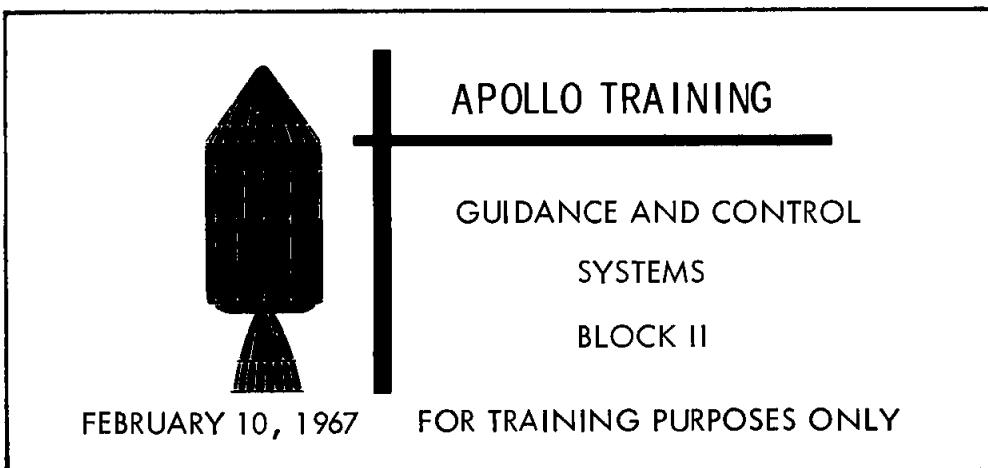


Hyl
3/13/67



Box 083-151

H. K. Flynn
Don Bennett

H. Schler
Martin Murray

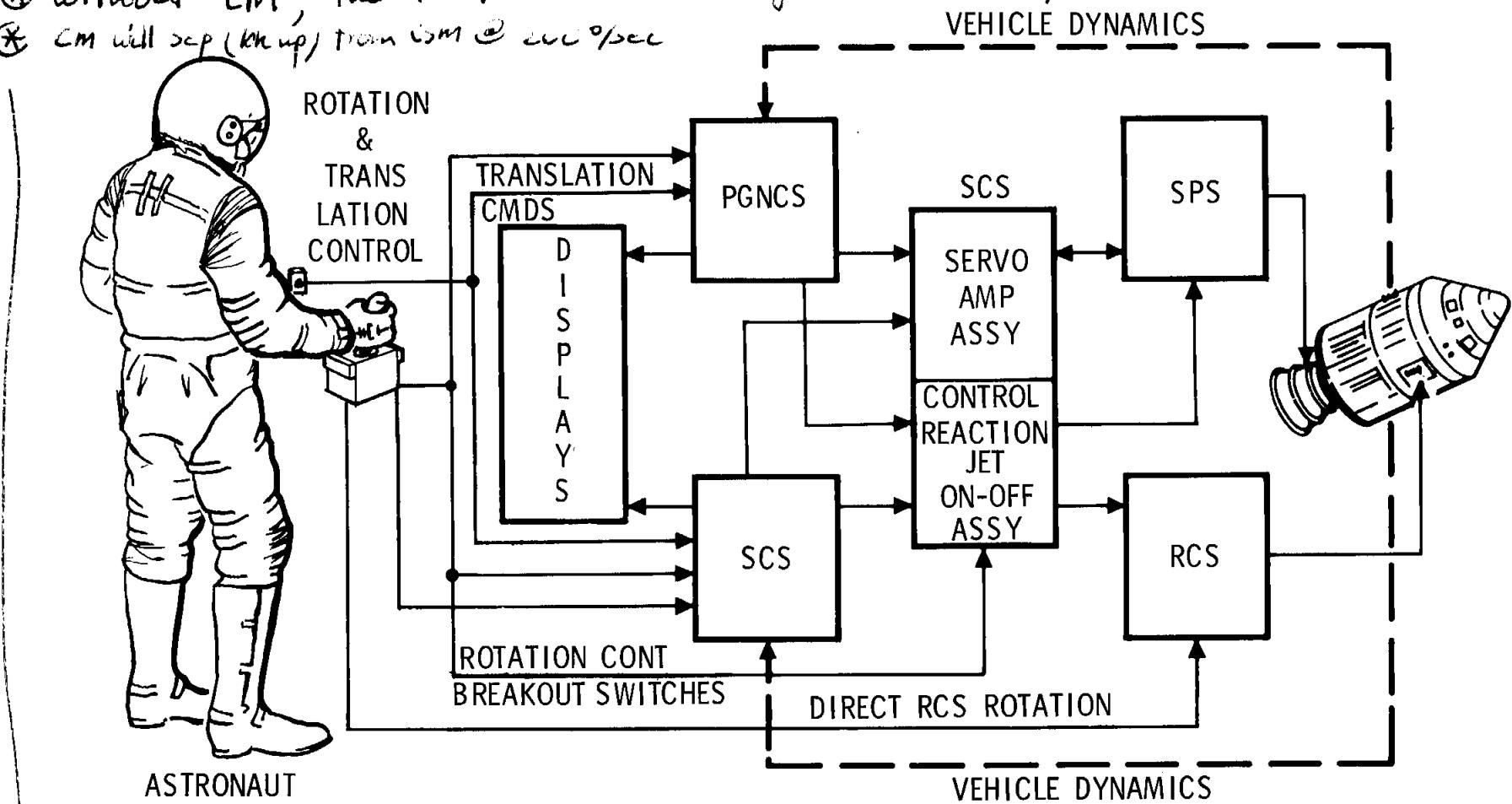
(X) We study cutting noise to -
of a precise
picture of what is

* If 6½N system isn't working
 ↪ LOI, jett. LM & return to earth.

* SCS is parallel with PGNCS
 ∴ it is a back up control system

CSM GUIDANCE & CONTROL

- * With LM attached, cg 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 decouple from CSM @ 2000/sec

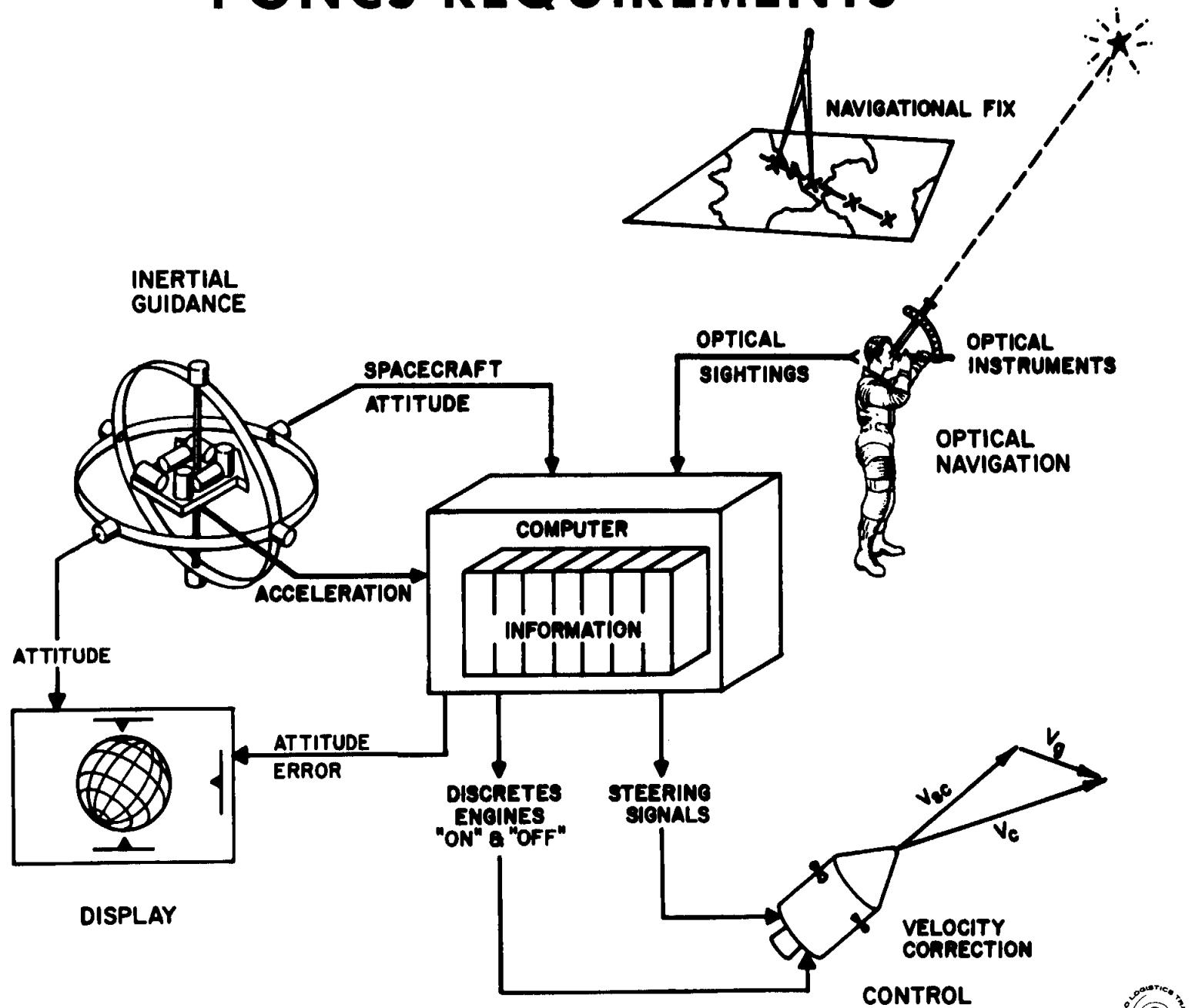


→ Backup actuator! if you know what I'm saying, 2nd one takes over & you can see it's working

SCS-3002A



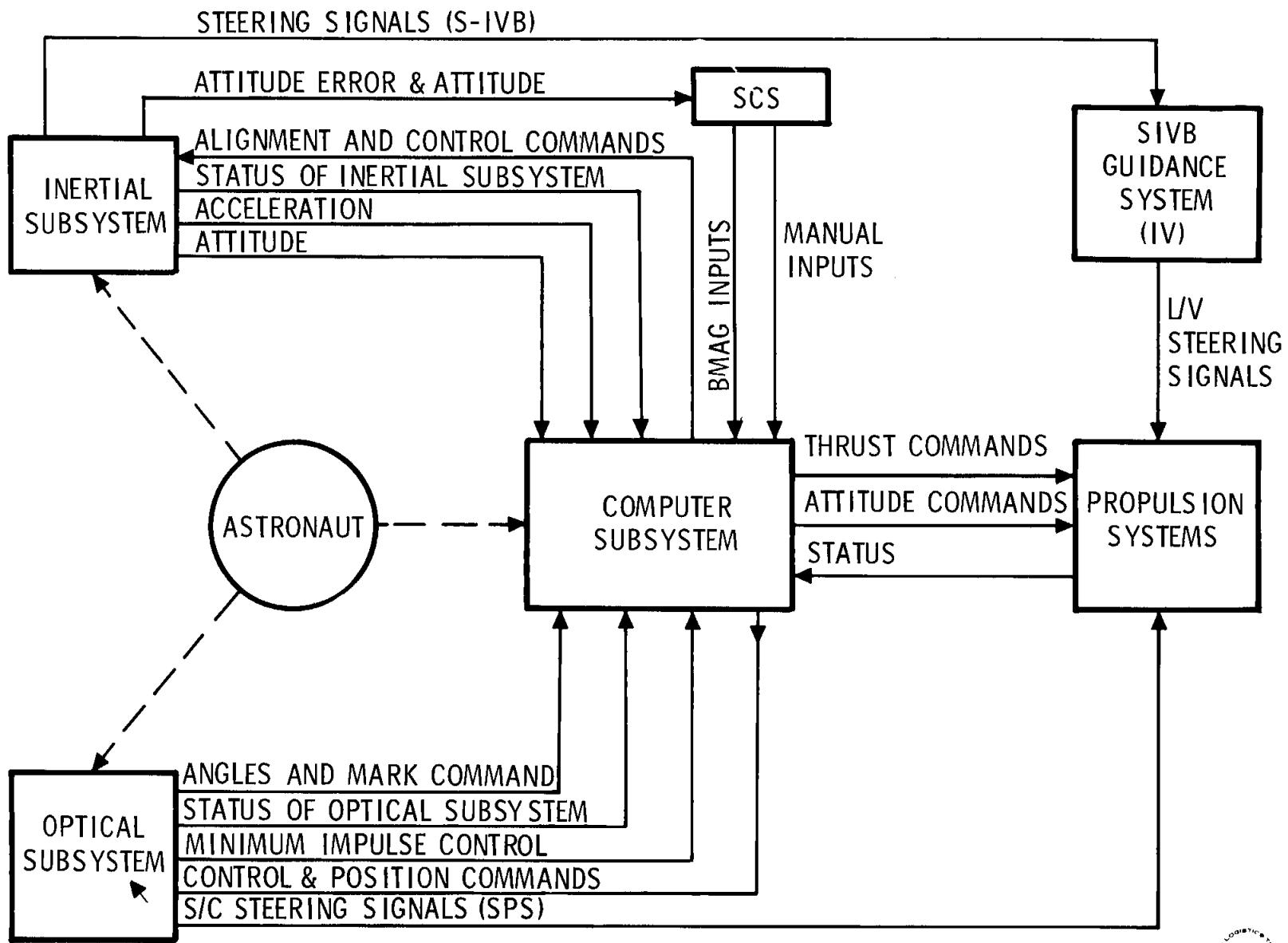
PGNCS REQUIREMENTS



GNC-1

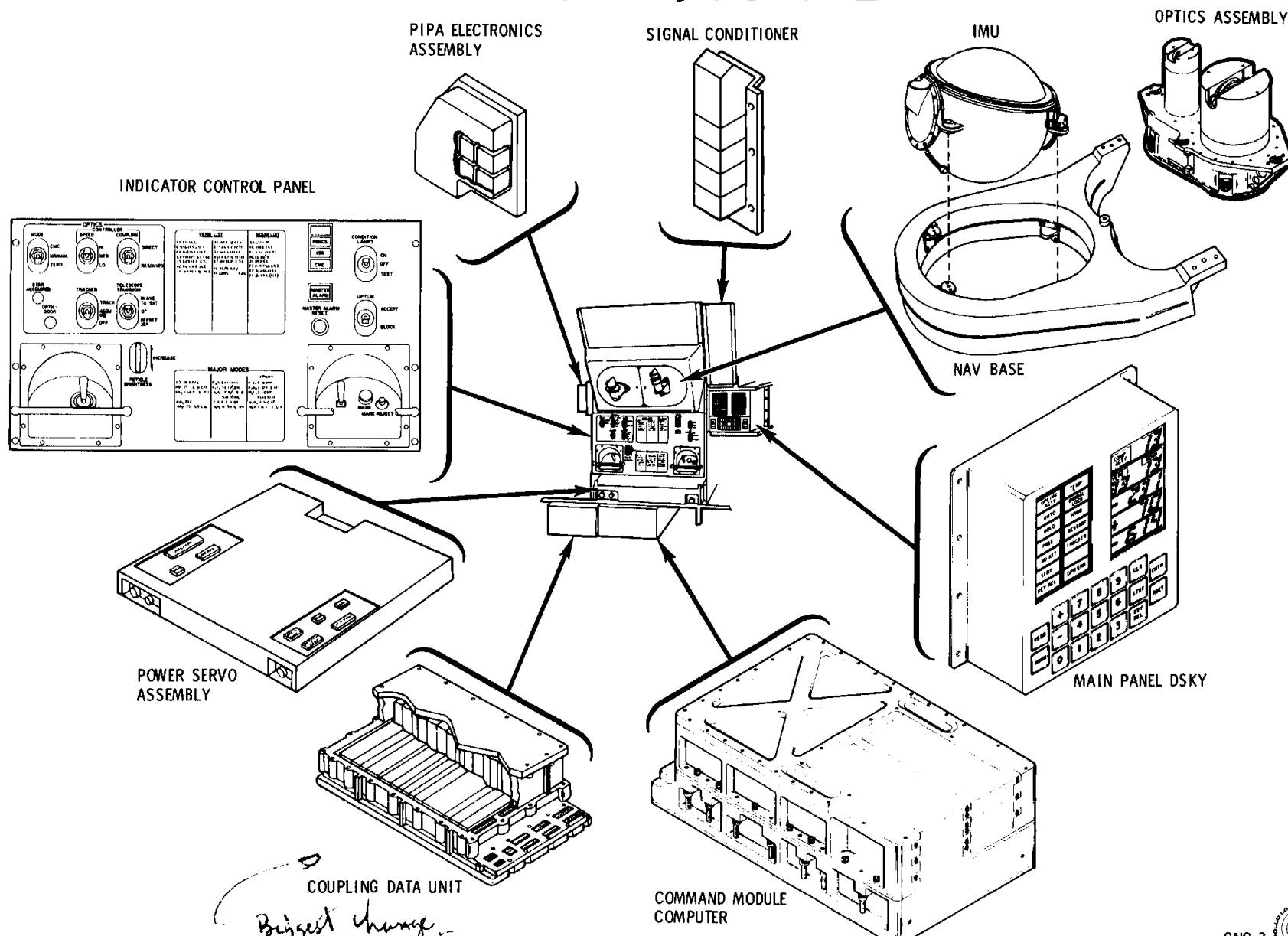


PGNCS DATA FLOW



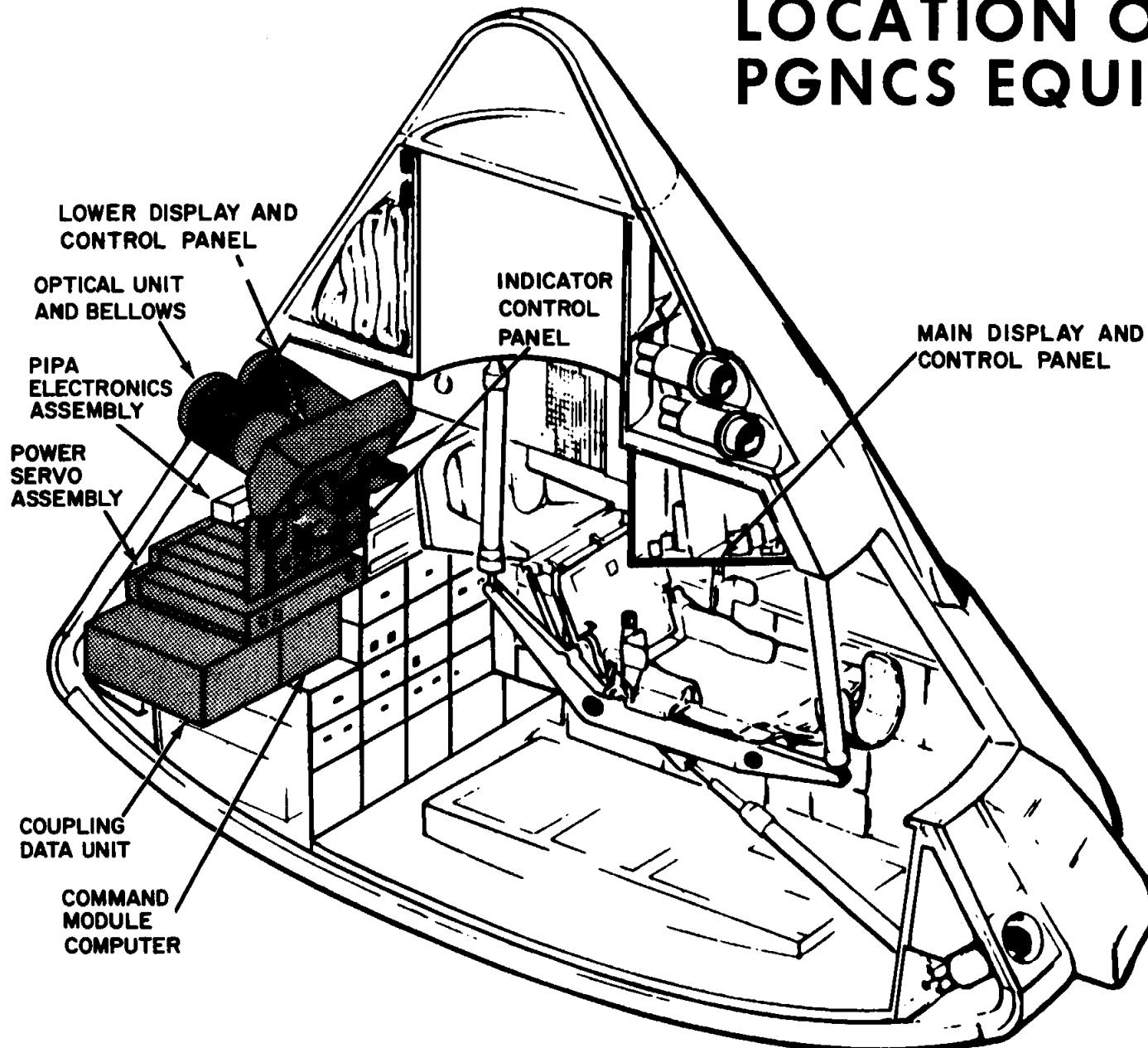
GNC-5A

PGNCS EQUIPMENT



*Bugfix change
blk 2 to blk 11
No display in blk 11
(extension of comp)*

LOCATION OF PGNCS EQUIPMENT

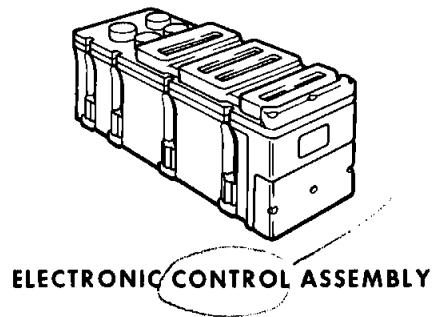


GNC-4

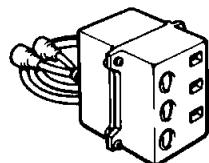


SCS FLIGHT HARDWARE

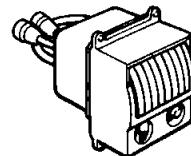
BLOCK II



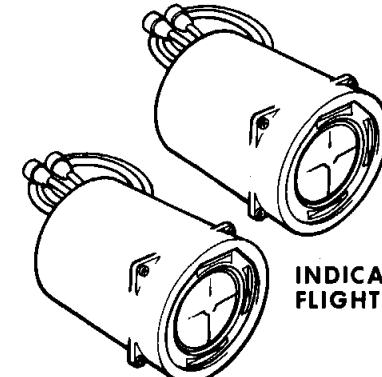
ELECTRONIC CONTROL ASSEMBLY



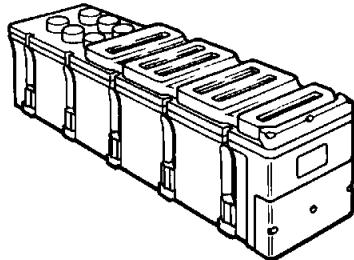
CONTROL PANEL, ATTITUDE SET



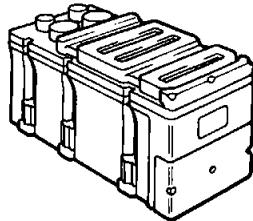
INDICATOR, GIMBAL POSITION
AND FUEL PRESSURE



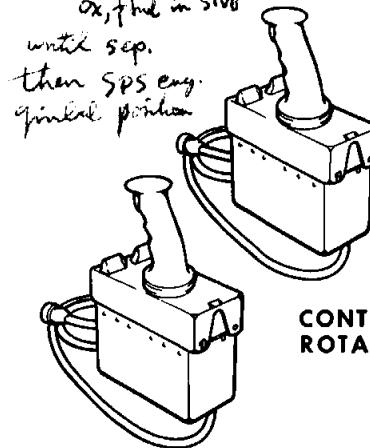
INDICATOR, ATTITUDE,
FLIGHT DIRECTOR (2)



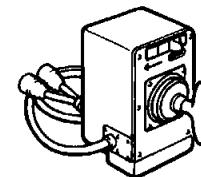
REACTION JET AND ENGINE
ON-OFF CONTROL



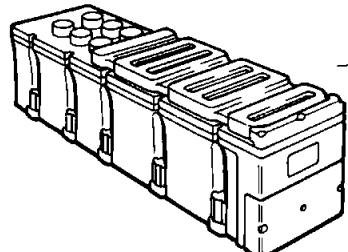
SERVO AMPLIFIER,
THRUST VECTOR POSITION



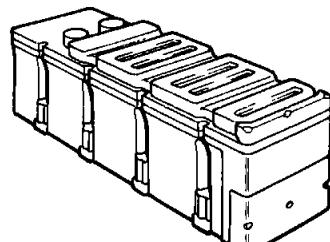
CONTROL,
ROTATION (2)



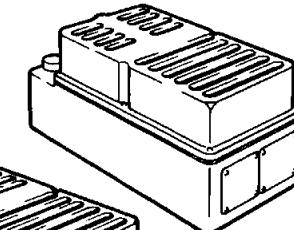
CONTROL, TRANSLATION



ELECTRONIC DISPLAY ASSEMBLY



COUPLER, GYRO DISPLAY



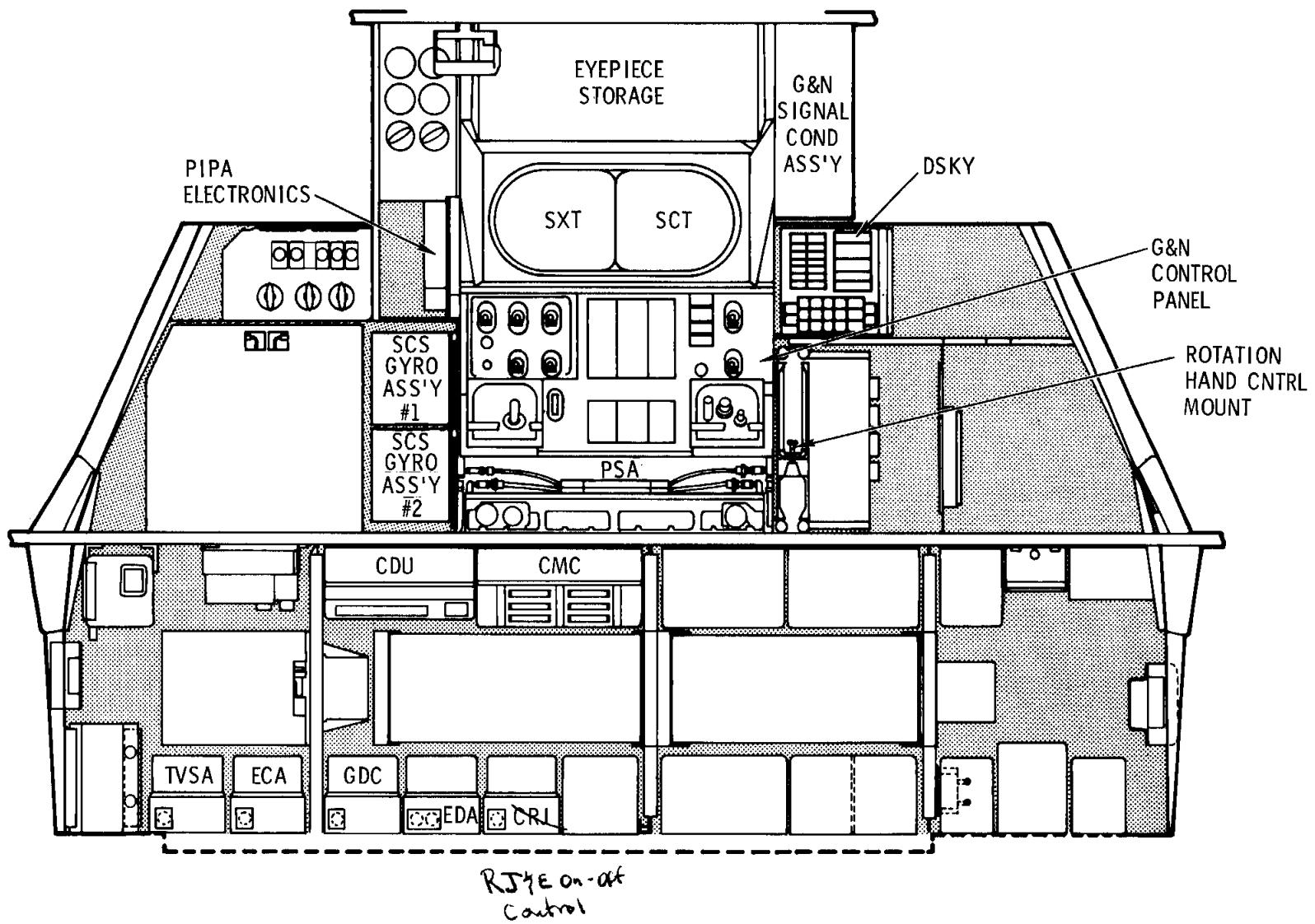
GYRO ASSEMBLY (2)

B MAGs

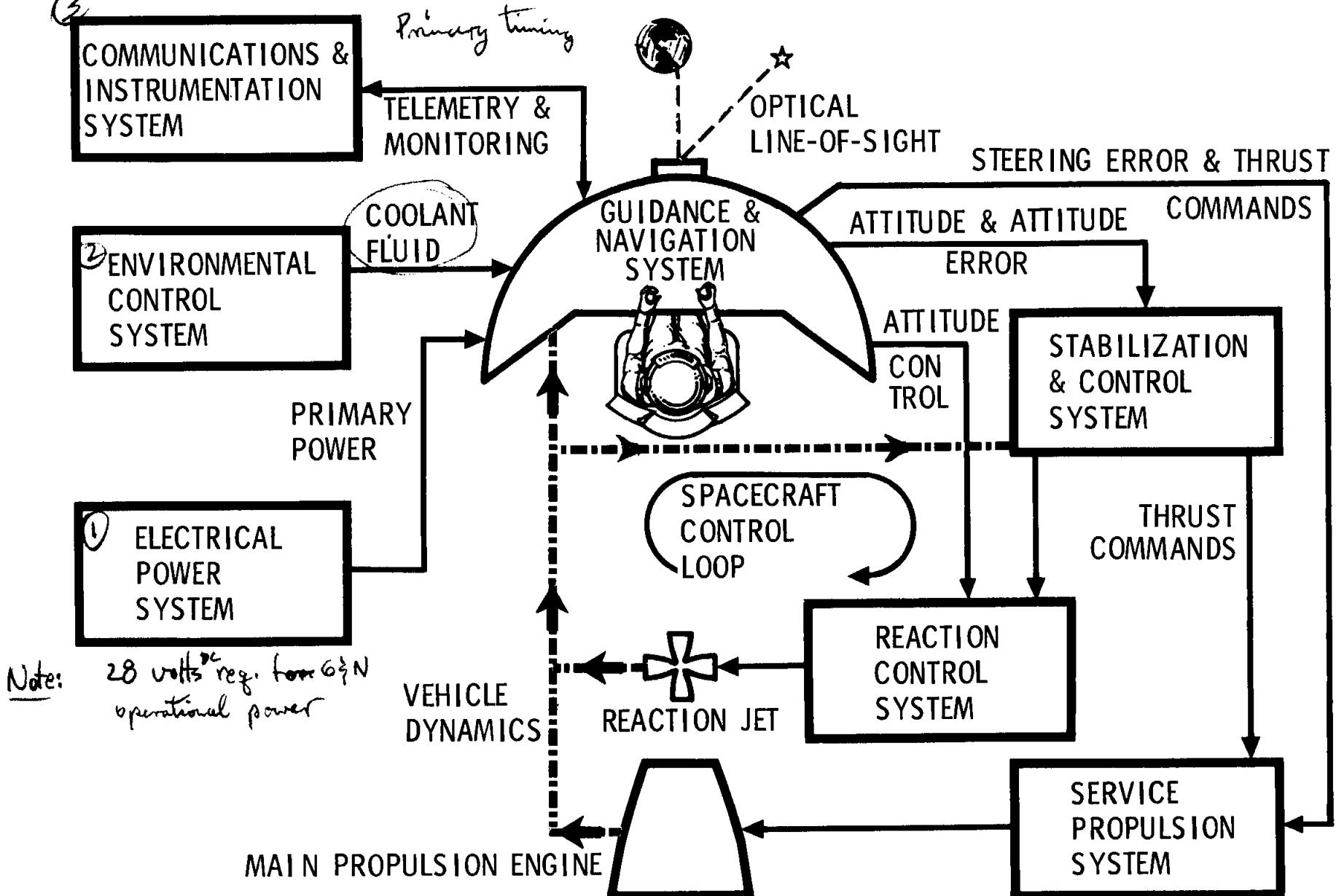
SCS-2010B

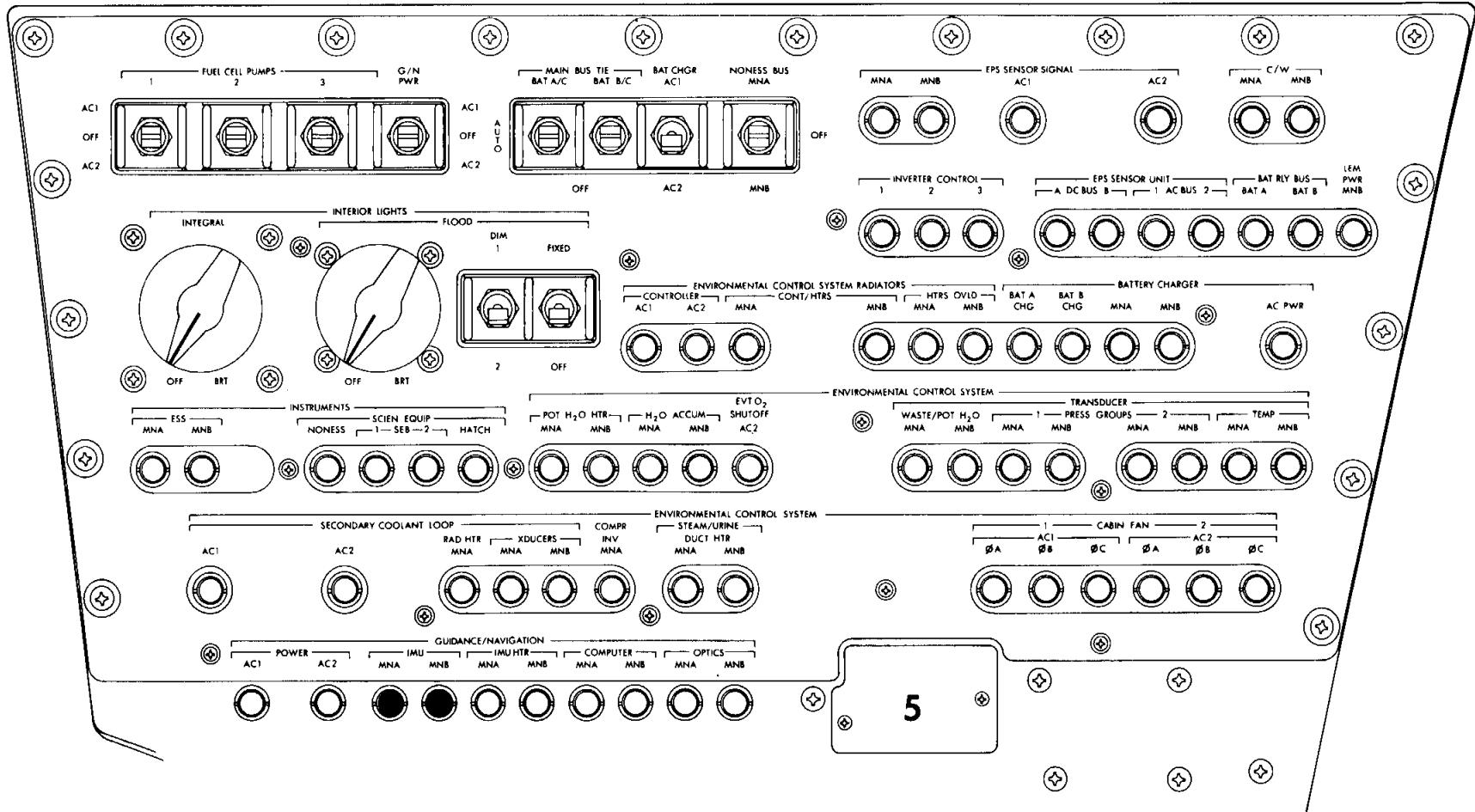


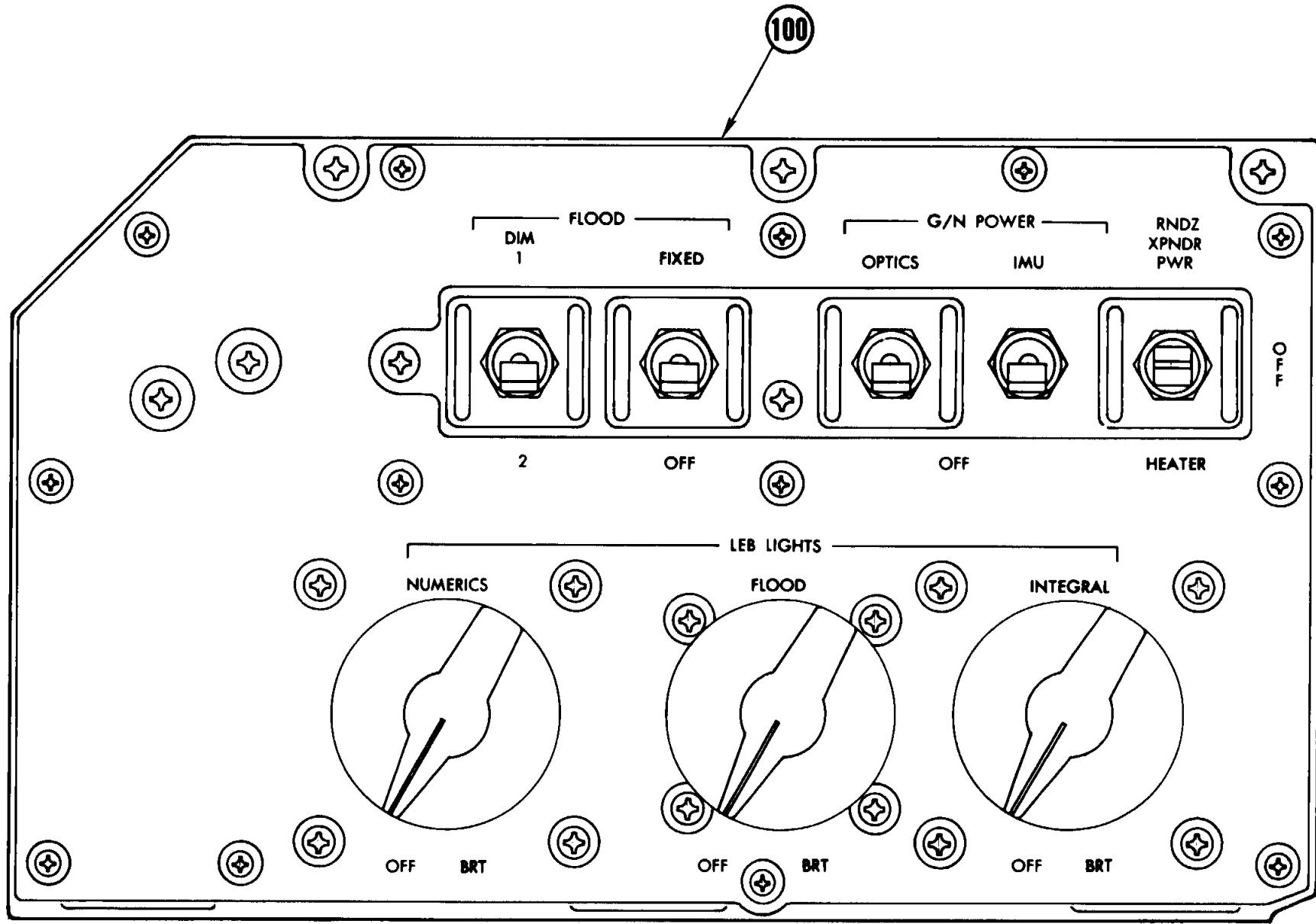
G&C EQUIPMENT LOCATION



PGNCS SPACECRAFT INTERFACE



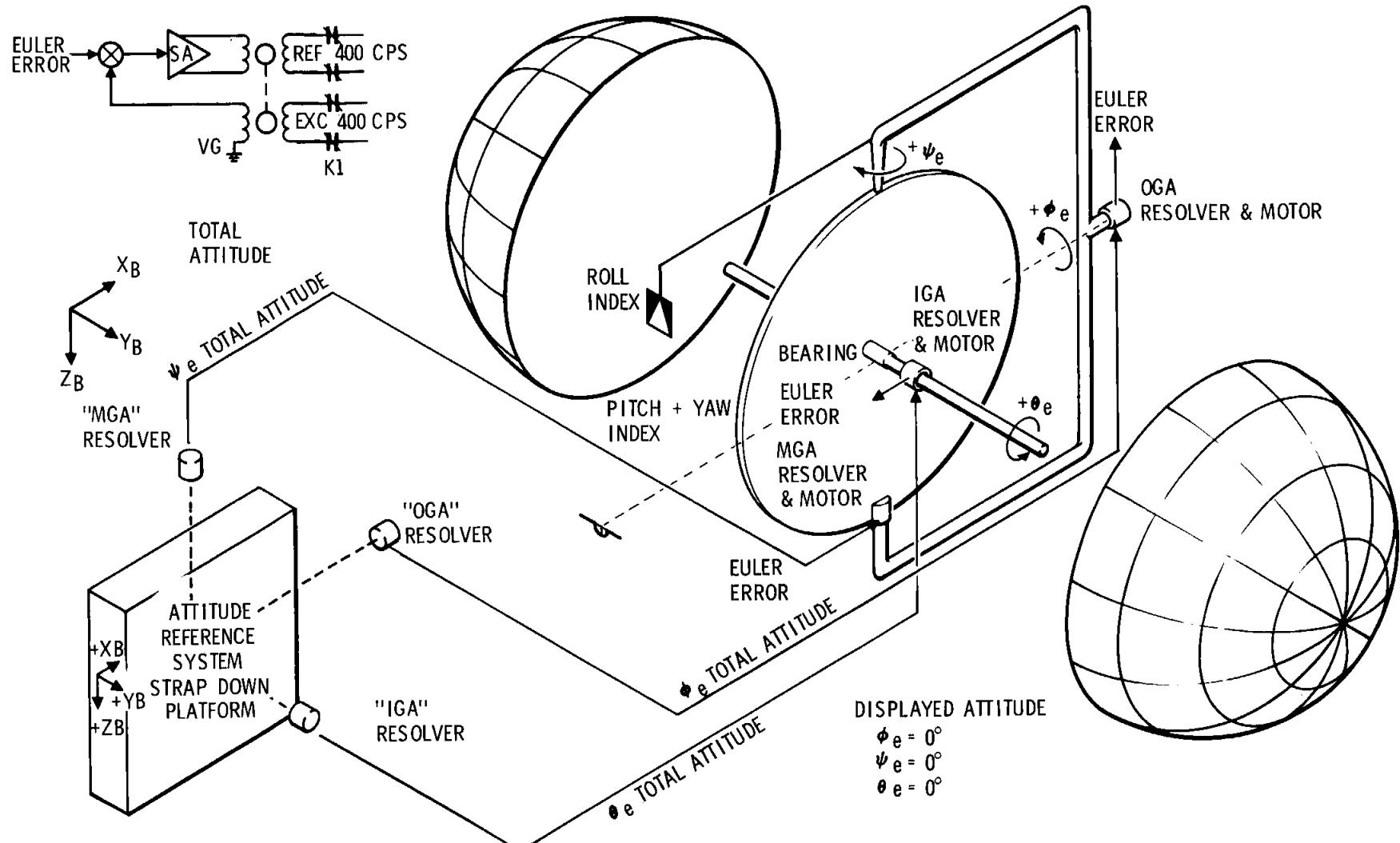




FAM-6301



FDAI/GDC SHAFT RELATIONSHIP



Euler Angles (P,Y,R seq.)

FLIGHT DIRECTOR ATTITUDE INDICATOR

This shows total att. wrt
to ball

PITCH & YAW
INDEX

ROLL
+ANGULAR VELOCITY-
+ATTITUDE ERROR-

Inside out system



ROLL INDEX

If s/c yaws rt,
needle moves left
(Att. error)

EULER ATTITUDE ON BALL

PITCH - $\theta = 014^\circ$

YAW - $\psi = 034^\circ$

ROLL - $\phi = 330^\circ$

NOTE:

ALL POLARITIES INDICATE
VEHICLE DYNAMICS

YAW
+ATTITUDE ERROR-
+ANGULAR VELOCITY-

ROLL TOTAL
ATTITUDE SCALE

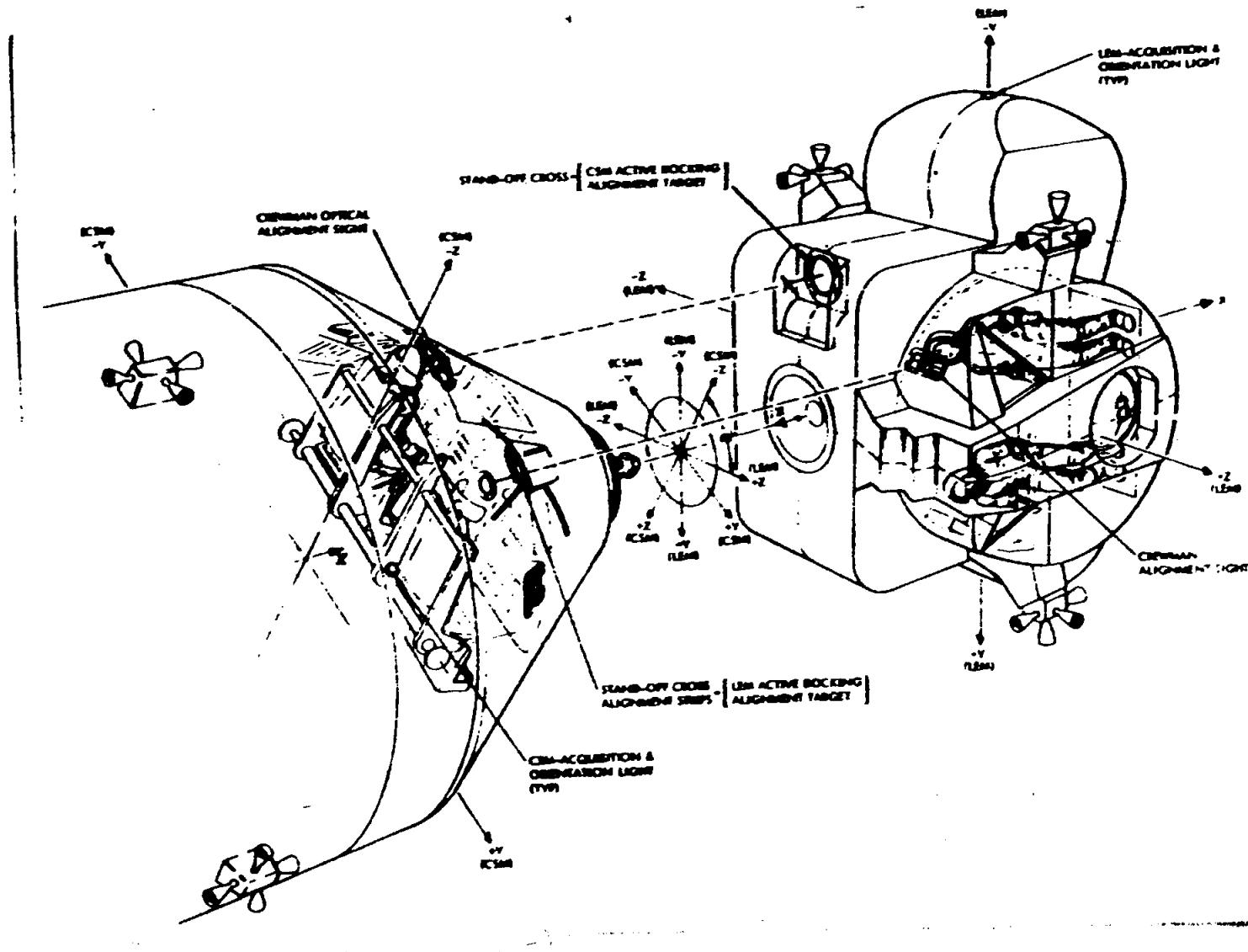
Fly to Commands

If s/c yaw rt, the yaw rate
needle moves left, to correct
pitch more rot. anti. in dir. of
scale drift, 3 pt. timing transfers fine 1 rot. s/c new.



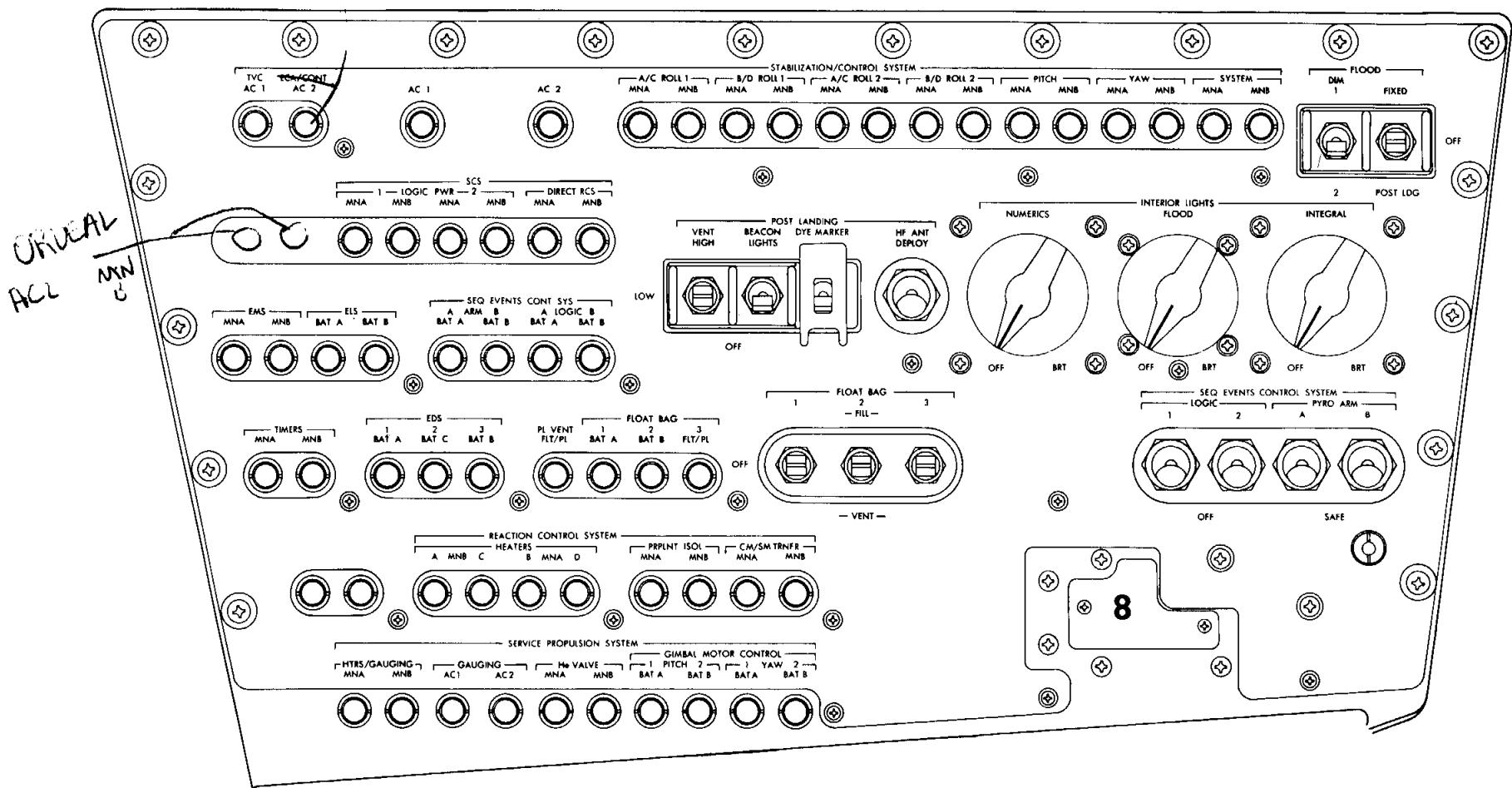
SCS-2100D

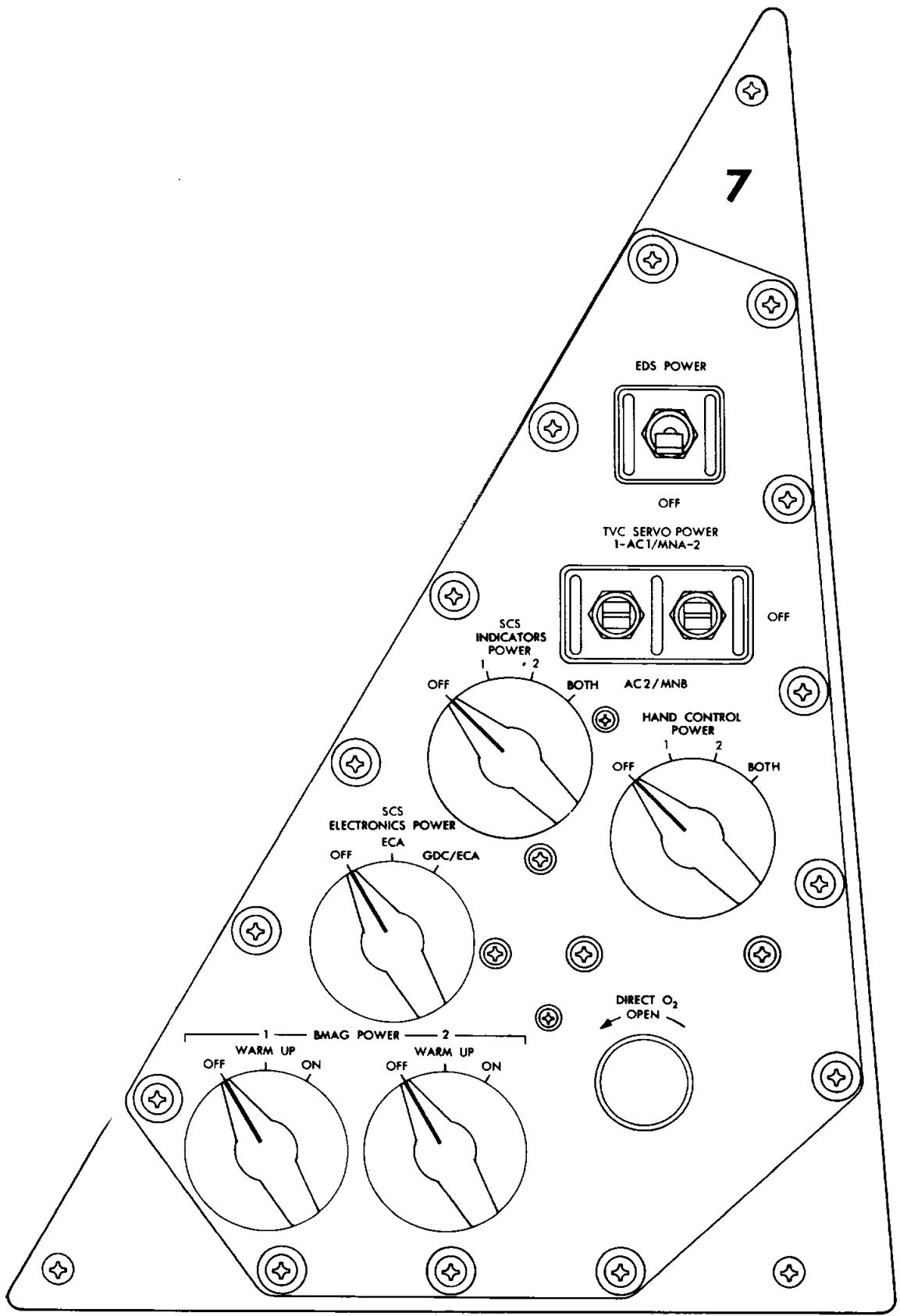




SCS Panel

ECA / TVC

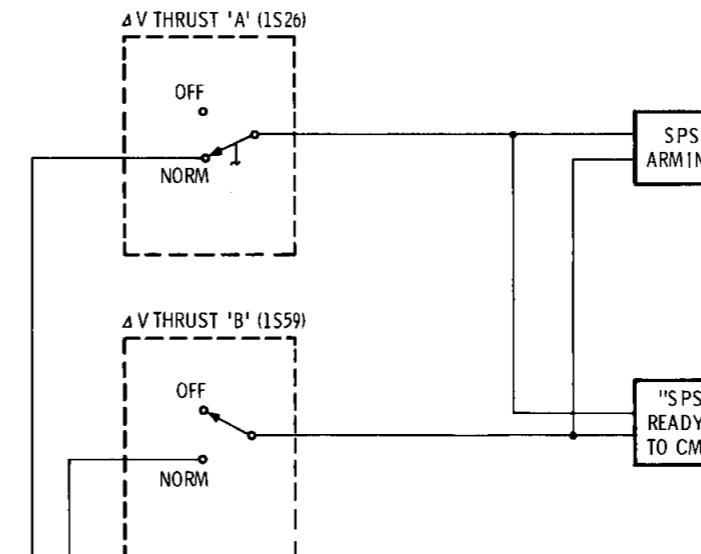
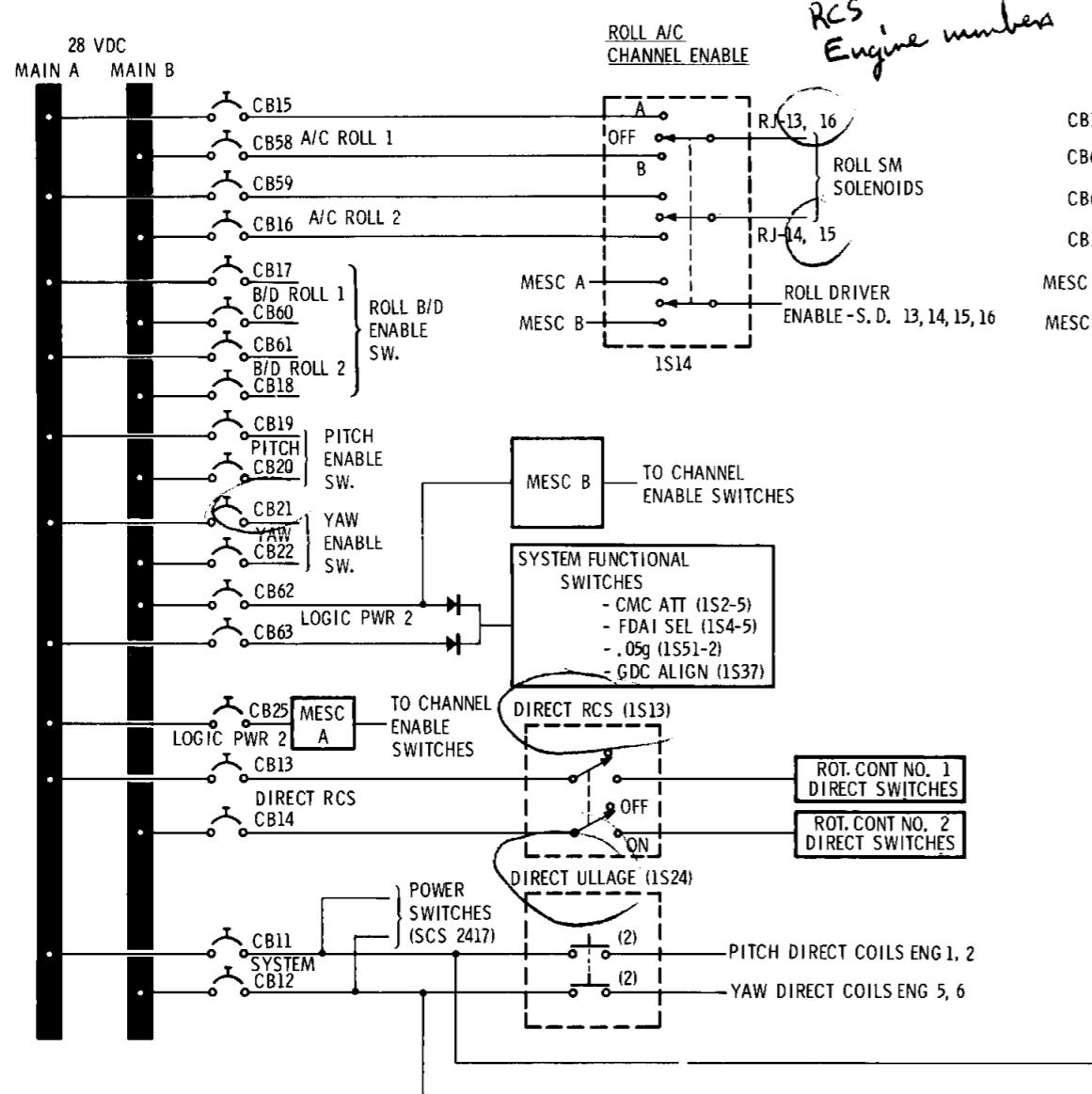




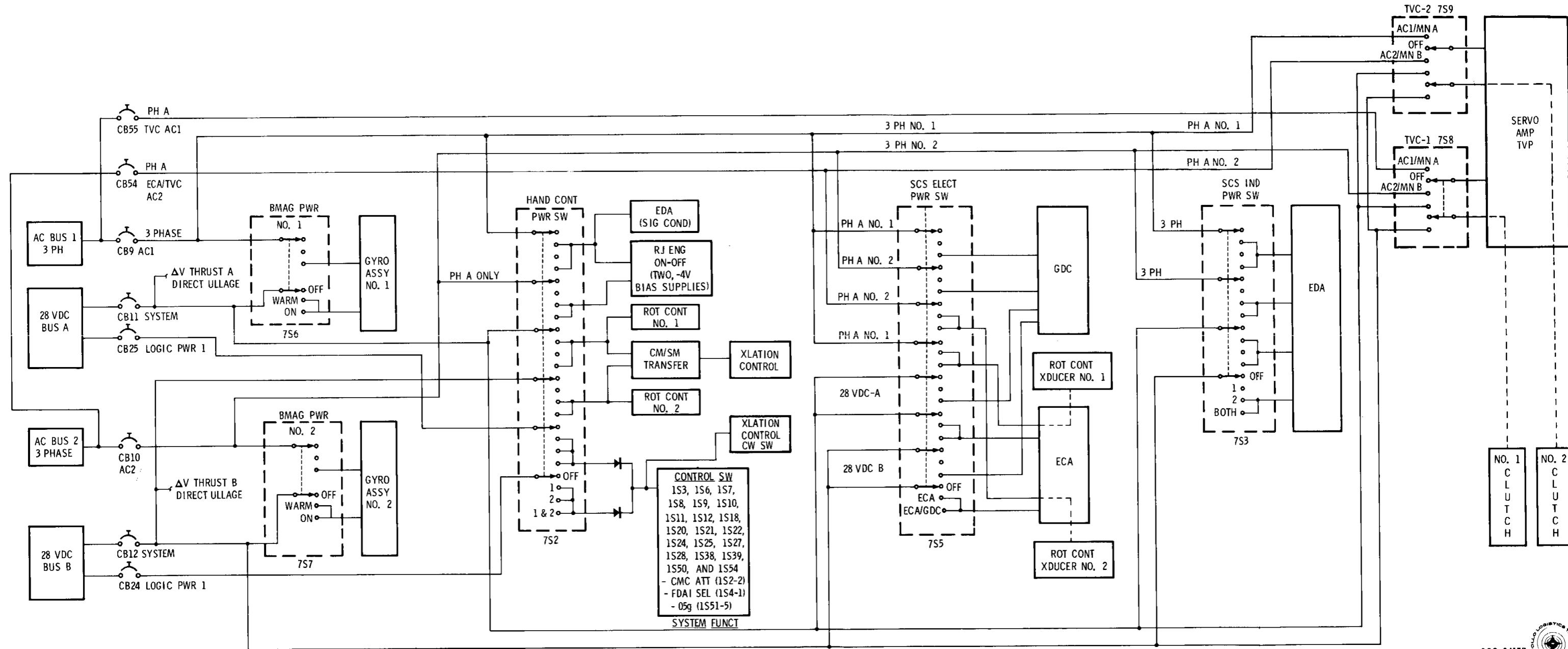
FAM-6370 A



SCS NON SWITCHED POWER



SCS SWITCHED POWER DISTRIBUTION



SCS-2417B



(*) TVC

s/c control switch is in CMC

If a G & N burn was initiated and the CMC light came on, the burn could be completed immel. if before starting burn you put SPS TVC into ~~auto~~ ^{for rate and} then when you get CMC light ~~on~~ ^{fixed off} ~~sc~~ ~~int~~ switch to SES. turn the translation control cw. (rotation)?

IMP!

6th N displays no att. rates!
Rates from SCS!

8 Bull #1 1m/s over 100
cm/s or CDUs for att error

GDC [att error, att set diff.]

ABORT

44 32

FDAI

Total att.

att. error

att. rates — from SCS

scaling

FDAI

8sec

SCS att. control

IMU vs dials
in Enter mode

Thrust Vector
Control

Att. set
dials

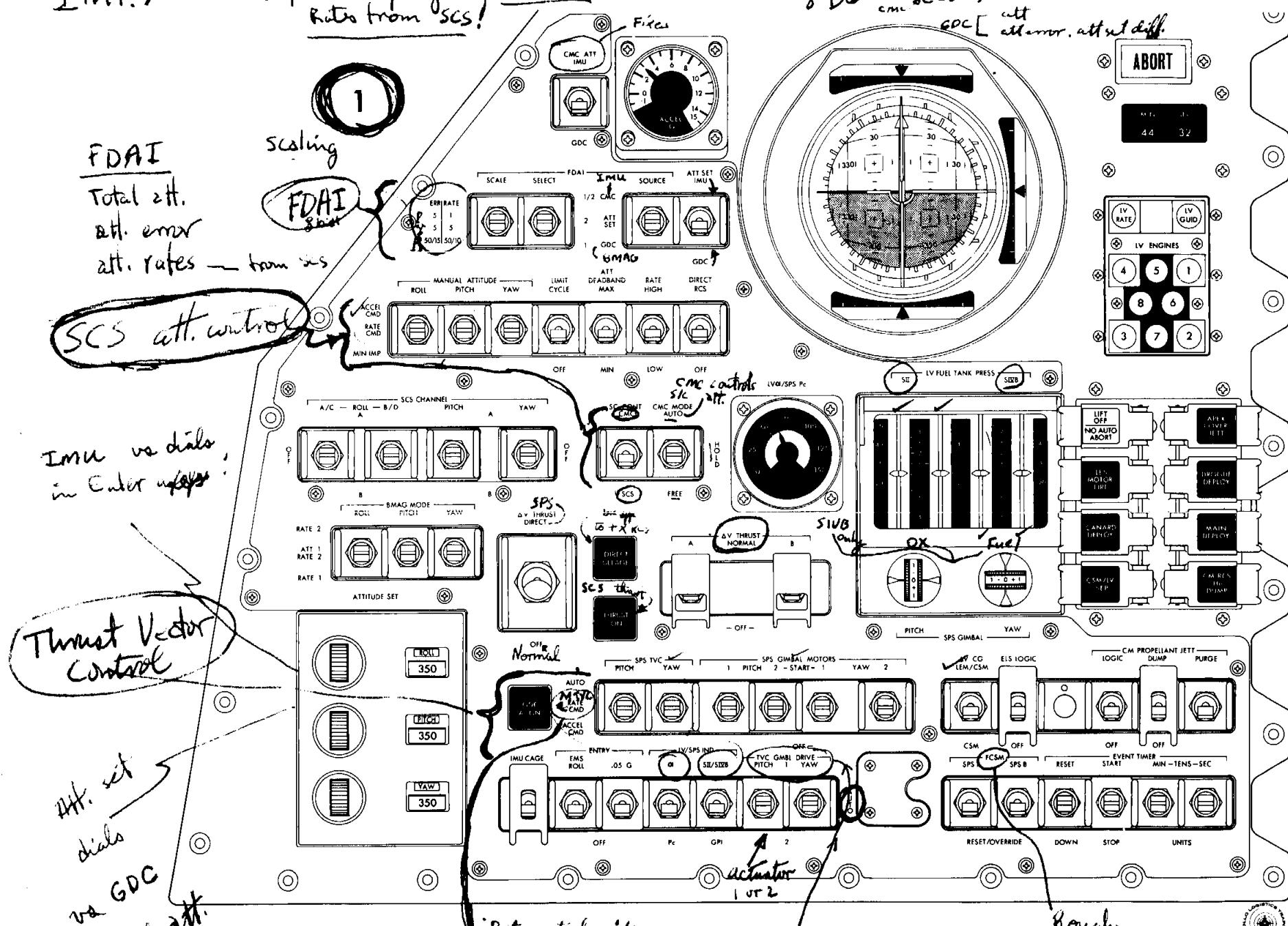
vs GDC
Compute att.
error

Buoying axes

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

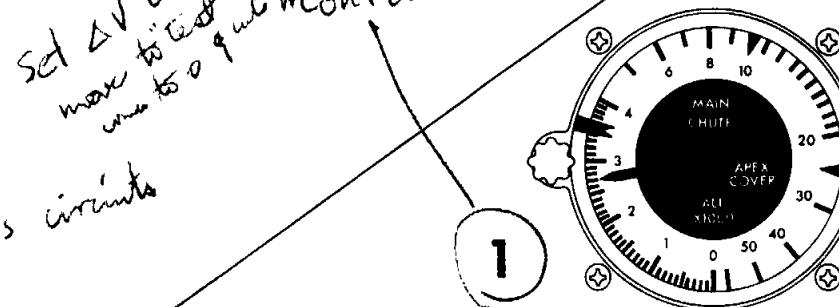
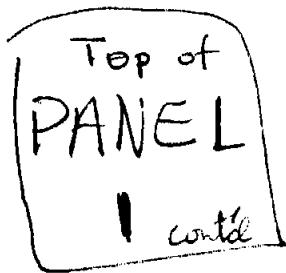
Same as press. gauge
if S/C is sup. from L/V.
Rough Start!

