

UNCLASSIFIED

G. SILVER

LECTURE SERIES NO.1

INTRODUCTION TO THE APOLLO GUIDANCE COMPUTER
AND ASSOCIATED GROUND SUPPORT EQUIPMENT

FR-65-114

RAYTHEON

RAYTHEON COMPANY

SPACE AND INFORMATION SYSTEMS DIVISION

LECTURE SERIES NO.1

INTRODUCTION TO THE APOLLO GUIDANCE COMPUTER
AND ASSOCIATED GROUND SUPPORT EQUIPMENT

FR-65-114

RAYTHEON
APOLLO FIELD SUPPORT TRAINING GROUP

LECTURE SERIES NO. 1

INTRODUCTION TO THE APOLLO GUIDANCE COMPUTER
AND ASSOCIATED GROUND SUPPORT EQUIPMENT

- I. Introduction
- II. General Description of Raytheon-Apollo Equipment
 - A. The Computer Subsystem (CSS)
 - 1. Mechanical Description
 - a. Logic Section
 - b. Memory Section
 - c. Display and Keyboard
 - 2. Basic Mission Functions
 - a. Perform Navigation
 - b. Perform Spacecraft Control
 - c. Perform Guidance Calculations
 - 3. Operational Characteristics
 - a. Type of Computer
 - b. Storage Capacity
 - c. Operational Speed
 - B. The Simulation Computer (SimCom)
 - 1. Mechanical Description
 - a. Logic and Memory
 - b. Power Supplies and Cooling
 - 2. Uses
 - a. Procedure Testing
 - b. Laboratory Simulation

C. The Core Rope Simulator (CRS)

1. Mechanical Description

- a. Memory Unit
- b. Control Unit
- c. Tape Reader
- d. Power Supplies

2. Operational Characteristics

- a. Speed
- b. Capacity

D. The AGC Test Set

1. Mechanical Description

- a. The Computer Test Set (CTS)
- b. The Operations Console (AGC/CTS)

2. Operational Characteristics

- a. Functions
- b. Speed

3. Testing Functions

- a. AGC Checkout and Verification
- b. AGC diagnostics and Troubleshooting

E. The Computer Simulator

1. Mechanical Description

- a. Logic Section
- b. Control Panel

2. Function

- a. Inertial Subsystem (ISS) and Optical Subsystem (OSS) Testing
- b. Replace AGC Outputs

3. Characteristics

- a. Outputs Available
- b. Manually programmed outputs

F. The AGC Calibration System

1. Mechanical Description

- a. The VLF Receiver
- b. The Manson Oscillator
- c. The CMC Counter
- d. The Recorder
- e. The Digital Ohmmeter

2. Operation

- a. Temperature Monitoring
- b. Frequency Monitoring

III. Signal Flow Between the CSS and the Spacecraft Systems

A. AGC to Spacecraft Engines

1. Thrust

- a. Turn ON and OFF
- b. Magnitude Determination

2. Thrust Direction

- a. Determination of Necessary Corrections
- b. Thrust Vector Changing

B. CSS to G & N System

1. Inertial Subsystem Control

- a. Stable Member Alignment
- b. Attitude Error for S/C Attitude Control
- c. IMU Mode Switching

2. Optical Subsystem

- a. Starline of Sight Positioning
- b. Mode Switching

C. CSS to Radar System

1. Lunar Landing

- a. Available Data
- b. Acquisition of Data

2. Rendezvous with CM

- a. Available Data
- b. Acquisition of Data

D. CSS to Telemetry

1. UPLINK

- a. Data Format
- b. Control Functions

2. DOWNLINK

- a. Data Format
- b. Sequencing of Data
- c. Types of Data

IV. Signal Flow Between the CSS and the AGC Test Set

A. Computer Logic Level Signal Transfer

1. AGC to Test Set

- a. Discrete Words
- b. Condition Bits
- c. Data Transfer Control
- d. Timing Control

2. Test Set to AGC

- a. Discrete Words
- b. Sequence Control
- c. Function Inhibits

B. Simulation of the System Interface Signal Transfer

1. AGC Output Reception

- a. Display on Oscilloscope
- b. Rerouted to Simulate Inputs

2. AGC Input Simulation

- a. Switching one AGC Output
- b. Looping all AGC Outputs

V. The Computer Subsystem

A. General Description of the CSS

1. Detailed Characteristics

- a. Number of Instructions
- b. Types of Involuntary Responses
- c. Speed of Instruction Execution
- d. Speed of Accumulation of Data

2. Functional Blocks

- a. Basic Description of Each Block
- b. Duties of Each Block

B. Organization and Operation

1. Timing

- a. Variety of Timing Controls
- b. Functions of the Timing Controls

2. Central Processor

- a. Register Identification
- b. Register Functions
- c. Data Format to and from Memory

3. Sequence Control

- a. Normal Operation
- b. Data Accumulation
- c. Interrupt Response

4. Memory

- a. Fixed Memory
- b. Erasable Memory
- c. Memory Addressing

- 5. Input-Output Section
 - a. Register Identification
 - b. Input Data Handling
 - c. Rate Outputs
- 6. Alarm Detection
 - a. Alarms Provided
 - b. Restart Function
- 7. DSKY Operation
 - a. Relay Matrix
 - b. Decoding, Relay Selection
 - c. Electroluminescent Lights

VI. The AGC Test Set

- A. General Description
 - 1. Modes of Operation
 - a. AGC Control Modes
 - b. Internal CTS Modes
 - 2. Functional Blocks
 - a. Basic Description of Each Block
 - b. Function of Each Block
 - 3. Displays
 - a. Data Displays
 - b. Condition Displays
 - c. AGC Interface Output Displays
- B. Analysis of Each Mode
 - 1. Monitor
 - a. Control of Data Transfer
 - b. Registers Displayed
 - c. Sample Operation

2. Load

- a. Address Selection and Storage
- b. Data Selection and Storage
- c. Data Transfer to AGC

3. Display

- a. Address Selection
- b. Data Storage in CTS

4. Tape Generation

- a. Preparation
- b. Verification
- c. Duplication

5. Data Recording

- a. Selection of Locations
- b. Data Transfer Control
- c. Tape Punching Sequence

6. AGC Transfer Control (TCSA)

7. UPLINK Testing

- a. Manual
- b. Tape

C. AGC Start and Stop Control

1. Stop Control

- a. AGC Stop Condition
- b. Stop Options

2. Start Control

- a. Proceed from Stop
- b. Fresh Start

D. The System Interface Unit

1. Functional Blocks

- a. Signal Generating Logic
- b. Switching

2. Signal Simulation

- a. Internally Generated signals
- b. AGC Outputs Utilized
- c. Switch Selection

VII. AGC Program Identification

A. The Executive Section

1. Purpose and Function

- a. Scheduling of Activities
- b. Job Definition

2. Scheduling Procedure

- a. Priority
- b. The Executive List

B. The Waitlister Section

1. Purpose and Function

- a. Task Definition
- b. Scheduling necessity

2. Scheduling Procedure

- a. Time Dependence
- b. The WAITLIST

C. Program Section Pinball

1. Interrupt Function

- a. Respond to Key
- b. Store Necessary Data
- c. Schedule Job to Perform Action

2. Sequence of Activity

- a. Individual Jobs for each Key
- b. Buildup of all Data Necessary to Complete a Function

- 3. Functions Available
 - a. Display Verbs
 - b. Load Verbs
 - c. AGC Activity Control Verbs

D. System Test Program Sections

- 1. G & N System Control Verbs
 - a. Mode Switching Verbs
 - b. Control Verbs
- 2. Testing Verbs
 - a. PIPA Scale Factor Determination
 - b. IRIG Coefficient Determination

VIII. CTS Operating Procedures

A. Data Loading

- 1. Keyboard Loading
 - a. Entering Address
 - b. Entering Data
 - c. Significance of Displays
- 2. Tape Loading
 - a. Preliminary Set-up
 - b. Display Significance While Loading
 - c. Verification of Load

B. Data Display

- 1. Entering Address
- 2. Interpreting Displays

C. Transfer Control

- 1. Entering Address
- 2. Initiating the TC
- 3. Display Significance

D. Data Record

1. Normal

- a. Location Selection
- b. Tape Punch Sequence Selection
- c. Tape Format Interpretation

2. Special Monitoring

- a. Location Selection
- b. Display Selection

E. Monitor

1. Interpretation of Data Displays

- a. Address Register
- b. Program Counter

2. Interpretation of Condition Displays

- a. Branch Bits
- b. SQ Display Bits

3. Operation Speed Control

- a. Single Stop
- b. Address Stops
- c. Free Run

4. Sample Interpretation

IX. CTS System Interface Unit Operation

A. Interpretation of AGC Outputs

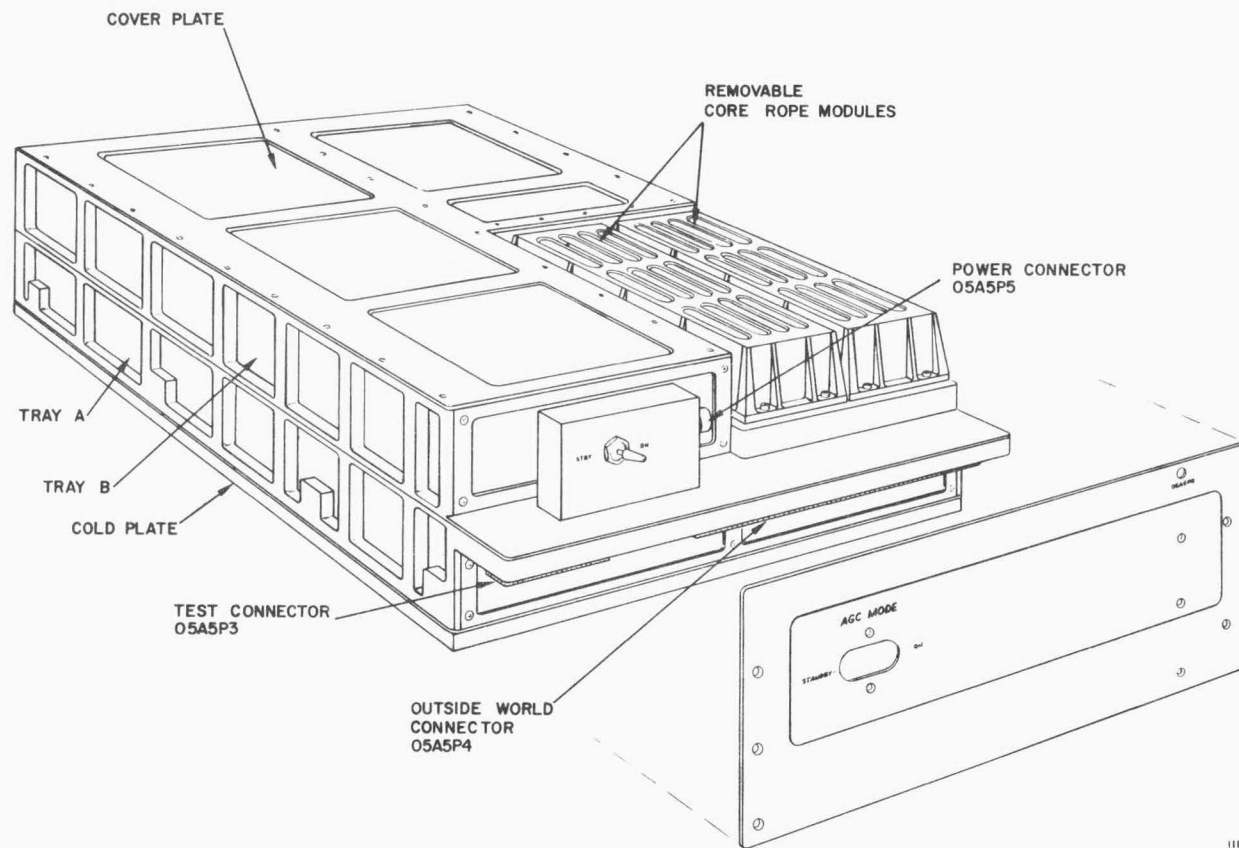
1. DSKY Relay Condition Display

- a. Navigational
- b. Main

2. AGC Telemetry Alarm Display

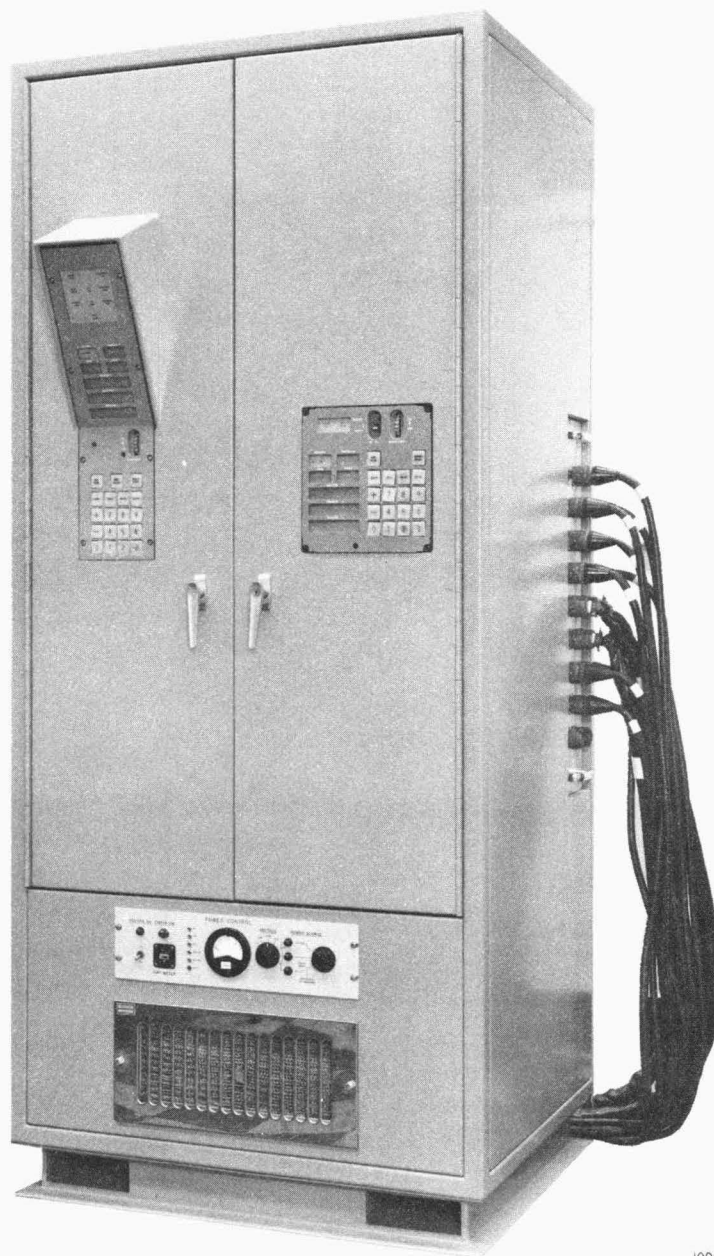
- a. Flag Indicating Lamp
- b. Selection Switch

3. Oscilloscope Display of Pulsed Outputs
 - a. Channel A Switches
 - b. Channel B Switches
 - c. Phase Comparison of Outputs
- B. AGC Input Selection
 1. Discrete Inputs
 - a. IMU Condition Bits
 - b. Optics Condition Bits
 - c. Radar System Condition Signals
 2. Errupt Inputs
 - a. System Fail Signals
 - b. Engine Signals
 3. Incremental Data Inputs
 - a. Using one AGC Output
 - b. Looping all AGC Outputs
 4. Downlink Testing
 - a. Using CTS Timing
 - b. Using AGC Programmed Outputs



