TP1571

FINAL TECHNICAL SUMMARY REPORT

AUGUST 1964 THRU AUGUST 1967

COMPUTER SYSTEMS
FOR
SATURN
GROUND COMPUTER COMPLEX
NAS 8-13007

PREPARED FOR

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

WEST COAST DIVISION
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BY

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WEST COAST DIVISION
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JULY 1967

ABSTRACT

This is the final technical summary report on the fabrication, delivery, and installation of seventeen Saturn SV Ground Computer Systems and is submitted in accordance with the requirements of contract NAS8-13007.

This report is primarily technical in nature, the objective being to present a summary of the technical results of the program. The functional operations of the systems are explained in detail in the Saturn Ground Computer System Instruction Manual, TP1270, which was published as part of the NAS8-13007 contract.

Section 1 of this report reviews the scope of the task and the time period of the contract. Included is a list of hardware items delivered. Also listed are contract modifications and deviation requests.

Section 2 contains a brief functional and mechanical description of each major assembly while a review of the major program milestones and accomplishments is presented in Section 3 of this report.

Problems that occurred during the course of the contract and the efforts made to resolve these problems are described in Section 4.

Section 5 contains a description of the configuration management program including listings of the documentations supplied.

Section 6 contains a description of the reliability program while Section 7 describes the documentation provided in support of this contract.

A summary of the installation and checkout of each system is contained in Section 8 together with a description of the problems encountered during installation and checkout.

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SECTION 1

SCOPE OF WORK

Contract NAS8-13007 was awarded to RCA, Van Nuys on August 1964. The extended term of this contract runs to August 1967. Under this contract, RCA furnished seventeen Saturn SV Ground Computer Systems each consisting of an RCA 110A digital computer plus the ancillary and peripheral equipment required to provide the capability of checking, monitoring, and recording the operation of various Saturn vehicle sub-systems.

1.1 HARDWARE

Table 1-1 itemizes the hardware, by unit and cabinet, that was manufactured:

Table 1-1. Manufactured Hardware

UNIT	QUANTITY	DESCRIPTION
0101	17	Power Supply Unit, Cabinets 01 and 05
0201	17	Main Frame Converter Unit, Cabinets 02 and 03
0401	17	Master Magnetic Tape Unit, Cabinet 04
0402	17	Master Magnetic Tape Unit, Cabinet 04
0601	17	Analog Converter Unit, Cabinet 06
0701	17	Discrete Input Converter Unit, Cabinet 07
0702	8	Discrete Input Converter Unit, Cabinet 07
0801	9	Discrete Output Converter Unit, Cabinet 08
1001 (3 IODC)	5	Data Input/Output Switching Unit, Cabinet 10
1001 (4 IODC)	12	Data Input/Output Switching Unit, Cabinet 10
1101 (No IODC)	6	High Speed Memory Switching Unit, Cabinet 11
1101 (With IODC)	11	High Speed Memory Switching Unit, Cabinet 11
1102 (No IODC)	9	High Speed Memory Switching Unit, Cabinet 11

Table 1-1. Manufactured Hardware (Cont)

UNIT	QUANTITY	DESCRIPTION
1102 (With IODC)	8	High Speed Memory Switching Unit, Cabinet 11
1201, 1202, 1203	17 each	Slave Magnetic Tape Units, Cabinet 12
1204	3	Slave Magnetic Tape Units, Cabinet 12
1205	3	Slave Magnetic Tape Units, Cabinet 12
1301	17	Line Printer Converter Unit, Cabinet 13
1401	17	Card Reader Programmer Unit, Cabinet 14
1501	17	Card Punch Programmer Unit, Cabinet 15
1601	13	Saturn Data Link Terminal, Cabinet 16
1602	10	Saturn Data Link Terminal, Cabinet 16

The final Saturn SV Ground Computer System equipment allocation is presented in table 1-2 showing the actual configuration of each system.

Initially, the contract called for fabrication, delivery, and installation of 19 Saturn SV Ground Computer Systems. (This was reduced to 17 systems by contract modification 14.)

1.2 DOCUMENTATION

Documentation supplied included logic diagrams, schematics, wire connection lists, module board assembly drawings, specification control drawings, instruction manuals, maintenance manuals, and programming manuals.

