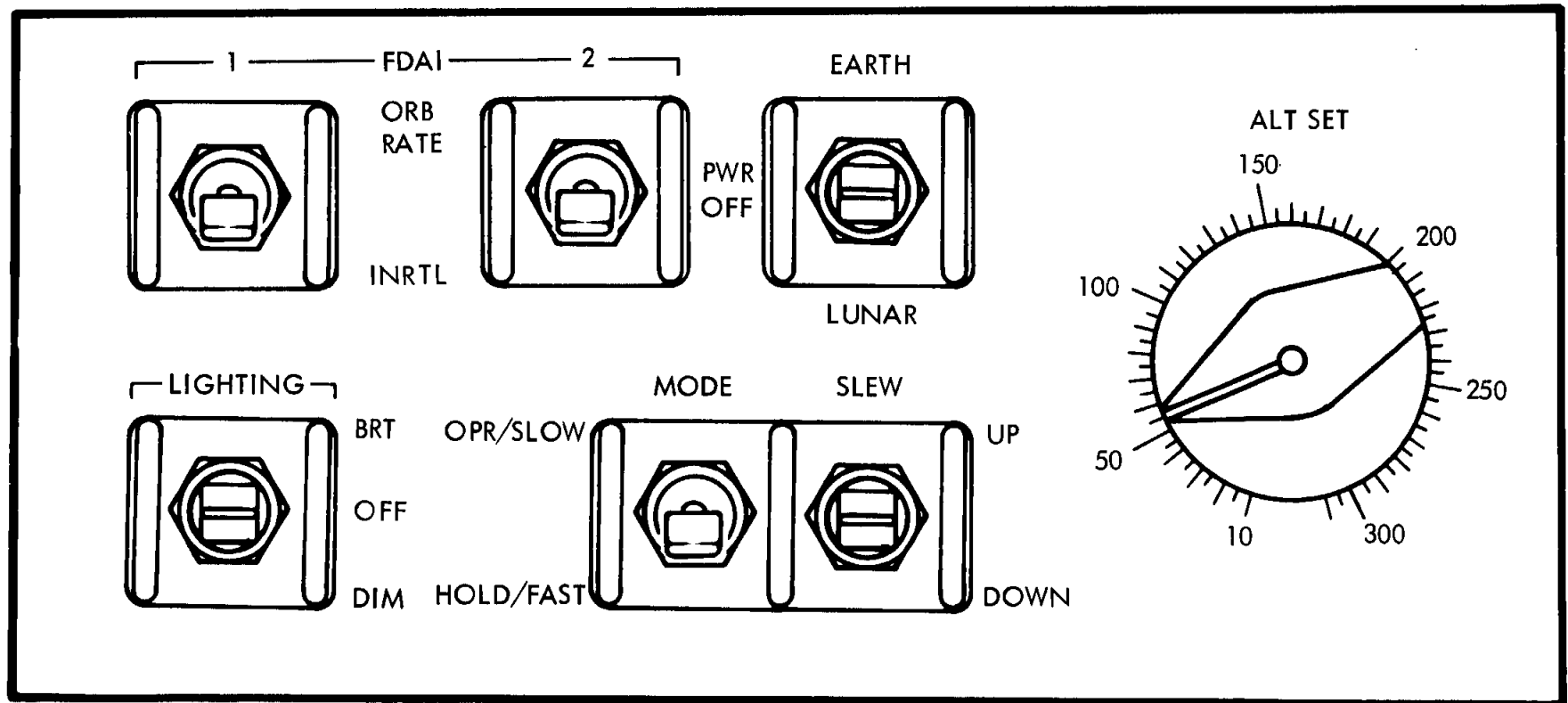
# SIMPLIFIED CMC RENDEZVOUS NAVIGATIONAL FUNCTIONAL DIAGRAM



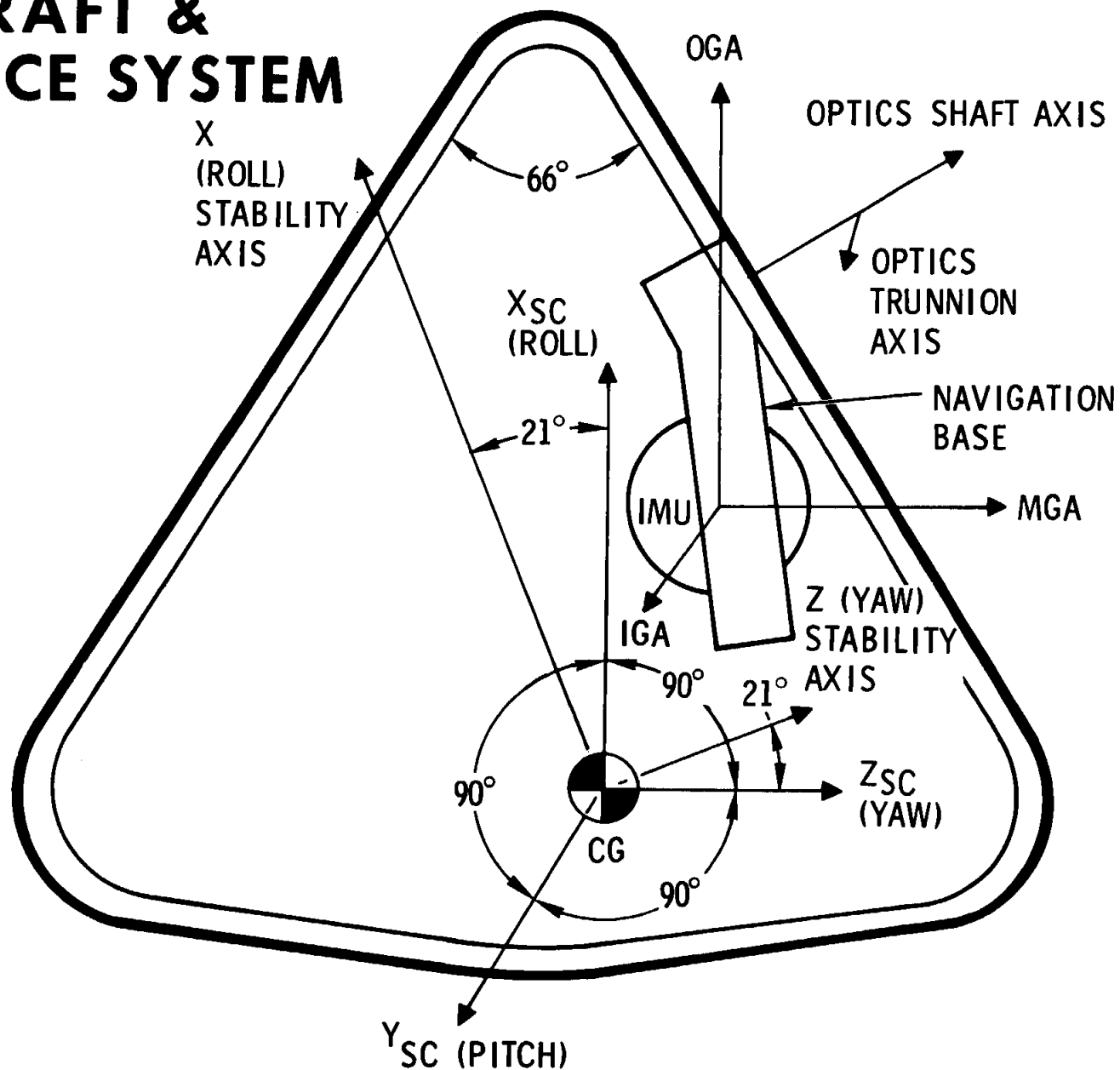
A diagram of a celestial sphere illustrating various coordinate systems and satellite positions. The sphere is centered at the origin. A vertical axis is labeled  $Z_I$  with an arrow pointing upwards. A horizontal axis is labeled  $X_I$  with an arrow pointing towards the bottom-left. Another horizontal axis is labeled  $Y_I$  with an arrow pointing towards the bottom-right. A dashed line represents the  $Y$ -axis in the geocentric system. A shaded band around the sphere represents the Earth's surface. A shaded band on the sphere's surface represents the satellite's path. Two points on this path are labeled  $CSM \text{ AT } T_0$  and  $CSM \text{ AT } T_1$ . A line from the center to  $CSM \text{ AT } T_1$  is labeled  $LAT \text{ \& LONG}$ . A line from the center to  $CSM \text{ AT } T_0$  is labeled  $LAT$ . A line from the center to  $CSM \text{ AT } T_1$  is labeled  $LONG$ . A line from the center to  $CSM \text{ AT } T_0$  is labeled  $AZ$ . A line from the center to  $CSM \text{ AT } T_1$  is labeled  $YE$ . A line from the center to  $CSM \text{ AT } T_0$  is labeled  $XE$ . A line from the center to  $CSM \text{ AT } T_1$  is labeled  $YI$ . A line from the center to  $CSM \text{ AT } T_0$  is labeled  $GREENWICH \text{ MERIDIAN}$ .