1189

Figure 1. Block IF Computer



1006

Figure 2. Simulation Computer

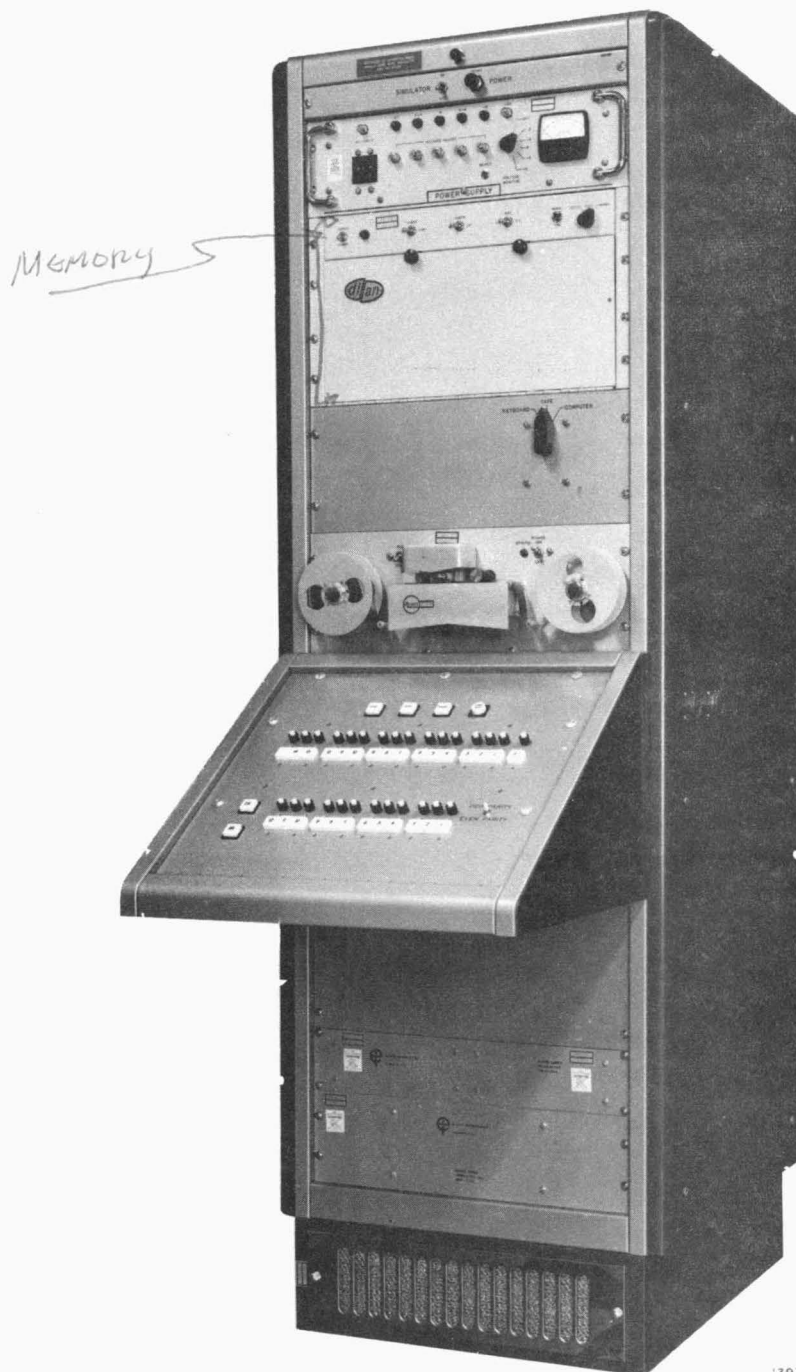
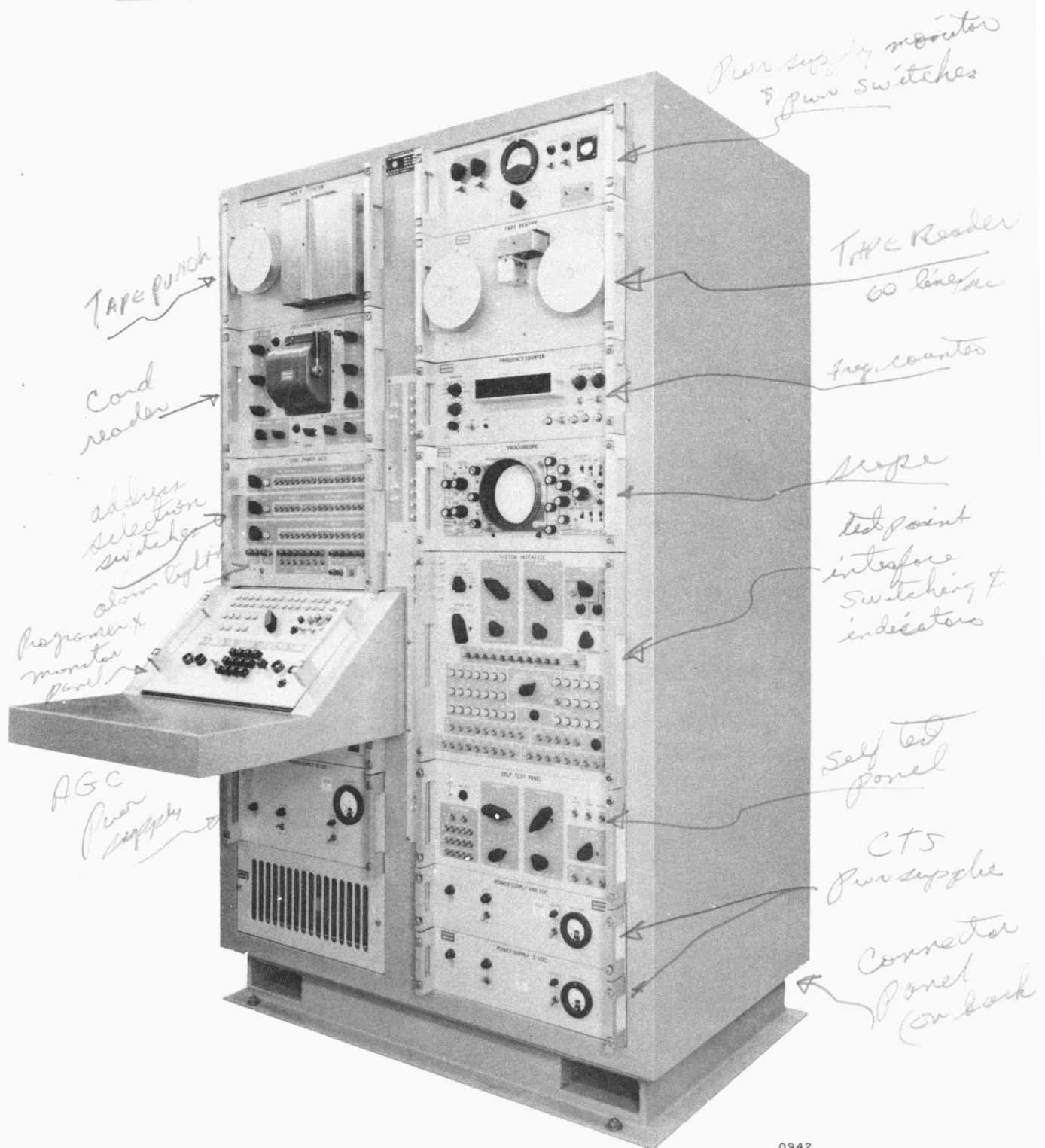
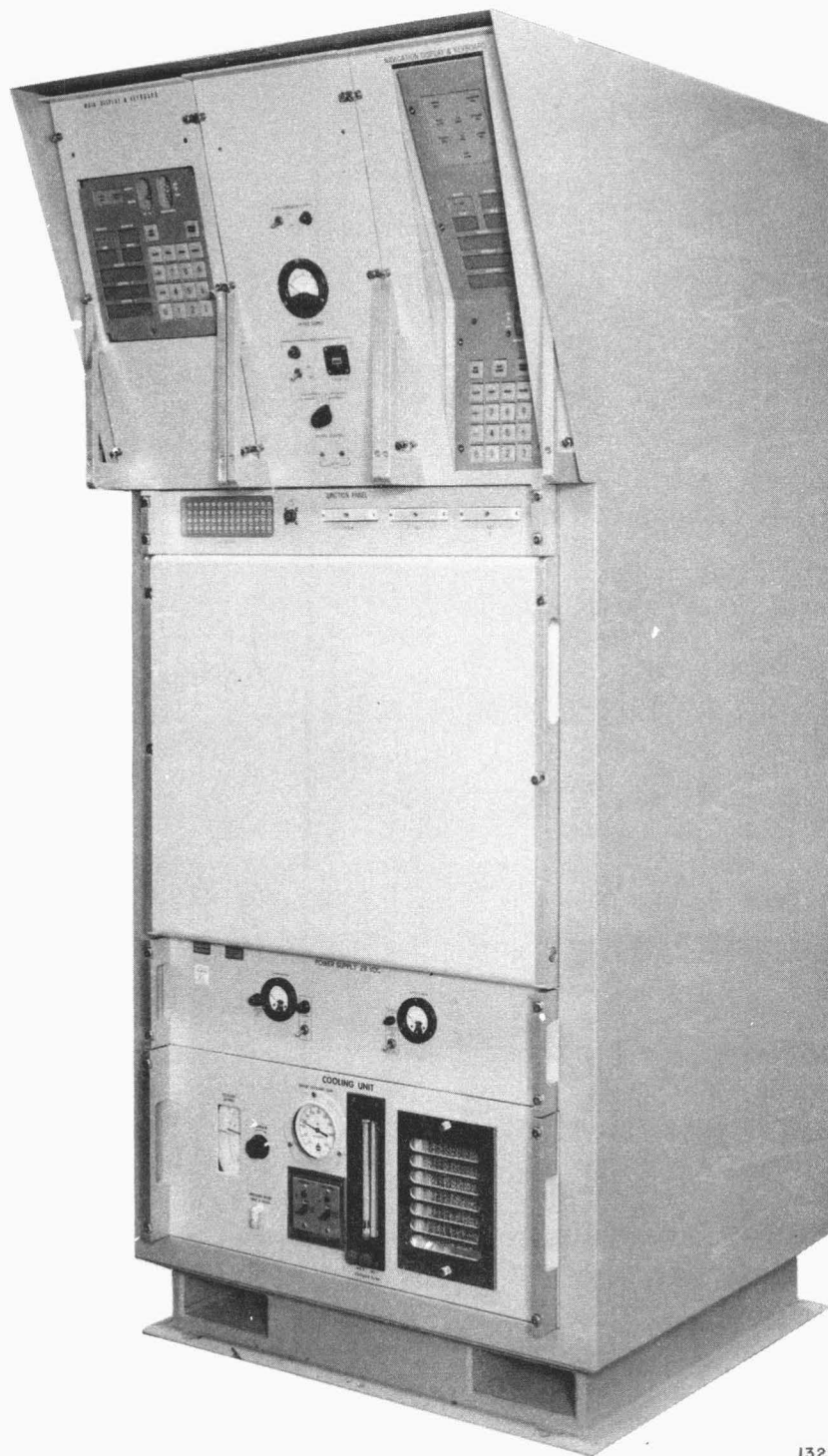


Figure 3. Core Rope Simulator



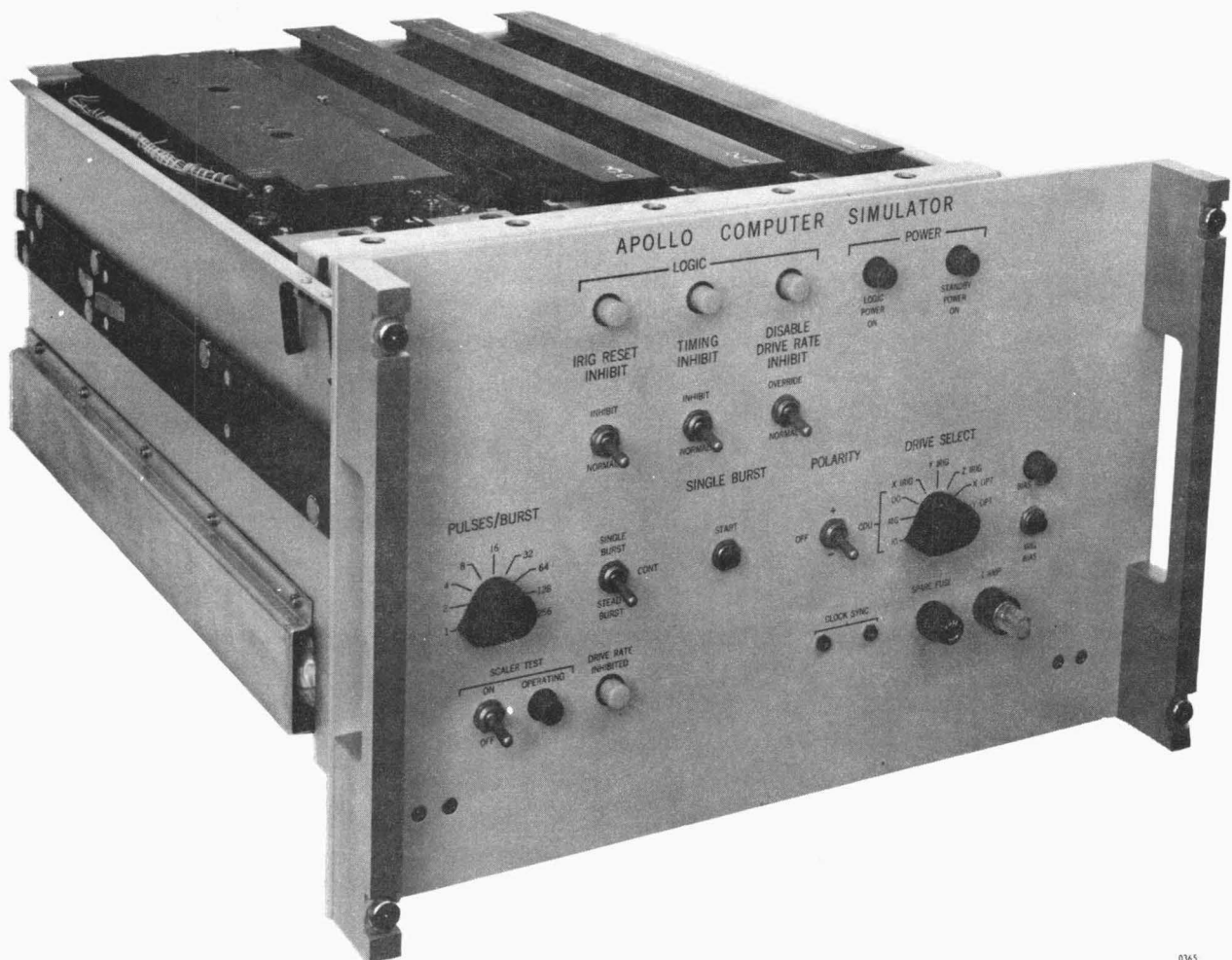
0942

Figure 4. Computer Test Set (CTS)



1329

Figure 5. AGC/CTS Operation Console



0365

Figure 6. Apollo Guidance Computer Simulator

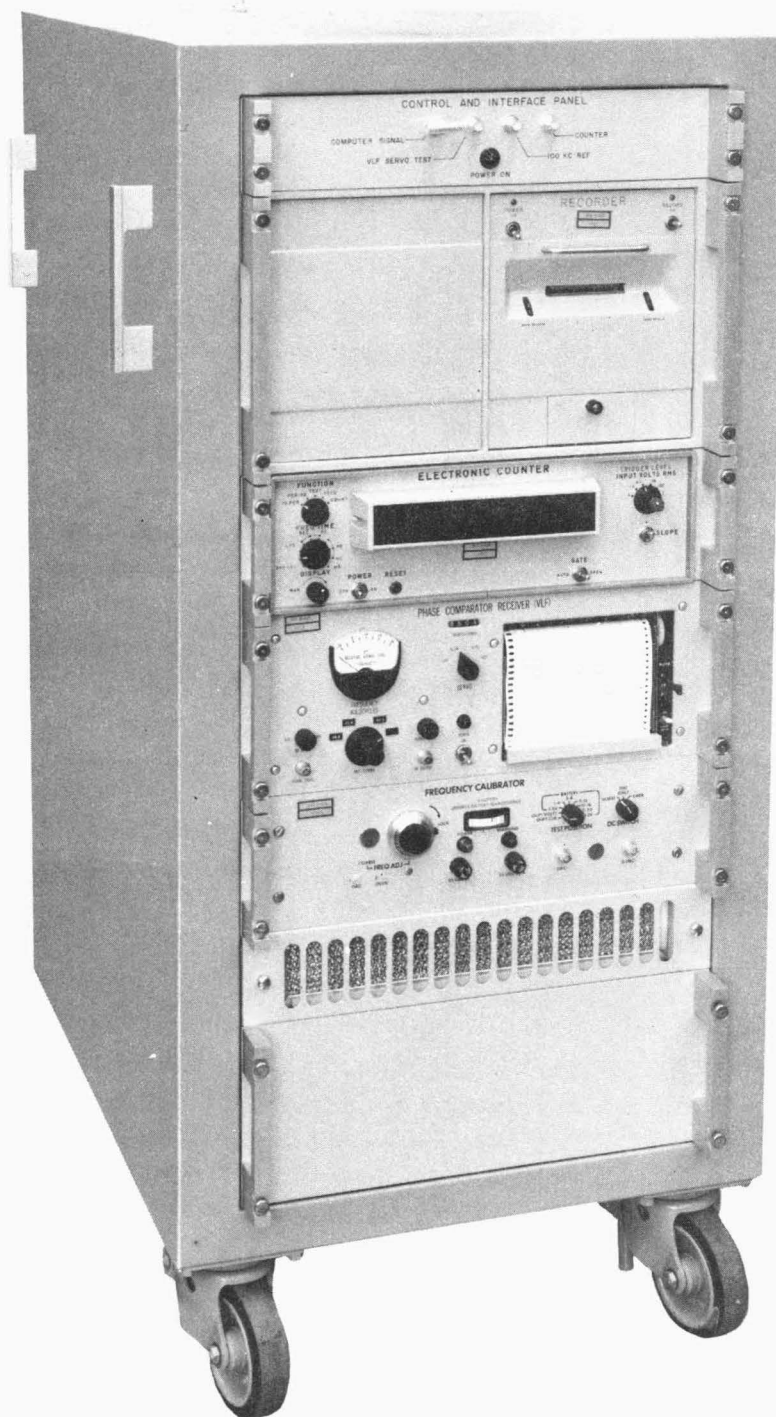
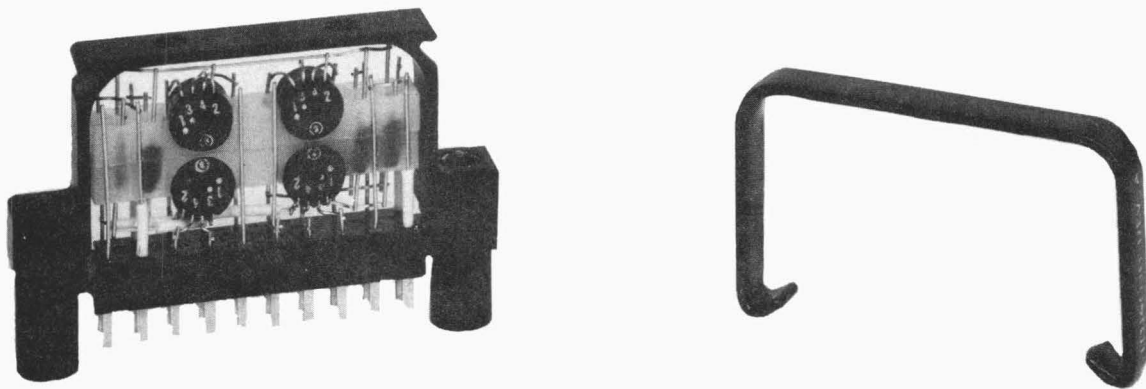