FAM-6312B

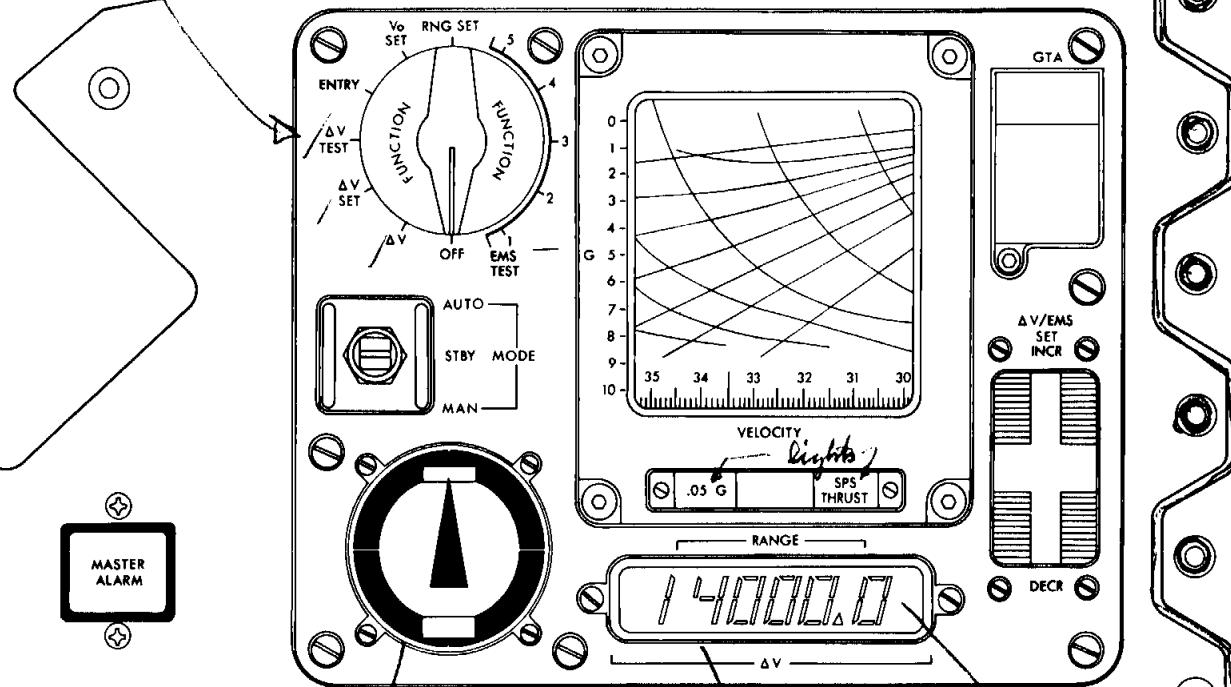


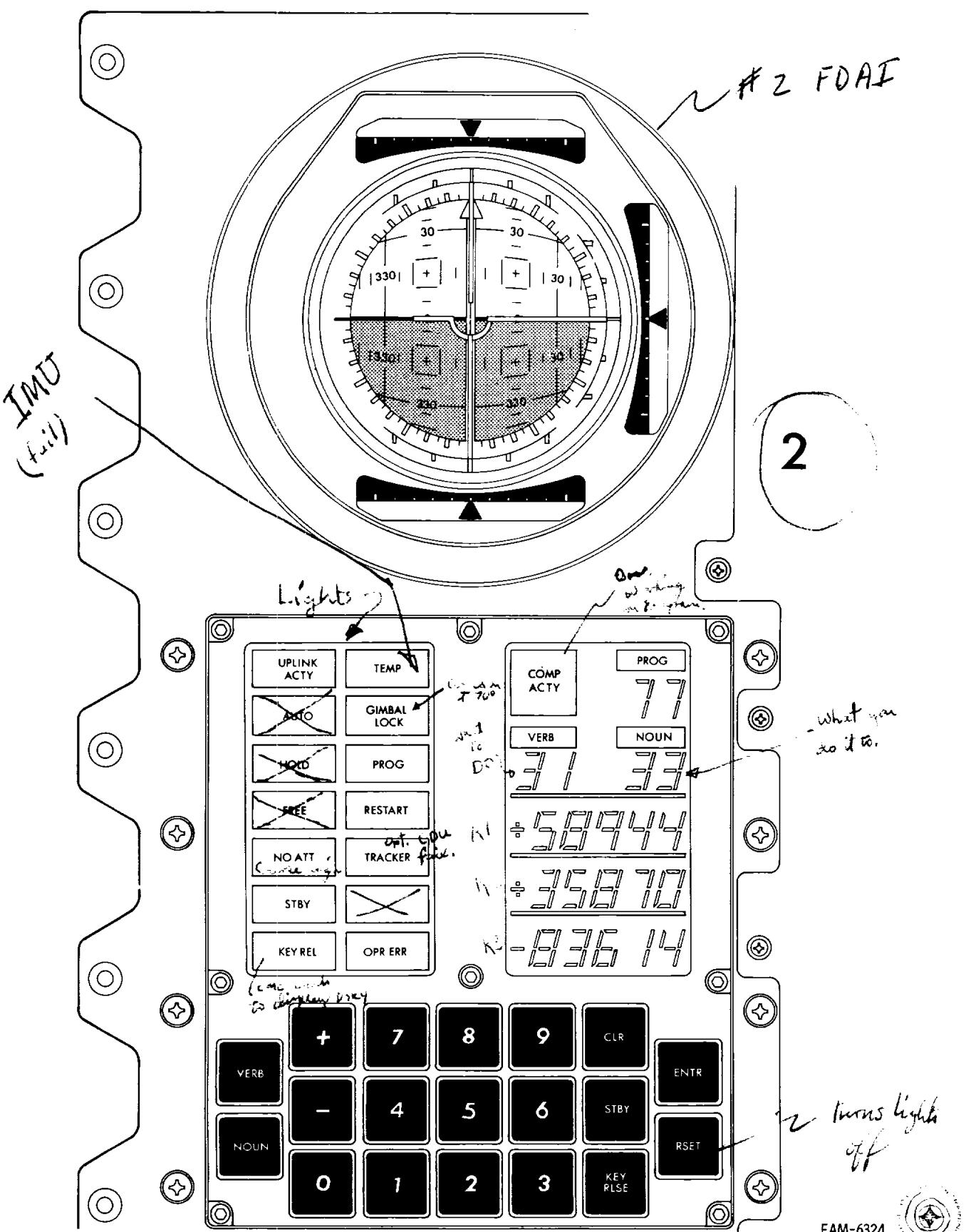
Entry Monitor Display

EMS



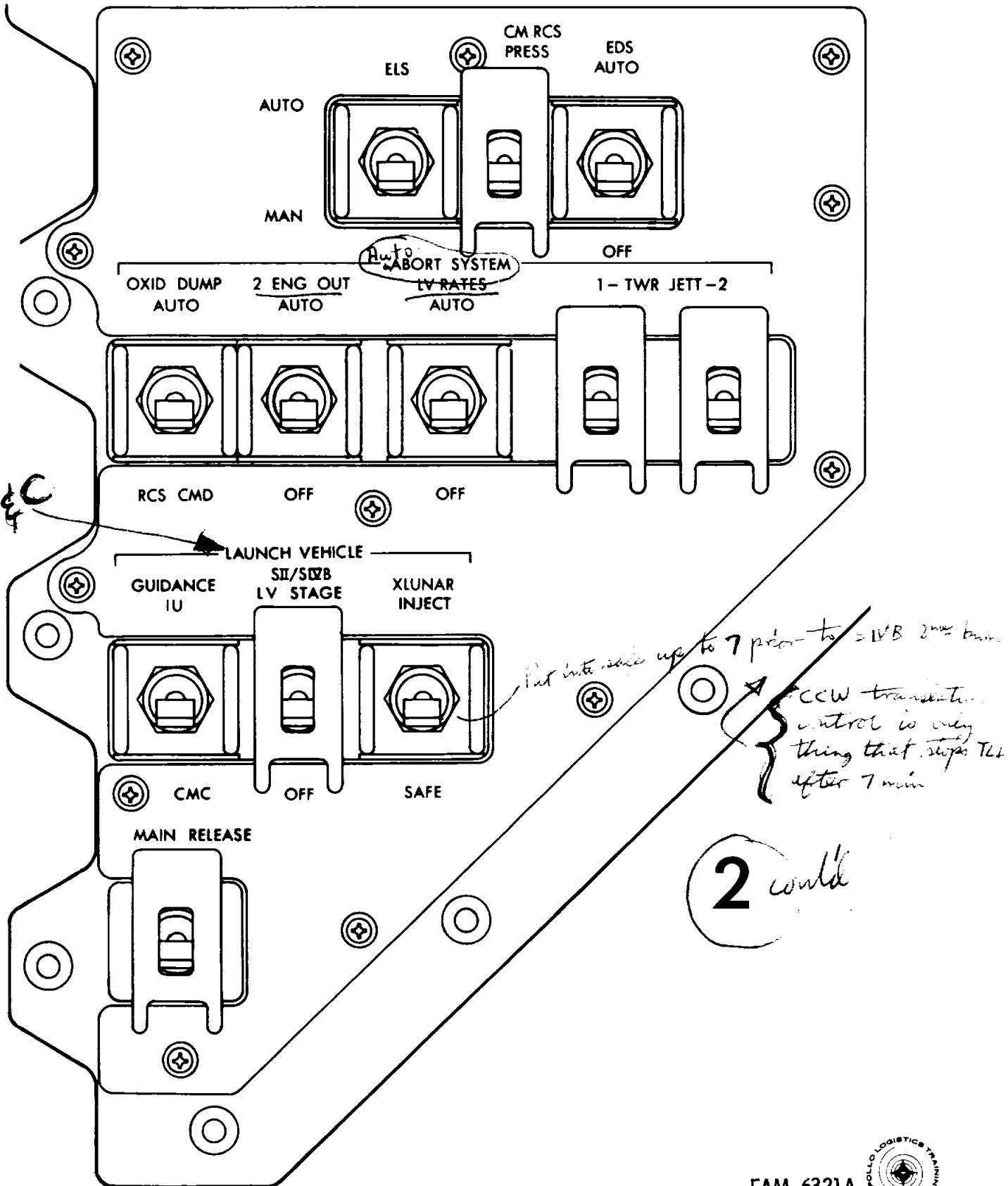
verifies circuit





FAM-6324

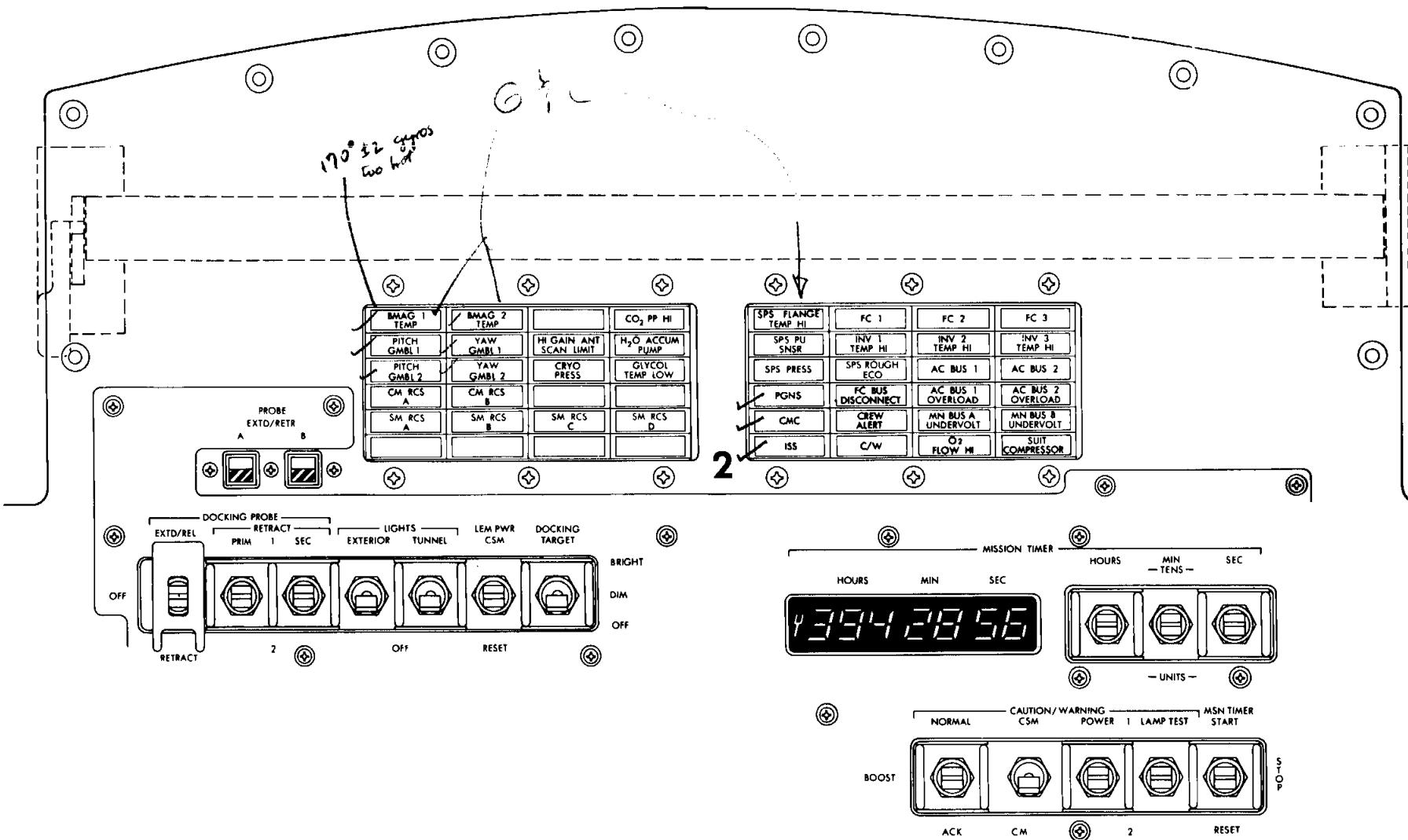




FAM-6321A

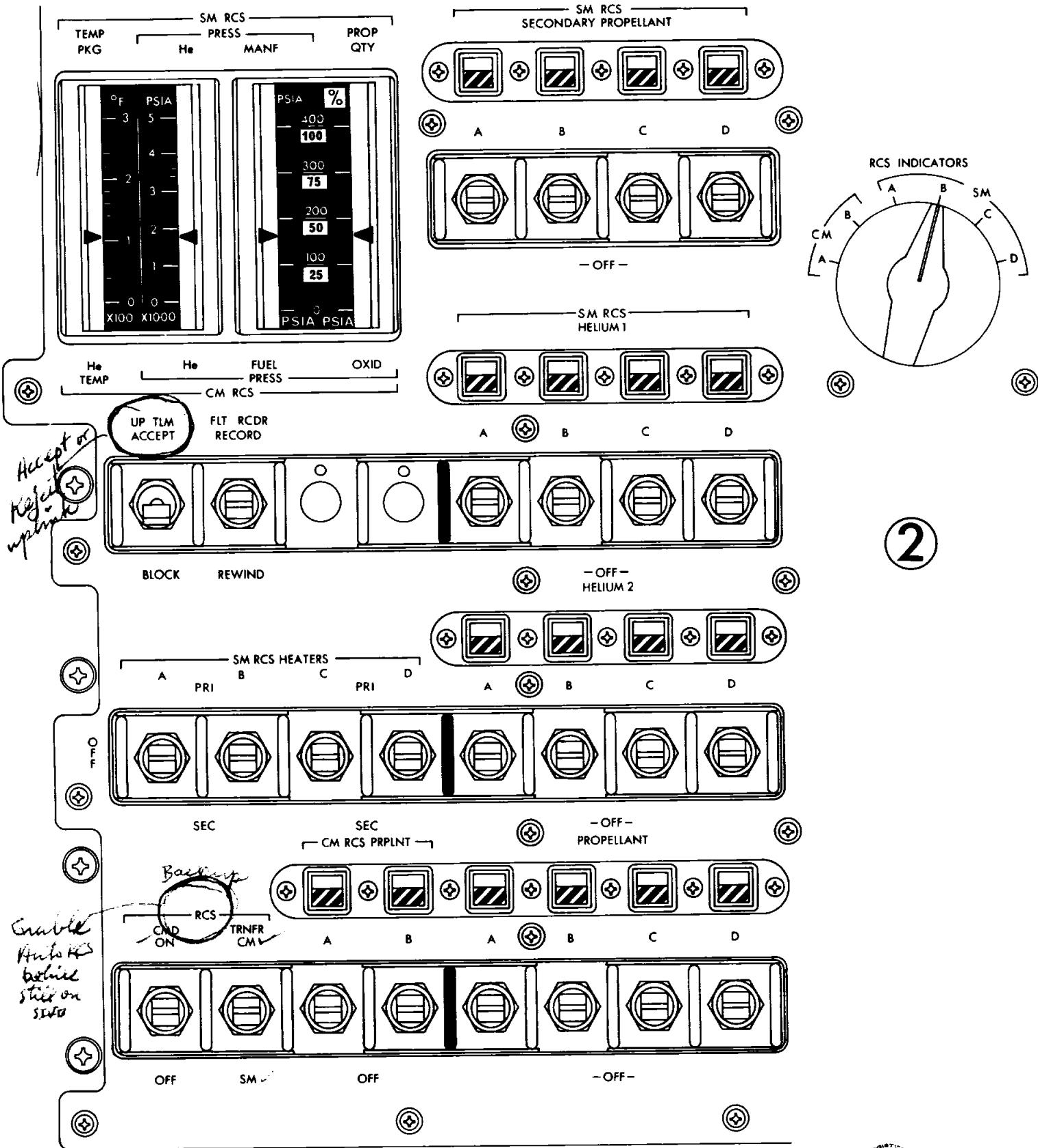


Caution & Warning Lights



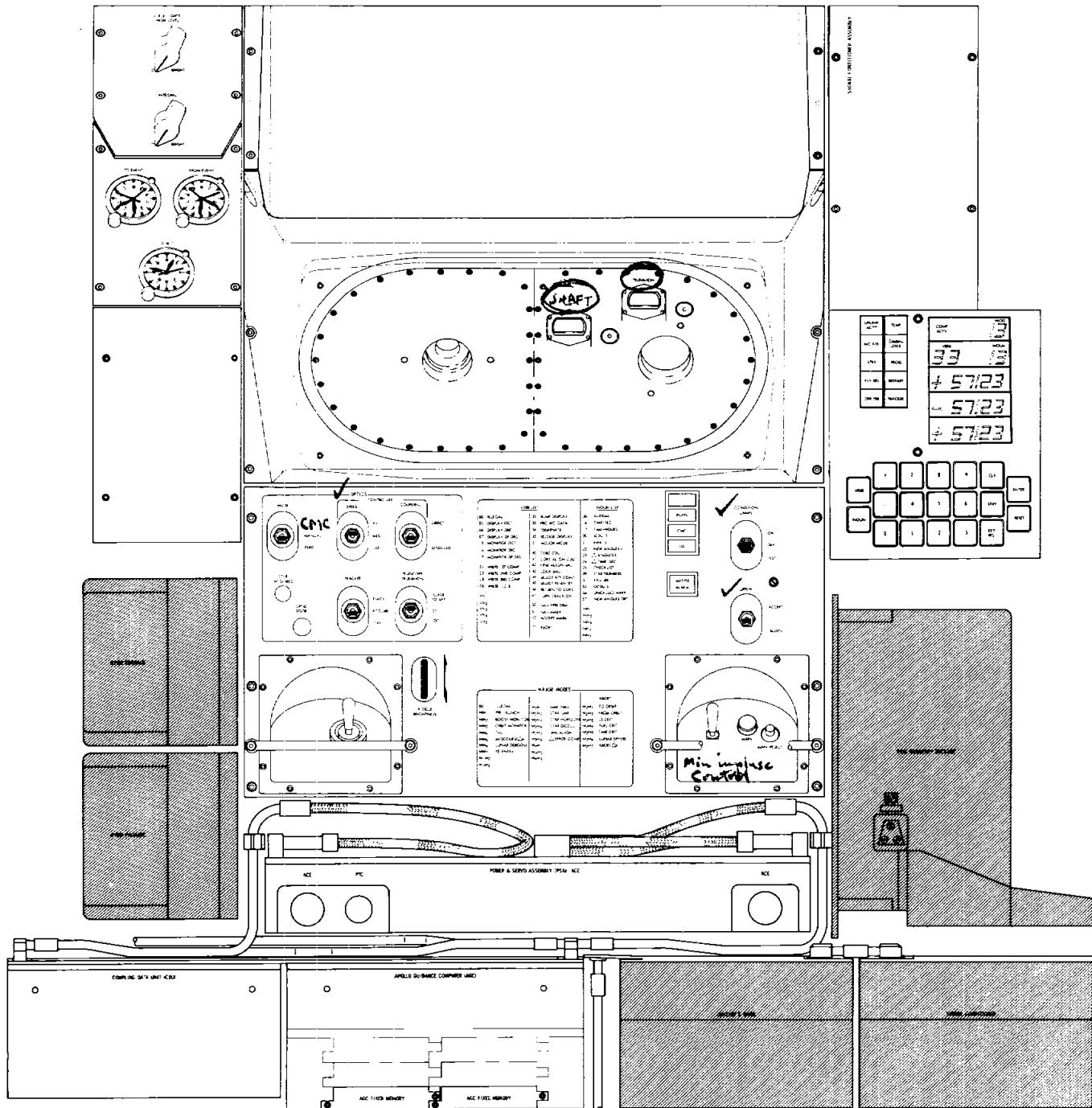
FAM-6323A





G&N LOWER EQUIPMENT BAY

BLOCK II



G & C ATTITUDE REFERENCE

① Total Attitude Displays

IMU

GDC
Entry
Roll

② Att. Error

CDUs

Gyro Ass. I

Source
IMU / Att. set control
GDC / Att. set dials

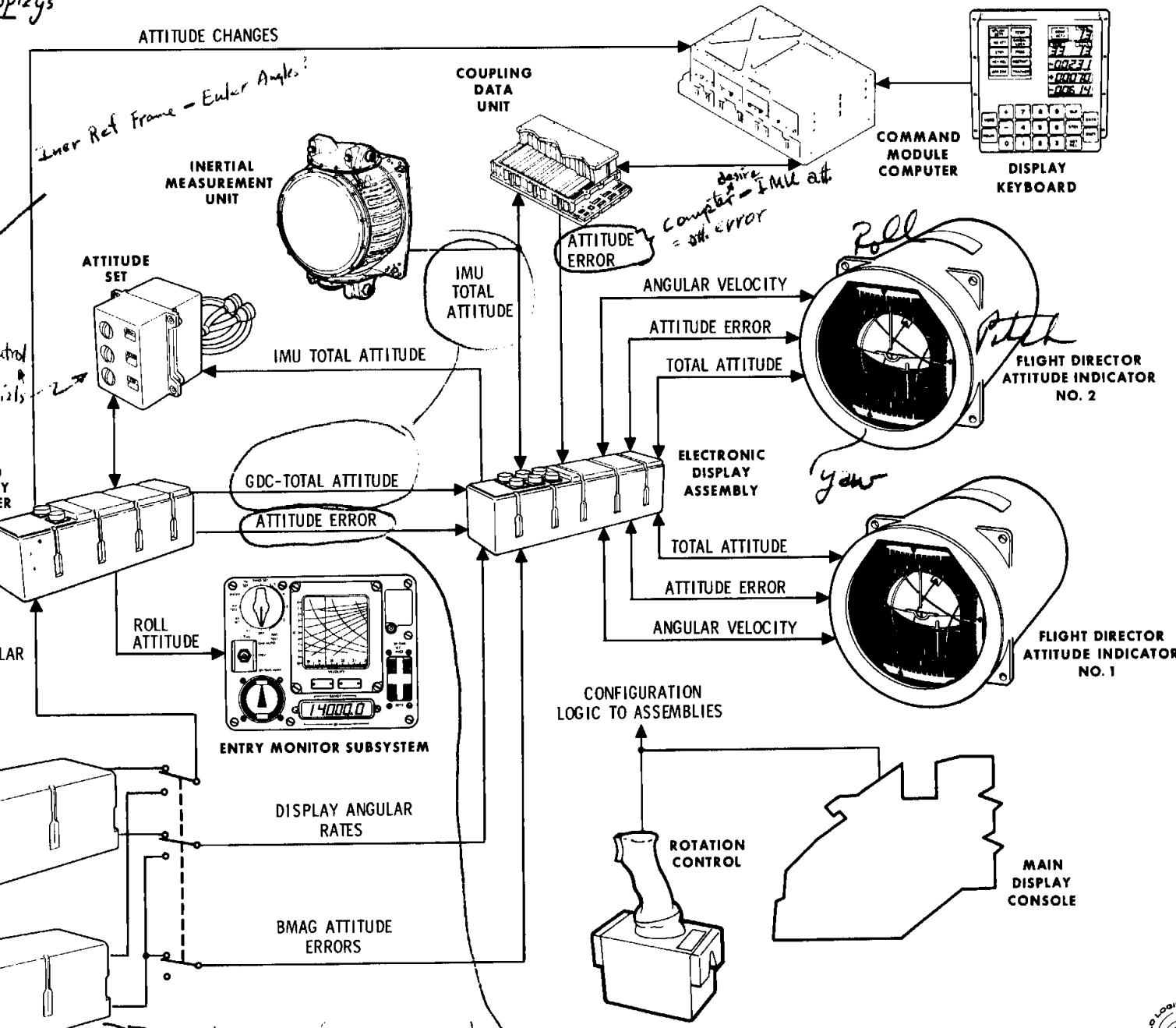
③ Att. Rates

GYRO
DISPLAY COUPLER

S/C ANGULAR
RATES

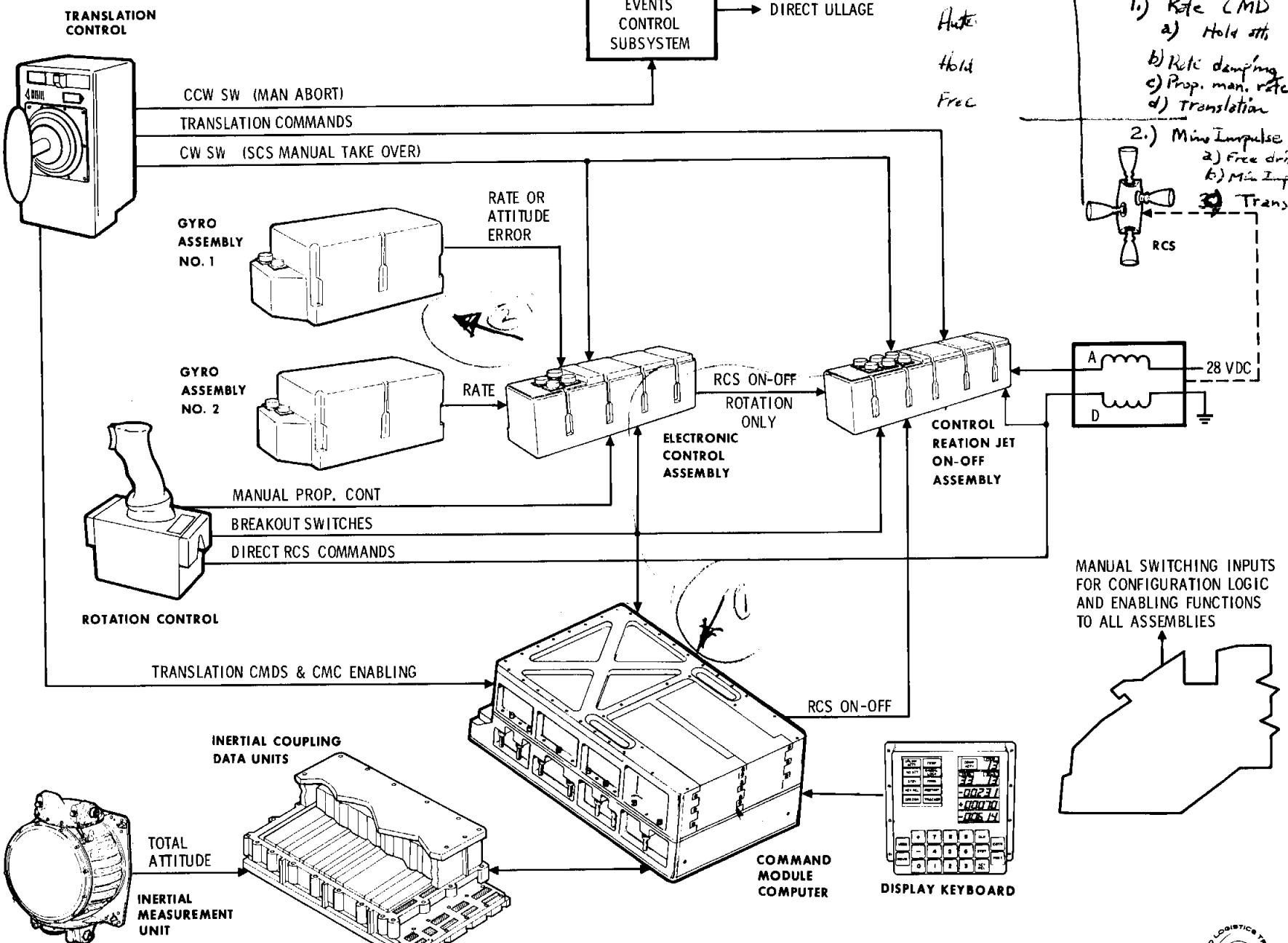
GYRO
ASSEMBLY
NO. 2

GYRO
ASSEMBLY
NO. 1



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

G&C ATTITUDE CONTROL



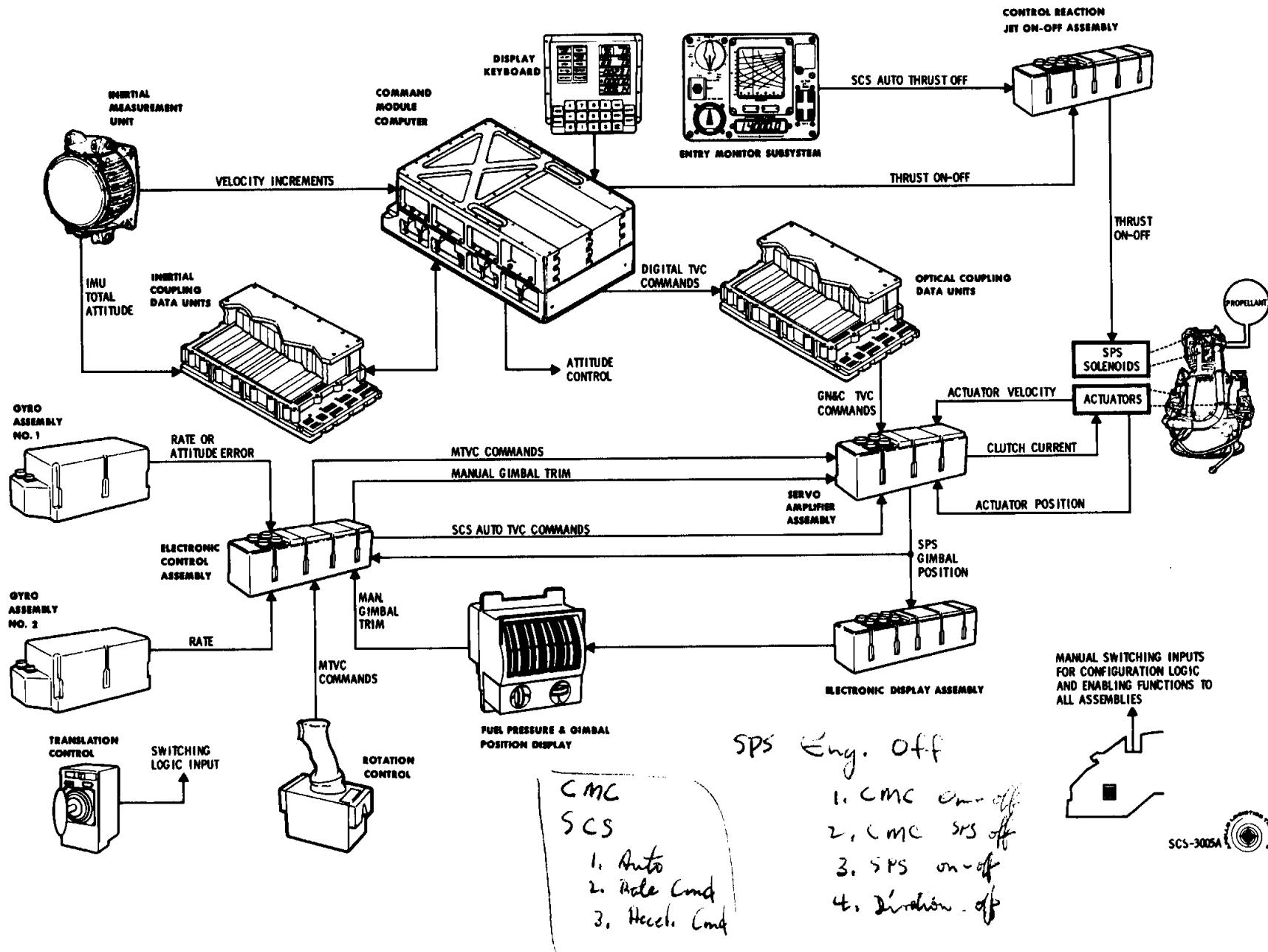
TVC

Actuator (eng/thr)

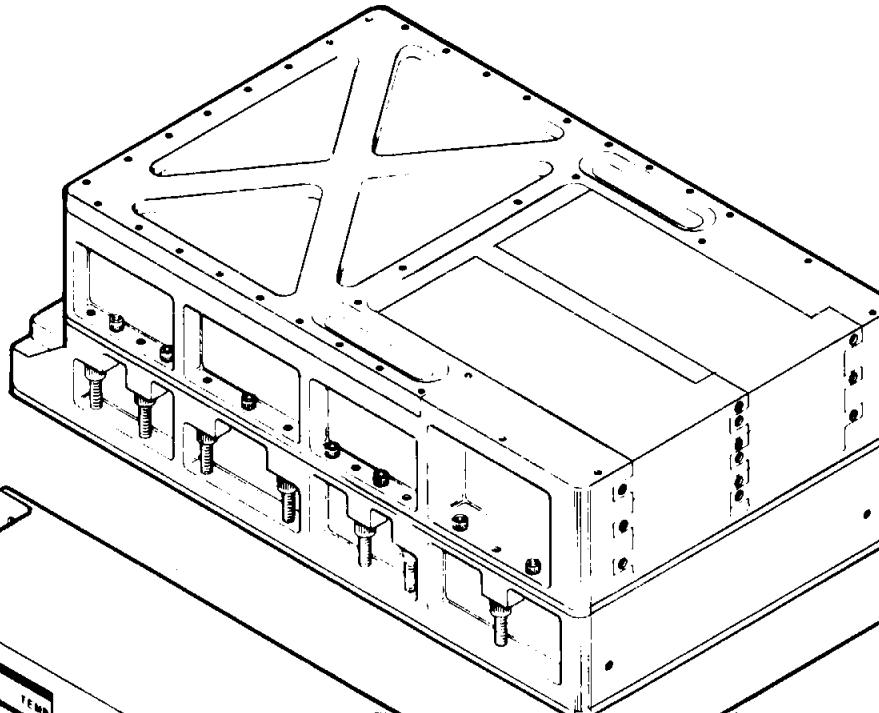
SPS on-off

See Panel Display ①

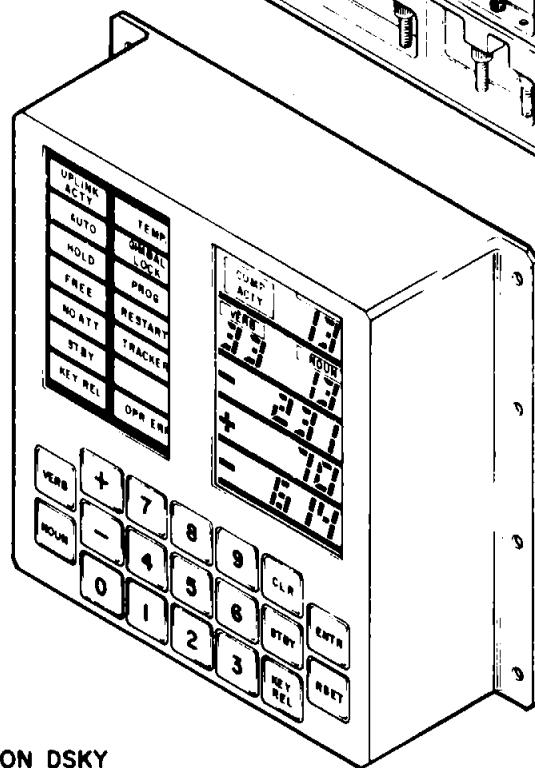
G & C THRUST VECTOR CONTROL



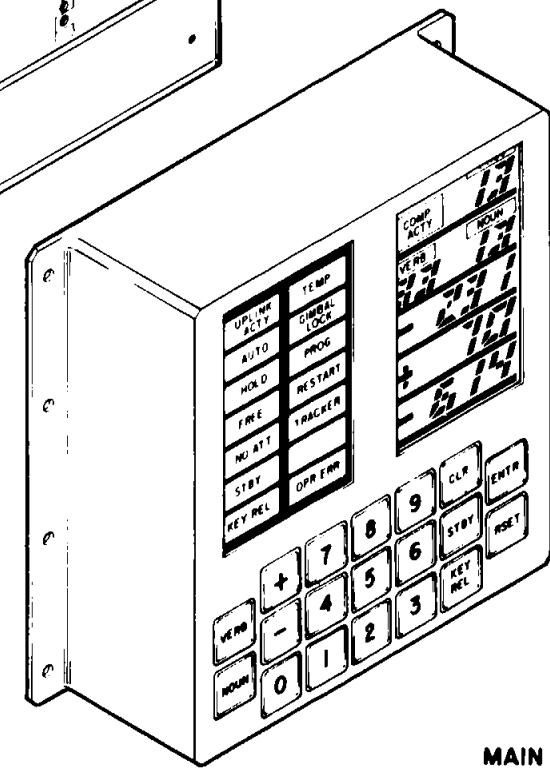
CSS EQUIPMENT



COMMAND
MODULE
COMPUTER



NAVIGATION DSKY

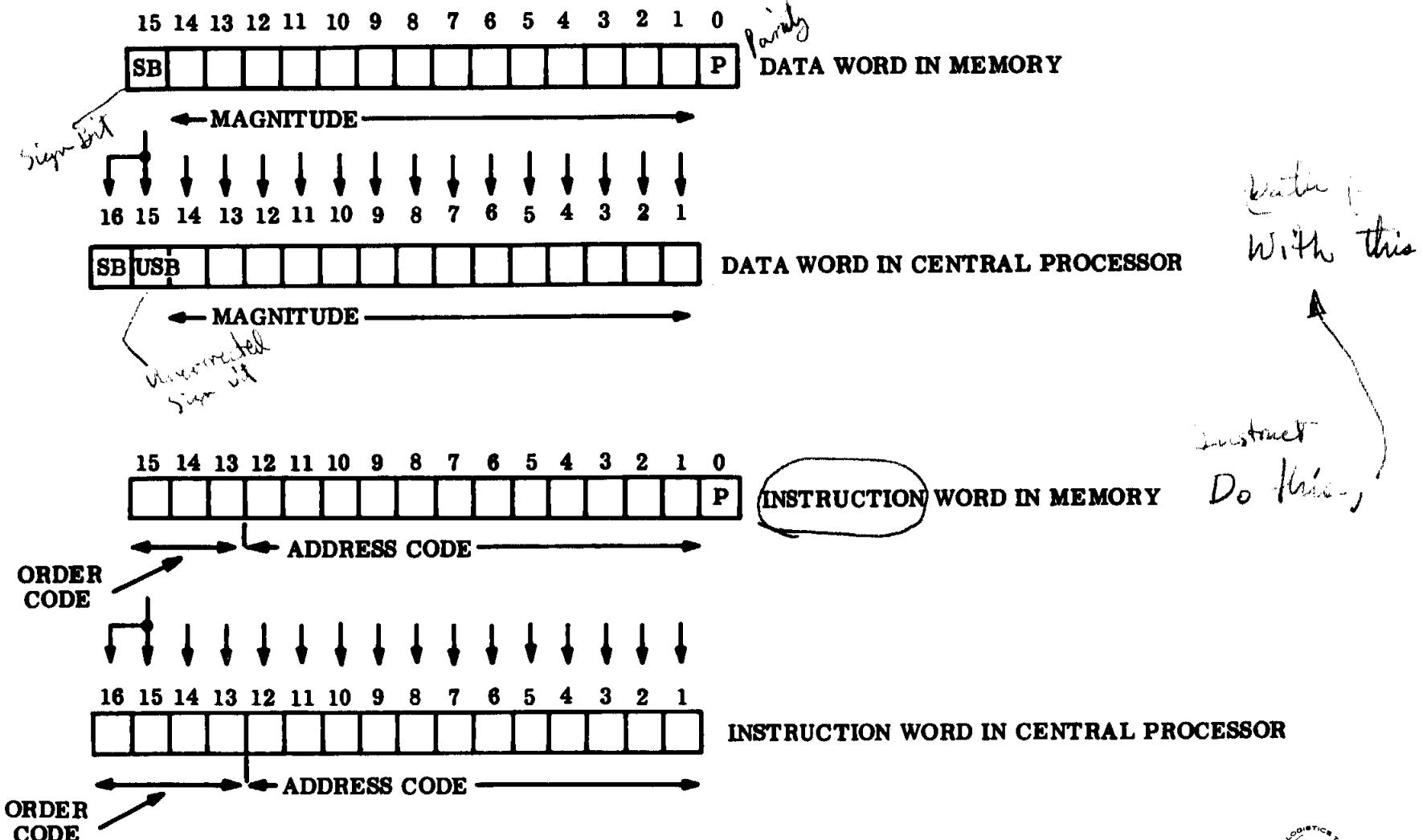


MAIN DSKY

GNC-32



WORD FORMATS IN MEMORY AND CENTRAL PROCESSOR



$101 = 5$

$1 = 1$

$10 = 2$

$11 = 3$

$100 = 4$

$101 = 5$

$110 = 6$

$111 = 7$

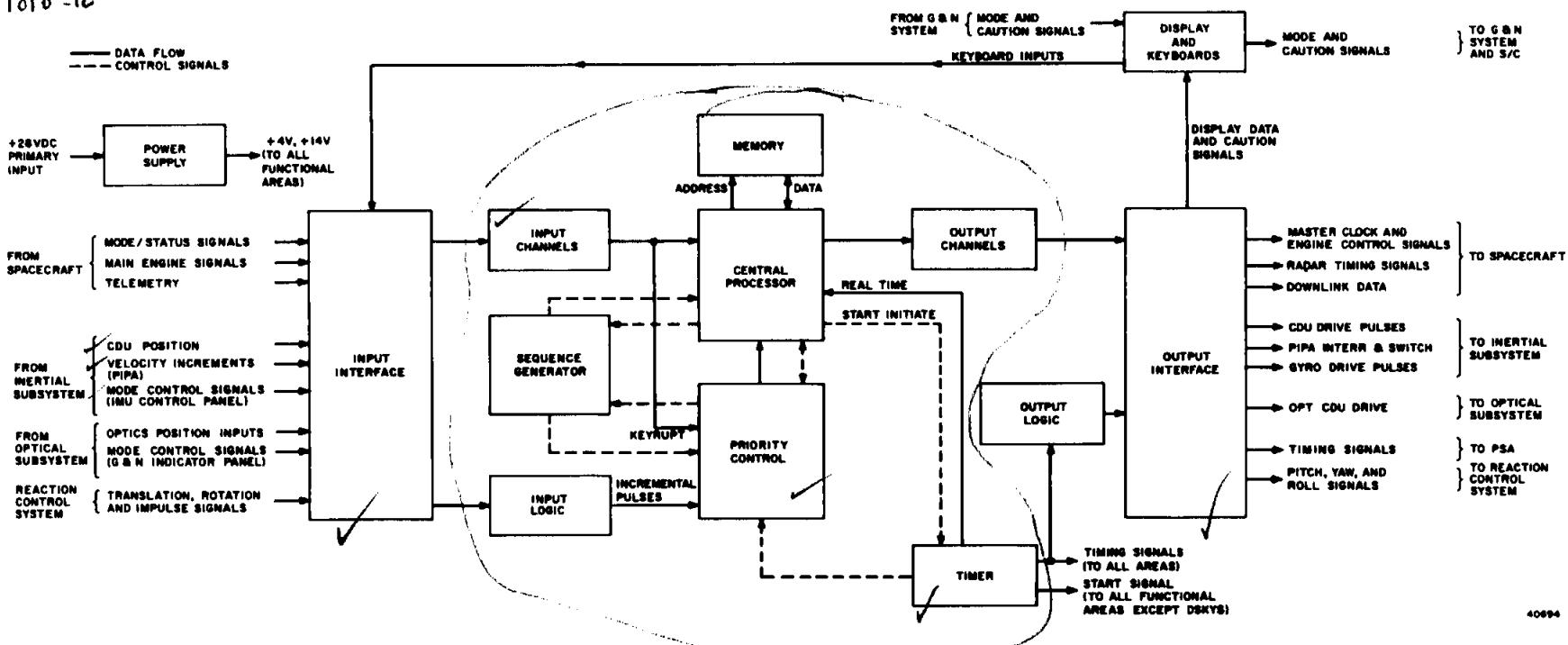
$1000 = 8$

$1011 = 9$

$1010 = 10$

101 Ones complement \rightarrow 7 - 5 111
010 \times 9
 1011 Enables comp. to subtract
 101 sum \rightarrow 010
 010 which is = 2.
 ✓
 - check

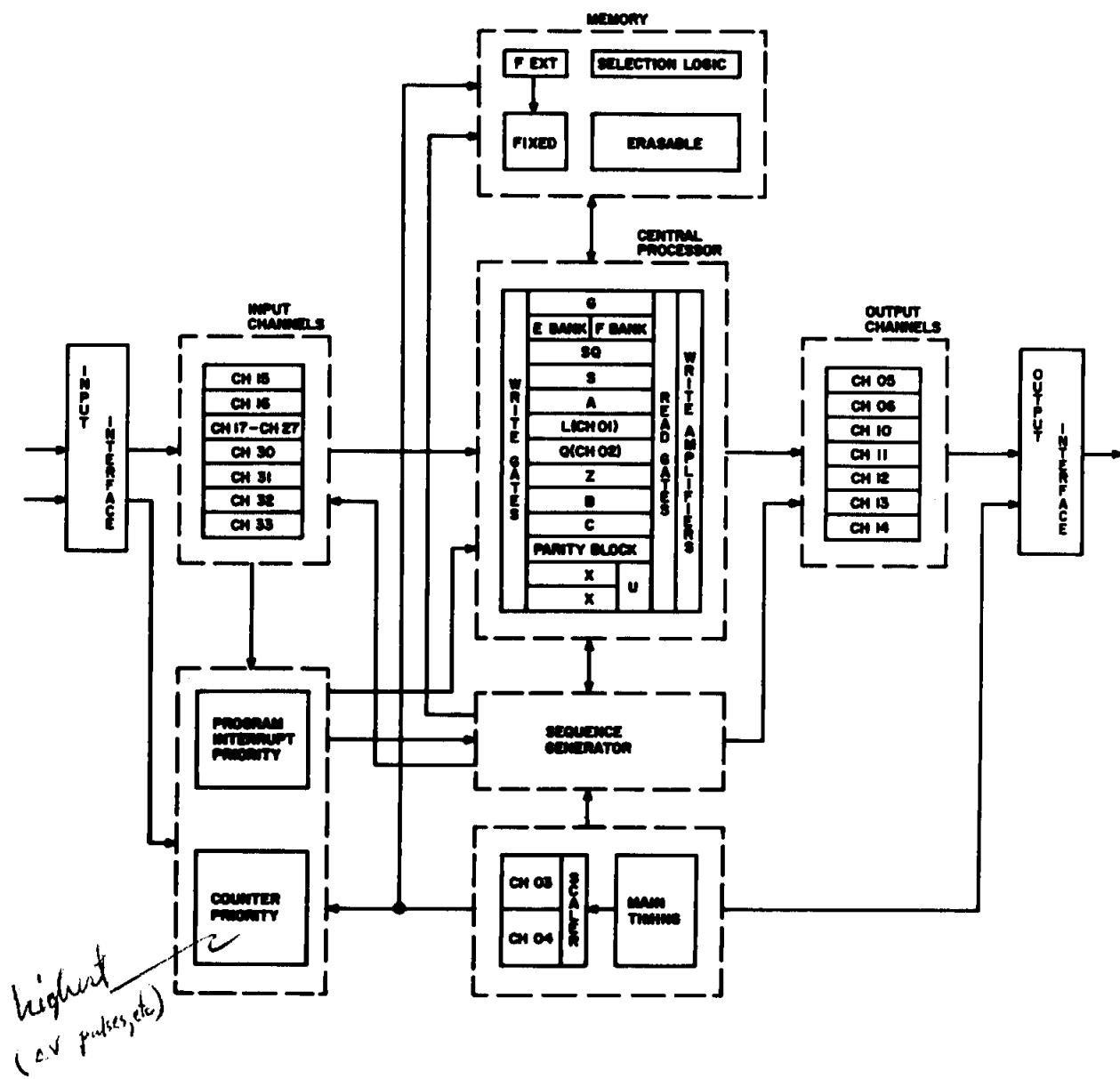
CSS BASIC FLOW



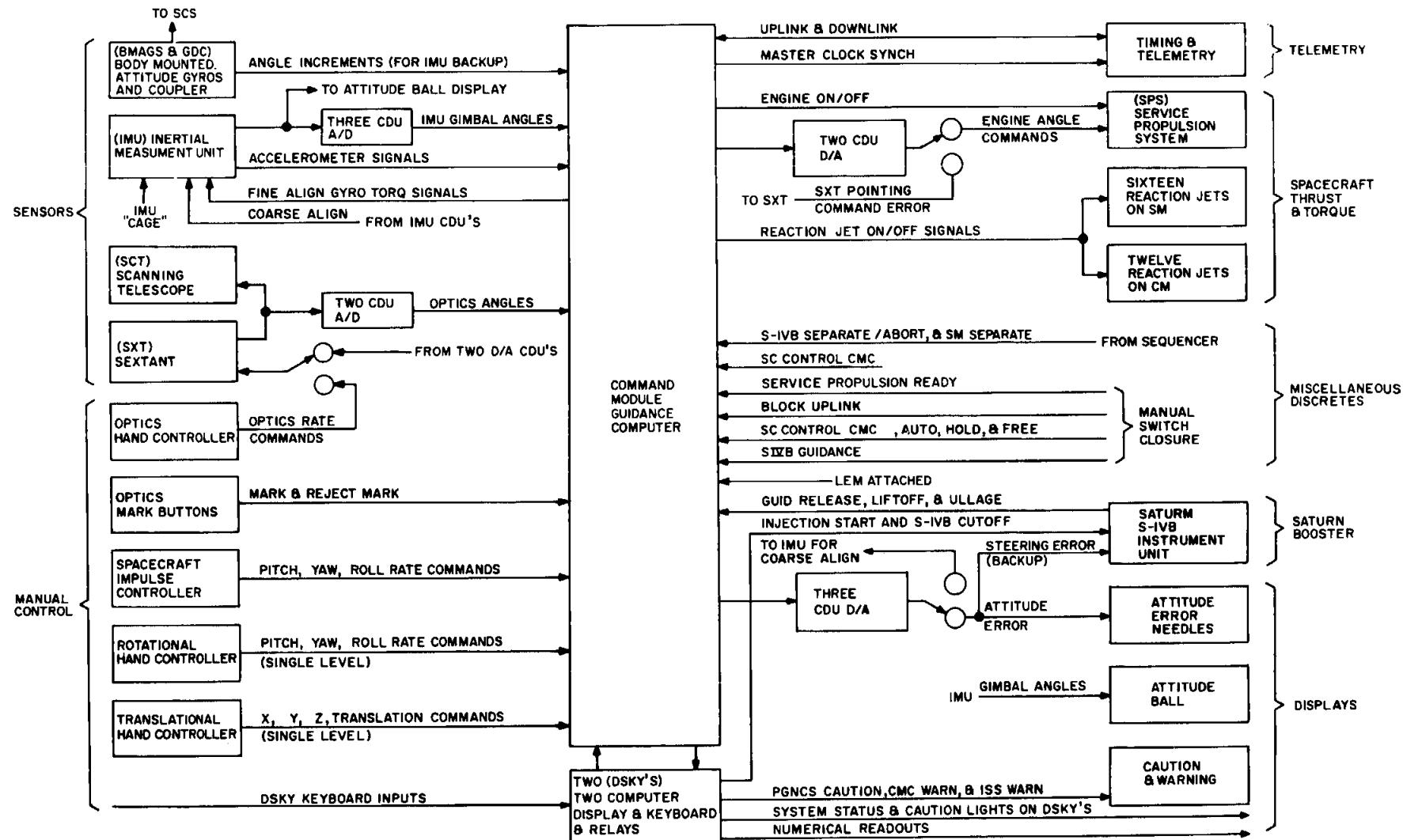
Next page



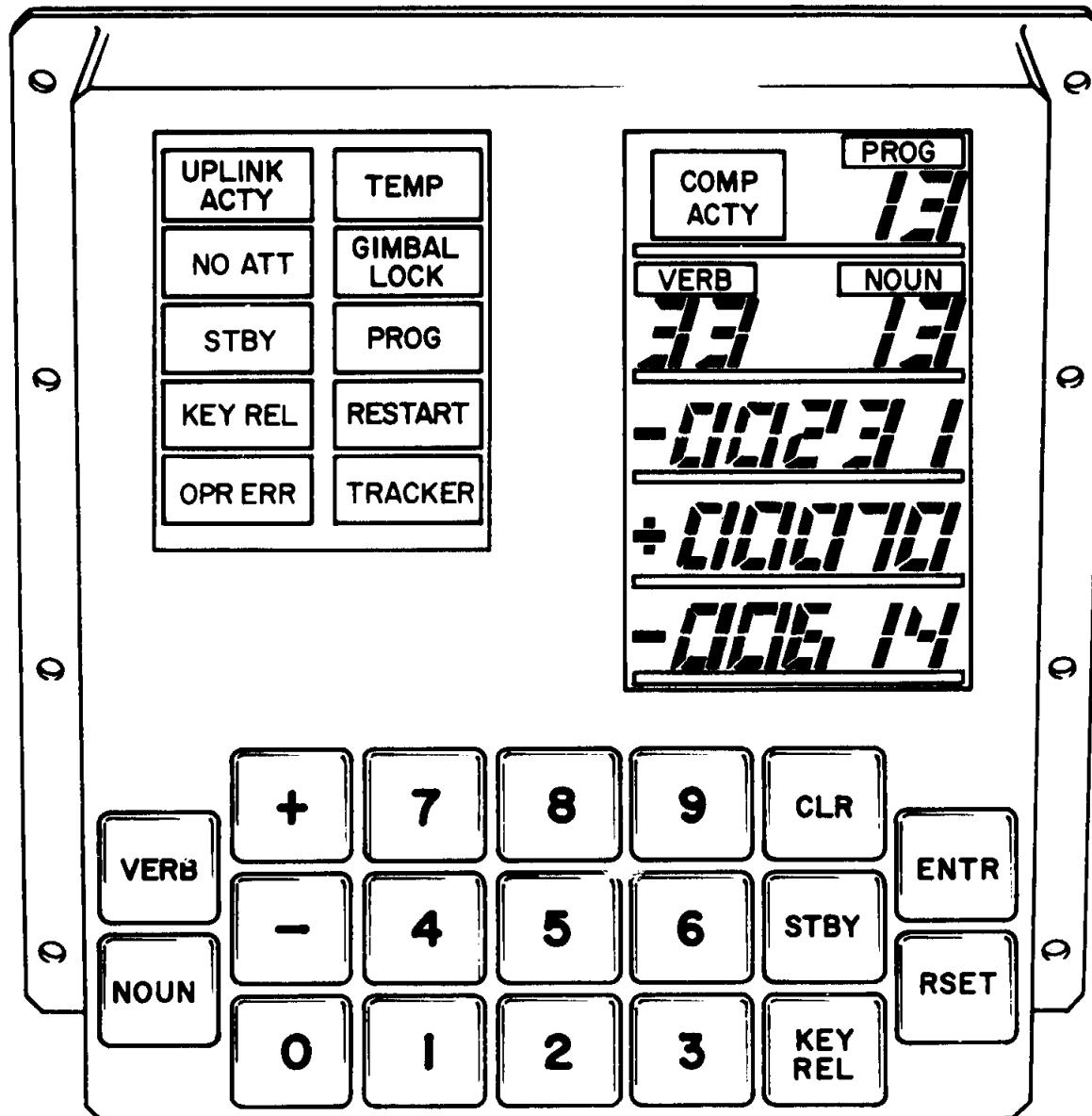
CSS BASIC FLOW DIAGRAM



PGNCS - BLOCK II FUNCTIONAL INTERFACE

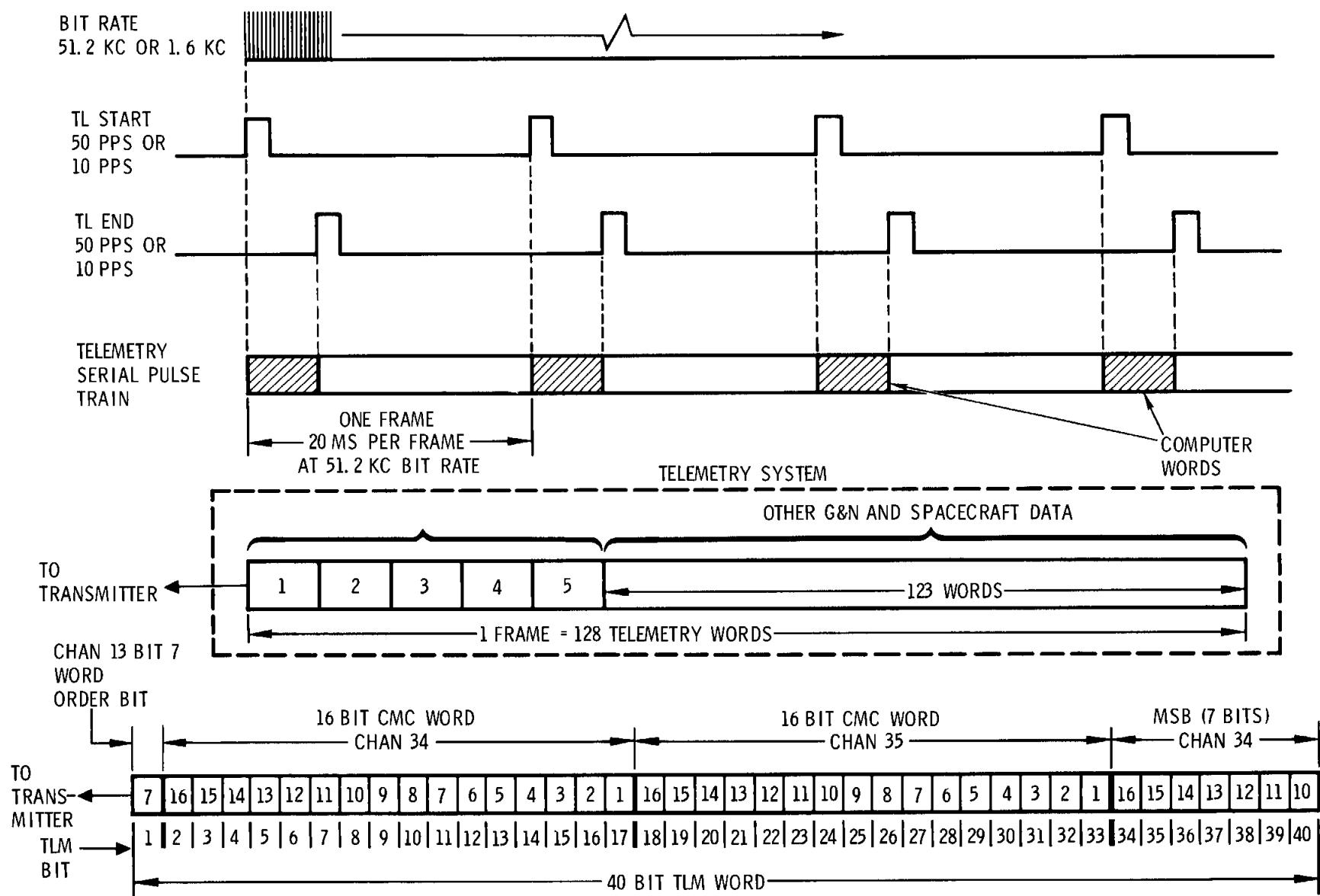


DISPLAY AND KEYBOARD (DSKY)



GNC-33 A 

DWN TLM FORMAT



50 WORD DWNTLM LIST

| TLM WORD NUMBER | WORD ORDER | CHAN 34 | CHAN 35 | MSB (7 BITS) CHAN 34 |
|-----------------|--------------|---------------|------------------|----------------------|
| | BIT 16 | 12 | 16 | 1 |
| 1 | 0 0101010101 | START ADDRESS | 0 00000100011111 | 1 |
| 2 | 1 | DATA MSB | DATA LSB | |
| 13 | 1 | DATA | DATA | |
| 14 | 1 | DATA | DATA | |
| 39 | 1 | DATA | DATA | |
| 40 | 1 | DSPTAB + 11D | DSPTAB + 10D | |
| 41 | 1 | DSPTAB + 9D | DSPTAB + 8D | |
| 42 | 1 | DSPTAB + 7 | DSPTAB + 6 | |
| 43 | 1 | DSPTAB + 5 | DSPTAB + 4 | |
| 44 | 1 | DSPTAB + 3 | DSPTAB + 2 | |
| 45 | 1 | DSPTAB + 1 | DSPTAB + 0 | |
| 46 | 1 | TIME 2 | TIME 1 | |
| 47 | 1 | CHAN 11 | CHAN 12 | |
| 48 | 1 | CHAN 13 | CHAN 14 | |
| 49 | 1 | CHAN 30 | CHAN 31 | |
| 50 | 1 | CHAN 32 | CHAN 33 | |
| | 1 | 16 | 16 | 7 |
| | | | 40 BITS | |

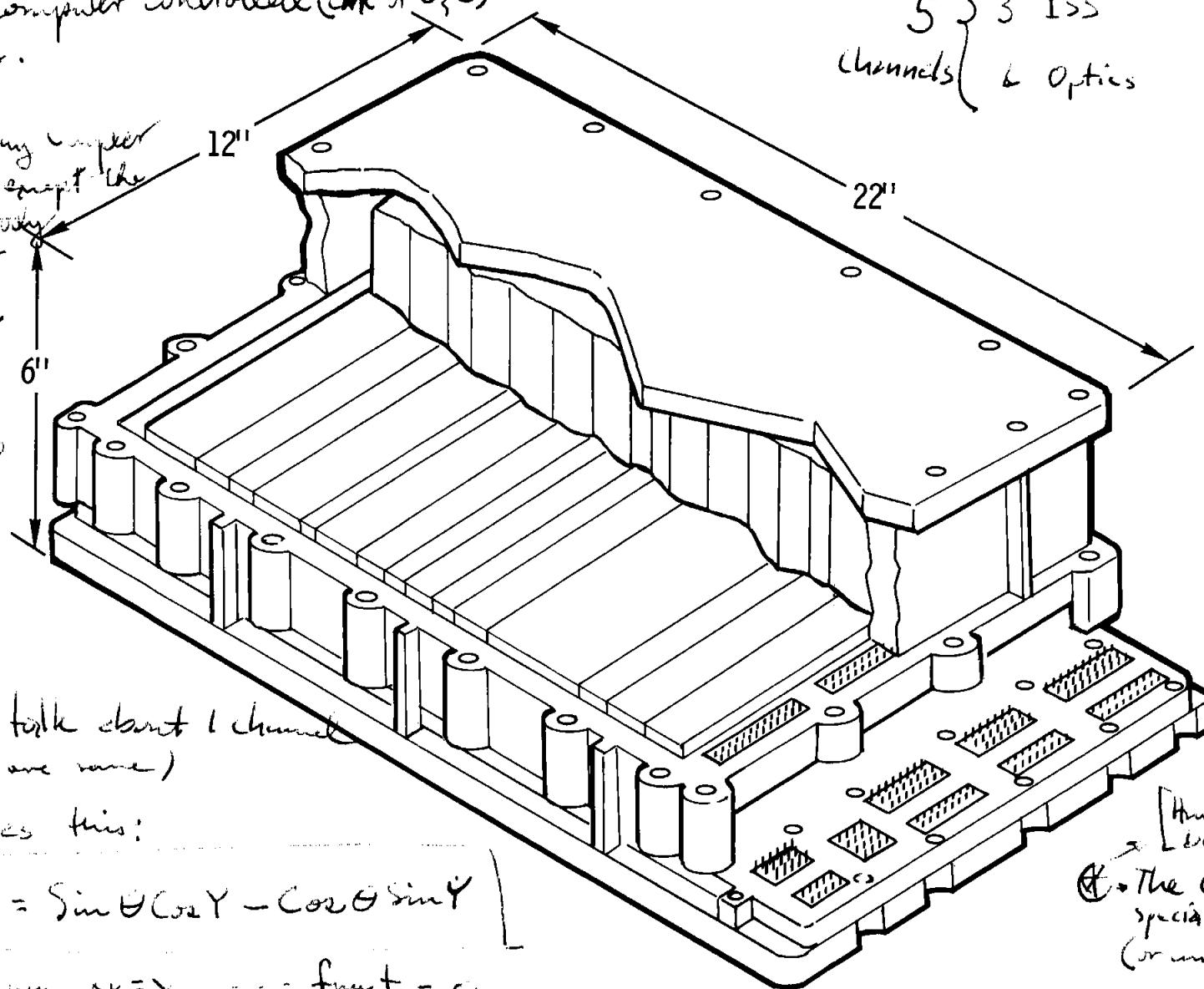
Relates S/C attitude
to the IMU ref. frame
for the computer controlled (att or op)
operations.

COUPLING DATA UNIT

Analogy to Digital
converter
Digital to Analogy
converter

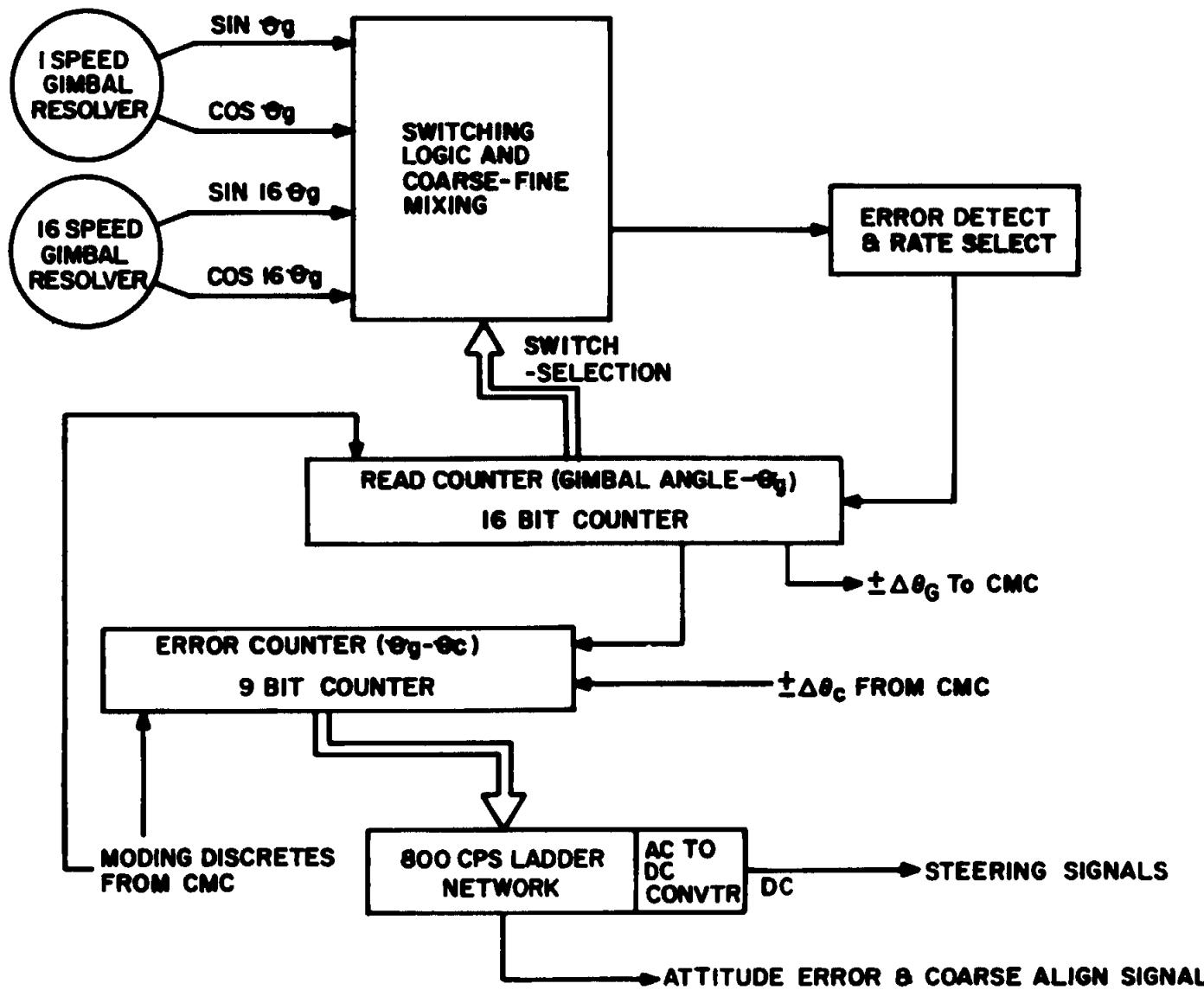
5 { 3 I_>
Channels & Optics

Opt display under
ins same except the
opt. is a very
stiff fixed at
the time you
initiate the
operation. No
time goes to
CMC



[How to Dig +]
[Dig to Anal]
• The CDU is a
special purpose computer
(or an extension of the CMC)

COUPLING DATA UNIT BLOCK DIAGRAM

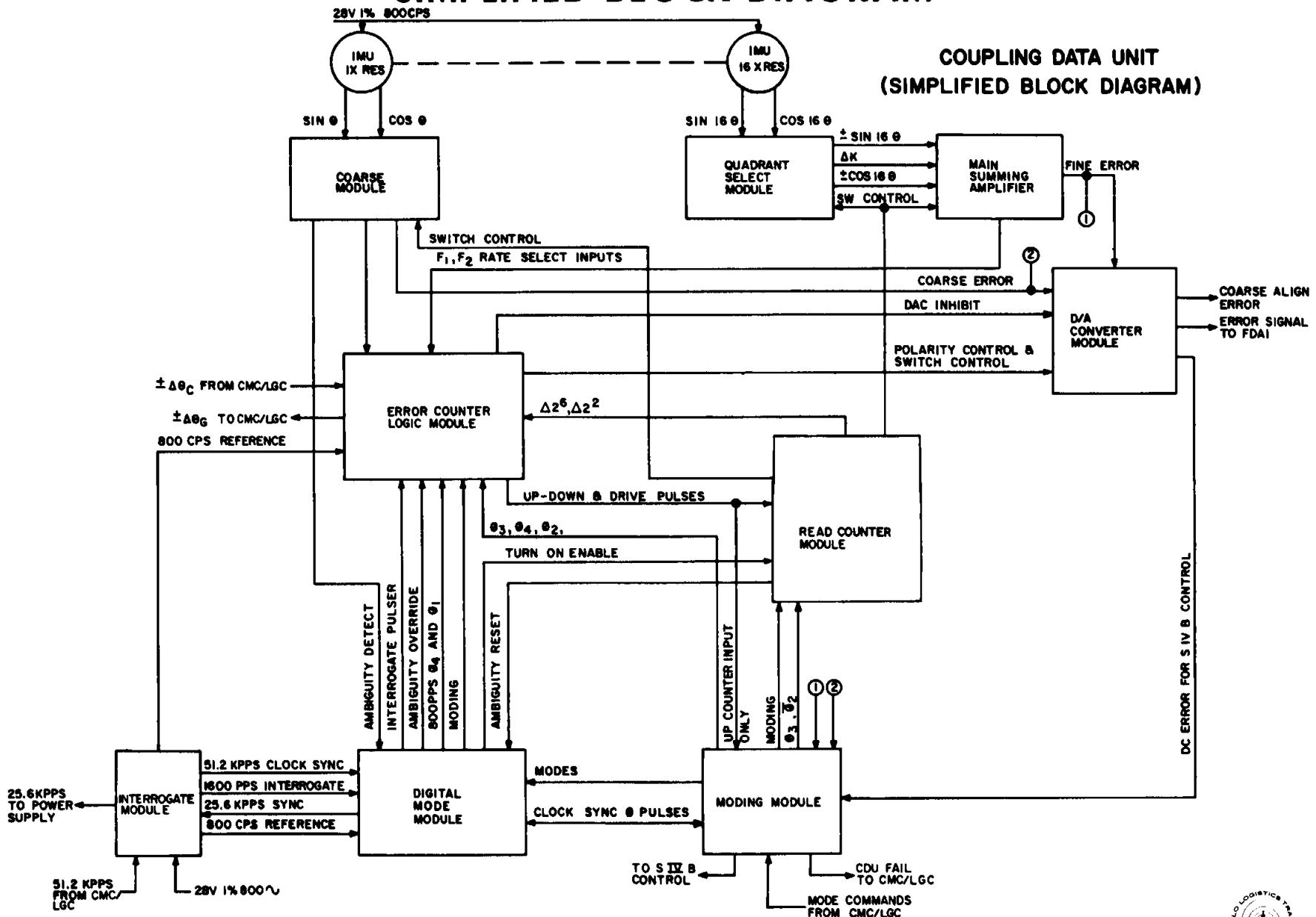


GNC-12



COUPLING DATA UNIT

SIMPLIFIED BLOCK DIAGRAM

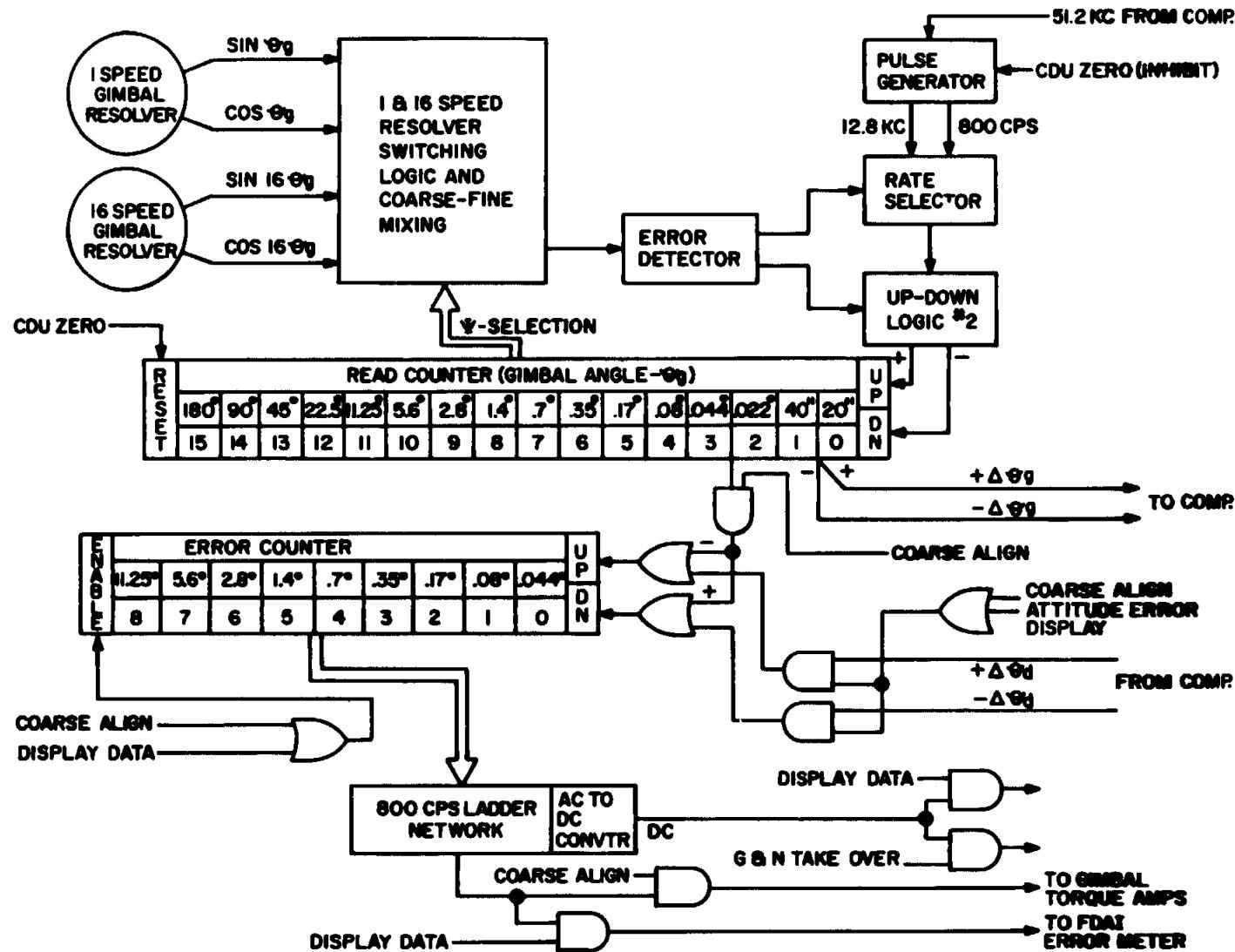


GNC-70

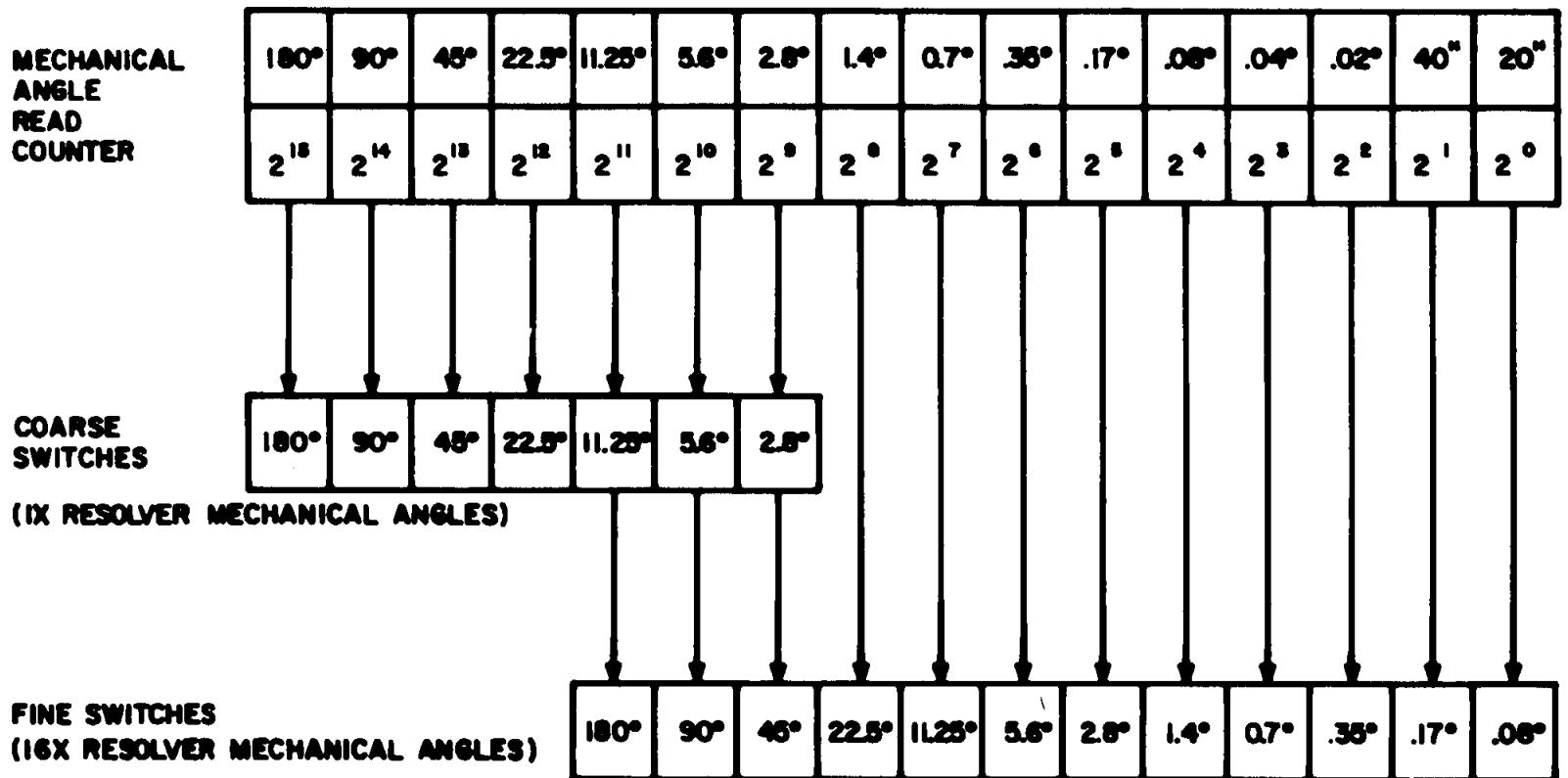
CDU



CDU FUNCTIONAL BLOCK DIAGRAM



READ COUNTER RELATIONSHIP TO COARSE FINE SWITCHING

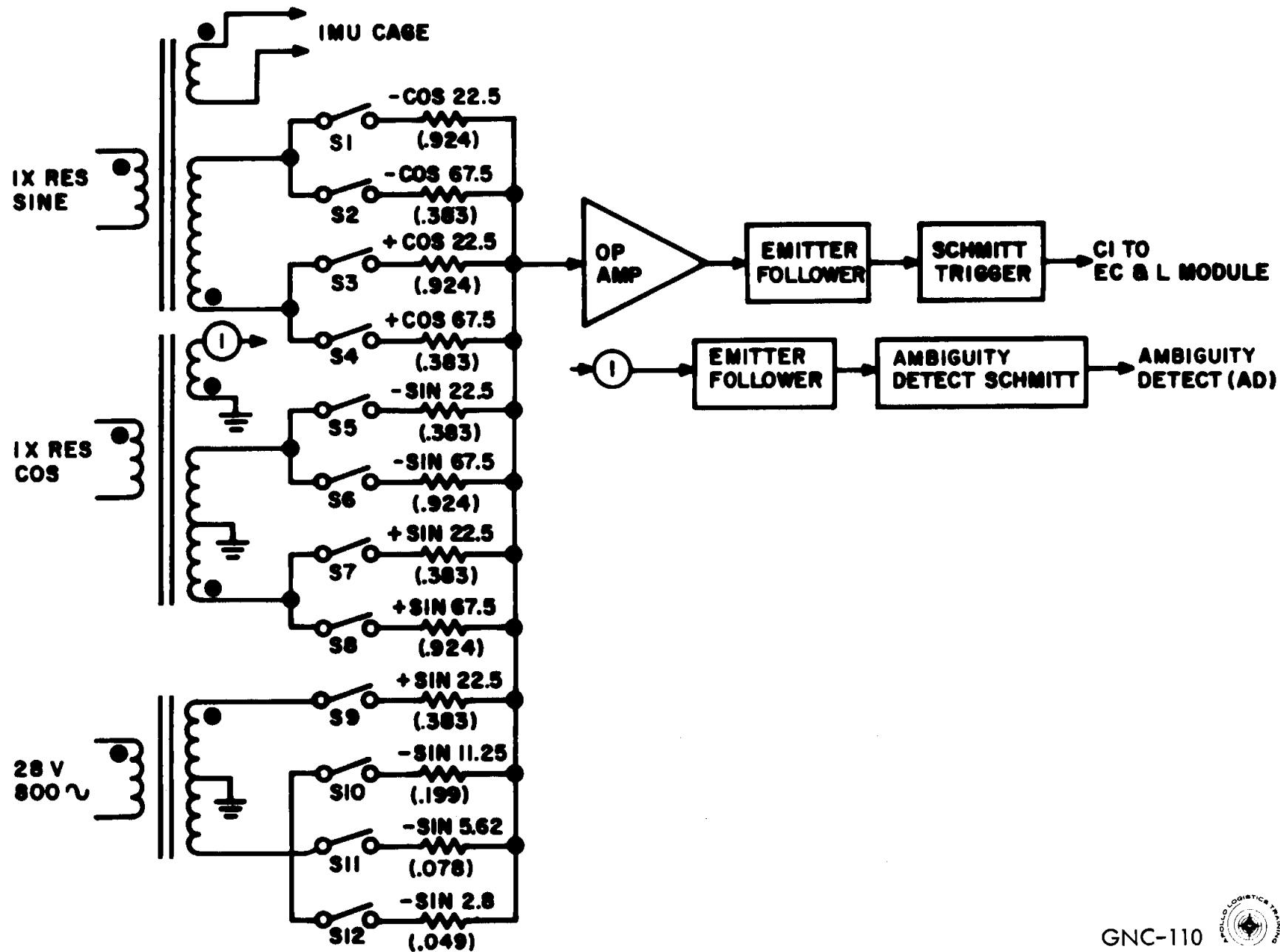


GNC-109

CDU



CDU COARSE MODULE BLOCK DIAGRAM



GNC-110



COARSE SWITCH LOGIC EQUATIONS

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

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

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

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

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

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

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

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

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

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

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

$$DC\ 12 = 2^9$$

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

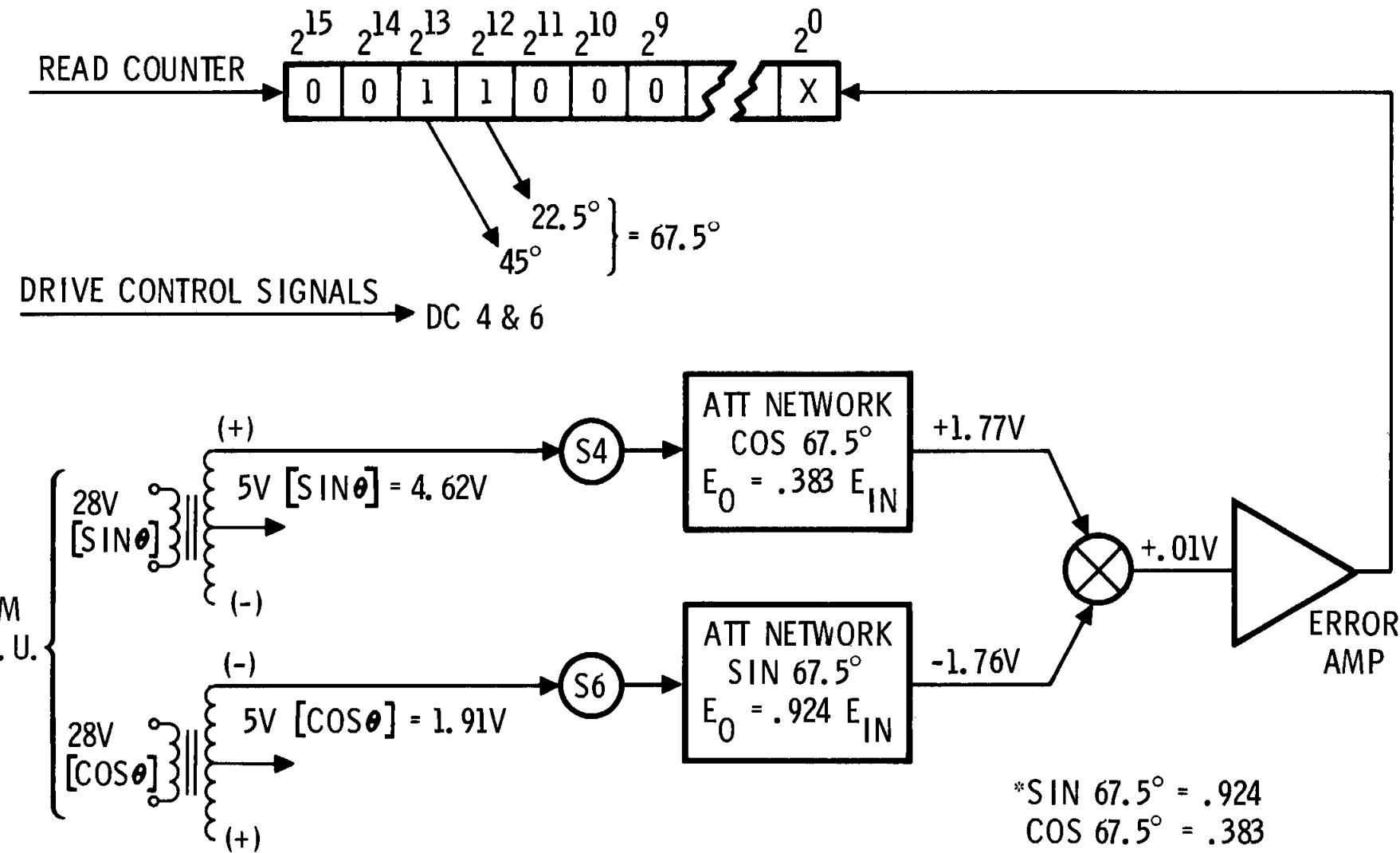
* DC "X" CLOSES SWITCH "X"