GNC-170 

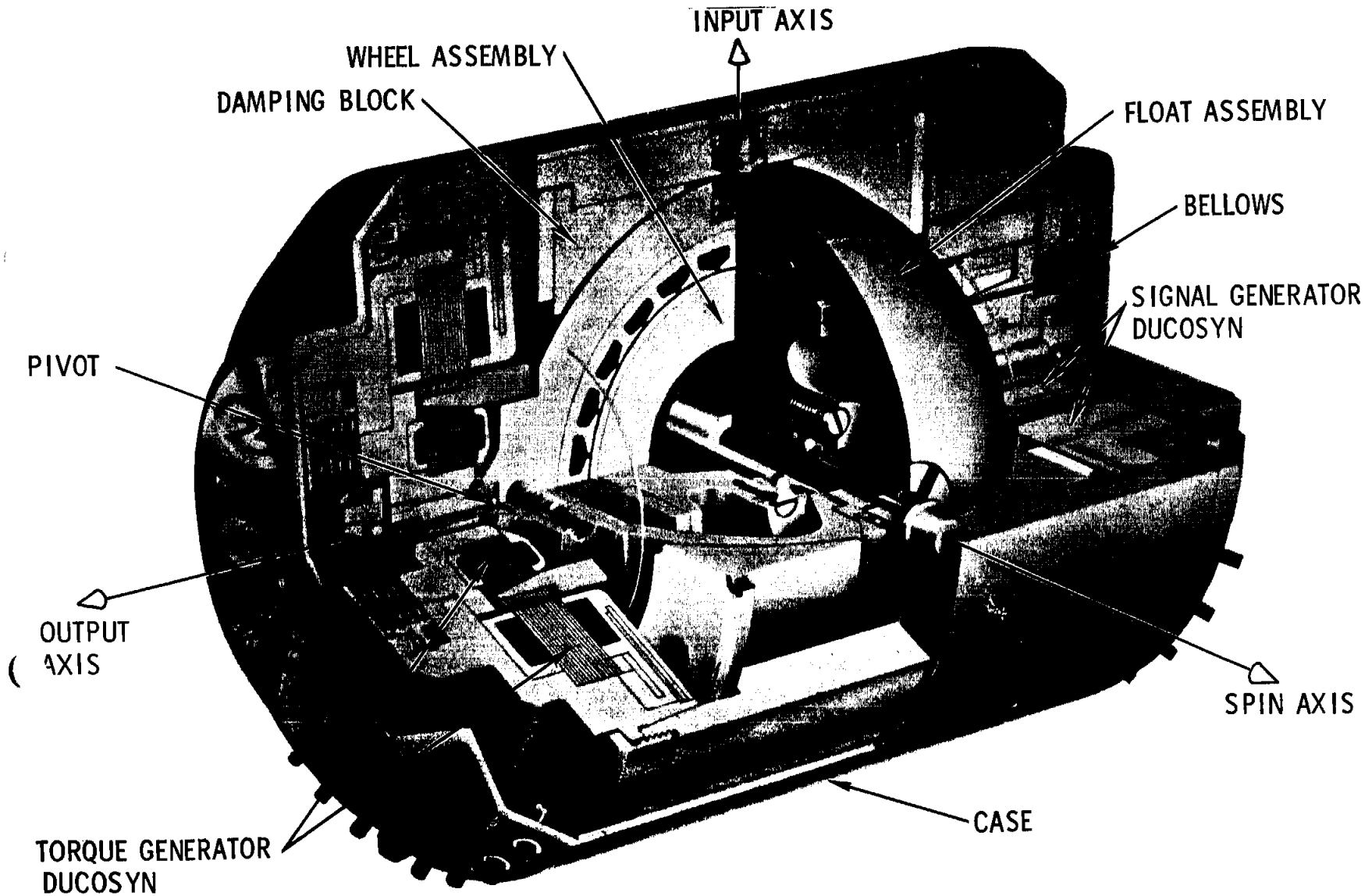
# ORDEAL PANEL



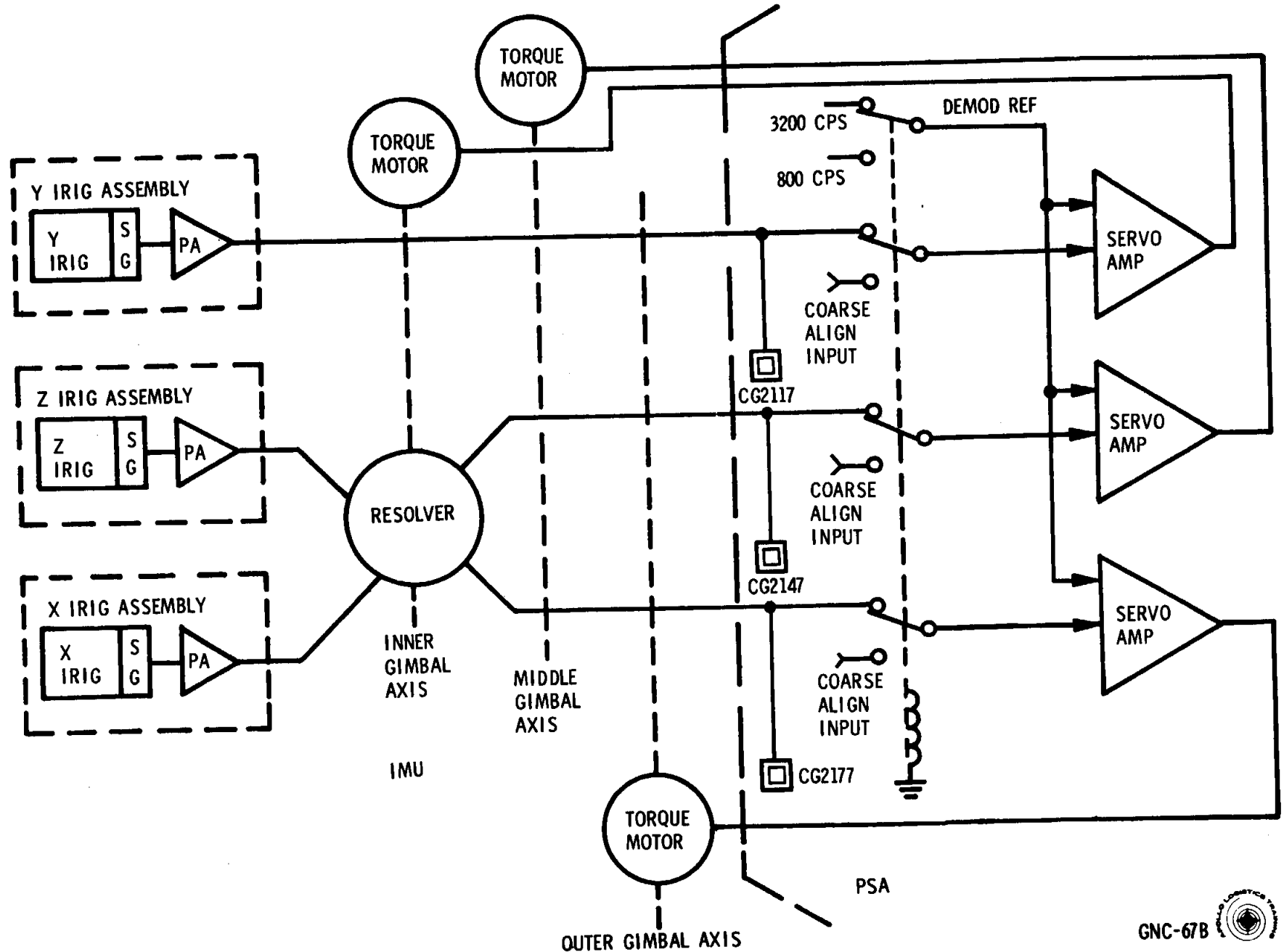
# SPACECRAFT & GUIDANCE SYSTEM AXES



# 25 IRIG



# BLOCK II STABILIZATION LOOPS



# PIP

SIGNAL  