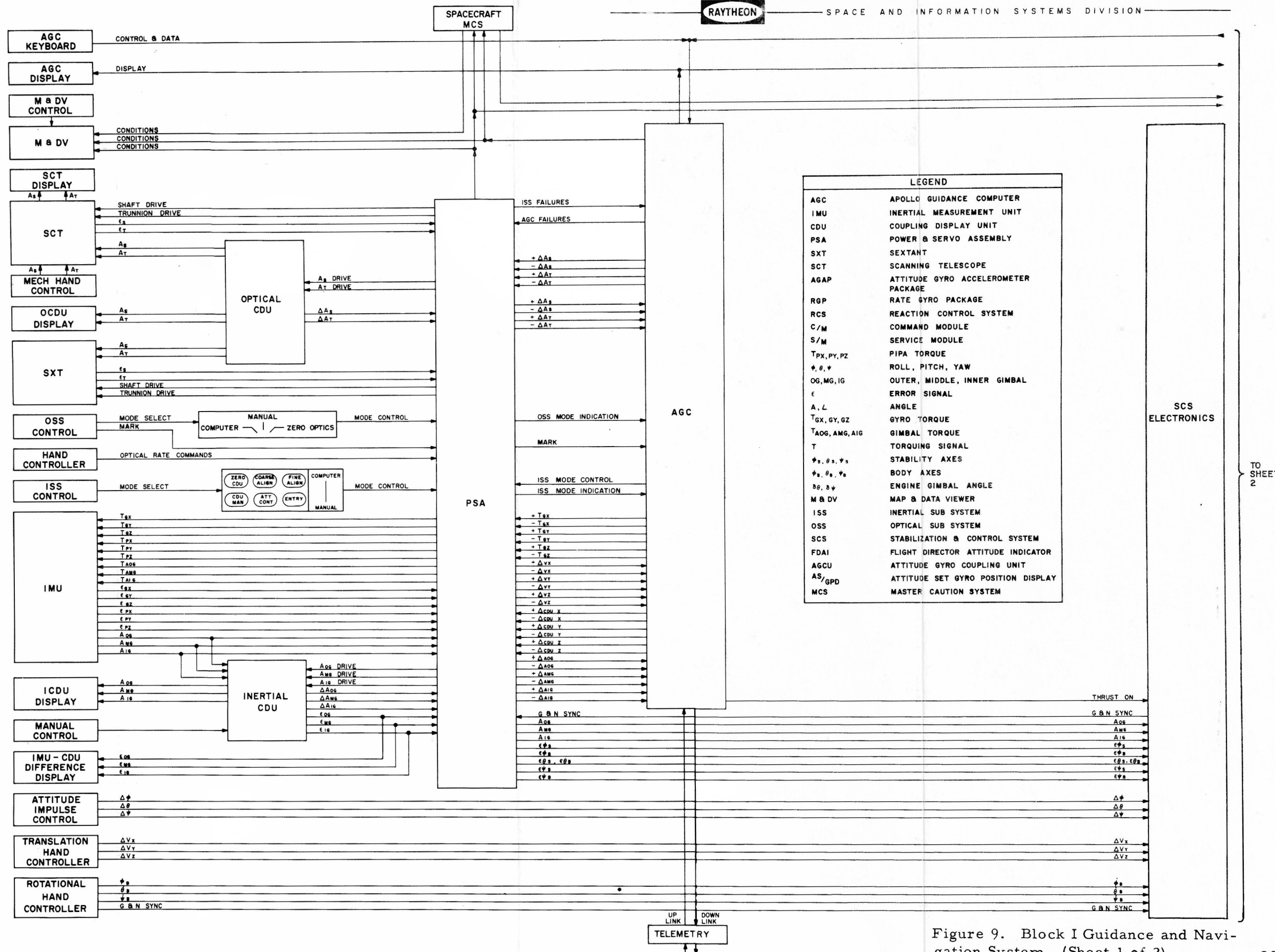
Figure 7. AGC Calibration System



0368

Figure 8. Logic Module and Extraction Tool

NAVIGATOR



TO SHEET 2

Figure 9. Block I Guidance and Navigation System (Sheet 1 of 2)

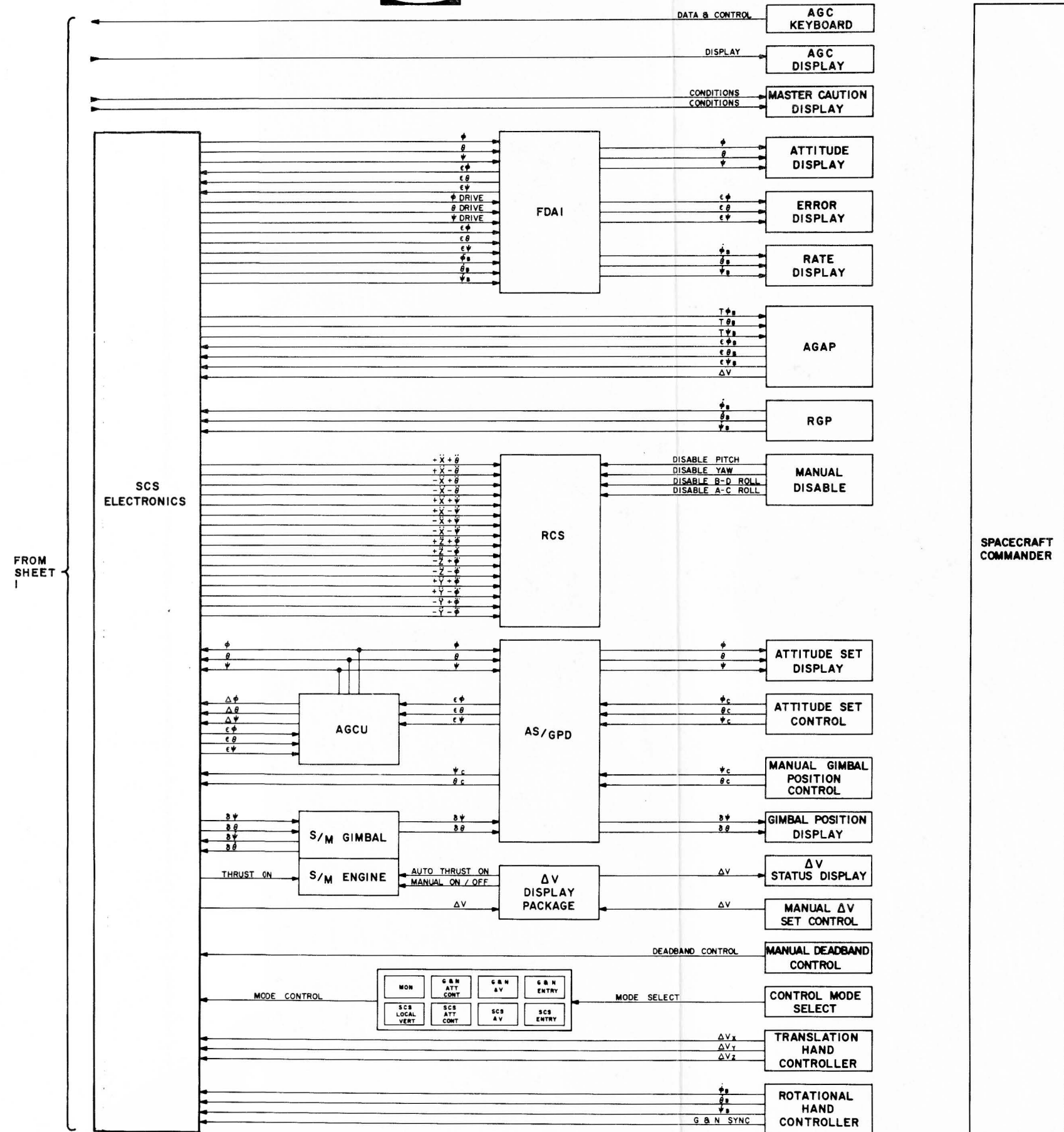
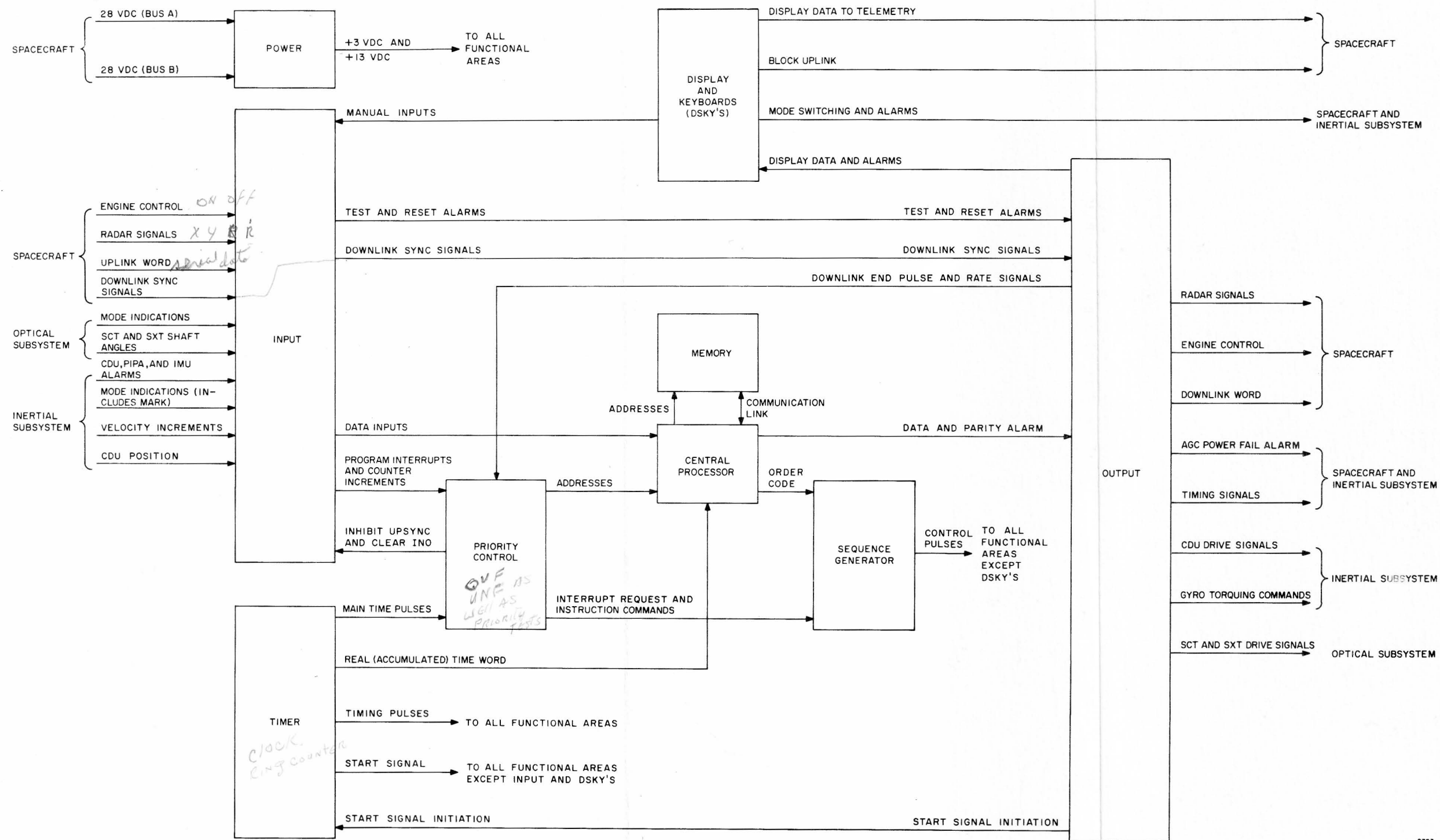
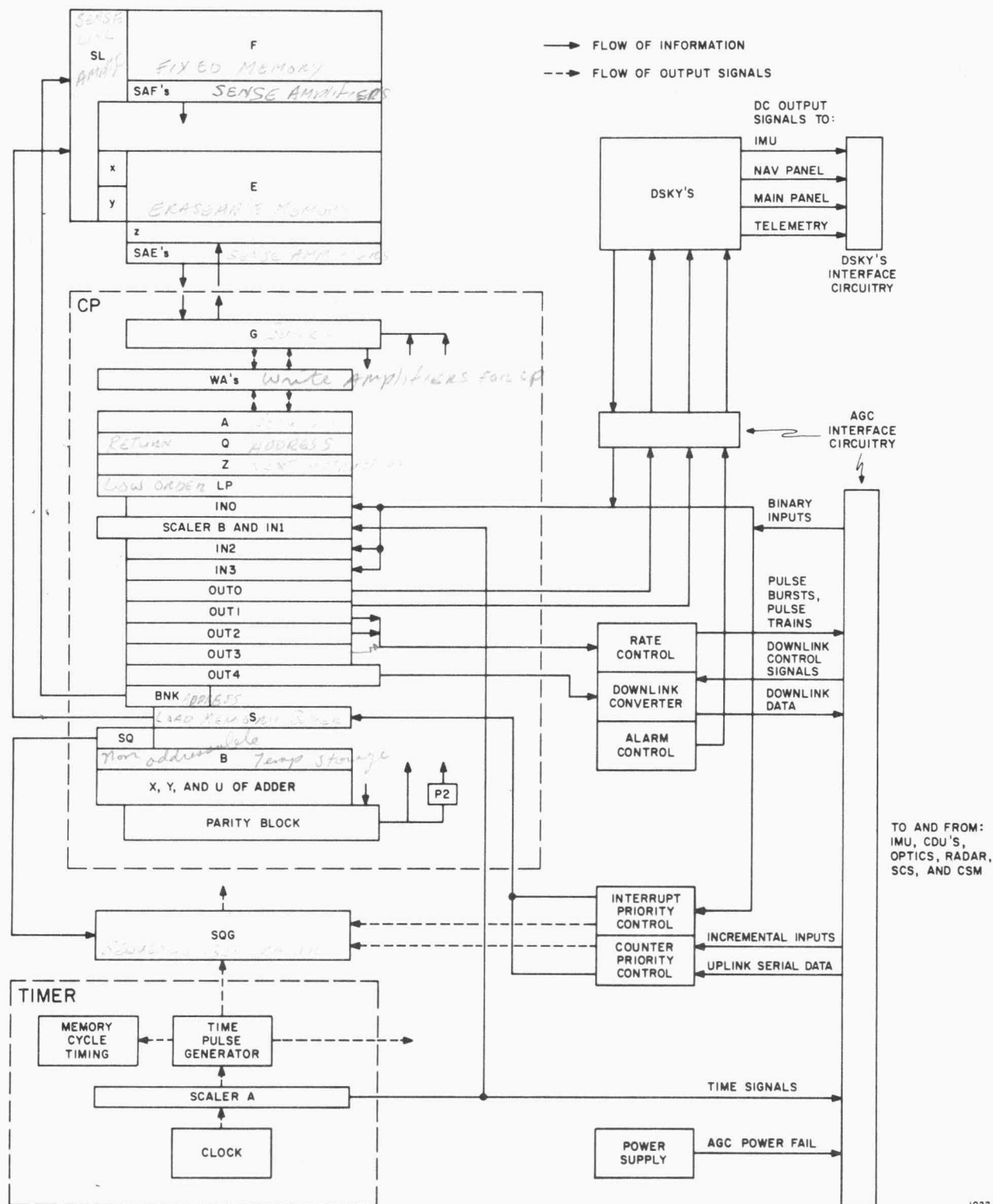