GNC-147

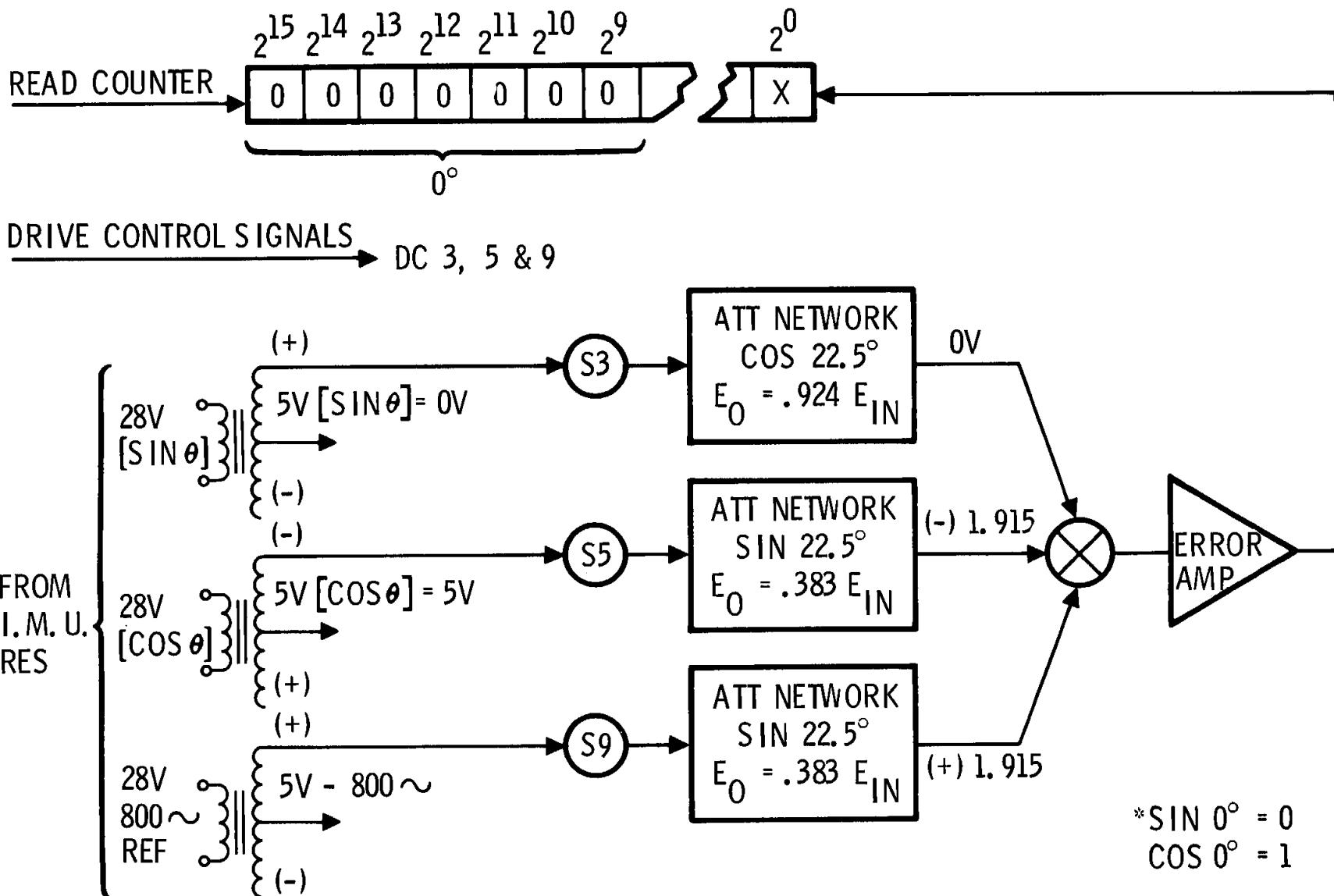


CDU

$$\theta = 67.5$$



$$\Theta = 0^\circ$$

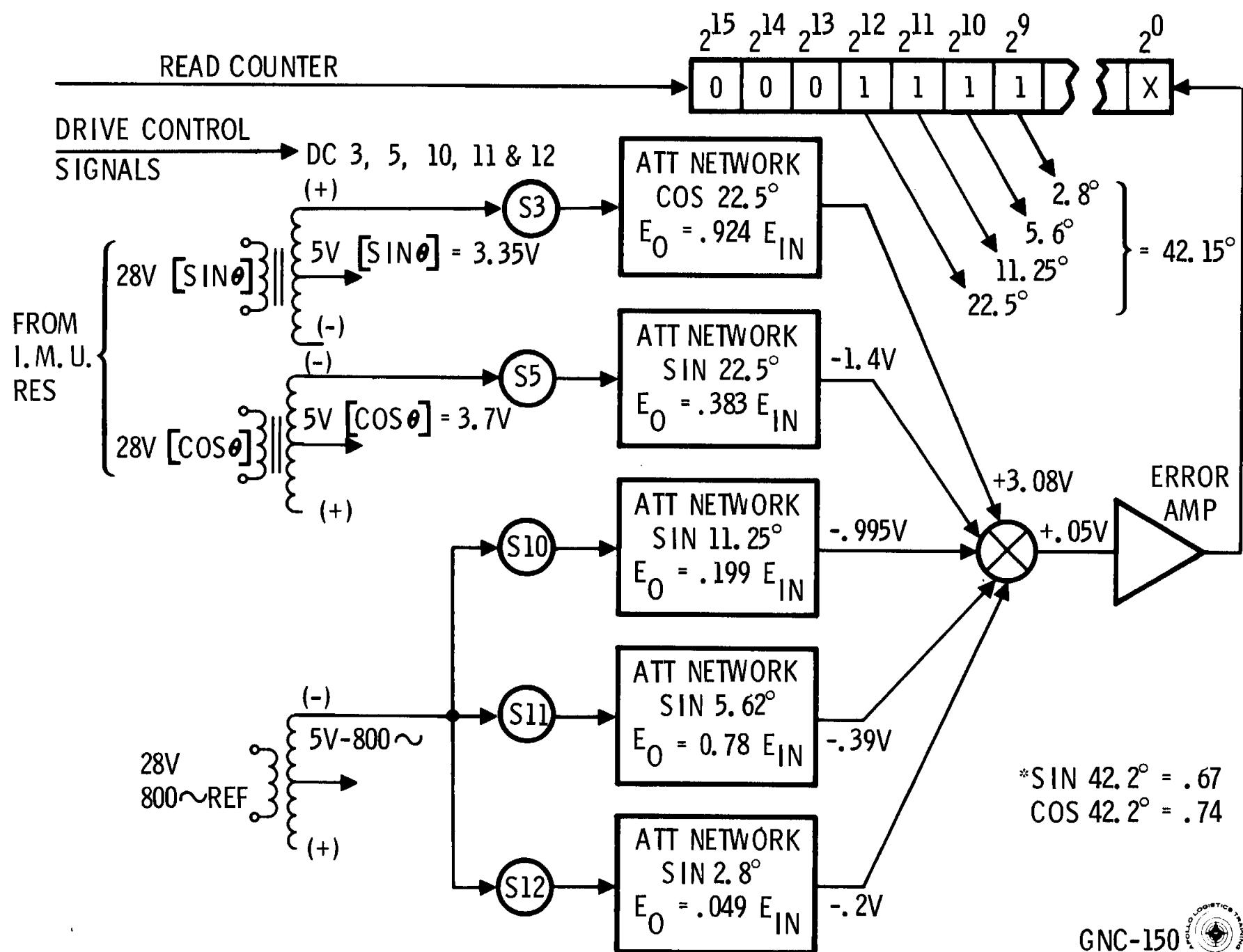


GNC-149

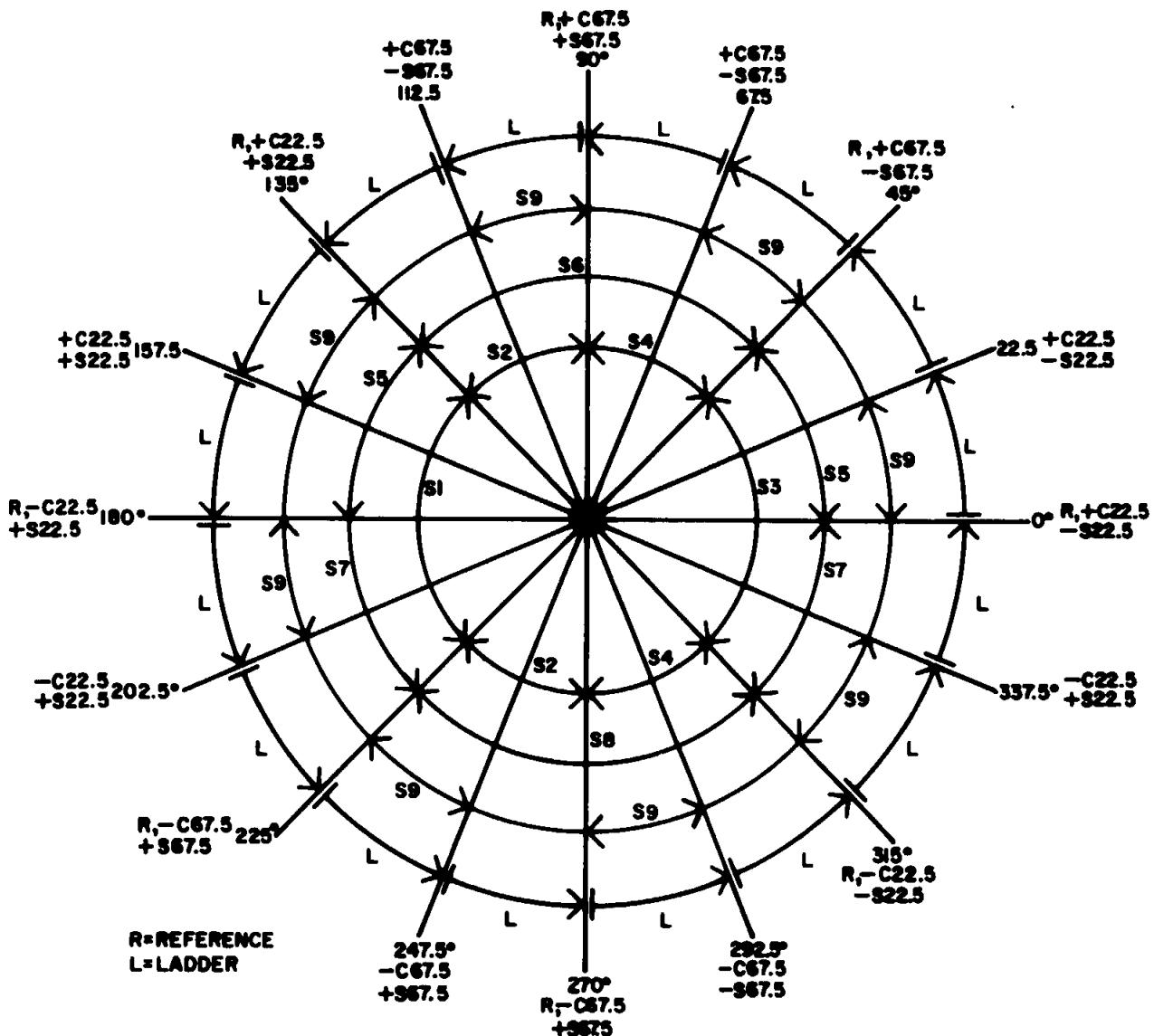


cmu

$$\theta = 42.2^\circ$$



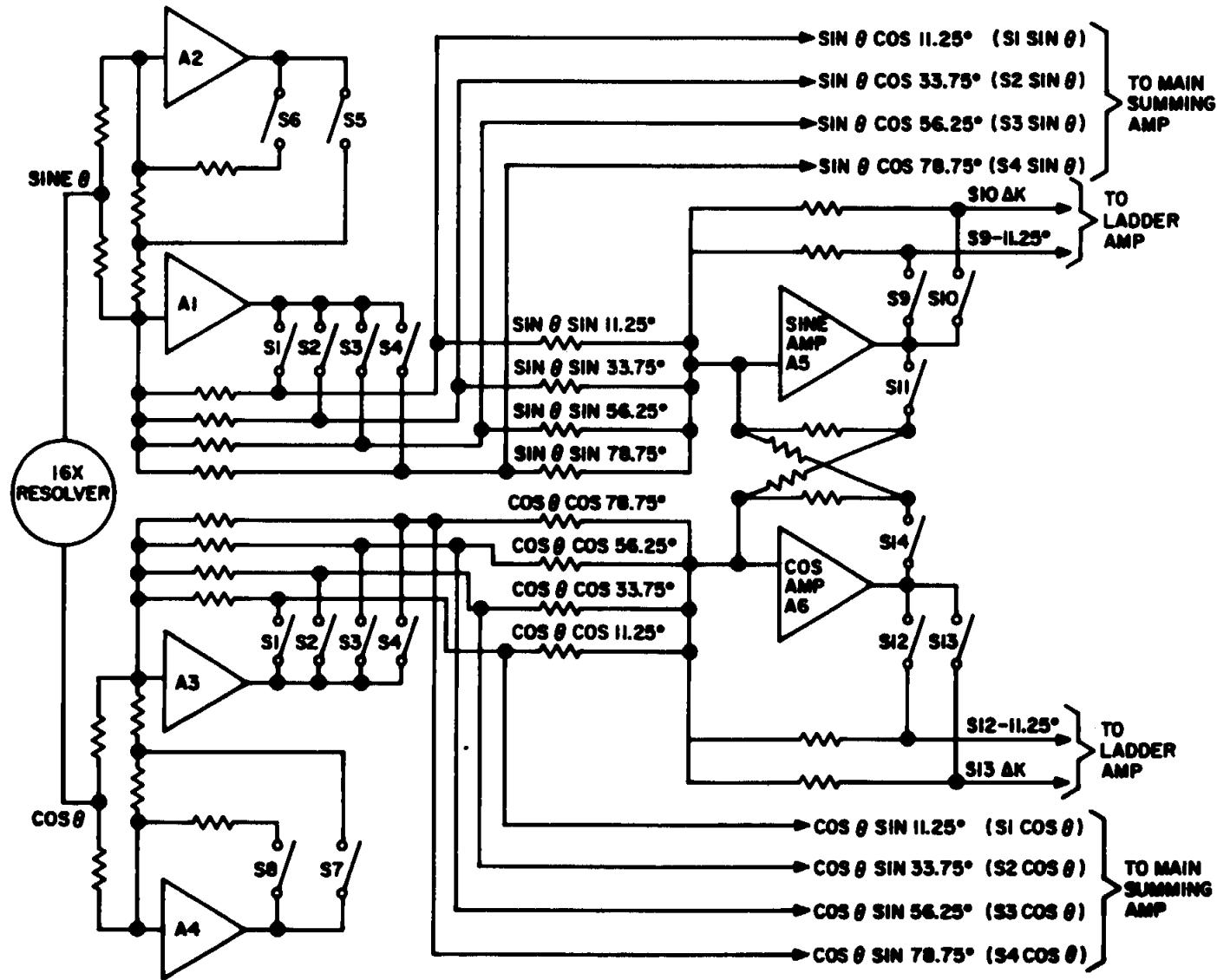
COARSE SWITCHING DIAGRAM



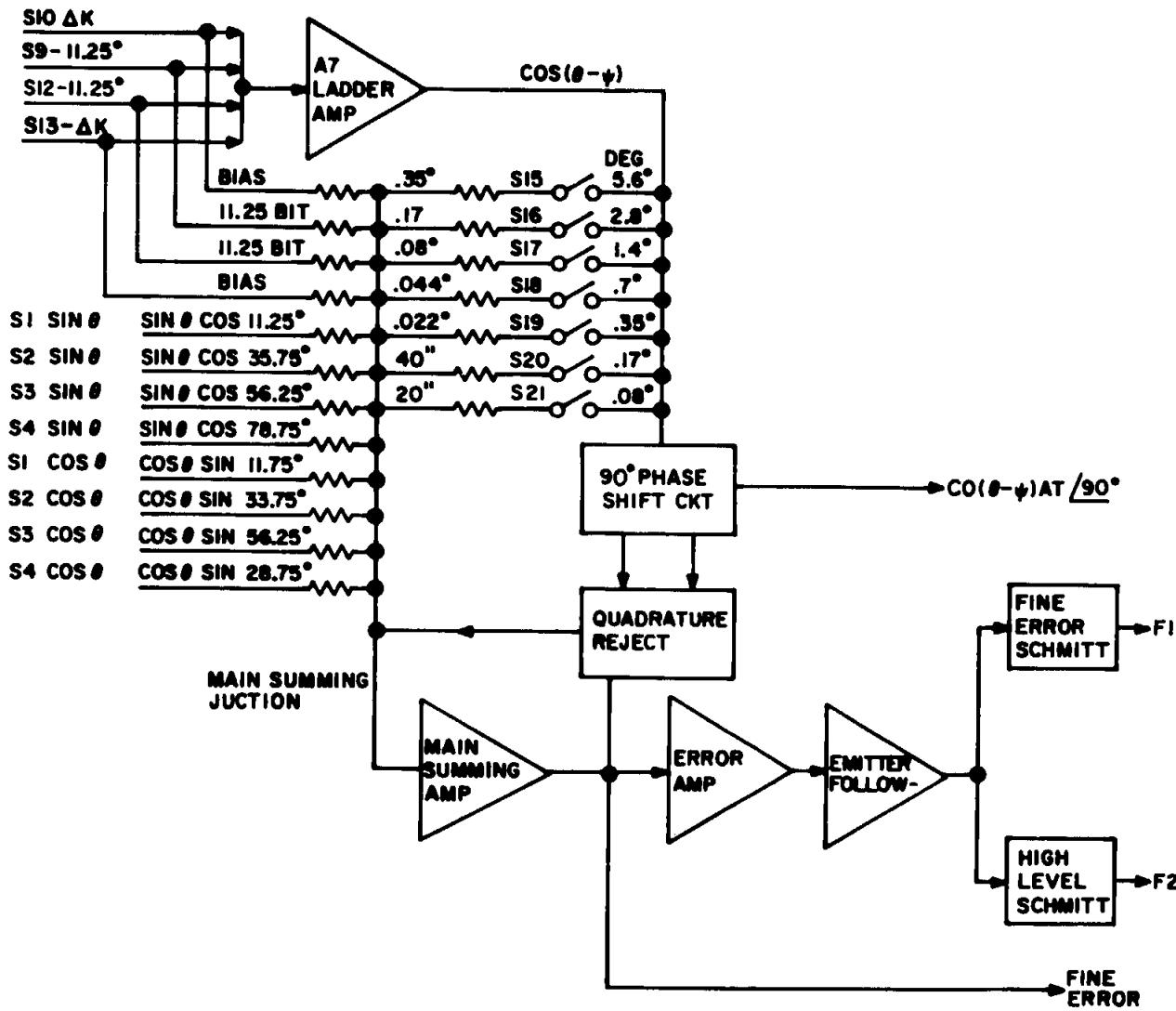
GNC-113

CIV

QUADRANT SELECT MODULE BLOCK DIAGRAM



MAIN SUMMING AMPLIFIER QUADRATURE REJECT MODULE BLOCK DIAGRAM

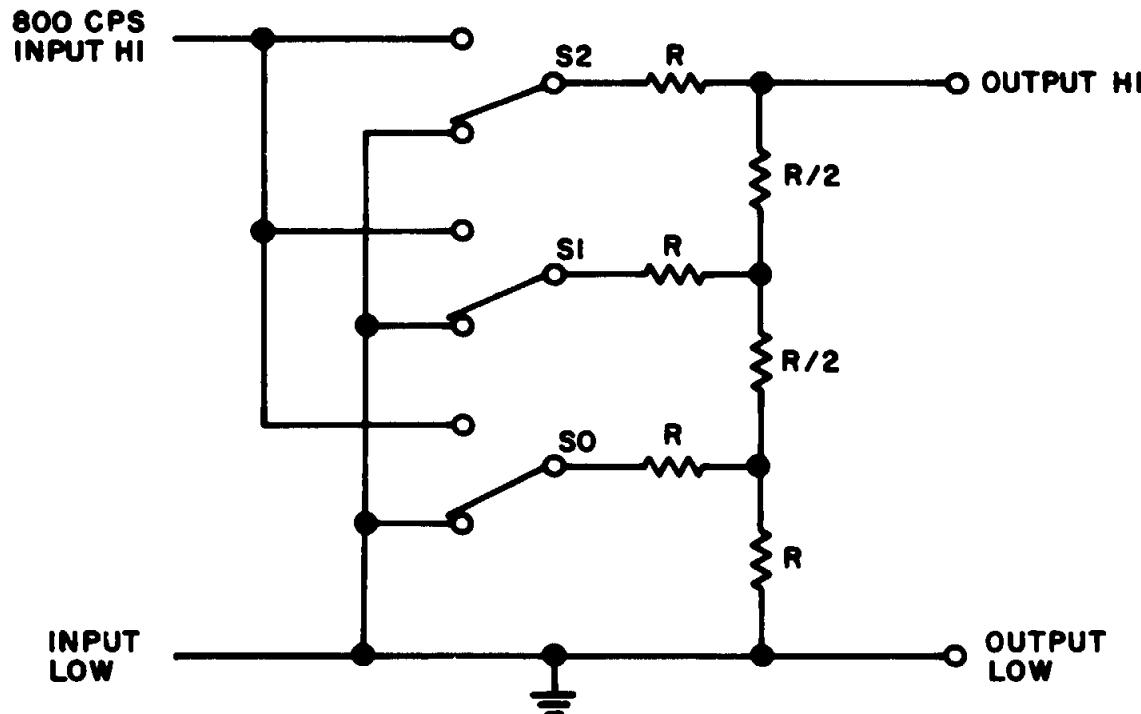


GNC-116

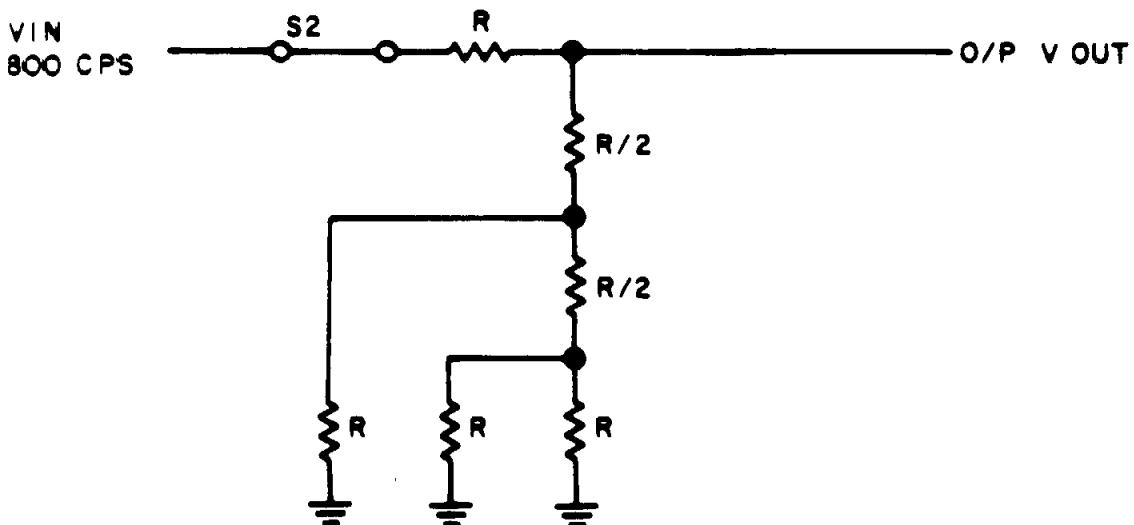


CDU

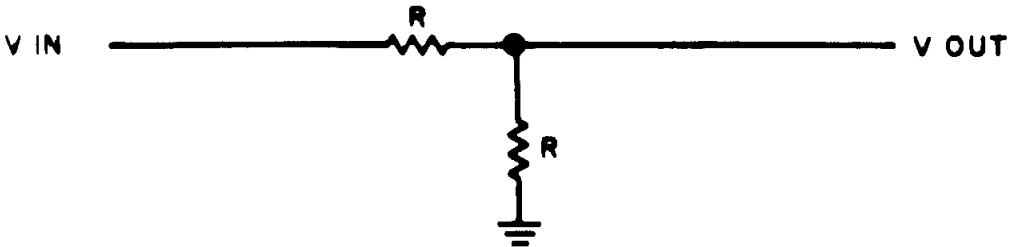
LADDER DECODER-SIMPLIFIED



LADDER CIRCUIT WITH S2 CLOSED



(A) CIRCUIT WHEN S_2 ONLY CLOSED

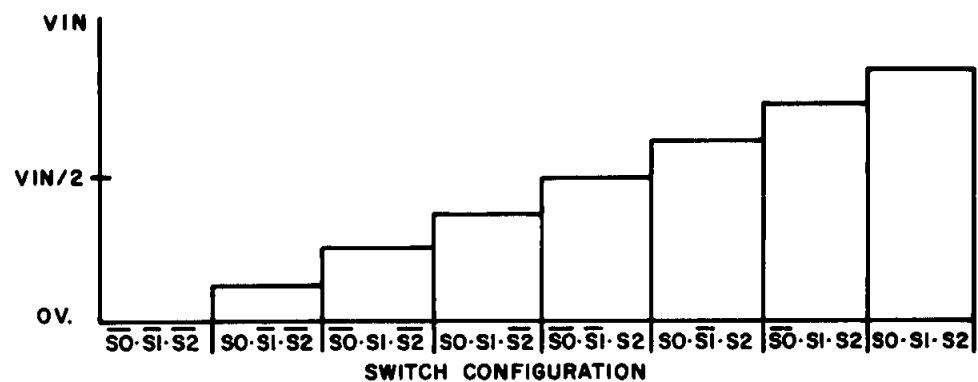


(B) EQUIVALENT CIRCUIT

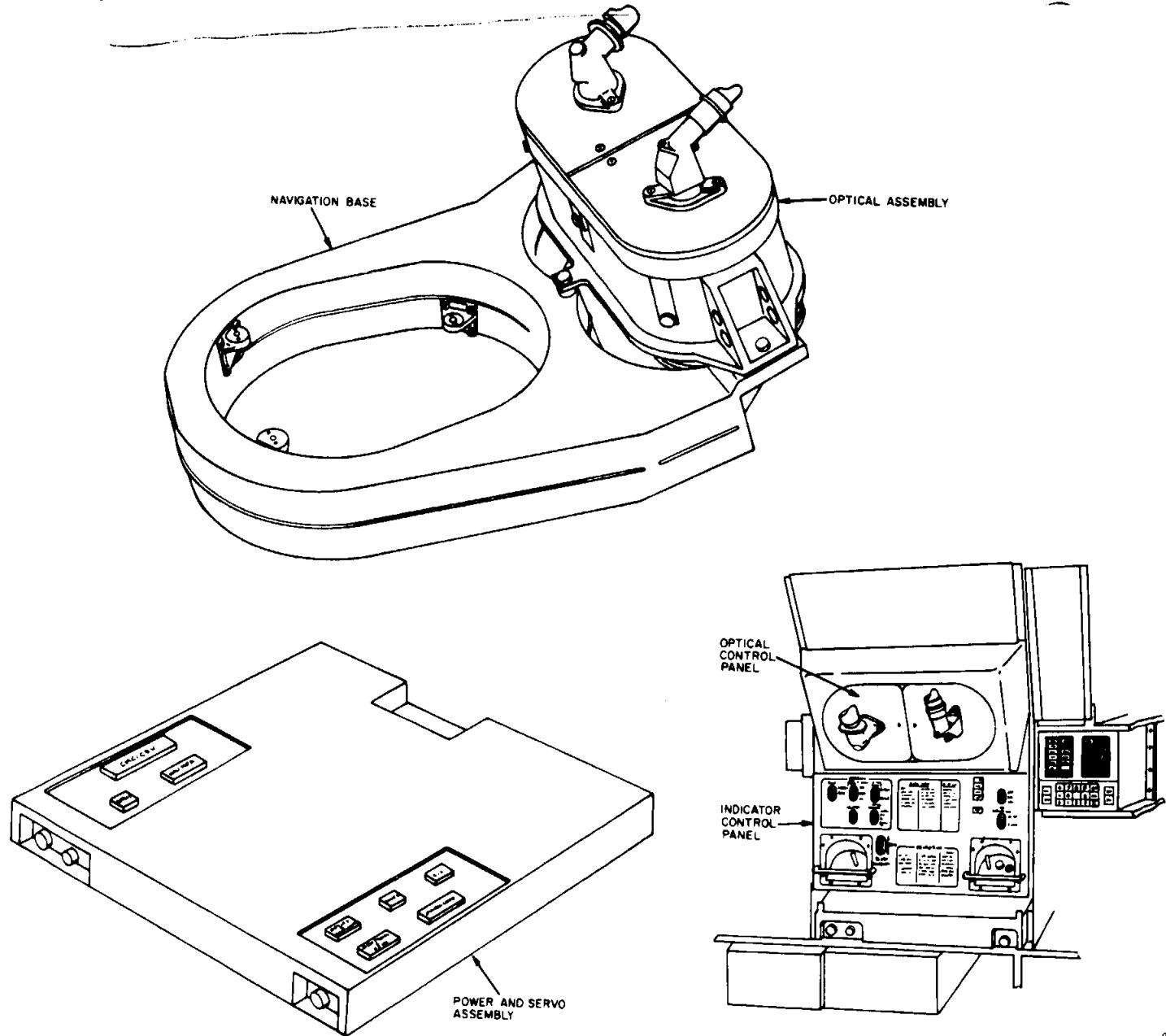
LADDER OUTPUT VOLTAGE

| S0 | S1 | S2 | V OUT |
|----|----|----|---------|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | VIN/8 |
| 0 | 1 | 0 | VIN/4 |
| 1 | 1 | 0 | 3/8 VIN |
| 0 | 0 | 1 | VIN/2 |
| 1 | 0 | 1 | 5/8 VIN |
| 0 | 1 | 1 | 3/4 VIN |
| 1 | 1 | 1 | 7/8 VIN |

Table 4-4. Ladder Decoder Truth Table



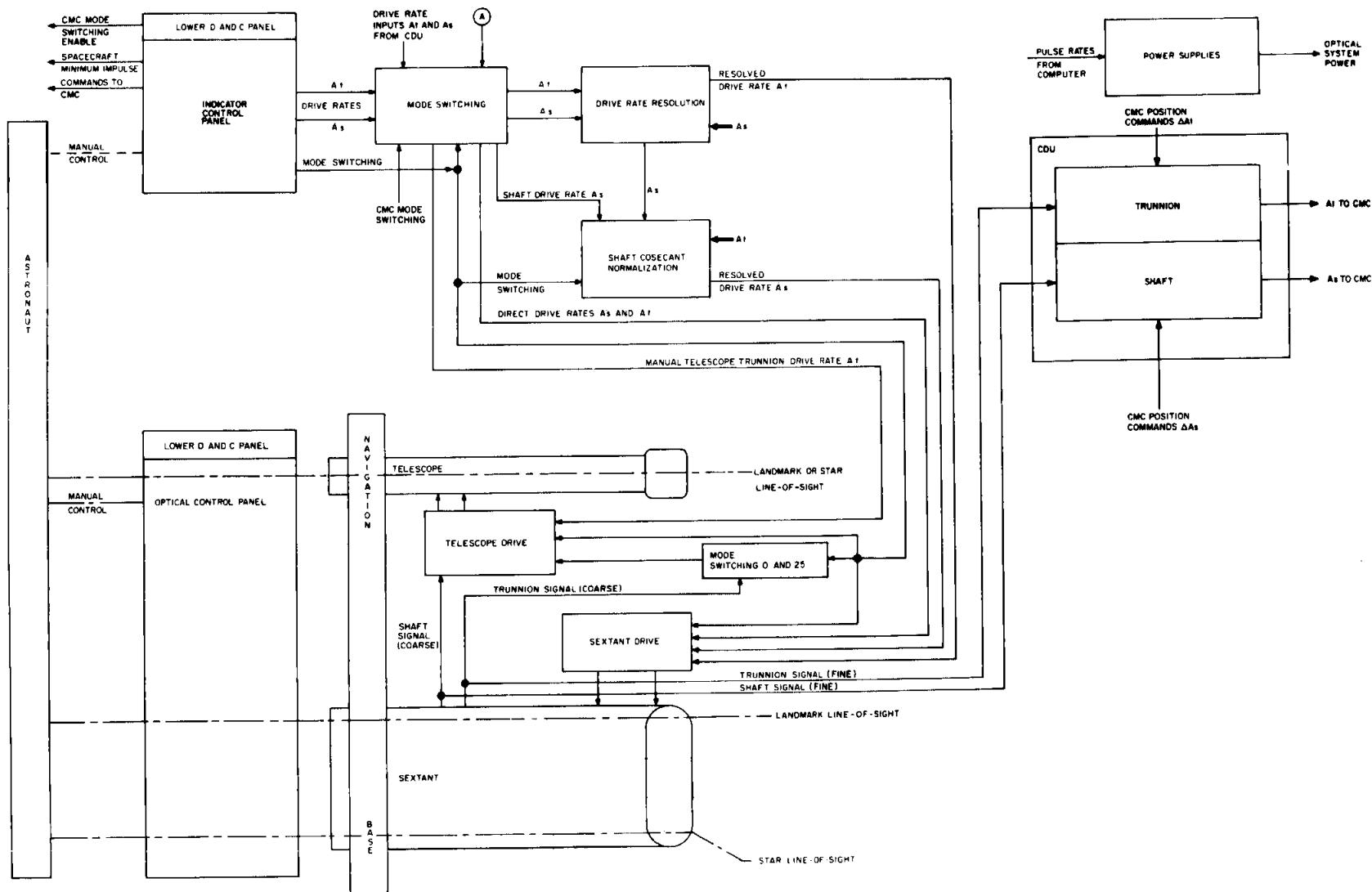
OPTICAL SUBSYSTEM EQUIPMENT



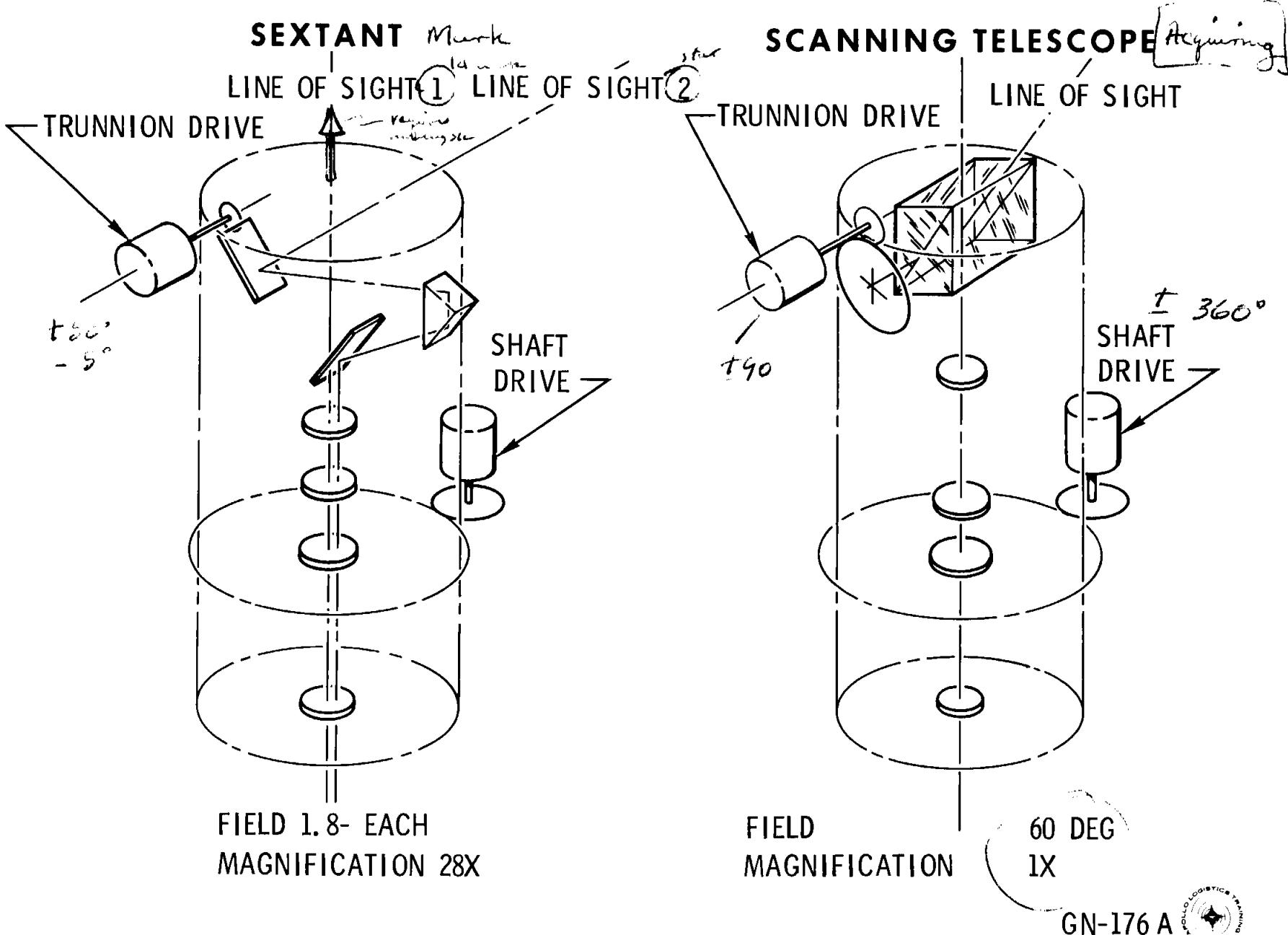
GNC-21



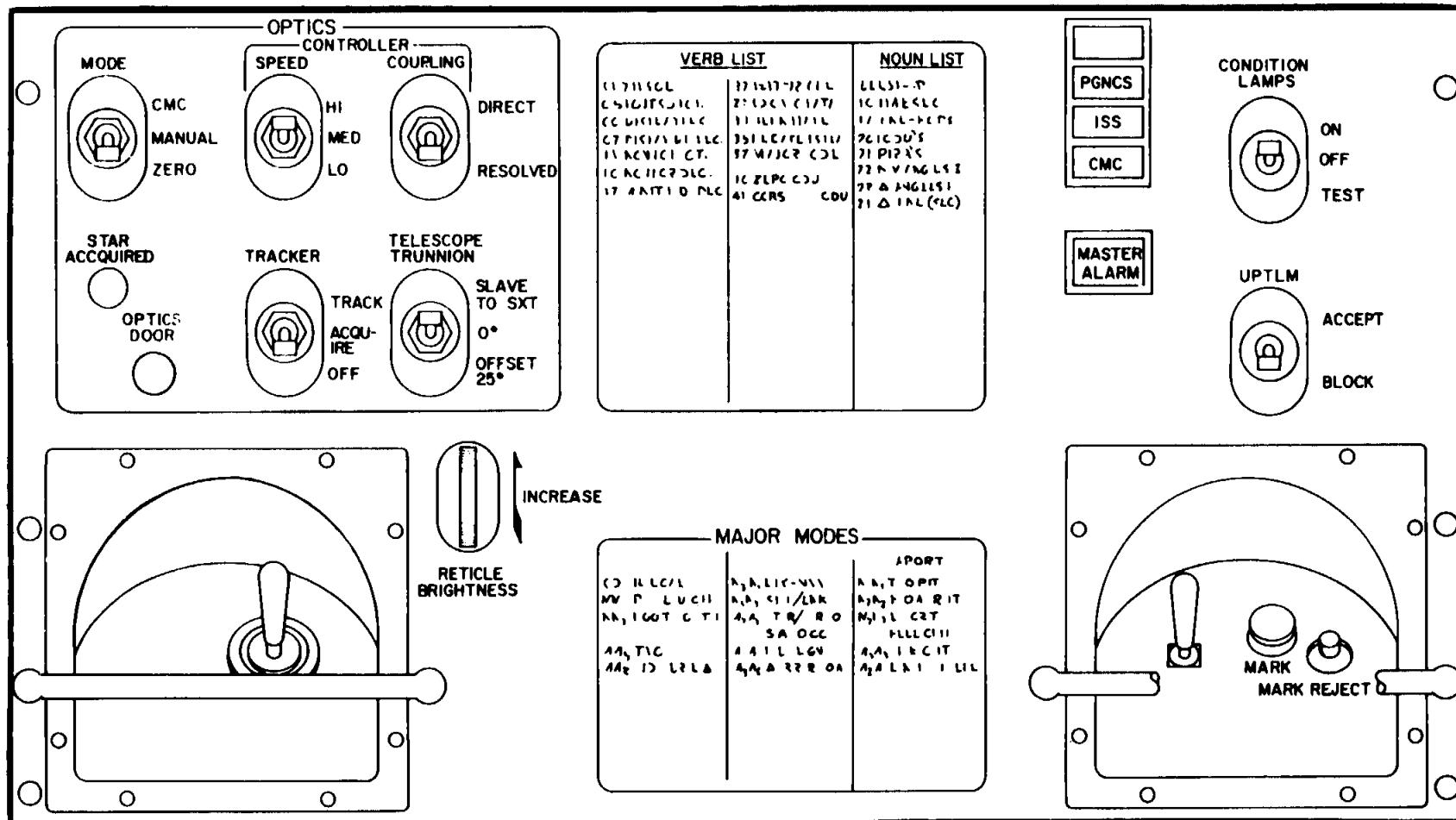
OPTICAL SUBSYSTEM INTERFACE



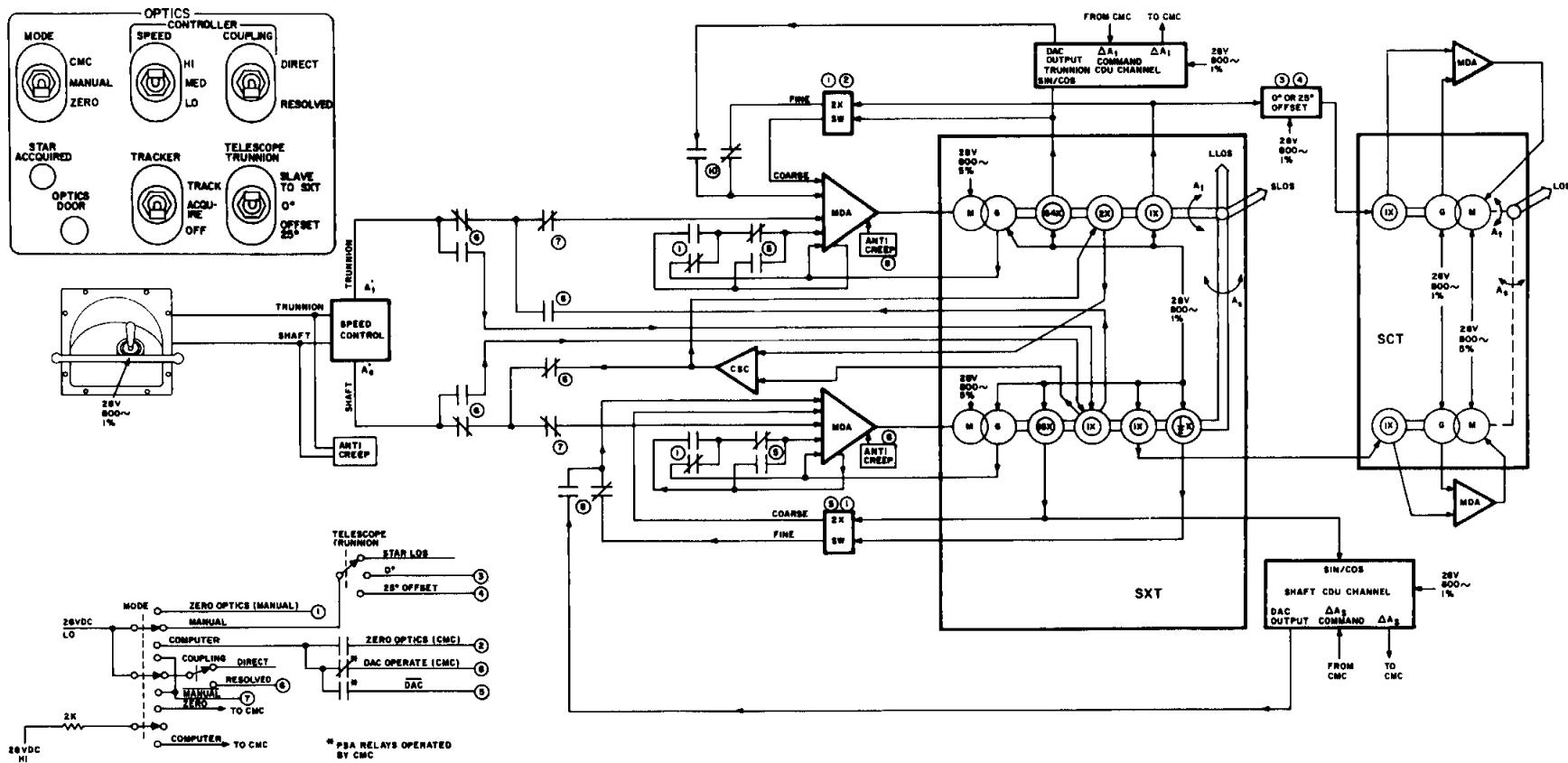
OPTICAL SCHEMATIC



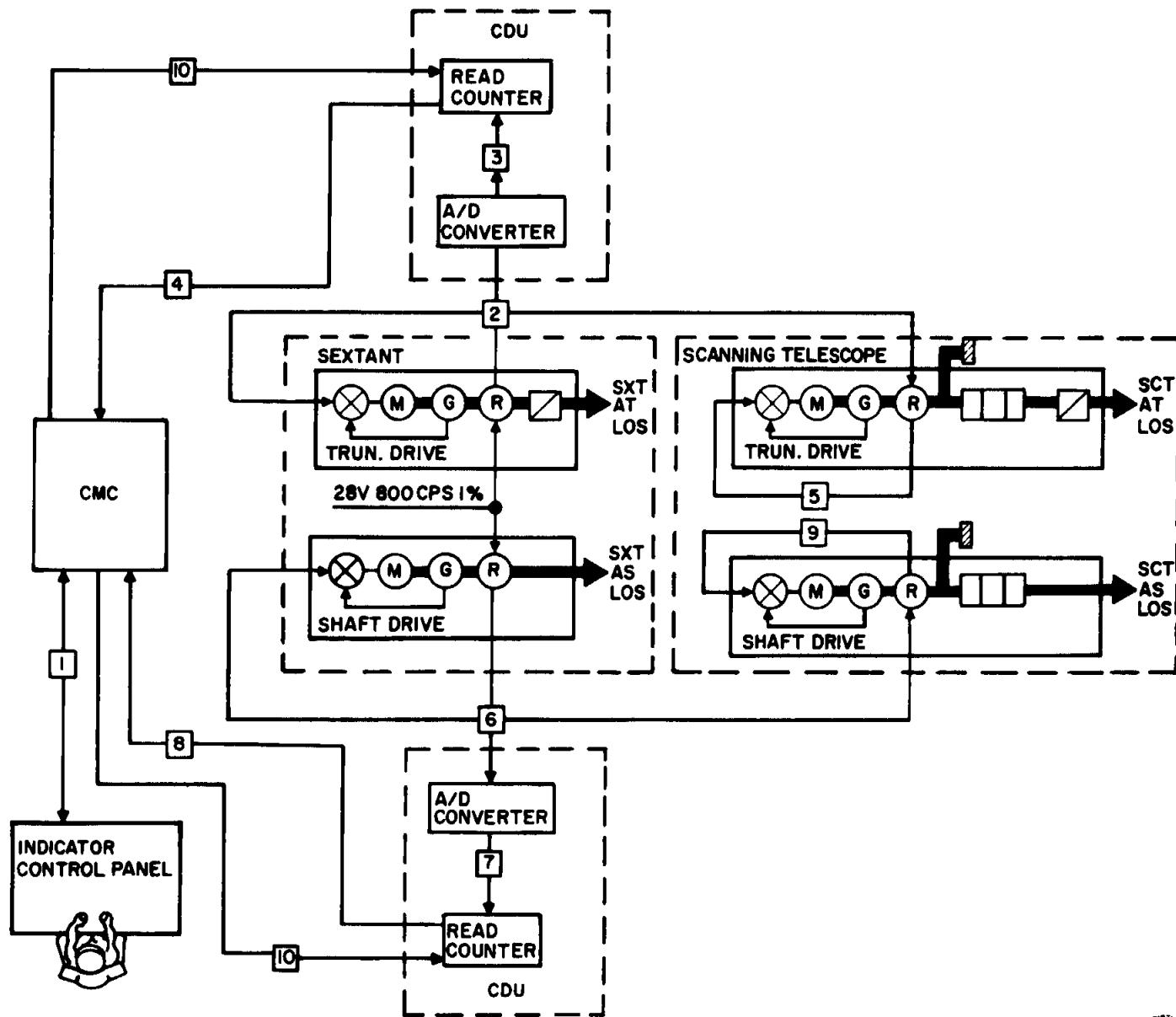
INDICATOR CONTROL PANEL



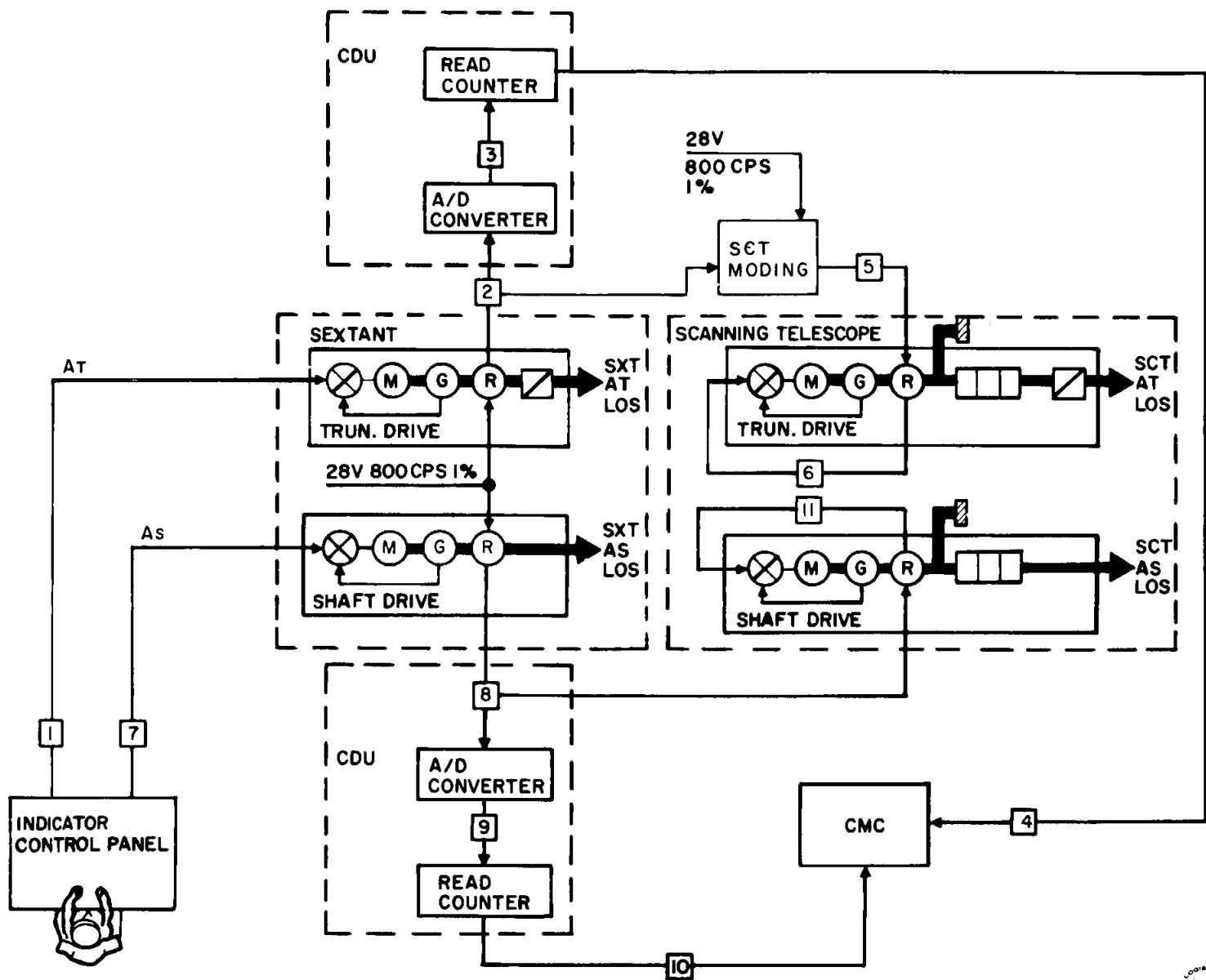
OPTICS MECHANIZATION



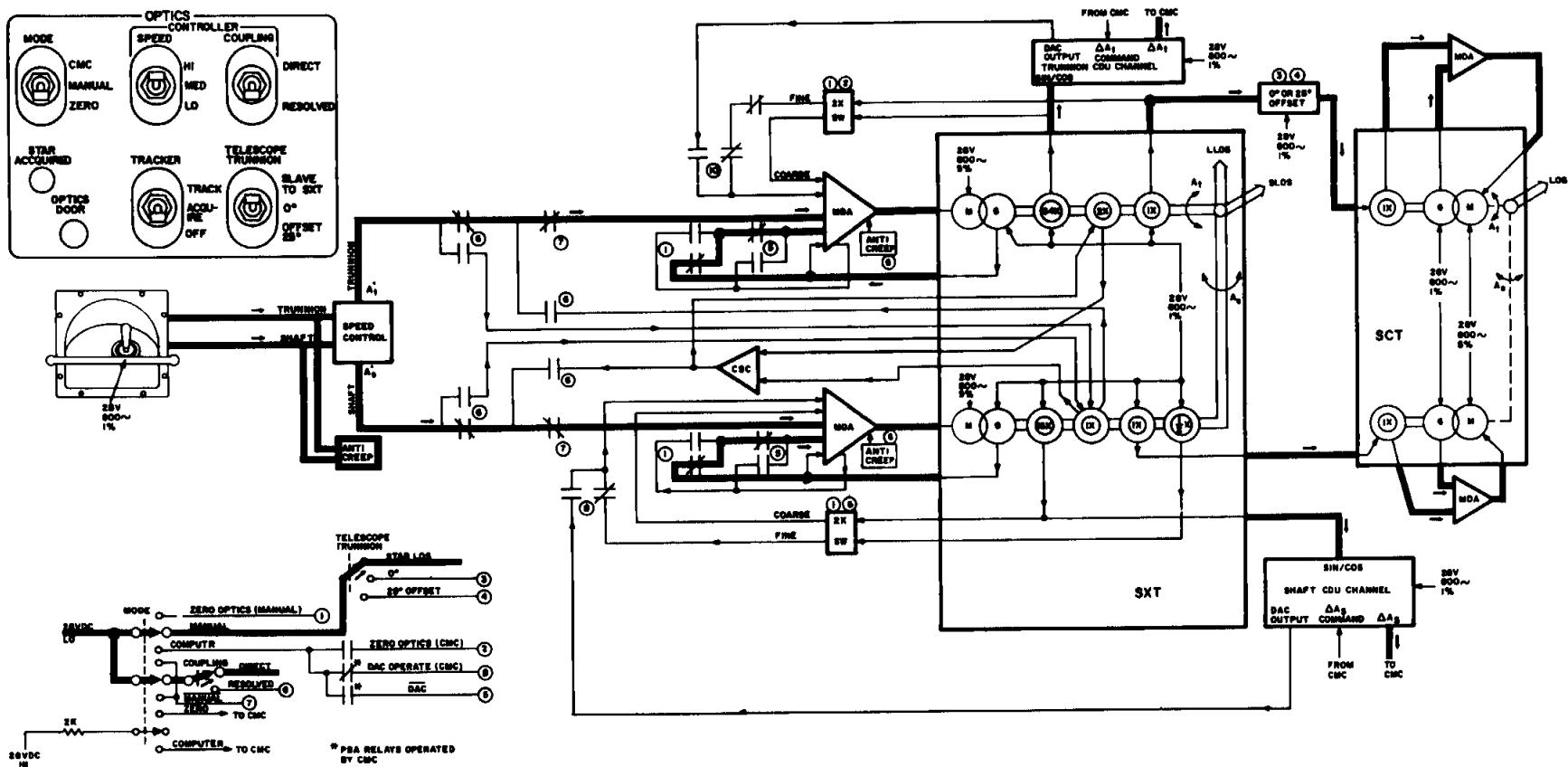
ZERO OPTICS MODE



MANUAL DIRECT MODE



MANUAL DIRECT MODE

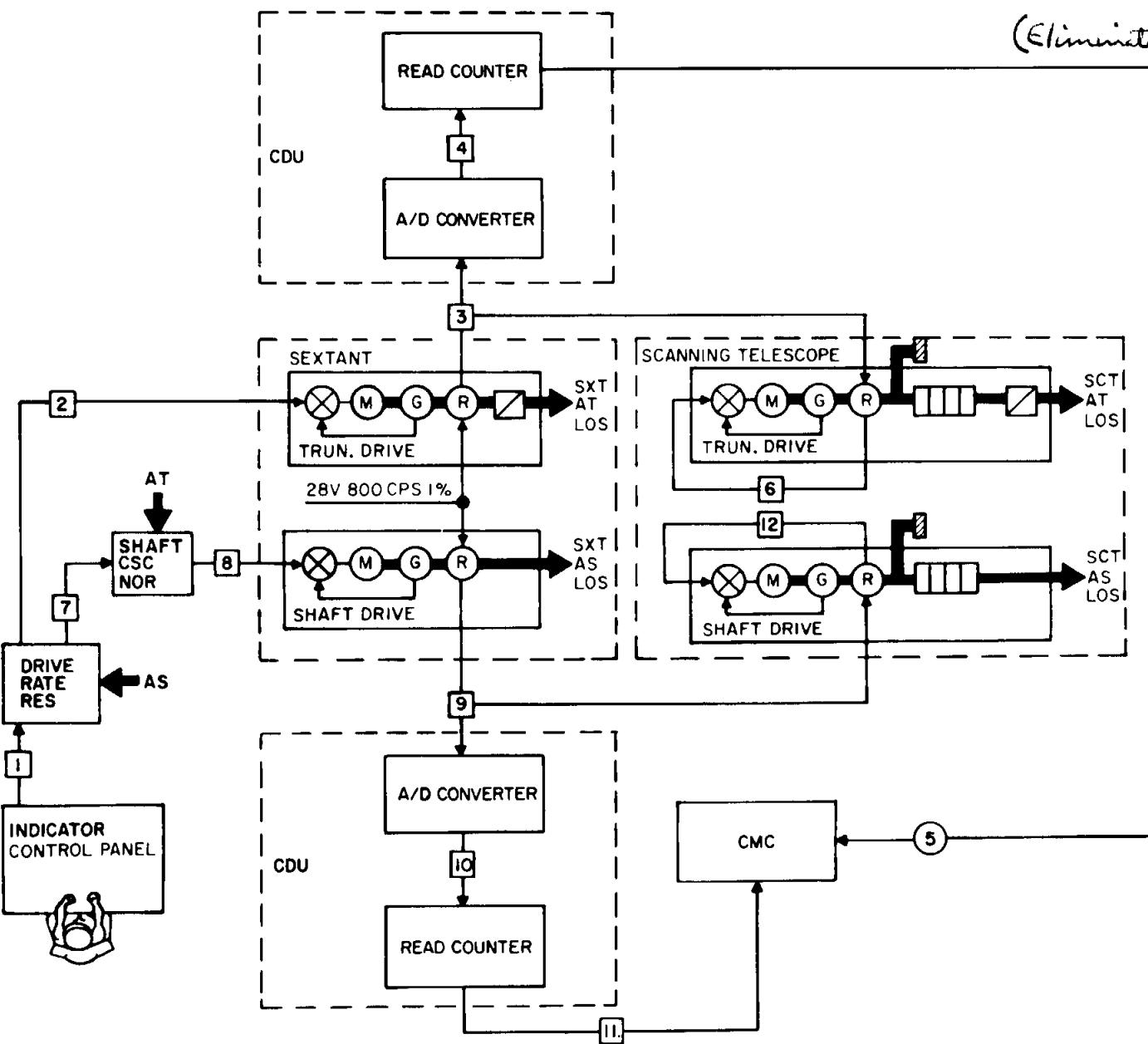


GNC-131A

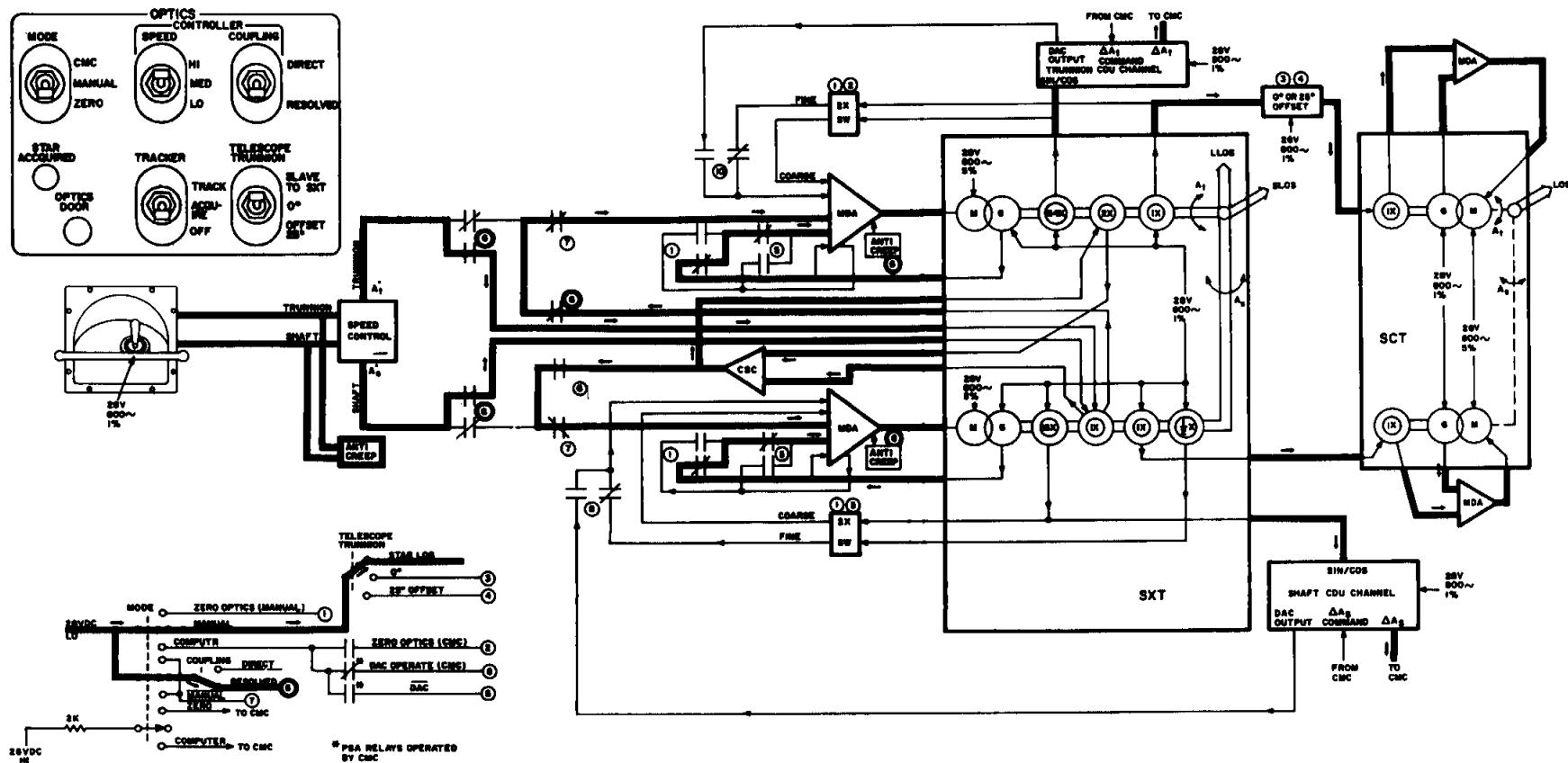


MANUAL RESOLVED MODE

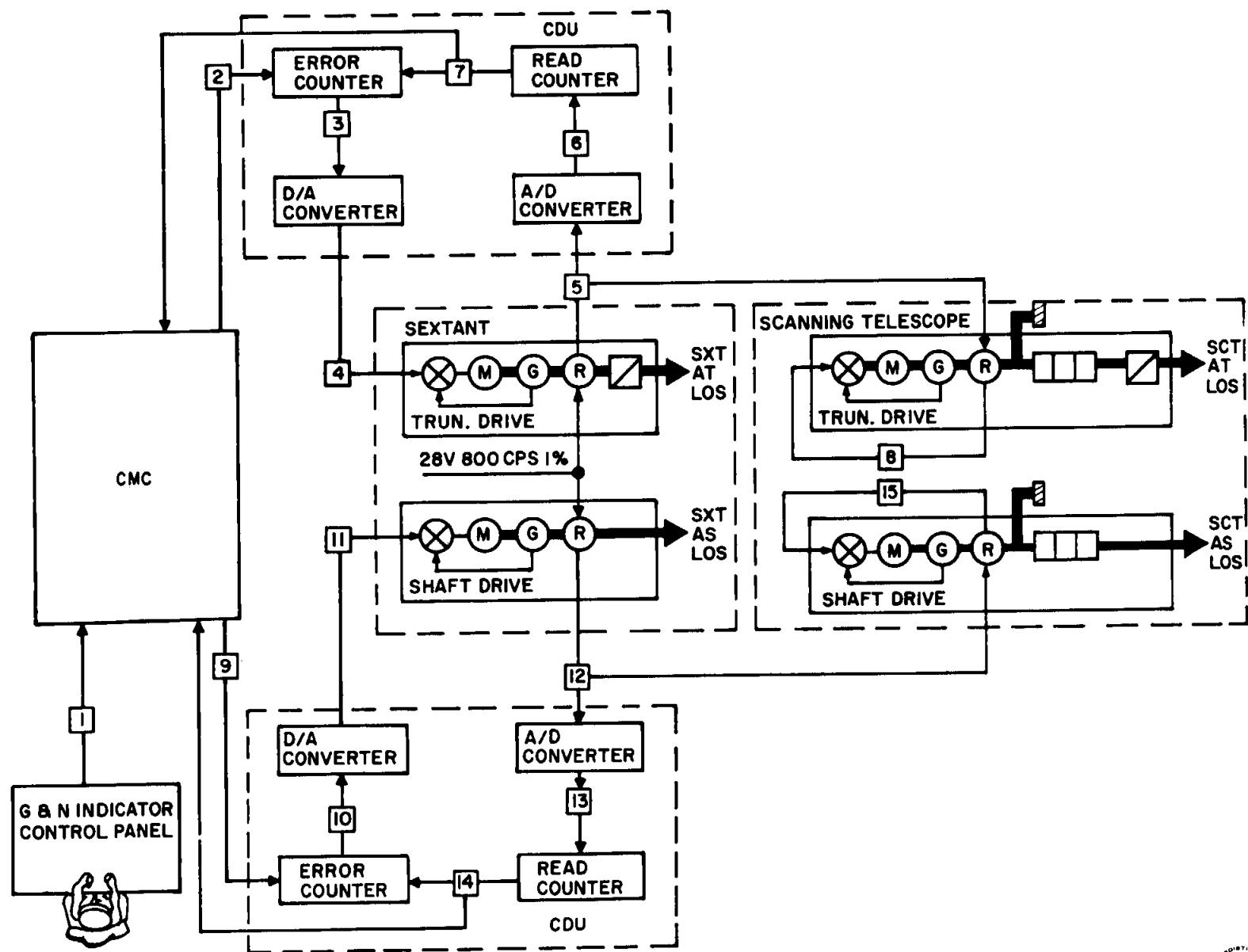
Object moves wrt
viewer
(Eliminates shift angle)



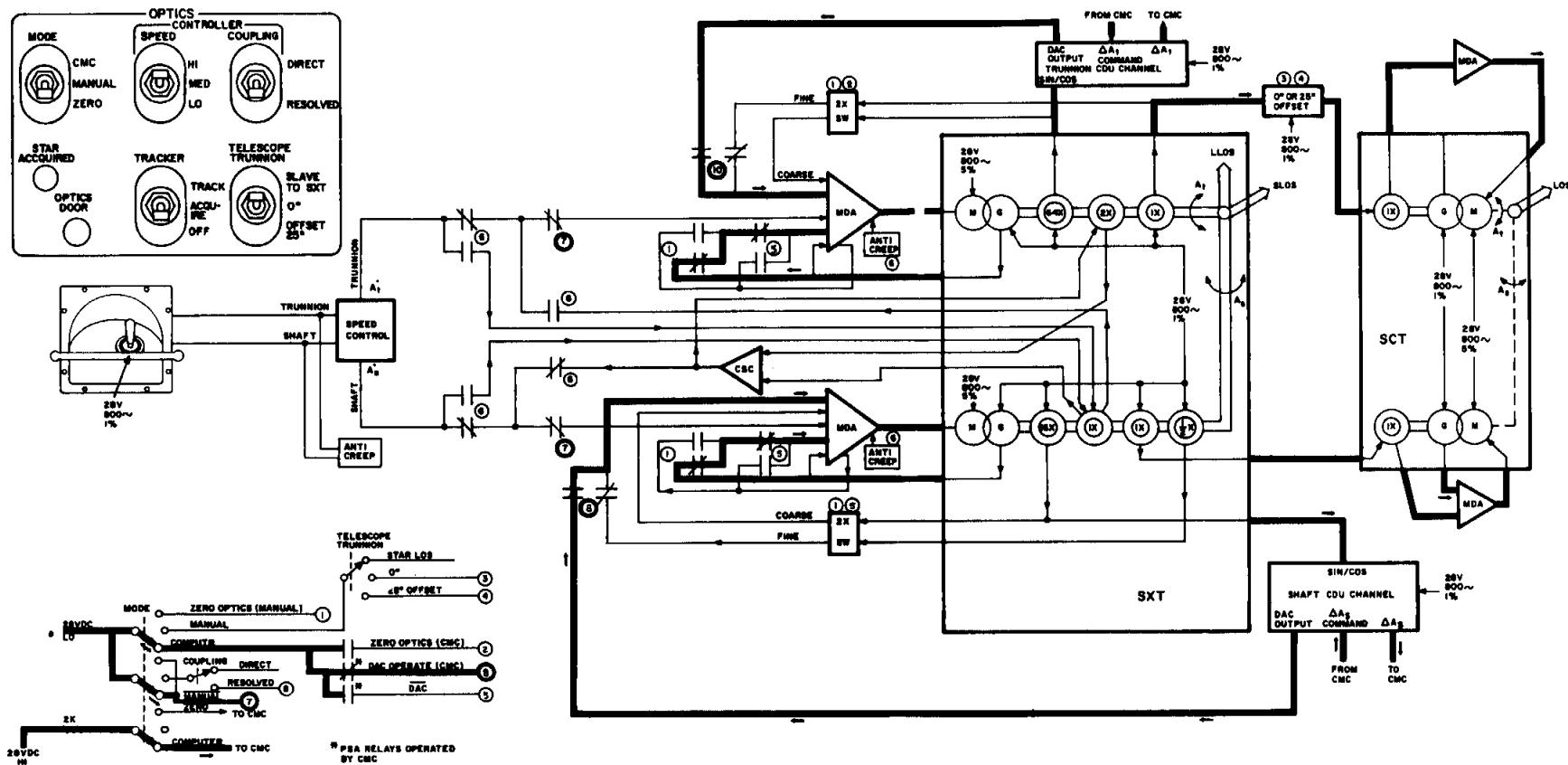
MANUAL RESOLVED MODE



COMPUTER MODE



COMPUTER MODE

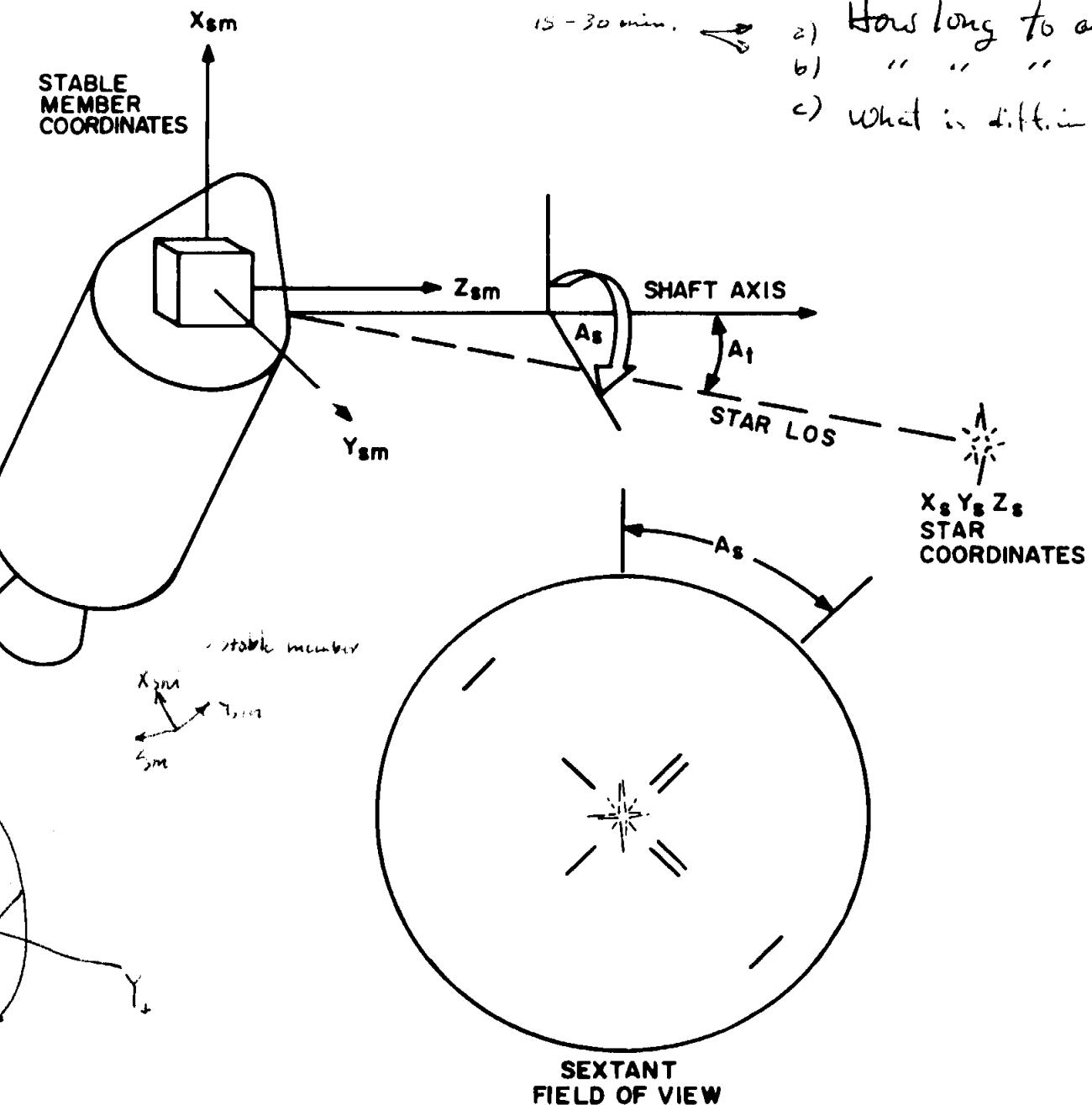


Al Sohler { Instructors (NNA)
Martin Murray }

Program 21

IMU ALIGNMENT MEASUREMENT

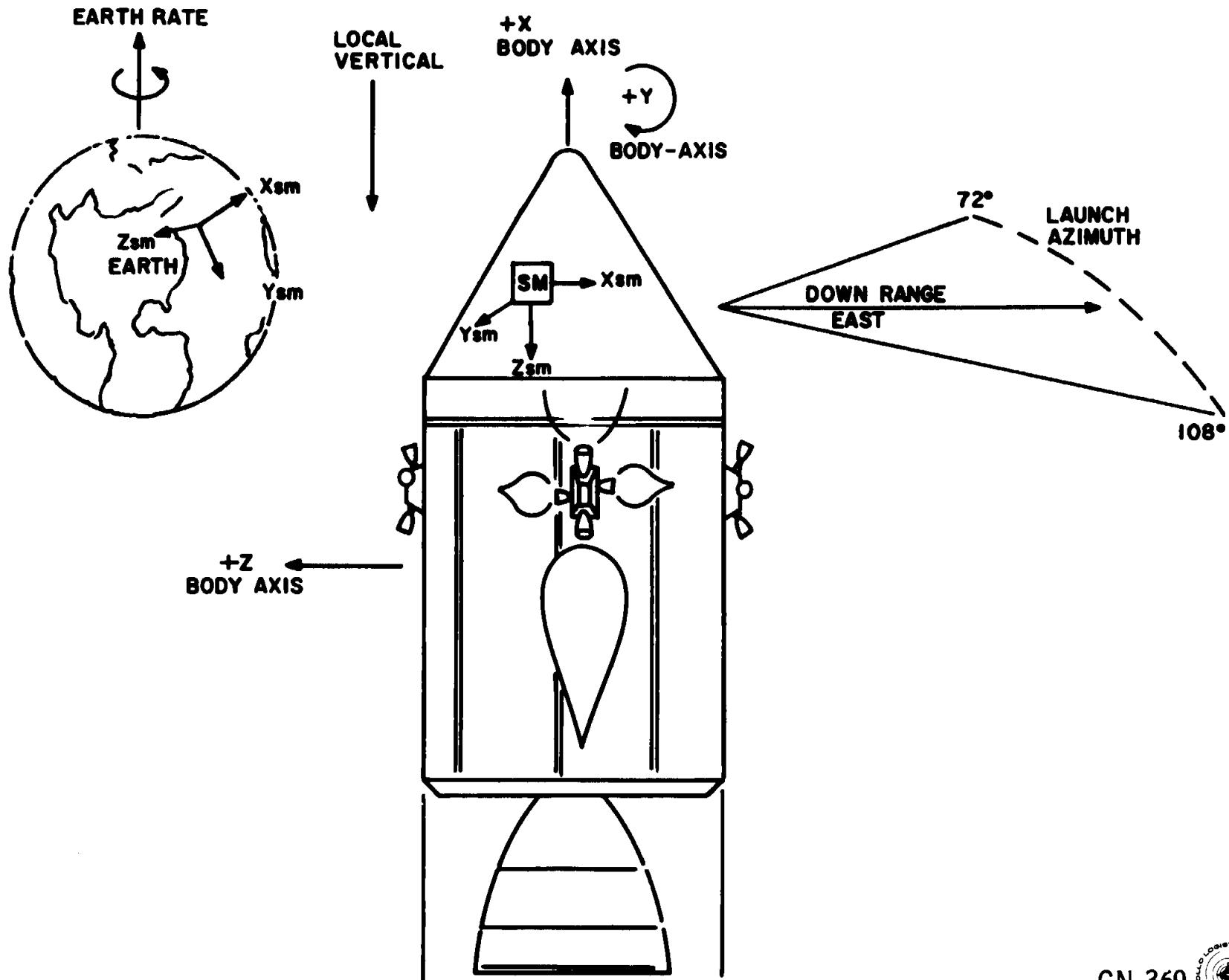
1. POS



GN-9100B



PRELAUNCH ALIGNMENT

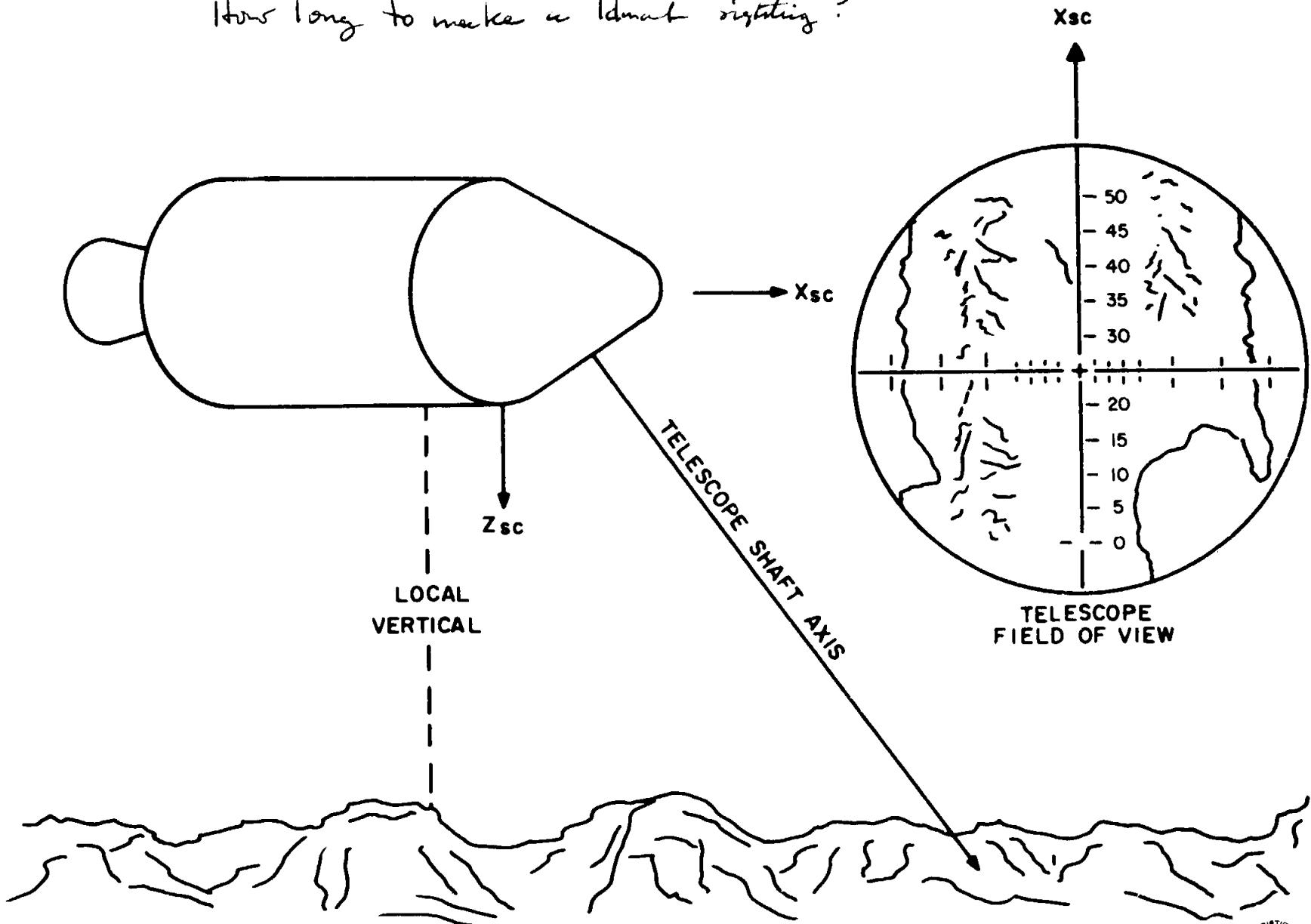


To Update State Vector

Program 21
22

ORBITAL NAVIGATION SIGHTING

How long to make a Idmat sighting?