GENERATOR  
DUCOSYN

PENDULUM

OUTPUT  
AXIS  
OA

BELLOWS

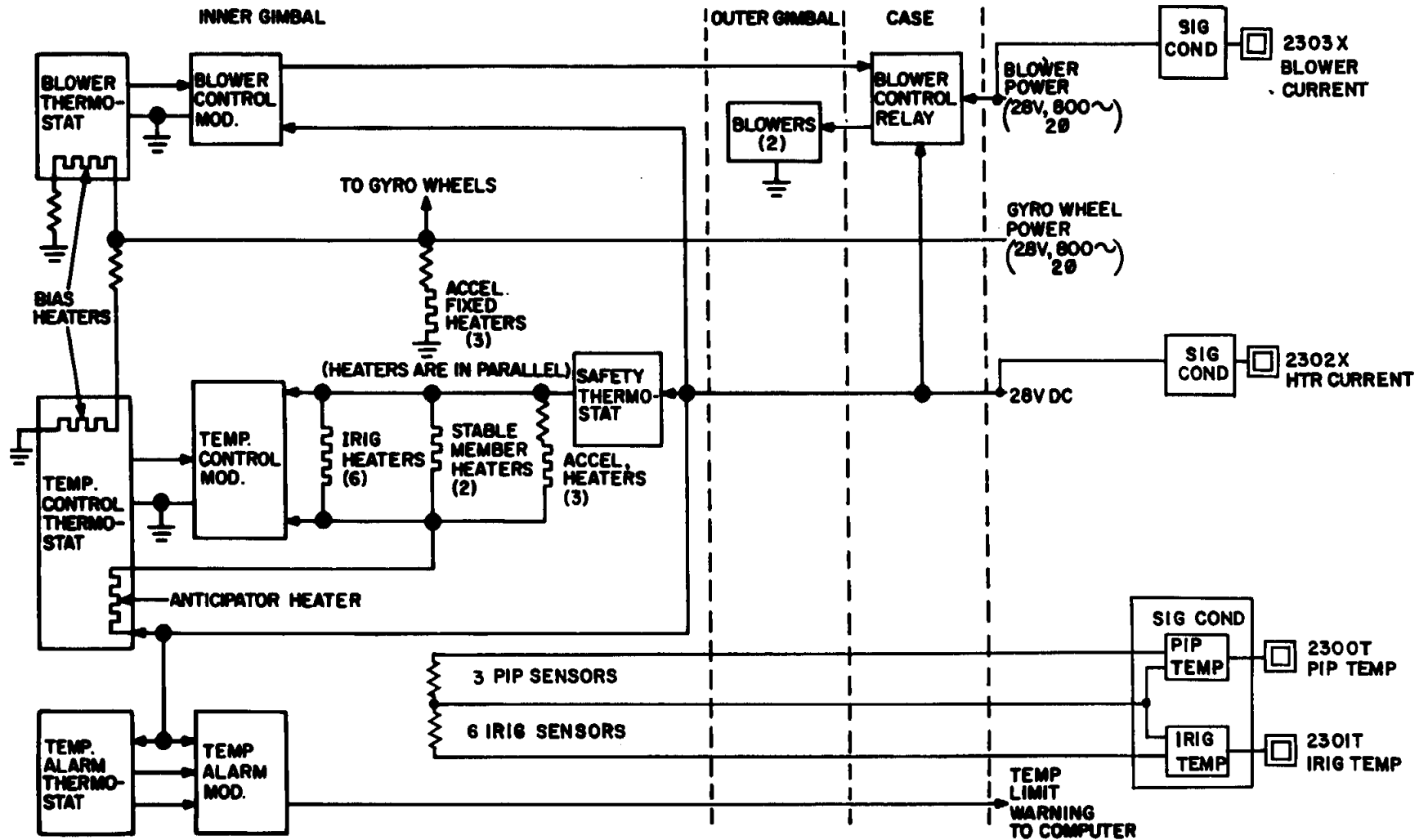
INPUT AXIS  
IA

TORQUE  
GENERATOR  
DUCOSYN

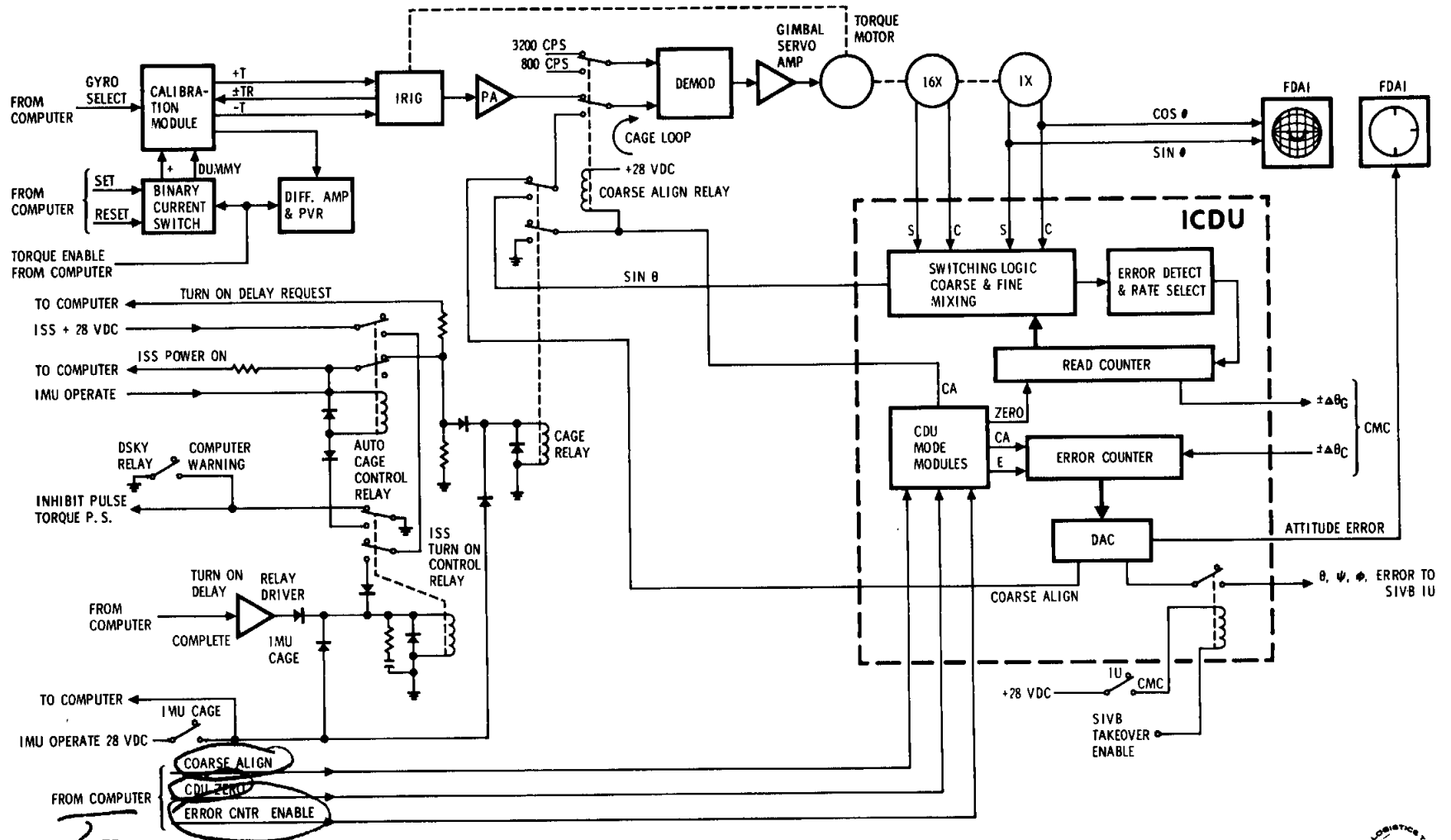