Figure 9. Block I Guidance and Navigation System (Sheet 2 of 2)



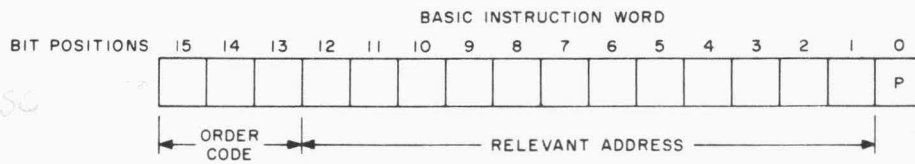
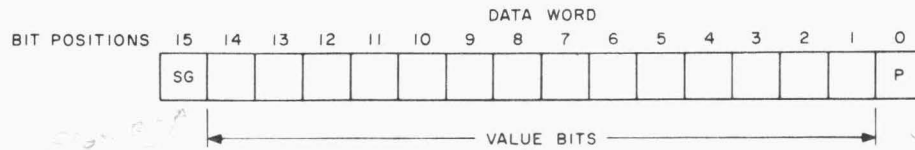
0763

Figure 10. Computer Subsystem General Block Diagram

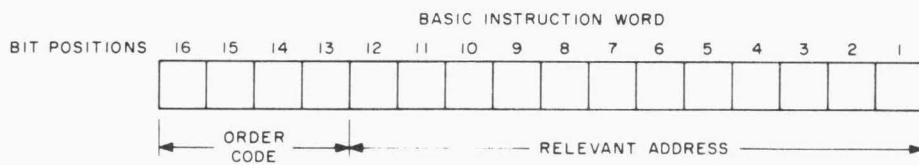
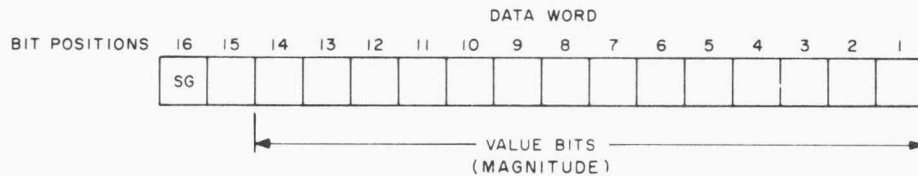


1022

Figure 11. Machine Organization



a. word format for Memory



b. word format for Central Processor registers

1056-1

Figure 12. Word Formats

TABLE I
INFORMATION FLOW BETWEEN CP REGISTERS,
WRITE AMPLIFIERS, AND MEMORY

Register			Control Pulse	Read and Write Lines of Write Amplifiers (WA)																Parity Bus	
Octal Address	Initials	Name																			
				16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
0	A	Accumulator	RA RSC	16 SG	15 US	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
			WA WSC	16 SG	15 US	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
			WALP	16 SG	15 SG	14 US	13	12	11	10	9	8	7	6	5	4	3	2	1		-
1	Q	Return Address Register	RQ RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
			WQ WSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
2	Z	Program Counter	RZ RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
			WZ WSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
3	LP	Low Order Product Register	RLP RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
			WLP WSC	-	-	13	12	11	10	9	8	7	6	5	4	3	2	1	16		15
			WALP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		14
4	IN 0	Input 0 Register	RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
5	IN 1	Input 1 Register	RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
6	IN 2	Input 2 Register	RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
7	IN 3	Input 3 Register	RSC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
10	OUT 0	Output 0 Register	RSC WSC	16 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
11	OUT 1	Output 1 Register	RSC WSC	16 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
12	OUT 2	Output 2 Register	RSC WSC	16 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
13	OUT 3	Output 3 Register	RSC WSC	16 16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
14	OUT 4	Output 4 Register	WSC	15	-	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
15	BNK	Memory Bank Select Register	RSC	15	-	14	13	12	11	-	-	-	-	-	-	-	-	-	-		
			WSC	15	-	14	13	12	11	-	-	-	-	-	-	-	-	-	-		

0571-1



SPACE AND INFORMATION SYSTEMS DIVISION

TABLE I

INFORMATION FLOW BETWEEN CP REGISTERS,
WRITE AMPLIFIERS, AND MEMORY (cont)

Register				Control Pulse	Read and Write Lines of Write Amplifiers (WA)																Parity Bits	
Octal Address	Initials	Name	16		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
	B C	Buffer Register with direct output B and complement output C	RBQ RB RC	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
			WB	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
	U X Y	Adder with input registers X and Y, and output gates U	RU	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
			WX WY	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			
	S	Address Register	WS	-	-	-	-	12	11	10	9	8	7	6	5	4	3	2	1			
	SQ	Sequence Register	NISQ WSQF WSQG	16 SG	15 US	14	13	-	-	-	-	-	-	-	-	-	-	-				
		Parity Block	WP	15 SG	-	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
	G	Memory Buffer Register		RG	15		14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
		Function	c(S)	Control Signal																		
		Direct	Any Other Address	WG1G, WG5G	WG	15 SG	-	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
		CYR	0020	WG2G, WG4G	WG	14 SG	-	13	12	11	10	9	8	7	6	5	4	3	2	1	15	
		SR	0021	WG2G, WG5G	WG	15 SG	14 SG	-	13	12	11	10	9	8	7	6	5	4	3	2	1	-
		CYL	0022	WG3G, WG6G	WG	1 SG	-	15	14	13	12	11	10	9	8	7	6	5	4	3	2	
		SL	0023	WG3G, WG5G	WG	1 SG	15 SG	-	-	14	13	12	11	10	9	8	7	6	5	4	3	2
	G	Memory Buffer Register		SBF SBE ZID	-	15 SG	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0020 through 7177		Erasable and Fixed Memory			-	15 SG	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	

RAYTHEON

SPACE AND INFORMATION SYSTEMS DIVISION

0571-1

TABLE II
COUNTER PRIORITY CONTROL INPUTS

Input Number	Level of Priority	Input Signal	Instruction Executed
1 2	1 1	Overflow } occurs during the ex- Underflow } ecution of instruction AD K or SU K	PINC OVCTR MINC OVCTR
3 4 5 6	3 2 4 5	10 msec time signal from Scaler A Overflow of counter TIME1 10 msec time signal from Scaler A 10 msec time signal which occurs 5 msec later than input signals 3 and 5	PINC TIME1 PINC TIME2 PINC TIME3 PINC TIME4
7 8	6 6	ZERO from Uplink ONE from Uplink	SHINC UPLINK SHANC UPLINK
9 10 11	7 8 20	Signal from register OUT2, bits 9 through 16 Signal from register OUT2, bits 4 through 8 Signal from register OUT2, bits 1 through 3	PINC OUTCR1 PINC OUTCR2 PINC OUTCR3
12 13 14 15 16 17	9 9 10 10 11 11	+DVX from PIPA X -DVX from PIPA X +DVY from PIPA Y -DVY from PIPA Y +DVZ from PIPA Z -DVZ from PIPA Z	PINC PIPA X MINC PIPA X PINC PIPA Y MINC PIPA Y PINC PIPA Z MINC PIPA Z
18 19 20 21 22 23	12 12 13 13 14 14	+XCDU from IMU CDU X -XCDU from IMU CDU X +YCDU from IMU CDU Y -YCDU from IMU CDU Y +ZCDU from IMU CDU Z -ZCDU from IMU CDU Z	PINC CDU X MINC CDU X PINC CDU Y MINC CDU Y PINC CDU Z MINC CDU Z
24 25 26 27	15 15 16 16	OPT+X from Optics OPT-X from Optics OPT+Y from Optics OPT-Y from Optics	PINC OPTX MINC OPTX PINC OPTY MINC OPTY
28 29 30 31 32 33	17 17 18 18 19 19	Reserved for signals from star tracker and/or tracking radar	PINC TRKR X MINC TRKR X PINC TRKR Y MINC TRKR Y SHINC TRKR R SHANC TRKR R

TABLE III
 INTERRUPT ~~MOTIONS~~
options












Level of Priority	Initiating Action	Signal Generated in Interrupt Priority Control	Instruction and Transfer Routine Executed	Further Actions Caused
1	Overflow of TIME3 counter	RP1	RPT TIME3RPT	1. Execution of major routine T3RUPT of Waitlist (Issue 12A). 2. Execution of Task due.
2	Presently none	TRP2	RPT ERRORUPT	Presently none.
3	Overflow of TIME4 counter	RP3	RPT TIME4RPT	Execution of T4RUPT to: drive relays in DSKY's drive IMU CDU's and Optics CDU's sample IMU CDU mode and Optics CDU mode scan IMU FAIL, PIPA FAIL, and CDU FAIL, and take proper action in case of failure monitor frequency of DKEND pulses.
4	KEYCODE signal from a DSKY	TRP4	RPT KEYMARPT	1. Execution of KEYRUPT to process mark and mark accept information. 2. Execution of PINBALL to process keycode information.
	Signal MARK from Optics	RP4		
5	Overflow of UPLINK counter or TRKR R counter	RP5	RPT UPLINKRPT	1. Execution of UPRUPT. 2. Execution of PINBALL to process uplink information.
6	Signal DKEND from Downlink Converter	RP6	RPT DOWNLRPT	Execution of DOWNRUPT to supply telemetry word to register OUT4 for downlink equipment.

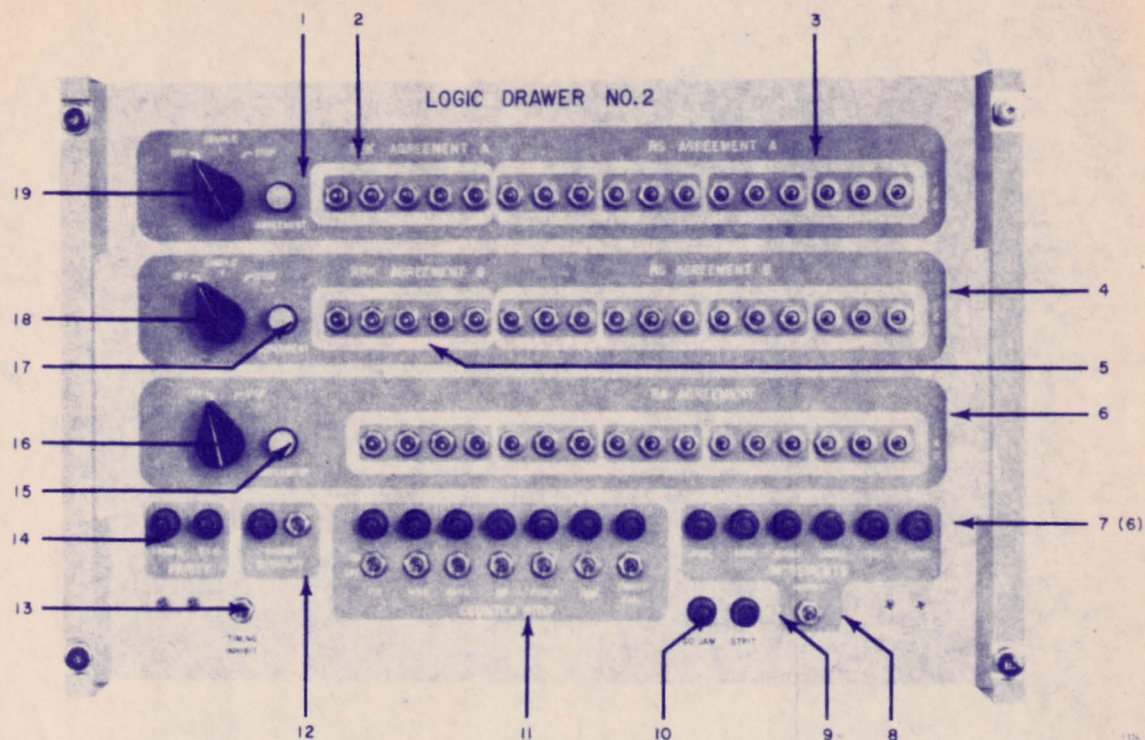
TABLE IV
ADDRESSING

Register Groups		Octal Address		Pseudo Address (Decimal)	Contents of BNK Δ					Contents of S Δ												
		Real	Pseudo		15	14	13	12	11	12	11	10	9	8	7	6	5	4	3	2	1	
CP	A, Q, Z, LP		0000 - 0003	Same	0 - 3	X	X	X	X	X	0	0	0	0	0	0	0	0	0	0	X	X
	IN		0004 - 0007	Same	4 - 7	X	X	X	X	X	0	0	0	0	0	0	0	0	0	1	X	X
	OUT		0010 - 0014	Same	8 - 12	X	X	X	X	X	0	0	0	0	0	0	0	0	1	X	X	X
	BNK		0015	Same	13	X	X	X	X	X	0	0	0	0	0	0	0	0	1	1	0	1
No Bit Location			0016 - 0017	Same	14, 15	X	X	X	X	X	0	0	0	0	0	0	0	0	1	1	1	X
E	Special		0020 - 0027	Same	16 - 23	X	X	X	X	X	0	0	0	0	0	0	0	1	0	X	X	X
	Spares		0030 - 0033	Same	24 - 27	X	X	X	X	X	0	0	0	0	0	0	0	1	1	0	X	X
	CTR		0034 - 0057	Same	28 - 47	X	X	X	X	X	0	0	0	0	0	0	X	X	X	X	X	X
	GE		0060 - 1777	Same	48 - 1023	X	X	X	X	X	0	0	X	X	X	X	X	X	X	X	X	X
FF	BANK 01	2000 - 3777	Same	1024 - 2047	X	X	X	X	X	0	1	X	X	X	X	X	X	X	X	X	X	X
	02	4000 - 5777	Same	2048 - 3071	X	X	X	X	X	1	0	X	X	X	X	X	X	X	X	X	X	X
F	FS	03	6000 - 7777	6000 - 7777	3072 - 4095	0	0	0	X	X	1	1	X	X	X	X	X	X	X	X	X	X
		04	6000 - 7777	10000 - 11777	4096 - 5119	0	0	1	0	0	1	1	X	X	X	X	X	X	X	X	X	X
		05	6000 - 7777	12000 - 13777	5120 - 6143	0	0	1	0	1	1	1	X	X	X	X	X	X	X	X	X	X
		06	6000 - 7777	14000 - 15777	6144 - 7167	0	0	1	1	0	1	1	X	X	X	X	X	X	X	X	X	X
		07	6000 - 7777	16000 - 17777	7168 - 8191	0	0	1	1	1	1	1	X	X	X	X	X	X	X	X	X	X
		10	6000 - 7777	20000 - 21777	8192 - 9215	0	1	0	0	0	1	1	X	X	X	X	X	X	X	X	X	X
		11	6000 - 7777	22000 - 23777	9216 - 10239	0	1	0	0	1	1	1	X	X	X	X	X	X	X	X	X	X
		12	6000 - 7777	24000 - 25777	10240 - 11263	0	1	0	1	0	1	1	X	X	X	X	X	X	X	X	X	X
		13	6000 - 7777	26000 - 27777	11264 - 12287	0	1	0	1	1	1	1	X	X	X	X	X	X	X	X	X	X
		14	6000 - 7777	30000 - 31777	12288 - 13311	0	1	1	0	0	1	1	X	X	X	X	X	X	X	X	X	X
		21	6000 - 7777	42000 - 43777	17408 - 18431	1	0	0	0	1	1	1	X	X	X	X	X	X	X	X	X	X
		22	6000 - 7777	44000 - 45777	18432 - 19455	1	0	0	1	0	1	1	X	X	X	X	X	X	X	X	X	X
		23	6000 - 7777	46000 - 47777	19456 - 20479	1	0	0	1	1	1	1	X	X	X	X	X	X	X	X	X	X
		24	6000 - 7777	50000 - 51777	20480 - 21503	1	0	1	0	0	1	1	X	X	X	X	X	X	X	X	X	X
		25	6000 - 7777	52000 - 53777	21504 - 22527	1	0	1	0	1	1	1	X	X	X	X	X	X	X	X	X	X
		26	6000 - 7777	54000 - 55777	22528 - 23551	1	0	1	1	0	1	1	X	X	X	X	X	X	X	X	X	X
		27	6000 - 7777	56000 - 57777	23552 - 24575	1	0	1	1	1	1	1	X	X	X	X	X	X	X	X	X	X
		30	6000 - 7777	60000 - 61777	24576 - 25599	1	1	0	0	0	1	1	X	X	X	X	X	X	X	X	X	X
		31	6000 - 7777	62000 - 63777	25600 - 26623	1	1	0	0	1	1	1	X	X	X	X	X	X	X	X	X	X
		32	6000 - 7777	64000 - 65777	26624 - 27647	1	1	0	1	0	1	1	X	X	X	X	X	X	X	X	X	X
33	6000 - 7777	66000 - 67777	27648 - 29671	1	1	0	1	1	1	1	X	X	X	X	X	X	X	X	X	X		
34	6000 - 7777	70000 - 71777	28672 - 29695	1	1	1	0	0	1	1	X	X	X	X	X	X	X	X	X	X		