1.3 REPORTS

The contract required monthly progress reports and a final technical summary report.

1.4 CONTRACT MODIFICATIONS

Table 1-3 lists the modifications that were issued on Contract NAS 8-13007.

1.5 APPROVED DEVIATION REQUESTS

The NAS8-13007 deviations are listed in table 1-4. The listing indicates the deviation number, approval date, and brief description of the deviation requests subject.

Table 1-2. Saturn SV Ground Computer System Equipment Allocation

RCA System Group No. 2112000-	System Location	Cab 01	Cab 02	Cab 03	Cab 04	Cab 05	Cab 06	Cab 0701	Cab 0702	Cab 08	Cab 10	Cab 11	Cab 11	Cab 12	Cab 12	Cab 12	Cab 12	Cab 12	Cab 13	Cab 14	Cab 15	Cab 16	Cab 16
-508	Michoud C/O Station No. 2	X	X	X	X	X	X	X		X	X	X	X_2	X	X	X			X	X	X		
-509	VLF 34 LCC	X	X	X	X	X	X	X		X	X_1	X	X_2	X	X	X			X	X	X	X	X
-510	VLF 34 AGCS	X	X	X	X	X	X	X		X	X_1	X_2	X_2	X	X	X			X	X	X	X	X
-511	Michoud C/O Station No. 1	X	X	X	X	X	X	X		X	X	X	X_2	X	X	X			X	X	X		
-512	MSFC Test	X	X	X	X	X	X	X		X	X	X	X_2	X	X	X			X	X	X		
-513	SV BB LUT	X	X	X	X	X	X	X	X		X_1	X_2	X	X	X	X			X	X	X	X	
-514	MILA Support Area	X	X	X	X	X	X	X		X	X_1	X	X_2	X	X	X			X	X	X	X	
-515	VLF 39 LCC No. 1	X	X	X	X	X	X	X	X		X_1	X	X	X	X	X	X	X	X	X	X	X	X
-516	Mississippi Test Facility	X	X	X	X	X	X	X		X	X	X	X_2	X	X	X			X	X	X		
-517	500 FS	X	X	X	X	X	X	X	X		X	X	X	X	X	X			X	X	X	X	X
-518	VLF 39 LUT No. 1	X	X	X	X	X	X	X	X		X_1	X_2	X	X	X	X			X	X	X	X	X
-519	VLF 37 LCC	X	X	X	X	X	X	X		X	X_1	X	X_2	X	X	X			X	X	X	X	X
-520	VLF 37 AGCS	X	X	X	X	X	X	X		X	X_1	X_2	X_2	X	X	X			X	X	X	X	X
-521	VLF 39 LCC No. 2	X	X	X	X	X	X	X	X		X_1	X	X	X	X	X	X	X	X	X	X	X	X
-522	VLF 39 LUT No. 2	X	X	X	X	X	X	X	X		X_1	X_2	X	X	X	X			X	X	X	X	
-523	VLF 39 LCC No. 3	X	X	X	X	X	X	X	X		X_1	X	X	X	X	X	X	X	X	X	X	X	X
-524	VLF 39 LUT No. 3	X	X	X	X	X	X	X	X		X_1	X_2	X	X	X	X			X	X	X	X	X
	1 Contain 4 IODC's 2 No IODC's																						

Table 1-3. Contract Modifications

MOD NO.	APPROVAL DATE	DESCRIPTION
1	8-25-64	Change of contract work order numbers
2	8-26-64	Increase of contract amount and change of coverage date to 9-30-64
3	9-28-64	Increase of contract amount and change of coverage date to 12-31-64
4	10-1-64	Change of requisition numbers
5	11-27-64	Deletion of cabinet 08 Converter Unit, Discrete Output, in nine systems
6	12-18-64	Increase of contract amount and change of coverage date to 6-30-65
7	12-18-64	Addition of Interval Timer per ECP 110A-49671-0005 dated 11-3-64
8	12-18-64	Modification to Discrete Subsystem and ABC Register per ECP 110A-49671-0006 dated 11-3-64
9	12-18-64	Modification to Digital Data Acquisition System IODC per ECP 110A-49671-0007 dated 11-3-64
10	12-24-64	Modification to Converter Mass Memory per ECP 110A-49671-0002 dated 10-27-64
11	12-22-64	Provision of Government Furnished Property items
12	1-14-65	Reinstatement of Cabinet 08 Converter Unit, Discrete Output, in two systems
13	1-29-65	Quality Assurance requirements to provide certified operators and inspectors per MSFC-PROC-158B, and improve environmental conditions of vendor facility
14	1-29-65	Scope of work amended, deleted two systems, this changed the total number of systems to 17 instead of 19
15	2-25-65	Addition of one cabinet 07 Converter Unit, Discrete Input, in eight systems
16	3-1-65	Implementation of NASA Specification NPC 500-1 exhibits II, IV, VII, IX, X, XI, XII, XIII, XIV, and XVI
17	3-4-65	Provision of Government Furnished Property items
18	3-9-65	Modification of Slave Tape Stations per ECP 110A-49671-0010 dated 2-1-65