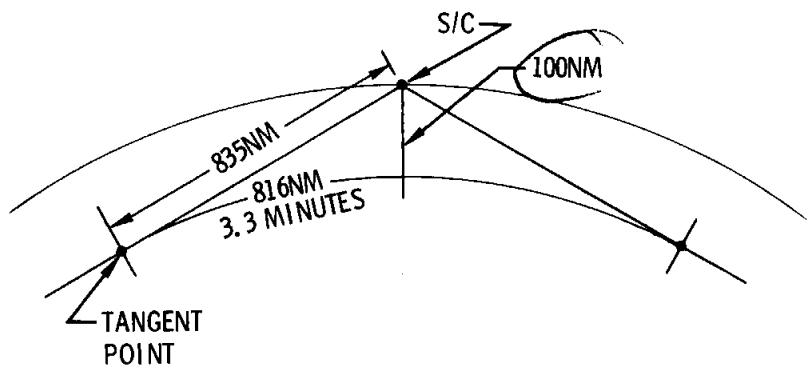


GN-9102B

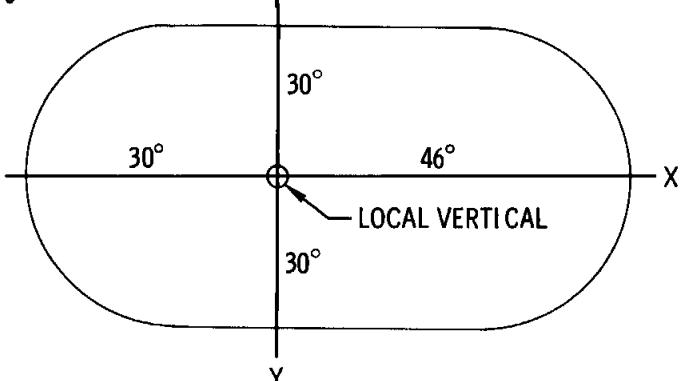


EARTH ORBIT NAVIGATION

How do you get valid update data from an unknown landmark



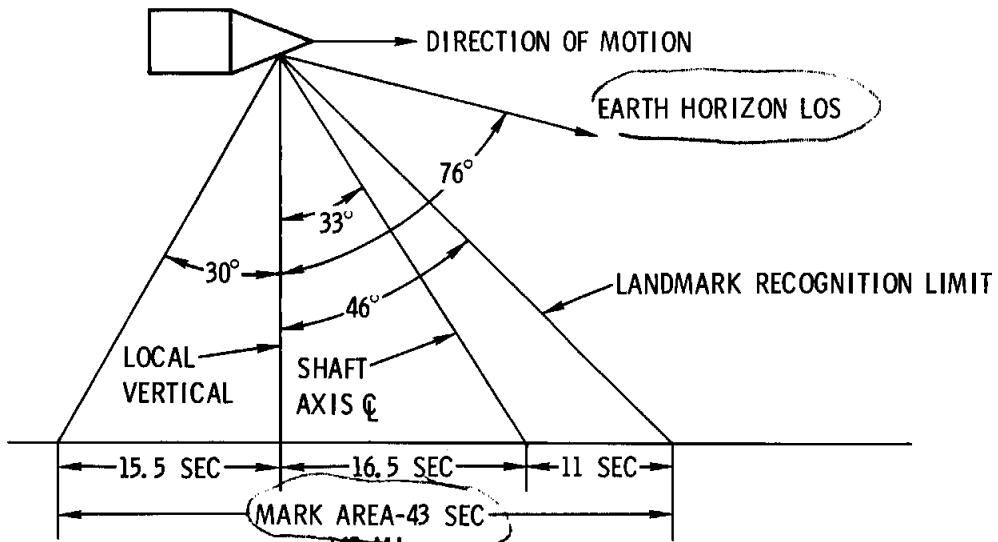
EARTH ORBIT GEOMETRY FIGURE 1



VIEW ON SURFACE FIGURE 3

- R1 ΔP_{os} (nm) 1000
- R2 ΔV (ft/sec) 5 ft/sec
- R3 00135

1 processing 3rd marker



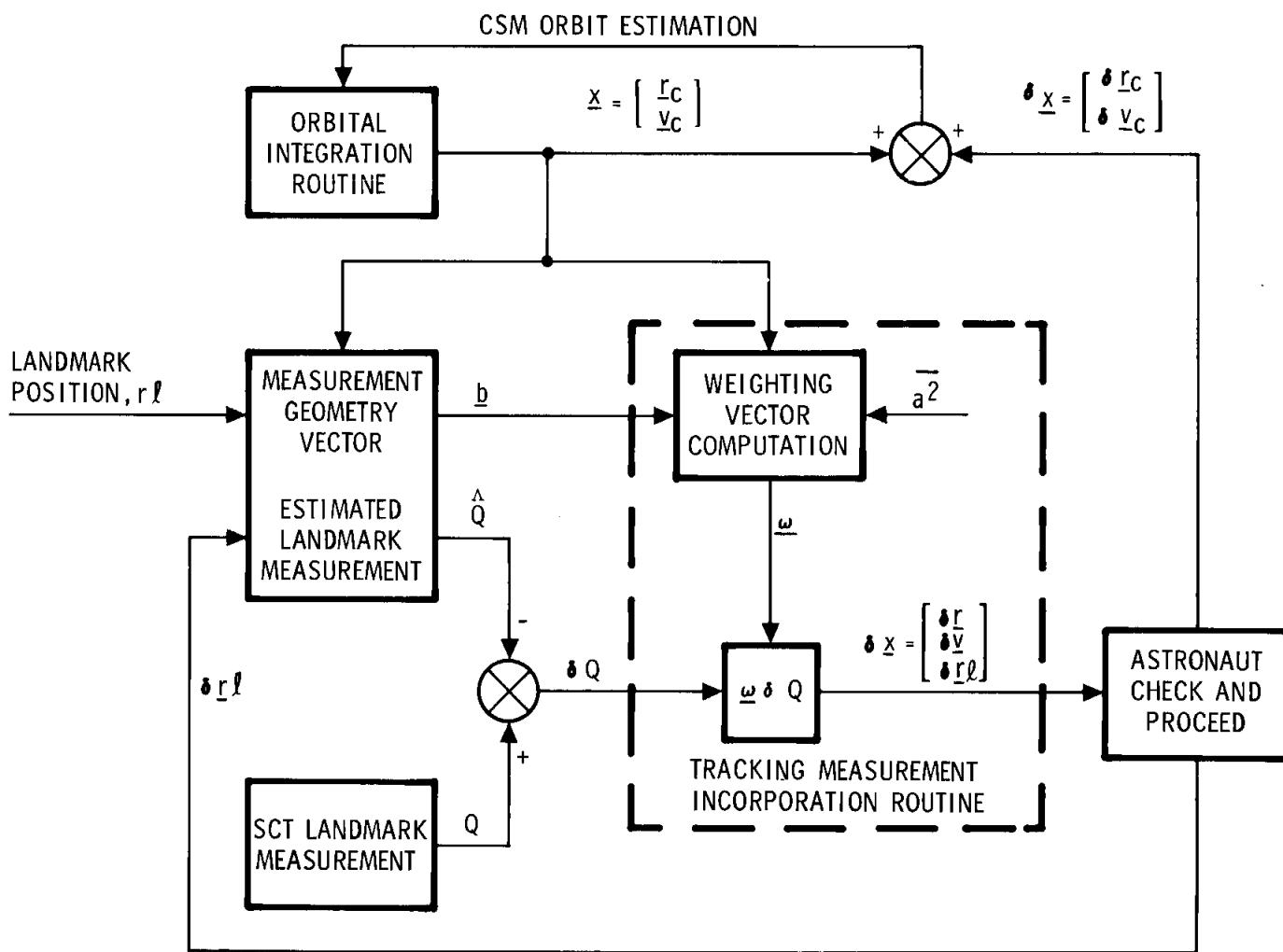
COVERAGE ON SURFACE FIGURE 2

Would like to have 5 sightings
(in 43 sec?)

GN-183A



SIMPLIFIED ORBITAL NAVIGATION FUNCTIONAL DIAGRAM

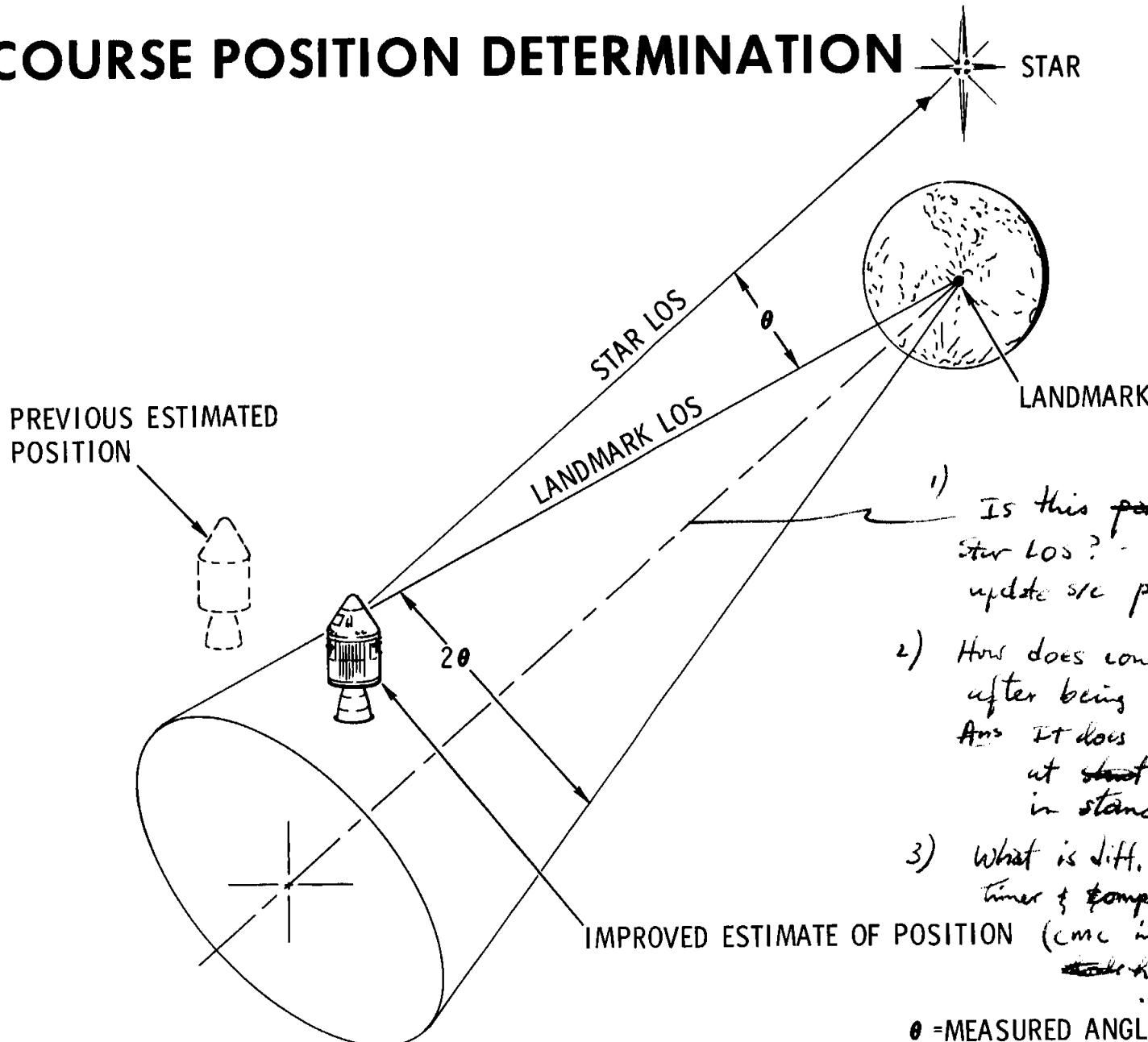


GNC-165



MIDCOURSE POSITION DETERMINATION

Program 23



IMPROVED ESTIMATE OF POSITION

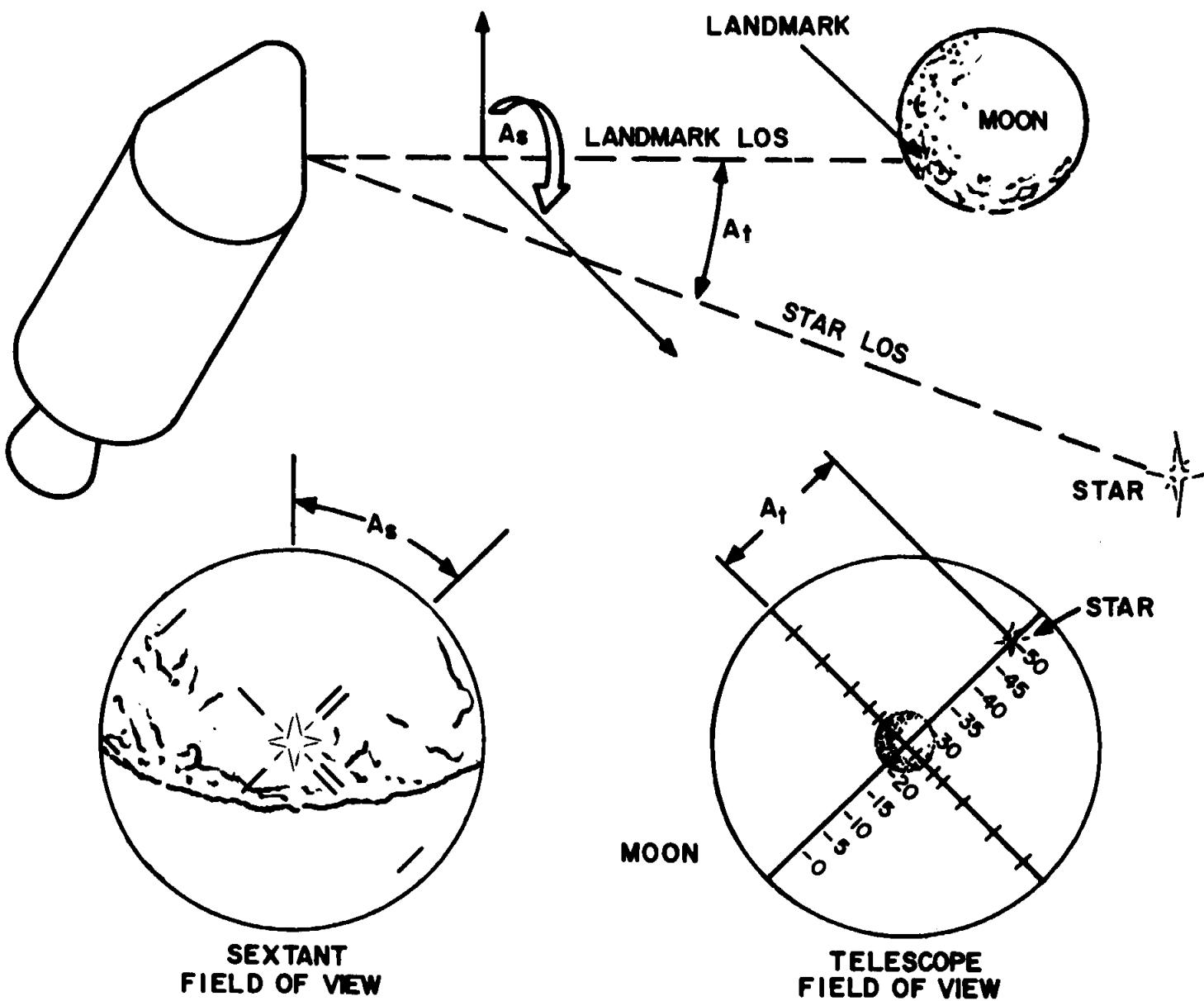
(cmc in standby can only
hold up to 13 hr
... it then comes
up)

θ = MEASURED ANGLE

GN-9101A



NAVIGATIONAL MEASUREMENT



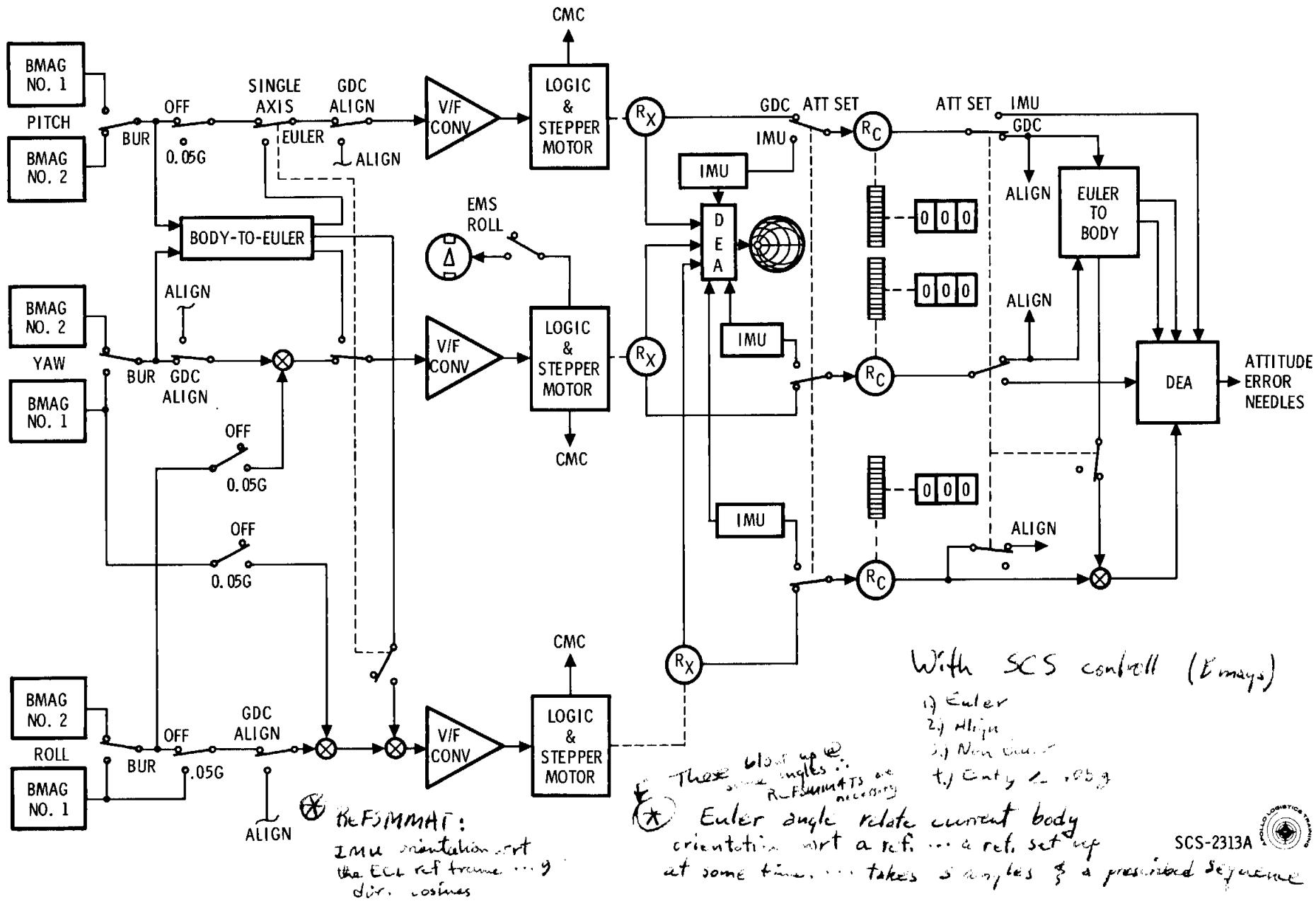
GN-9103B



ATTITUDE REFERENCE SUBSYSTEM

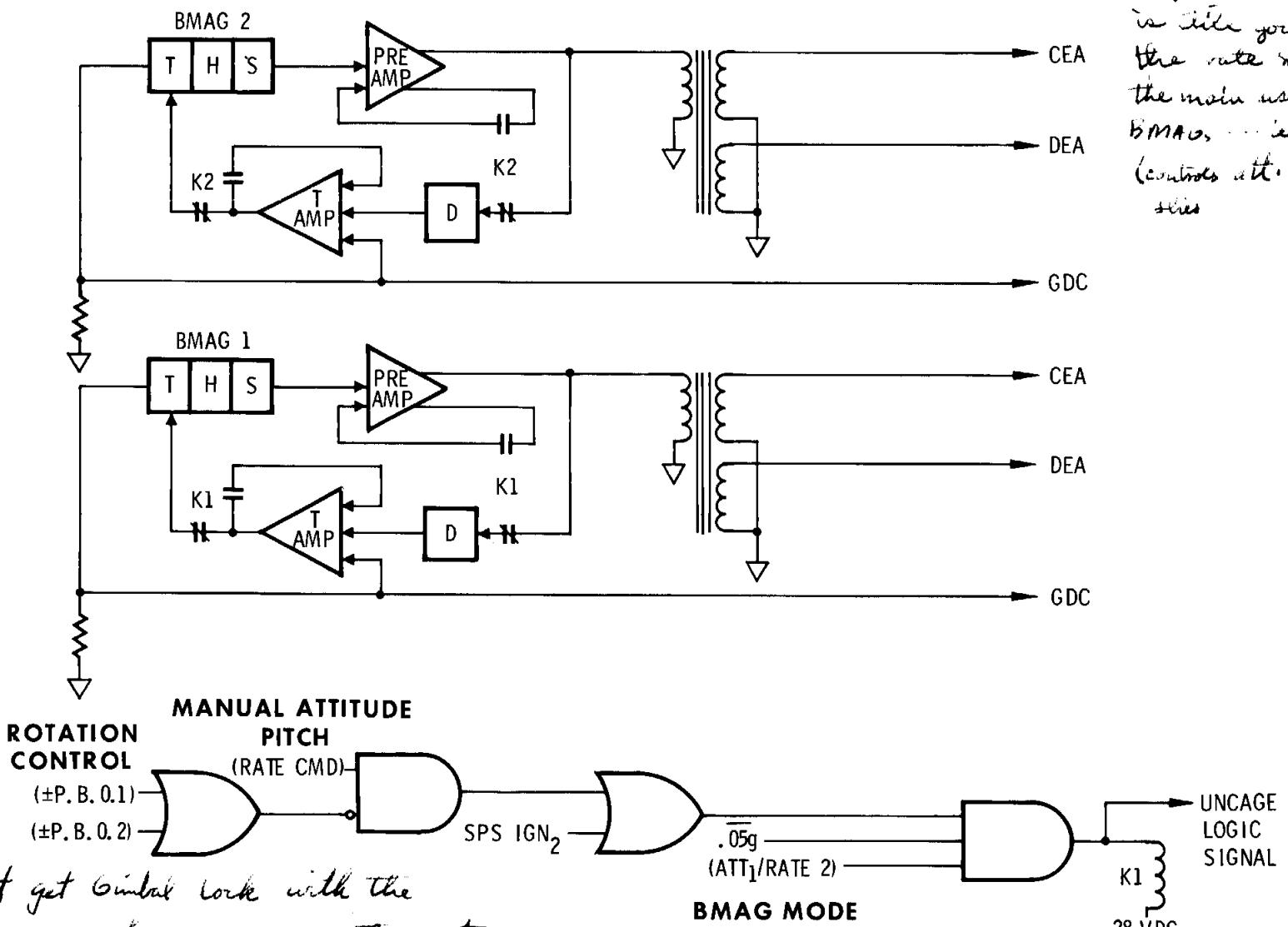
SCS

FUNCTIONAL OPERATION



(*) Temp. limit of $170^{\circ} \pm 1^{\circ}$ on BMAGs
 If temp goes up to 115° the att. motor
 goes to pos, but
 the rate meas.
 is still good. Also
 the rate signal is
 the main use of the
 BMAGs, i.e. MTVL
 controls att. while con-
 trols

PITCH BMAG LOGIC AND OUTPUTS



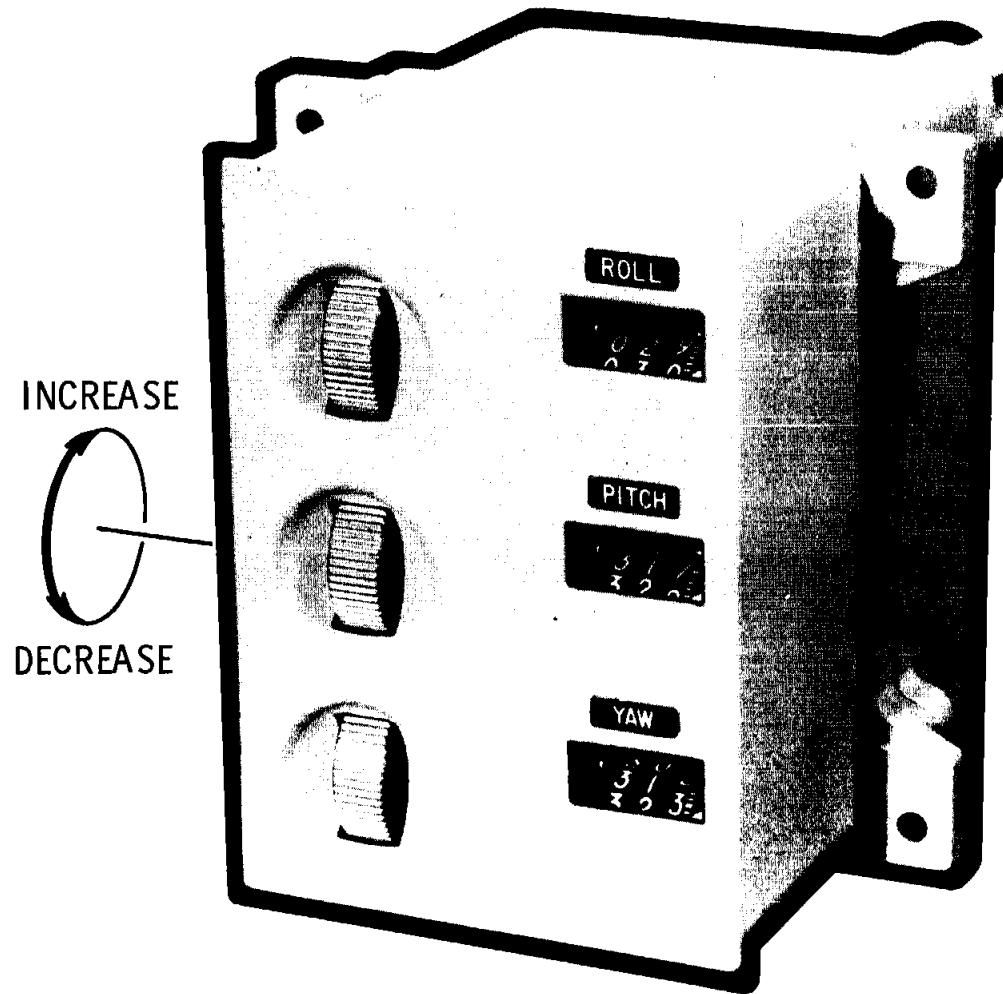
(*) You can't get Gimbal lock with the
 SCS because of a program interrupt
 You get a wind up with the SCS - BMAGs
 at a yaw of 90°

28 VDC

SCS-2404C



ATTITUDE SET DISPLAY

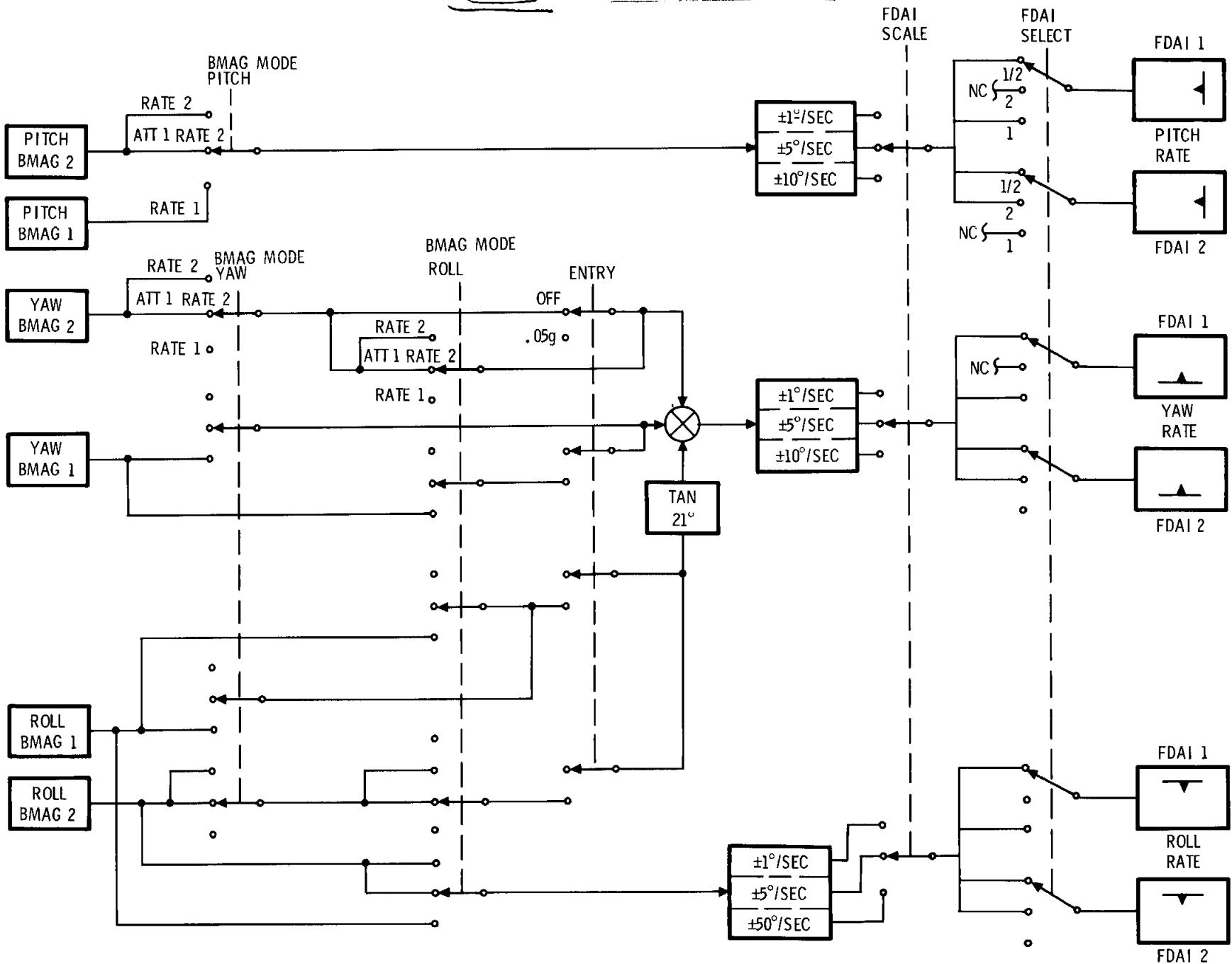


SCS-2102 A

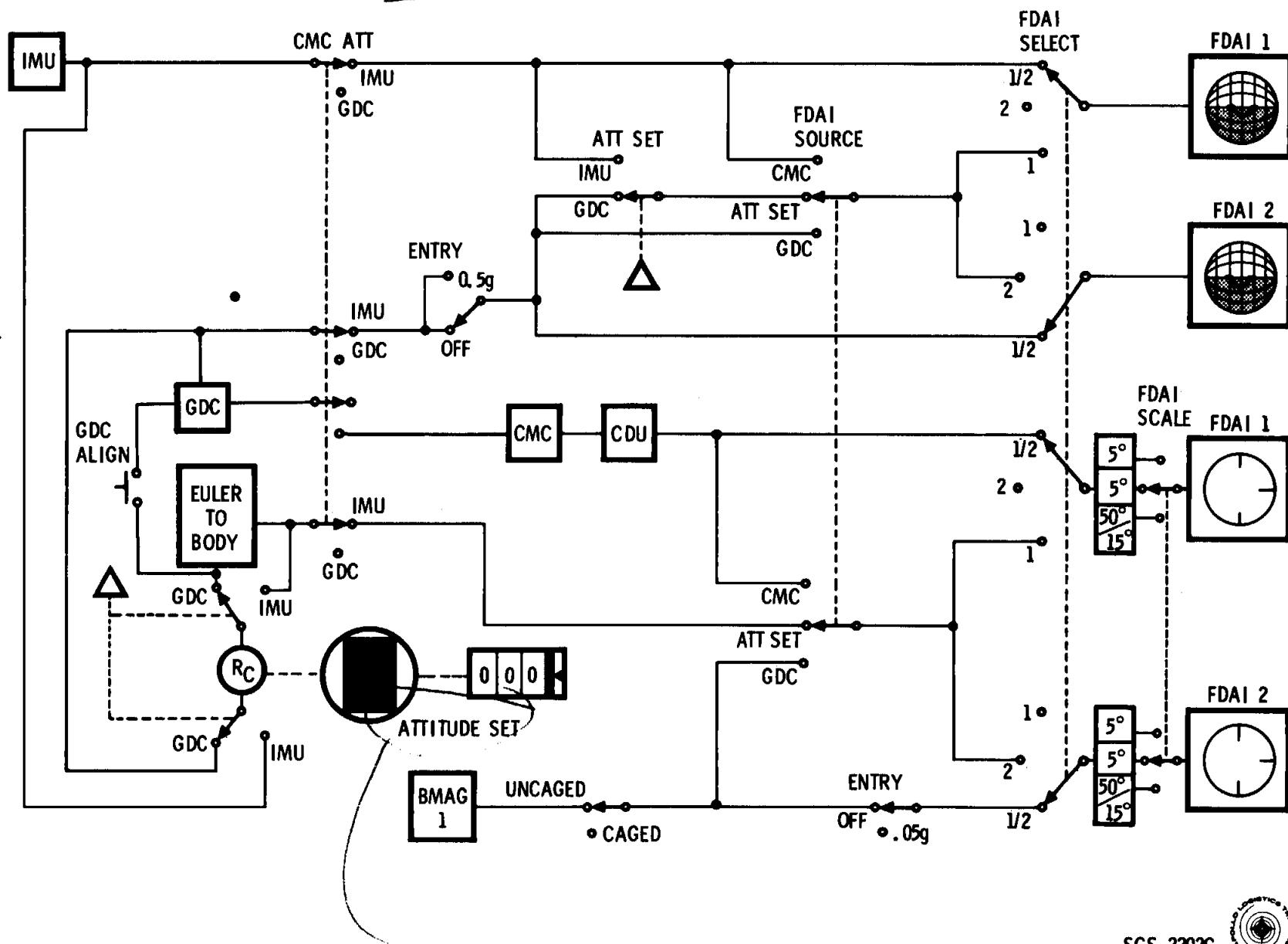


FDAI RATE SELECT LOGIC

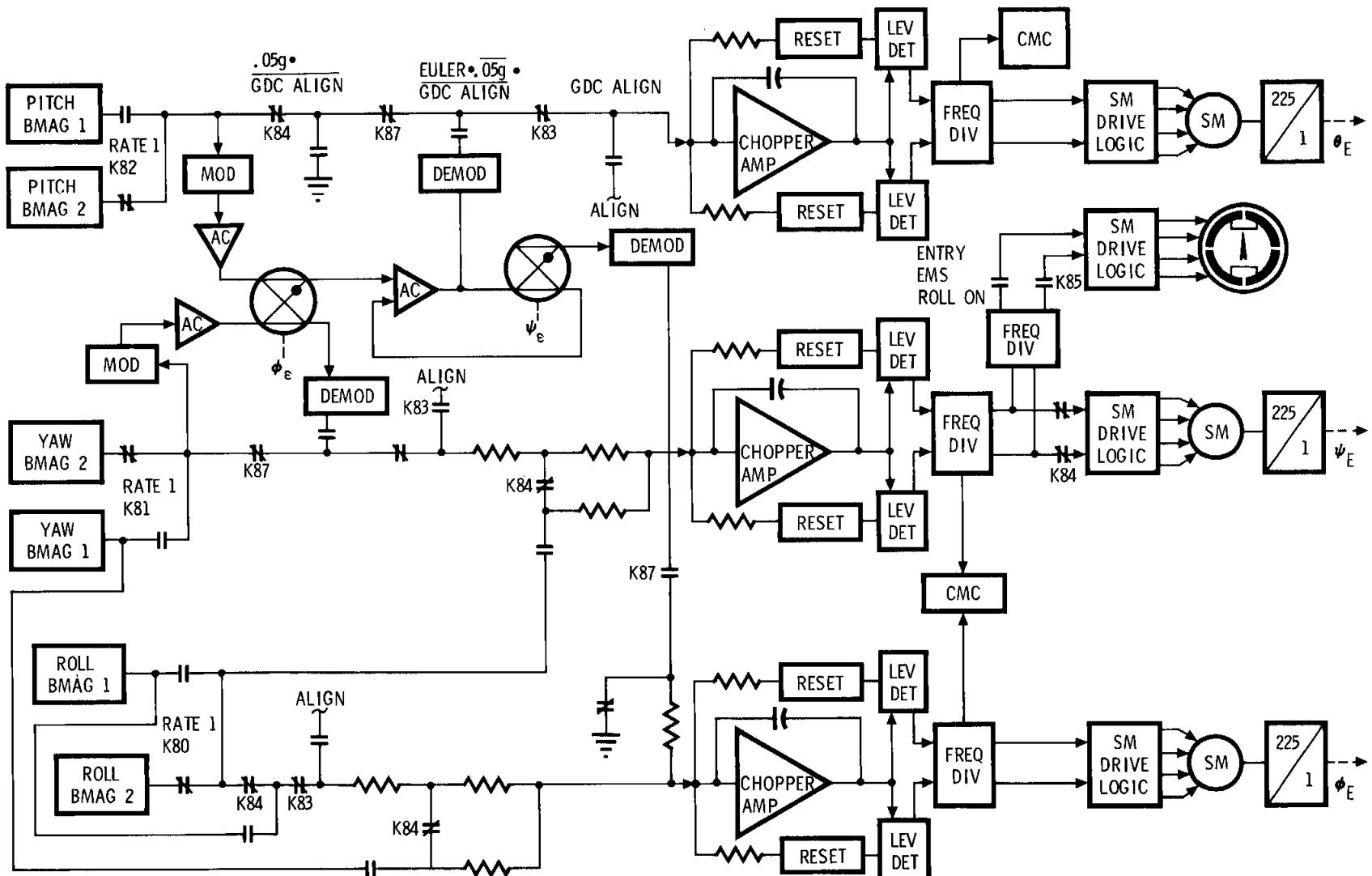
SCS



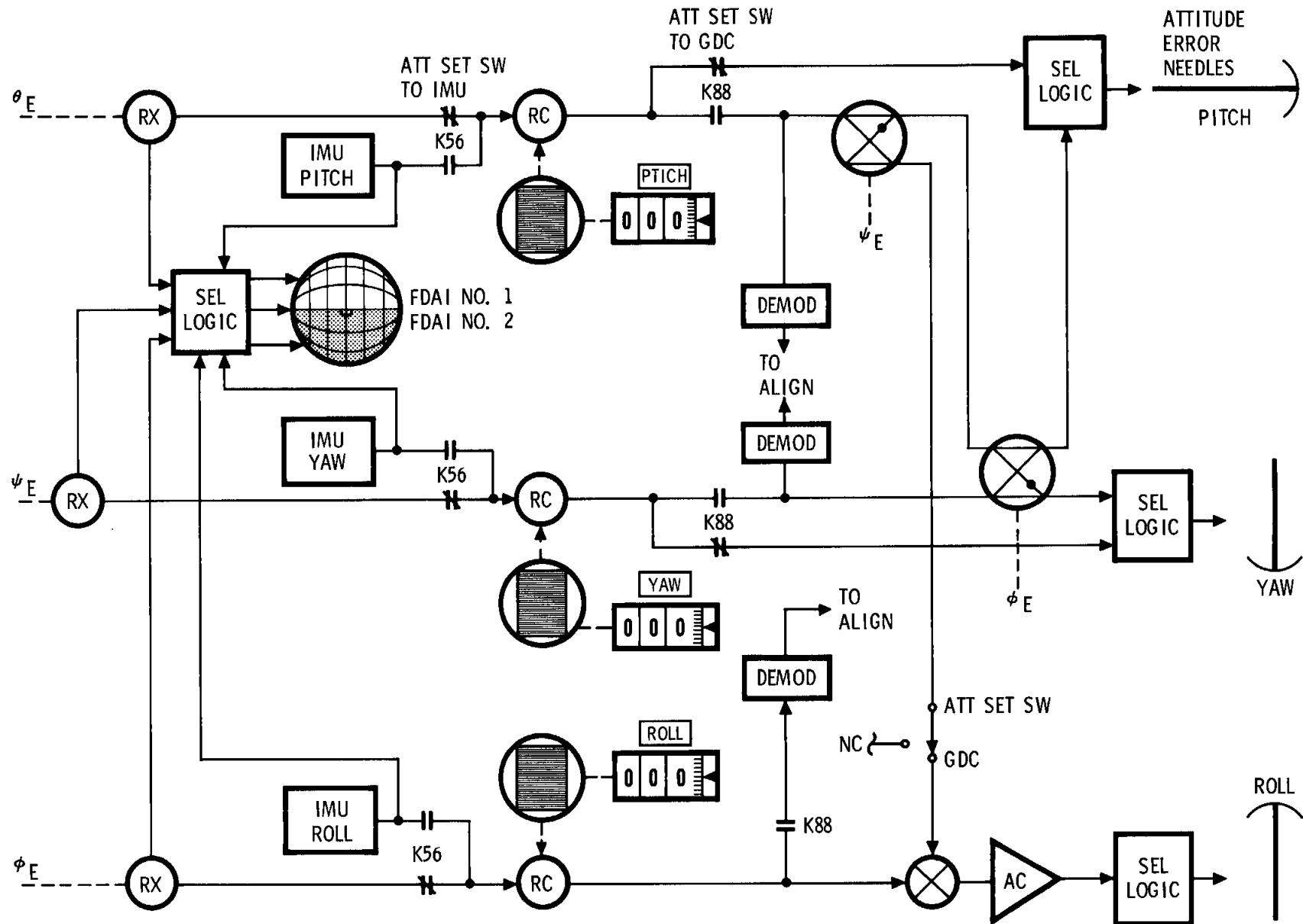
FDAI ATTITUDE SELECT LOGIC



GYRO DISPLAY COUPLER



FDAI SIGNAL FLOW



SCS-2405A



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 M | PITCH | RATE 2 | | | | | | | | | | ✓ | | |
| | | ATT 1/ RATE 2 | | | | | | | | | | ✓ | | |
| | | RATE 1 | | | | | | | | | | | ✓ | |
| A G M | YAW | RATE 2 | | | | | | | | | | ✓ | | |
| | | ATT 1/ RATE 2 | | | | | | | | | | ✓ | | |
| | | RATE 1 | | | | | | | | | | | ✓ | |
| O D E | ROLL | RATE 2 | | | | | | | | | | ✓ | | |
| | | ATT 1/ RATE 2 | | | | | | | | | | ✓ | | |
| | | RATE 1 | | | | | | | | | | | ✓ | |
| E N | .05G | .05G | | | | ✓ | | ✓ (2) | | | | | | |
| | | OFF | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ (4) | ✓ (4) | |
| T R Y | EMS ROLL | EMS ROLL | | | | | ✓ (2) | | | | | | | |
| | | OFF | | | | | | | | | | | | |
| F D A I S E L C T | FDI SELECT | (1) 1/2 | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | |
| | | 2 | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | | 1 | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| F D A I S O U R C E | FDI SOURCE | CMC | | | | ✓ | | | | | | | ✓ | |
| | | ATT SET | | | | | ✓ | | ✓ | | ✓ | ✓ | | |
| | | GDC | | | | | ✓ | | ✓ | | | | | |
| A T T S E T | ATT SET | IMU | | | | | ✓ | | | | | ✓ | | |
| | | GDC | ✓ | | | | | ✓ | ✓ | | ✓ | | | |
| C M C A T T | CMC ATT | IMU | | ✓ | | | ✓ | | ✓ | | | | | |
| | | GDC | | ✓ | | | | | | | | | | |
| G D C A L I N G | GDC ALIGN | PRESS | ✓ | | | | | | | | | | | |
| | | OFF | | ✓ | ✓ | ✓ | | | | | | | | |
| ATTITUDE SET CONT PANEL | 3 THUMB-WHEELS | ✓ | | | | | | | | | ✓ | ✓ | | |

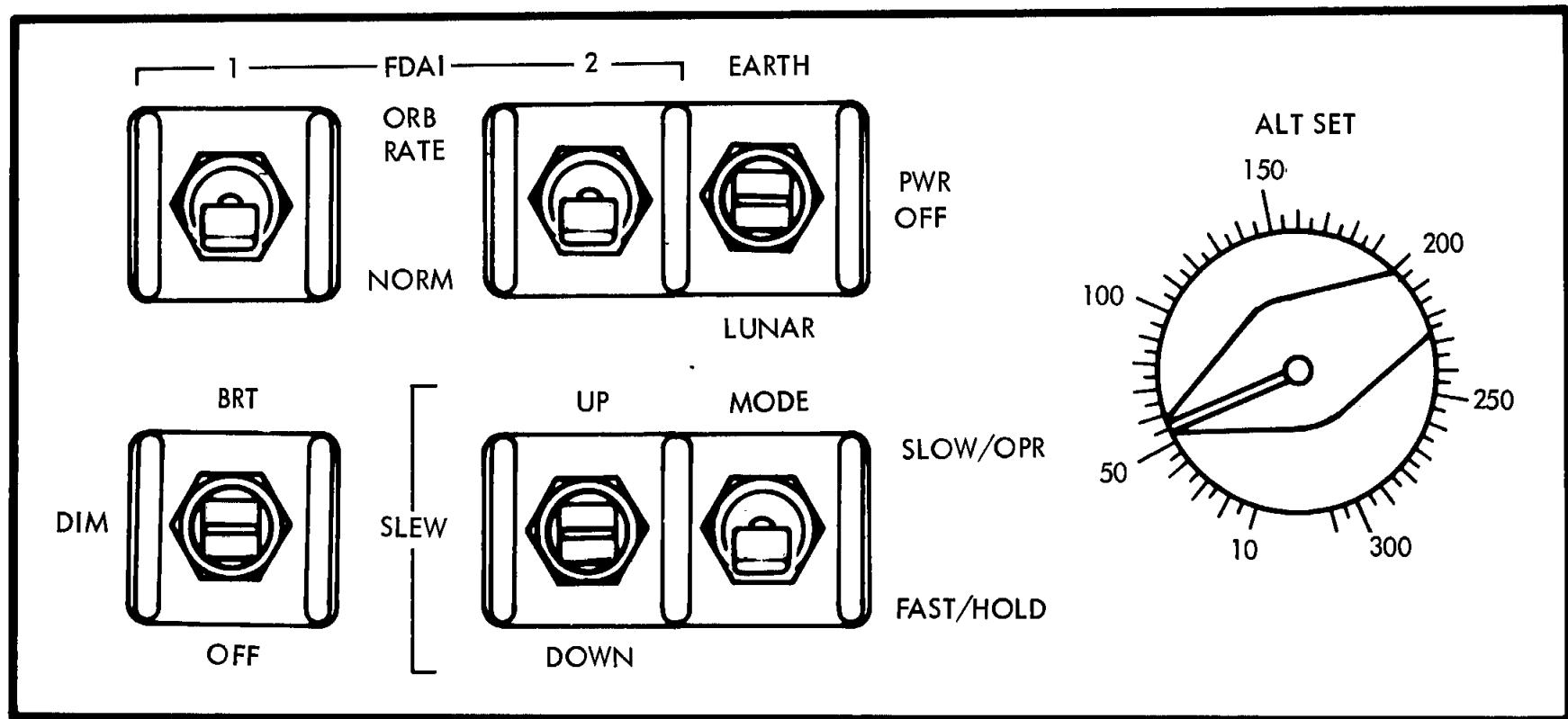
- (1) ATTITUDE AND ATTITUDE ERROR TO FDI #1 FROM G&N AND TO FDI #2 FROM THE SCS
- (2) DURING ENTRY, STABILITY ROLL ONLY IS SUPPLIED TO THE FDI SELECTED AND TO THE ROLL STABILITY INDICATOR ON THE ENTRY MONITOR SYSTEM.
- (3) BMAG UNCEGE LOGIC MUST ALSO BE SATISFIED IN ADDITION TO SWITCHES SHOWN.
- (4)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

CHART 1

SCS-2804B



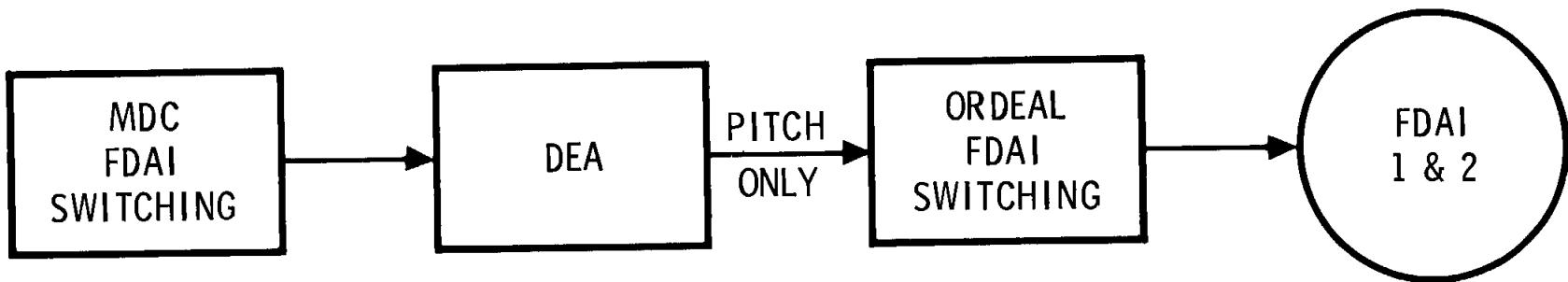
ORDEAL PANEL



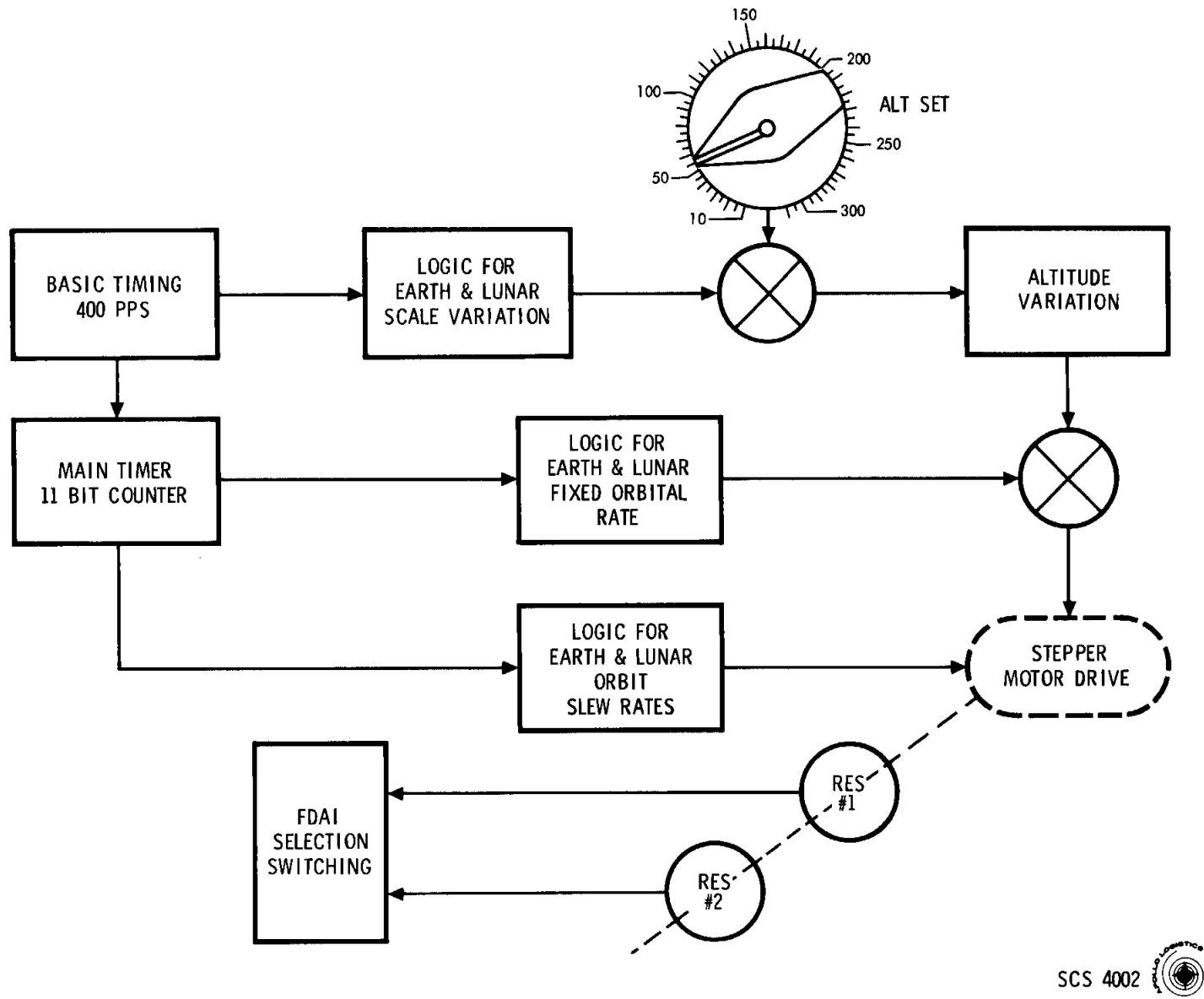
*Orbital Rule
Vive Electronics
Apollo LM*

ORDEAL INTERFACE

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

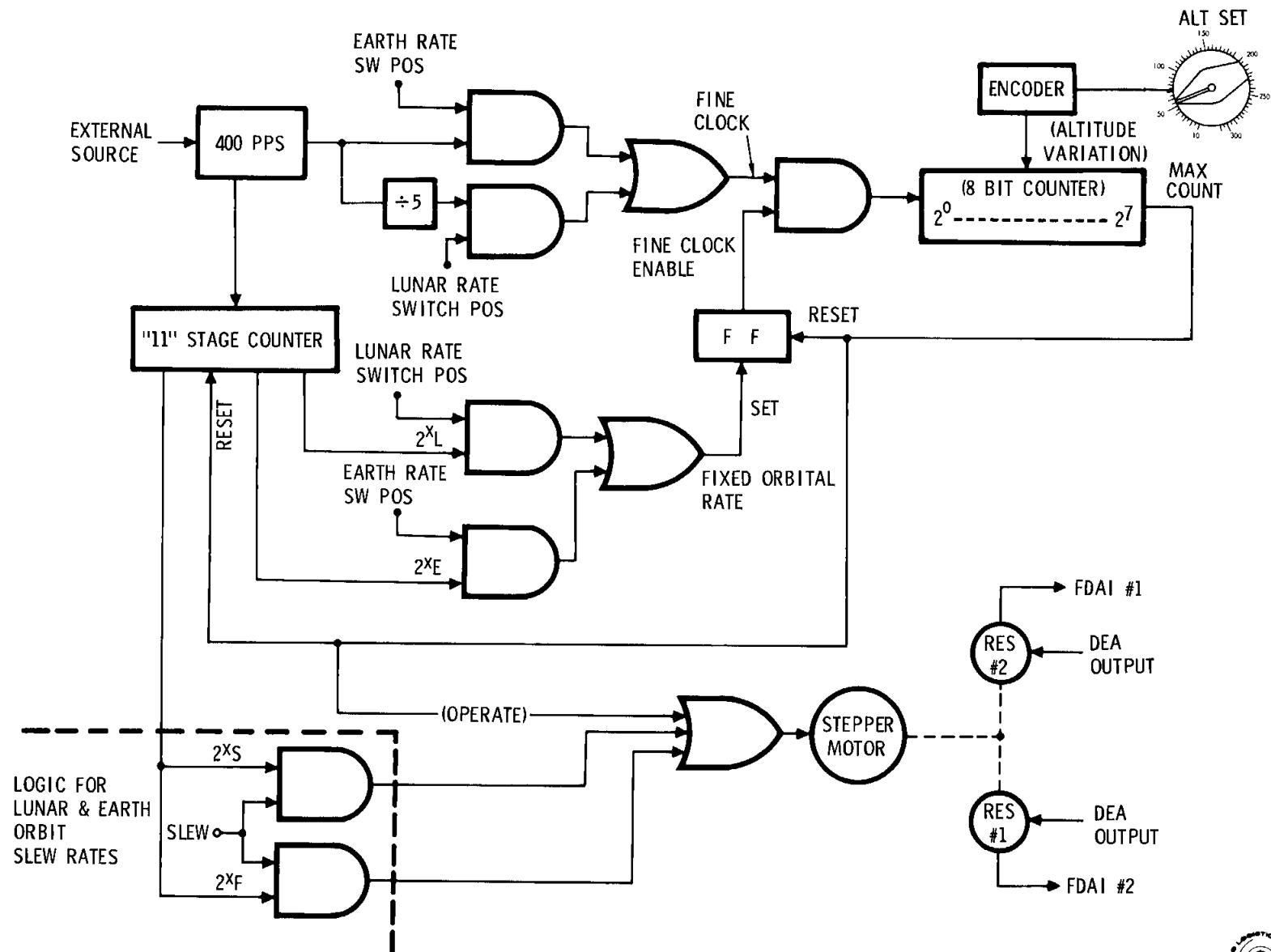


ORDEAL FUNCTIONAL BLOCK DIAGRAM



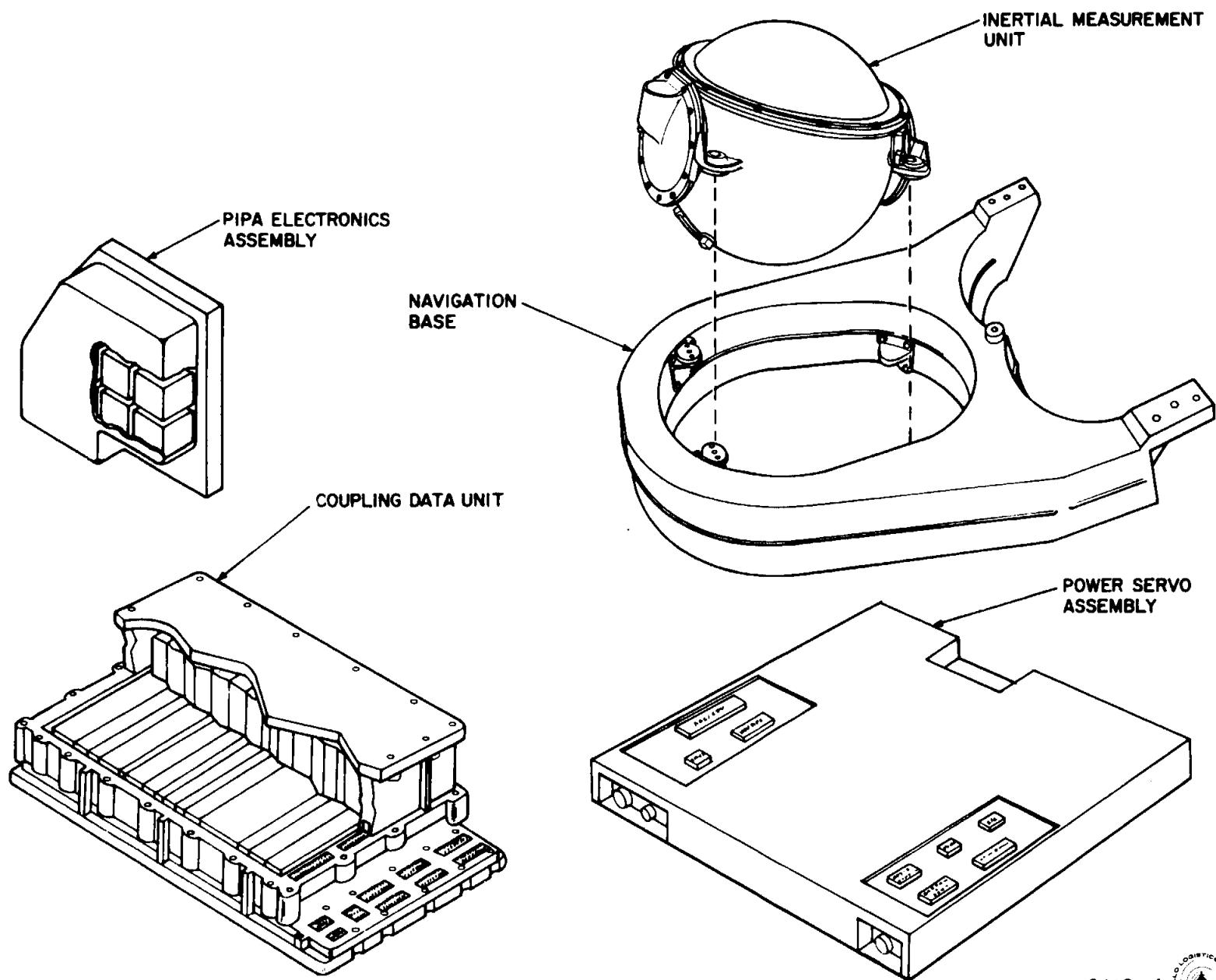
SCS 4002

ORDEAL SIGNAL FLOW DIAGRAM



SCS 4003

ISS EQUIPMENT

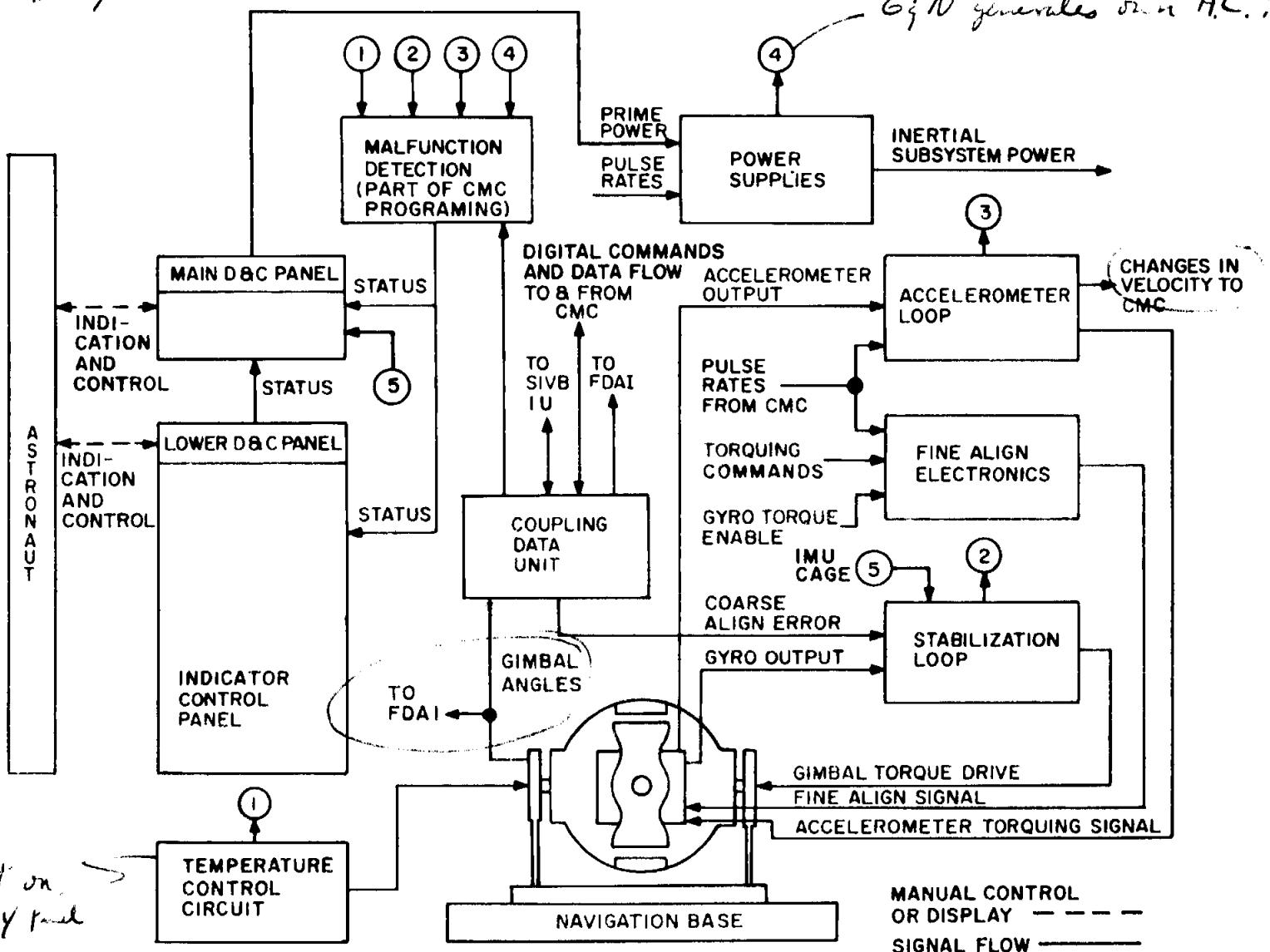


GNC-6
ORBITAL LOGISTICS EXPANDING

Course Align: (1° - 1.5 $^{\circ}$)

Fine Align: (80 Arcsec)

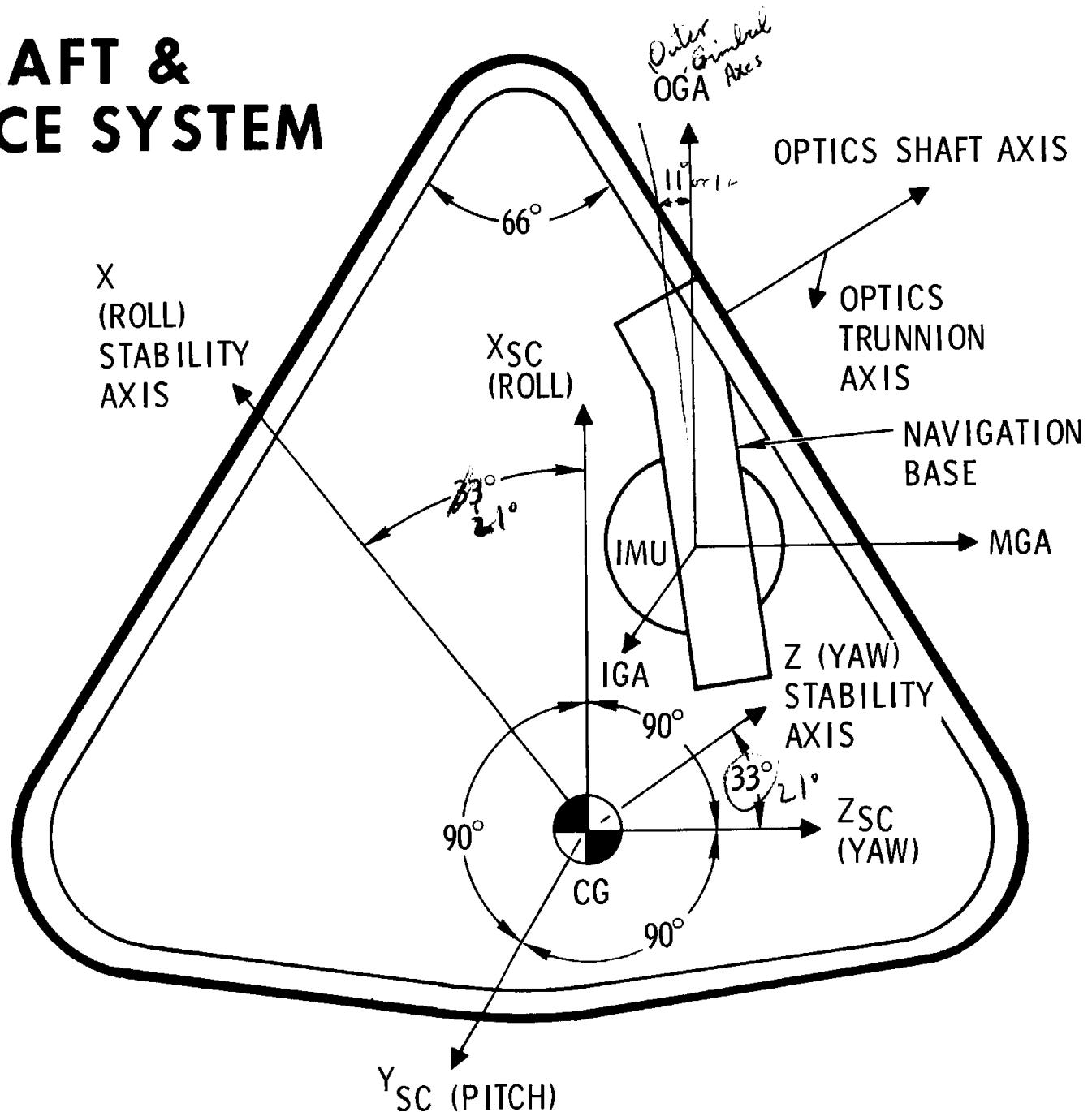
INERTIAL SUBSYSTEM INTERFACE



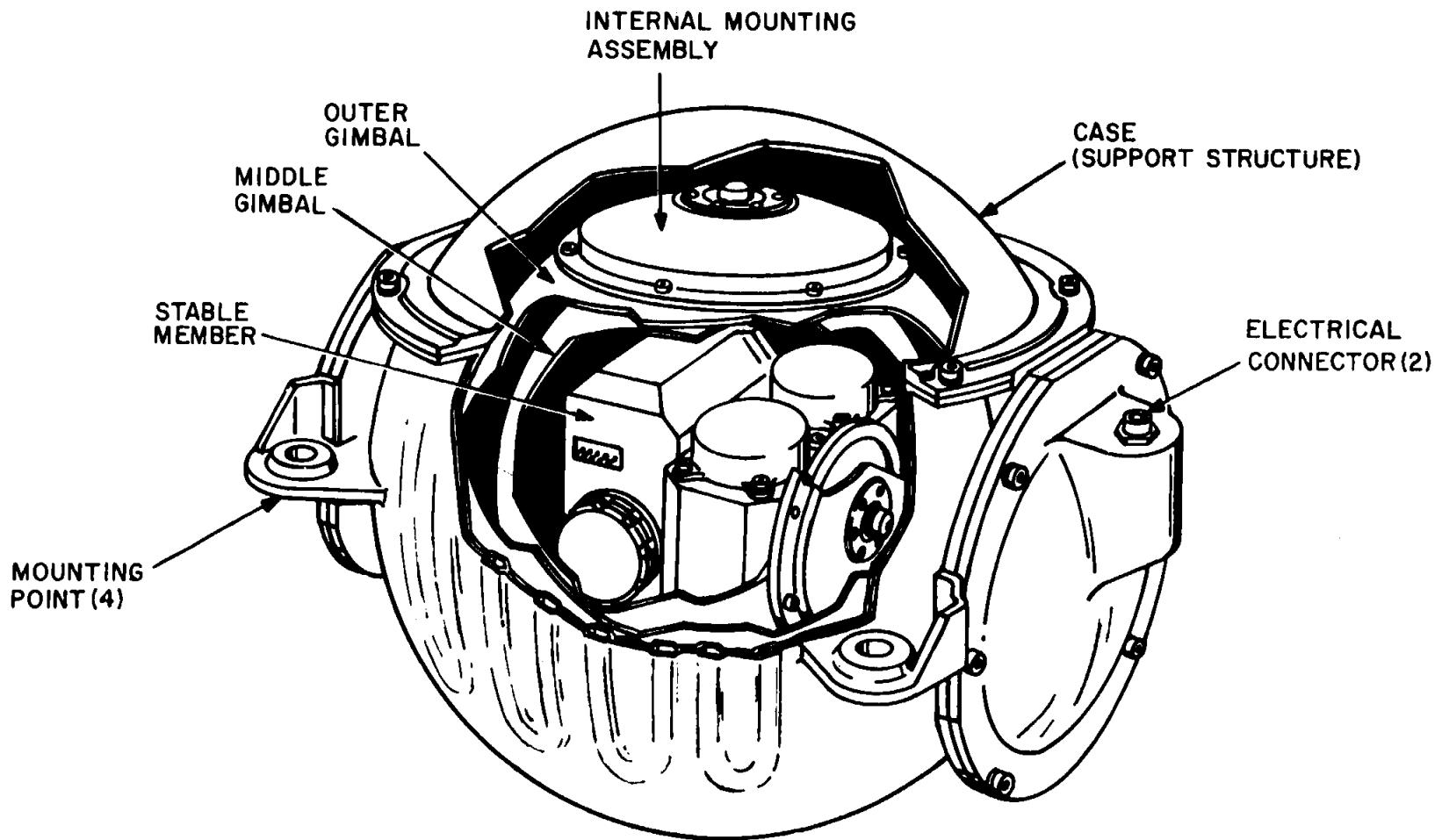
Uncaged means platform is providing an inertial ref. frame & measures s/c motion
wtf this ref.
Can't move, etc doesn't get output from 205 --- Gimbal angle driven to zero.