Δ X means 0 or 1

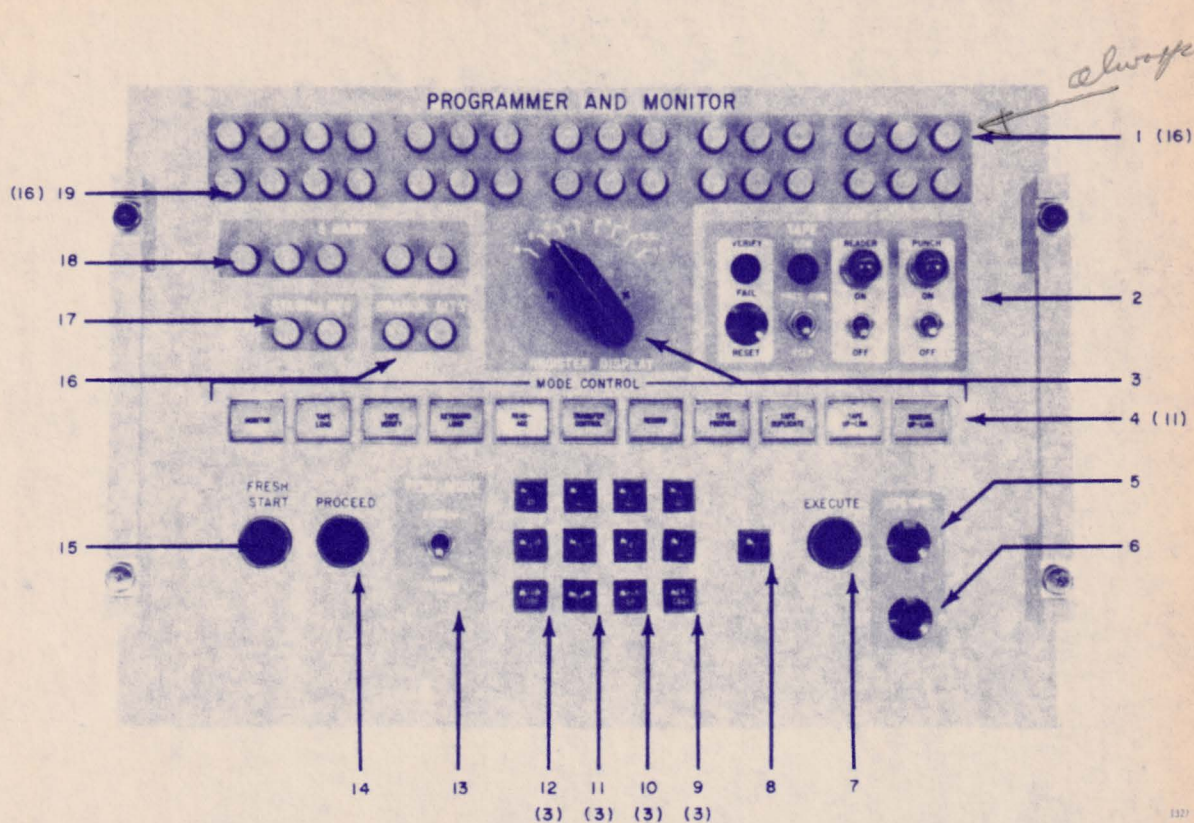
TABLE V
IN AND OUT REGISTER
BIT ASSIGNMENT

REGISTER	OCTAL ADDRESS	BIT POSITION 															
		16,15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
IN0	0004	MARK (102) [RP4 KEYRUPT]	SPARE	<i>GEN ENTRY MODE</i> SPARE	<i>GEN BY MODE</i> SPARE	<i>GEN AT CENT MODE</i> SPARE	SPARE	SPARE	SPARE	INHIBIT UPSYNC 	ACCEPT UPLINK (246)	KEY CODE BITS [TRP4 KEYRUPT]					
												5 (205)	4 (204)	3 (203)	2 (202)	1 (201)	
IN1	0005	16 BITS REPRESENTS CONDITION OF TIME SCALER B (BITS 16 THROUGH 1)															
IN2	0006	PARITY ALARM 	<i>OFF MONITOR MODE</i> SPARE	<i>SCS BY MODE</i> SPARE	IMU FAIL (141)	PIPA FAIL (138)	CDU FAIL (124)	<i>SPY/CM</i> SPARE	<i>SING</i> SEPARATE SPARE	<i>SATURN</i> WIRGE OR VENT SPARE	<i>GUID</i> RELEASE FM SING SPARE	<i>LIFT OFF</i> SPARE	TIME SIGNALS 				
													200 PPS	400 PPS	800 PPS	1600 PPS	
IN3	0007	OR OF C RELAYS (210)	OPTICS MODE BITS - SCANNED BY T4RUPT					SPARE	SPARE	IMU MODE BITS - SCANNED BY T4RUPT							
			5 (106)	4 (105)	3 (104)	2 SPARE	1 (107)			7 (163)	6 (164)	5 (162)	4 (161)	3 (160)	2 (159)	1 (158)	
OUT0	0010	RELAY WORDS					RELAY BITS										
		4 (228)	3 (227)	2 (226)	1 (225)	11 (224)	10 (223)	9 (222)	8 (221)	7 (220)	6 (219)	5 (218)	4 (217)	3 (216)	2 (215)	1 (214)	
OUT1	0011	SPARE	SPARE	ENGINE ON 	SPARE	SPARE	BLOCK DOWNLINK 	ID WORD 	SPARE	RUPT TRAP RESET  [TRP2]	SPARE	CHECK FAIL ALARM (232)	TELEMETRY ALARM (231)	KEY RELEASE (236)	COMPUTER ACTIVITY (230)	PROGRAM ALARM (229)	
OUT2	0012	OUTCR1 					OUTCR2 					OUTCR3 					
		-	+	IMU CDU'S	IMU GYROS	X	Y	Z	-	+	OPT X CDU	OPT Y CDU	THRUST	RADAR A	RADAR B	RADAR C	
IN OR OUT3		SPARE REGISTER, NOT CONNECTED															
OUT4		16 BITS FOR DOWNLINK DATA (BITS 15 THROUGH 0)															



- | | | |
|------------------------------|--|----------------------------|
| 1- AGREEMENT indicator | 8- INCREMENTS INHIBIT switch | 15- AGREEMENT indicator |
| 2- RBK AGREEMENT A switches | 9- STPIT indicator - <i>Computer stopped</i> | 16- OFF STOP switch |
| 3- RS AGREEMENT A switches | 10- GO JAM indicator - | 17- AGREEMENT indicator |
| 4- RS AGREEMENT B switches | 11- COUNTER STOP switches and indicators | 18- OFF SAMPLE STOP switch |
| 5- RBK AGREEMENT B switches | 12- INHIBIT INTERRUPT switch and indicator | 19- OFF SAMPLE STOP switch |
| 6- RA AGREEMENT switches | 13- TIMING INHIBIT switch | |
| 7- INCREMENTS indicators (6) | 14- PARITY indicators | |

Figure 2. Logic Drawer No. 2



- | | | |
|---|-------------------------------------|--|
| 1- Register RZ indicators (16) | 8- CL pushbutton | 15- FRESH START pushbutton |
| 2- TAPE operation switches and indicators | 9- 3-7-ER CODE keyboard keys (3) | 16- BRANCH BITS indicators |
| 3- REGISTER DISPLAY switch | 10- 2-6-BACK SP keyboard keys (3) | 17- STAGING REG indicators |
| 4- MODE CONTROL annunciators (11) | 11- 1-5-SP keyboard keys (3) | 18- S BANK indicators |
| 5- UPLINK-1 pushbutton | 12- 0-4-STOP CODE keyboard keys (3) | 19- Time-shared CTS register indicators (16) |
| 6- UPLINK-0 pushbutton | 13- TEST MODE switch | |
| 7- EXECUTE pushbutton | 14- PROCEED pushbutton | |

Figure 3. Programmer and Monitor Panel

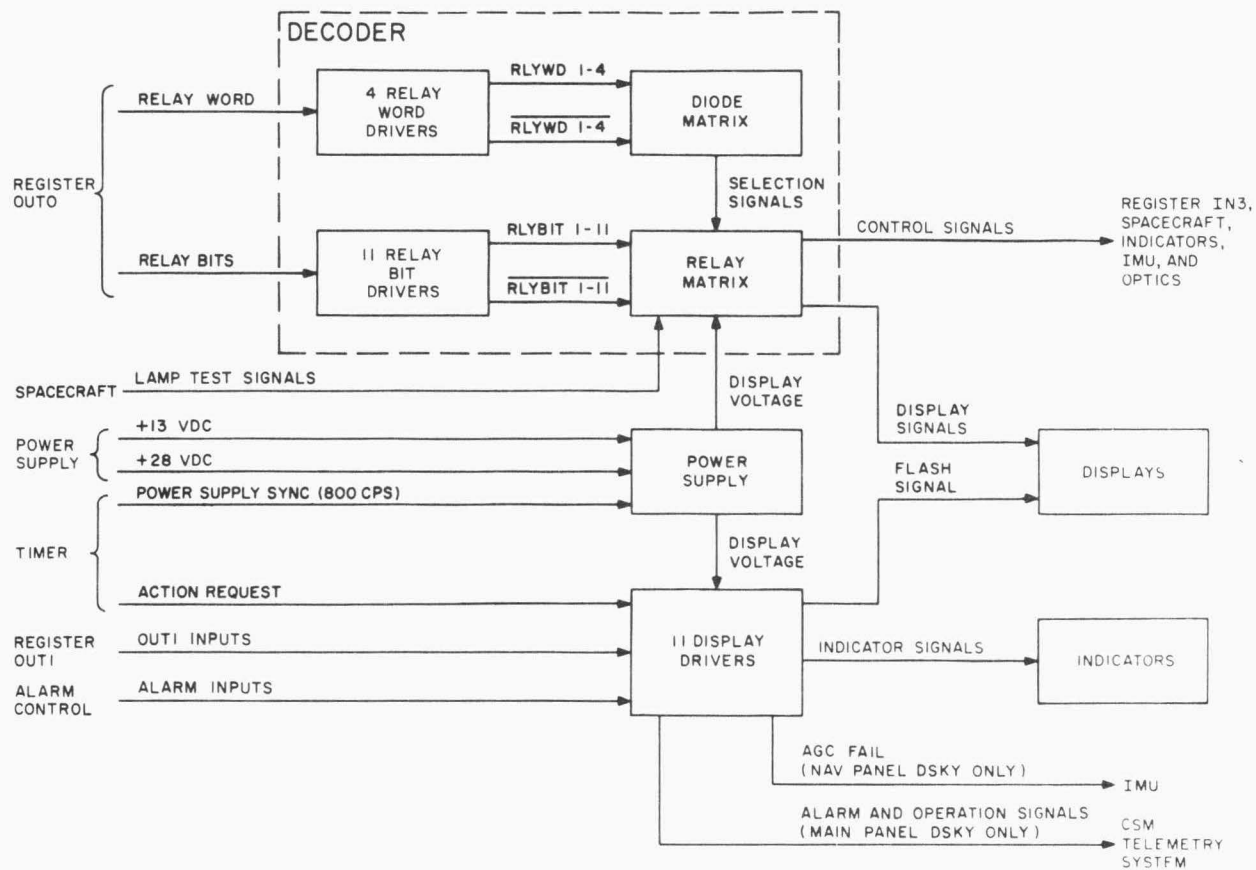
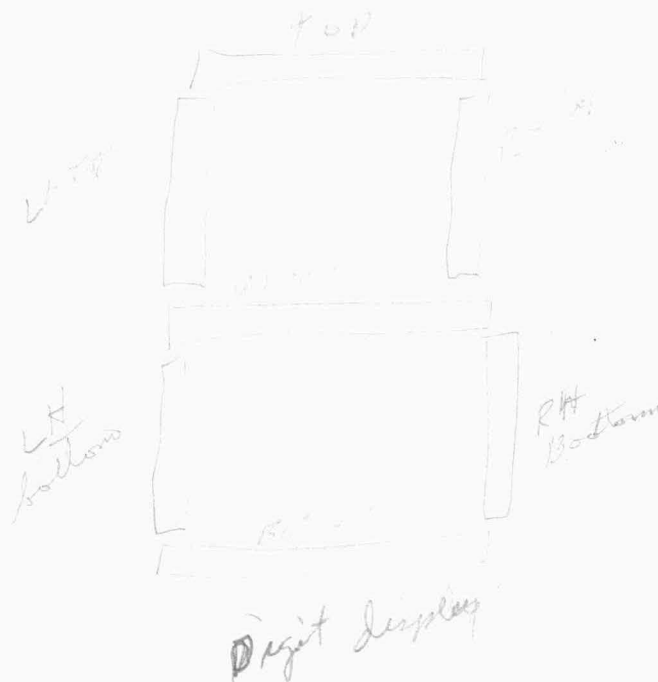


Figure 13. Display

TABLE VI
CHARACTER CODE

Relays $\triangle 1$					Character Displayed
K5	K4	K3	K2	K1	
K10	K9	K8	K7	K6	
1	0	1	0	1	0
0	0	0	1	1	1
1	1	0	0	1	2
1	1	0	1	1	3
0	1	1	1	1	4
1	1	1	1	0	5
1	1	1	0	0	6
1	0	0	1	1	7
1	1	1	0	1	8
1	1	1	1	1	9

$\triangle 1$ "1" sets the relay; a "0" resets the relay.



Signal going from AGC to CTS
is labeled M

CTS to AGC is labeled C

Signal to

AGC from CTS

MOINE

MTC SA

CTS from AGC

RDFB

TCFB

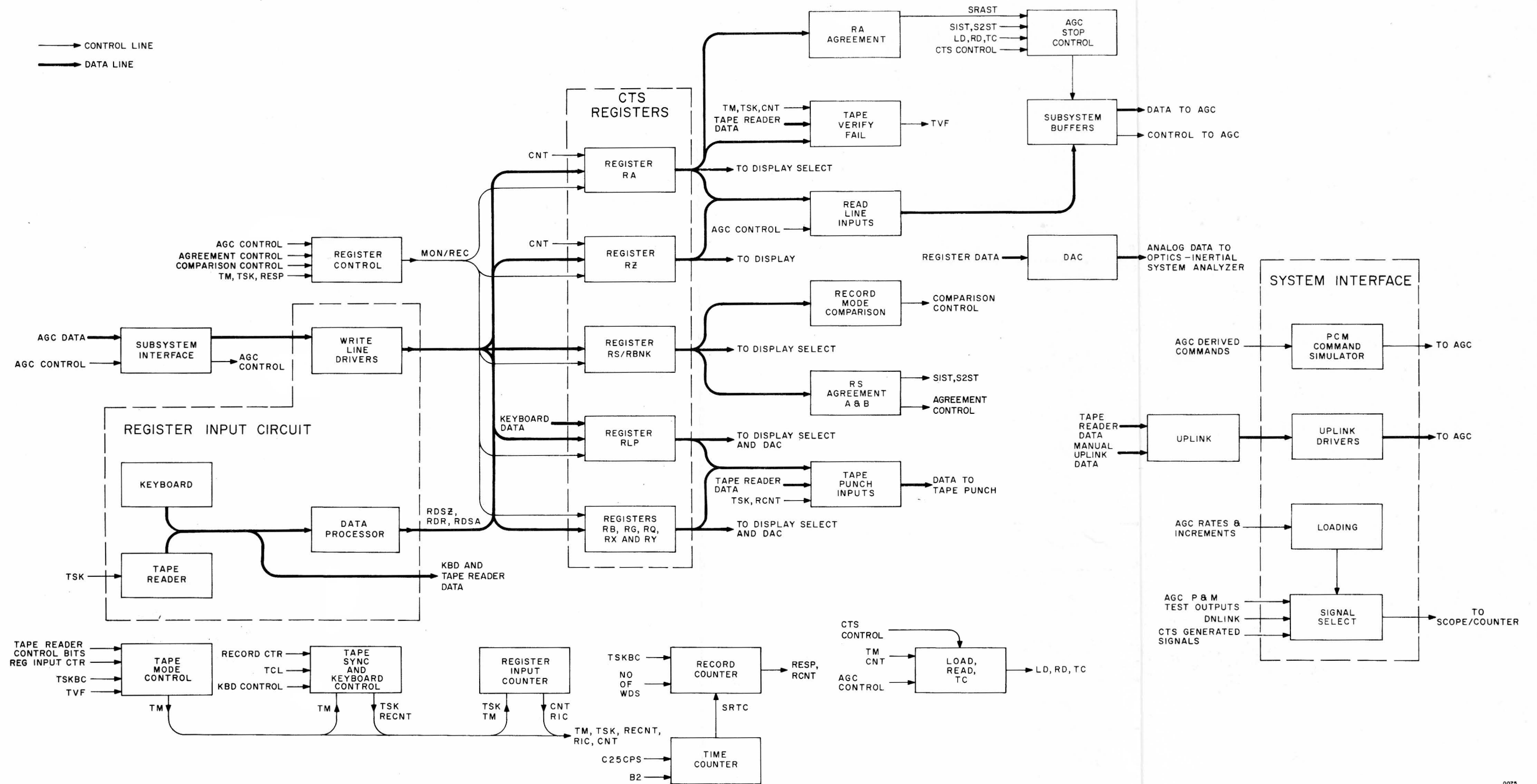
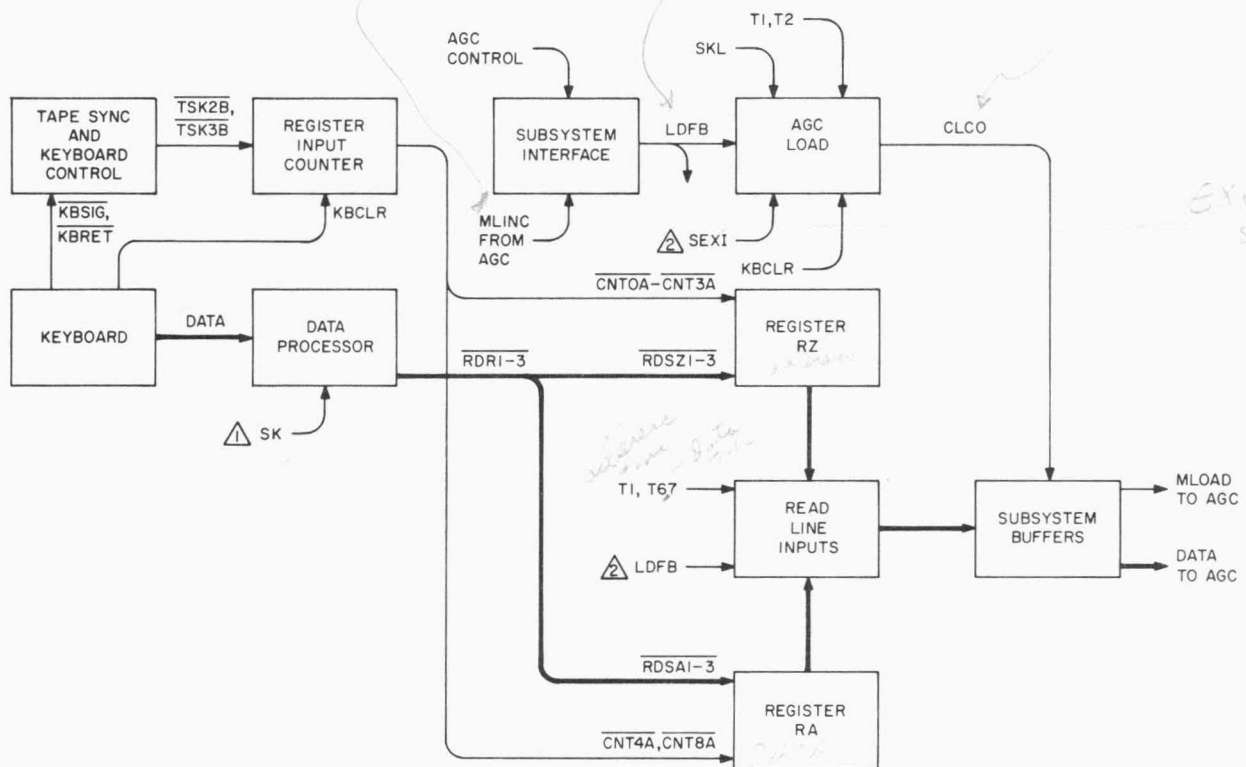