Table 1-3. Contract Modifications (Cont)

MOD NO.	APPROVAL DATE	DESCRIPTION
19	3-9-65	Quality Assurance requirement pertaining to minimum soldering standards
20	3-15-65	Increase of contract amount and change of coverage date to 6-30-65
21	3-18-65	Cancellation of contract modification 16 (Implementation of NASA specification NPC 500-1)
22	3-19-65	Reallocation of computer systems; definitized delivery of IODC equipments and technical changes to systems
23	3-30-65	Incorporation of SV Display IODC per ECP 110A-49671-0017 dated 3-18-65; reallocation of display IODC's
24	4-22-65	Reallocation of computer systems
25	4-22-65	Addition of two wires in cabinet 03 per ECP 110A-49671-0016 dated 3-6-65
26	4-26-65	Disposition of spares resulting from compliance of contract modifications 5, 12, and 14
27	5-5-65	Scope of Work revised to implement NASA Specification NPC 500-1 exhibits II, IV, VI, VII, IX, X, XI, XII, XIII, XIV, XV, and XVI
28	5-21-65	Revision of contract amount
29	5-21-65	Definitize destination, delivery, and final acceptance of exhibit A items
30	6-3-65	Revision of contract amount
31	6-23-65	Incorporation of ECP's 110A-49671-0018 and -0021 covering SV Display IODC
32	7-13-65	Deletion of reference to NASA Specification NPC 105 by substitution of NPC 105A
33	7-8-65	Revision of contract amount and change of coverage to 9-30-65
34	8-18-65	Incorporation of ECP's 110A-49671-0027-1, -0038-1, 0032-1 and -2, -0022, -0033-1, -0056, -0054, -0035, and -0046
35	8-27-65	Provision of Government Furnished Property items
36	8-27-65	Incorporation of ECP 110A-49671-0049-1 thru -18
37	8-27-65	Revision of contract amount

Table 1-3. Contract Modifications (Cont)

MOD NO.	APPROVAL DATE	DESCRIPTION
38	10-12-65	Incorporation of ECP's 110A-49671-0017-R2, 0058-E, -0066-1 and -2
39	9-30-65	Provision of Government Furnished Property items
40	9-30-65	Incorporation of ECP's 110A-49671-0062-1 thru -7
41	10-14-65	Revision of contract amount and change of coverage to 11-30-65
42	10-15-65	Incorporation of ECP's 110A-49671-0052-1 thru -4; -0061, -0067, -0068, -0081 and -0093E
43	10-23-65	Incorporation of ECP 110A-49671-0077P
44	11-24-65	Revision of contract amount; allocation of system and site installation, and delivery schedule
45	12-17-65	Revision of contract amount resulting from affects of contract modifications 15, 18, 23, and 31
46	11-22-65	Revises contract modification 38 incorporation of ECP's 110A-49671-0066-1 and -2 to show effectivity to all systems
47	11-22-65	Incorporation of ECP's 110A-49671-00115CC, -0124P, -0070-1, -3 thru -11, -13, -15, -16, -18, -19, -20 and -21
48	12-7-65	Incorporation of ECP's 110A-49671-0091-1, -4, -5, -8, -9, -14, -18, and -19
49	12-9-65	Revision of contract amount and change of coverage to 12-31-65
50	12-15-65	Incorporation of ECP's 110A-49671-0029, -0075-1 thru -3, -0086, -0097-1 thru -9, and -0099
51	12-17-65	Incorporation of ECP 110A-49671-0113
52	12-23-65	Incorporation of ECP's 110A-49671-0070-12, -14, and -17; -0095-1, -0101, and -0132
53	1-7-66	Incorporation of ECP's 110A-49671-0091-2 and -3, -6 and -7, -10 thru -17; and 0088
54	1-7-66	Incorporation of ECP 110A-49671-150E
55	1-14-66	Revision of contract amount and change of coverage to 3-31-66
56	1-17-66	Documentation update to assure compatibility of instruction manuals and individual site system hardware