GNC-8

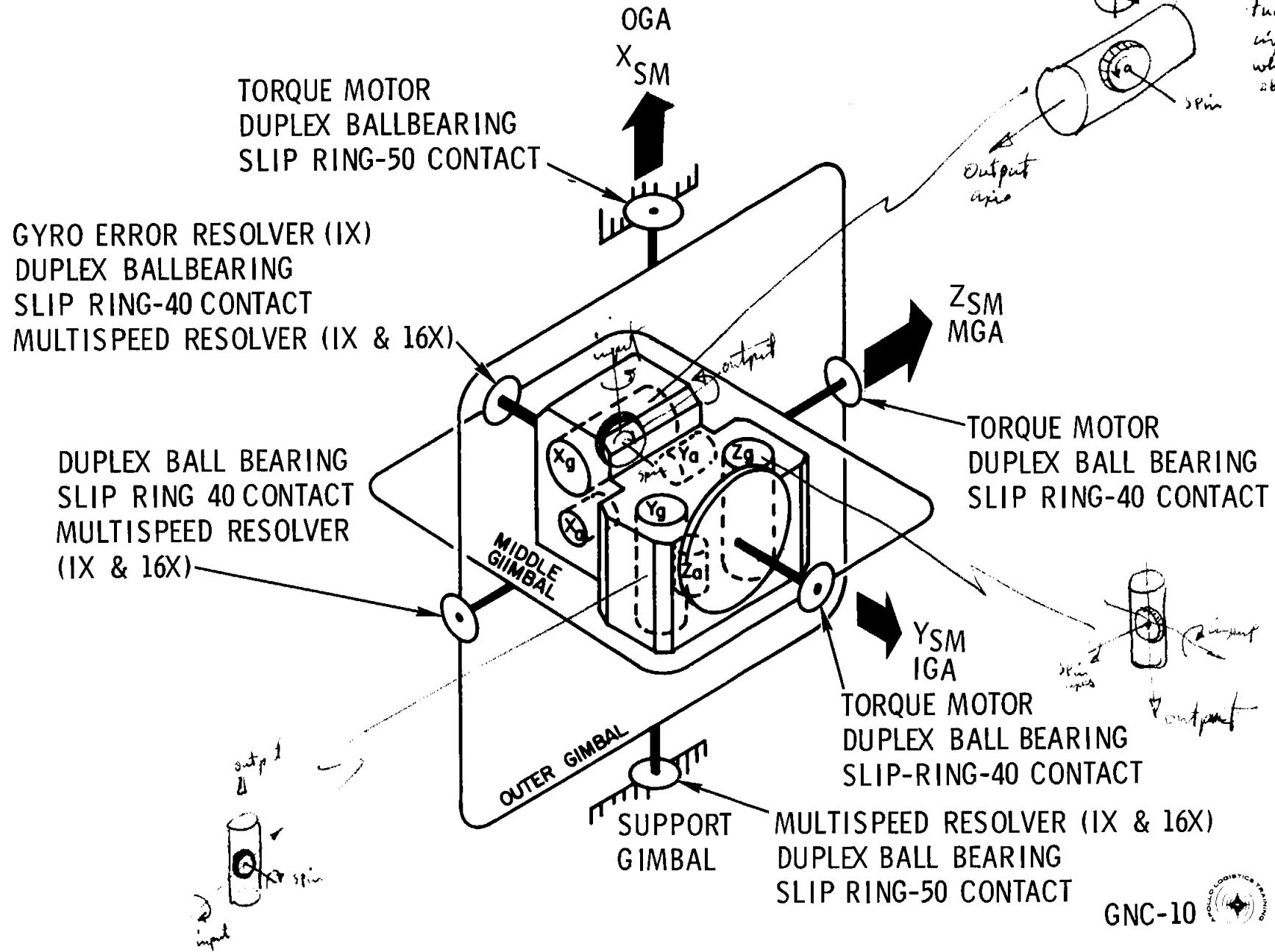
SPACECRAFT & GUIDANCE SYSTEM AXES



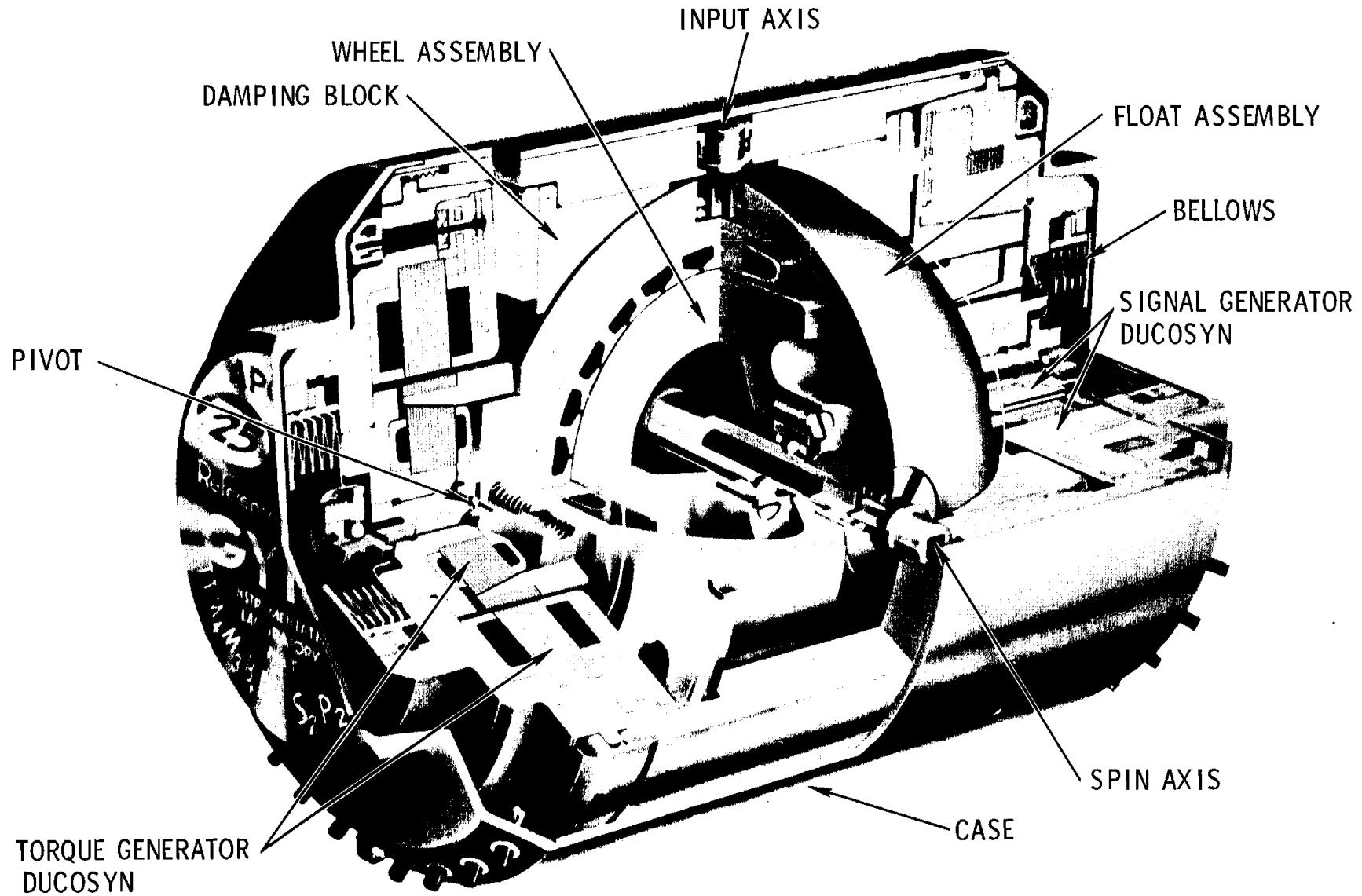
INERTIAL MEASUREMENT UNIT



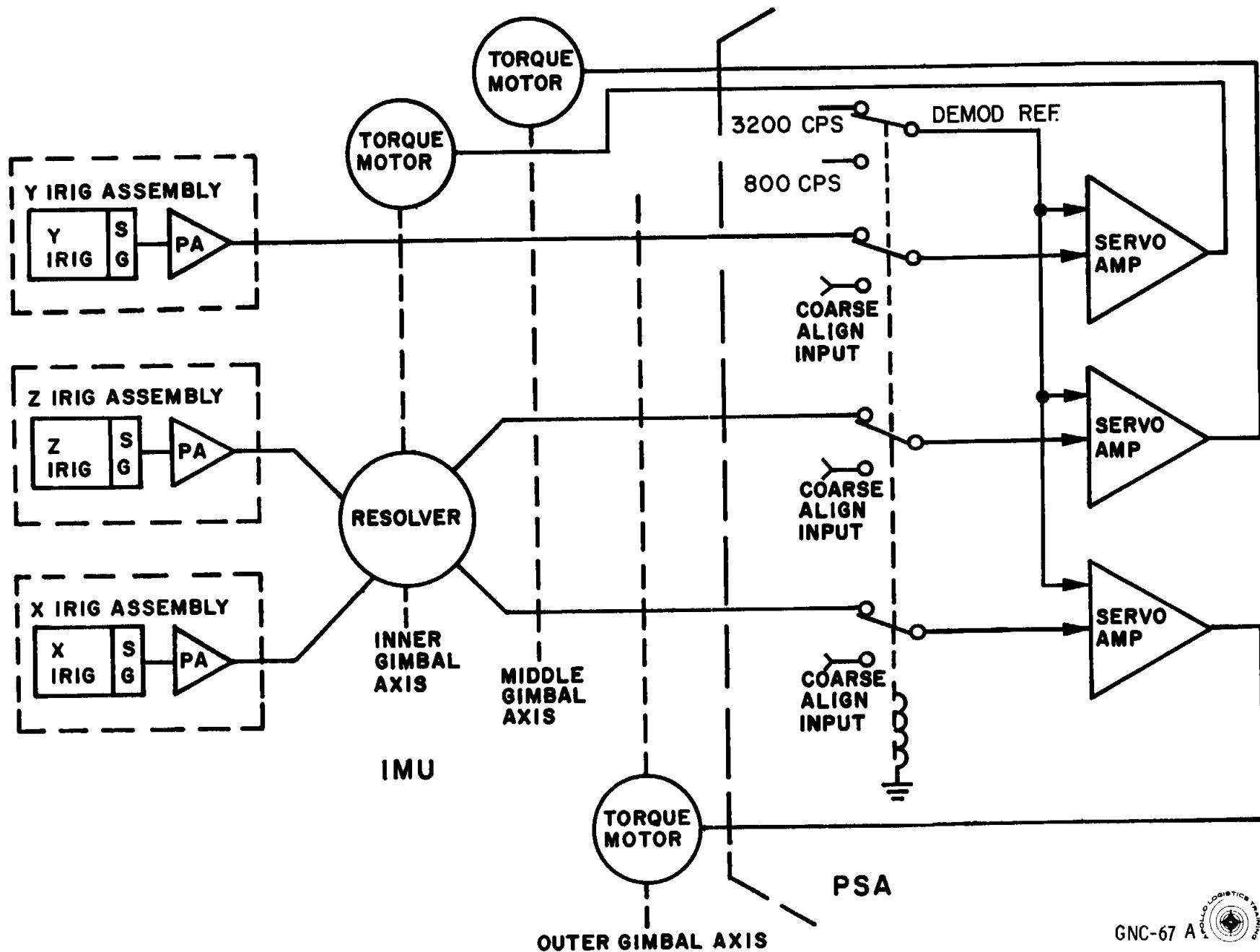
IMU GIMBAL ASSEMBLY



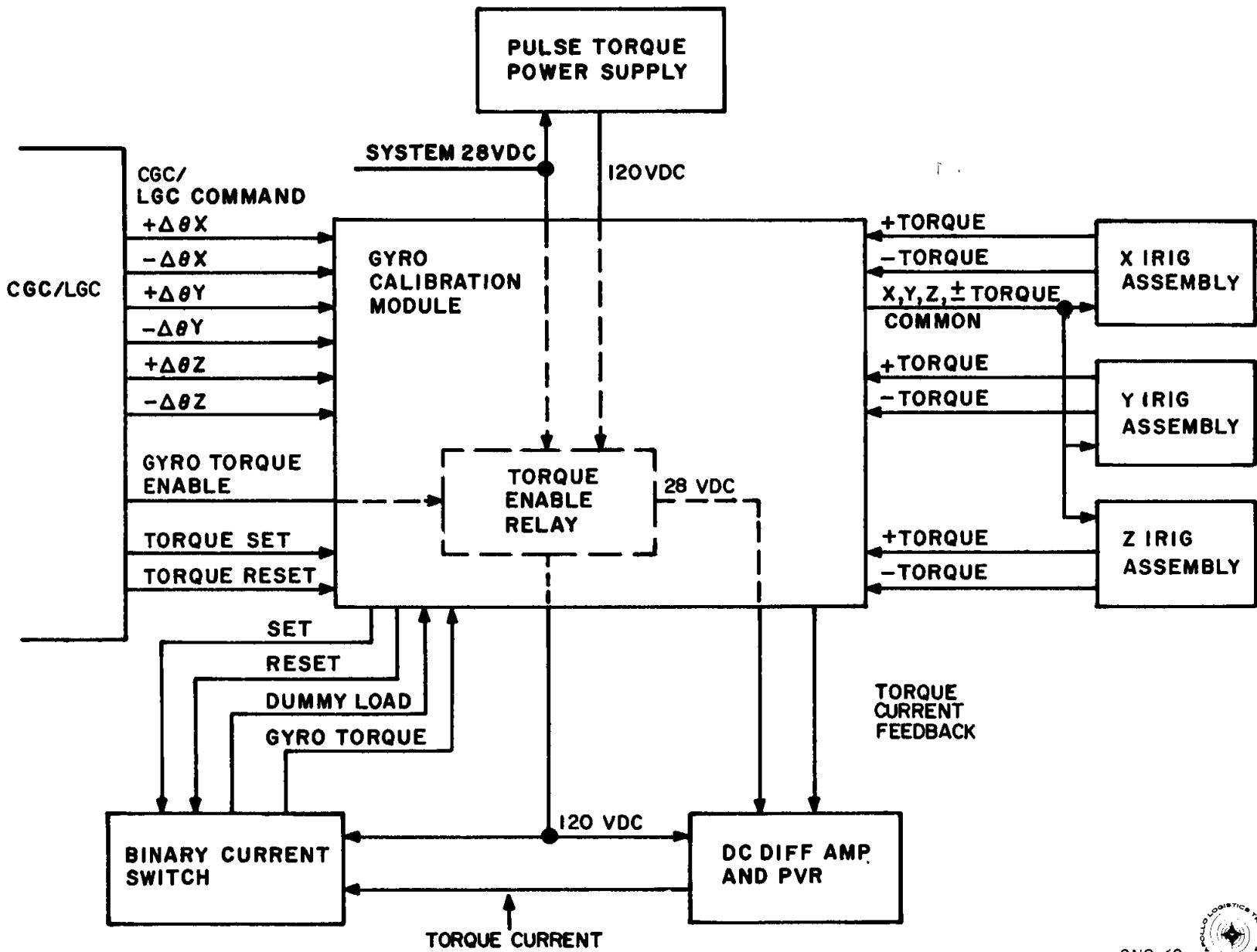
25 IRIG



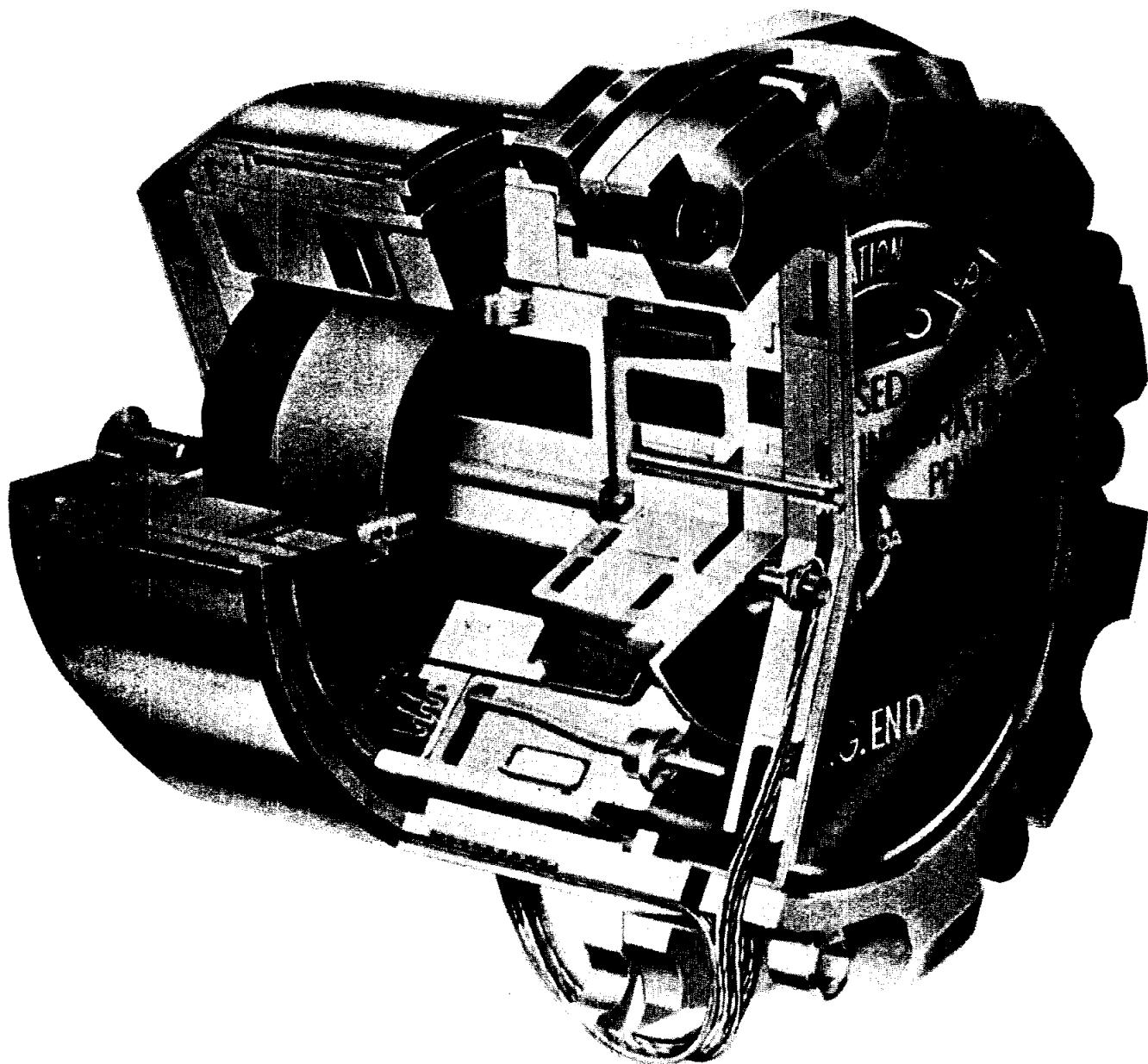
BLOCK II STABILIZATION LOOPS



FINE ALIGN ELECTRONICS



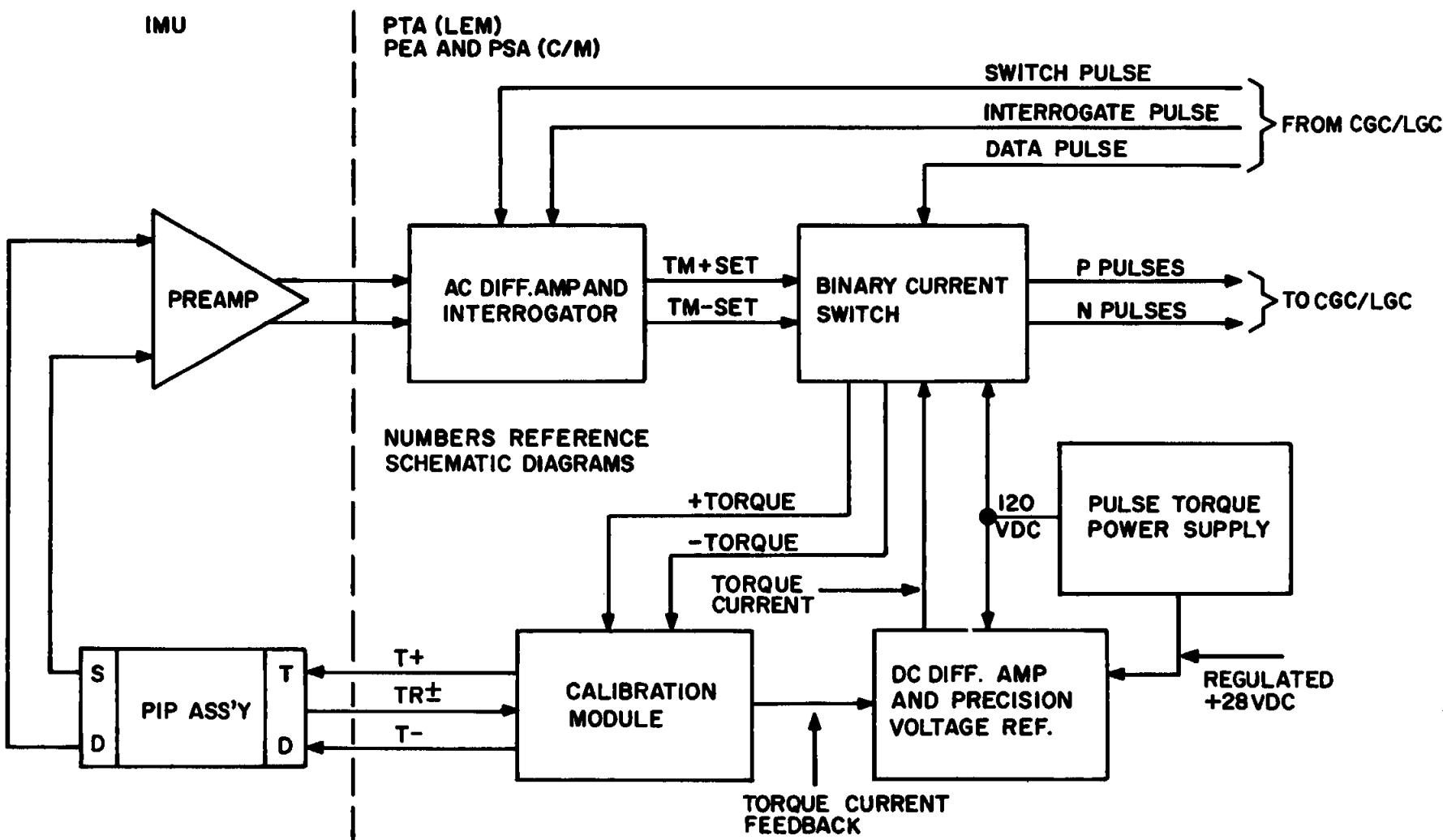
PIP



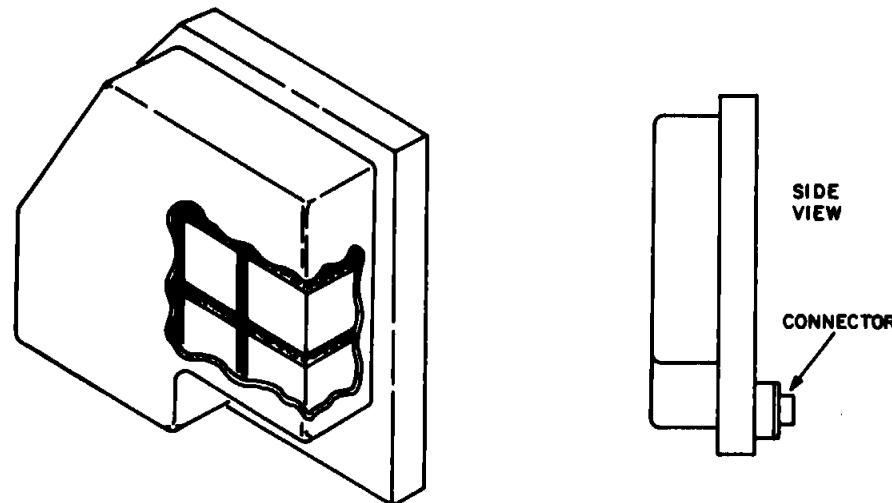
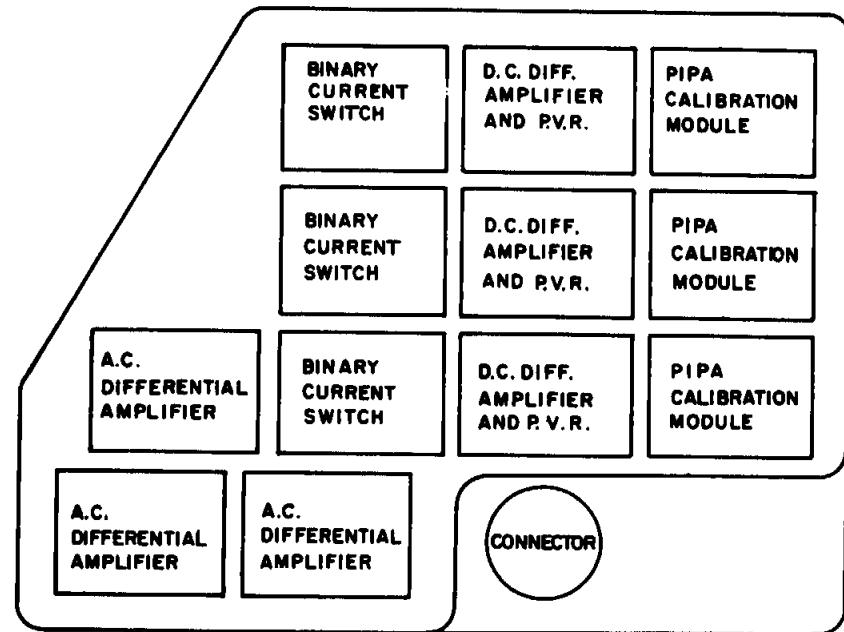
GN-263



BLOCK II ACCELEROMETER LOOP



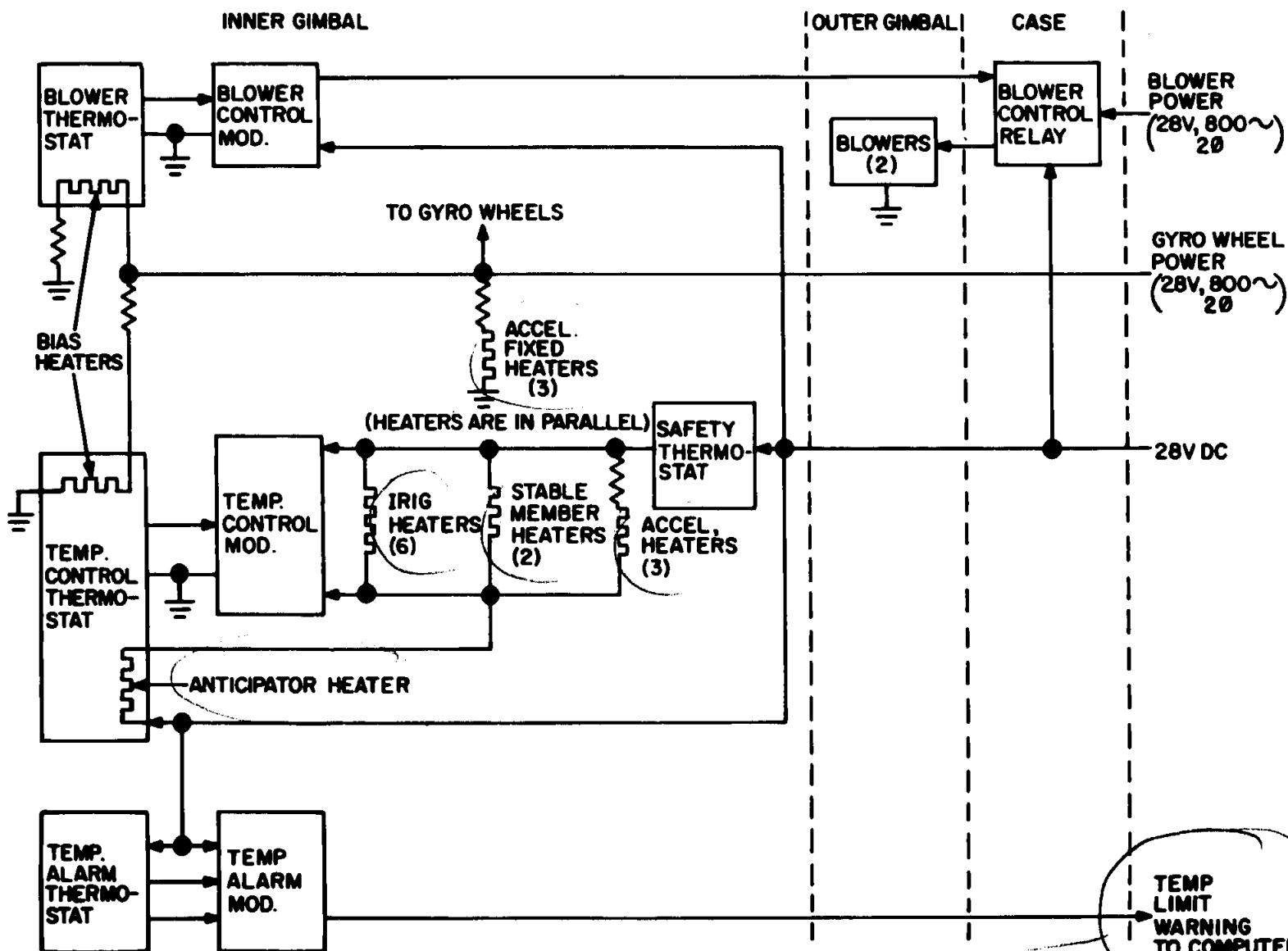
PIP. ELECTRONICS ASSEMBLY



6 heaters

TEMPERATURE CONTROL SYSTEM

located on IMU



(X) Normal temp 158°

Hallometer deteriorates with temp.

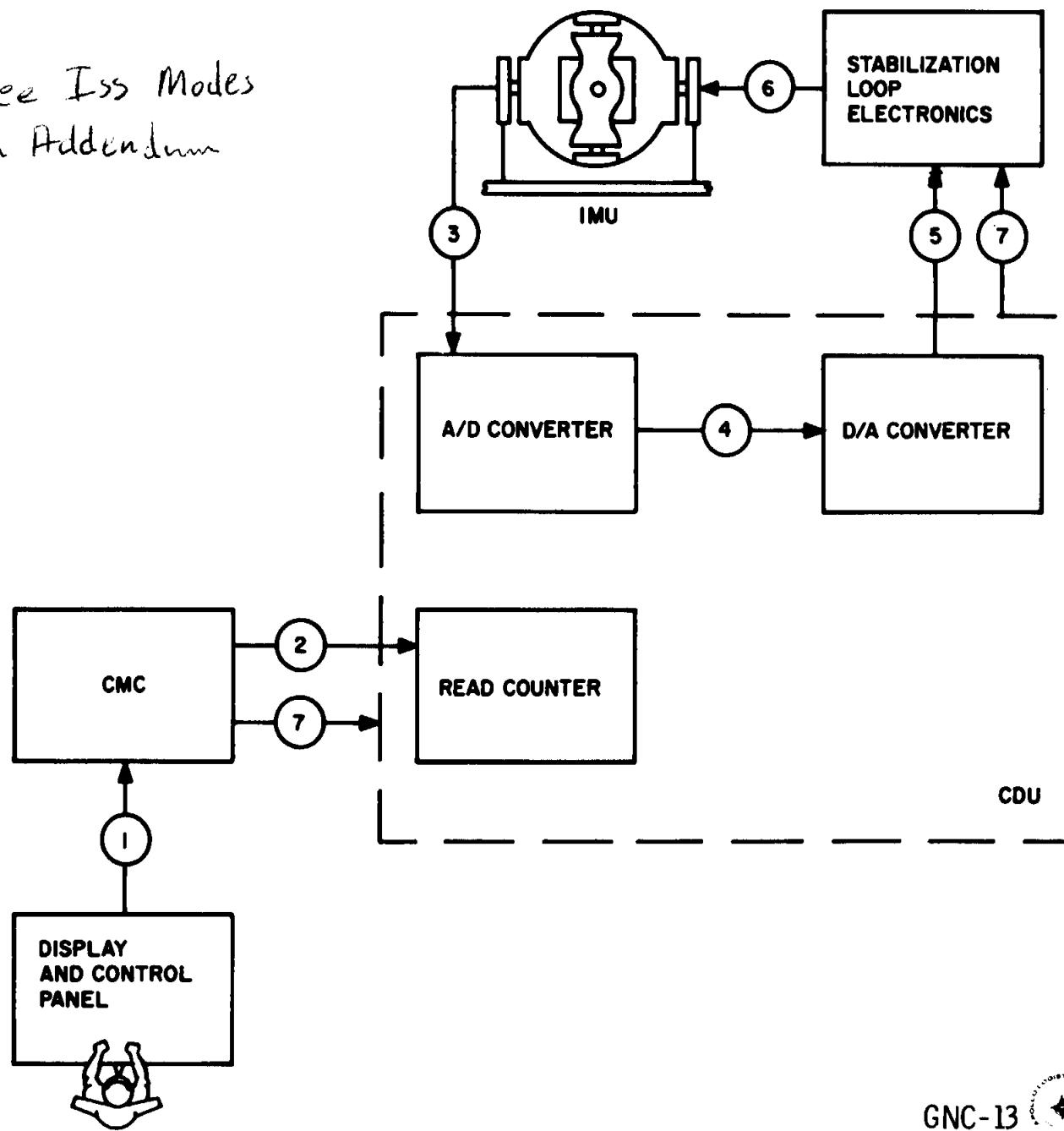
No control over this

(X) What limit (temp) before you wouldn't use mech?

GNC-81

IMU TURN-ON

(*) See ISS Modes
on Addendum



POS on
PO6 off



except in CMC, Att. Mode

CMC standby?

bit operates then

2. V37 major mode change

or put into POS

Coarse Align - true

line fine alignment is done; inertial

We don't want to do it until now.

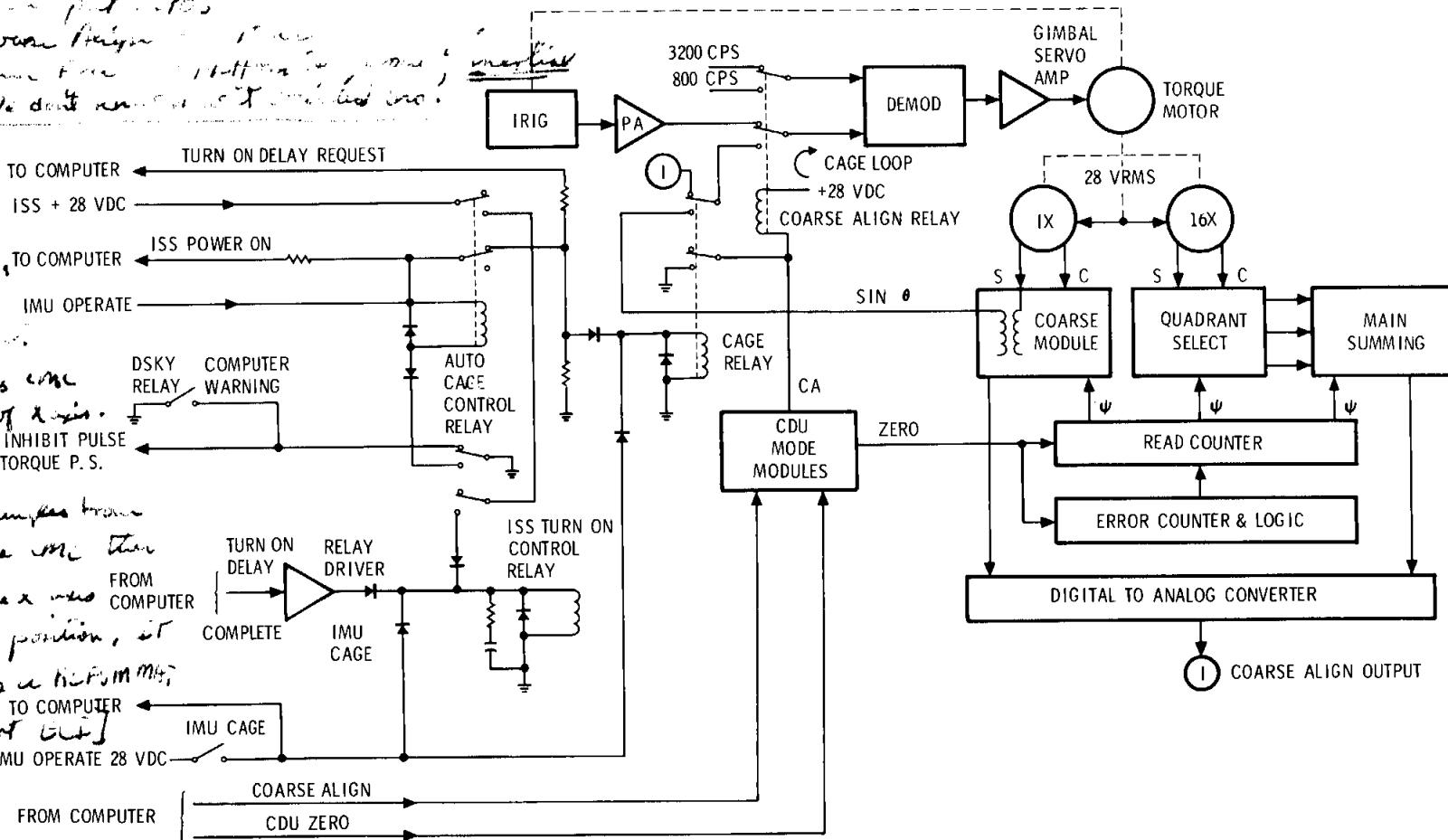
uses w/ CMC

IMU TURN-ON MODE

ISS Modes

1. IMU - Turn On Pos PO6
2. IMU - cage
3. Coarse Align
4. Fine Align } Pos
5. Inert. Ref.
6. Att. Error Display

PSI
Final Line
wt cf



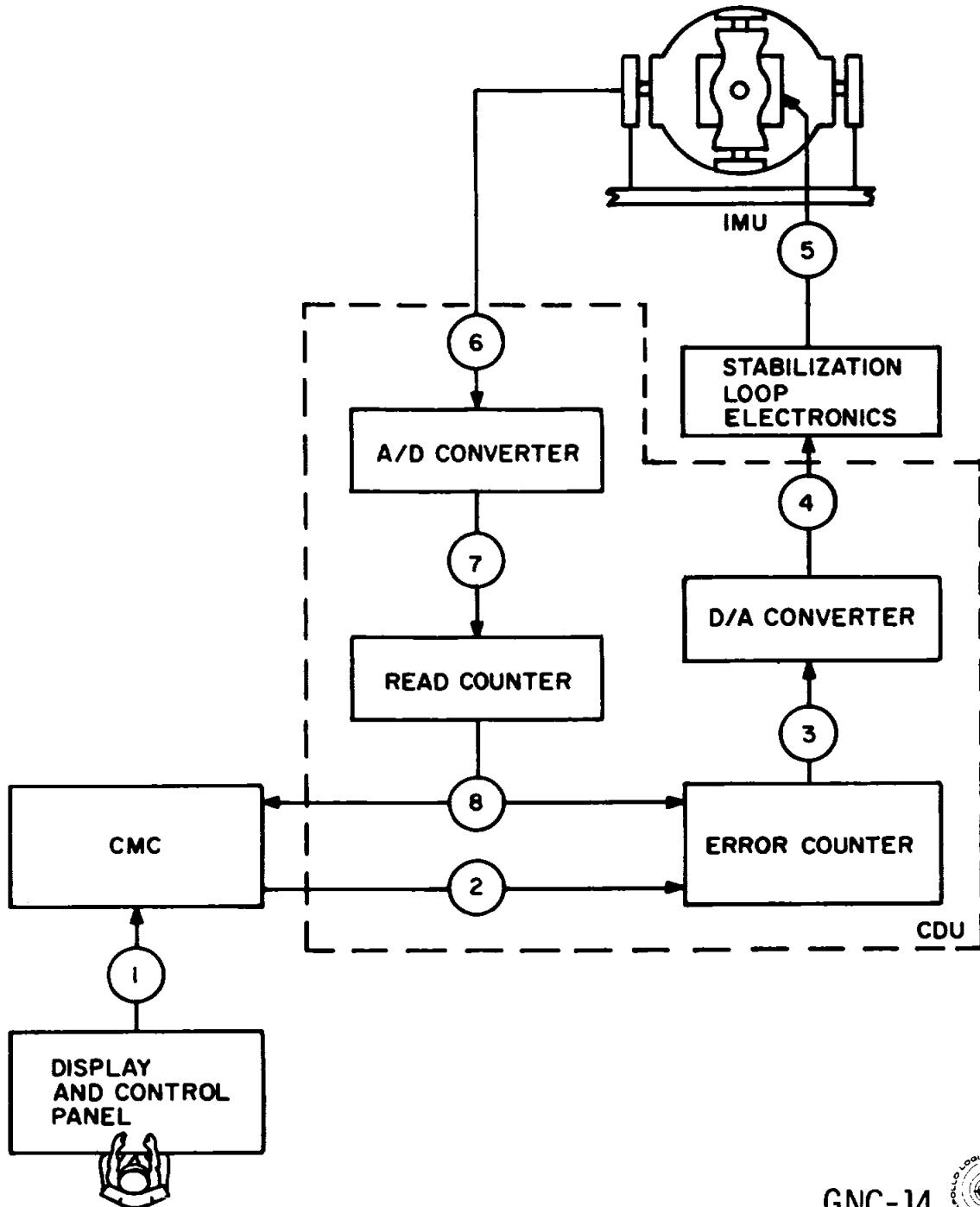
Next step: Inertial

To get out of fine align in CMC

GNC-117B



COARSE ALIGN MODE



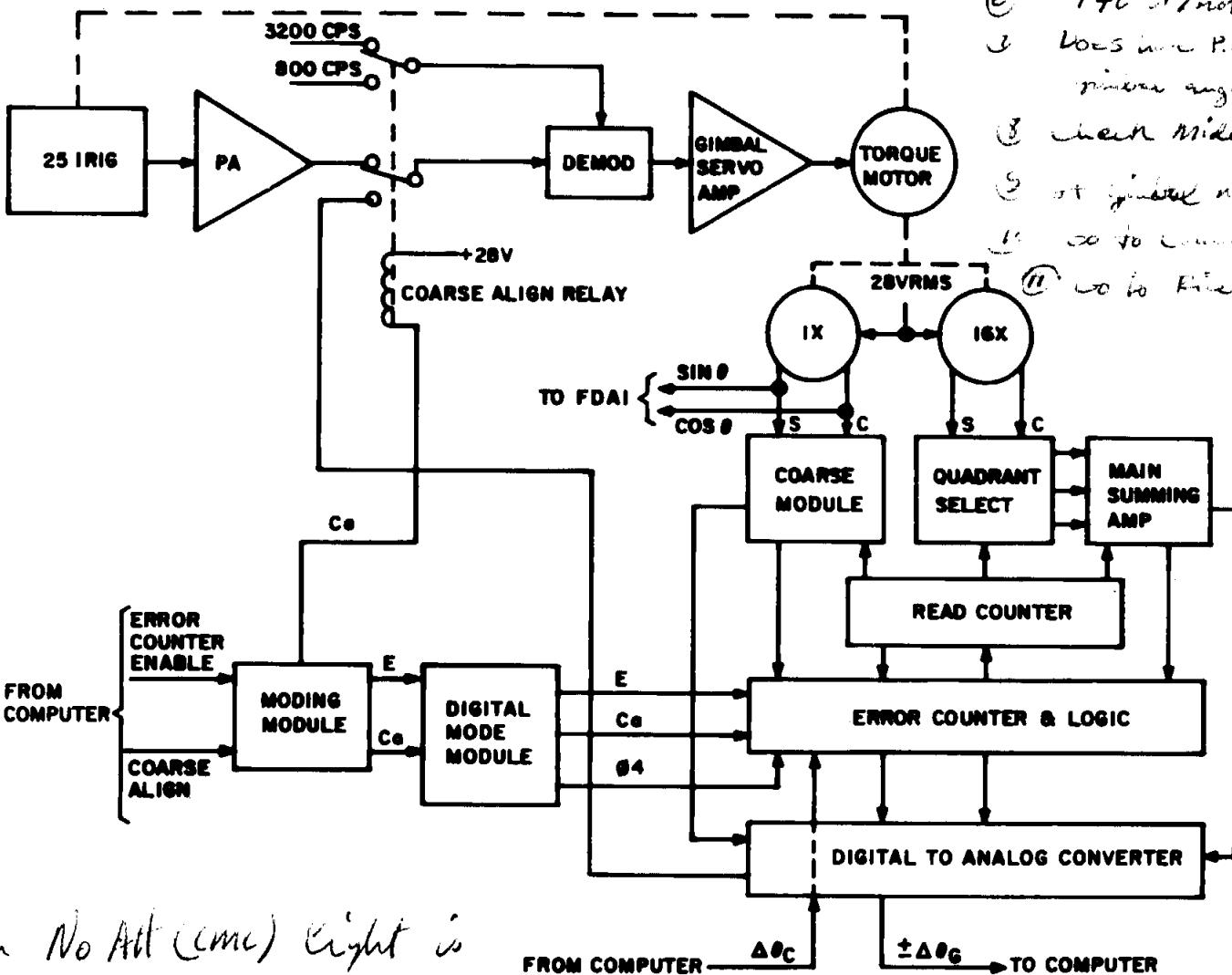
GNC-14



Modulation
V37 → PS2 High Priority

- 1 Turn On 25 CPS
- 2 Pot Find and set to zero
- 3 001 Interface orientation
- 4 740 if not ... Axis or not
- 5 Does one P.C. flag the angle in reverse angle
- 6 Check Middle position ... 60°
- 7 Set gyros to zero ... yes
- 8 Go to coarse alignment ... no
- 9 Go to fine align

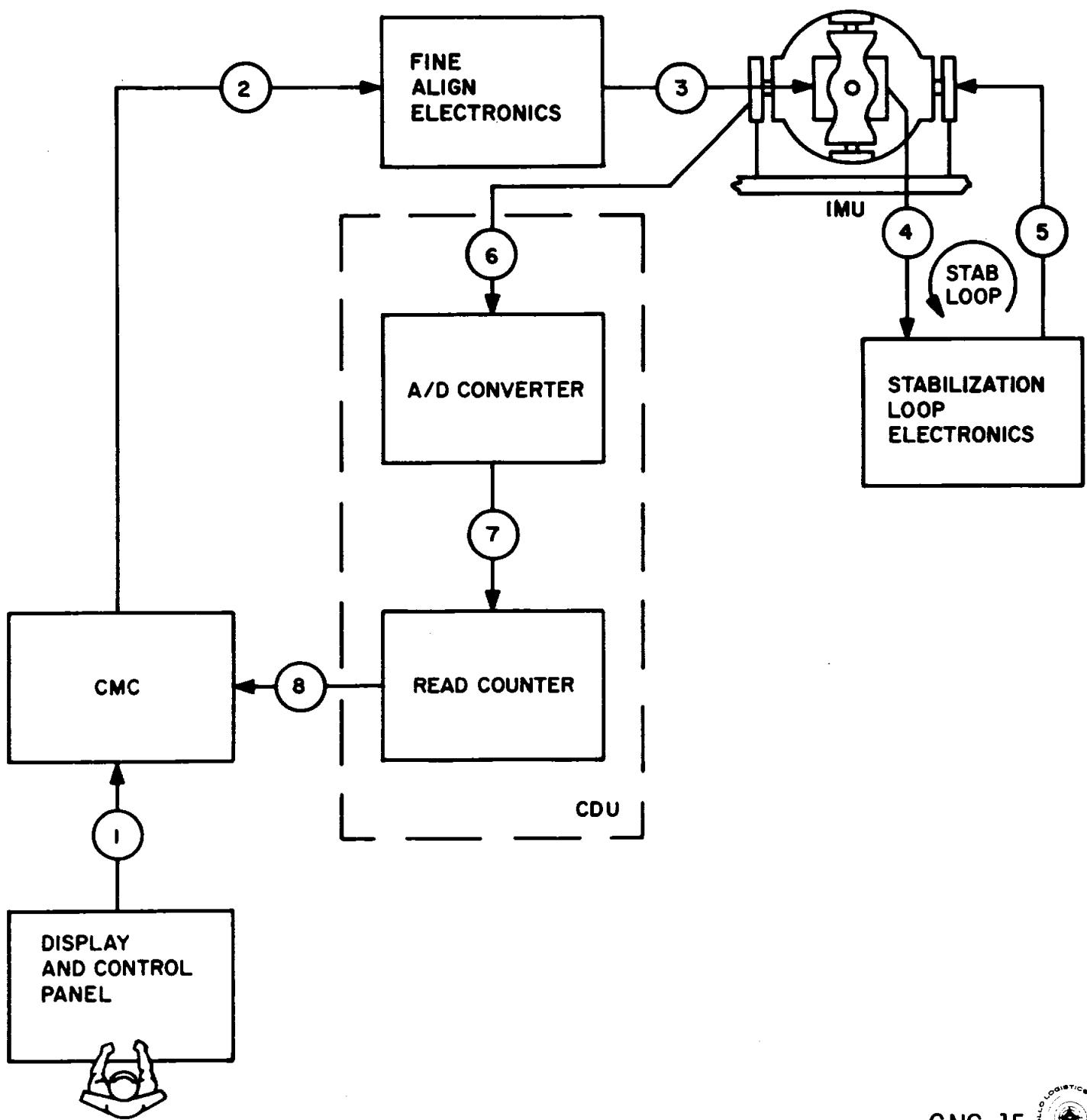
COARSE ALIGN MODE



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

V&K Plastics in the white light

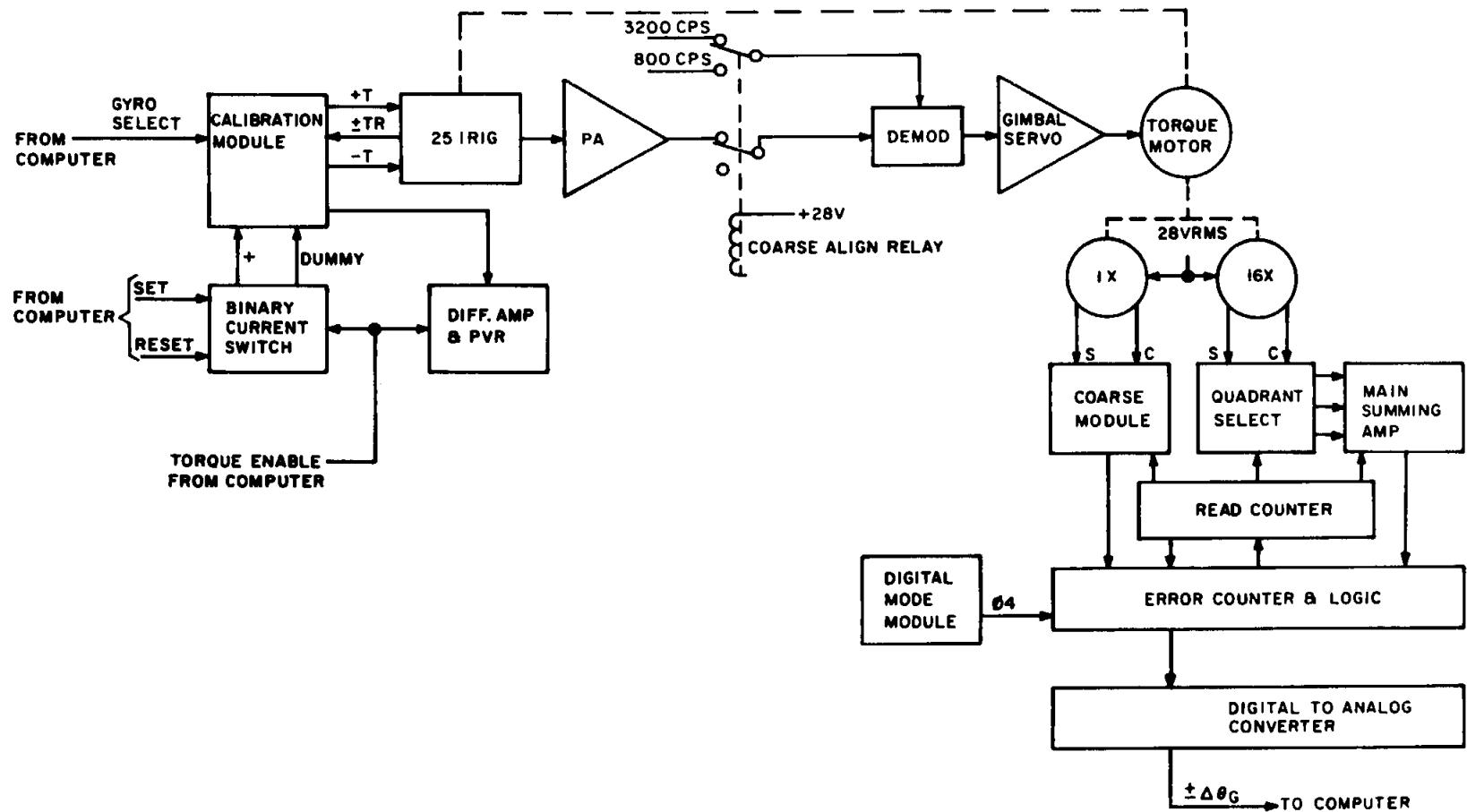
FINE ALIGN



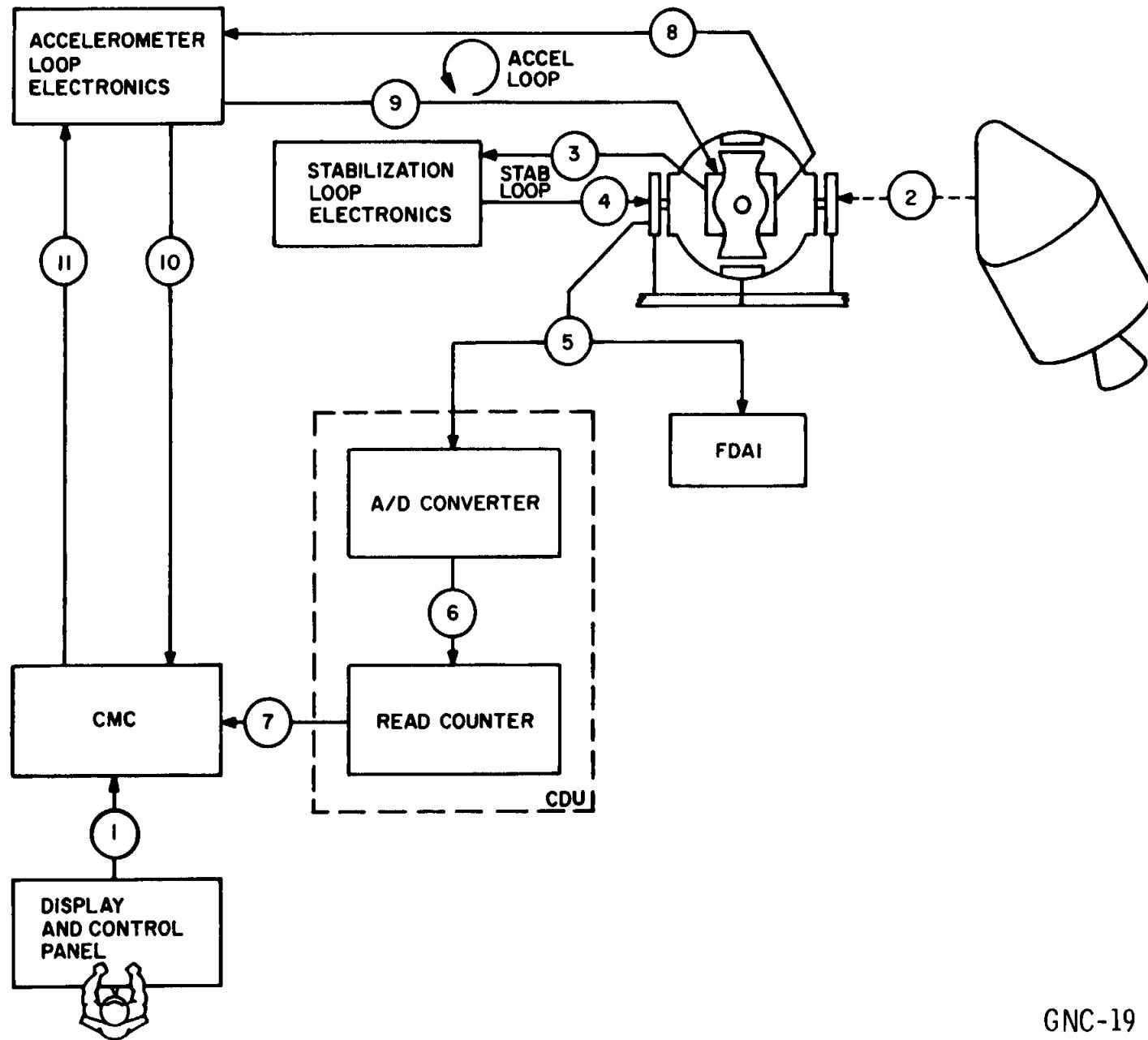
GNC-15



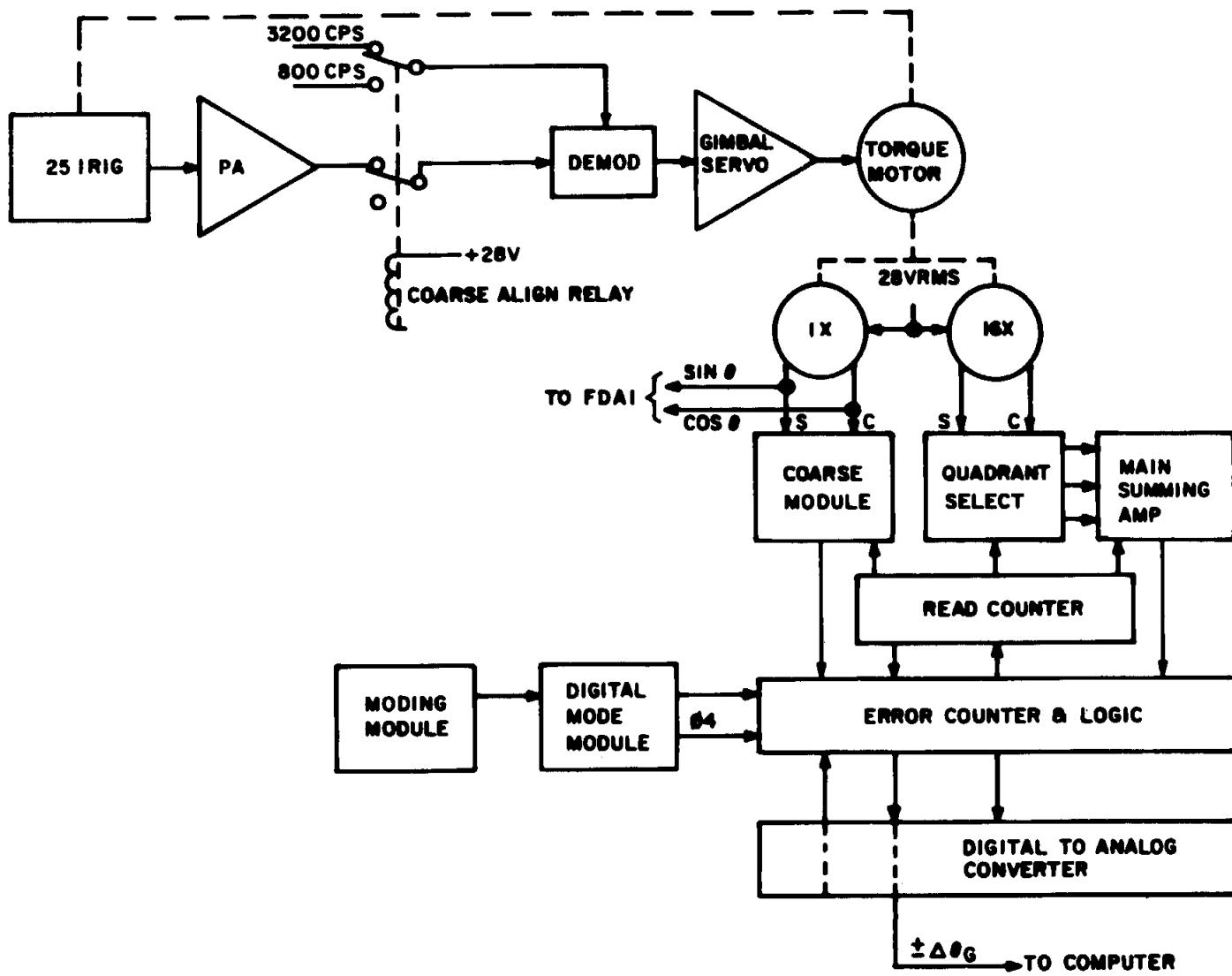
FINE ALIGN MODE



INERTIAL REFERENCE MODE



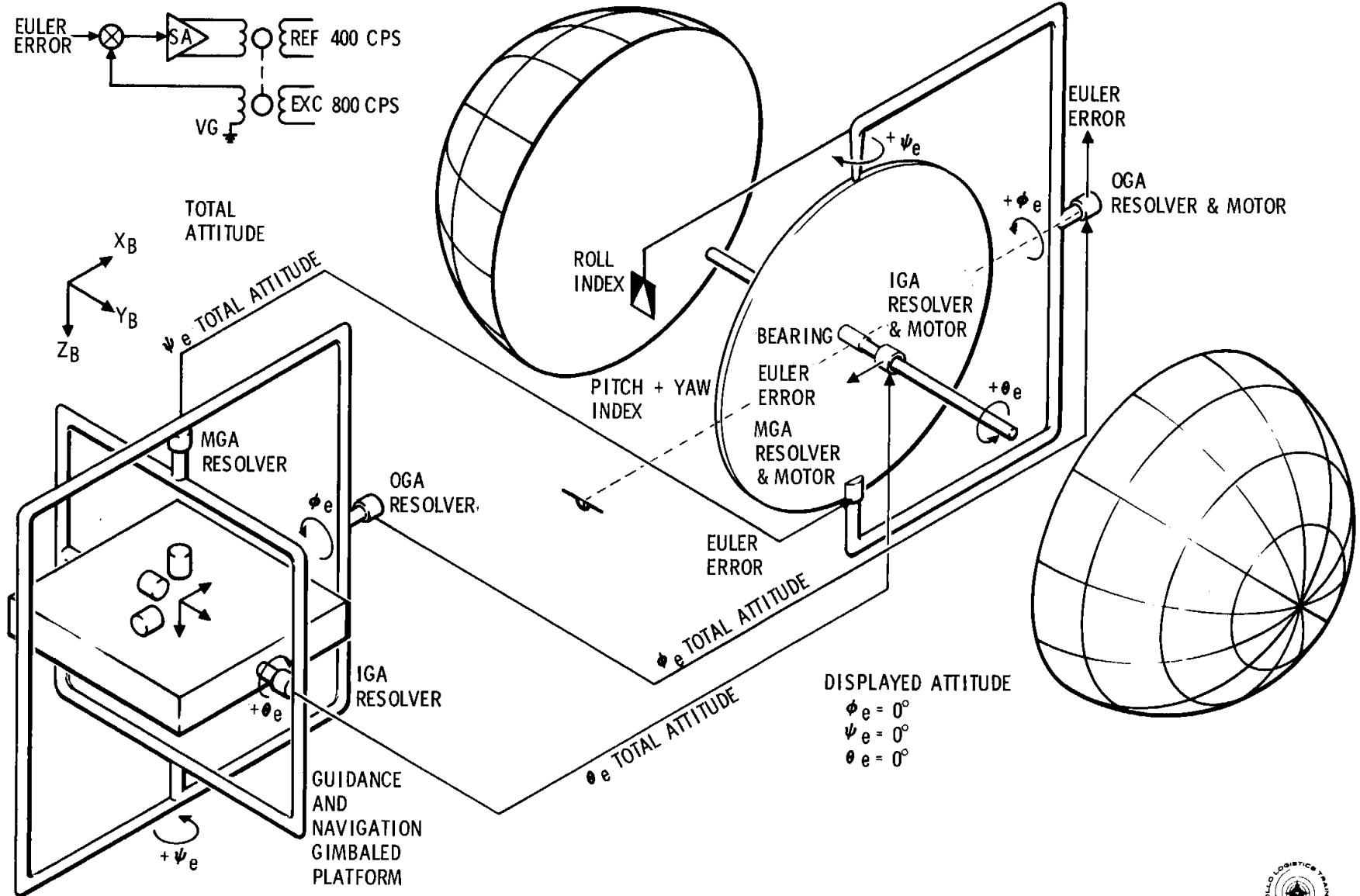
INERTIAL REFERENCE MODE



GNC-121

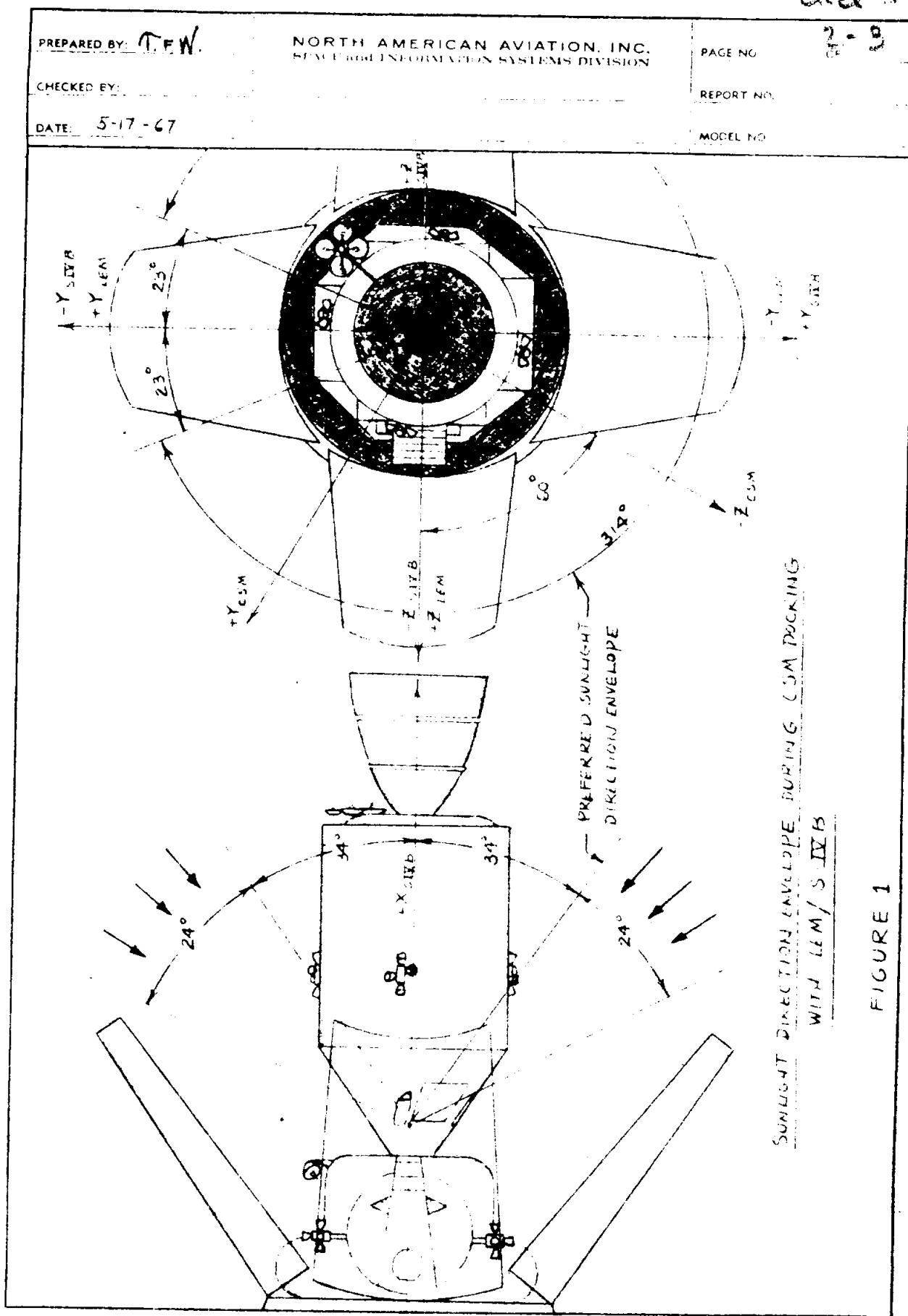


FDAI/IMU GIMBAL RELATIONSHIP

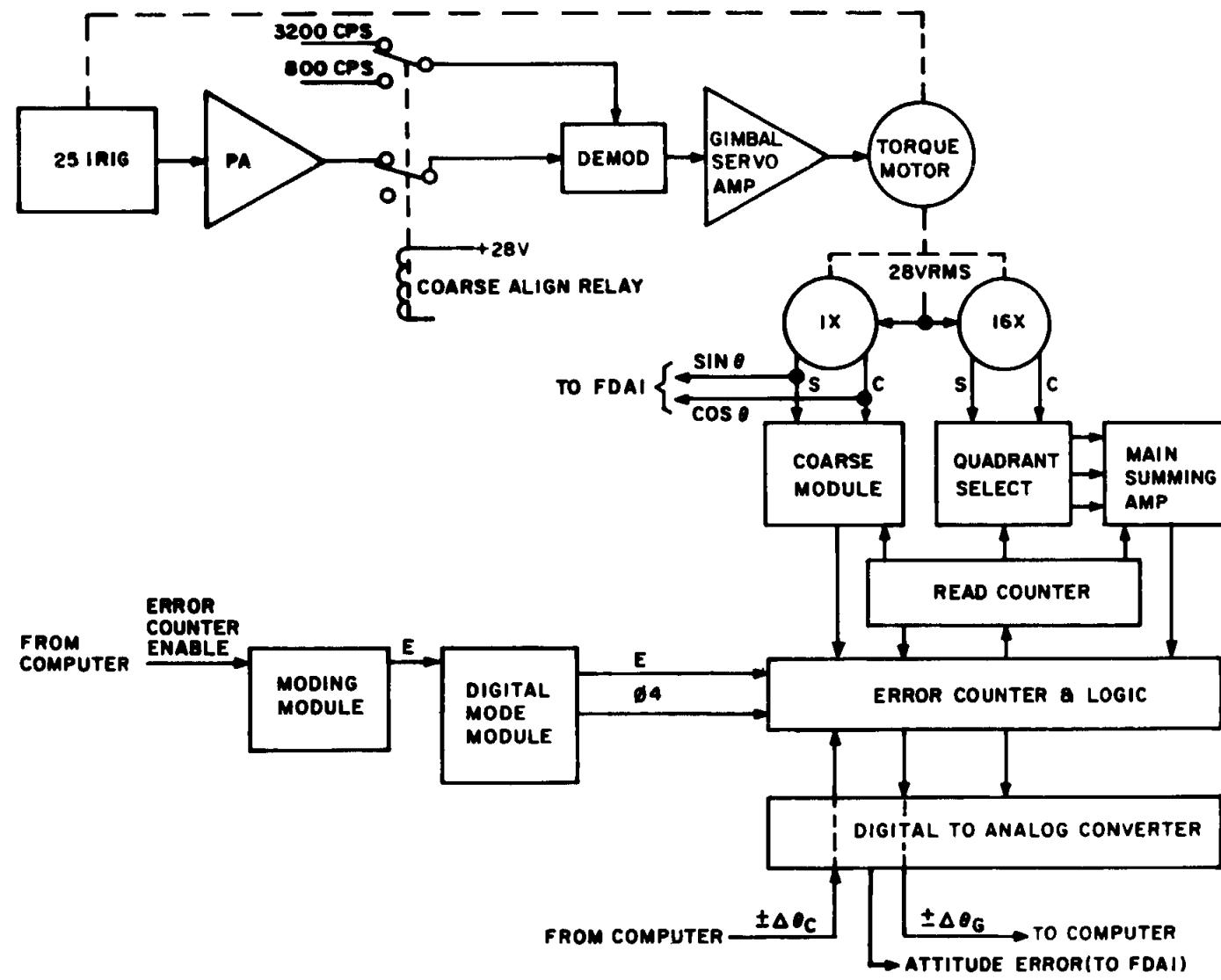


SCS-2203A





ATTITUDE ERROR DISPLAY



GNC-120

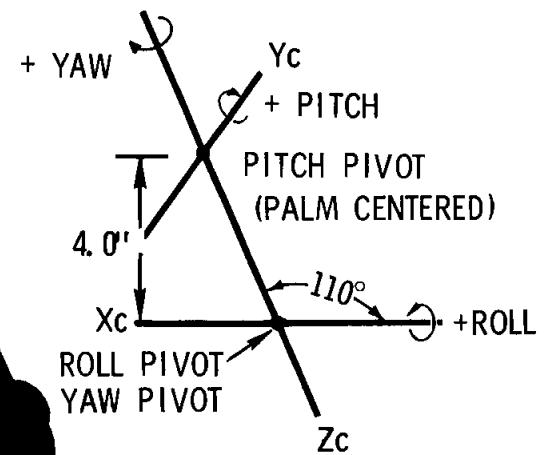
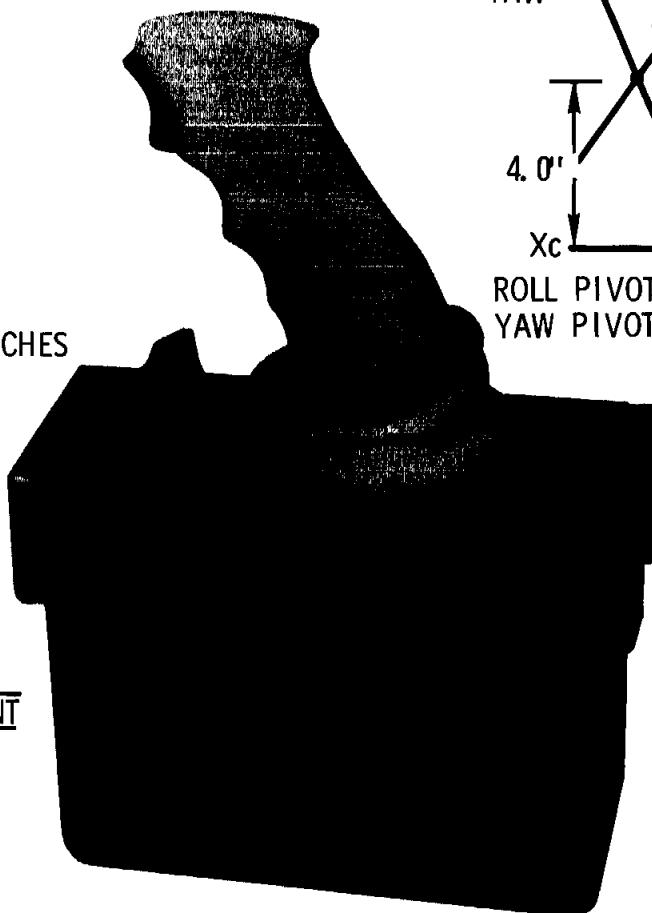
ROTATION CONTROL

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

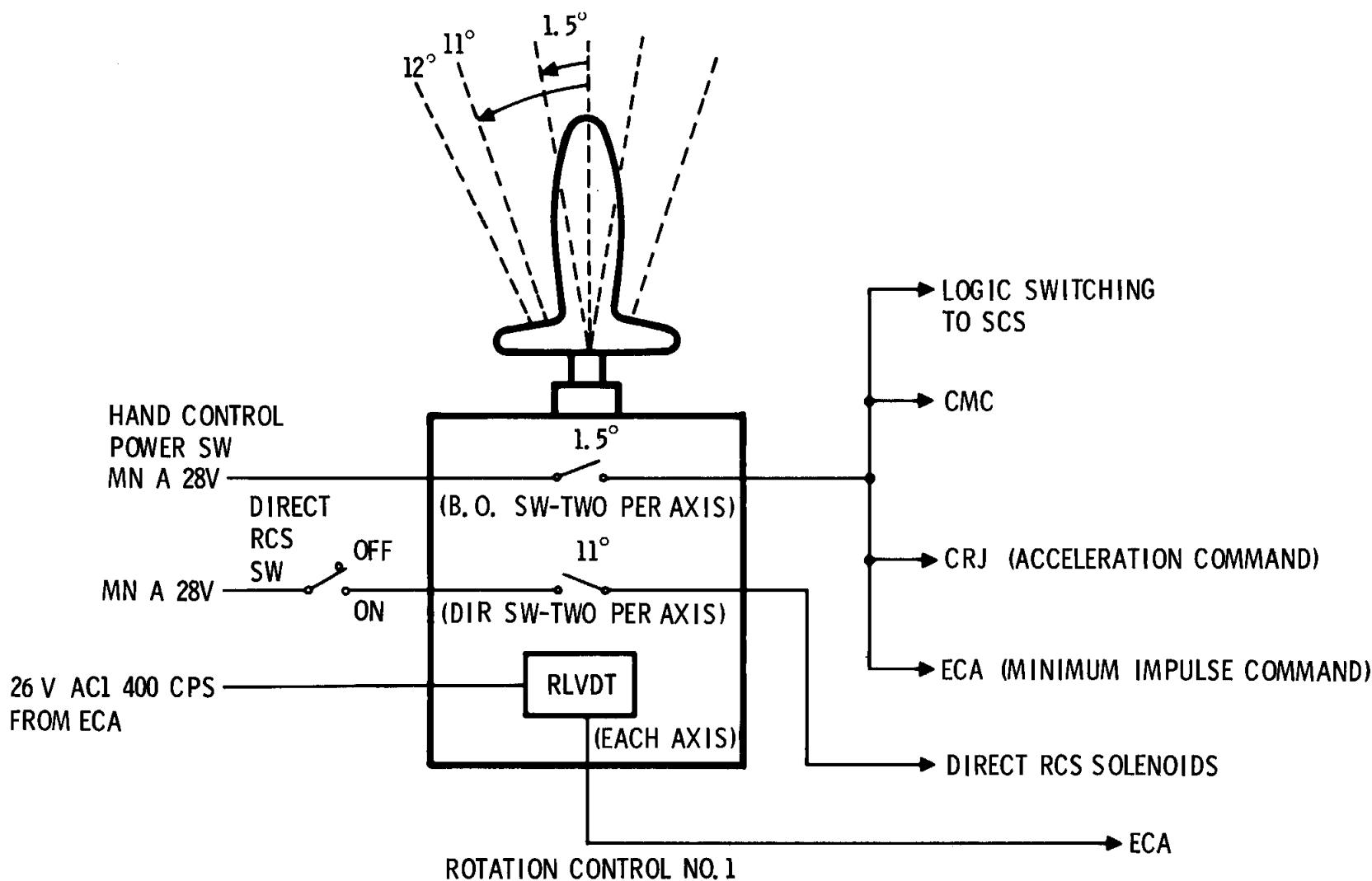
| | <u>DISPLACEMENT</u> |
|---------------------------|---------------------|
| HARD STOP | 11.5±0.50 |
| DIRECT SWITCH ACTUATION | ≈11.0° |
| SOFT STOP | 10±1° |
| BREAKOUT SWITCH ACTUATION | 1.5± 0.5° |
| CONTROLLER LOCK TO ARM | 50.0° |



SCS-2002B



ROTATION CONTROL INTERFACES



TRANSLATION CONTROL

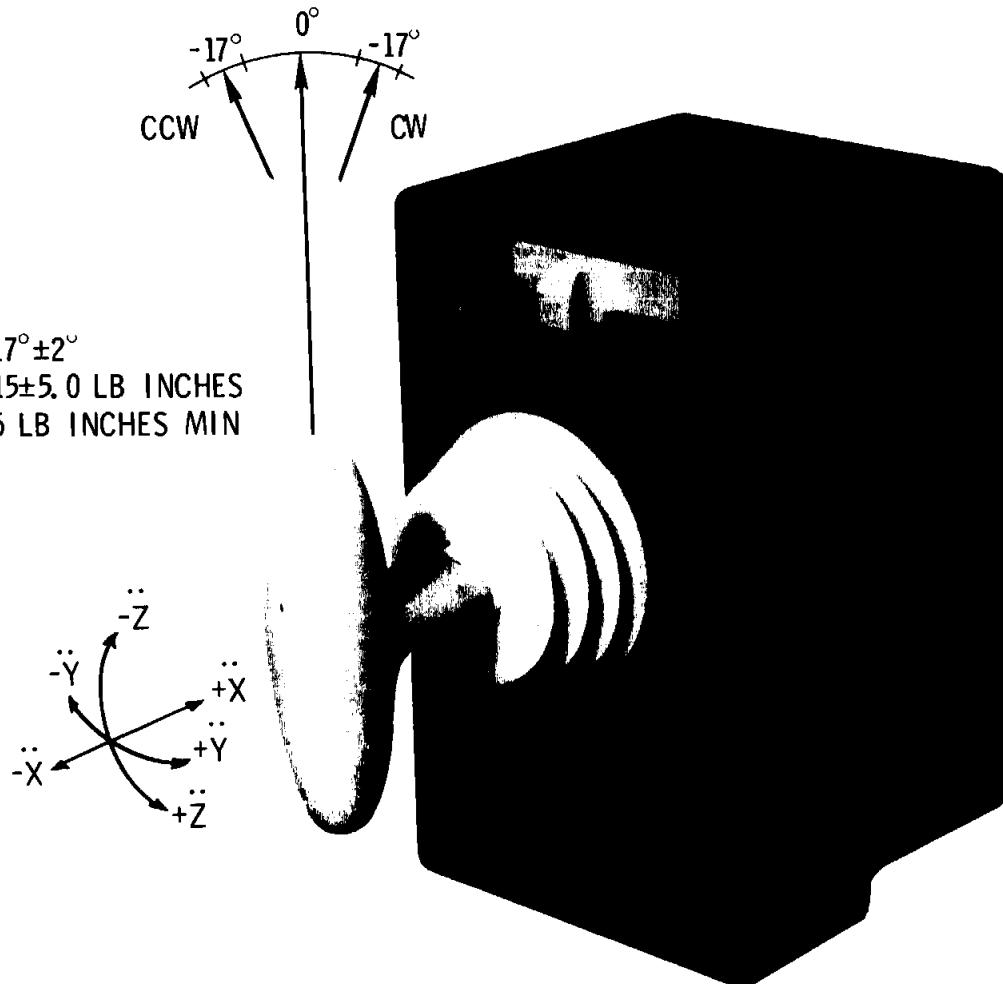
CW & CCW CONTROL MOTION LIMITS

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

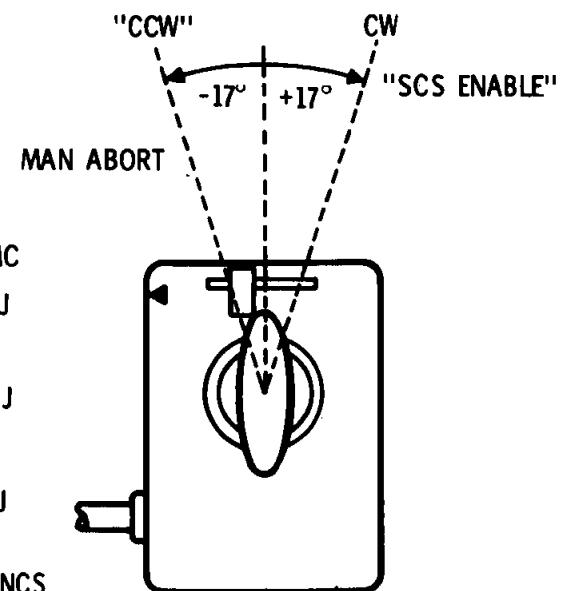
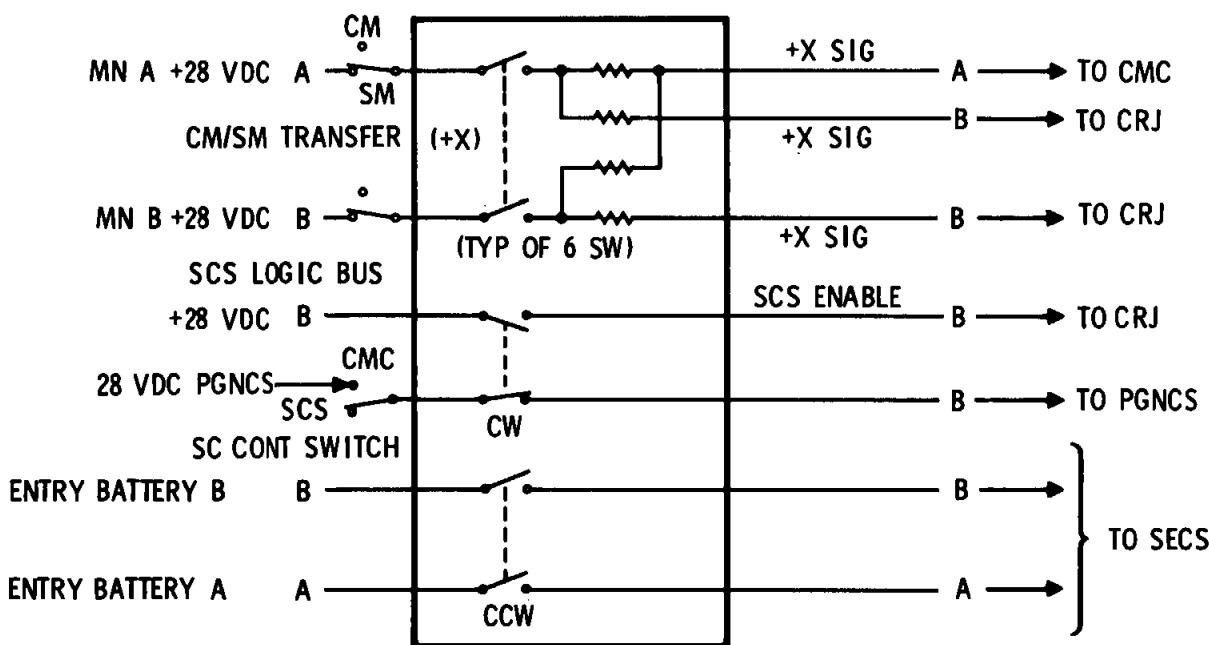
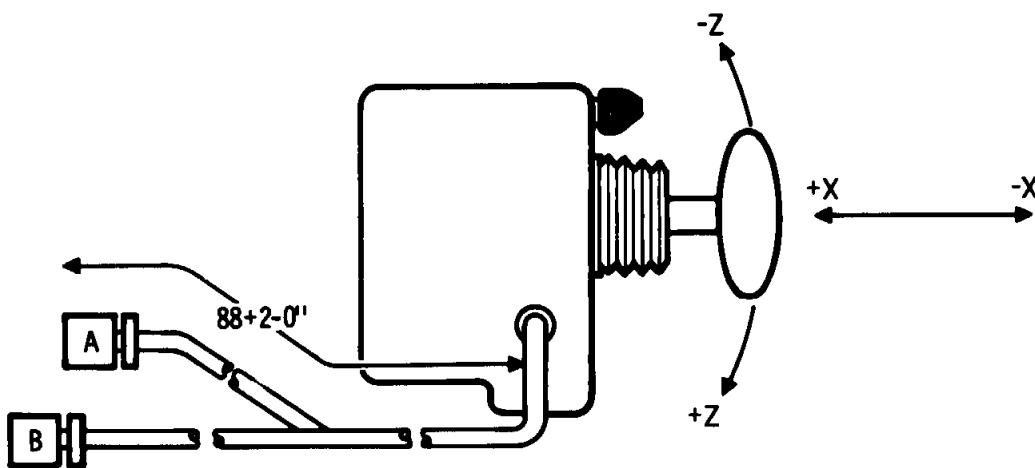
$17^\circ \pm 2^\circ$
 15 ± 5.0 LB INCHES
6 LB INCHES MIN

TRANSLATION CONTROL MOTION LIMITS

| | |
|----------------|----------------------------------|
| MAXIMUM | ± 0.5 INCHES |
| SWITCH CLOSURE | ± 0.375 $+0.025$ -0.075 |
| FORCE | 2.1 ± 0.3 POUNDS |

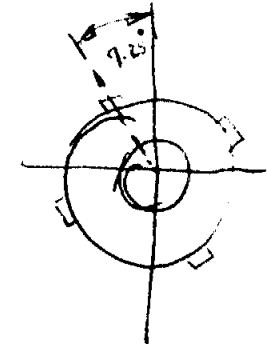
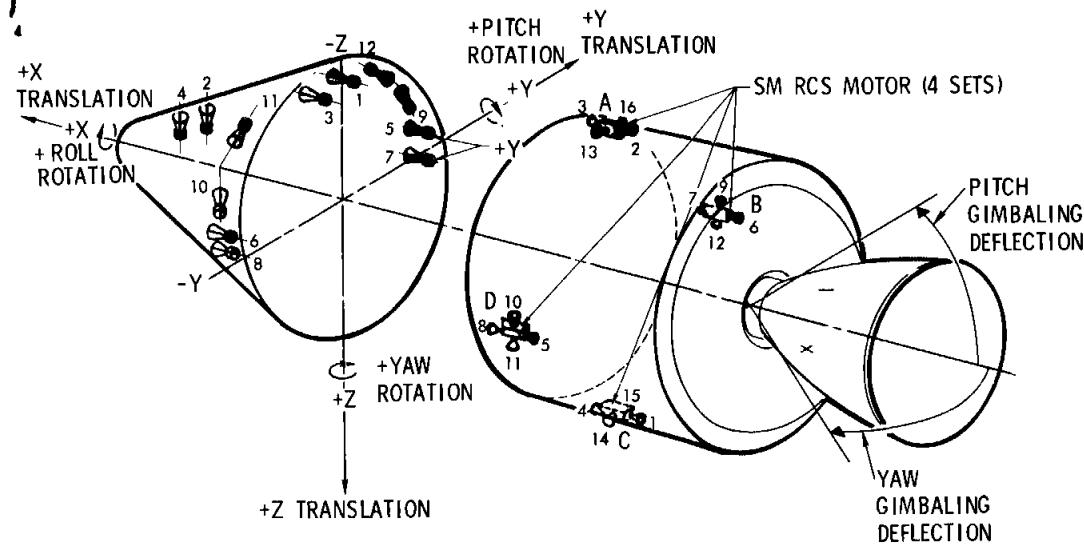


TRANSLATION CONTROL INTERFACES



SM JET FUNCTIONS

Could deorbit with the
cm RCS only!