Figure 14. Apollo Guidance Computer Test Set Simplified Block Diagram



NOTES: $\Delta SK = SKL + SRD + STC$
 Δ AND COMPLEMENT

0312

Figure 15. Keyboard Lead Block Diagram

SKL. SEX
TDIC } *you load reg.*
T1 SEX } *T1 = LDFB*
T2 } *you load*
CLCO } *clear*
load sequence control

CPS Timing Signals

TCL

60 cycle

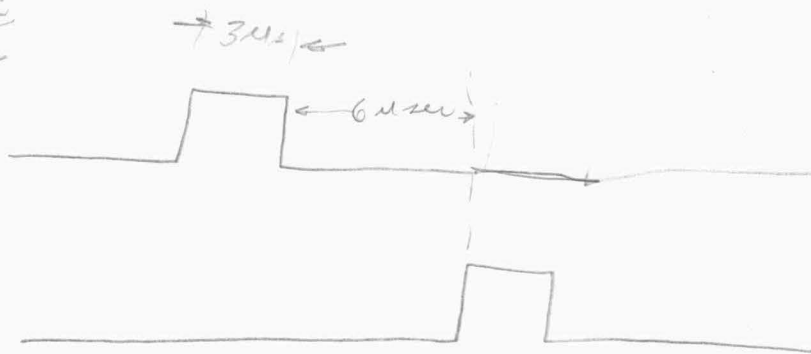
TCL

gating signals

$125 \frac{Kc}{2}$

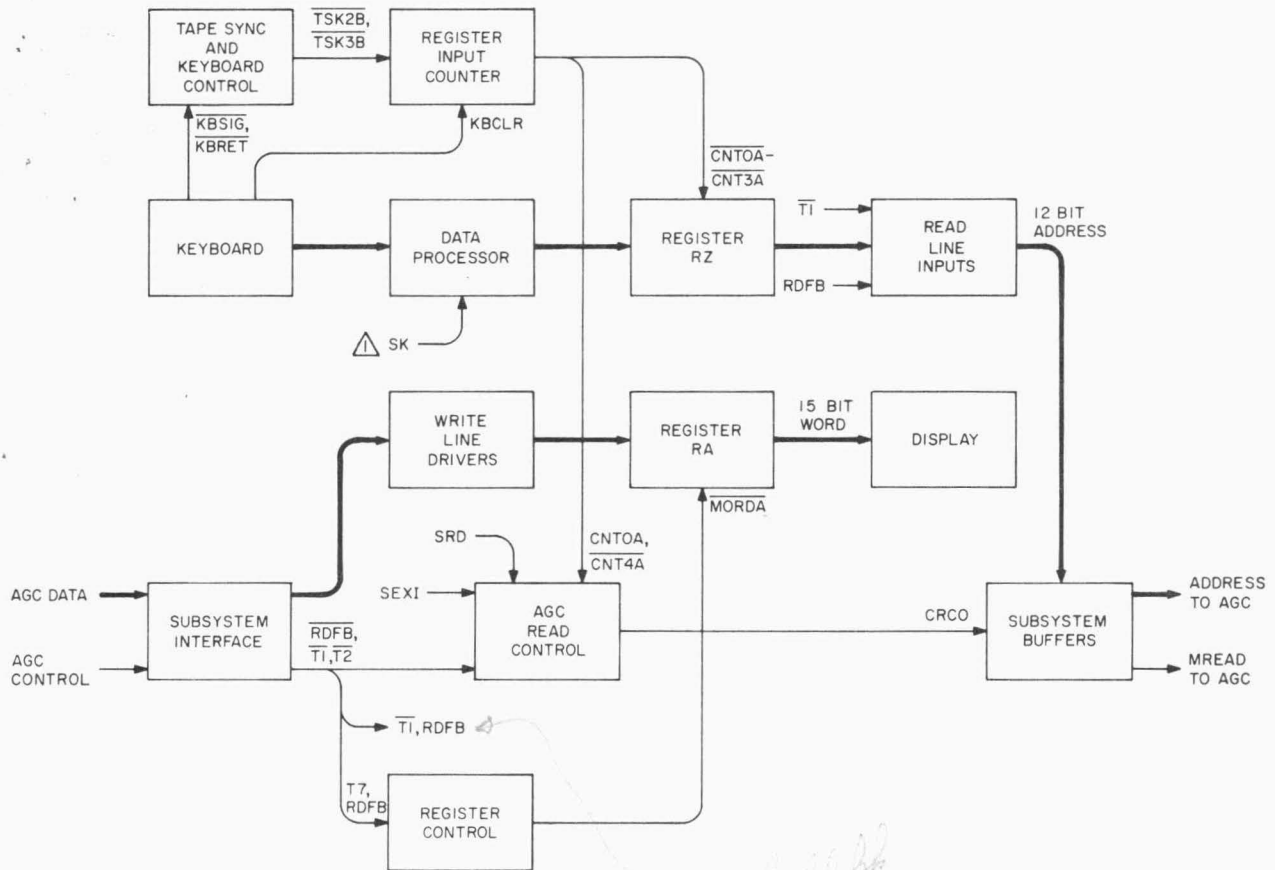
CLA

CLB



CLA controls TMOA, TSKOA etc

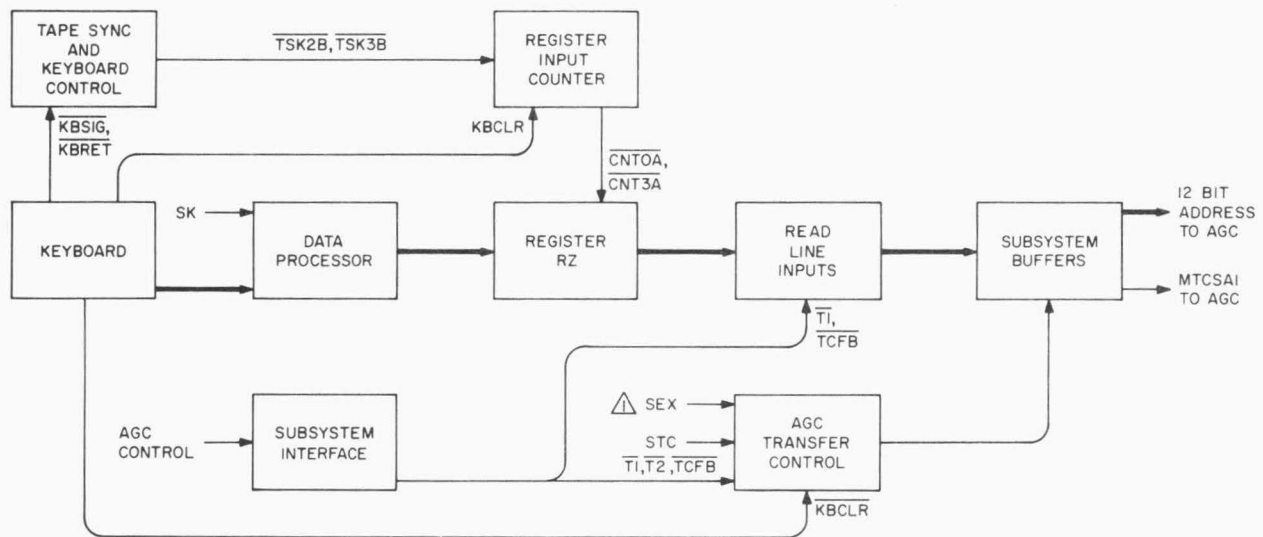
CLB controls TMOB, TSKOB etc



NOTES Δ SK = SKL + SRD + STC

0313

Figure 16. Read AGC Mode Block Diagram



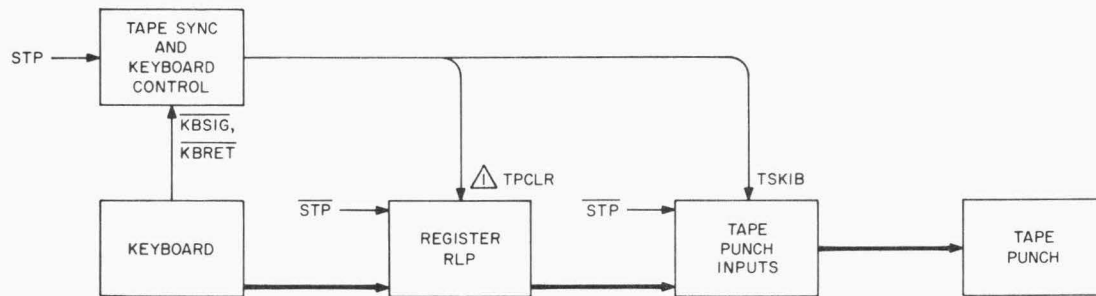
NOTES: Δ AND COMPLEMENT

0314

Figure 17. Transfer Control Block Diagram



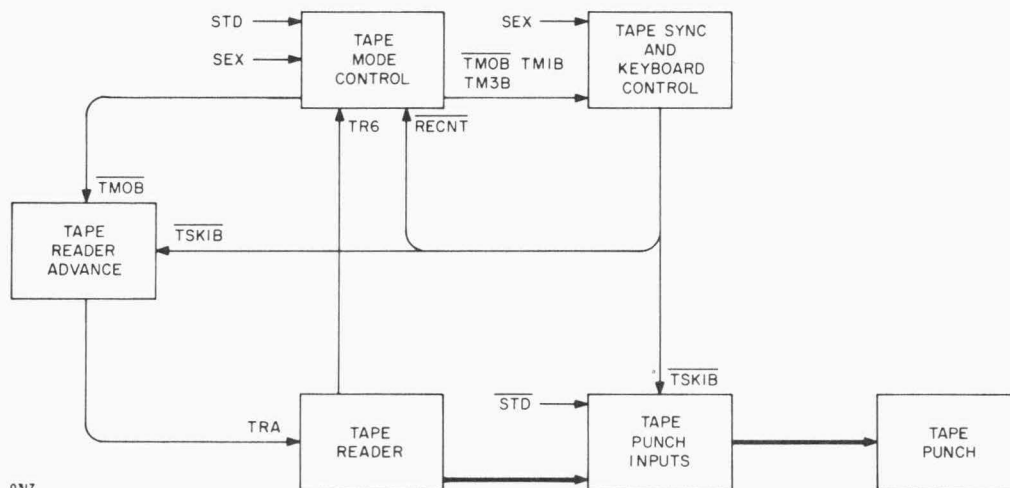
37



NOTES: Δ TPCLR = STP TSK3B TSKIB TSKOB

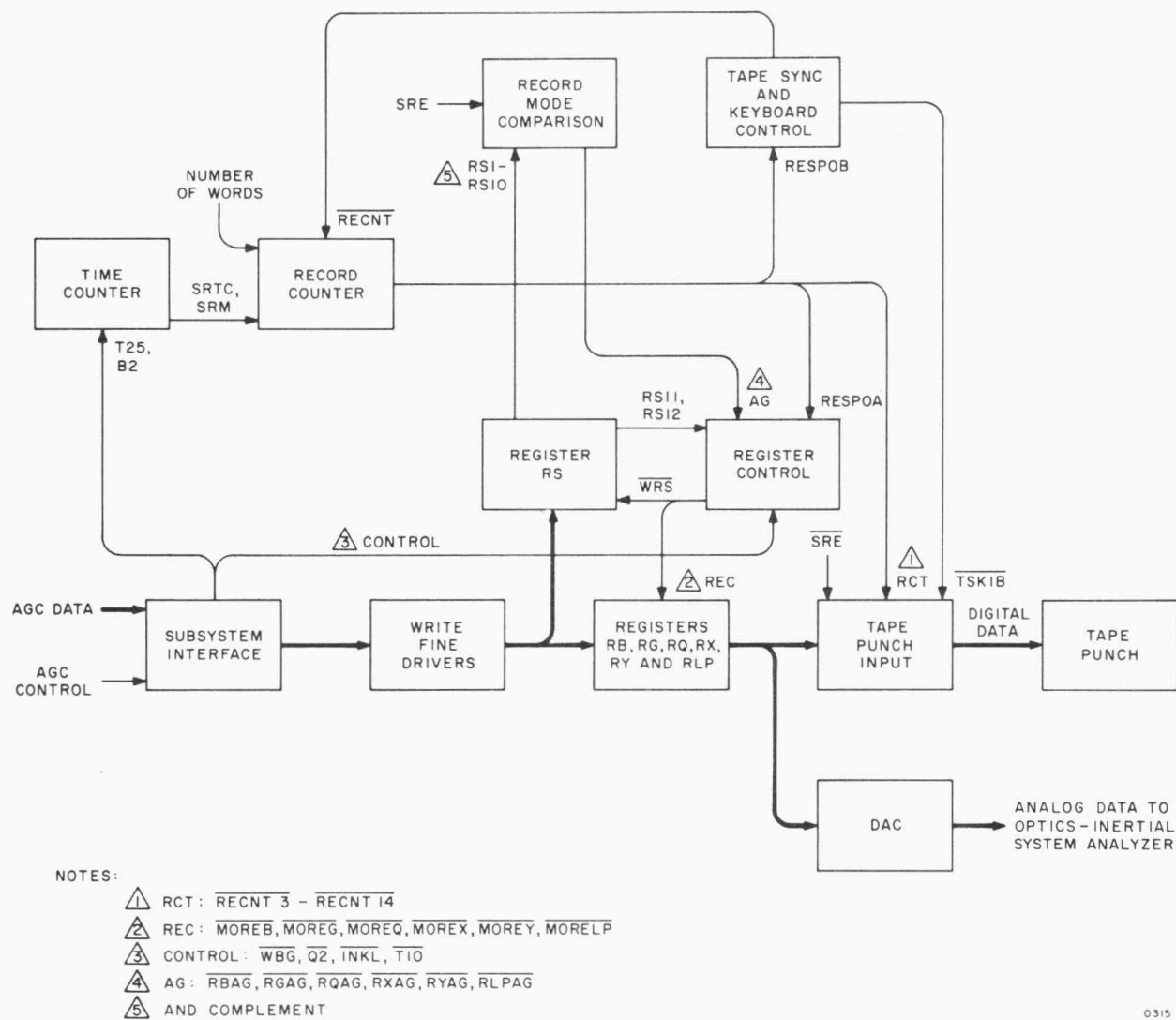
0316

PREPARE
Figure 19. Tape ~~Preface~~ Mode Block Diagram



0317

Figure 20. Tape Duplicate Mode Block Diagram



0315

Figure 21. Record Mode Block Diagram

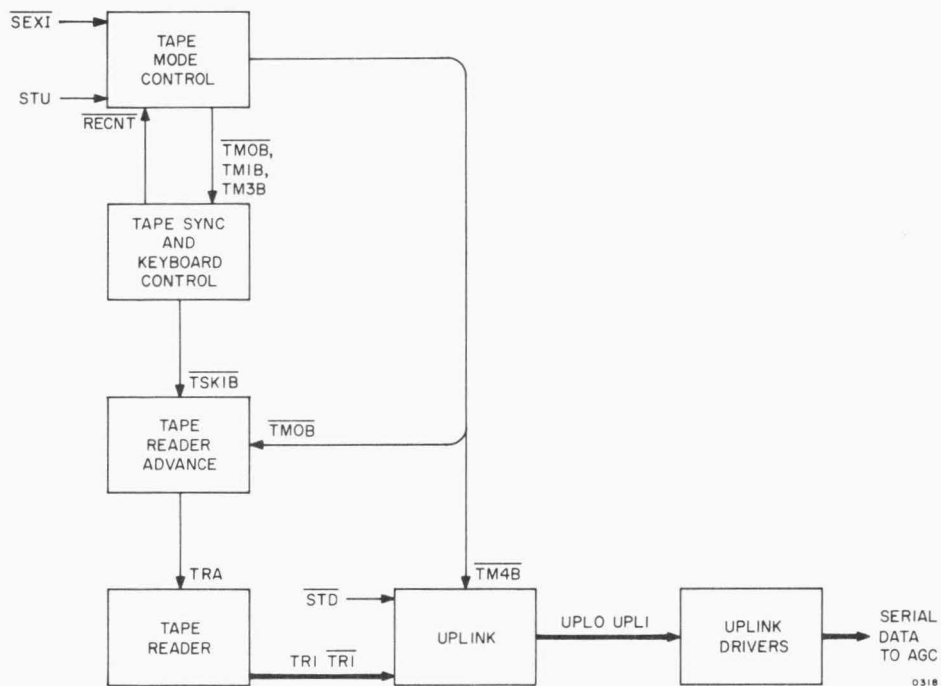
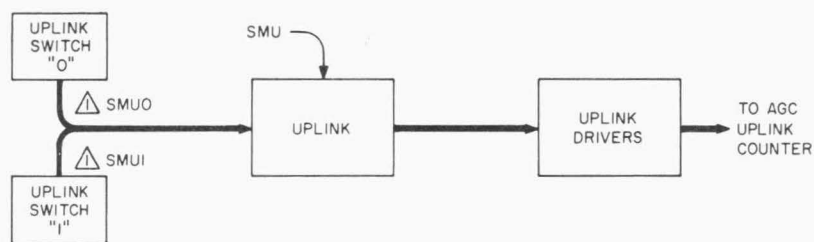


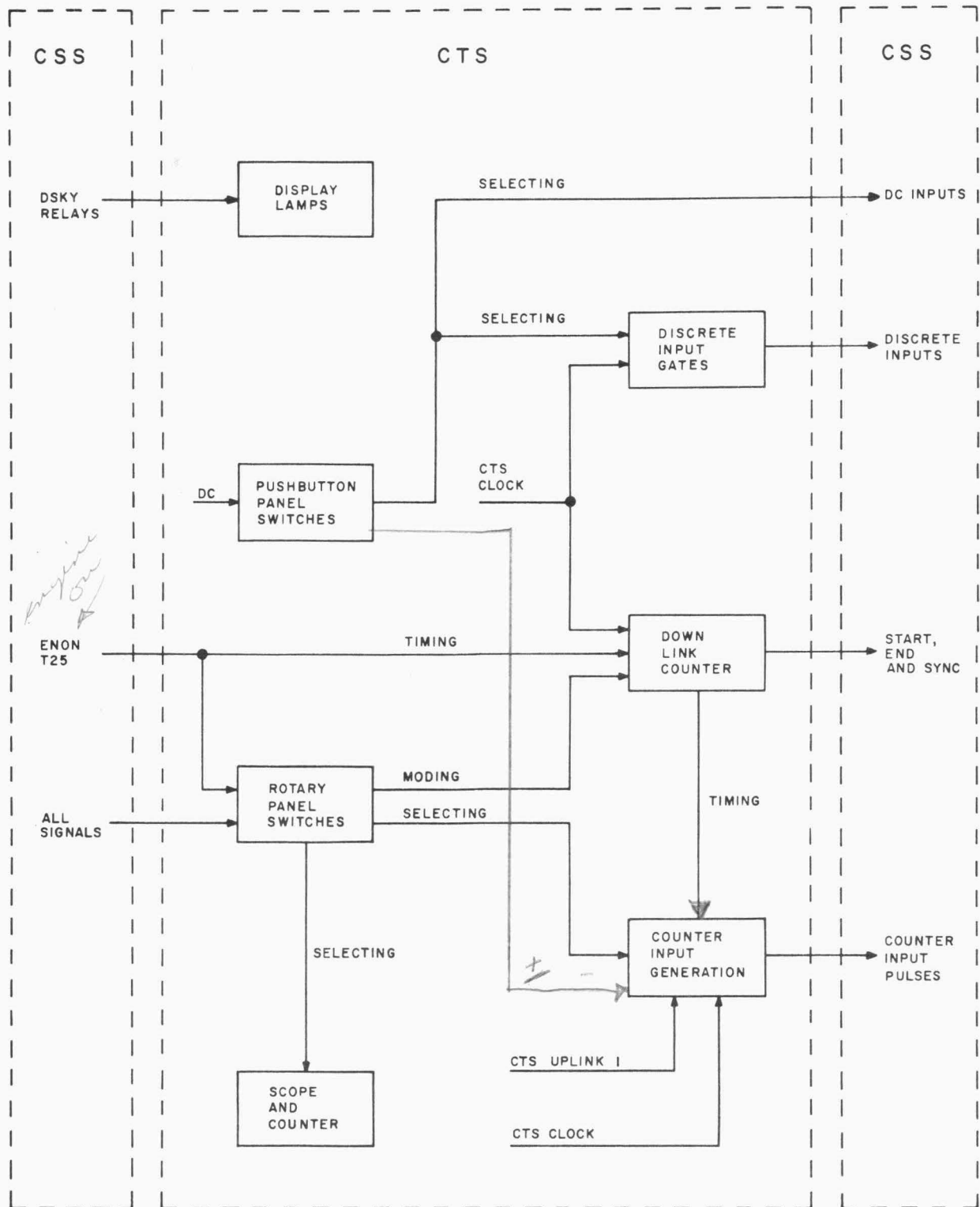
Figure 22. Tape Uplink Mode Block Diagram



NOTES: Δ AND COMPLEMENT

0319

Figure 23. Manual Uplink Mode Block Diagram



1982

Figure 24. System Interface Unit

Program section Job Control (originally named Executive) consists of two major routines: the Load routine and the Swap routine. Table 12-1 lists the execution times of these two routines. The Job Control carries out the following operations:

- a. It enters pertinent information concerning a Job, whose execution has been requested, into a Job Area and, if necessary, also into a Work Area. A Job Area consists of 8 locations in E memory; 8 different Job Areas are provided; a Work Area consists of 43 locations in E memory; 5 different Work Areas are provided (see table 15-15). The execution of a Job (paragraphs 12-4 through 12-6) may be requested by another Job or by a Task.
- b. It schedules the execution of active Jobs according to their priority.
- c. It puts a Job into a dormant state if that Job requests so.
- d. It returns a Job to the active state if another Job or a Task requested so.

Program section Task Control (previously referred to as Waitlist) consists of two major routines: the WAITLIST routine and the T3RUPT routine. Table 12-1 lists the execution times of these two routines. The WAITLIST routine carries out the following operations:

- a. It determines the time when the execution of a requested Task shall be initiated. The execution of a Task (paragraph 12-7) may be requested by a Job, another Task, or itself.
- b. It schedules the execution of the requested Task according to its times of initiation. This is accomplished by entering pertinent information of the requested Task into the proper place in the Waitinglist.

The T3RUPT routine carries out the following operations:

- a. It initiates the execution of the Task due now.
- b. It moves the Tasks whose execution is due next into place 1 of the Waitinglist; and moves the remaining Tasks up one place. Tasks located in places 2 through 6 are moved into places 1 through 5 of the Waitinglist, and Dummy Task is entered into place 6.

The T4RUPT and downlink output functions are Auxiliary Functions as defined in paragraphs 15-104 and 15-112. The T4RUPT functions listed below are executed by program sections T4RUPT Output Control and Mode-switching And Mark:

- a. Transfer Next Word to DSKY's.
- b. Drive IMU CDU's.
- c. Drive Optics CDU's.
- d. Collect Current IMU and Optics Mode Bits.
- e. Check IMU Mode.
- f. Check Optics Mode.
- g. Scan IMU FAIL, PIPA FAIL, and CDU FAIL Bits and Display Failures.
- h. Check Downlink Operation for a Rate that is too Slow.

The downlink functions mentioned below are executed by program section DOWNRUPT Processor:

- i. Check Downlink Operation for a Rate that is too Fast.
- j. Provide the Next Word for Downlink Transmission.

TABLE VII
DSKY CONTROLS AND INDICATORS (continued)

Control or Indicator	Function
VERB key	Conditions the AGC to interpret the two numerical characters punched in next as an action request code.
NOUN key	Conditions the AGC to interpret the two numerical characters punched in next as an address code.
ENTER key	Informs the AGC that the assembled data are complete; therefore, execute the requested function.
Plus (+) and minus (-) keys	Inform the AGC that the following data are decimal and enter the sign of the data.
0 through 9 keys	Enter data, address code, and action request code into AGC.
UPTTEL (up telemetry) switch ²	Controls the reception of information from UPLINK.

² Main panel DSKY only.

TABLE VIII
VERB DEFINITIONS

Code	Action	Description
00	Illegal Verb	When Code 00 is used, the CHECK FAIL indicator is turned on.
01	Display in register R1 (in octal numbers) the first component of the Object specified by the Noun code used with this Verb code. $\triangle 1$	Causes execution of routine DSPA.
02	Display in register R1 (in octal numbers) the second component of the Object specified by the Noun code used with this Verb code. $\triangle 1$	Causes execution of routine DSPB.
03	Display in register R1 (in octal numbers) the third component of the Object specified by the Noun code used with this Verb code. $\triangle 1$	Causes execution of routine DSPC.
04	Display in registers R1 and R2 (in octal numbers) the first and second component of the Object specified by the Noun code used with this Verb code. $\triangle 1$	Causes execution of routine DSPAB.

TABLE VIII
VERB DEFINITIONS (cont)

Code	Action	Description