GN-263A



# TEMPERATURE CONTROL SYSTEM



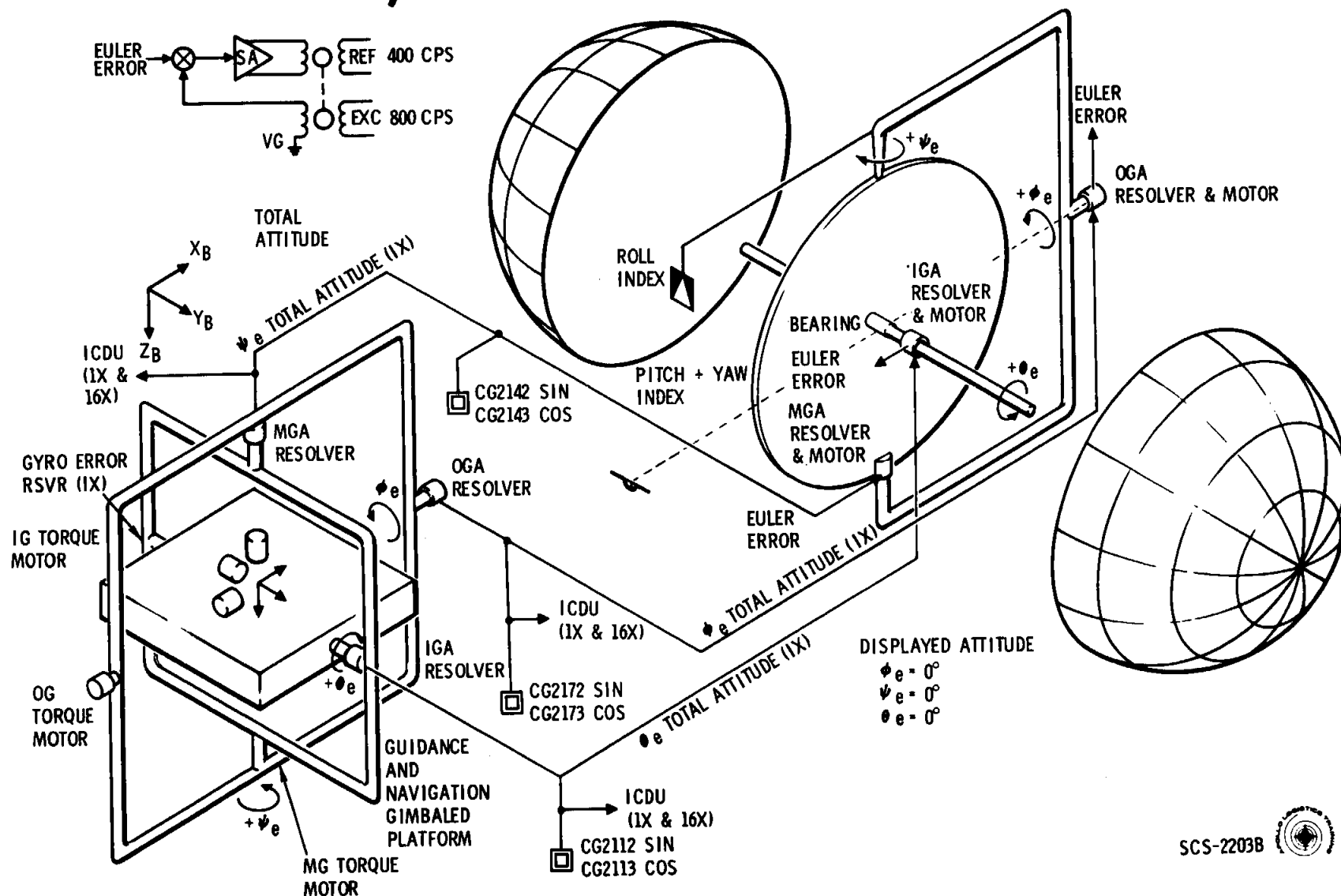
# ISS MODES



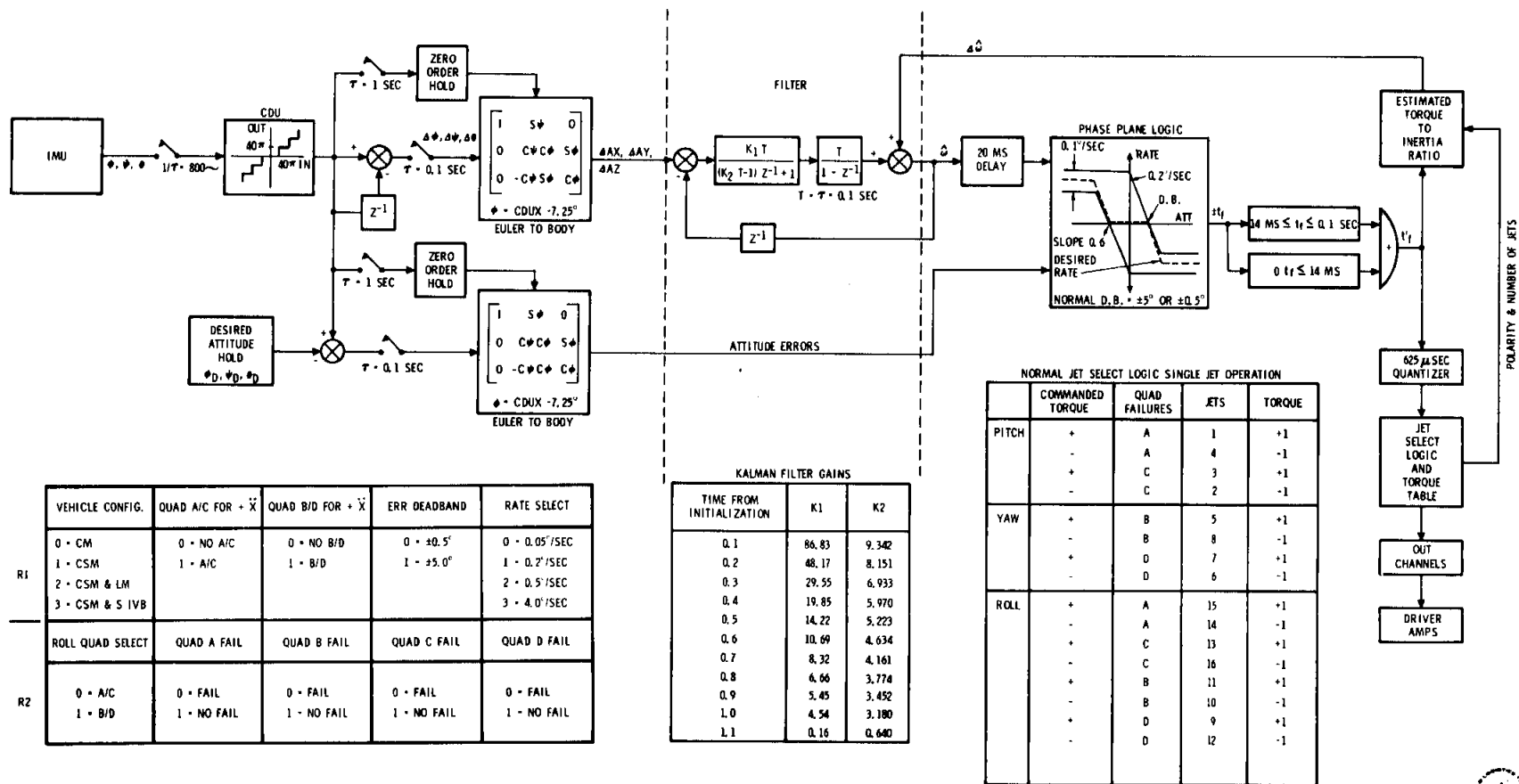
channels from  
computer (discrete switches)