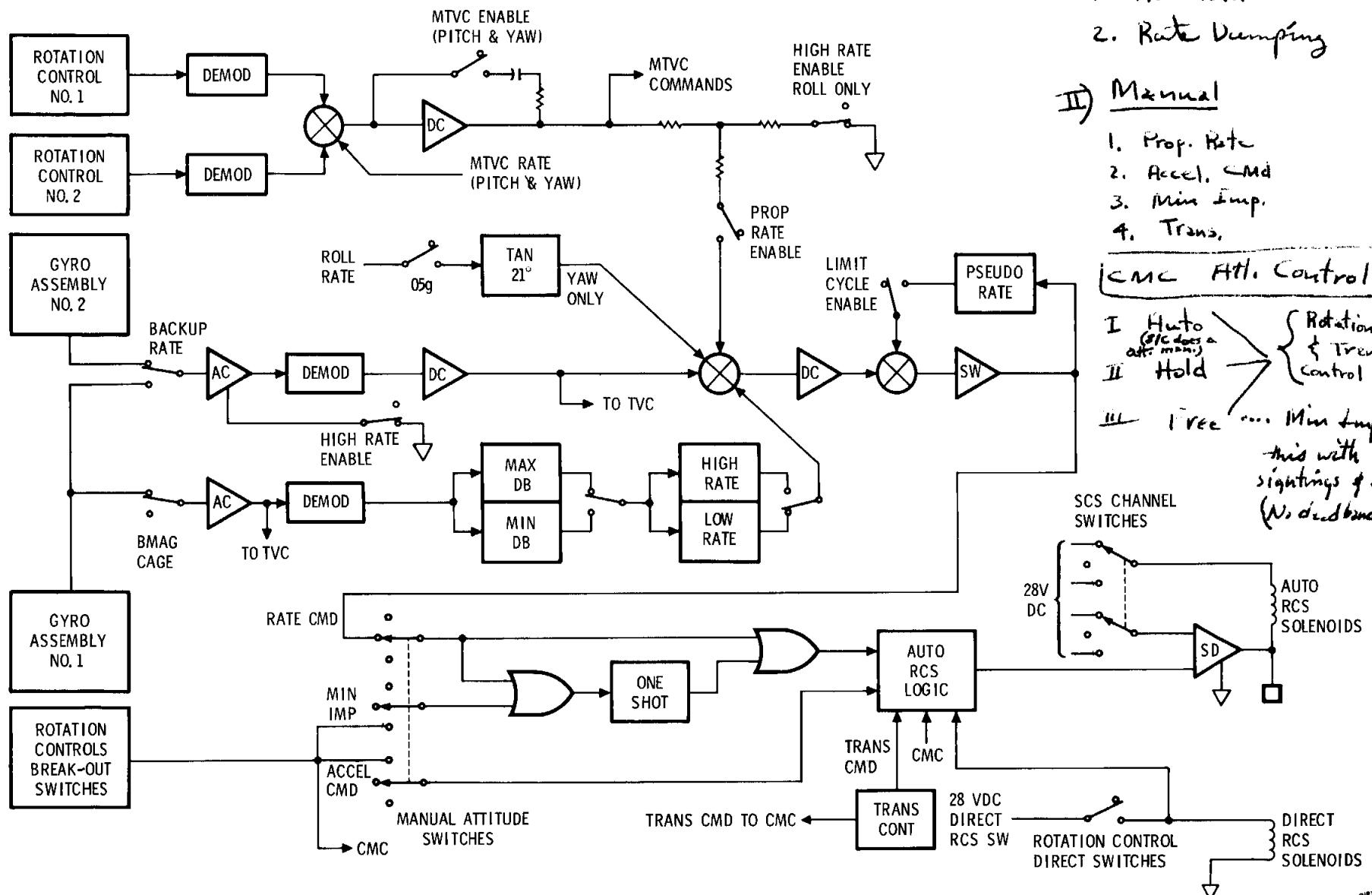
| RCS ENG NO. | COMMANDS | QUAD | CHANNEL | CHANNEL SWITCH A POSITION B |
|-------------|----------|------|---------|-----------------------------|
| 1 | +X +θ | C | PITCH | A CB'S B |
| 2 | +X -θ | A | PITCH | A CB'S B |
| 3 | -X +θ | A | PITCH | B CB'S A |
| 4 | -X -θ | C | PITCH | B CB'S A |
| 5*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

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

* SM ONLY

SCS ATTITUDE CONTROL

FUNCTIONAL OPERATION



SCS Att. Control

Auto

1. Att. hold

2. Rate Dumping

Manual

1. Prop. Rate

2. Accel. Cmd

3. Min Imp.

4. Trans.

CMC Att. Control (Logic)

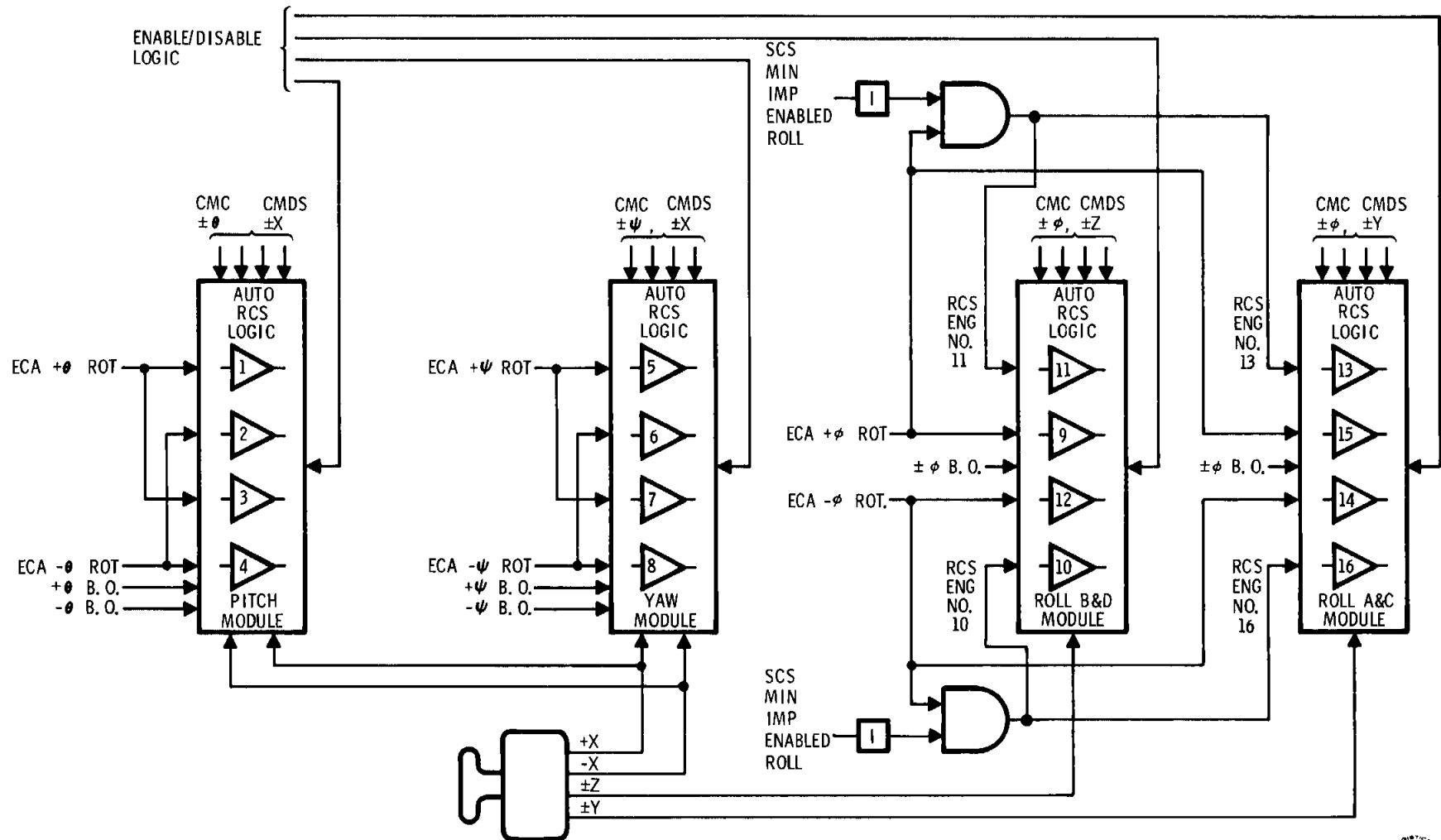
I Auto (CMC does auto man.) → {Rotation Control + Translation Control OVERRIDE}

II Hold → ... Min Imp. - use this with star sightings of alignments (No deadband required)

III Free ... Min Imp. - use this with star sightings of alignments (No deadband required)

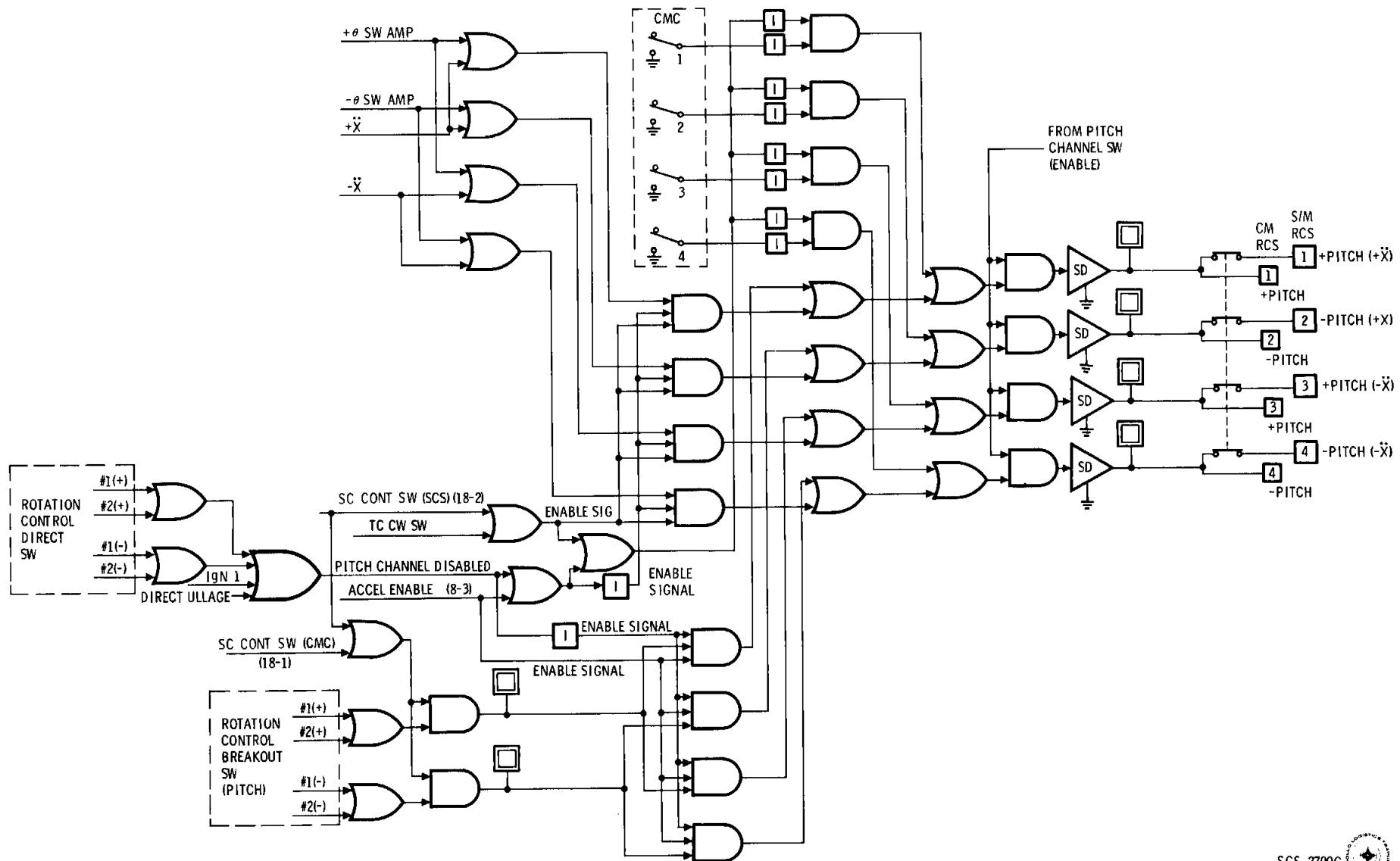


AUTO RCS LOGIC SIG FLOW

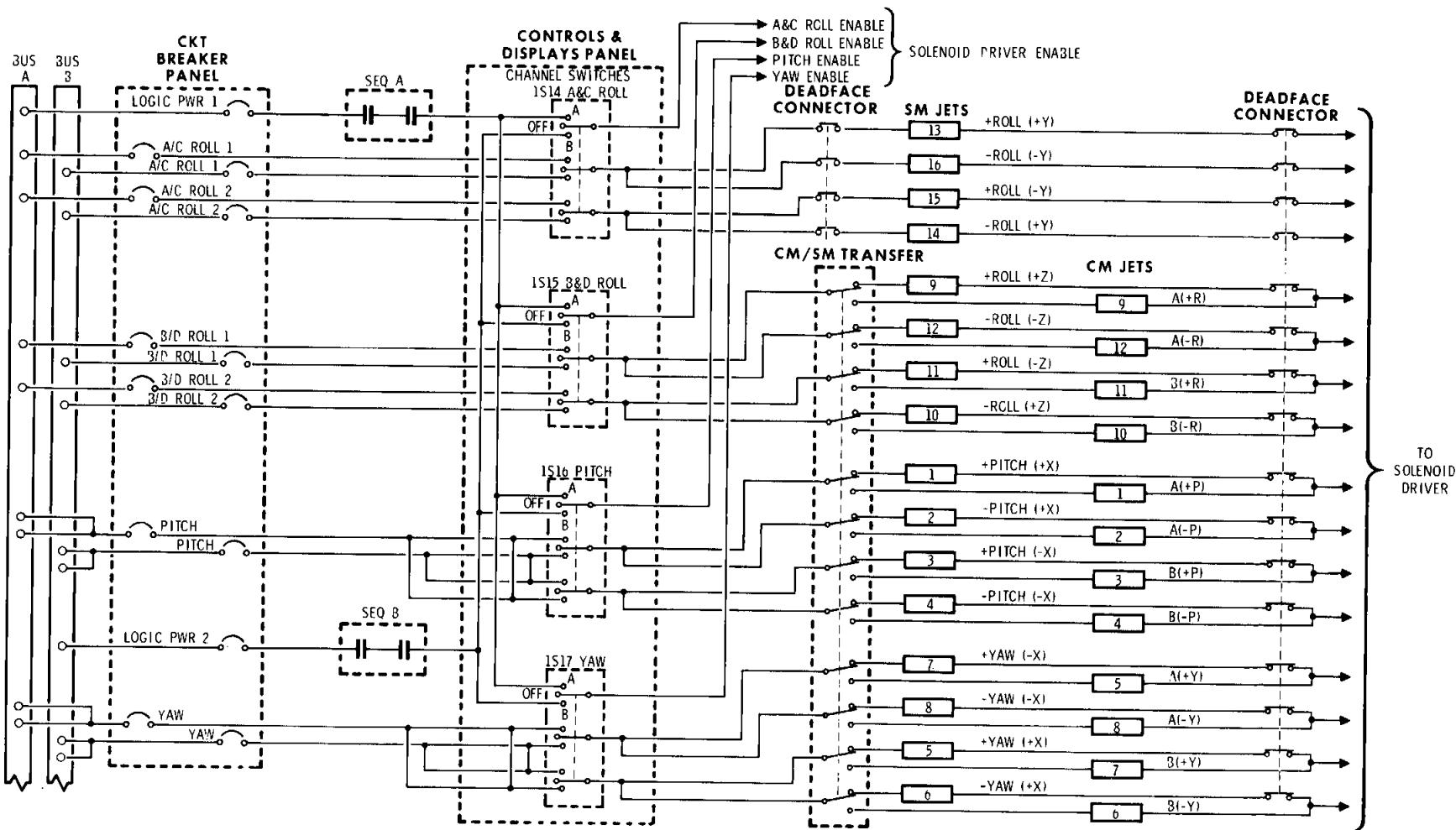


AUTO RCS LOGIC

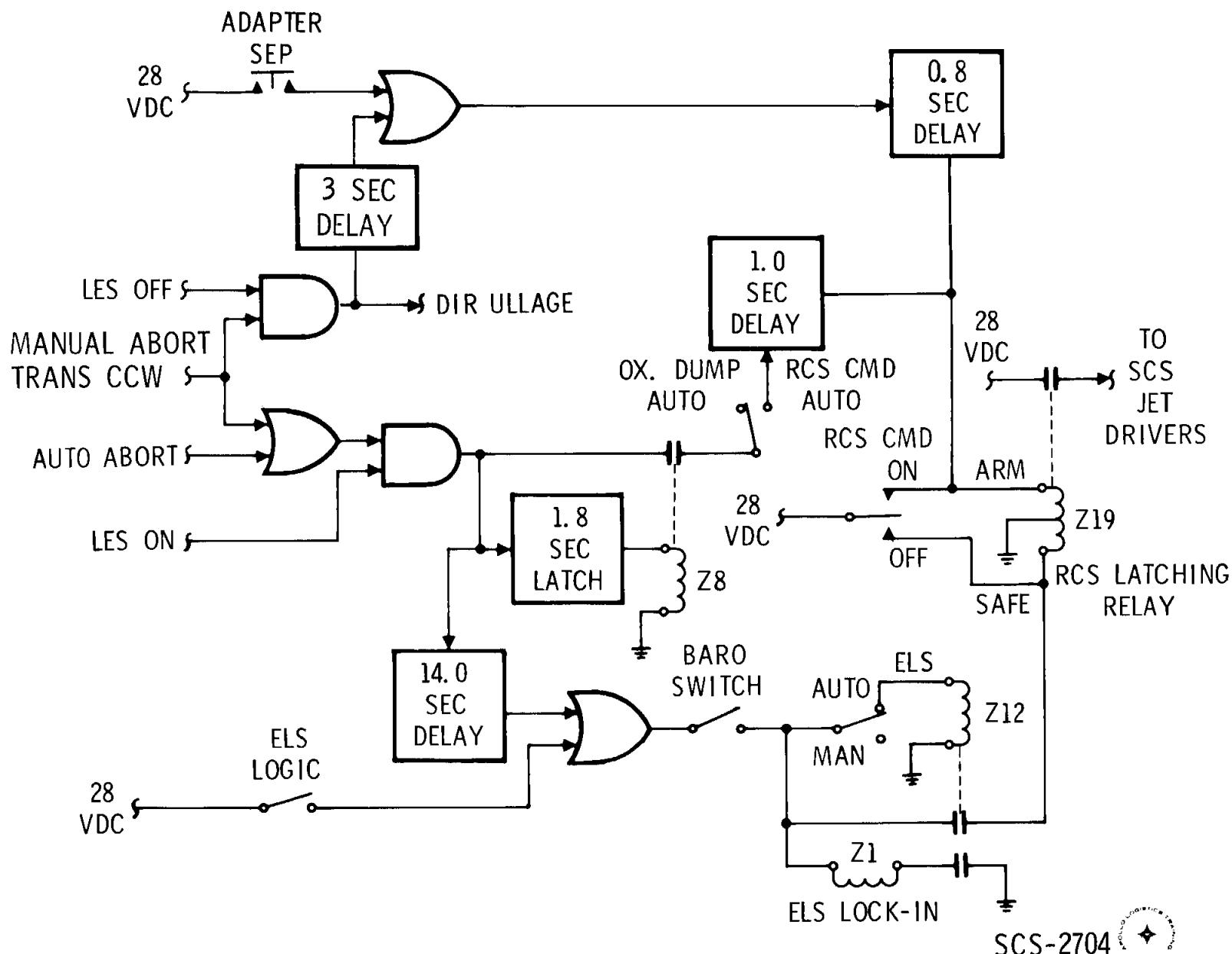
TYPICAL CHANNEL (PITCH)



ENABLING POWER - AUTO RCS

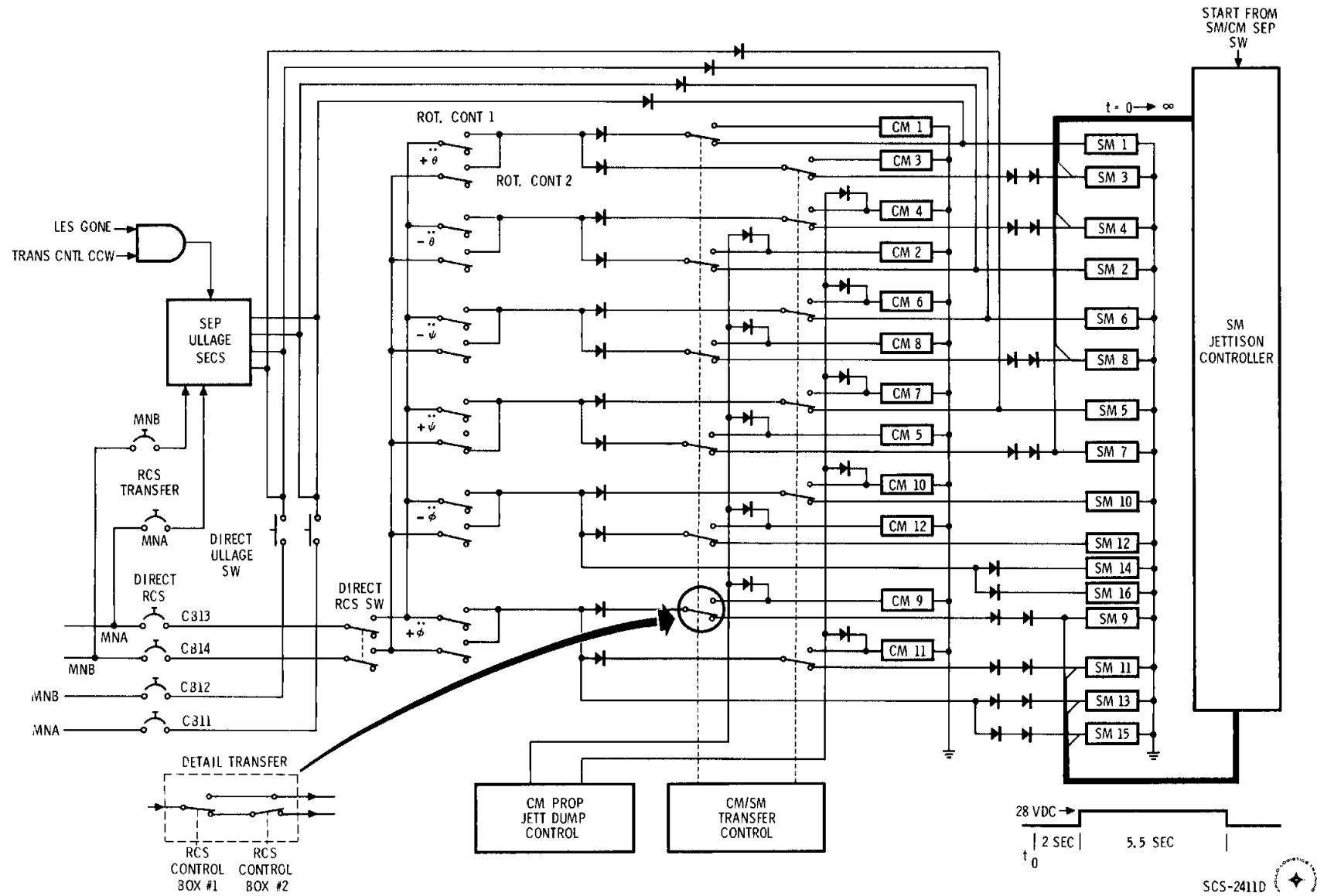


RCS LATCHING RELAY LOGIC



SCS-2704

DIRECT CONTROL LOOP



ACS CONTROL CAPABILITIES

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

(1) NOT REQUIRED TO ENABLE A PARTICULAR FUNCTION.

INDICATES DESIRED POSITION FOR RCS PROPELLANT CONSERVATION.

(2) IF B.O. SW IS OPEN THE S/C WILL BE IN FREE DRIFT.

(3) IF "ON", DIRECT SW IN ROTATION CONTROL MUST BE "OPEN".

(4) MAXIMUM RATE ATTAINABLE IS FUNCTION OF RATE-HIGH/LOW SWITCH

GENERAL COMMENTS:

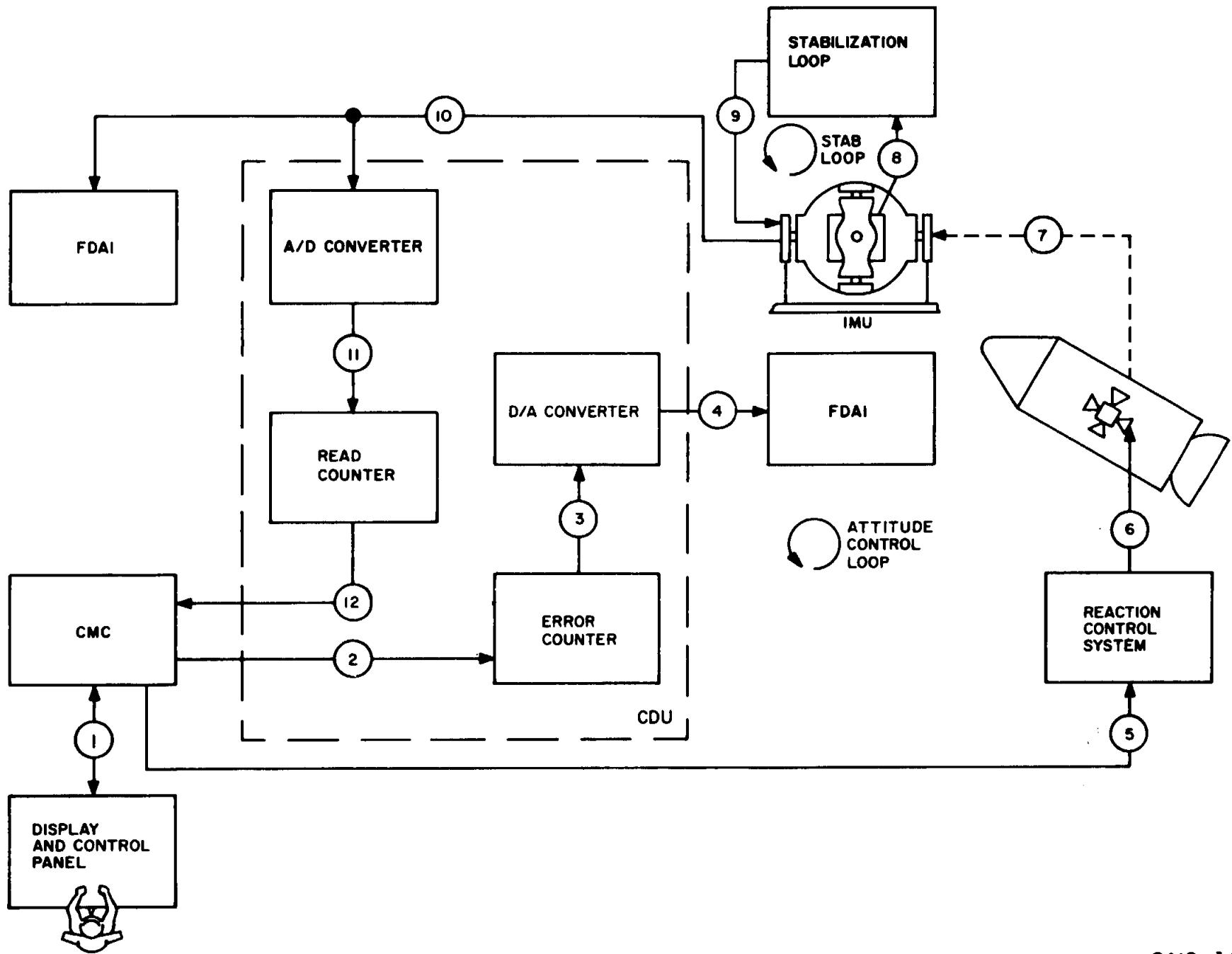
A. THE CAPABILITIES, IN GENERAL, ARE LISTED IN ORDER OF THEIR PRIORITY.

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

SCS-2803C

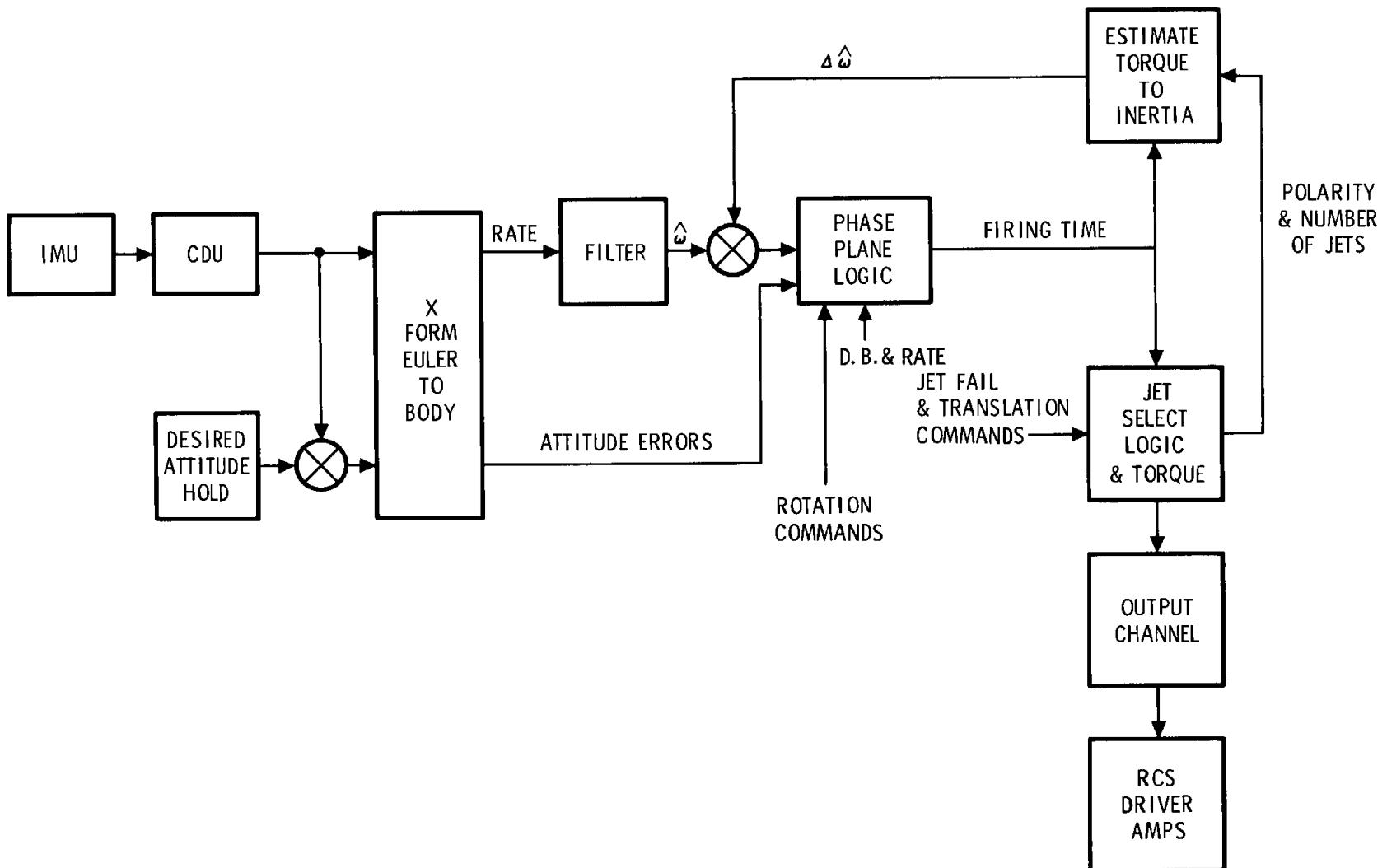


ATTITUDE CONTROL MODE

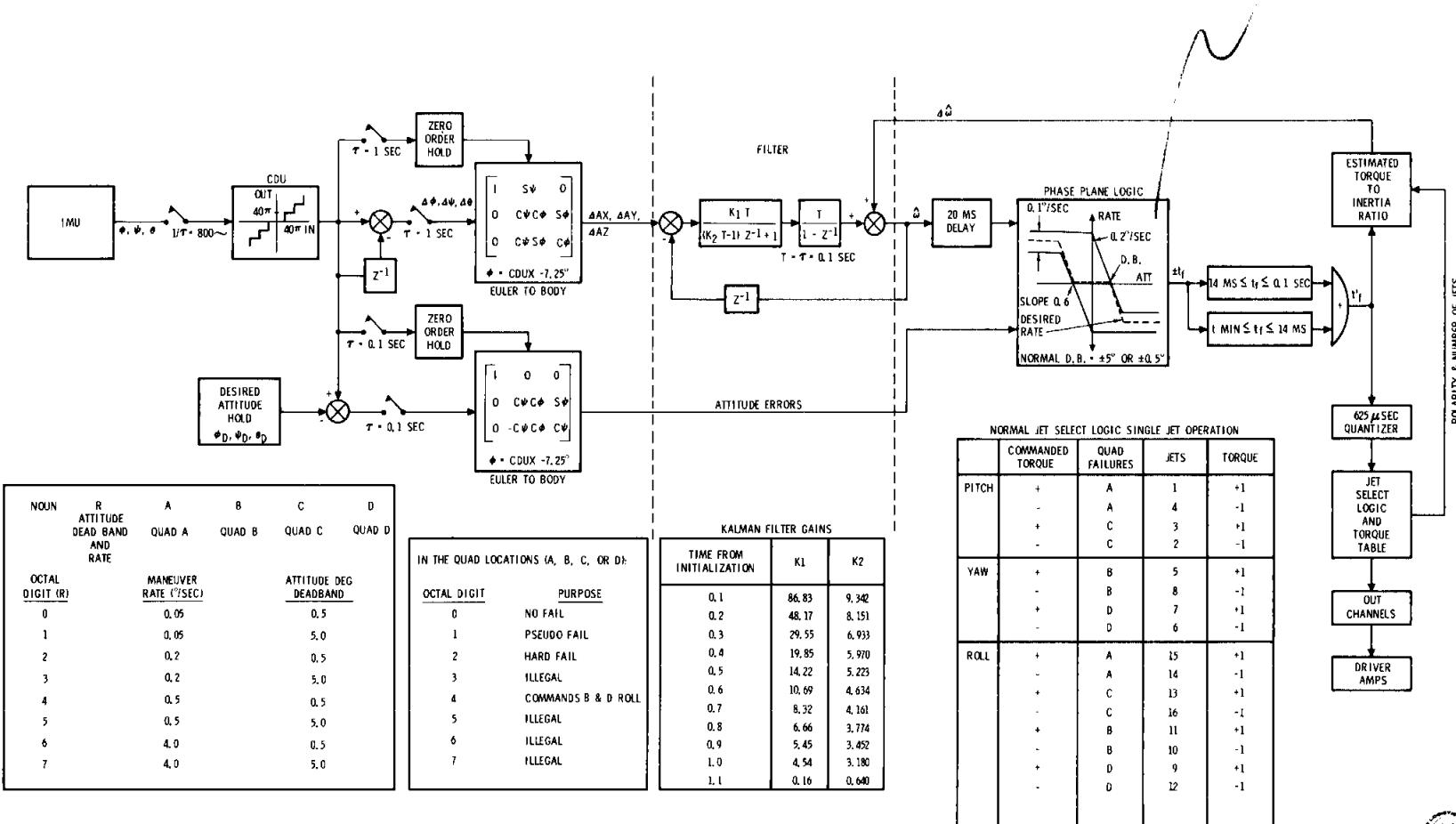


RCS DAP

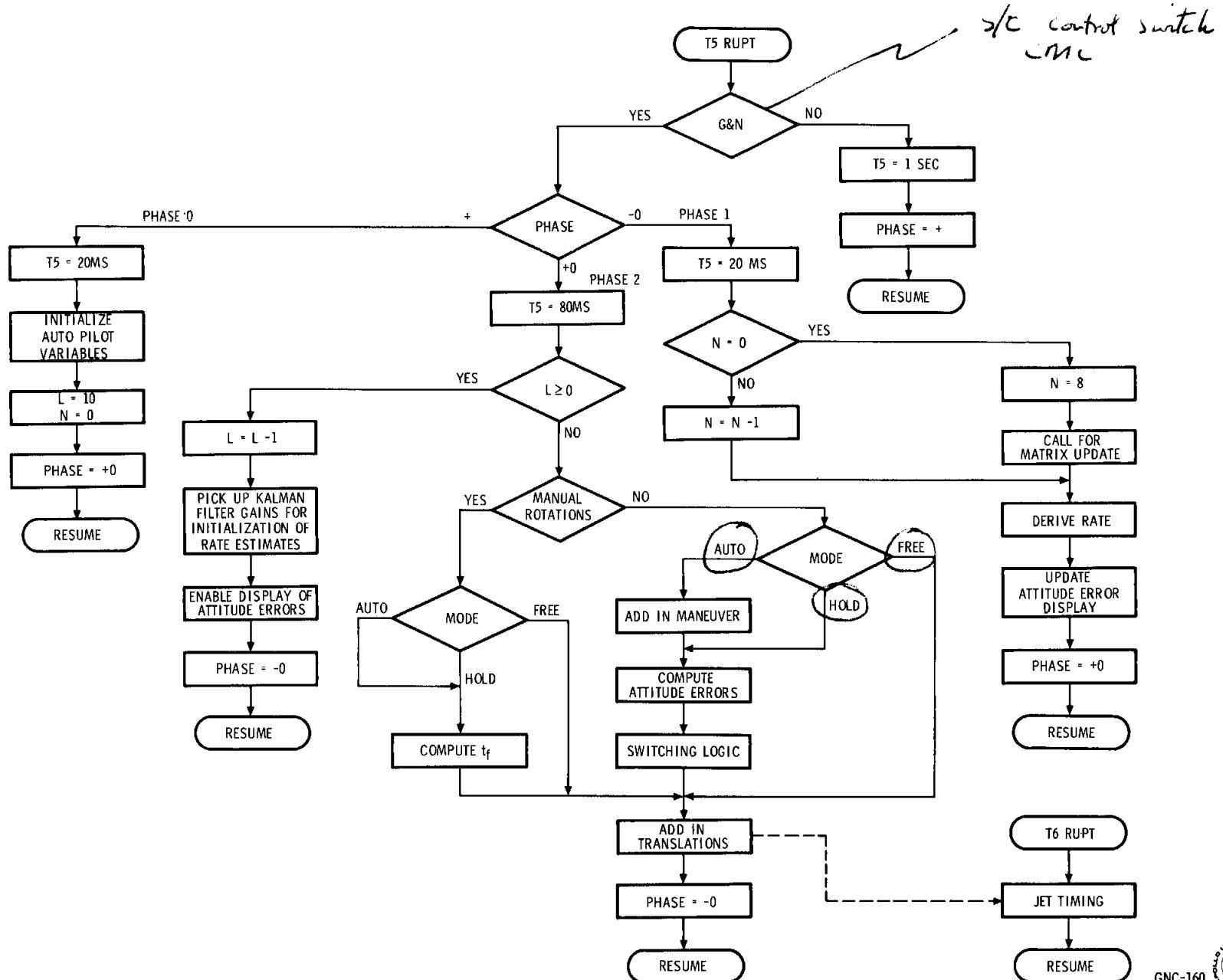
SIMPLIFIED BLOCK DIAGRAM



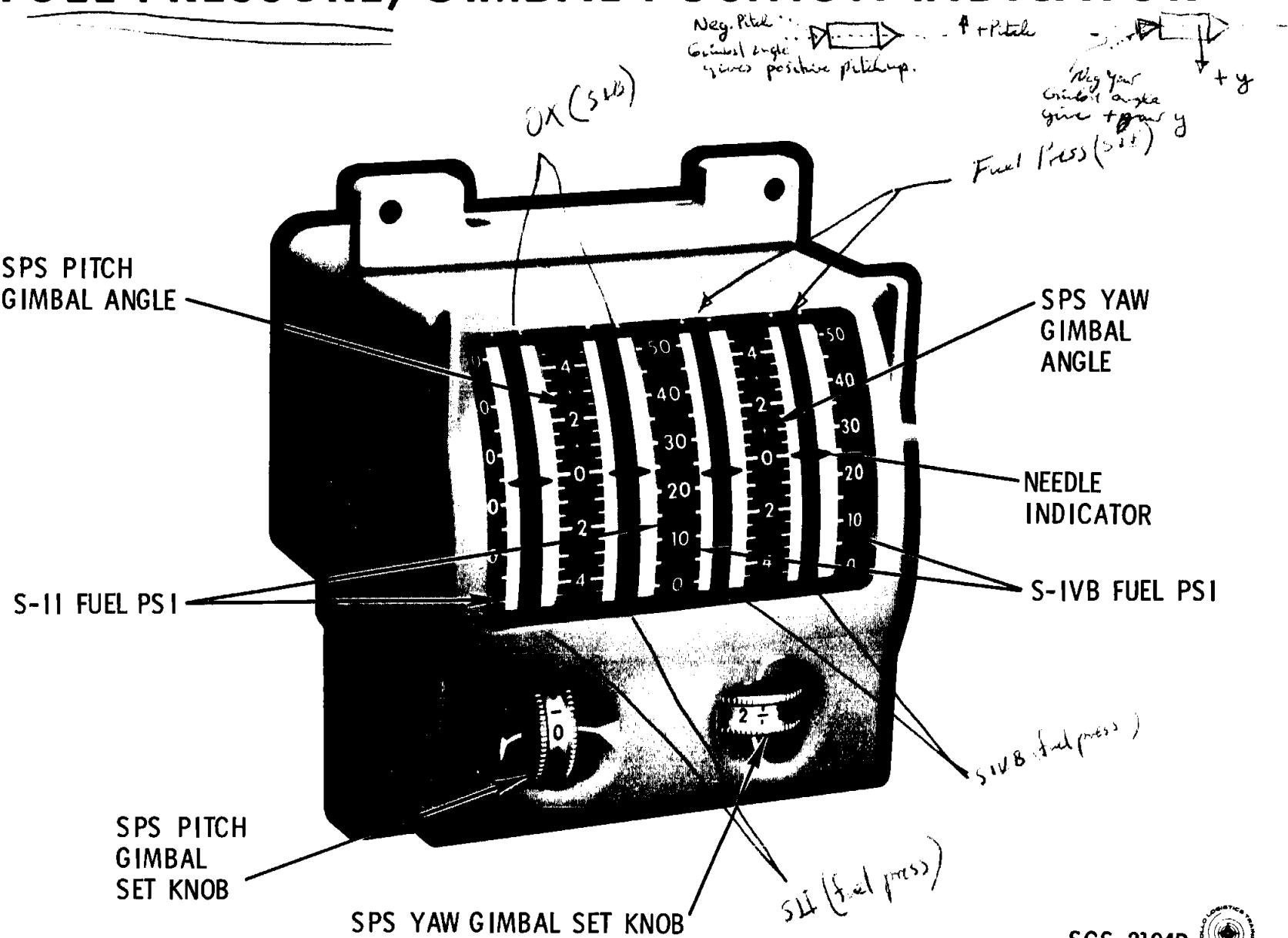
RCS DAP MODEL



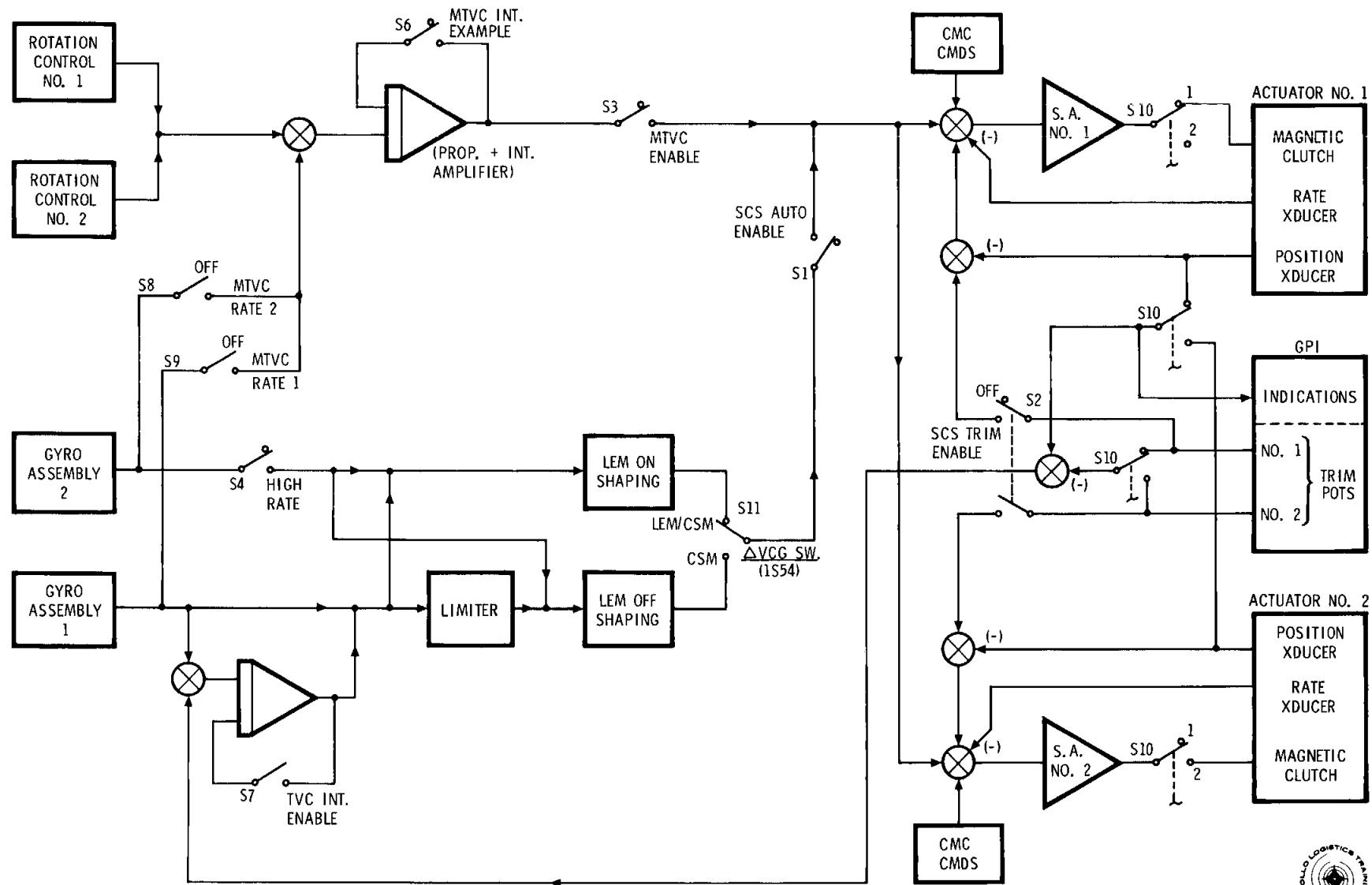
PROGRAM LOGIC FLOW RCS DAP



FUEL PRESSURE/GIMBAL POSITION INDICATOR



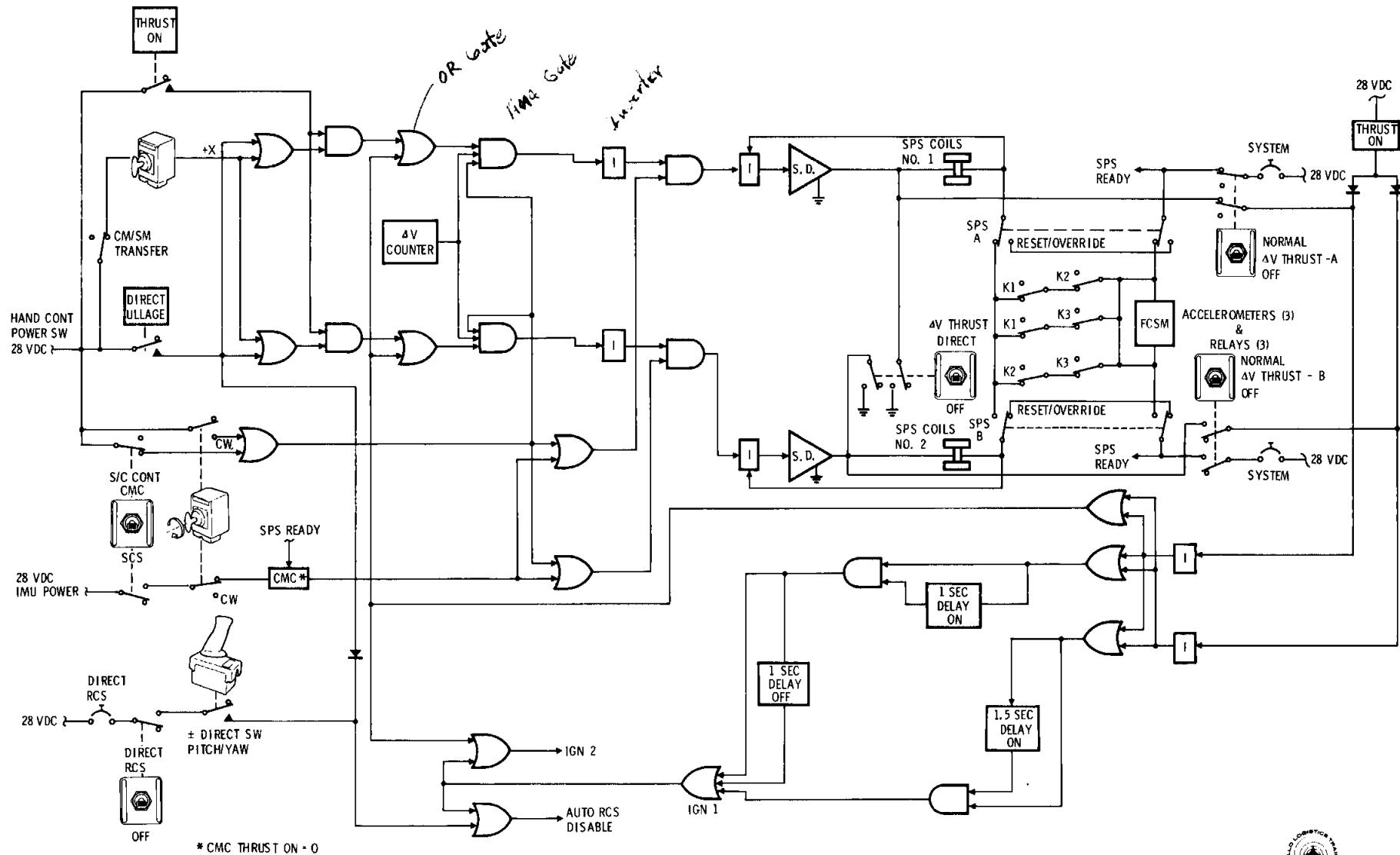
THRUST VECTOR CONTROL-SIGNAL FLOW



SCS 2314



SPS ENGINE ON-OFF LOGIC



TVC FUNCTION ENABLING LOGIC

| SYSTEM CONFIGURATION | FUNCT SW./POSITION SWITCH | PANEL SWITCHING AND LOGIC FOR ENABLING FUNCTIONAL SWITCH POSITION | | | | | | | | | | | | |
|----------------------|---------------------------|---|-----|--------|--------------|--------|------|----------|-----------|---|------|---|-----------------|---------------------|
| | | SCS | CMC | RATE 2 | ATT 1/RATE 2 | RATE 1 | AUTO | RATE CMD | ACCEL CMD | 1 | AUTO | 2 | XLATION CONTROL | FAIL SENSE (P OR Y) |
| SCS AUTO TVC (1) | S1 SCS AUTO ENABLE | X | | | (2) | | X | | | | | | X | |
| | S2 SCS TRIM ENABLE | X | X | | | | X | | | | | | X | |
| | S4 (3) HIGH RATE | | | | | | | | | | | | | X(3) |
| | S7 TVC INT. ENABLE | X | | | | | | | | | | | | X |
| | | | X | | | | | | | | | | X | X |
| COMMON FUNCTION | S3 MTV C ENABLE | X | | | | | | X OR X | | | | | | |
| | | X | | | | | X | | | | | | X | |
| | | | X | | | | | X OR X | | | | | X | |
| M T | S6 MTV C INT. ENABLE | SWITCH POSITIONS ARE SAME AS FOR S3 BUT LOGIC REQUIRES 'IGN 2' SIGNAL | | | | | | | | | | | | |
| V C RATE CMD | S8 MTV C RATE 2 OR | X | | X OR X | | | | X | | | | | | X |
| | | X | | X OR X | | | X | | | | | | X | X |
| | | | X | X OR X | | | | X | | | | | X | X |
| ACCEL CMD | S8 AND S9 OFF | | | | | | | | X | | | | | |
| SERVO NO. 1 | S10 1 | | | | | | | | | X | | | | |
| SERVO NO. 2 | S10 2 | | | | | | | | | | X | | | |
| | | | | | | | | | | | 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).

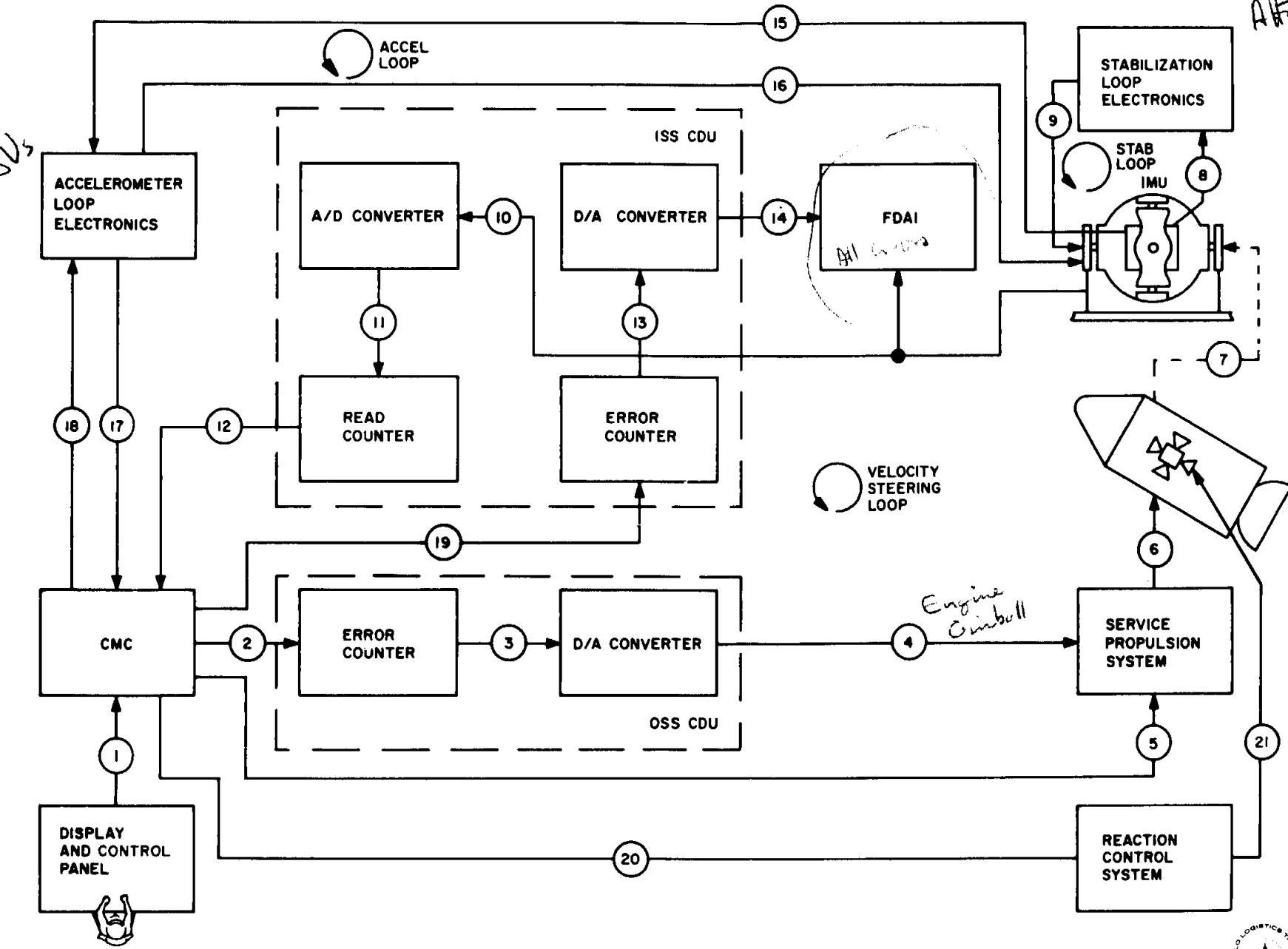
SCS-2802A



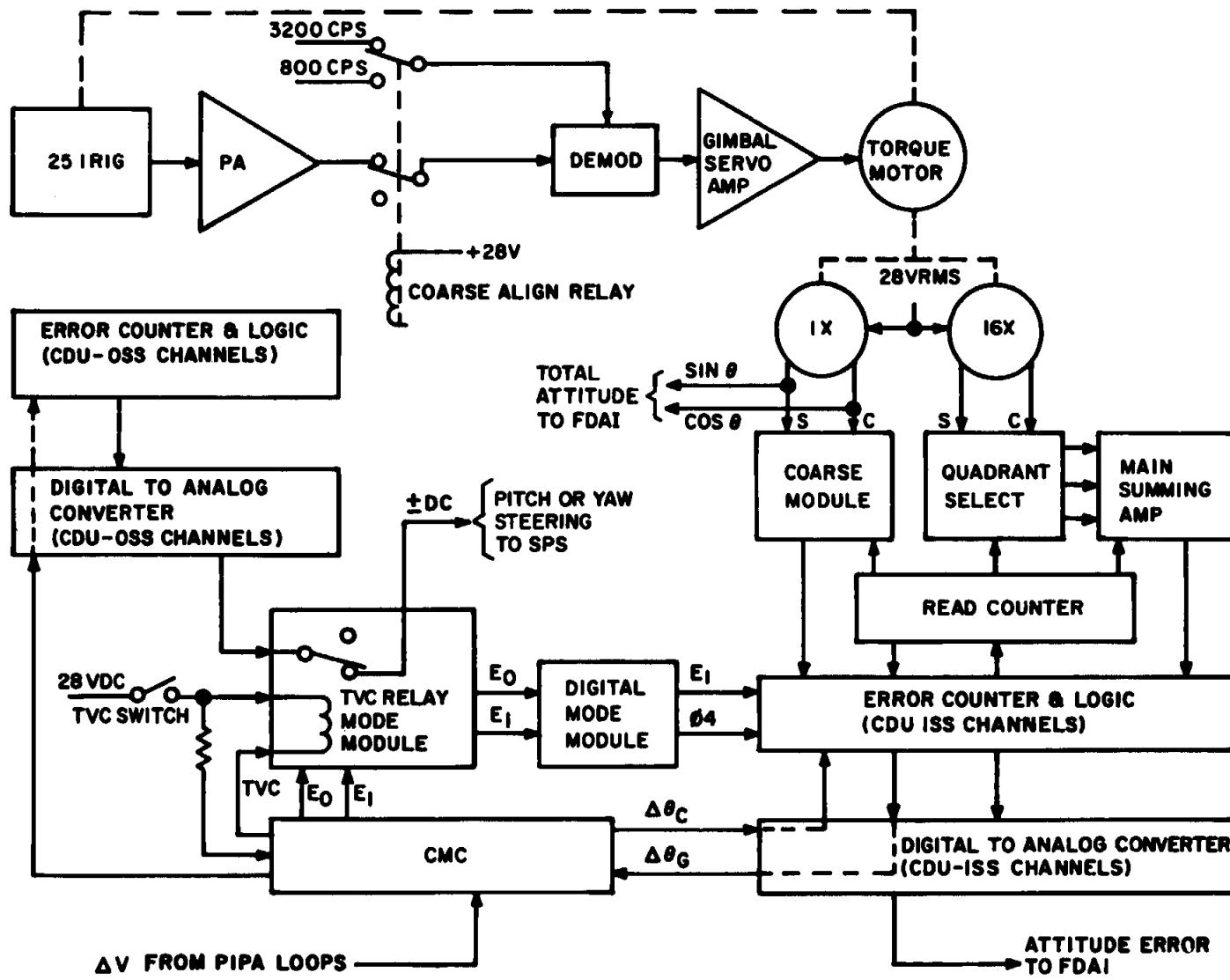
6xN

THRUST VECTOR CONTROL

Aftitude



THRUST VECTOR CONTROL

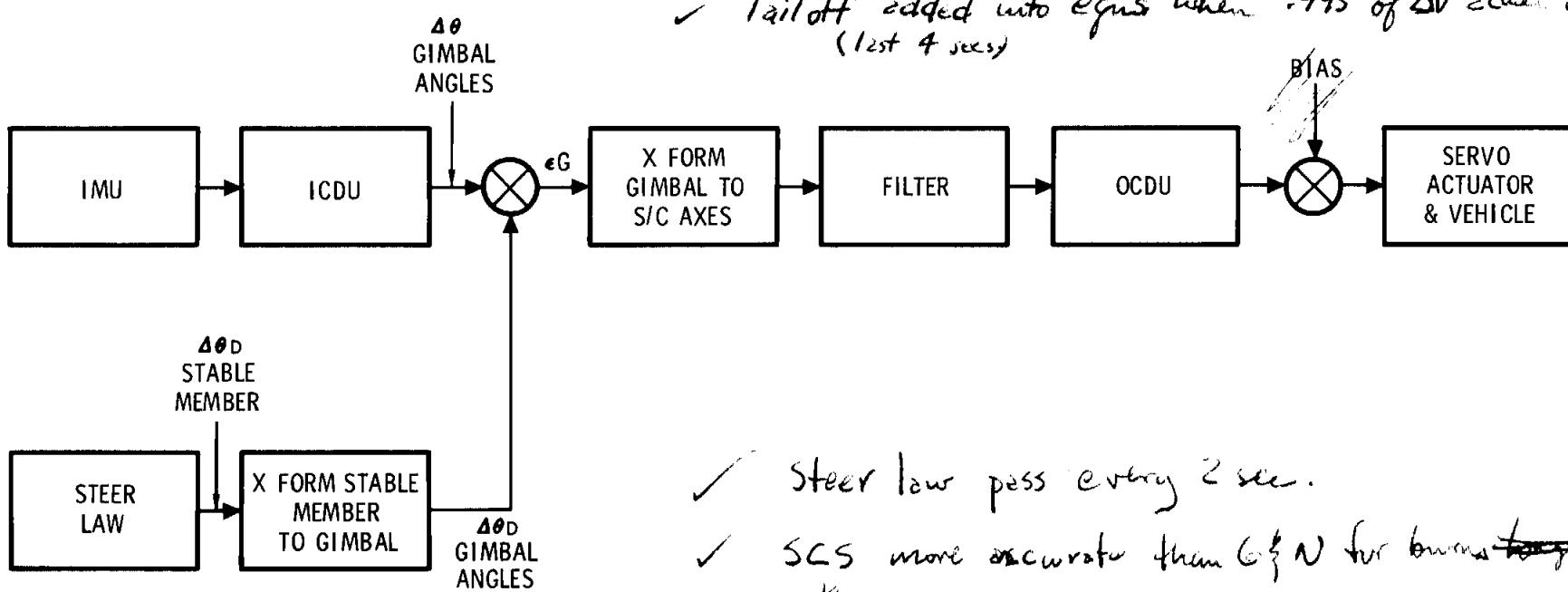


$t_{ig} \rightarrow$
 t_B left
 V_G left
 V_m vel. add so far

sundise program

TVC DAP

SIMPLIFIED BLOCK DIAGRAM



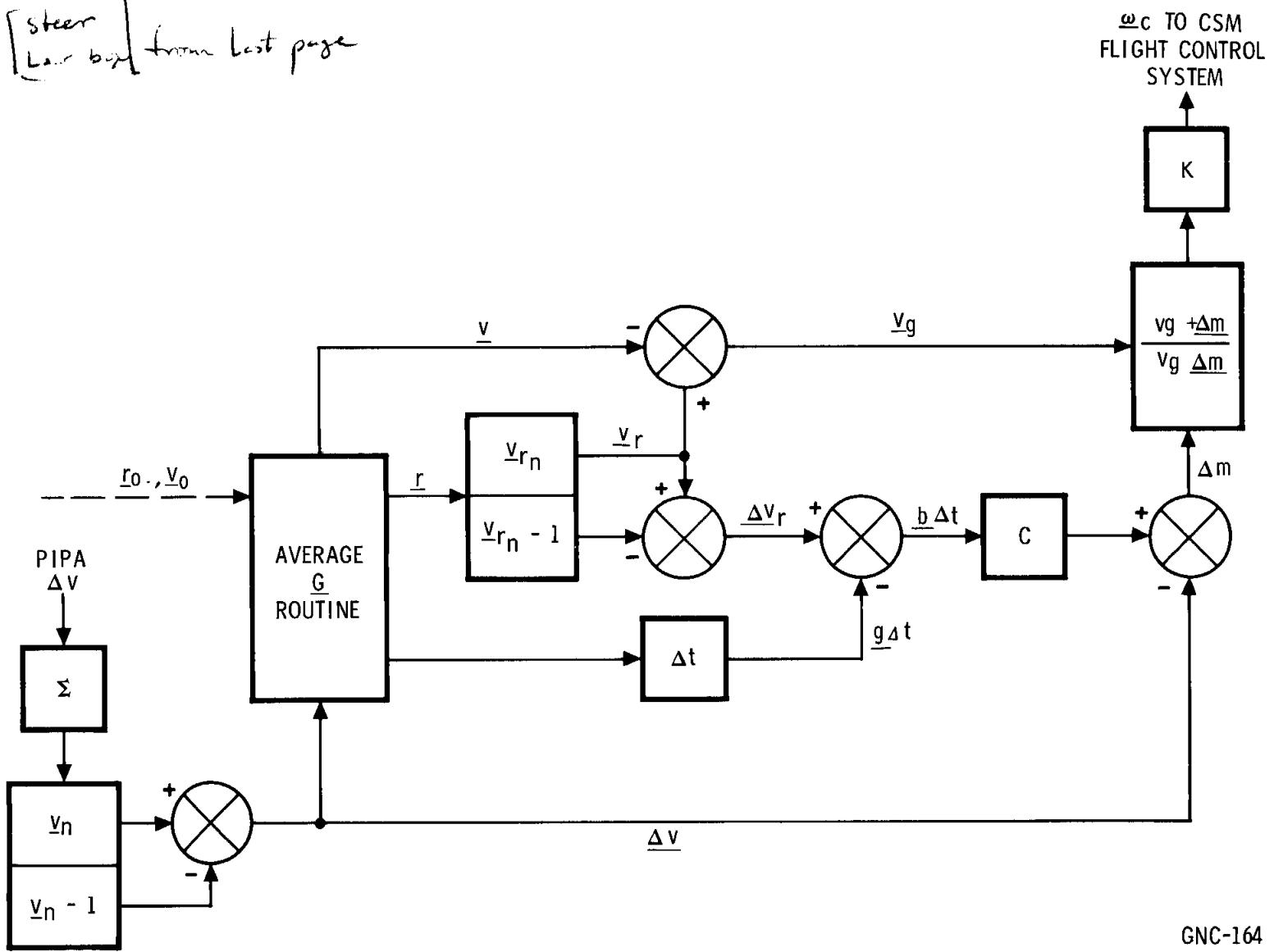
- Ⓐ ✓ No steeringcmds until after 4 sec of burn
- ✓ If burn is less than 4 sec - no steering.
- ✓ No steering in last 4 sec --- cutoff based on predicted cutoff time.
- ✓ Tailoff added into eqns when .995 of ΔV achieved (last 4 secs)

G: N only: can do a "straight" burn (fixed inertial) - SPS banking -- TEE
 ? curved burn

~~EE~~ can't do the more efficient (first) curved burn

CMC POWERED FLIGHT STEERING BLOCK DIAGRAM

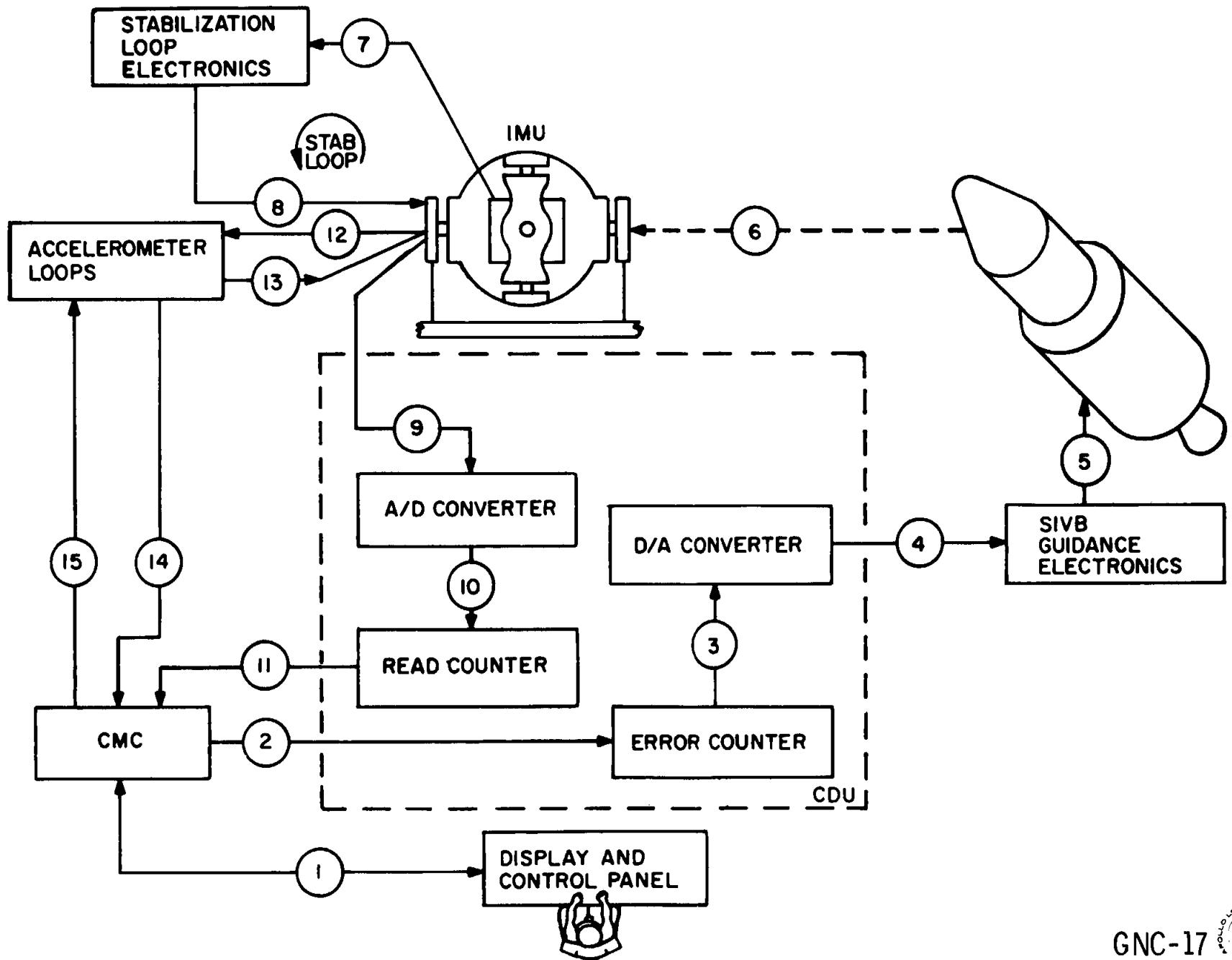
[steer
law box] from last page



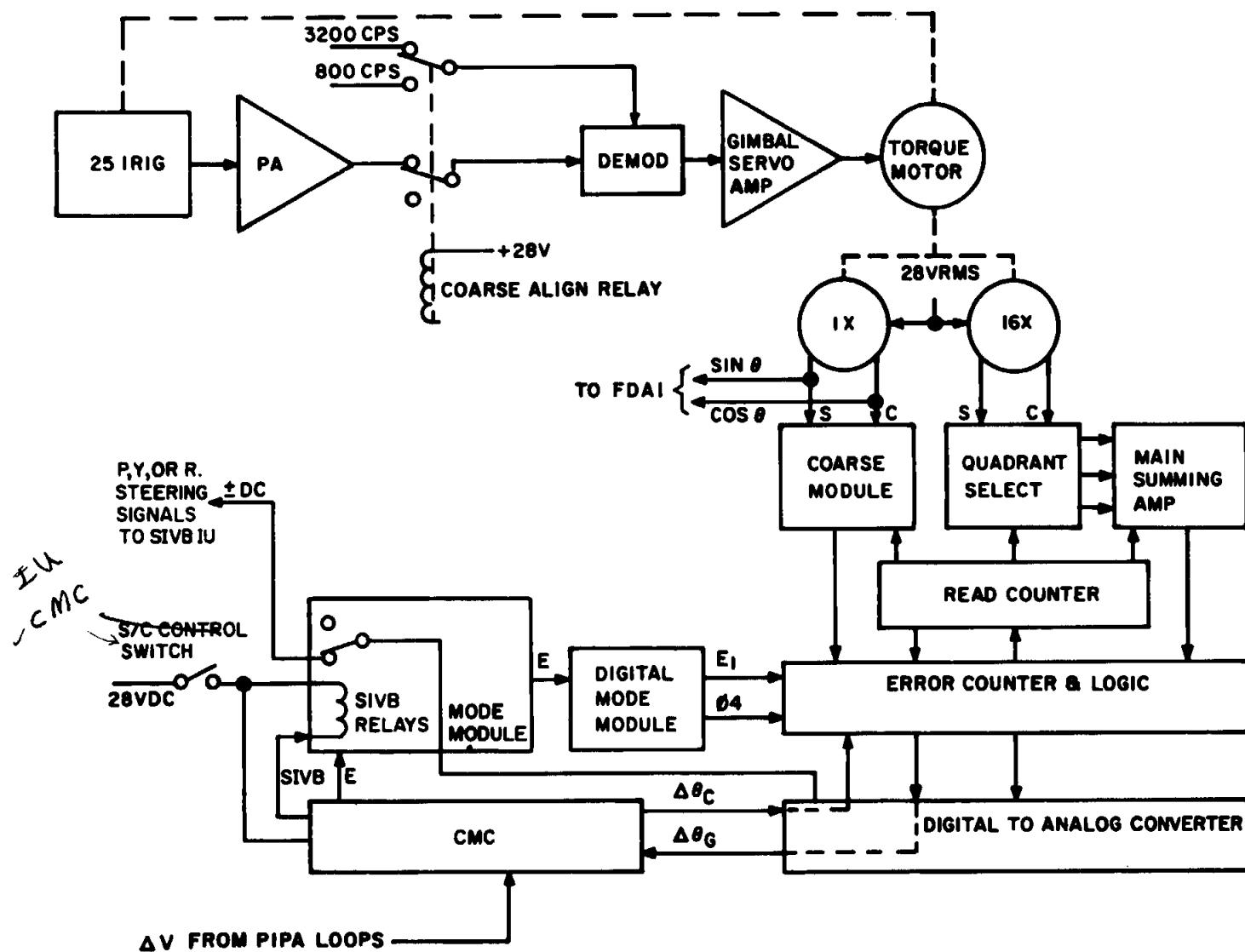
GNC-164



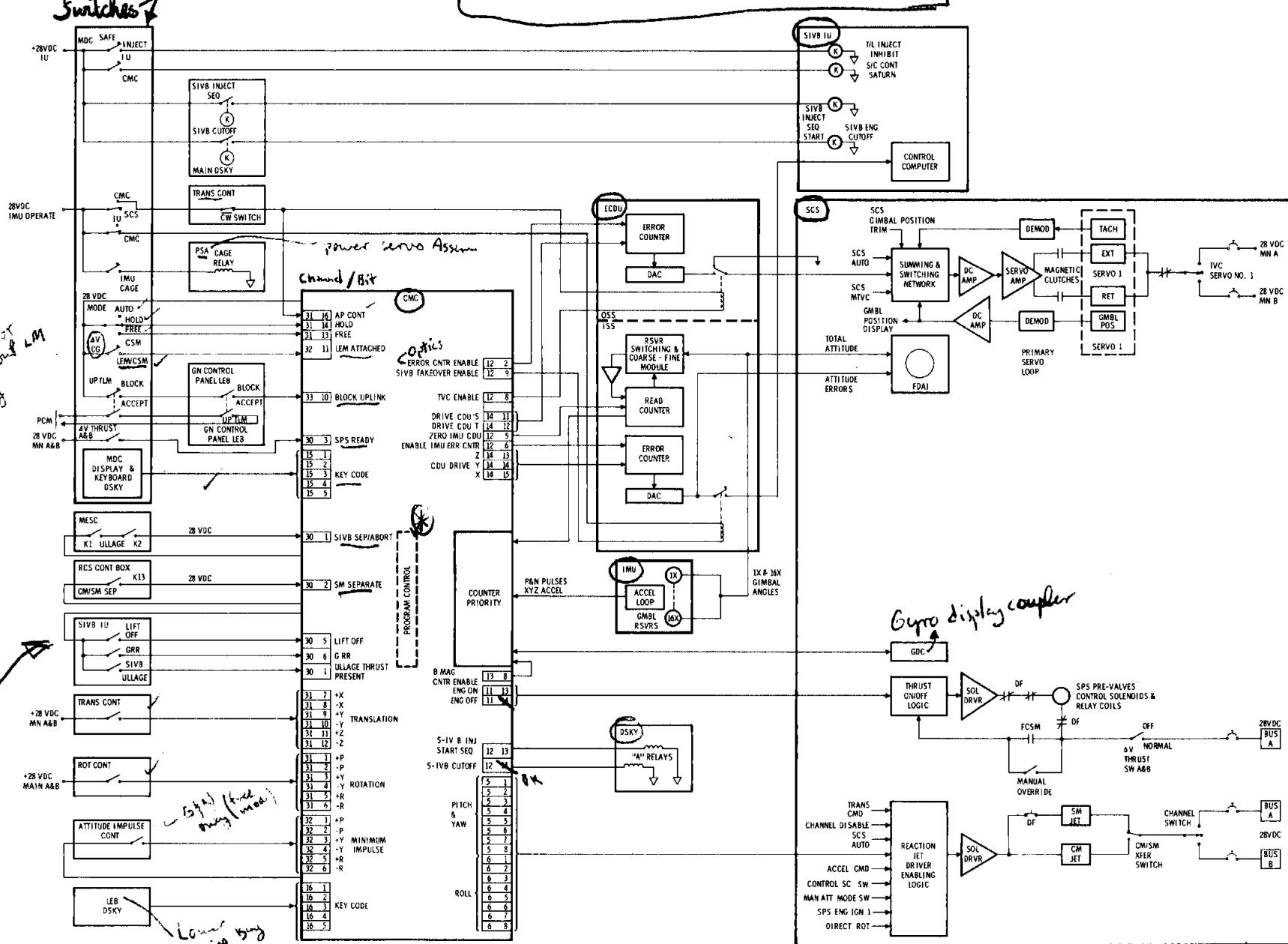
S/C CONTROL OF SATURN MODE



SIV B TAKEOVER



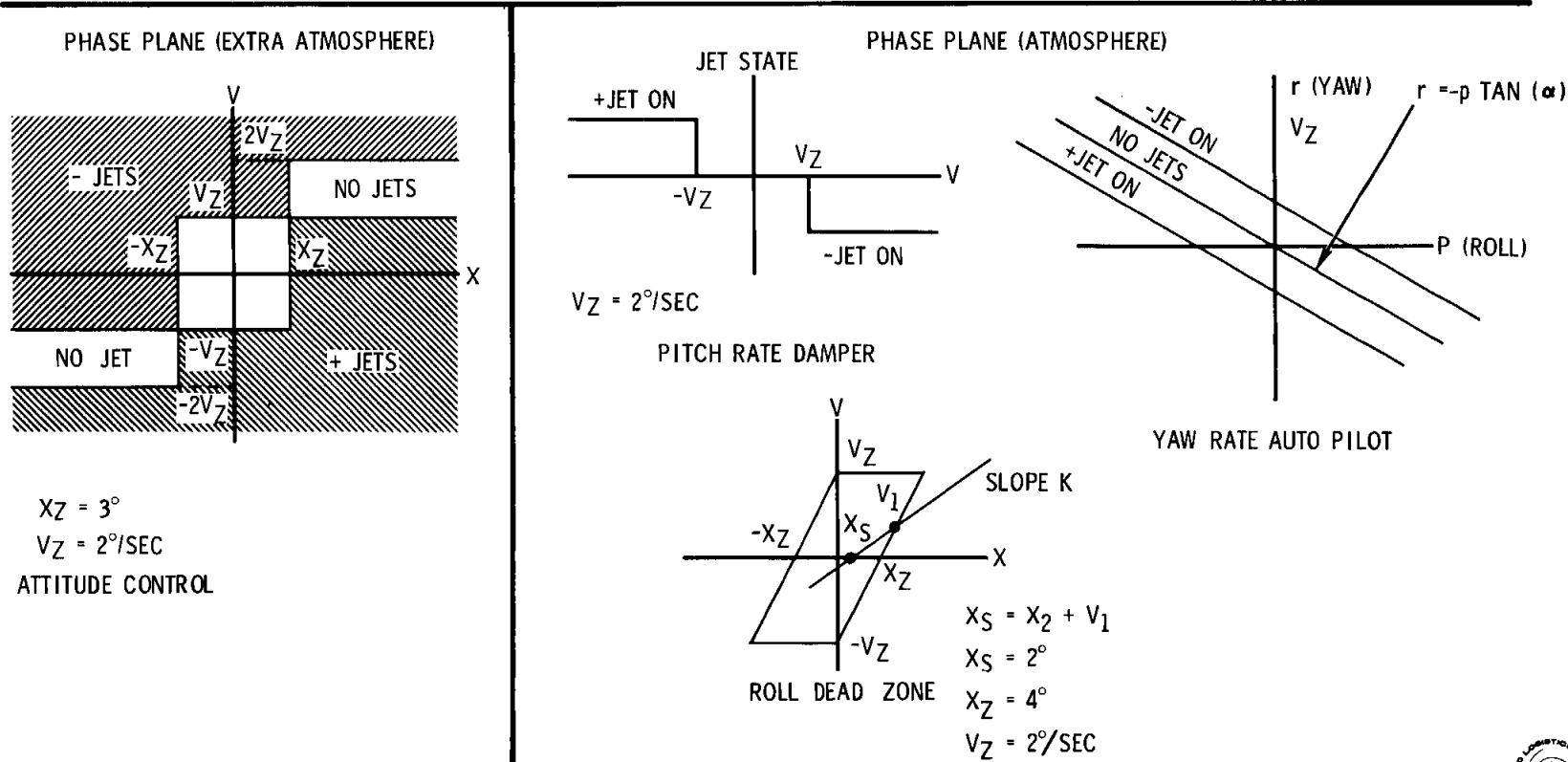
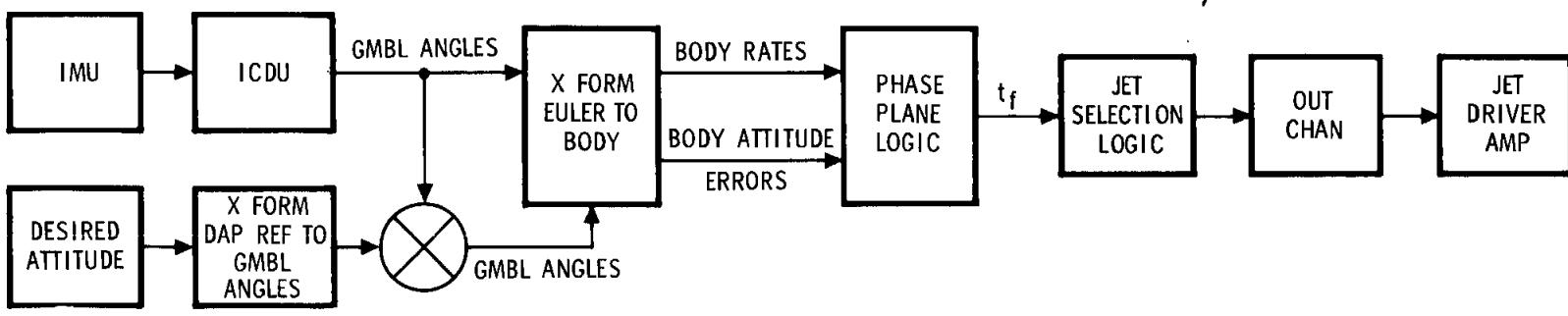
G & C FUNCTIONAL FLOW