05	Display in registers R1, R2, and R3 (in octal numbers) the first, second, and third component of the Object specified by the Noun code used with this Verb code. <div style="text-align: center;">△₁</div>	Causes execution of routine DSPABC.
06	Display in register R1, and in registers R2 and R3 as appropriate (in decimal numbers) all components of the Object specified by Noun code used with this Verb code. <div style="text-align: center;">△₂</div>	Causes execution of routine DECDSP. All data is stored in the AGC in octal quantities and converted to decimal numbers when displayed. The scale factors for each component of all Objects to be displayed in decimal numbers are stored in Noun tables within the computer.
07	Display in registers R1 and R2 (in decimal numbers) the double precision quantity (as contained in two consecutive E locations) of the Object specified by the Noun code (primarily code 01 - 07) used with this Verb code. <div style="text-align: center;">△₂</div>	Causes execution of routine DSPDPDEC. The octal double precision quantity, which is considered to be a fractional number with 28 bits following the binary point, is converted into a decimal number where the decimal point is located between character displays R1S and R1D1 (figures 17-1). The sign is displayed at R1S; R2S is kept blank.
10	Request execution of Task specified by address to be entered via Noun 01, or 02, etc., through 07. <div style="text-align: center;">△₂</div>	Causes execution of routine VBRQWAIT. Upon entering Verb-Noun combination 10-01, or 10-02, etc, through 10-07, the Verb and Noun displays flash and the operator has to punch in the complete address of the Task, which

TABLE VIII
VERB DEFINITIONS (cont)

Code	Action	Description
10 (cont)		is displayed at register R3. The execution initiation time (number of 10 msec units of delay as defined in paragraph 12-73) is taken from register DSPTEML which <u>must be</u> loaded previously by means of Verb-Noun combination 21-26. (Difficulty could arise if register DSPTEML does not contain a quantity larger than 00000 but smaller than 27340, or 120). Verb 10 makes program section Keyboard And Display available for internal use.
11	Monitor (display every 0.5 second) in register R1 (in octal numbers) the first component of the Object specified by the Noun code used with this Verb code. <div style="text-align: center;">△ 2</div>	Causes execution of routine MONITOR which makes program section Keyboard And Display available for internal use and requests the WAITLIST routine of the Task Control to schedule the execution of Task MONREQ. Task MONREQ requests the WAITLIST routine to schedule another execution of Task MONREQ 0.5 sec later and requests JOB control to execute Verb 01. The execution of Task MONREQ (and of JOB MONDO) is repeated every 0.5 sec until suspended or terminated. Monitoring is suspended by depressing any key (except keys ERROR RESET and TEST ALARM) and continues after depressing key KEY RLSE. Monitoring can be terminated by: <ul style="list-style-type: none"> 1. any routine which calls routine NVSUB 2. another monitor Verb 3. execution of Verb 34 or 36 4. certain alarm conditions.

TABLE VIII
VERB DEFINITIONS (cont)





Code	Action	Description
12	Monitor (display every 0.5 sec.) in register R1 (in octal numbers) the second component of the Object specified by the Noun code used with this Verb code. 	Similar to operations described for Verb 11 except that Job MONDO executes Verb 02.
13	Monitor (display every 0.5 sec.) in register R1 (in octal numbers) the third component of the Object specified by the Noun code used with this Verb code. 	Similar to operations described for Verb 11 except that Job MONDO executes Verb 03.
14	Monitor (display every 0.5 sec.) in register R1 and R2 (in octal numbers) the first and second components of the Object specified by the Noun code used with this Verb code. 	Similar to operations described for Verb 11 except that Job MONDO executes Verb 04.
15	Monitor (display every 0.5 sec.) in registers R1, R2, and R3 (in octal numbers) the first, second, and third component of the Object specified by the Noun code used with this Verb code. 	Similar to operations described for Verb 11 except that Job MONDO executes Verb 05.

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
16	Monitor (display every 0.5 sec.) in register R1, and in register R2 and R3 as appropriate (in decimal numbers) all components of the Object specified by the Noun code used with this Verb code. \triangle	Similar to operations described for Verb 11 except that Job MONDO executes Verb 06.
17	Monitor (display every 0.5 sec.) in register R1 and R2 (in decimal numbers) the double precision quantity (as contained in two consecutive E locations) of the Object specified by the Noun code used with this Verb code.	Similar to operations described for Verb 11 except that Job MONDO executes Verb 07.
20	Request execution of Job specified by the address to be entered via Noun 01, or 02, etc., through 0). \triangle	Causes execution of routine VBRQEXEC. Upon entering Verb-Noun combinations 20 - 01, or 20 - 02, etc., through 20-0), the Verb and Noun displays flash and the operator has to punch in the complete address of the Job which is displayed at register R3. The priority code is taken from bit positions 14 through 10 of register DSPTEM1 which <u>must be</u> loaded previously by means of Verb-Noun combination 21 - 26. (Difficulty could arise if register DSPTEM1 does not contain a priority code when Verb 20 is executed.) Verb 20 makes program section Keyboard And Display available for internal use.