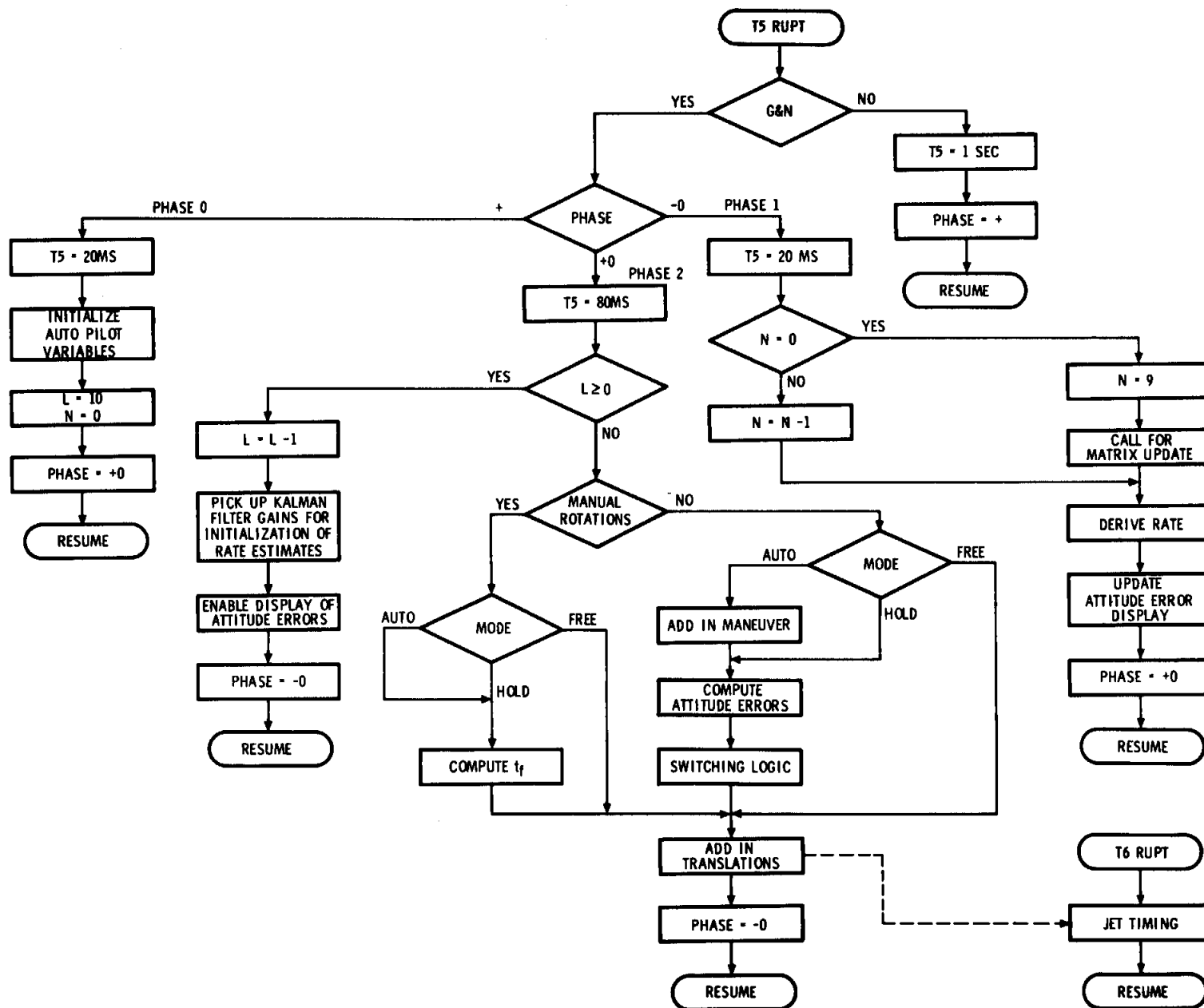
# FDAI/IMU GIMBAL RELATIONSHIP



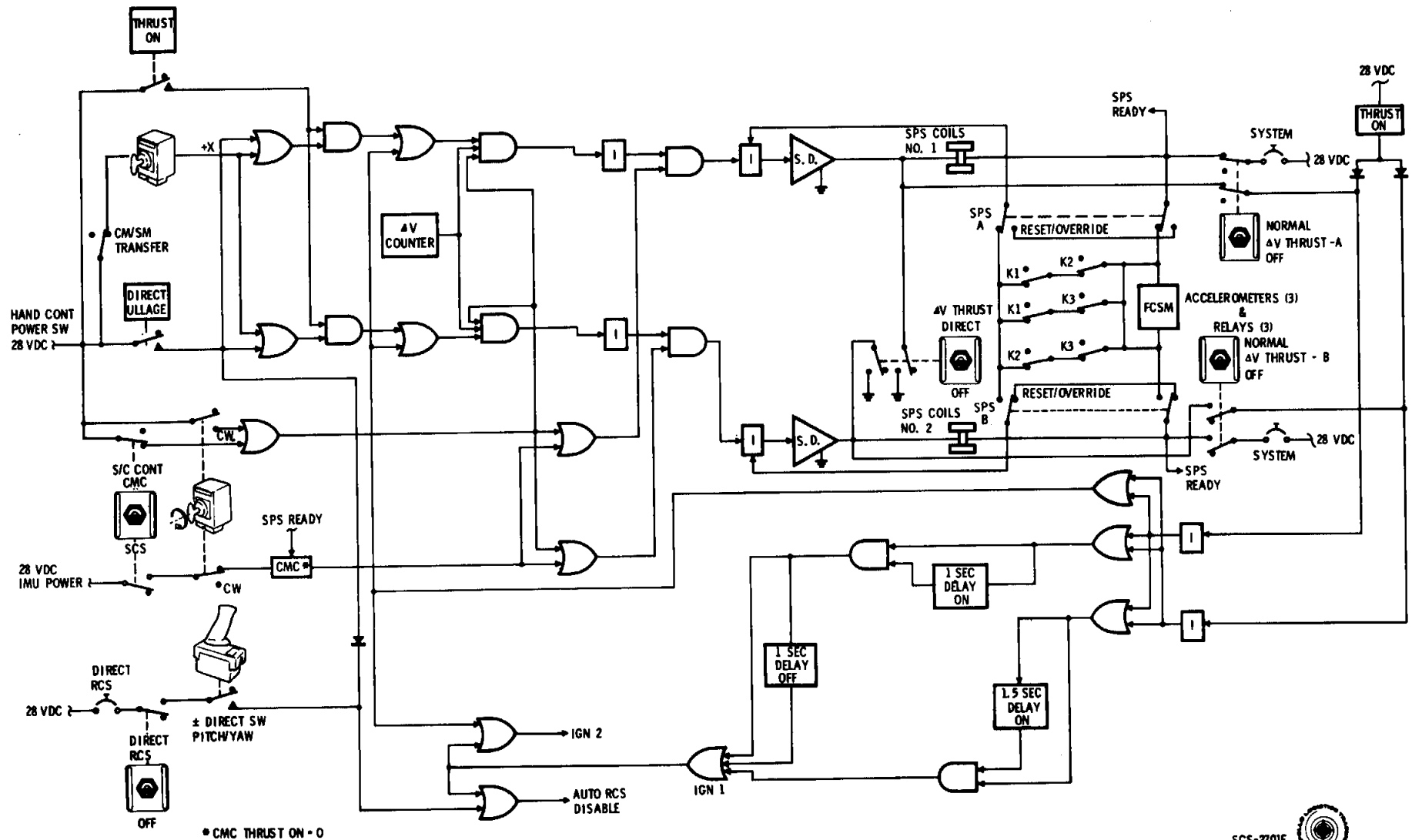
# RCS DAP MODEL



# PROGRAM LOGIC FLOW RCS DAP