During Program 62
the Entry DAP is entered

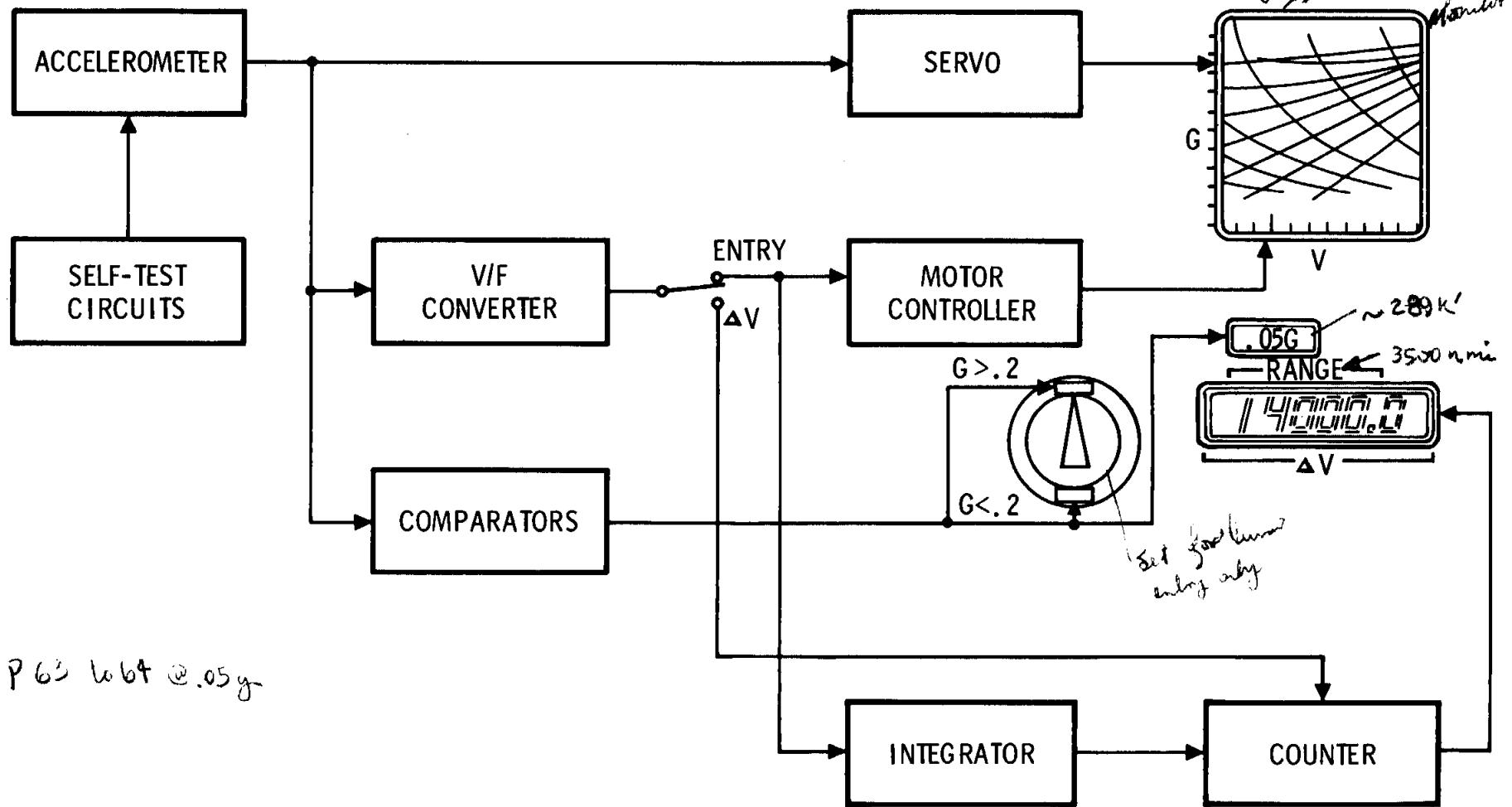
SCS has rate damp
No att. hold.
(you can hold lift vector
with ROT control)
G/N has att. hold

ENTRY DAP



—Independent of G_{3N}
and SCS

EMS BLOCK DIAGRAM

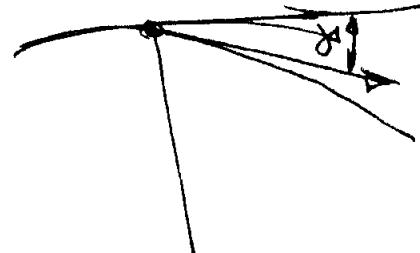
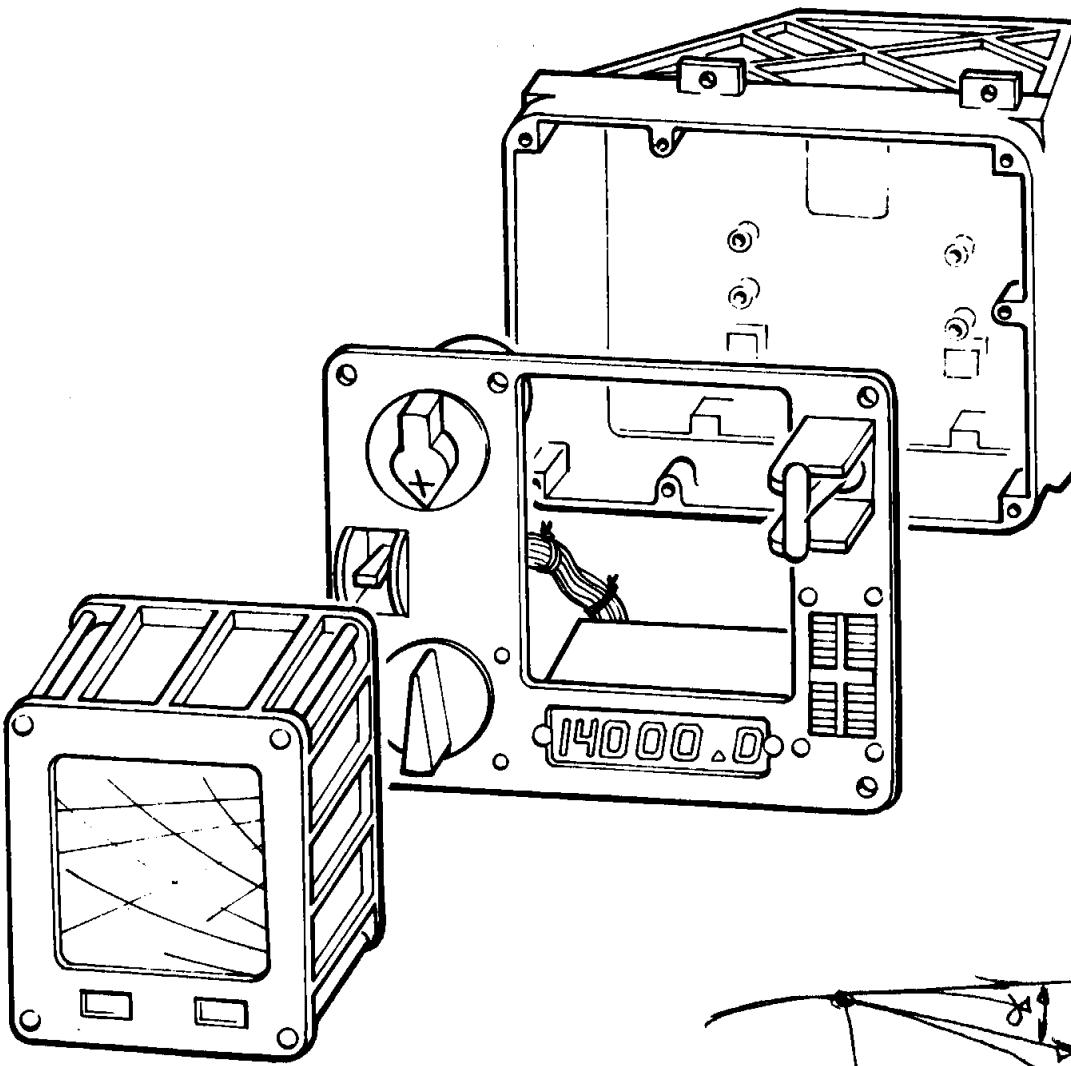


SCS-2205



P40 Dovorit ΔV
 P61 dep alt.
 P62 dep to VAT
 P63

EMS HOUSING FRONT PANEL



δ limits for laser entry

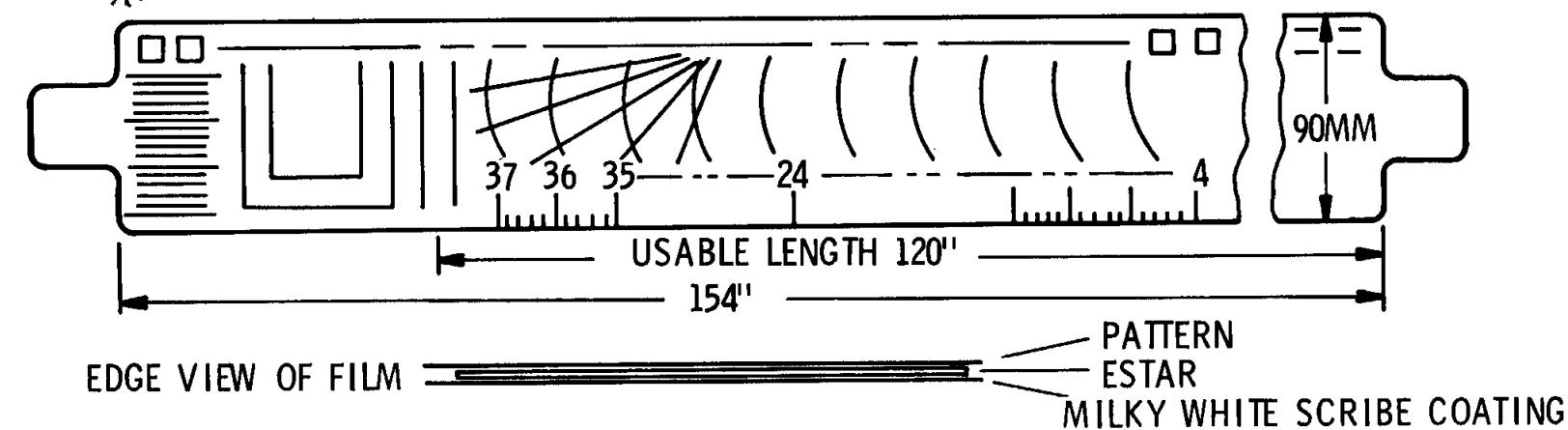
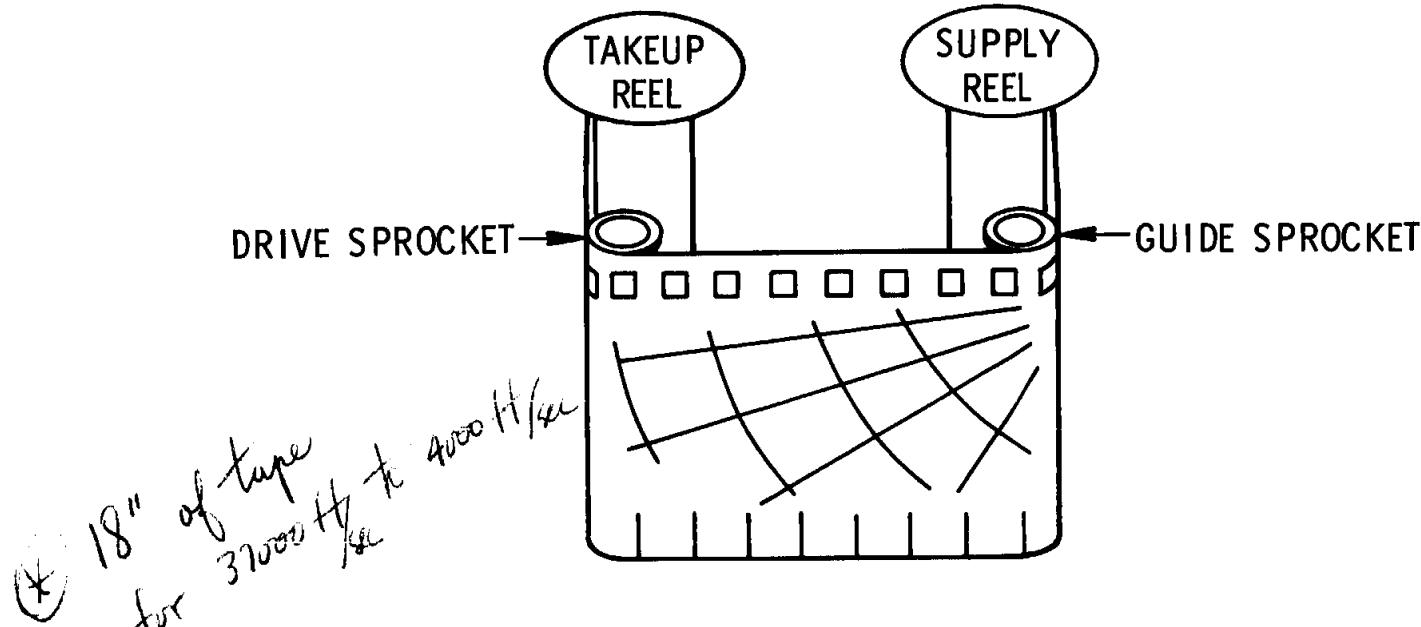
-5.2 - -1.2°

SCS-2012

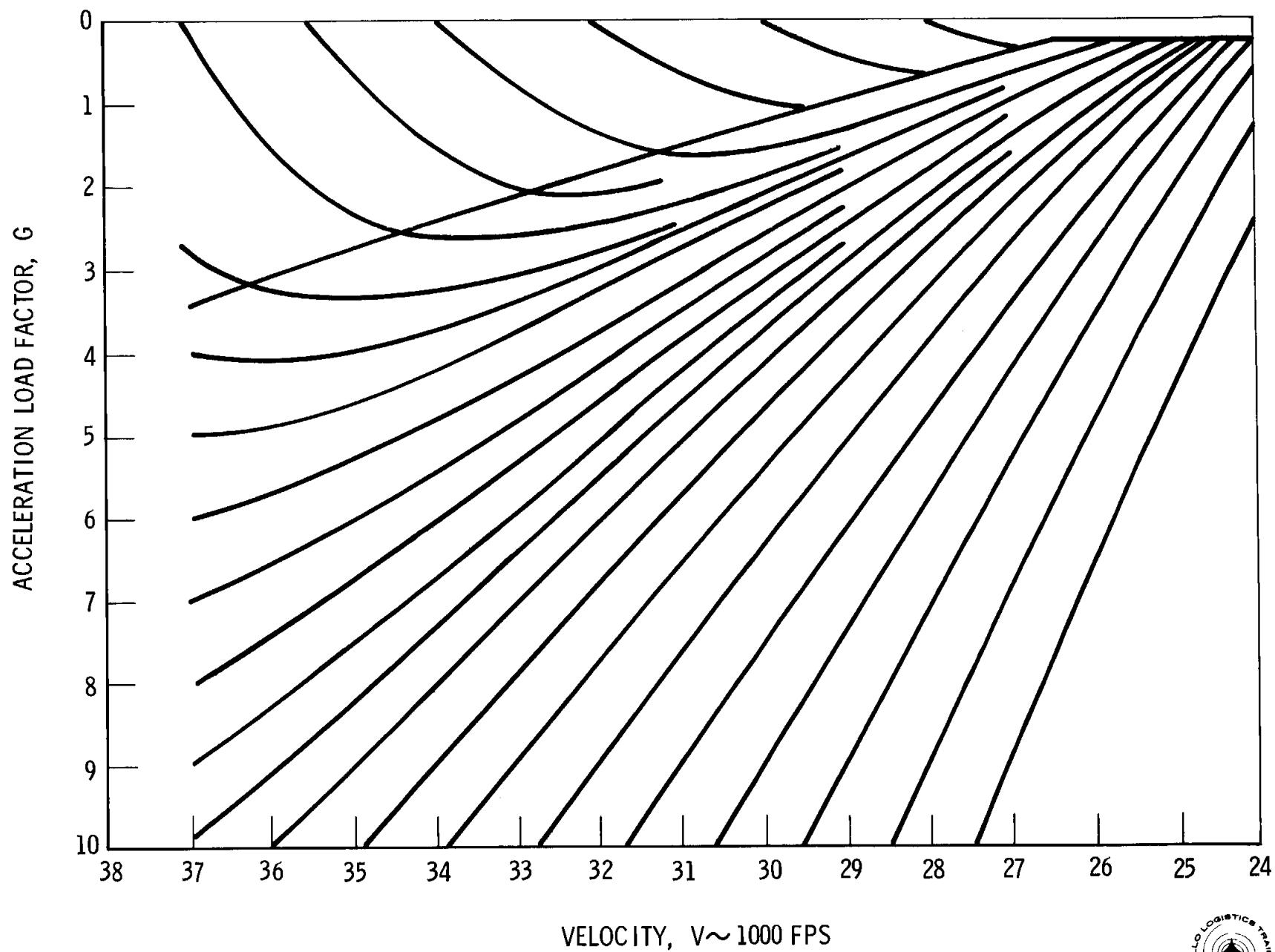


Cmax
 ?
 18
 4000
 R_{To Go}
 V_z
 t_{on} 0.5 s
 4
 1
 lift out limit
 G
 V
 h
 Cmax
 Known range
 Known range
 max range
 min range

EMS SCROLL & SCRIBE



OFF-SET FLIGHT LIMITS

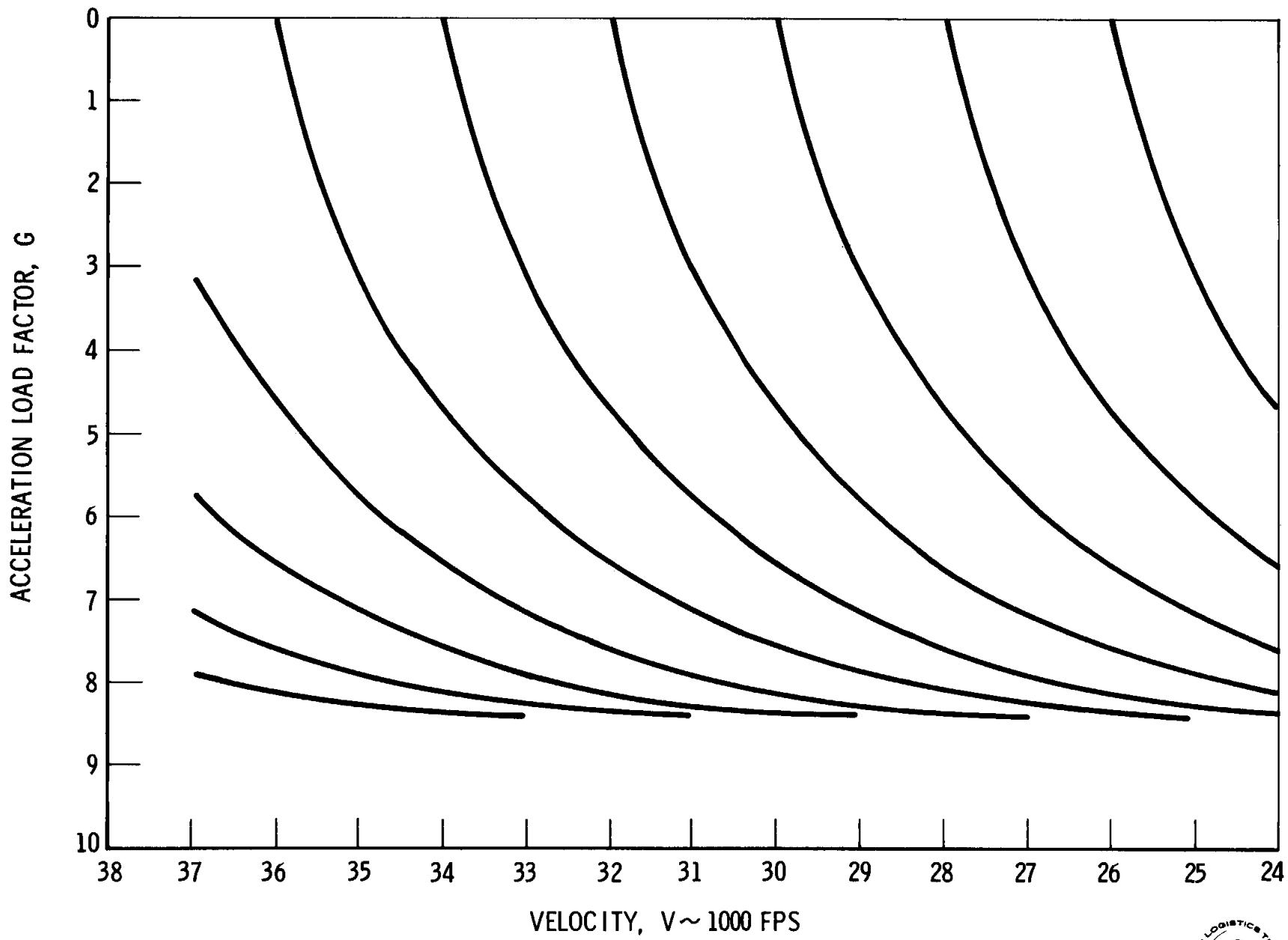


VELOCITY, $V \sim 1000$ FPS

SCS-2309

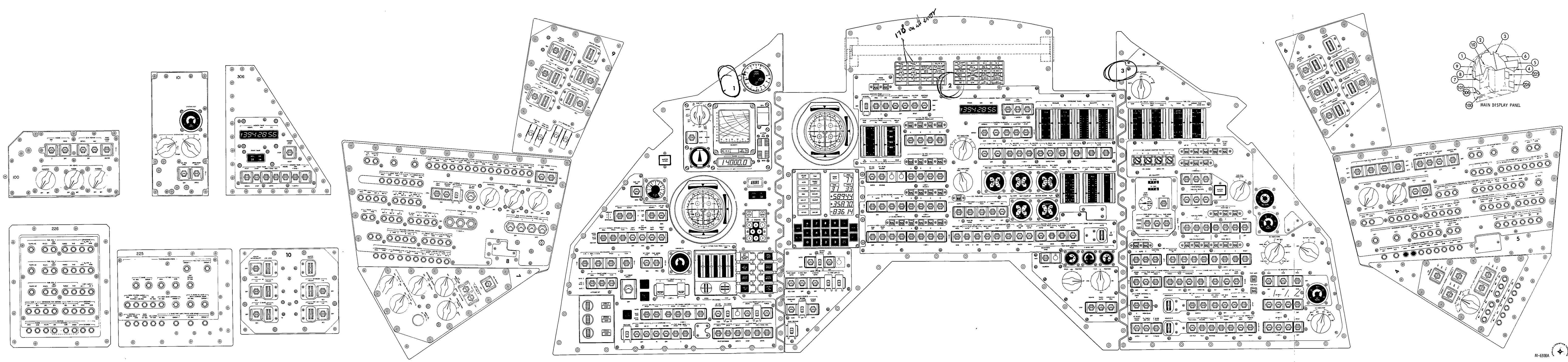


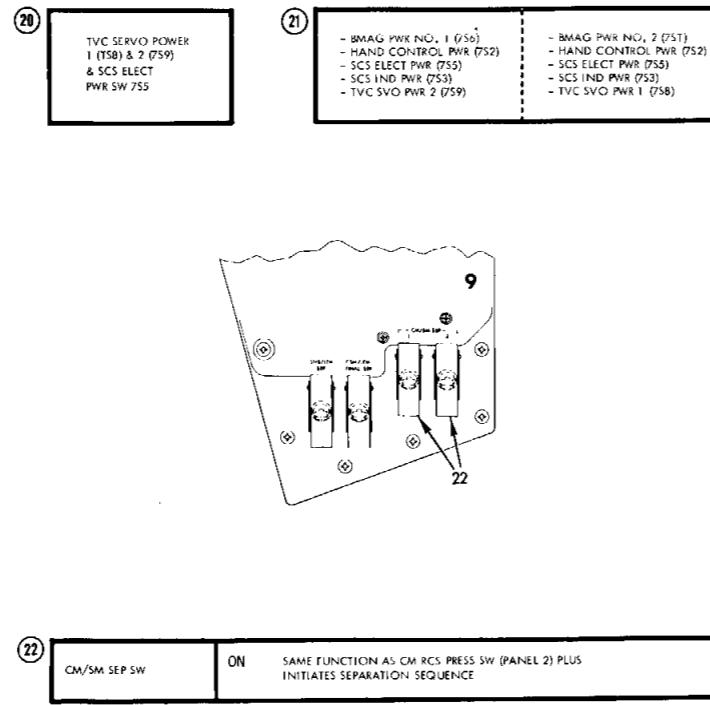
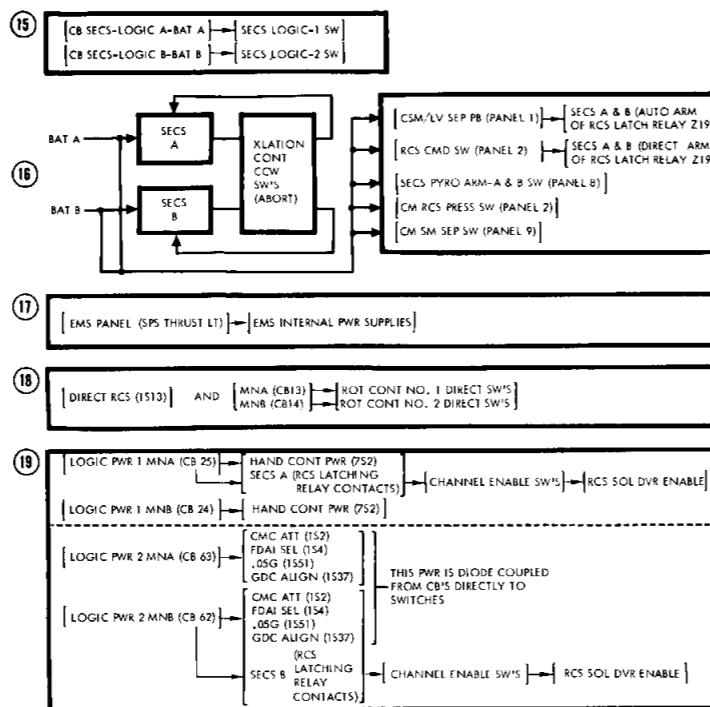
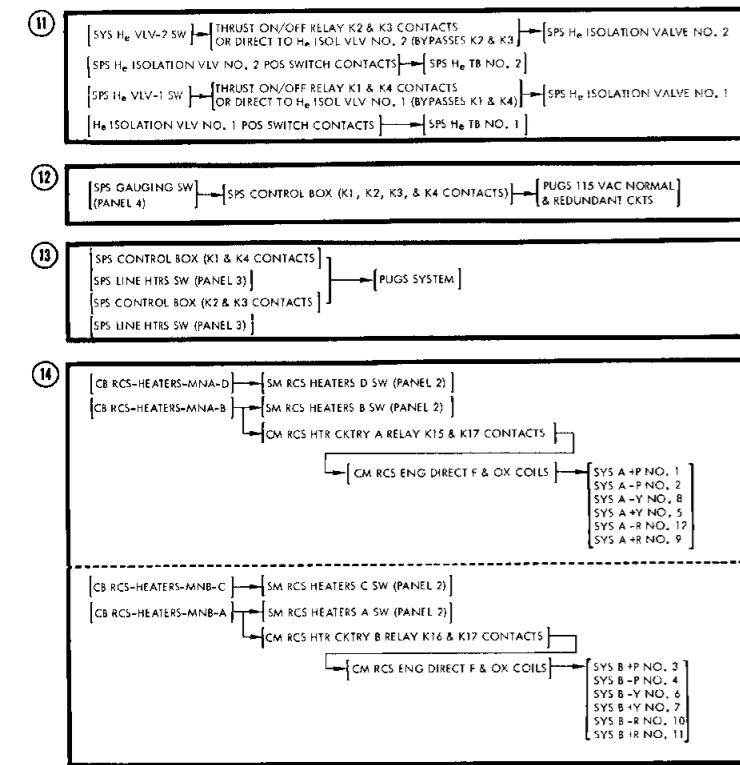
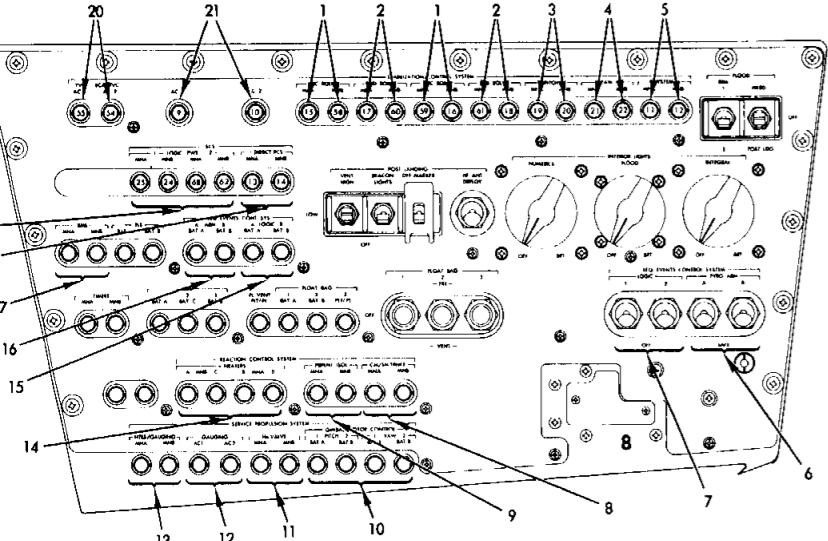
ON-SET FLIGHT LIMITS



SCS-2312

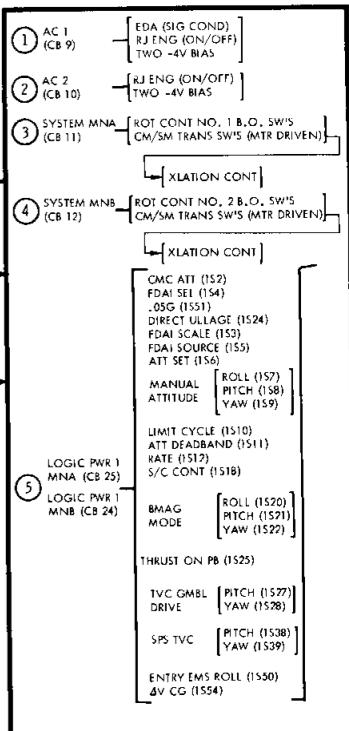
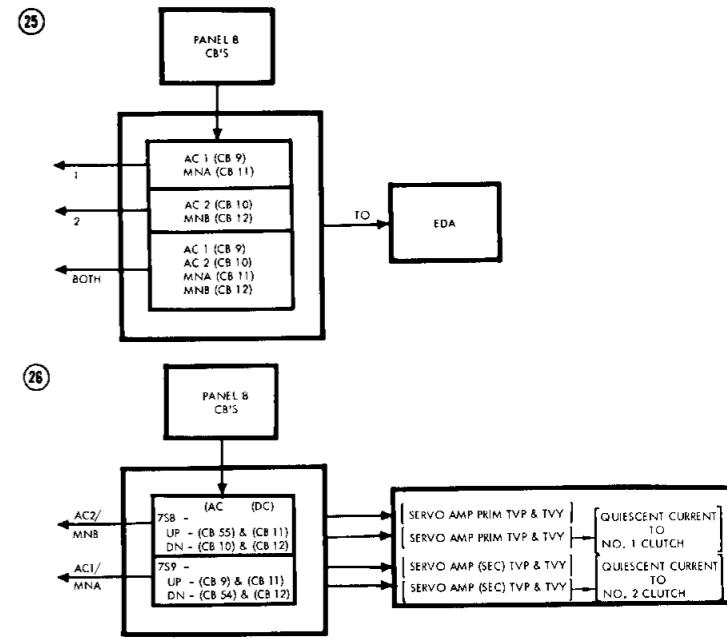
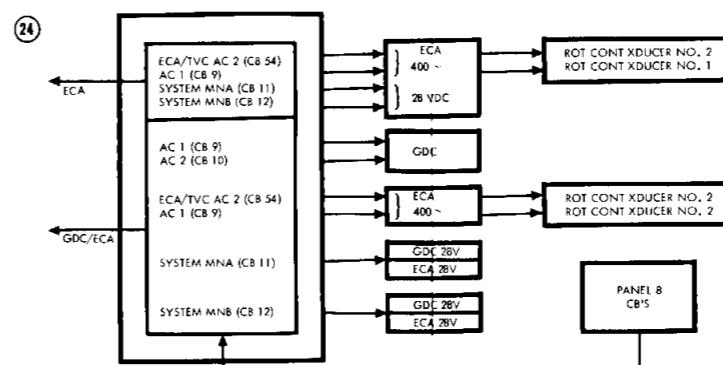
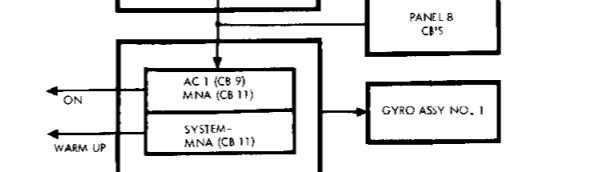
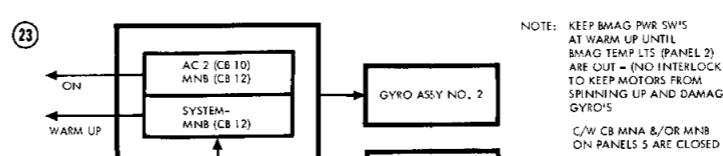
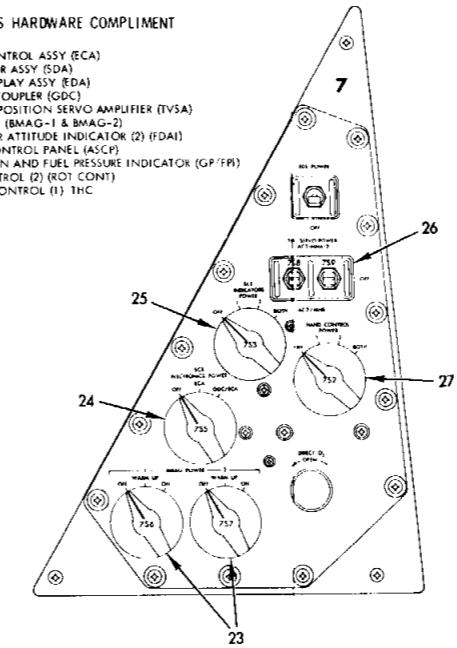


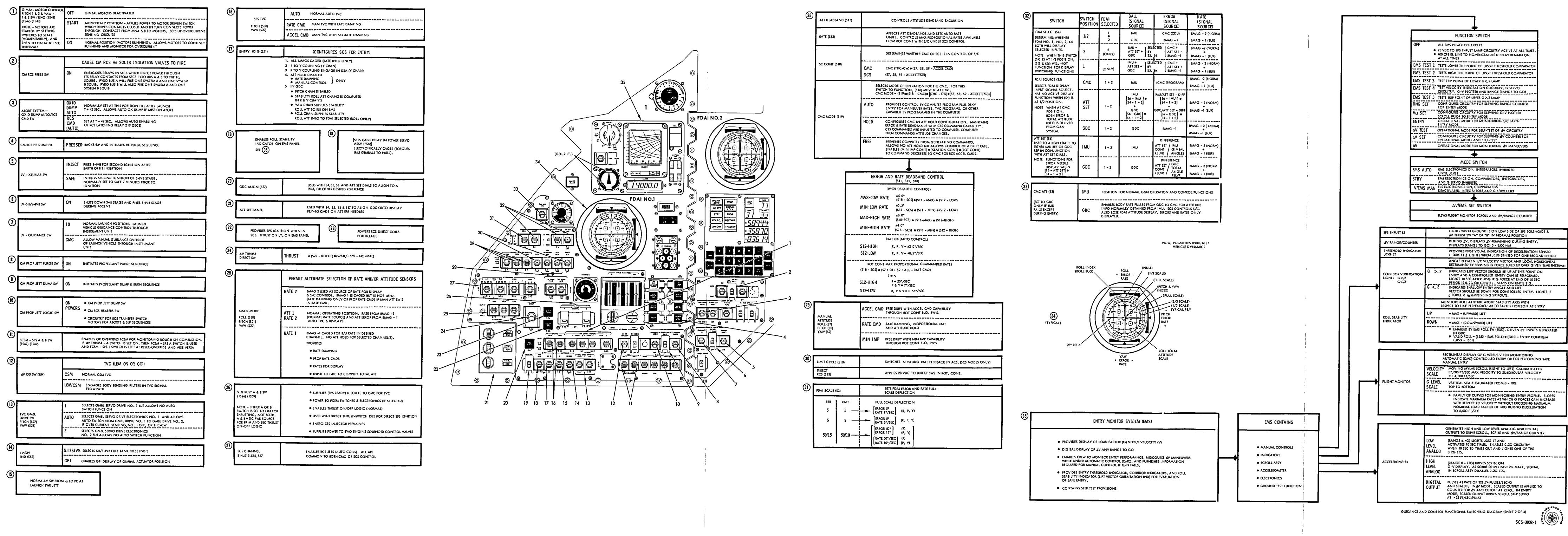


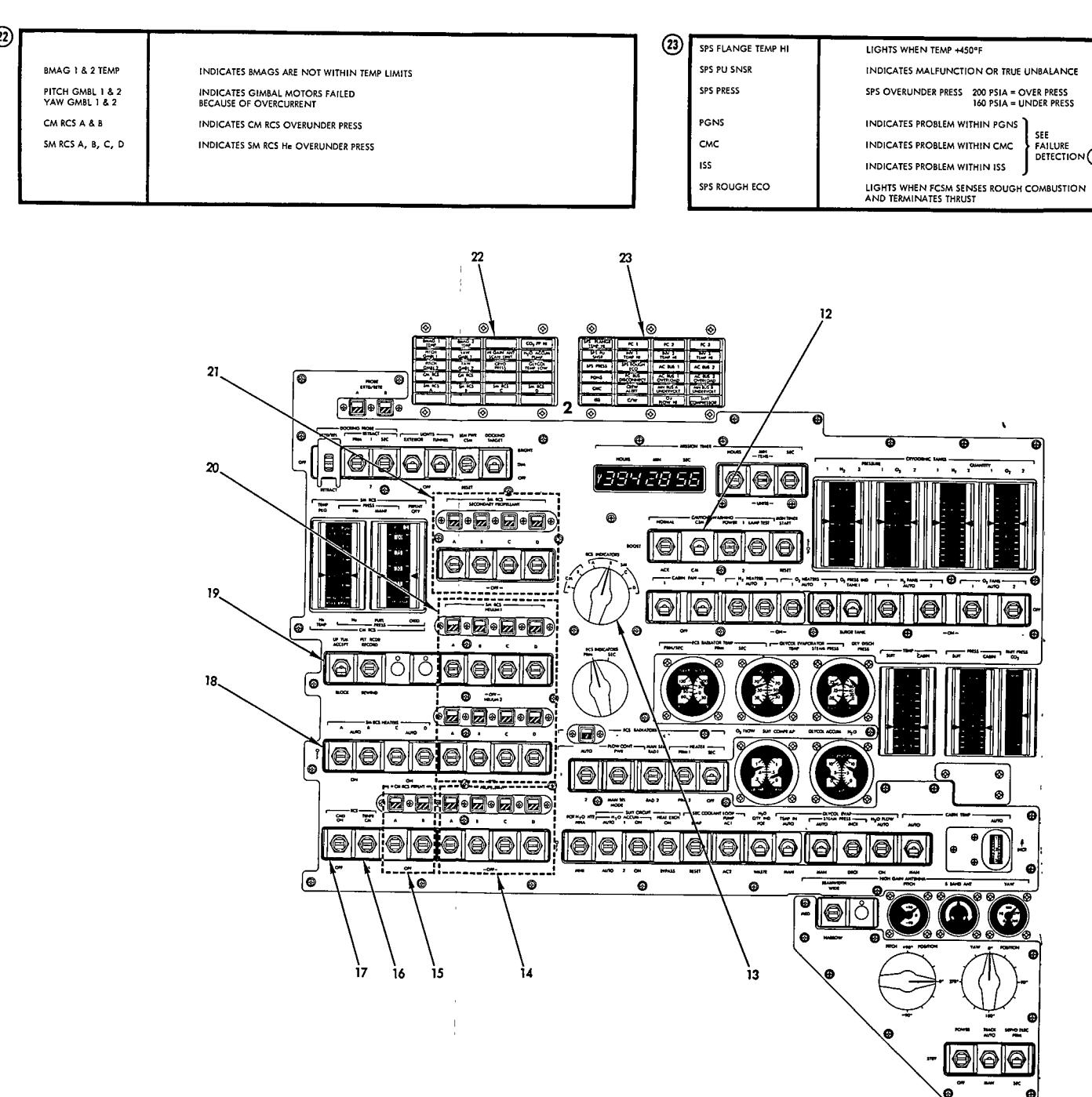
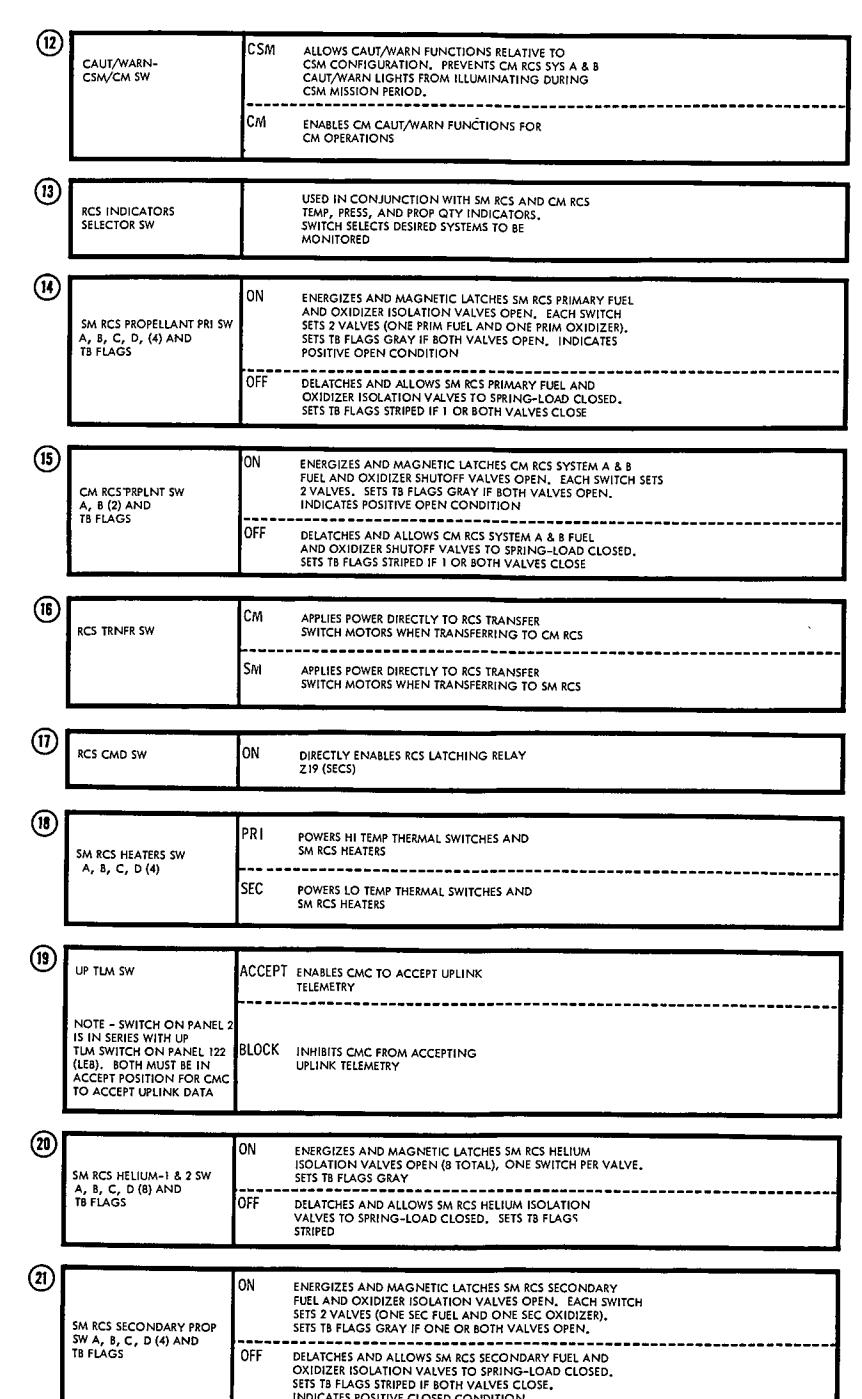
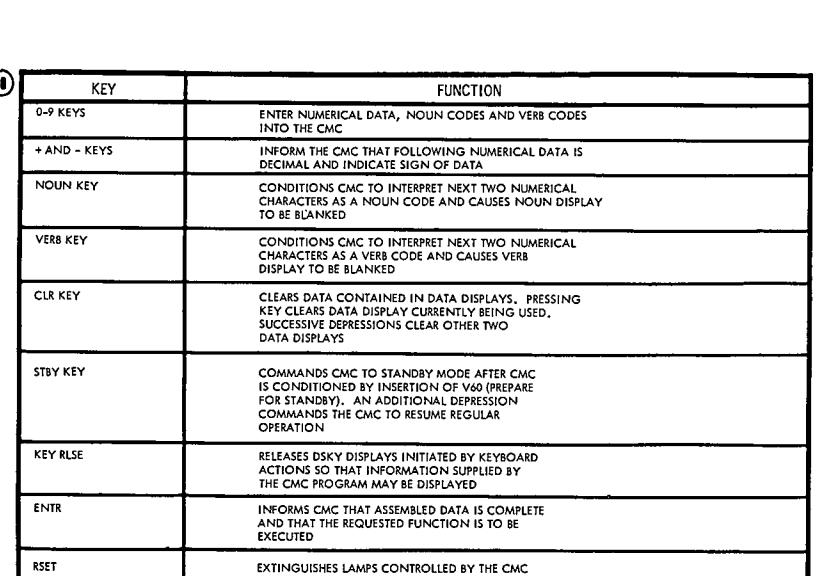
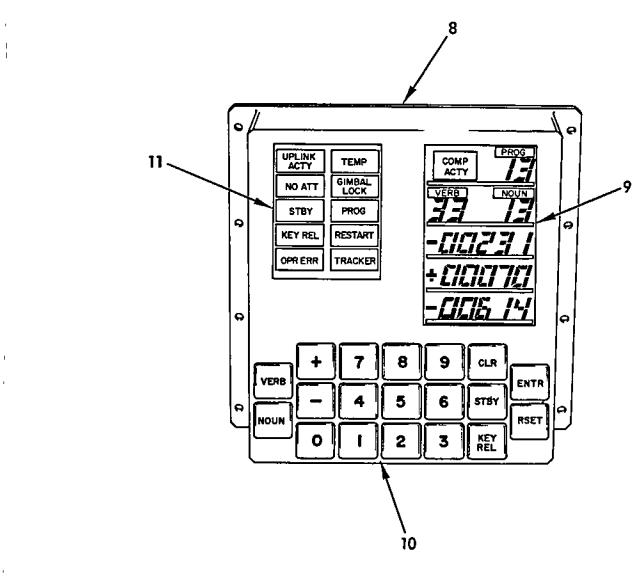
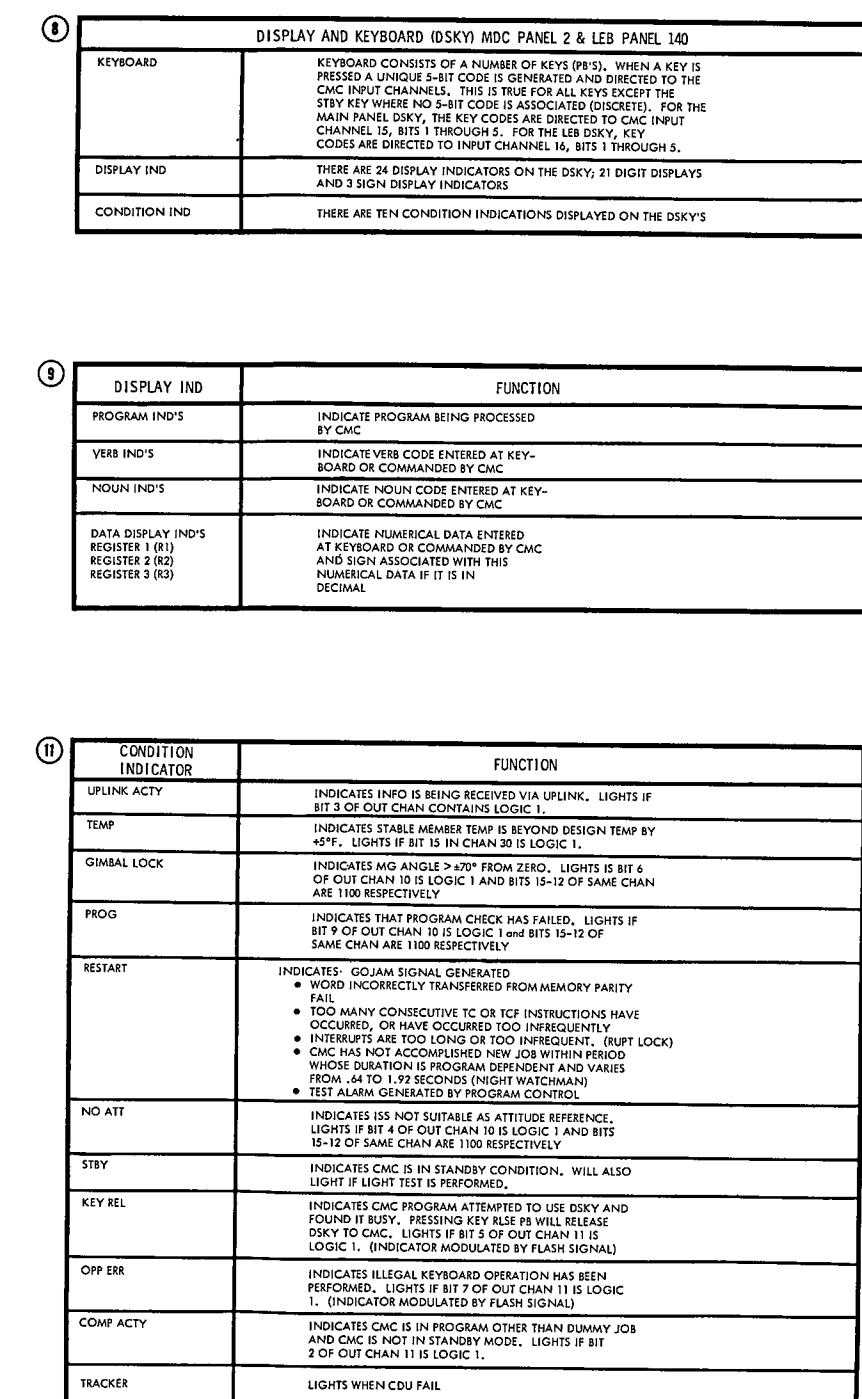
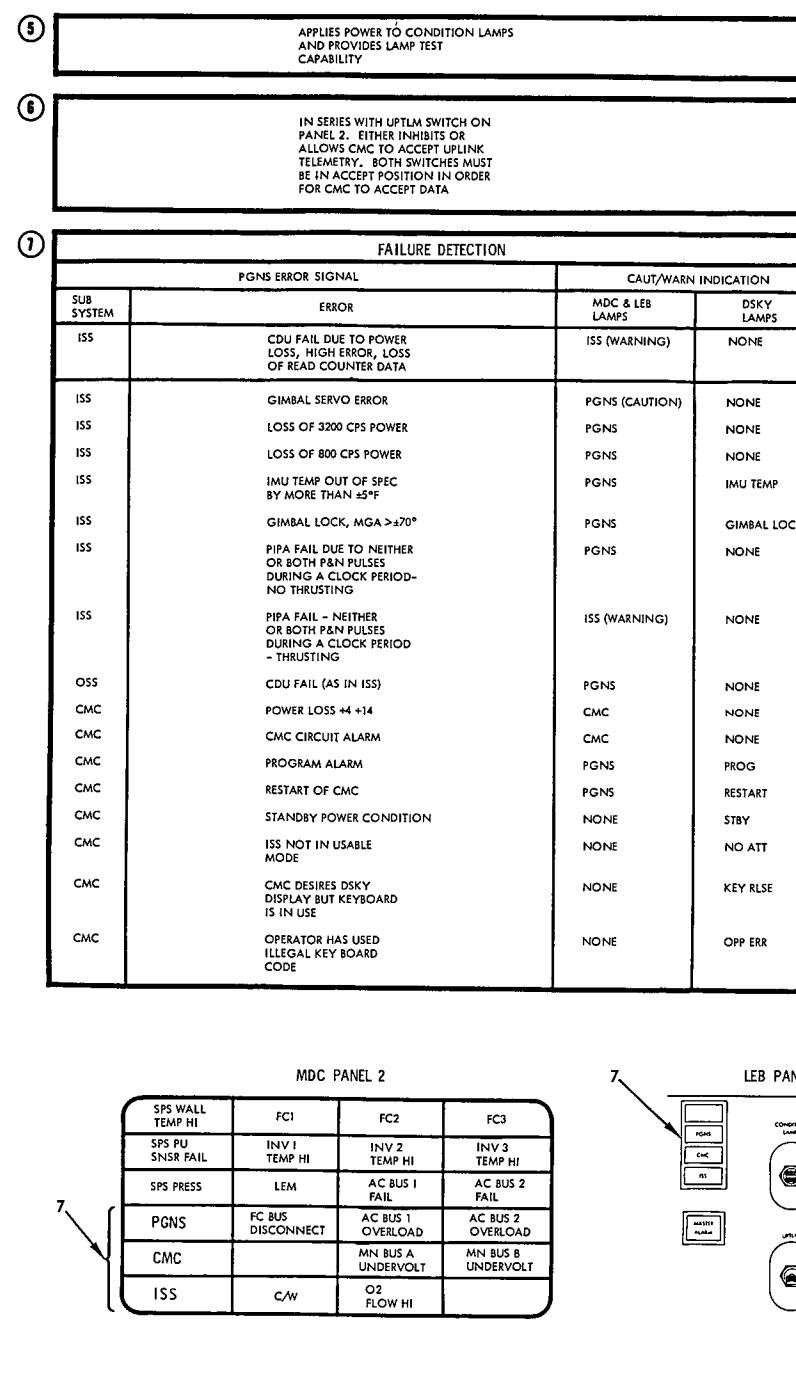
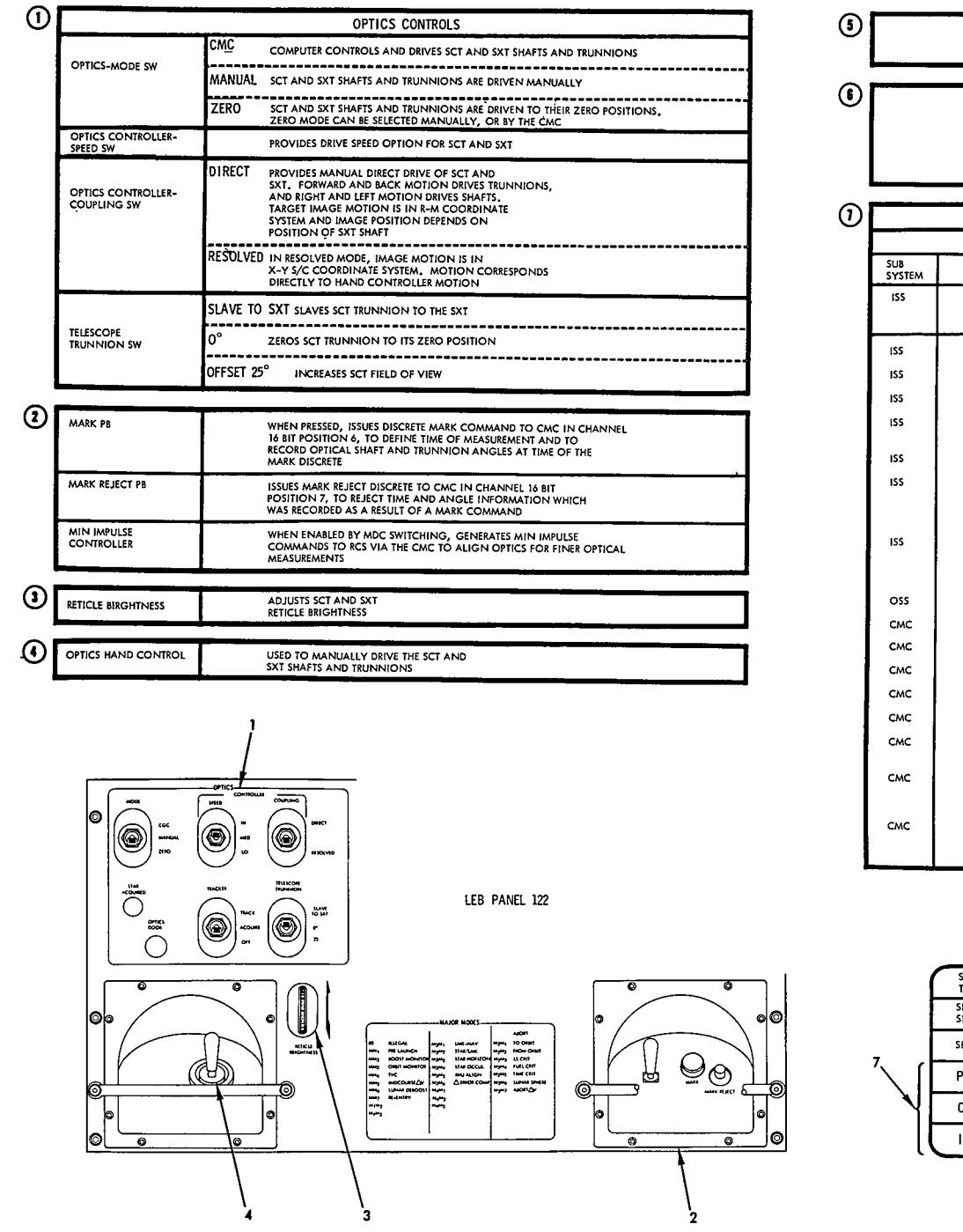


SCS HARDWARE COMPLIMENT

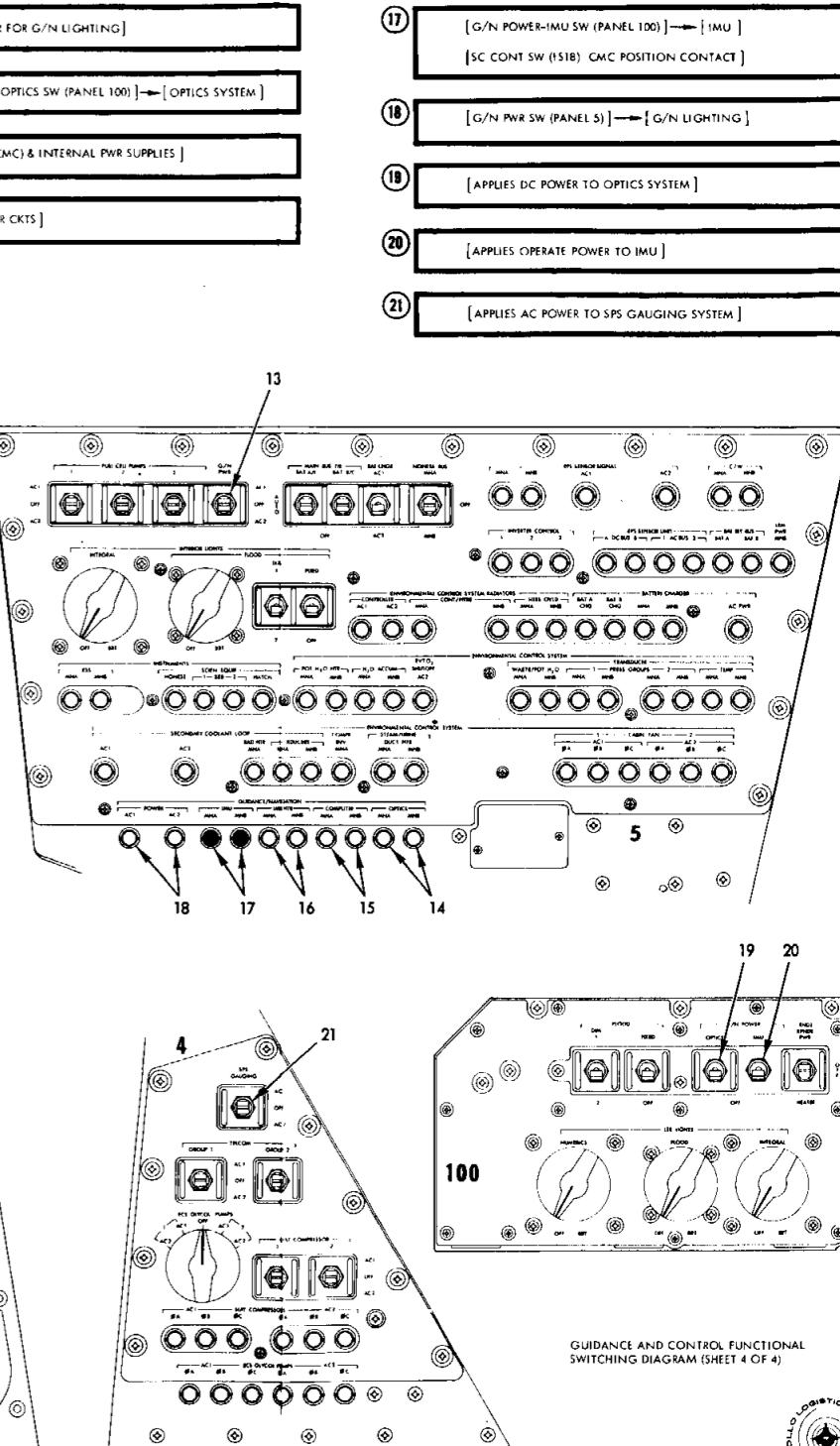
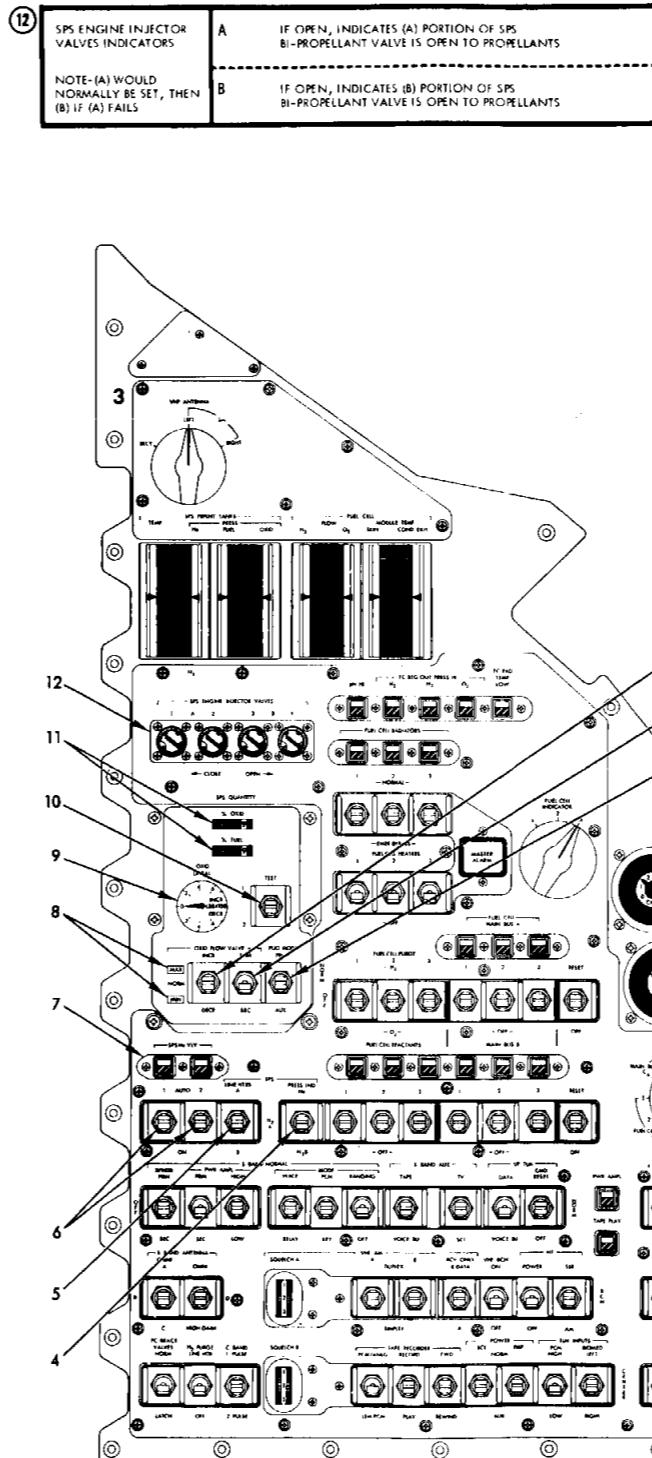
ELECTRONIC CONTROL ASSY (ECA)
 SOLENOID DRIVER ASSY (SDA)
 ELECTRONIC DISPLAY ASSY (EDA)
 GYRO DISPLAY COUPLER (GDC)
 THRUST VECTOR POSITION SERVO AMPLIFIER (TVSA)
 GYRO ASSY'S (2) (BMA-1 & BMAG-2)
 FIGHT DIRECTOR ATTITUDE INDICATOR (2) (FDAI)
 ATTITUDE SET CONTROLLER (ASC)
 CHIMNEY INDICATOR AND FUEL PRESSURE INDICATOR (GP)
 ROTATION CONTROL (2) (ROT CONT)
 TRANSITION CONTROL (TC)







| | | |
|---|---|---|
| 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 PRESSURING PROP SYSTEMS A & B ON BYPASSES AUTOMATIC FUNCTION AND ENERGIZES SPS H ₂ ISOLATION VALVES DIRECT, THEREBY PRESSURING 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 NOTE - THESE INDICATIONS OCCUR ONLY WHILE THRUSTING OR TESTING 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 |



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

Block II Computer Programs

Idling

P00 - - - housekeeping (watchdog, memory)

Pre-launch Servicing

P05 Power up
P06 " down

Boost

P11 Boost monitor
(alt & uttavor)

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
 cnc time } 4 types
 of updates,

Pre Thrusting

P30 External DV (DV required & big)
 P34 Transfer Phase Initiation(TPI) time (down to ready)
 P35 TPI - Midcourse render e (line of sight to eng)
 P36 TPI Final render

Thrusting

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

Entry

P61 Fly to cm/syn cap wth
 P62 syn & fly to tri. P64 .2G
 P63 .2G

| BIT CHANNEL | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | | |
|------------------------------|----------------------------|----------------------------|---|--|-------------------|----------------------|---|---|--|----------------------------|----------------------------|-----------------------------------|----------------------------|----------------------------|--|--|--------------------------------------|---------|
| 0 (VACANT) | | | | | | | | | | | | | | | | | | |
| 1 | | | IDENTICAL | TO | REGISTER | #1 | (L) | | | | | | | | | | | |
| 2 | | | IDENTICAL | TO | REGISTER | #2 | (Q) | | | | | | | | | | | |
| 3 | | | HIGH ORDER 23.3 HRS | SCALER | | 14 | BIT | POS # | | | | | | | | 5.12 SEC | | |
| 4 | | | LOW 5.12 SEC | ORDER SCALER | | 14 | BIT | POS # | | 6 | 7 | 8 | 5 | 2 | 3 | 4 Jet 1 1/3200 SEC | | |
| OUTBITS 5 RCS (P&Y) | | | | | | | | | | +X +Y -Y -X +P 1D | -X -Y +YW -X +P 1U | +X +Y -YW -X +P 2D | +X -P -P +Z 2U | -X +P +P -X -YW 3D | -X -P -P +Z 3U | +X +P +P -X -YW 4D | S/M C/M LEM | |
| OUTBITS 6 RCS (ROLL) | | | | | | | | | | +Y -R 14 -Y +R 15 IS | -Y -R 16 -Y +R 17 4S | +Y +R 13 +Z -R 10 3S | +Z +R 10 -Z +R 11 2S | -Z +R 11 -Z -R 12 1F | -Z -R 12 +Z +R 9 4F | S/M C/M LEM | | |
| FMA 7 | | | | | | | | | | *** FE7 | *** FE6 | *** FE5 | | | | C/M LEM | | |
| SKY OUTBITS 10 "R" RELAYS | 4 | 4 | 3 | 2 | 1 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 C/M | | |
| | | RELAY ADDRESS | | | | | | | RELAY BITS [OUTBITS, "R" RELAYS] | | | | | | | | | |
| OUTBITS 11 "A" RELAYS | SPARE | SPARE | ENGINE OFF | SPARE | SPARE | CAUTION RESET | TEST CONNECTOR OUTBIT | SPARE | OPERATOR ERROR FLASH | VERB-NOUN FLASH | KEY RELEASE FLASH | TEMP CAUTION | UPLINK ACTIVITY | COMPUTER ACTIVITY | I.S.S. WARNING | C/M LEM | | |
| OUTBITS 12 GN&C | ISS TURN ON DELAY COMPLETE | ISS TURN ON DELAY COMPLETE | SIVB CUTOFF ("A" RELAY) R.R. ENABLE RELAY | SIVB INJ SEQ START L.R. POS COMMAND | -ROLL GIMBAL TRIM | DISENGAGE OPTICS DAC | ZERO OPTICS | SIVB TAKE OVER ENABLE +PITCH GIMBAL TRIM | TVC ENABLE | DISPLAY INERTIAL DATA | SPARE | ENABLE IMU ERROR COUNTER | ZERO IMU CDU'S | COARSE ALINE ENABLE | STAR TRACKER ON HORIZONTAL VELOCITY LO-SCALE | ENABLE OPTICS ERROR COUNTER ENABLE R.R. ERROR COUNTER | ZERO OPTICS CDU'S ZERO R.R. CDU'S | C/M LEM |
| OUTBITS 13 RADAR & AGC | ENABLE T6 RUPT | ENABLE T6 RUPT | RESET TRAP 32 | RESET TRAP 31-B | RESET TRAP 31-A | ENABLE STANDBY | TEST ALARMS | START RHC READ | B MAG COUNTER ENABLE RHC COUNTER ENABLE | DOWLINK WORD ORDER | BLOCK INLINK | INHIBIT UPLINK, ENABLE CROSS-LINK | RADAR ACTIVITY | RADAR SELECTION A* | RADAR SELECTION B* | RADAR SELECTION C* | C/M LEM | |
| OUTBITS 14 IMU | DRIVE CDU X | DRIVE CDU Y | DRIVE CDU Z | DRIVE CDU T | DRIVE CDU S | GYRO ACTIVITY | GYRO SIGN MINUS | GYRO SELECT A** | GYRO SELECT B** | GYRO ENABLE | ENTRY VEL DRIVE | — | — | ALTITUDE METER ACTIVITY | ALTITUDE RATE SELECT | OUTLINK ACTIVITY | C/M LEM | |
| INBITS 15 MAIN KEYBOARD | | | | | | | | | | | | | | | | C/M LEM | | |
| INBITS 16 NAV KEYBOARD | | | | | | | | | MARK REJECT | MARK | KEY 5N | KEY 4N | KEY 3N | KEY 2N | KEY 1N | C/M | | |
| | | | | | | | | | (TRAP 16B-RUPT 6) | (TRAP 16A-RUPT 6) | | | | | | | | |
| 17 & 20 THRU 27 VACANT | | | | | | | | | (-) DESCENT | (+) DESCENT | MARK REJECT | MARK Y | MARK X | — | — | LEM | | |
| INBITS 30 GN&C | TEMP IN LIMITS | TEMP IN LIMITS | I.S.S. TURN-ON REQUEST | IMU FAIL | IMU CDU FAIL | IMU CAGE | S/C CONTROL OF SATURN G&N CONTROL OF S/C | IMU OPERATE | SPARE | OPTICS CDU FAIL | GUID REF RELEASE | LIFTOFF | SIVB SEPARATE, ABORT | SPS READY | SM SEPARATE | ULLAGE THRUST PRESENT | C/M LEM | |
| INBITS 31 TRANS & ROT | G&C A/P CONTROL | G&C A/P CONTROL | FREE FUNCTION | HOLD FUNCTION | -Z TRANSLATION | +Z TRANSLATION | -Y TRANSLATION | +Y TRANSLATION | -X TRANSLATION | +X TRANSLATION | -ROLL MAN ROT | +ROLL MAN ROT | -YAW MAN ROT | +YAW MAN ROT | -PITCH MAN ROT | +PITCH MAN ROT | C/M | |
| INBITS 32 IMPULSE | (SPARE) | | G&N CONTROL OF S/C | AUTO STABILIZATION | ATTITUDE HOLD | | | | | | -AZ (LPD) -RMI | +AZ (LPD) +RMI | -YMI | +YMI | -EL (LPD) +PMI | +EL (LPD) +PMI | LEM | |
| INBITS 33 OPTICS & AGC | OSC ALARM | OSC ALARM | WARNING | PIPA FAIL | DOWLINK TOO FAST | UPLINK TOO FAST | LEMS ATTACHED | — | — | -ROLL MIN IMPULSE | +ROLL MIN IMPULSE | -YAW MIN IMPULSE | +YAW MIN IMPULSE | -PITCH MIN IMPULSE | +PITCH MIN IMPULSE | C/M | | |
| 34 | | | | | | | | | | | | | | | | LEM | | |
| 35 | | | | | | | | | | | | | | | | C/M LEM | | |
| | | | | | | | | | | | | | | | | | | |

| RADAR SELECTION | | | |
|-----------------|---|---|-----------------|
| A | B | C | FUNCTION |
| 0 0 0 | | | R.R. RANGE |
| 0 0 1 | | | R.R. RANGE RATE |
| 0 1 0 | | | — |
| 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 | | |
|-------------|---|------|
| A | B | GYRO |
| 0 0 | | — |
| 0 1 | | X |
| 1 0 | | Y |
| 1 1 | | Z |

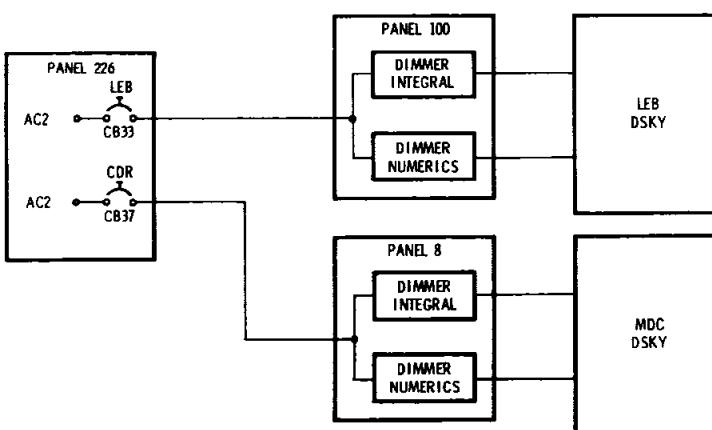
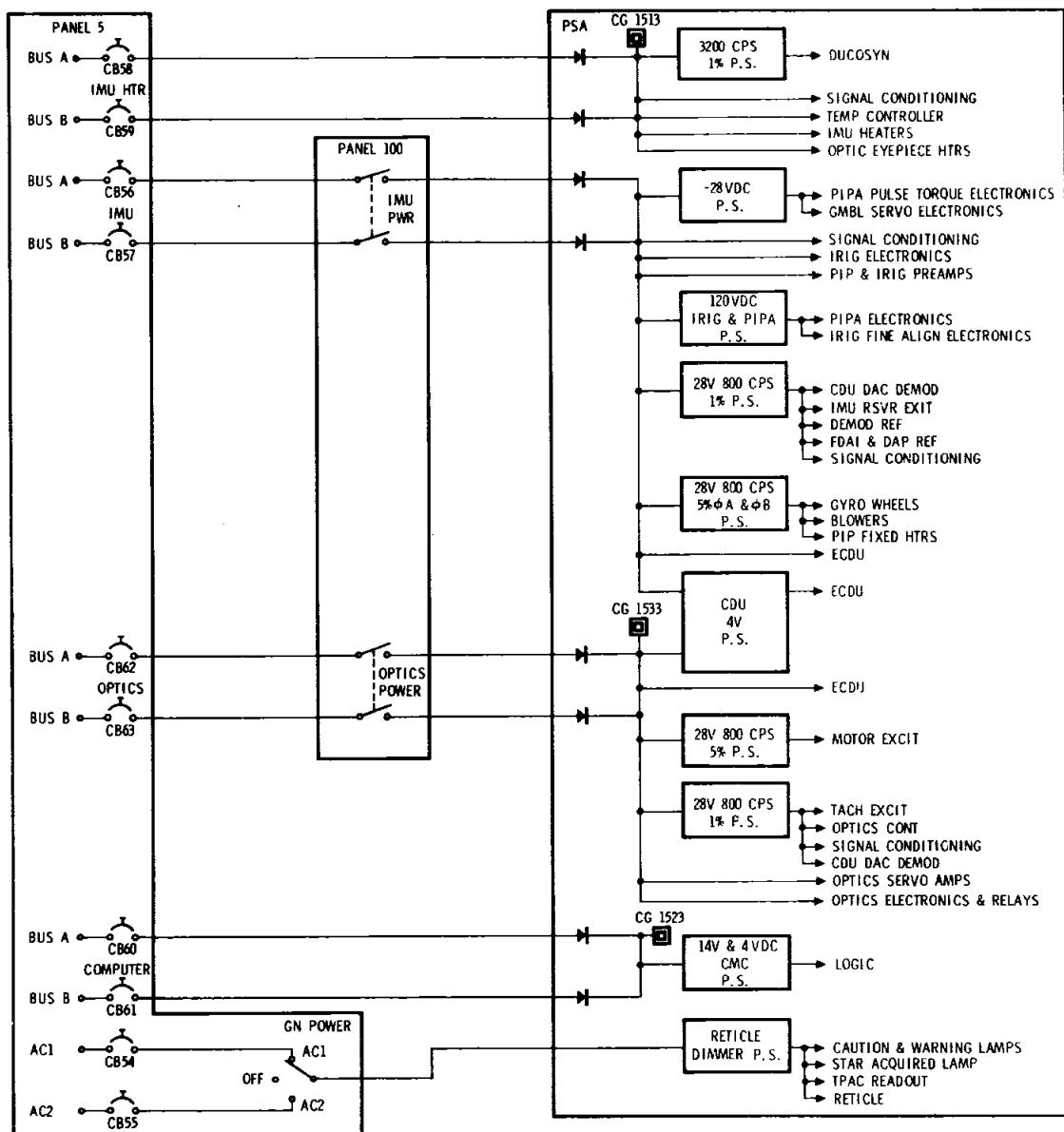
BLOCK II CMC & LGC