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
21	Load the first component of the Object specified by the Noun code used with this Verb code. \triangle_2	Causes the execution of routine A LOAD. Upon execution of this Verb, the Verb and Noun displays flash and the operator has to punch in a data word, either in octal or decimal numbers. As each character is punched in, it is displayed in the appropriate character display of register R1 and stored temporarily in register XREG. Decimal data is converted to its octal equivalent as it is punched in. After the last character has been punched in, the operator depresses key ENTER which causes the termination of the flashing. Octal data is then taken from register XREG and stored in the location specified by the Noun code used with this Verb code. If the data loaded is decimal, the appropriate scale factors are applied before it is stored into the location specified by the Noun code.
22	Load the second component of the Object specified by the Noun code used with this Verb code. \triangle_2	Causes execution of routine B LOAD. Similar to operations described for Verb 21 except that, as the data is punched in, it is displayed in the appropriate character display of register R2, and stored temporarily in register YREG. After the operator depresses key ENTER, the data is taken from YREG and is stored into the location specified by the Noun code.
23	Load the third component of the Object specified by the Noun code used with this Verb code. \triangle_2	Causes execution of routine C LOAD. Similar to operation described for Verb 21 except that as the data is punched in, it is displayed in the appropriate character display of register R3 and is stored temporarily in register ZREG. After the operator depresses key ENTER,

TABLE VIII

VERB DEFINITIONS (cont)



Code	Action	Description
23 (cont)		the data is taken from ZREG and is stored into the location specified by the Noun code.
24	Load first and second components of the Object specified by the Noun code used with the Verb code. 	Causes execution of routine AB LOAD. Upon execution of this Verb, its code number is changed to code number 21 (A LOAD) and this new code is displayed. Data is loaded in the same manner as if Verb 21 had been punched in, except that depressing key ENTER does not cause the transfer of data from register XREG to a specified location. Storing data into a specified location does not take place until all requested data has been punched in. Therefore, depressing key ENTER changes the Verb code from 21 to 22 (B LOAD) and the data load proceeds as if Verb 22 had been punched in. Depressing key ENTER the second time causes the data to be taken from register XREG and YREG and stored into the locations specified by the Noun code.
25	Load first, second, and third components of the Object specified by the Noun code used with this Verb code. 	Similar to Verb 24 except that depressing key ENTER the second time changes the Verb code from 22 to 23 (C LOAD). This new code is displayed and the data load proceeds as if code 23 had been punched in. Depressing key ENTER the third time indicates that all the data has been punched in, therefore, the data is transferred from register XREG, YREG, and ZREG into the locations specified by the Noun code.
26	Spare	When code 26 is used, the CHECK FAIL indicator is turned on.

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
27	Spare	When code 27 is used, the CHECK FAIL indicator is turned on.
30	Spare	When code 30 is used, the CHECK FAIL indicator is turned on.
31	Display in register R1 (in octal numbers) the content of any location within FS memory to be specified.	Causes execution of routine DSPBANK. Upon execution of Verb-Noun combinations 31-01, or 31-02, etc, through 31-05, the Verb and Noun displays flash and the operator has to punch in the complete address of the location where the content is to be displayed. This Verb differs from Verbs 01 through 05 in that any location within FS memory can be displayed.
32	Shift the content of display R2 into R3, the content of R1 into register R2 and blank register R1.	Causes execution of routine BUMP.
33	Inform the routine which requested data that the operator chooses not to supply the data, and wishes the routine to continue its execution as best it can without the requested data.	Causes execution of routine VBPROC which terminates the flashing of Noun and Verb displays, makes program section Keyboard And Display available for internal use, and reactivates the Job that requested the data if the requesting routine is a Job and the Job is in the dormat state.

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
34	Inform the routine which requested data that the operator chooses not to supply data, and wishes the routine to be terminated. (Final decision on what to do after the termination is left to the requesting routine.)	Causes execution of routine VBTERM which terminates monitoring and the flashing of the Noun and Verb displays. This routine makes program section Keyboard And Display available for internal use, and reactivates the Job that requested the data if the requesting routine is a Job and if the Job is in the dormant state.
35	Make program section Keyboard And Display available for internal use.	Causes execution of routine VBRELDSP which performs the same function as depressing key KEY RLSE. The following actions occur: <ol style="list-style-type: none"> 1. Program section Keyboard And Display is made available by unblocking entry to routine NVSUB. 2. A Job is reactivated if it is awaiting the release of program section Keyboard And Display. 3. The KEY RLSE indicator is turned off if it is on. 4. The UPTL indicator is turned off.
36	Re-initiate the system operation by executing the Auxiliary Function Fresh Start.	Causes execution of routine SLAPB. This routine enters 00000 into register FAILREG, executes an INHINT, and then proceeds to re-initialize E memory. (For detail, refer to Issue 16.) In regard to program section K&D, the following actions take place: <ol style="list-style-type: none"> 1. Indicators PROG ALM, COMP ACTIVITY, KEY RLSE, TM FAIL, and CHECK FAIL are turned off. 2. The character displays NOUN, VERB, R1, R2, and R3 are blanked and the quantity 00 will be displayed in the PROGRAM displays.

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
36 (cont)		<p>3. Registers GRABLOCK, DSPLOCK, CADRSTOR, Re-QRET, DSPCNT, CLPASS, MONSAVE, MONSAVEL, VERBREG, NOUNREG, DSPLIST, DSPLIST+1, DSPLIST+2, MARKSTAT, TMKEYBUF are set to 00000.</p> <p>4. Register DSPCOUNT is set to 77754 to indicate that an operation key must be depressed next.</p> <p>After E memory is re-initialized, the Phase tables are set to indicate that all Mission Functions have been terminated. The entrance to the SELF CHECK routine is then blocked and T4RUPT is instructed to turn off the C relays. A RELINT is given and control is transferred to routine DSPMM where the quantity 00 is displayed in the PROGRAM windows. The VERB 36 sequence terminates leaving the DUMMYJOB in execution until a keyboard request is taken.</p>
37	Set Mission Function and Function Phase as specified by a two digit code to be punched in.	<p>Causes execution of routine MMCHANG (Change Major Mode). Upon execution of this routine, the NOUN display is blanked and the flashing of the VERB and NOUN displays is initiated to inform the operator that additional inputs are required. However, since the NOUN display has been blanked, only the VERB display will flash. Since the quantity 37 appears in the VERB displays, the operator knows he has to enter a two digit code, hereafter called D1D2. The first digit D1 refers to a Mission Function; the second, D2, to a Phase of that Mission Function. As these digits are keyed in they are stored in register NOUNREG and are displayed in the NOUN displays. After key ENTER is depressed, the NOUN display is blanked</p>

TABLE VIII

VERB DEFINITIONS (cont)

Code	Action	Description
37 (cont)		<p>and program control is transferred to routine MODROUTB in program section Progress Control. Routine MODROUTB assembles the two-digit code in a form which can be utilized by routine REPHASE2. Routine REPHASE2 enters the phase code into the proper position of the Phase Tables and then tests the previous content of the Phase Tables to determine whether the Mission Function represented by D1 is currently active. If it is not, register MODREG is updated and a Job is requested which, when executed, will begin the execution of the Mission Function at the specified Phase. The PROGRAM displays are updated to indicate that the Mission Function has just been activated and Job CHARIN is terminated. If the Mission Function represented by D1 is active when the two-digit code is entered, instruction TC ENDOFJOB is executed immediately with only a change in the Phase Tables accomplished. The change in the Phase Tables will not have an effect on the system until the Mission Function specified by D1 checks the Phase Tables in the course of its execution.</p> <p>A VERB 36 ENTER keyboard action followed by a VERB 37 ENTER; D1, D2, ENTER, could be used to change Mission Functions immediately and to begin the new Mission Function at a specified Phase. The keyboard action VERB, 3, 7, ENTER; D1, D2, ENTER where D2 is 0, will cause the Mission Function, defined by D1, to terminate when it checks the Phase Tables.</p>

1 Noun may refer to E or FF memory only.

2 Noun may refer to E memory only.

TABLE IX

NOUN DEFINITIONS

Code	Object	Description
00	-----	Not in use.
01	Fractional data stored or to be loaded at a location to be specified. (dec. max. $\pm .99999$)	Upon entering these nouns, the Verb and Noun displays start to flash and the operator has to enter the five character octal address (of any location in E or FS memory) which is then displayed in display register R3 and stored in register NOUNADD. The flashing ceases after the address has been entered. These nouns are used primarily with load, display, or monitor verbs.
02	Whole data (integer) stored or to be loaded at a location to be specified. (dec. max. ± 16383)	
03	Angular data (in degrees) stored or to be loaded at a location to be specified. (dec. max. ± 359.99)	
04	Time (in hours) stored or to be loaded at a location to be specified. (dec. max. $+ 745.65$)	
05	Time (in seconds) stored or to be loaded at a location to be specified. (dec. max. $+ 999.99$)	
06	Gyro data (in degrees) stored or to be loaded at a location to be specified. (dec. max. $+ 9.9999$)	
07	Optics data (in degrees) stored or to be loaded at a location to be specified. (dec. max range I $+ 179.99$ range II $+ 89.999$ Range is selected from bit 13 of WASOPSET	

TABLE IX

NOUN DEFINITIONS (cont)

Code	Object	Description
10 through 14	Spare	
15	Increment Machine Address	Increments previously stored machine address [c(NOUNADD)] by one.
16	Time in seconds $\triangle 1$	Refers to time counters TIME1 and TIME2 (0035 and 0036) for time data given in seconds. If decimal displaying or monitoring is desired, the time is given up to a maximum of 999.99 seconds.
17	Time in hours $\triangle 1$	Refers to time counters TIME1 and TIME2 (0035 and 0036) for time data given in hours. If decimal displaying or monitoring is desired, the time is given up to a maximum of 745.65 hours.
20	IMU CDU angles in degrees $\triangle 1$	Refers to counters CDUX, CDUY, and CDUZ (0047 through 0051). If decimal displaying or monitoring is desired, the angles are given up to a maximum of ± 359.99 degrees.
21	PIPA's $\triangle 1$	Refers to the number of PIPA counts contained in counters PIPAX, PIPAY, and PIPAZ (0044 through 0046). If decimal displaying or monitoring is desired, the number of counts is given up to a maximum of ± 16383 .

TABLE IX

NOUN DEFINITIONS (cont)

Code	Object	Description
22	Desired platform angles [θ_D 's]	Refers to the desired platform angles θ_D (in degrees) contained in registers THETAD, THETAD+1, and THETAD+2 (0705 through 0707). If decimal displaying, monitoring, or loading is desired, the angles are given up to a maximum of ± 359.99 degrees.
23	Delta Angles	Refers to the angles (in degrees) that must be added to the present angles (IMU angles, or platform angles) in order to give a desired angle. These angles are stored or are to be loaded into register DSPTEM2, DSPTEM2+1, and DSPTEM2+2 (0632 through 0634). If decimal displaying, monitoring, or loading is desired, the angles can be given up to a maximum of ± 359.99 degrees.
24	Delta Time in Seconds	Refers to the time in seconds that must be added to the present time in order to give a desired time. This property would be useful if it is necessary to do something for a specific length of time or at a specific time. This time is stored or is to be loaded into registers DSPTEM1 and DSPTEM1+1 (0627 through 0630). If decimal displaying, monitoring, or loading is desired, the time may be given up to a maximum of 999.99 seconds.

TABLE IX

NOUN DEFINITIONS (cont)


Code	Object	Description
25	Checklist 	Refers to register DSPTEM1 (0627). Preceding the use of VERB 50 (Please Perform, see table 17-2), this location should have been loaded with the coded number of the checklist items to be performed. This Noun is primarily used for displaying the checklist items requested of an operator. If decimal displaying, monitoring, or loading is desired, the number may be given up to a maximum of + 16383.
26	Prio/Delay	Refers to the DSPTEM1 register (0627). Preceding the use of Verb 20 (Request Executive, see table 17-4), this location should have been loaded with the desired priority in bit positions 14 through 10. Preceding the use of Verb 10 (Request Waitlist, see table 17-4), this location should have been preloaded with the desired number of 10 msec units of delay. Octal scaling must be used for the Priority, but either decimal or octal scaling may be used for the delay. If decimal scaling is used for the delay, the number may be given up to a maximum of + 12000 which is equivalent to a 2 min delay.
27	Self Test On/Off Switch	Refers to register SMODE (1567). The contents of SMODE refer to the number of times that program section Self Check is to be done while waiting for a new Job to be requested. If location 1567 is loaded with +0 or -0 then no checking is done and the program remains in a loop until c(NEWJOB)

TABLE IX

NOUN DEFINITIONS (cont)

Code	Object	Description
27 (cont)		is greater than 0. If location 1567 is loaded with a quantity less than minus zero, then Self Check is executed indefinitely with c(NEWJOB) being checked about every 2 msec. If loaded with a quantity greater than plus zero, then Self Check is done N times where N is the number loaded into location 1567. After Self Check has been done N times and if the c(NEWJOB) still equals 00000, the program proceeds as mentioned above since the contents of SMODE equal 00000.
30	Star Numbers $\triangle 3$	Refers to registers DSPTEM1, DSPTEM1+1, and DSPTEM1+2 (0627 through 0631). Preceding the use of VERB 51 (Please Mark, see table 17-4), these locations should have been loaded with the coded numbers of the stars to be marked. This Noun is primarily used for displaying the Star Number of interest to the operator. If decimal displaying, monitoring, or loading is desired, this number may be given up to a maximum of + 16383.
31	Failreg $\triangle 1$ $\triangle 3$	Refers to the FAILREG register (0756). The contents of FAILREG consist of a coded number referring to the type of failure that occurred. This register is loaded by the ALARM and ABORT routines. This noun is primarily used for displaying the system failure conditions where a coded number will be displayed (in octal) in register R1 representing the failure condition.

TABLE IX

NOUN DEFINITIONS (cont)

Code	Object	Description
32 through 54	Spare	
55	Optics CDU's	Refers to the OCDU counters (00052 and 00053). If displaying or monitoring is desired, the X Optics is given up to a maximum of + 359.99 degrees and the Y Optics is given up to either a maximum of + 179.99 degrees or + 89.999 degrees.
56	Optics CDU's. Time in seconds. \triangle_2	Refers to registers DSPTEML, DSPTEML+1, and DSPTEML+2 (0627, 0630, and 0631). Noun 56 is used by internal routines to display the OCDU angles and the time in seconds when an unrequested mark is performed. If decimal displaying, monitoring, or loading is desired, the X Optic angle (0627) may be given up to a maximum of + 359.99 degrees, the Y Optics angle (0630) to either a maximum of + 179.99 degrees or + 89.999 degrees, and time up to a maximum of 999.99 seconds.
57	Desired Optics CDU's \triangle_2	Refers to the desired Optics angle registers, DESOPTX (0724) and DESOPTX+1 (DESOPTY, 0725). If decimal displaying, monitoring, or loading is desired, the X Optic angle (0724) may be given up to a maximum of + 359.99 degrees and the Y Optics angle (0725) may be given up to a maximum of either + 179.99 degrees or + 89.999 degrees.

TABLE IX

NOUN DEFINITIONS (cont)


Code	Object	Description
60	IMU CDUX given in degrees and Time given in seconds. \triangle_2	Refers to counter CDUX (0047) and time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, the IMU CDUX angle is given up to a maximum of + 359.99 degrees and the time is given up to a maximum of 999.99 seconds.
61	IMU CDUY given in degrees and Time given in seconds. \triangle_2	Refers to counter CDUY (0050) and time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, the IMU CDUY angle is given up to a maximum of \pm 359.99 degrees and the time is given up to a maximum of 999.99 seconds.
62	IMU CDUZ given in degrees and Time given in seconds. \triangle_2	Refers to counter CDUZ (0051) and time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, the IMU CDUZ angle is given up to a maximum of \pm 359.99 degrees and the time is given up to a maximum of 999.99 seconds.
63	Optics CDUX given in degrees and Time given in seconds. \triangle_1 \triangle_2	Refers to OPTX counter (0052) and time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, the Optics CDUX angle is given up to a maximum of + 359.99 degrees and the time is given up to a maximum of 999.99 seconds.

TABLE IX

NOUN DEFINITIONS (cont)

Code	Object	Description
64	Optics CDUY given in degrees and Time given in seconds. $\triangle 1$ $\triangle 2$	Refers to OPTY counter (0053) and time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, the Optics CDUY angle is given up to a maximum of either + 179.99 degrees or 89.999 degrees, and the time is given up to a maximum of 999.99 seconds.
65	Time given in hours and seconds. $\triangle 1$ $\triangle 2$	Refers to time counters TIME1 and TIME2 (0035 and 0036). If decimal displaying or monitoring is desired, hours will be displayed in R1 up to a maximum of + 745.65 hours and seconds will be displayed in R2 up to a maximum of + 999.99 seconds.
66	System Test Results $\triangle 2$	Refers to registers DSPTEM2, DSPTEM2+1, and DSPTEM2+2 (0632 through 0634). If decimal displaying, monitoring, or loading is desired, the c(DSPTEM2) can be scaled up to a maximum of + 16383, the c(DSPTEM2+1) to a maximum of .99999 and the c(DSPTEM2+2) to a maximum of + 16383.
67	Delta Gyro Angles	Refers to the double precision GYRO angle registers GYROD through GYROD+5 at locations 0715 through 0722. These locations contain the double precision Gyro angles that must be added to the present Gyro angles to give the correct position. If decimal displaying, monitoring, or loading is desired, the angles can be given up to a maximum of ± 9.9999 degrees.

TABLE IX
NOUN DEFINITIONS (cont)

Code	Object	Description
70 through 77	Spare 	



Since this noun refers to counters, it is not normally loaded. However, the capability exists and loading may be useful in special applications.



Mixed nouns.



These nouns reference lists. The content of the location specified by one of these nouns is a coded number. This coded number indicates a certain position in the referenced list.