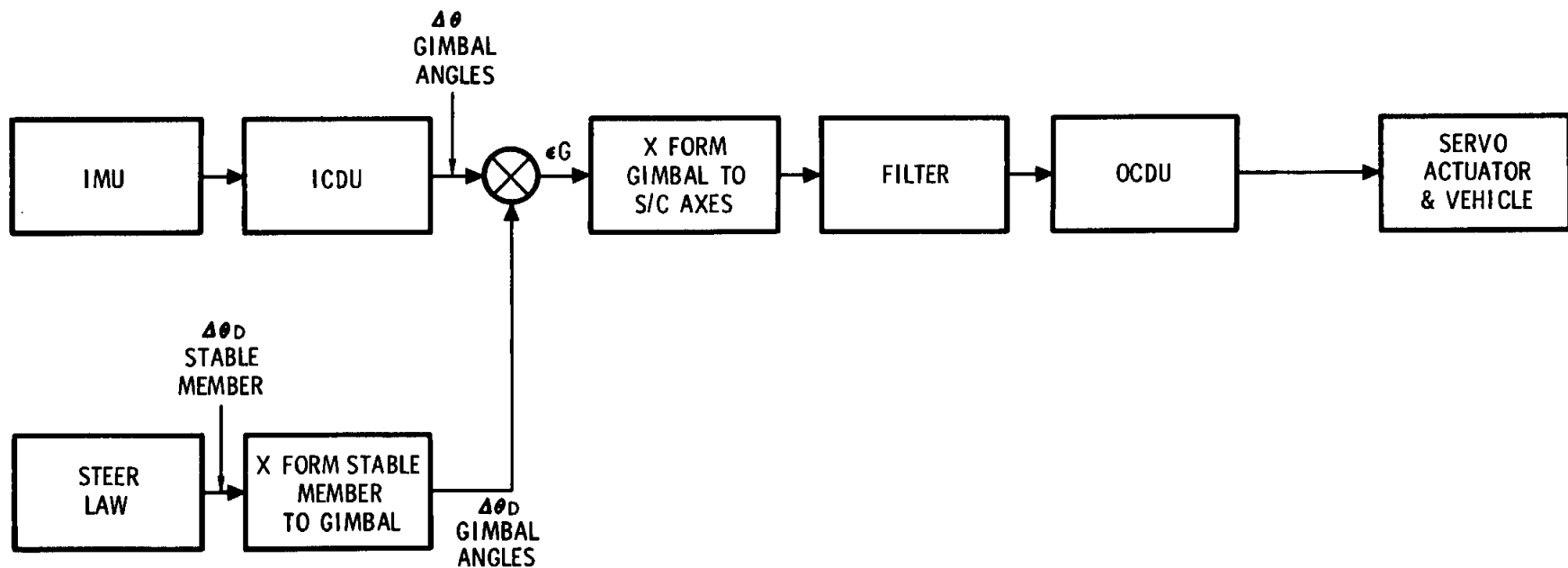


# SPS ENGINE ON-OFF LOGIC



# TVC DAP

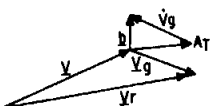
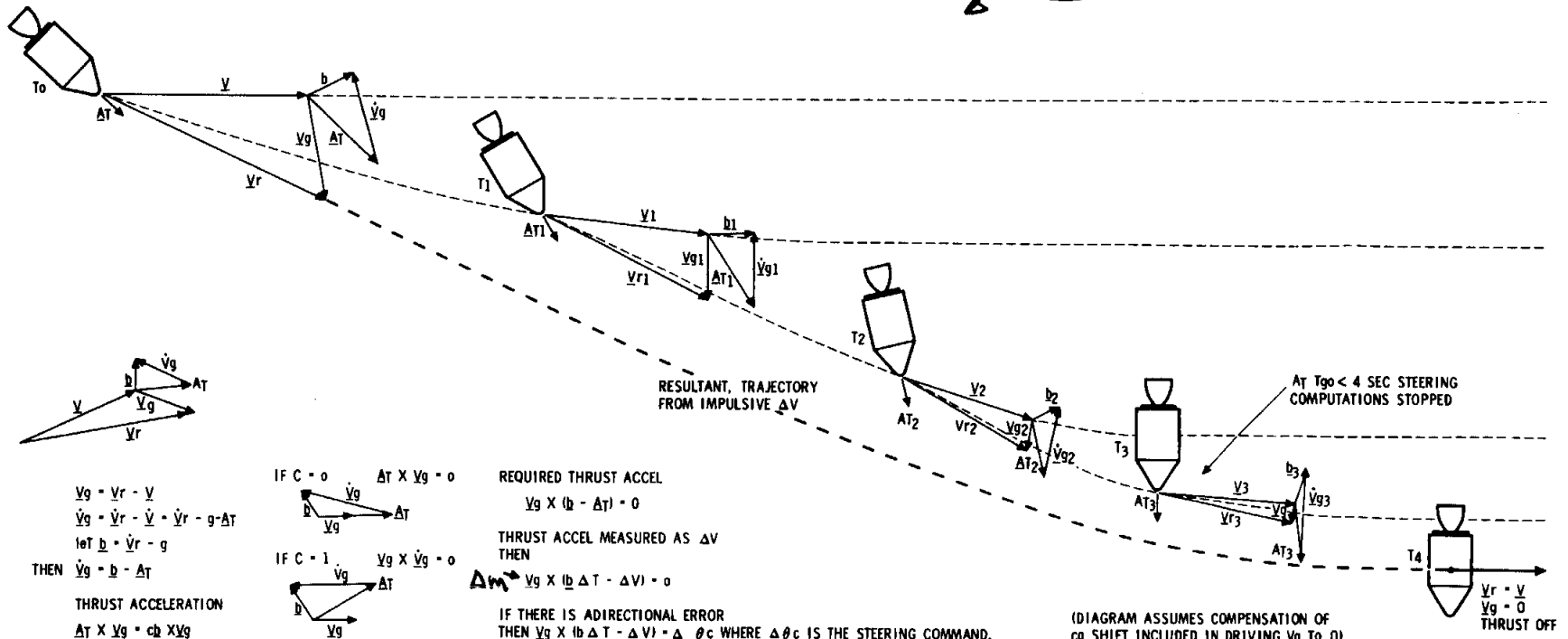
## SIMPLIFIED BLOCK DIAGRAM