Table 1-3. Contract Modifications (Cont)

MOD NO.	APPROVAL DATE	DESCRIPTION
57	1-17-66	Incorporation of ECP's 110A-49671-0084, -0134, and -0135
58	2-1-66	Incorporation of ECP's 110A-49671-0042, -108-1 thru -3, -0147P, -0168, -0128, and -0130
59	2-1-66	Incorporation of ECP's 110A-49671-0126-1 thru -6
60	2-23-66	Incorporation of ECP's 110A-49671-0159, -0162, and -0180
61	3-15-66	Incorporation of ECP's 110A-49671-0064, -0141, -0178, and -0184
62	5-18-66	Revision of contract amount
63	3-21-66	Incorporation of ECP 110A-49671-0186
64	4-1-66	Revision of contract amount and change of coverage to 6-30-66
65	5-13-66	Revision of contract amount and requirements
66	4-27-66	Provision of Government Furnished Property, Module Tester
67	4-27-66	Incorporation of ECP 110A-49671-0190
68	5-26-66	Change of ECP 110A-49671-0184 referenced in contract modification 61 to remove after SA 201 launch
69	7-3-66	Incorporation of ECP's 110A-49671-0203, -0206, -0208, -0209, -0210, and -0211P
70	6-15-66	Incorporation of ECP 110A-49671-0213
71	6-16-66	Incorporation of ICP 40M11704, 40M05838, 63A11715, 40M11715, and 40M11701
72	7-7-66	Revision of contract amount and change of coverage to 8-31-66
73	6-26-66	Supersedes contract modification 69 to incorporate ECP's 110A-49671-203, -206, -208, -209, 210, and 211P
74	6-28-66	Supersedes contract modification 71
75	7-29-66	Revision of contract amount; change of effectivity of ECP's 110A-49671-0134, -0135, in lieu of contract modification 57 and ECP 110A-49671-0168 in lieu of contract modification 58
76	8-16-66	Revision of contract amount and change of coverage to 8-31-66

Table 1-3. Contract Modifications (Cont)

MOD NO.	APPROVAL DATE	DESCRIPTION
77	7-8-66	Incorporation of ECP 110A-49671-210R
78	7-12-66	Rework of RCA module boards in accordance with stated priority; MES 0268 and 0269
79	8-16-66	Deletion of ECP 110A-49671-211P
80	9-22-66	Definitization of change directed by contract modification 66
81	9-1-66	Revision of contract amount and change of coverage to 9-30-66
82	9-6-66	Deletion of ICD 40M05838 and incorporation of ICD 40M17259
83	9-7-66	Rework of RCA module boards including system and sub-depot spares, prime depot spares supplied under other contracts; MES 0268 and 0269
84	9-14-66	Incorporation of ICD 40M17402 and 40M16406
85	9-26-66	Preflight Readiness Review reports and Flight Readiness Review reports for flight vehicles AS-204 and AS-205
86	10-11-66	Change to accounting and appropriation data
87	1-12-67	Supersedes contract modification 83
88	10-26-66	Incorporation of IRN 3 to ICD 40M17259
89	11-10-66	Revision of contract amount as a result of contract modification 78
90	1-12-67	Revision of contract amount
91	1-7-67	Packaging and shipment
92	1-25-67	Repair of scrapped PA2807 module boards
93	3-15-67	Delivery schedule
94	2-10-67	MES procedures in module board rework program
95	2-10-67	Revision of contract amount resulting from contract modification 78
96	3-13-67	Revision of contract amount; notice of 30 day completion of rework, exchange, and verification of systems
97	3-13-67	Revision of contract amount
98	3-15-67	Coverage date changed to 7-31-67
99	--	--
100		Total target price