CHANNEL-BIT ASSIGNMENTS

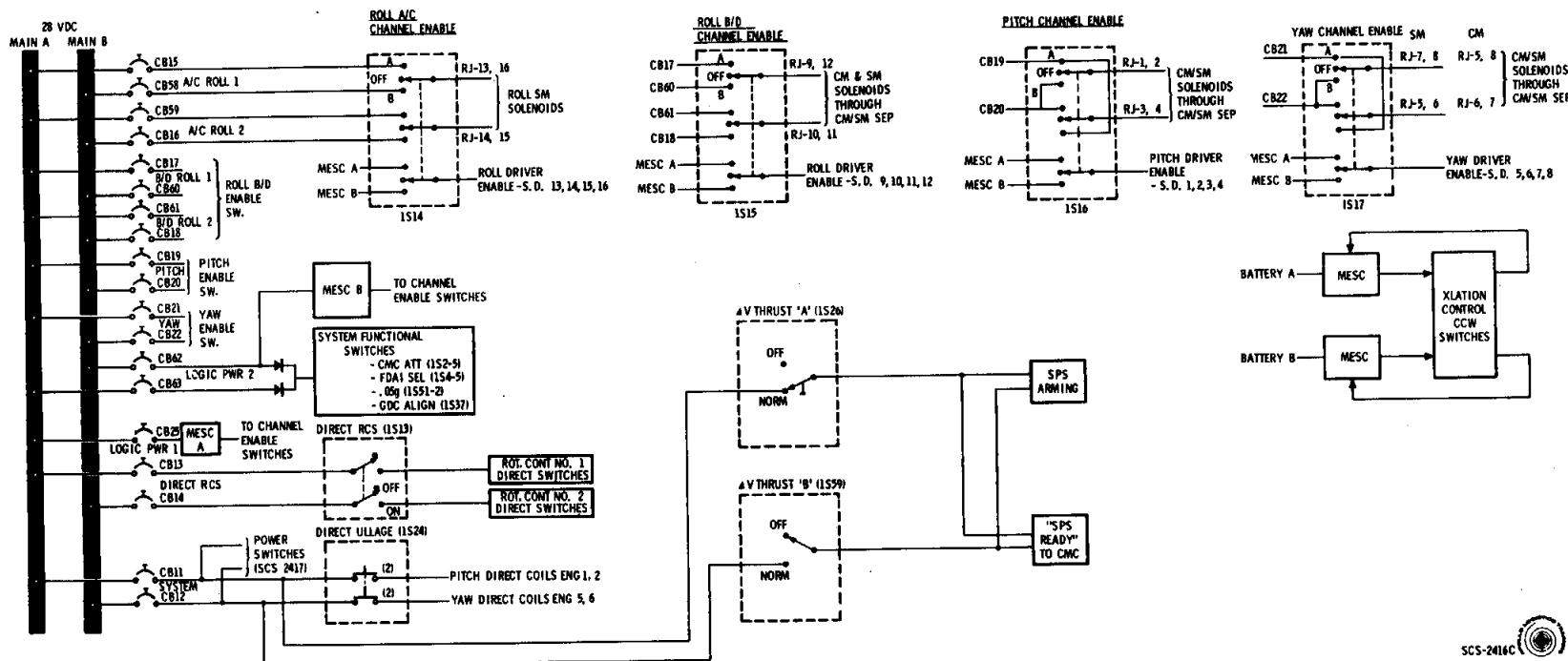
| FE7 | FE6 | FE5 | HIGH BANKS |
|-------|-----|-----|------------|
| 0 X X | | | 30-37 |
| 1 0 0 | | | 40-43 |
| 1 0 1 | | | EMPTY |
| 1 1 0 | | | EMPTY |
| 1 1 1 | | | EMPTY |

ALL SIGNALS INVERTED

GNC POWER DISTRIBUTION

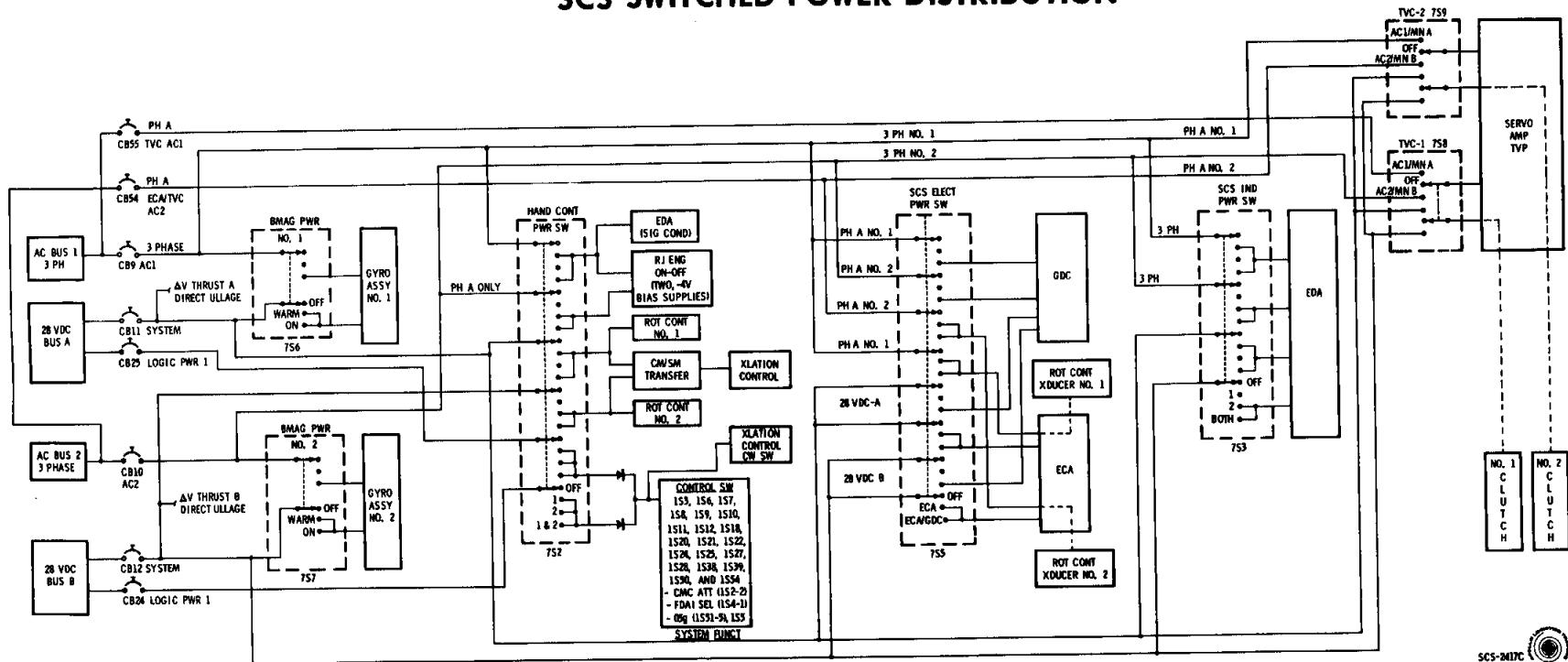


SCS NON SWITCHED POWER



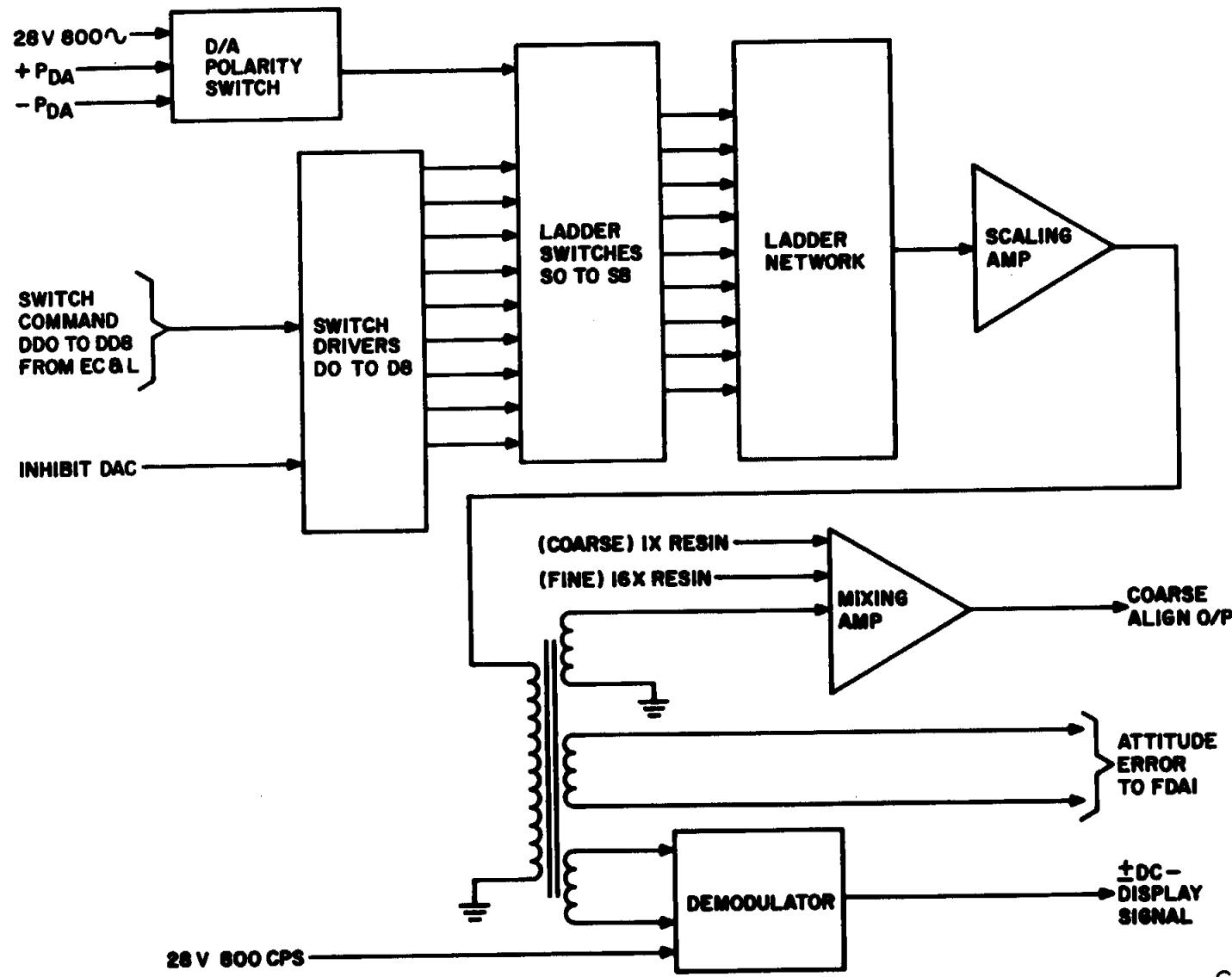
SCS-241

SCS SWITCHED POWER DISTRIBUTION



SCS-MTC

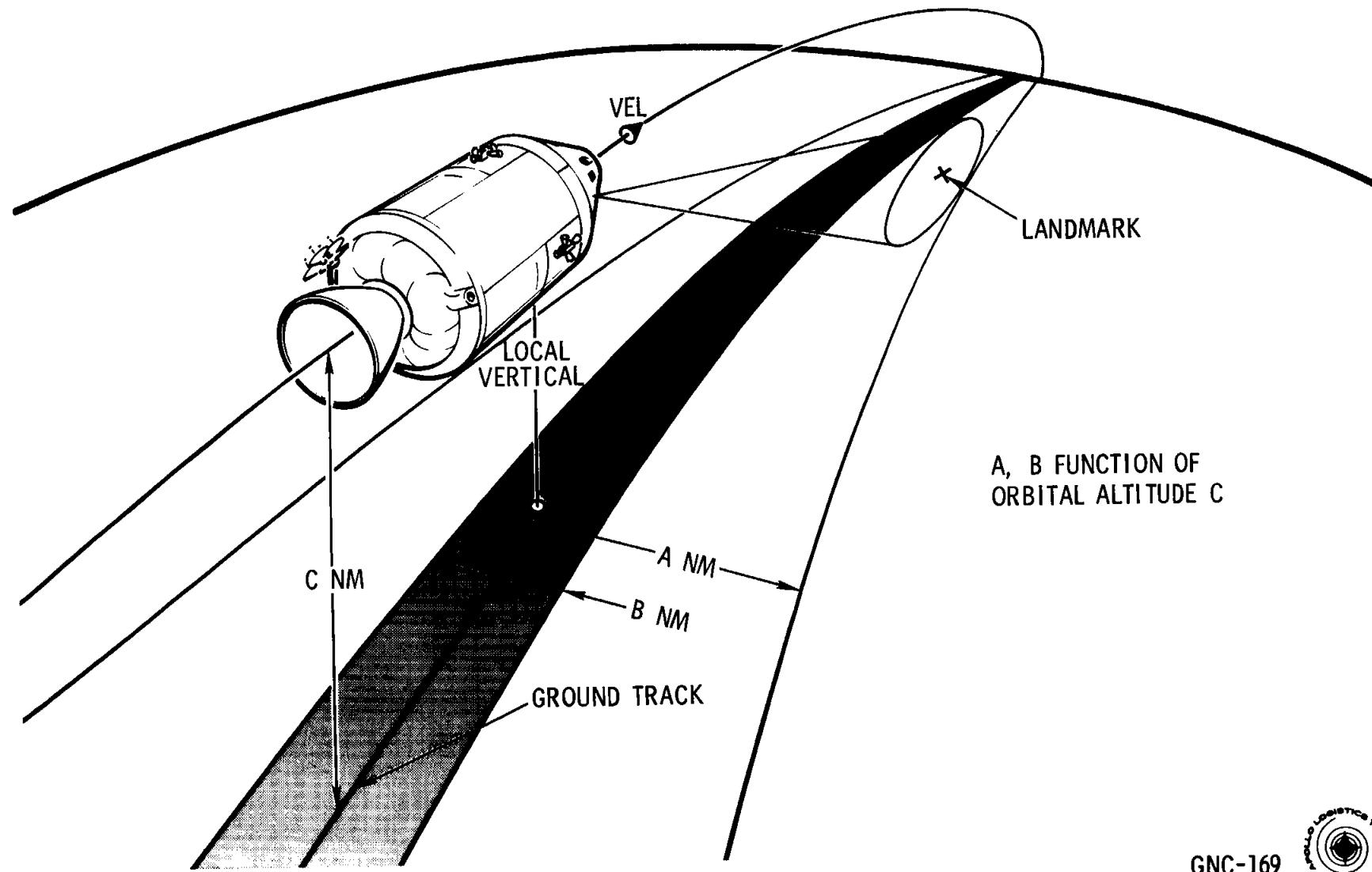
DIGITAL TO ANALOG CONVERTER MODULE BLOCK DIAGRAM



GNC-104



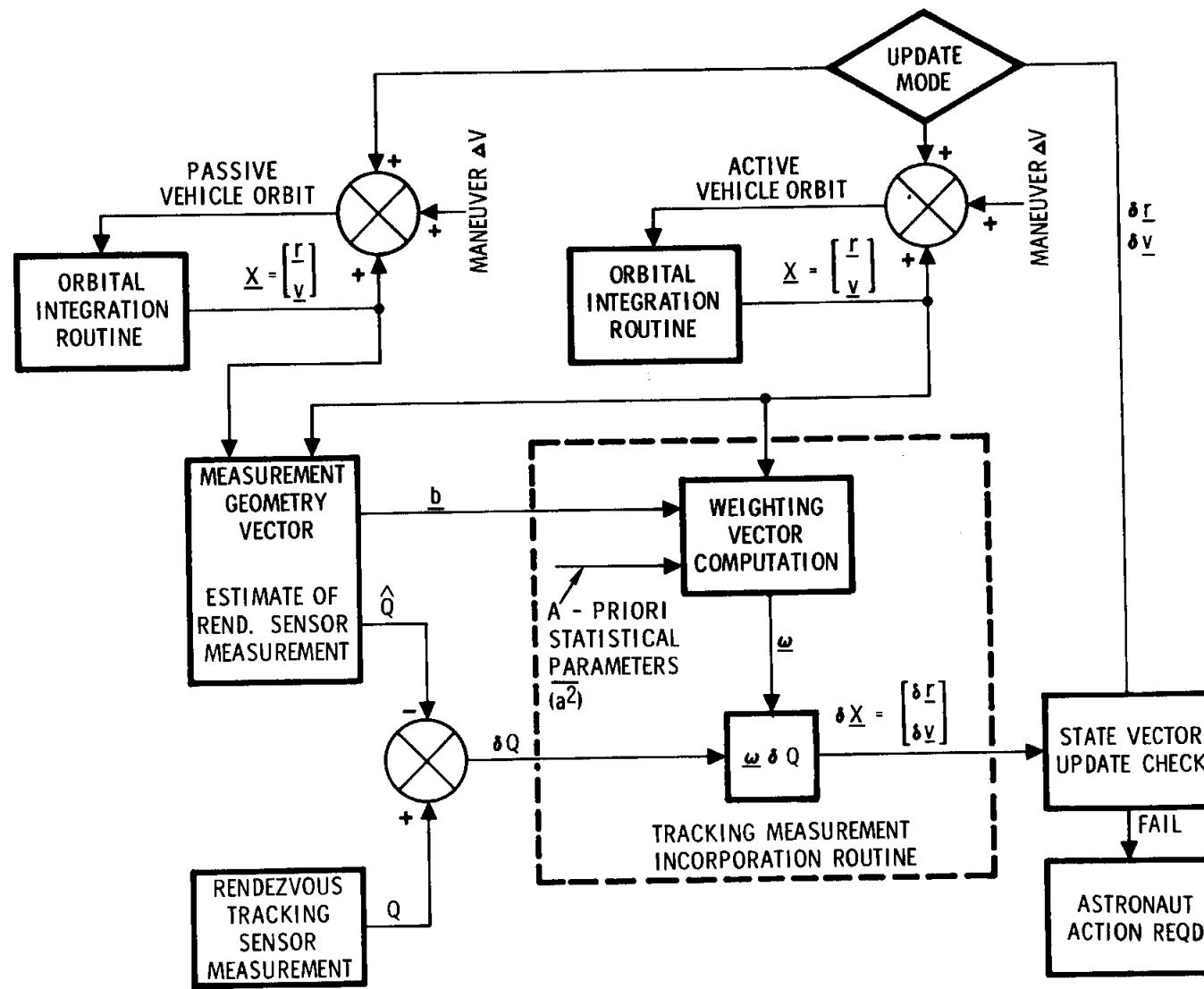
ORBITAL LANDMARK TRACKING



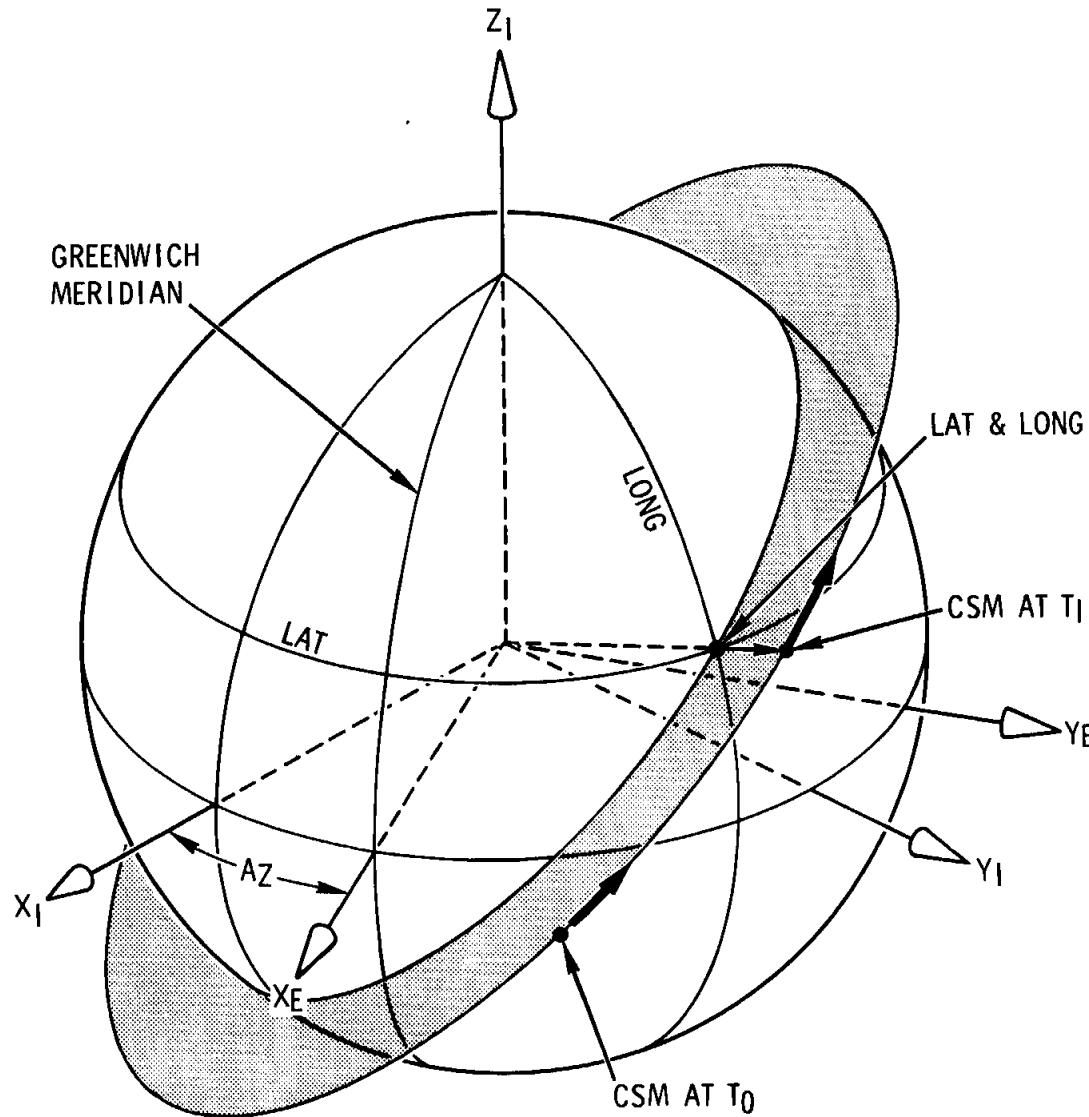
GNC-169



SIMPLIFIED CMC RENDEZVOUS NAVIGATIONAL FUNCTIONAL DIAGRAM

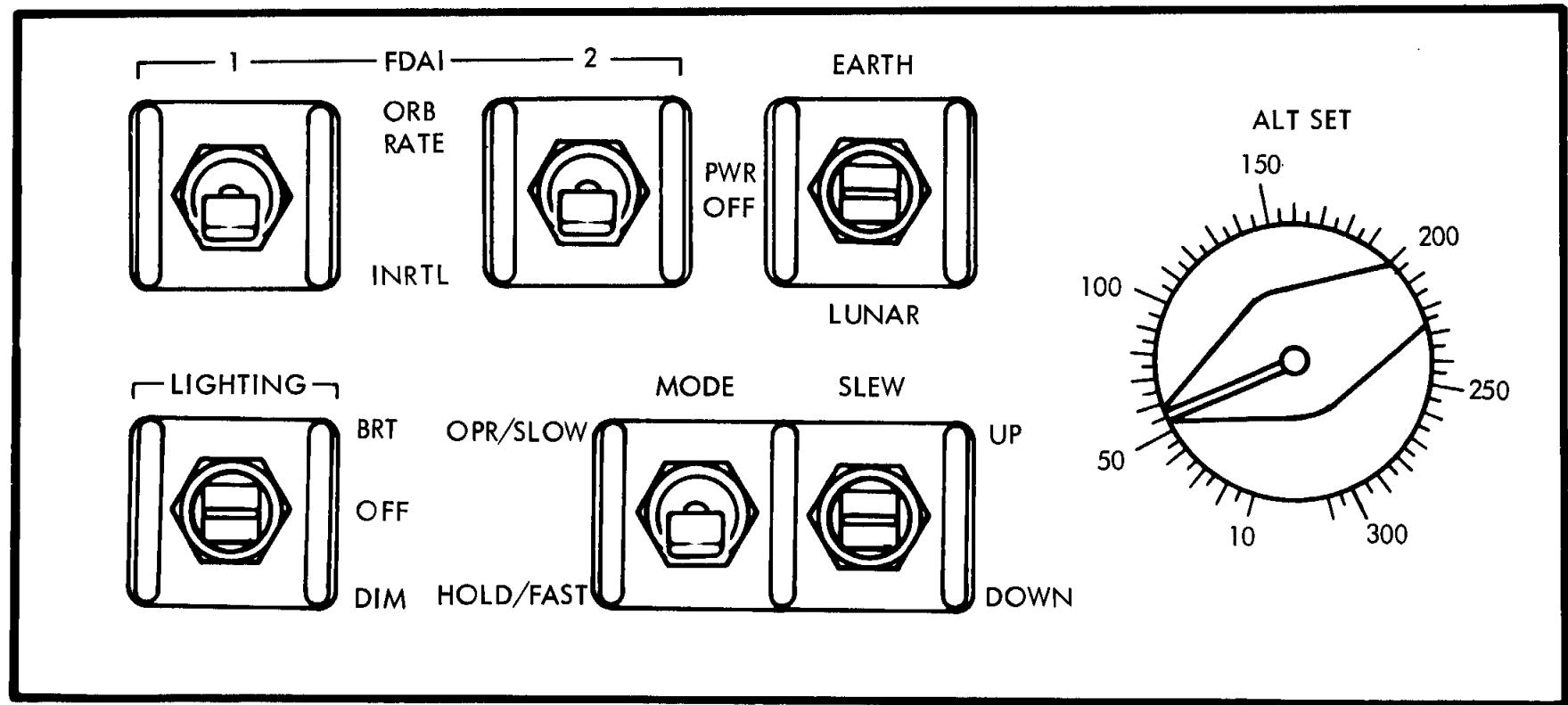


LONGITUDE-LATITUDE DETERMINATION

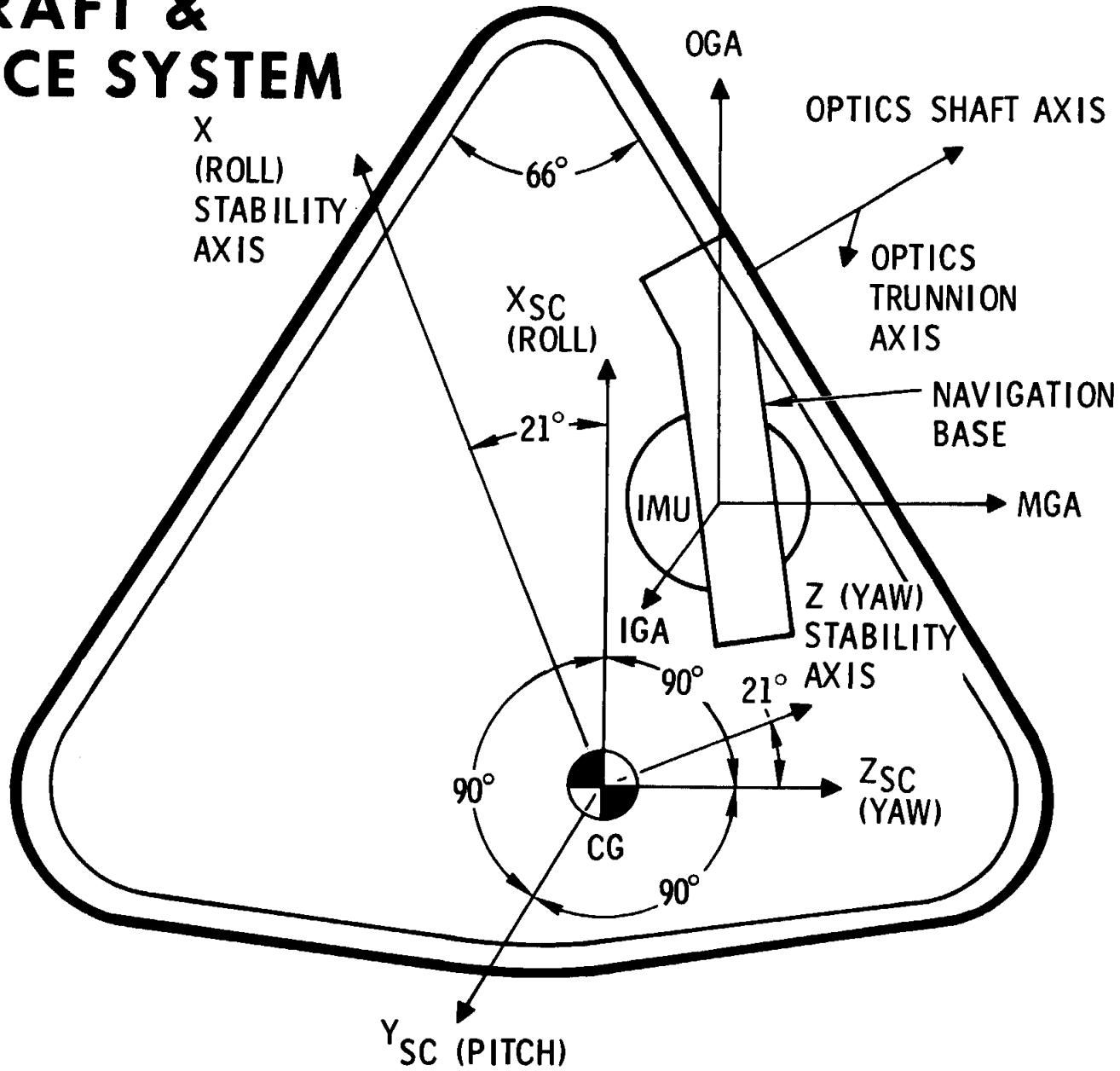


$$AZ = AZ_0 + \omega(t + t_{\text{ephem}})$$

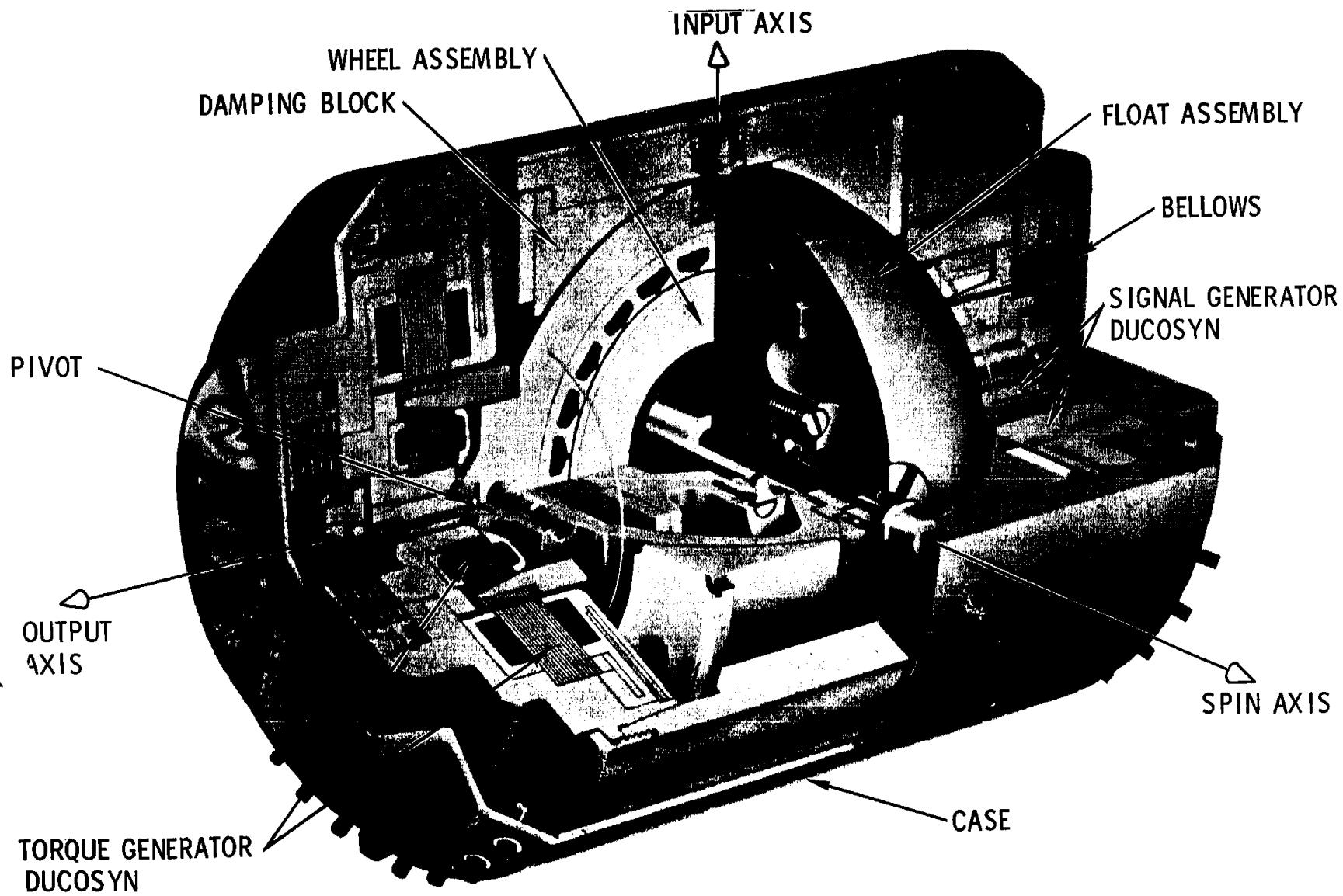
ORDEAL PANEL



SPACECRAFT & GUIDANCE SYSTEM AXES



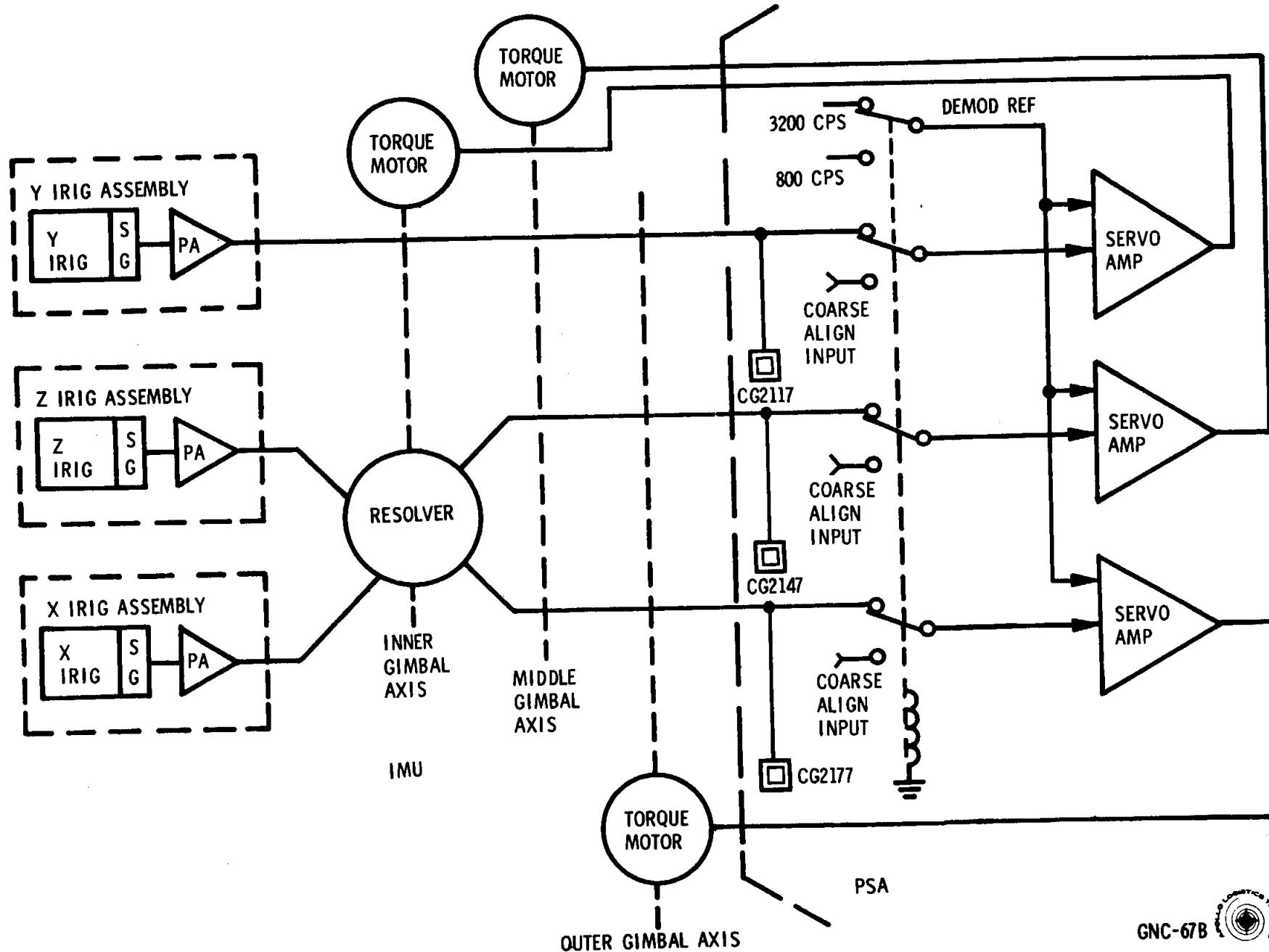
25 IRIG



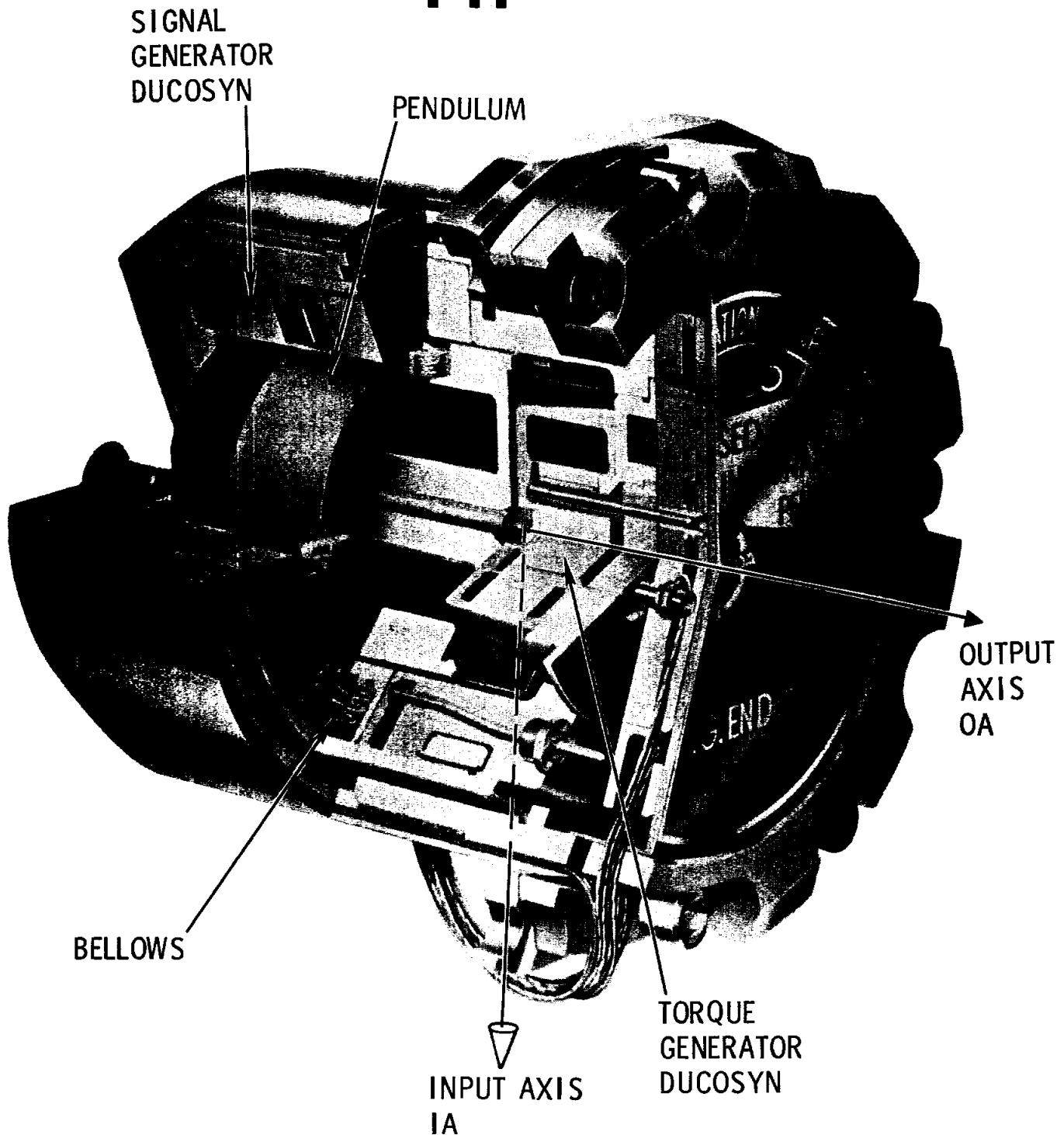
GN-264B



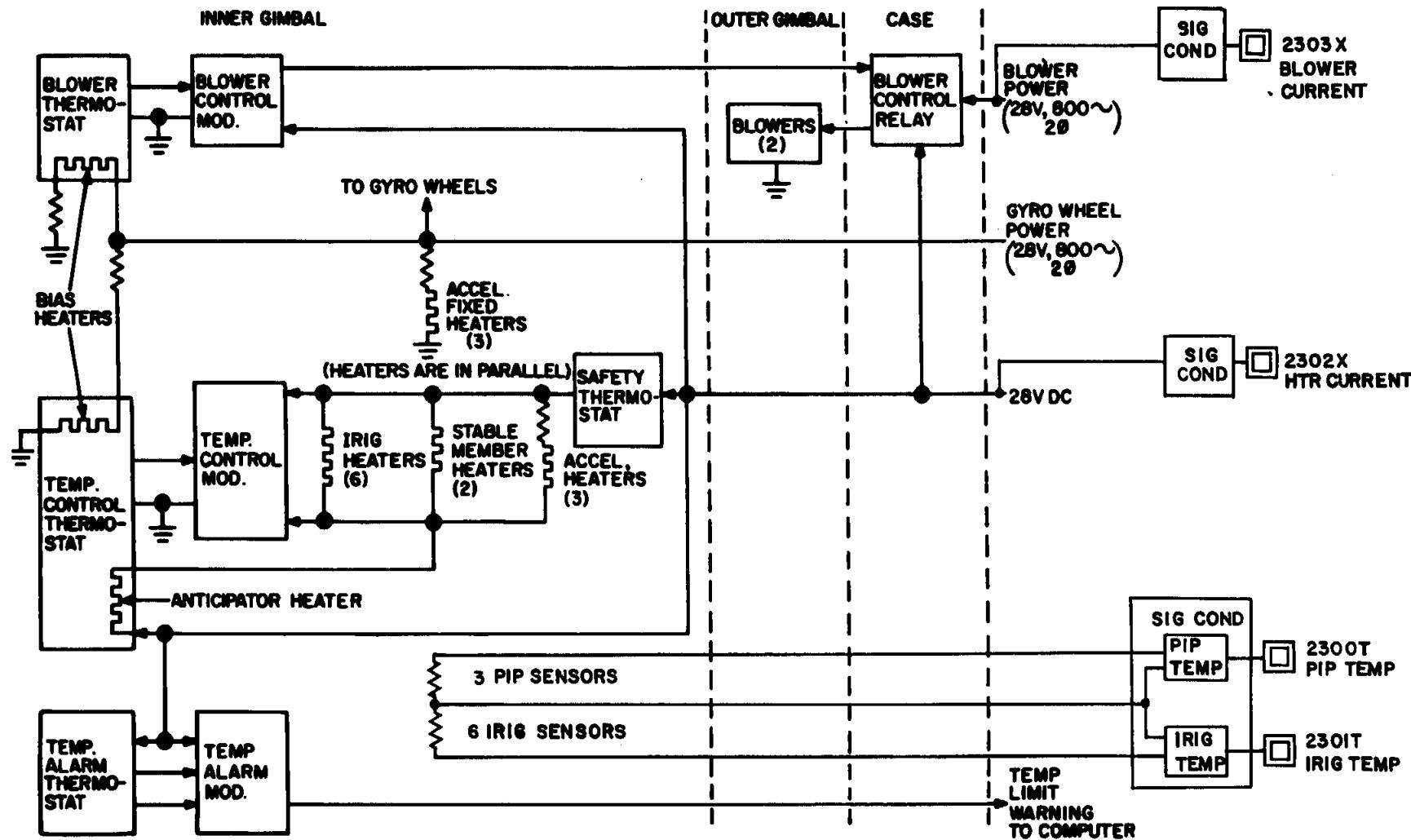
BLOCK II STABILIZATION LOOPS



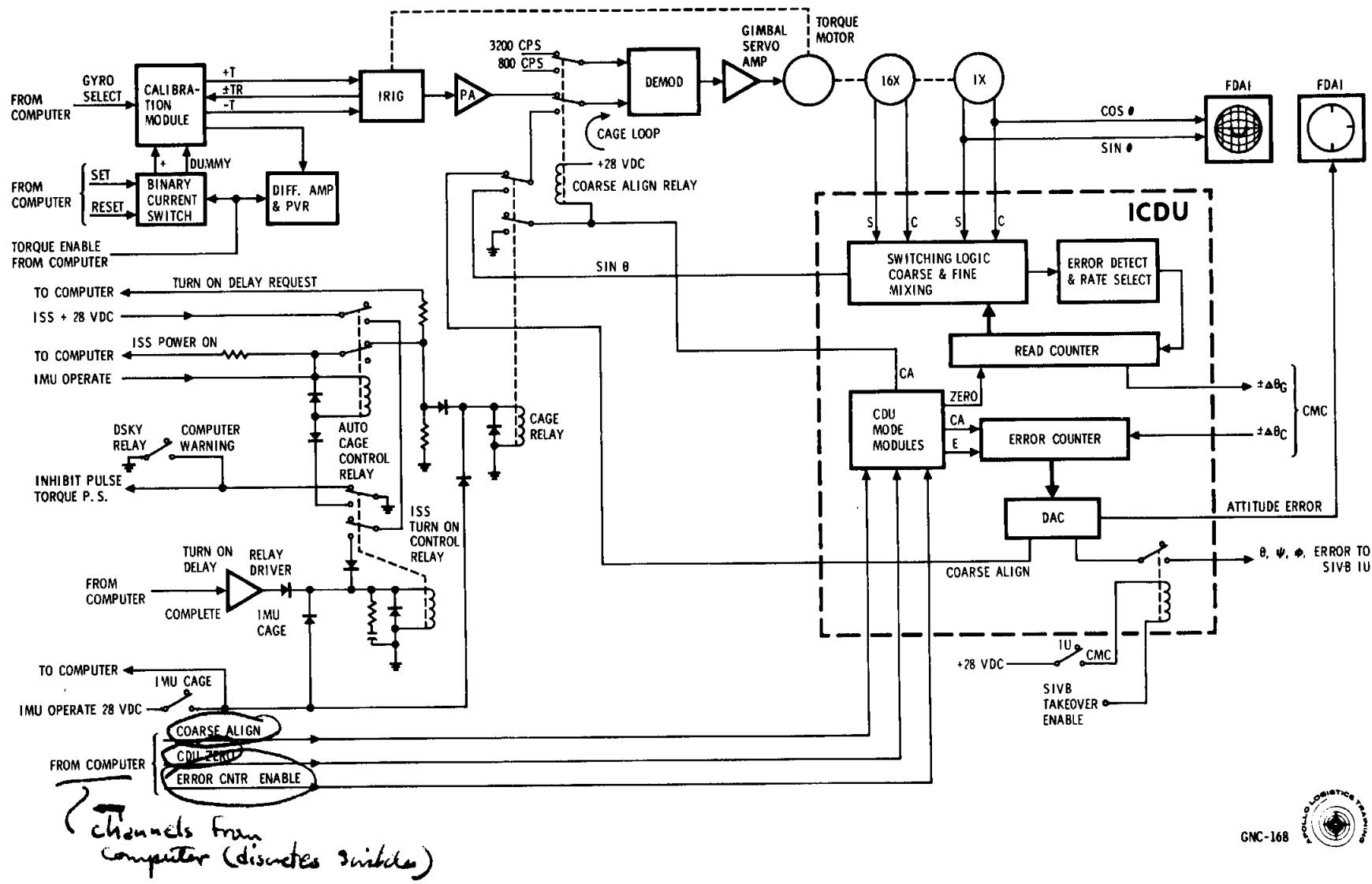
PIP



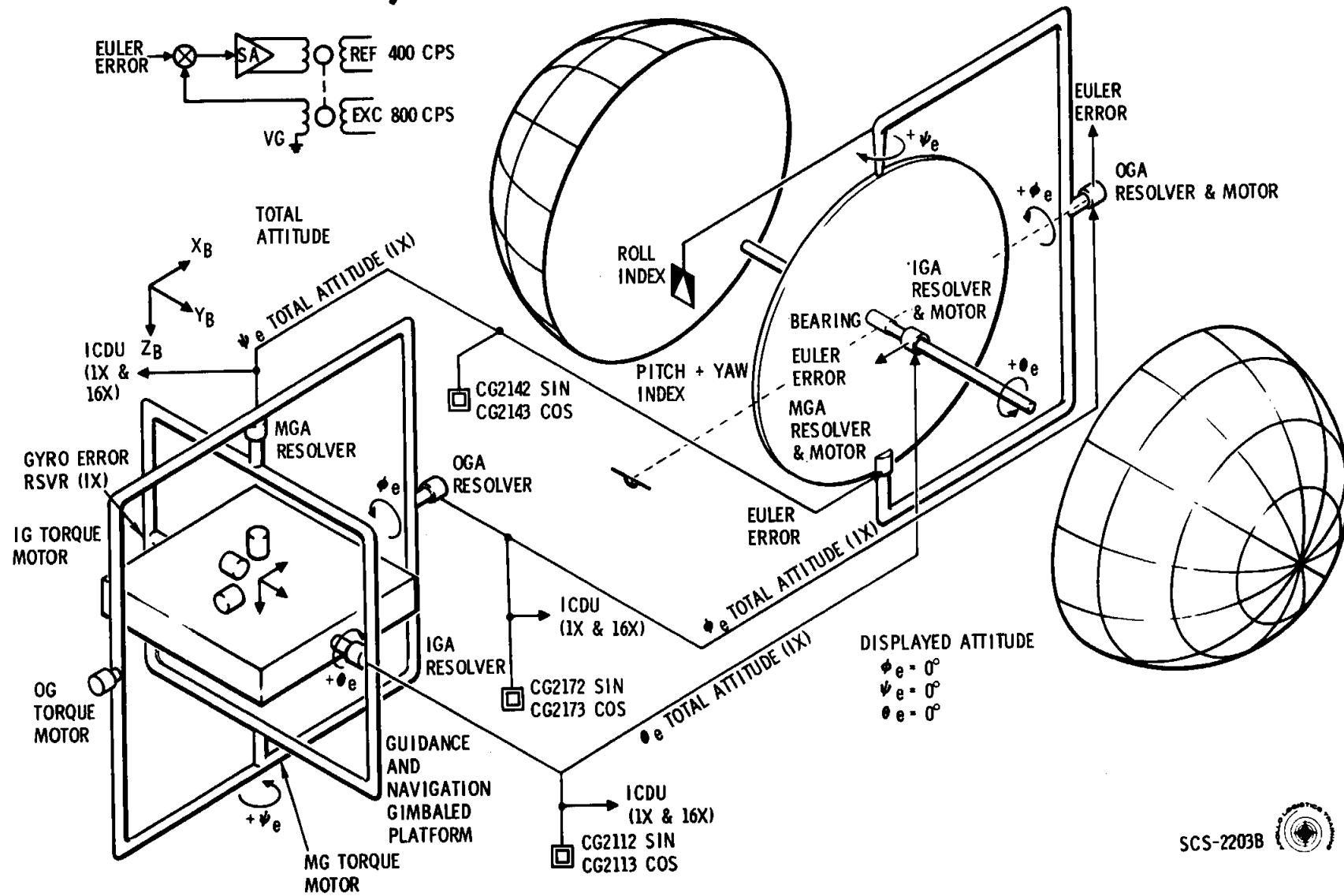
TEMPERATURE CONTROL SYSTEM



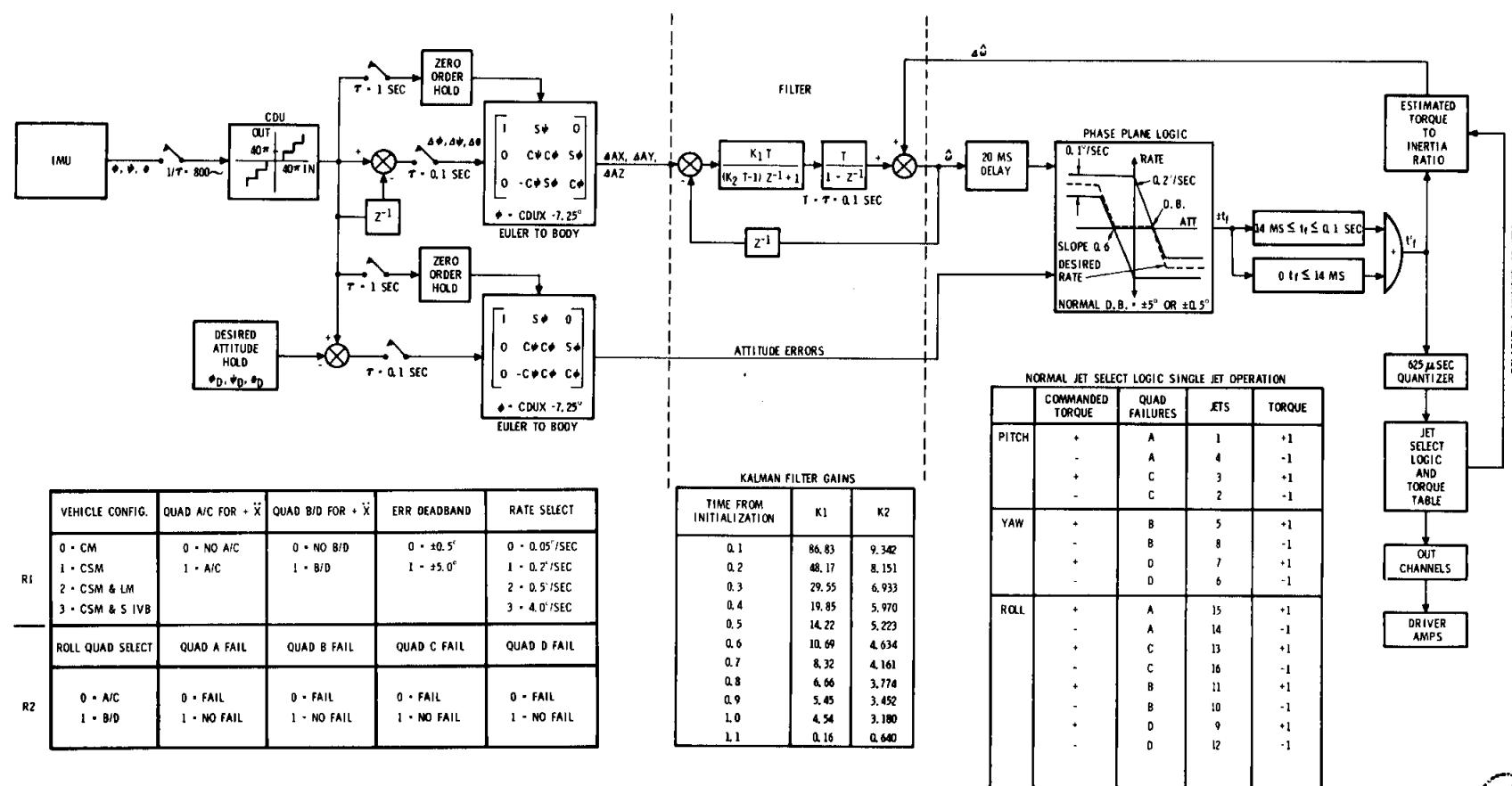
ISS MODES



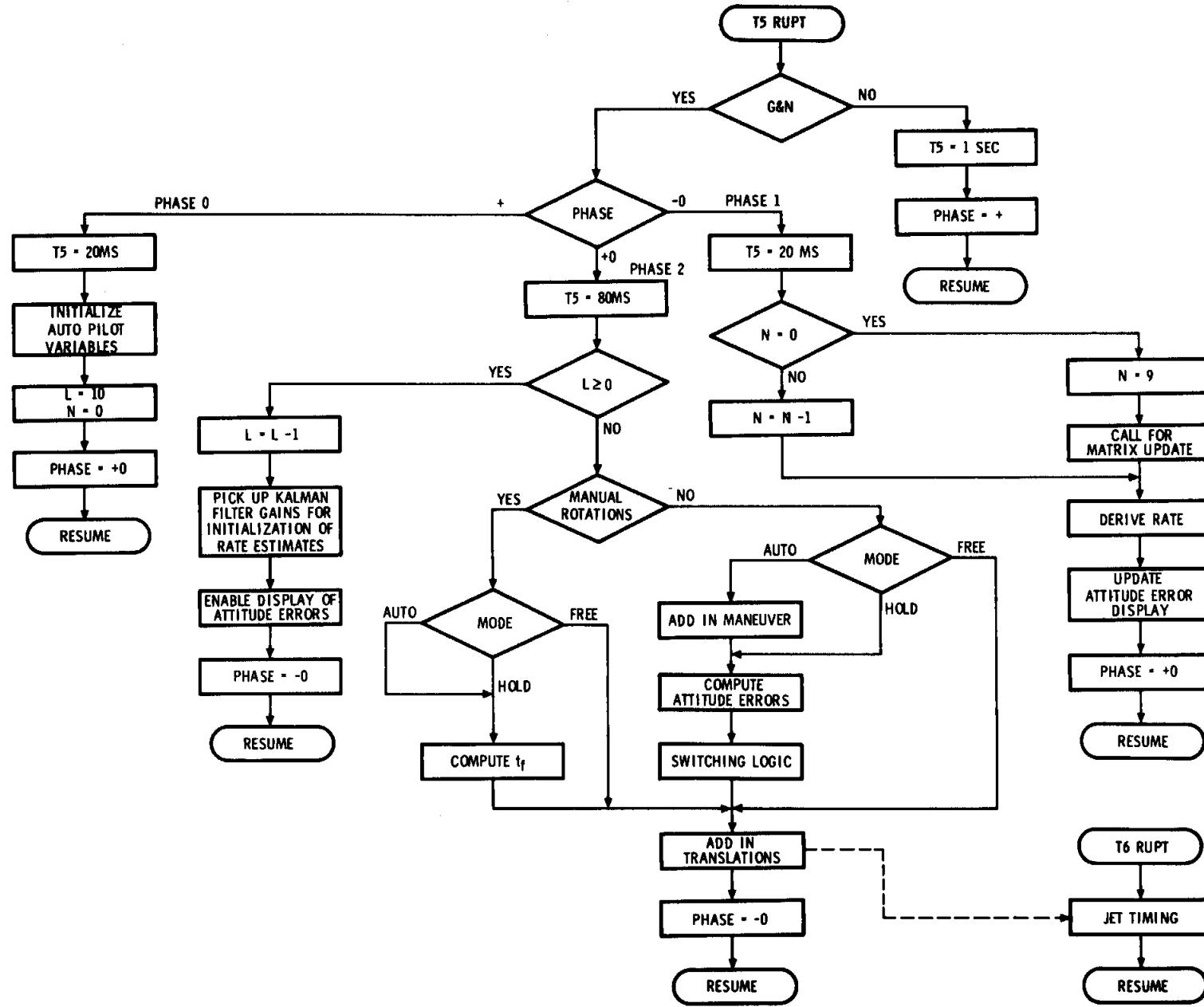
FDAI/IMU GIMBAL RELATIONSHIP



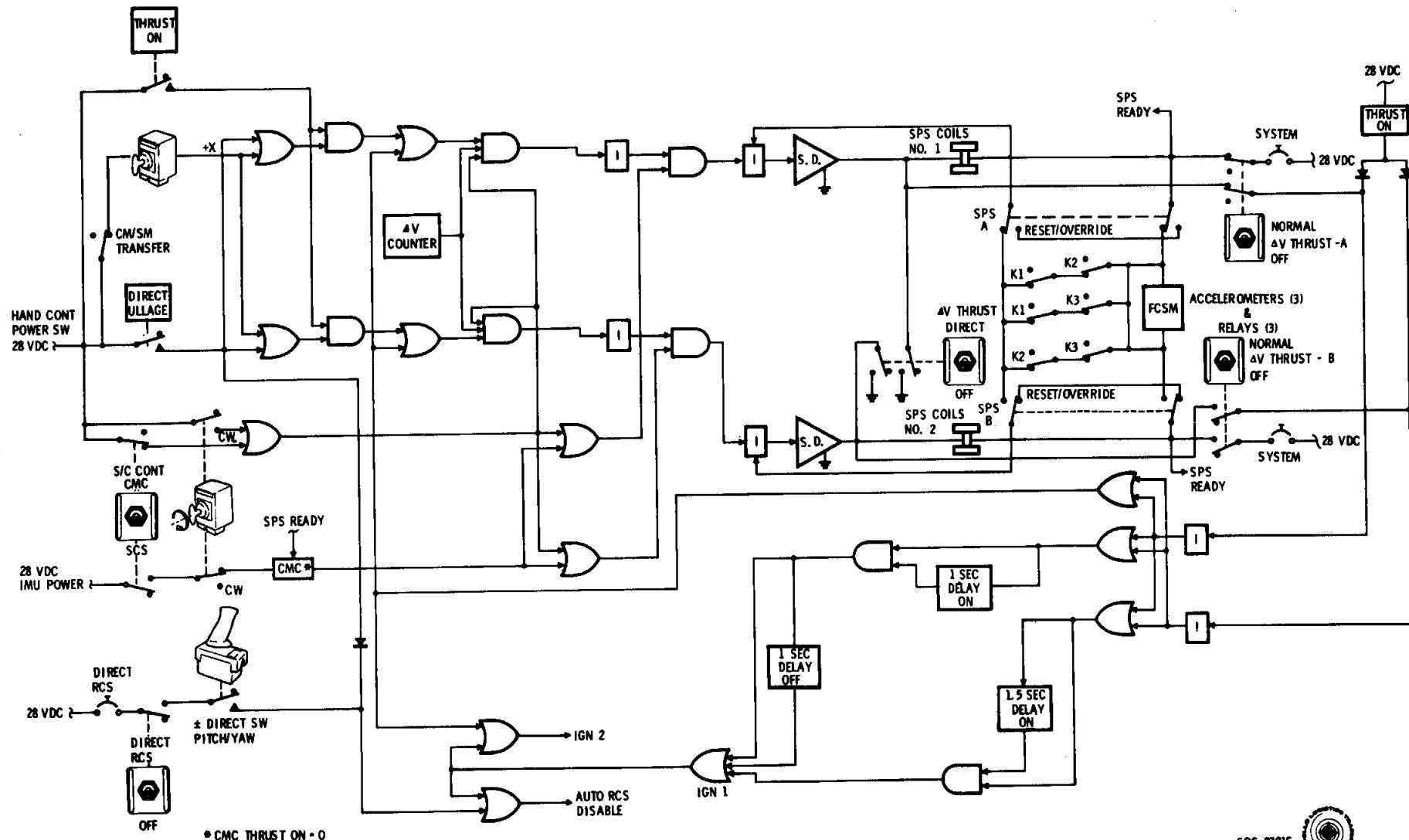
RCS DAP MODEL



PROGRAM LOGIC FLOW RCS DAP



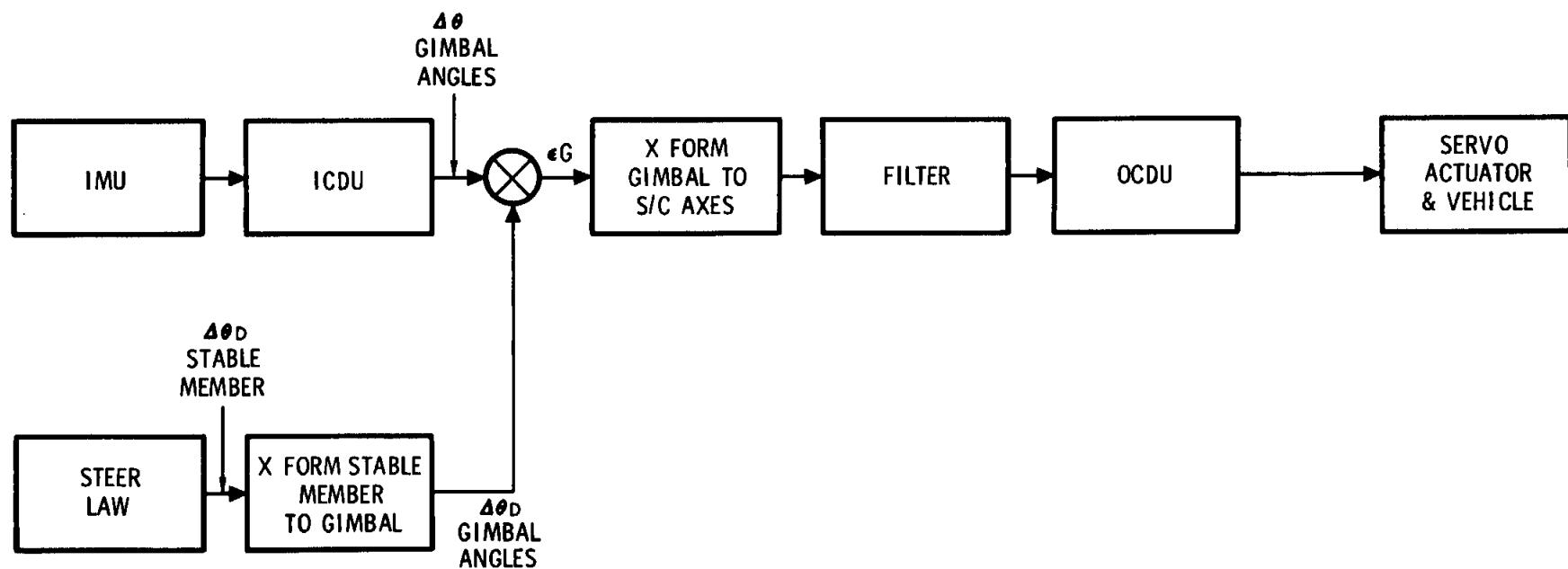
SPS ENGINE ON-OFF LOGIC



SCS-2701F

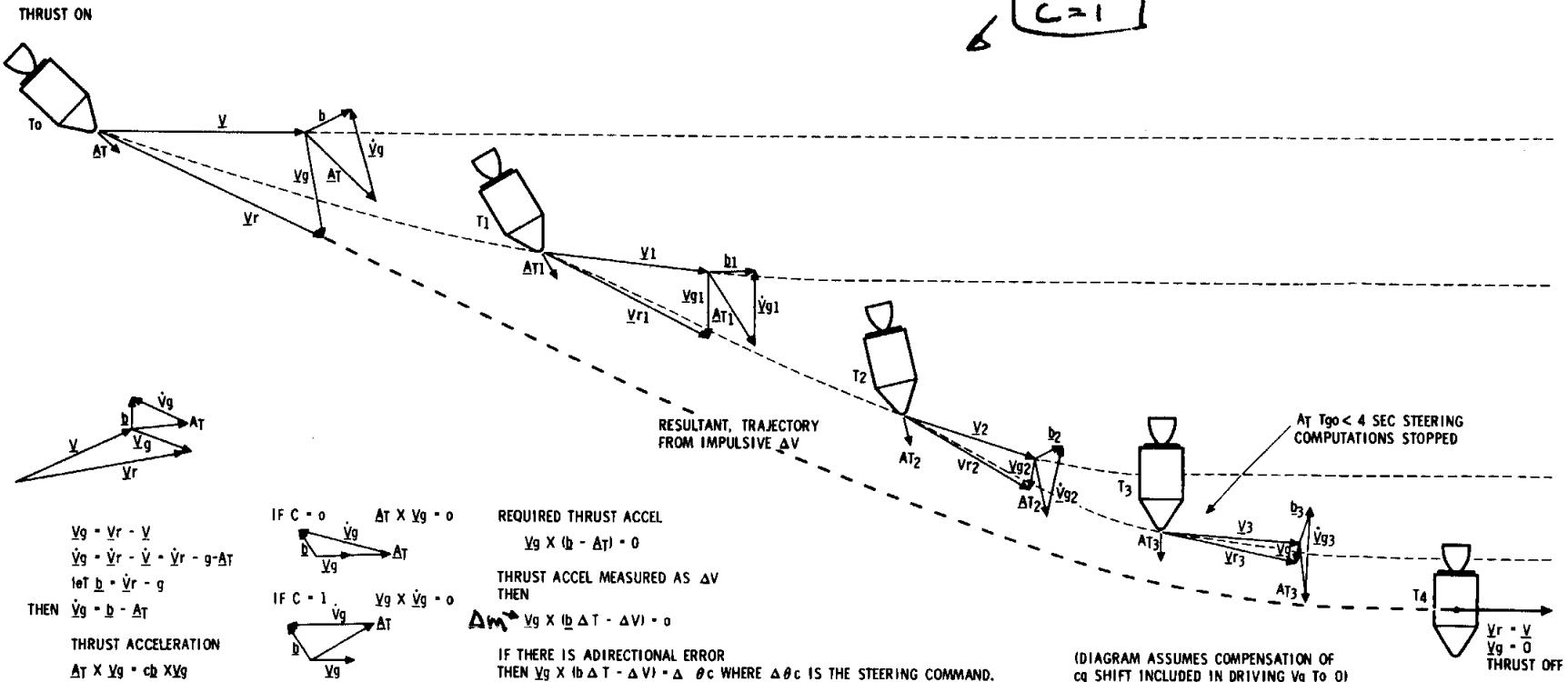
TVC DAP

SIMPLIFIED BLOCK DIAGRAM

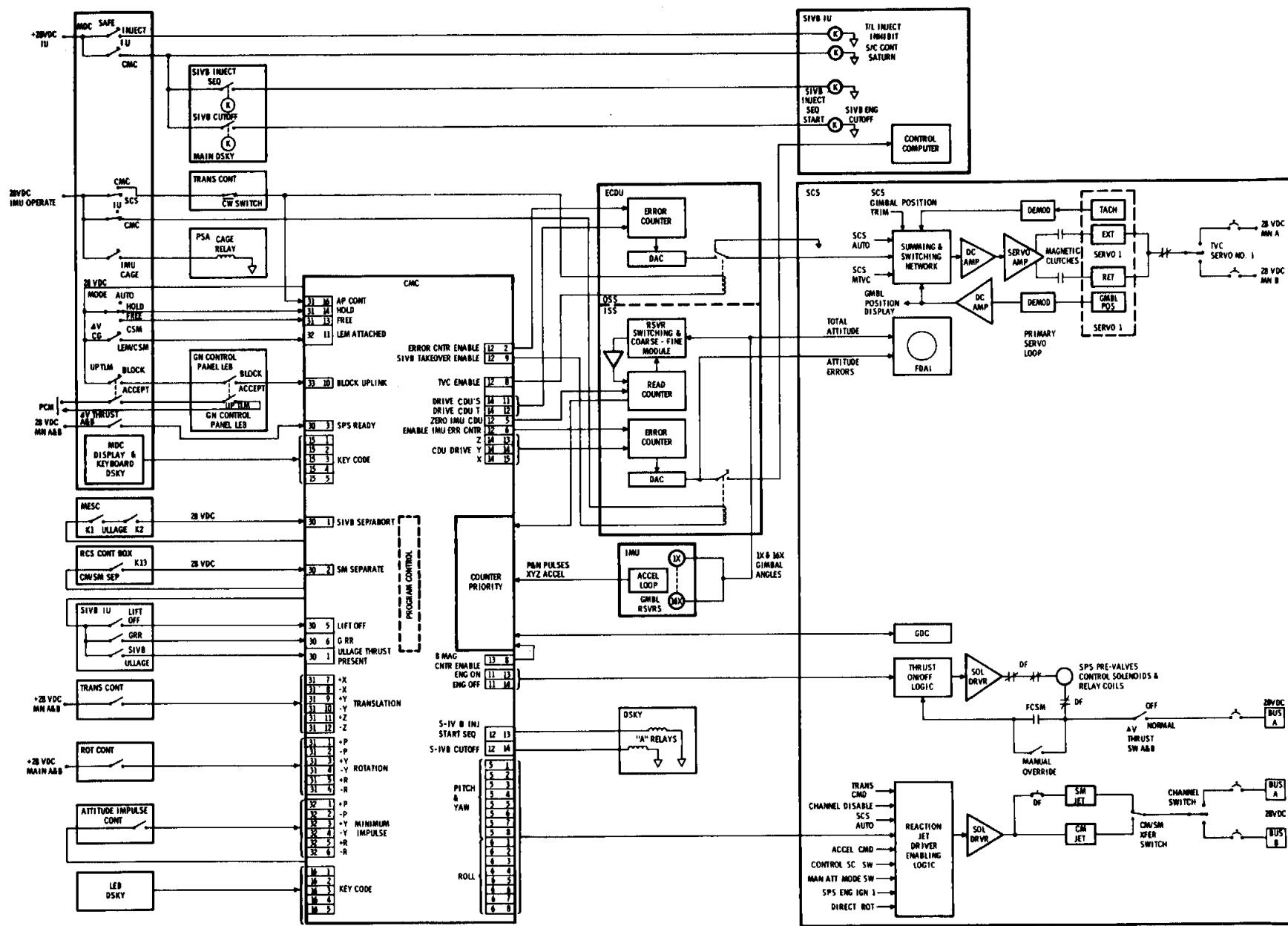


STEERING FOR ORBITAL MANEUVERS

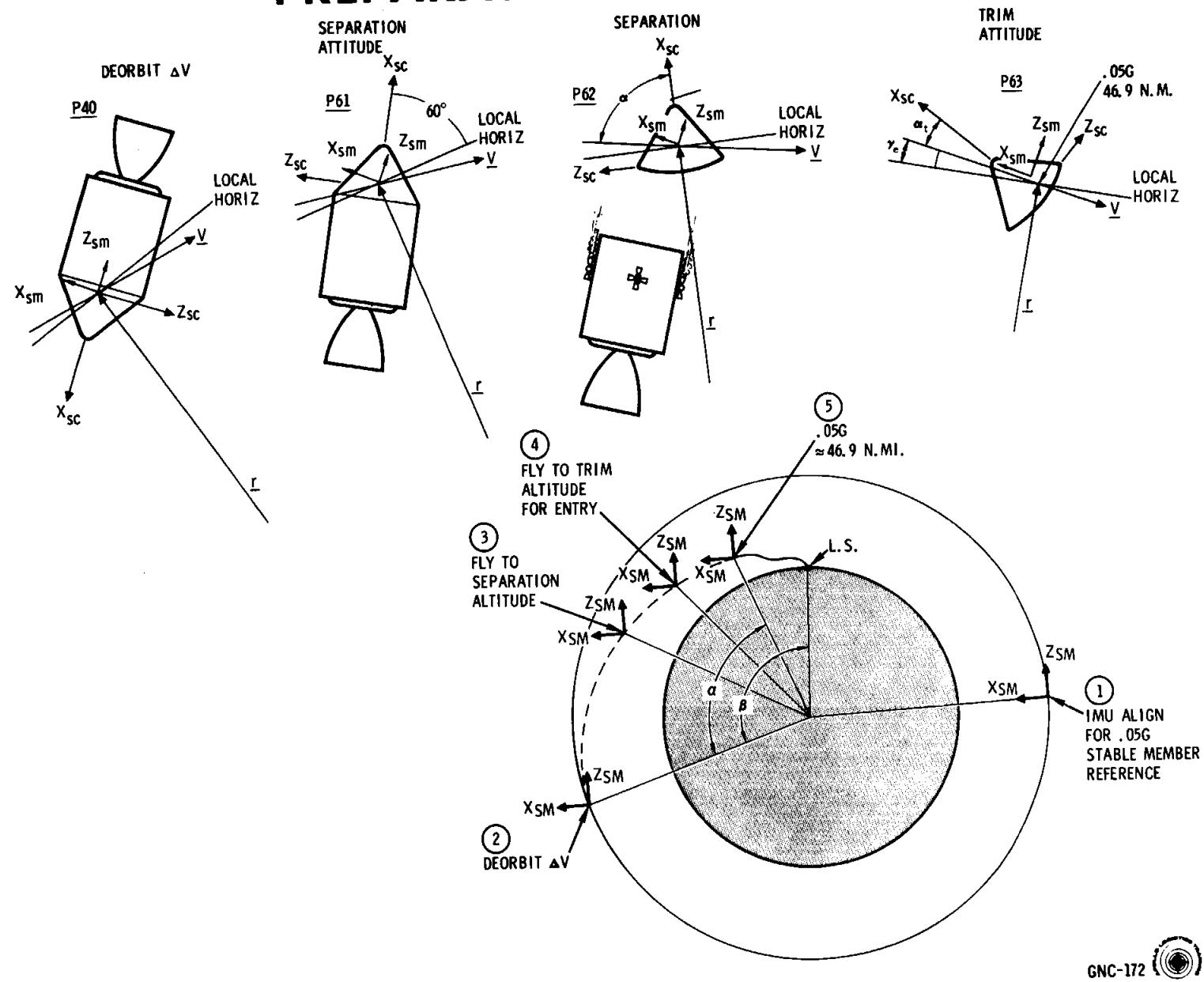
$$C = 1$$



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 | 11E15-2 | 10 |
| CG 1523X | +28V CMC OPERATE | 11E15-3 | 10 |
| CG 1533X | OPTX OPERATE +28 VDC | 11E15-4 | 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 No.</u> | <u>Measurement Description</u> | <u>Channel Code</u> | <u>S/S</u> |
|------------------------|--------------------------------|---------------------|------------|
| CG 3140V | SXT SHAFT TACHOMETER OUTPUT | 11A172 | 10 |
| CG 3150V | SXT TRUNNION TACHOMETER OUTPUT | 11A173 | 10 |
| CG 3160V | SCT SHAFT TACHOMETER OUTPUT | 10A13 | 1 |
| CG 3170V | SCT TRUNNION TACHOMETER OUTPUT | 10A14 | 1 |
| CG 3721V | SHAFT CDU DAC OUTPUT | 11A52 | 10 |
| CG 3722V | TRUNNION CDU DAC OUTPUT | 11A53 | 10 |
| CG 5040X | CMC WARNING | 11E19-1 | 10 |

SCS TM List

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

SCS TM List

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

SCS TM List

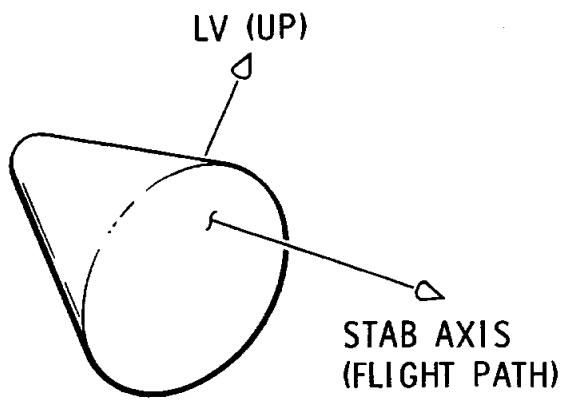
| <u>Measurement ID</u> | <u>Measurement Description</u> | <u>Response Rate</u> | <u>Sensor Range</u> | <u>Display Readout</u> | <u>Channel Code</u> |
|-----------------------|-----------------------------------|----------------------|------------------------|------------------------|---------------------|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

ENTRY DISPLAYS

CREW



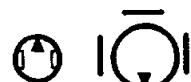
LV (UP)



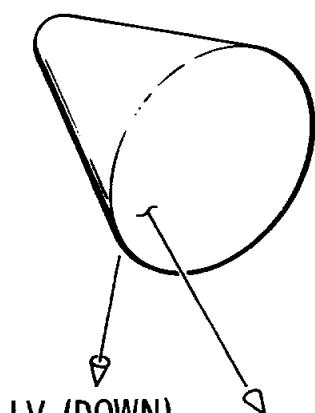
OUTSIDE



LV (NORTH)



STAB AXIS
(FLIGHT PATH)



STAB AXIS
(FLIGHT PATH)