# STEERING FOR ORBITAL MANUEVERS

$C=1$

THRUST ON



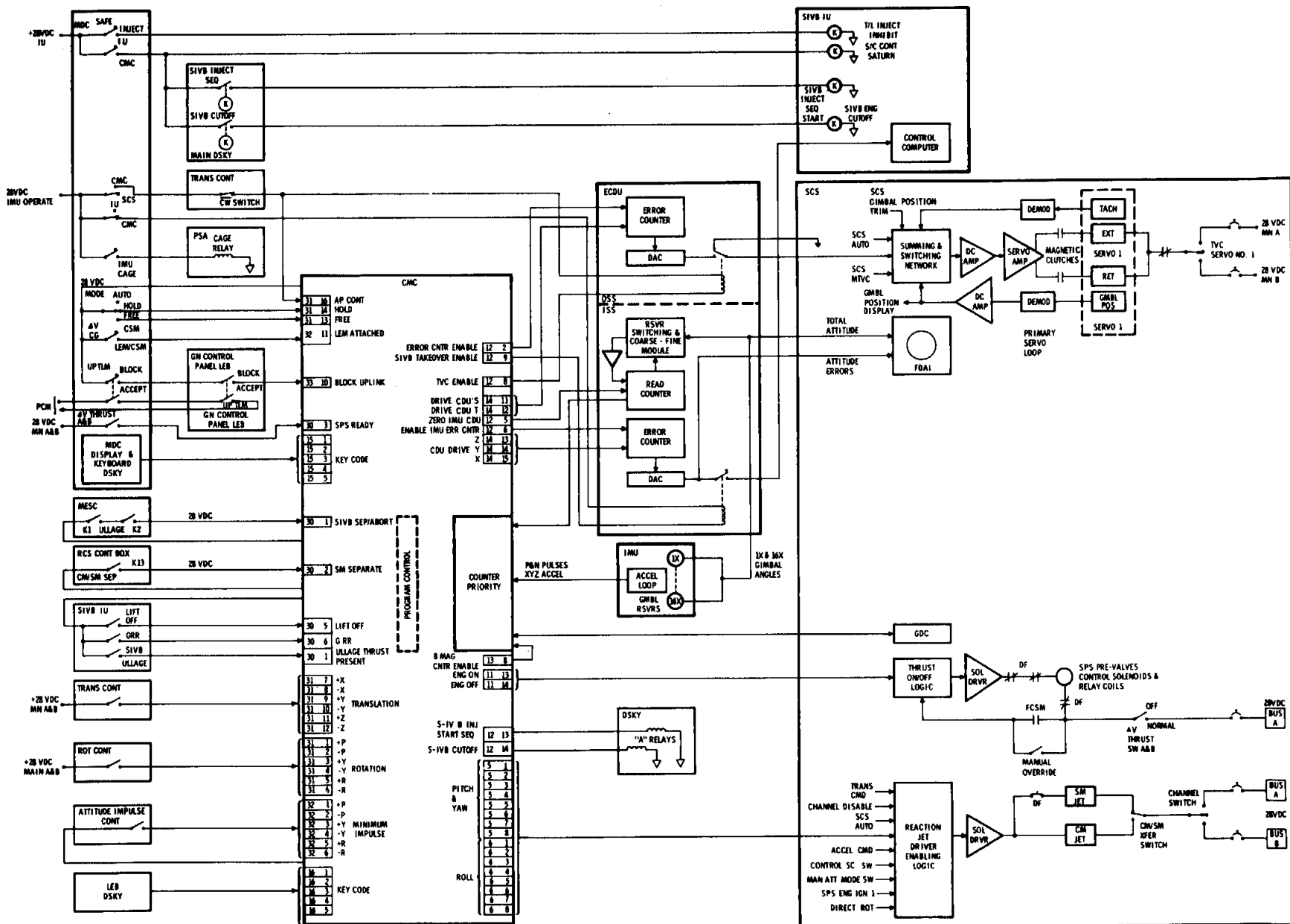
$$\begin{aligned} V_g &= V_r - V \\ \dot{V}_g &= \dot{V}_r - \dot{V} = \dot{V}_r - g \cdot \Delta T \\ \text{let } b &= \dot{V}_r - g \\ \text{THEN } \dot{V}_g &= b - \Delta T \\ \text{THRUST ACCELERATION} \\ \Delta T \times V_g &= c_b \times V_g \end{aligned}$$

$$\begin{aligned} \text{IF } C &= 0 \quad \Delta T \times V_g = 0 \\ \text{IF } C &= 1 \quad V_g \times \dot{V}_g = 0 \end{aligned}$$