Table 1-4. Deviation Requests

DR NO.	APPROVAL DATE	DESCRIPTION
003	10-21-64	Procedure for conformal coating of module boards
004	1-12-64	Wire lead bending of designated module board components
005	3-3-65	Design and fabrication of magnetic tape connecting cables
006	3-3-65	Use of double sided module boards
007	3-6-65	Soldering techniques and use of tubing
008	3-3-65	Wiring and soldering of transistors
009	3-6-65	Elimination of conformal coating on designated Redcor module boards
010	3-6-65	Record purpose to facilitate end item inspection resulting from contract modification 13
011	3-6-65	Same as 010
012	3-5-65	Same as 010
013	3-5-65	Same as 010
013A	--	Use of solder eyelet
014	4-1-65	Same as 010
016	3-5-65	Relaxation of specification for proprietary item consideration
017A	3-5-65	Soldering procedure to provide concurrence with qualified parts list
18	3-12-65	Wire connection to bus bars in Ampex equipment
018	3-12-65	Same as 010
019	3-12-65	Same as 010
020	3-12-65	Same as 010
021	4-1-65	Same as 010
022	3-12-65	Same as 010
023	3-12-65	Same as 010
024	3-12-65	Same as 010
025	3-12-65	Same as 010
026	3-12-65	Same as 010

Table 1-4. Deviation Requests (Cont)

DR NO.	APPROVAL DATE	DESCRIPTION
027	4-13-65	Clamping of cables at designated locations
028	4-26-65	Same as 010
029	5-4-65	Same as 010
030	5-4-65	Same as 010
031	4-26-65	Environmental conditions at RCA Needham plant which did not meet specification requirements
032	4-30-65	Same as 010
033	5-4-65	Use of resistors without GSI and lot identification
034	5-4-65	Same as 033
035	5-4-65	Same as 010
036	5-4-65	Same as 010
037	5-4-65	Same as 010; also soldering of type 2N1183 semiconductor
038	5-4-65	Same as 010
039	5-4-65	Relaxation of specification for test cable fabrication
040	5-4-65	Use of potentiometer without GSI and lot identification
041	5-4-65	Use of commercial quality transistors in place of military to facilitate delivery schedule
042	7-16-65	Excessive copper exposure on desigrated module boards
045	7-30-65	Diodes with scored leads on systems 9, 10, 11, and 12
046	9-8-65	Accidental use of incorrect solder flux
047	8-12-65	Same as 010
048	9-8-65	Same as 010
049	9-8-65	Same as 010
050	9-8-65	Same as 010
051	9-8-65	Same as 010
052	9-8-65	Same as 010
053	9-13-65	Borderline operation of transistors during 1000 hour test

Table 1-4. Deviation Requests (Cont)

DR NO.	APPROVAL DATE	DESCRIPTION
054	Rejected 10-8-65	Discoloration of hook-up wires used on back plane of RCA Needham core memory
055	10-8-65	Same as 042
056	--	Repair of module boards with copper path pattern on module boards lifting
057	7-29-66	Salvage of RCA Needham core memory module boards
058	7-29-66	Bend radius of capacitor wires on module boards due to construction limitations
059	--	Solder flux residue under conformal coating resulting from improper cleaning of module boards
059A	--	Park specks on solder under conformal coating of module boards
059B	10-17-66	Same as 059A

SECTION 2

MAJOR ASSEMBLIES

A typical Saturn SV Ground Computer System as defined by this contract, consists of 19 cabinets arranged as shown in figure 2-1. A block diagram of a typical system is shown in figure 2-2.