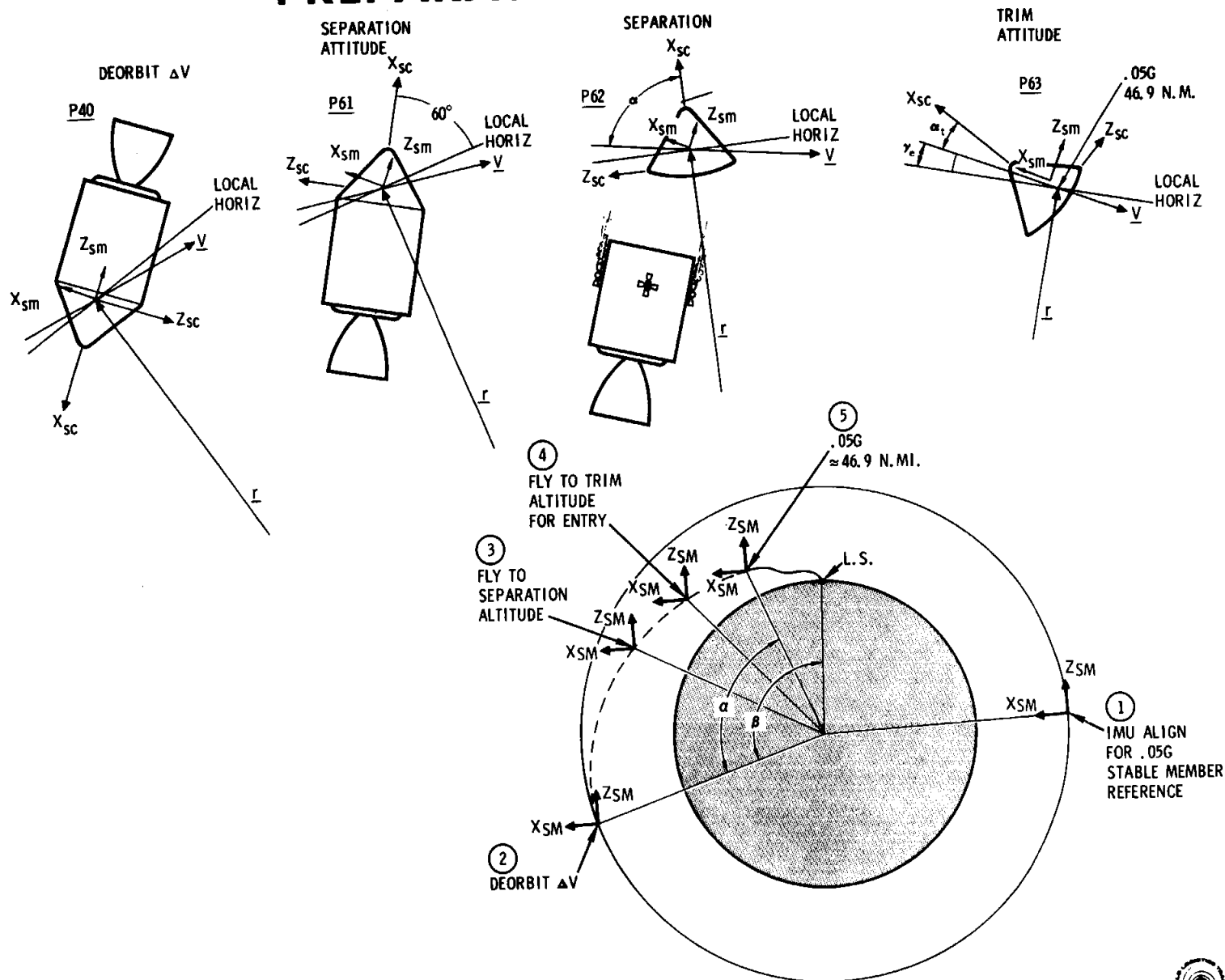
$$\begin{aligned} \text{REQUIRED THRUST ACCEL} \\ V_g \times (b - \Delta T) &= 0 \\ \text{THRUST ACCEL MEASURED AS } \Delta V \\ \text{THEN} \\ \Delta m &= V_g \times (b \Delta T - \Delta V) = 0 \\ \text{IF THERE IS A DIRECTIONAL ERROR} \\ \text{THEN } V_g \times (b \Delta T - \Delta V) &= \Delta \theta_c \text{ WHERE } \Delta \theta_c \text{ IS THE STEERING COMMAND.} \end{aligned}$$

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

## G & C FUNCTIONAL FLOW



# PREPARATION FOR ENTRY



# PGNCS A/B TLM LIST

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              | 11EI5-2             | 10         |
| CG 1523X               | +28V CMC OPERATE                 | 11EI5-3             | 10         |
| CG 1533X               | OPTX OPERATE +28 VDC             | 11EI5-4             | 10         |
| CG 20018               | X PIPA SG OUTPUT IN PHASE        | 51A2                | 50         |
| CG 20218               | Y PIPA SG OUTPUT IN PHASE        | 51A3                | 50         |
| CG 20418               | 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<br/>No.</u> | <u>Measurement Description</u> | <u>Channel<br/>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<br>+Pitch/-X | 200 S/S              | Event               |                 | None                   | 22E1-1              |
| CH3547X               | RCS Solenoid Activate<br>-Pitch/+X | 200 S/S              | Event               |                 | None                   | 22E2-2              |
| CH3548X               | RCS Solenoid Activate<br>+Pitch/-X | 200 S/S              | Event               |                 | None                   | 22E3-3              |
| CH3549X               | RCS Solenoid Activate<br>-Pitch/-X | 200 S/S              | Event               |                 | None                   | 22E4-4              |
| CH3550X               | RCS Solenoid Activate<br>+Yaw/-X   | 200 S/S              | Event               |                 | None                   | 22E5-5              |
| CH3551X               | RCS Solenoid Activate<br>-Yaw/-X   | 200 S/S              | Event               |                 | None                   | 22E6-6              |
| CH3552X               | RCS Solenoid Activate<br>+Yaw/-X   | 200 S/S              | Event               |                 | None                   | 22E7-7              |
| CH3553X               | RCS Solenoid Activate<br>-Yaw/-X   | 200 S/S              | Event               |                 | None                   | 22E8-8              |
| CH3554X               | RCS Solenoid Activate<br>+Roll/+Z  | 200 S/S              | Event               |                 | None                   | 22E9-1              |
| CH3555X               | RCS Solenoid Activate<br>-Roll/-Z  | 200 S/S              | Event               |                 | None                   | 22E13-5             |
| CH3556X               | RCS Solenoid Activate<br>+Roll/-Z  | 200 S/S              | Event               |                 | None                   | 22E14-6             |
| CH3557X               | RCS Solenoid Activate<br>-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><br><u>Low</u> <u>High</u> | <u>Display Readout</u> | <u>Channel Code</u> |
|-----------------------|-------------------------------------|----------------------|-----------------------------------------------|------------------------|---------------------|
| CH3558X               | RCS Solenoid Activate<br>+Roll/+Y   | 200 S/S              | Event                                         | None                   | 22E15-7             |
| CH3559X               | RCS Solenoid Activate<br>-Roll/+Y   | 200 S/S              | Event                                         | None                   | 22E11-3             |
| CH3560X               | RCS Solenoid Activate<br>+Roll/-Y   | 200 S/S              | Event                                         | None                   | 22E12-4             |
| CH3561X               | RCS Solenoid Activate<br>-Roll/-Y   | 200 S/S              | Event                                         | None                   | 22E16-8             |
| CH3588X               | Attitude Deadband Minimum           | 10 S/S               | Event                                         | Panel<br>Switch        | 11E8-2              |
| CH3590X               | SCS High Rot-Rate Selected          | 10 S/S               | Event                                         | Panel<br>Switch        | 11E8-4              |
| CH3592X               | FDAI Scale Error 5, Rates 5         | 10 S/S               | Event                                         | Panel<br>Switch        | 11E8-5              |
| CH3593X               | FDAI Scale ERR50/15,<br>Rate 50/10  | 10 S/S               | Event                                         | Panel<br>Switch        | 11E8-6              |
| CH3600X               | LM ATTACHED Selected                | 10 S/S               | Event                                         | Panel<br>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<br>Switch | 10 S/S               | Event                                         | Panel<br>Switch        | 11E9-5              |
| CH3623X               | Gyro 1 Comb. SPIN MOTORS<br>Run Det | 10 S/S               | Event                                         | None                   | 11E8-7              |
| CH3624X               | Gyro 2 Comb. SPIN MOTORS<br>Run Det | 10 S/S               | Event                                         | None                   | 11E8-8              |
| CH3635X               | BMAG Mode SW-Roll Att 1/Rate 2      | 10 S/S               | Event                                         | Panel<br>Switch        | 11E33-1             |
| CH3636X               | BMAG Mode Sw-Roll Rate 2            | 10 S/S               | Event                                         | Panel<br>Switch        | 11E33-2             |
| CH3638X               | BMAG Mode Sw-Pitch Att 1/<br>Rate 2 | 10 S/S               | Event                                         | Panel<br>Switch        | 11E33-3             |

SCS TM List

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

# ENTRY DISPLAYS

CREW



OUTSIDE