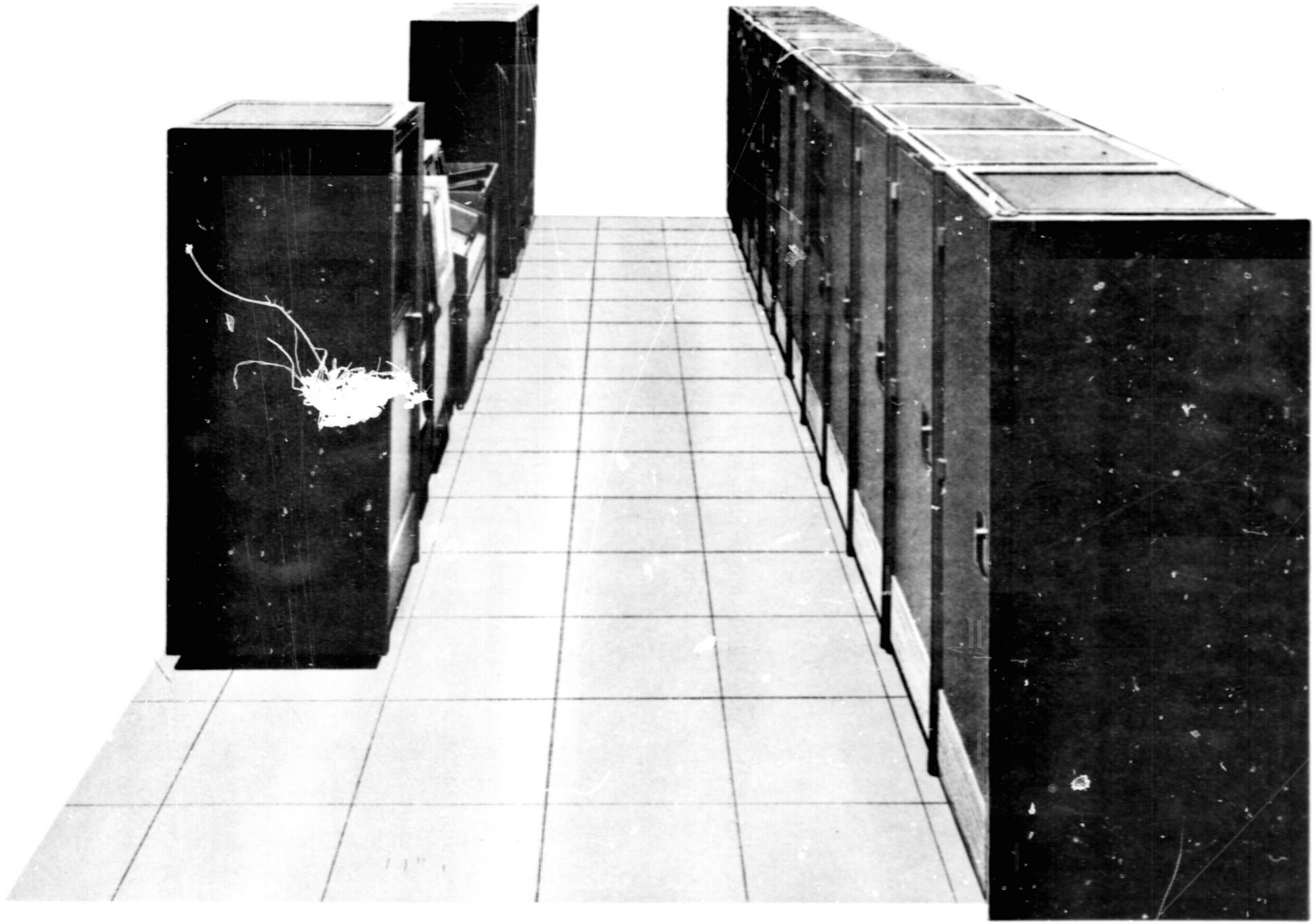
2.1 FUNCTIONAL DESCRIPTION

To provide an understanding of the basic computer equipment supplied under this contract the following functional description includes appropriate references to the display and data link equipment.

The RCA 110A computer consists of two mainframe cabinets, two power supply cabinets, two memory cabinets, and an input/output buffering and switching cabinet. Peripheral devices include; a card reader, a card punch, a line printer, up to 20 magnetic tape stations, and up to 18 display/control consoles. Checkout and control equipment includes; an analog signal control and switching unit, a two-cabinet discrete signal control and switching unit, and a data link terminal.

2.1.1 RCA 110A Computer

The logical organization of the RCA 110A computer utilizes serial processing with parallel transfers between the arithmetic and control unit, and the data channel and core memory subsystems. System storage includes the 32,768-word core memory subsystem and a 32,768-word bulk storage drum. The memory subsystem consists



4142-1100-1

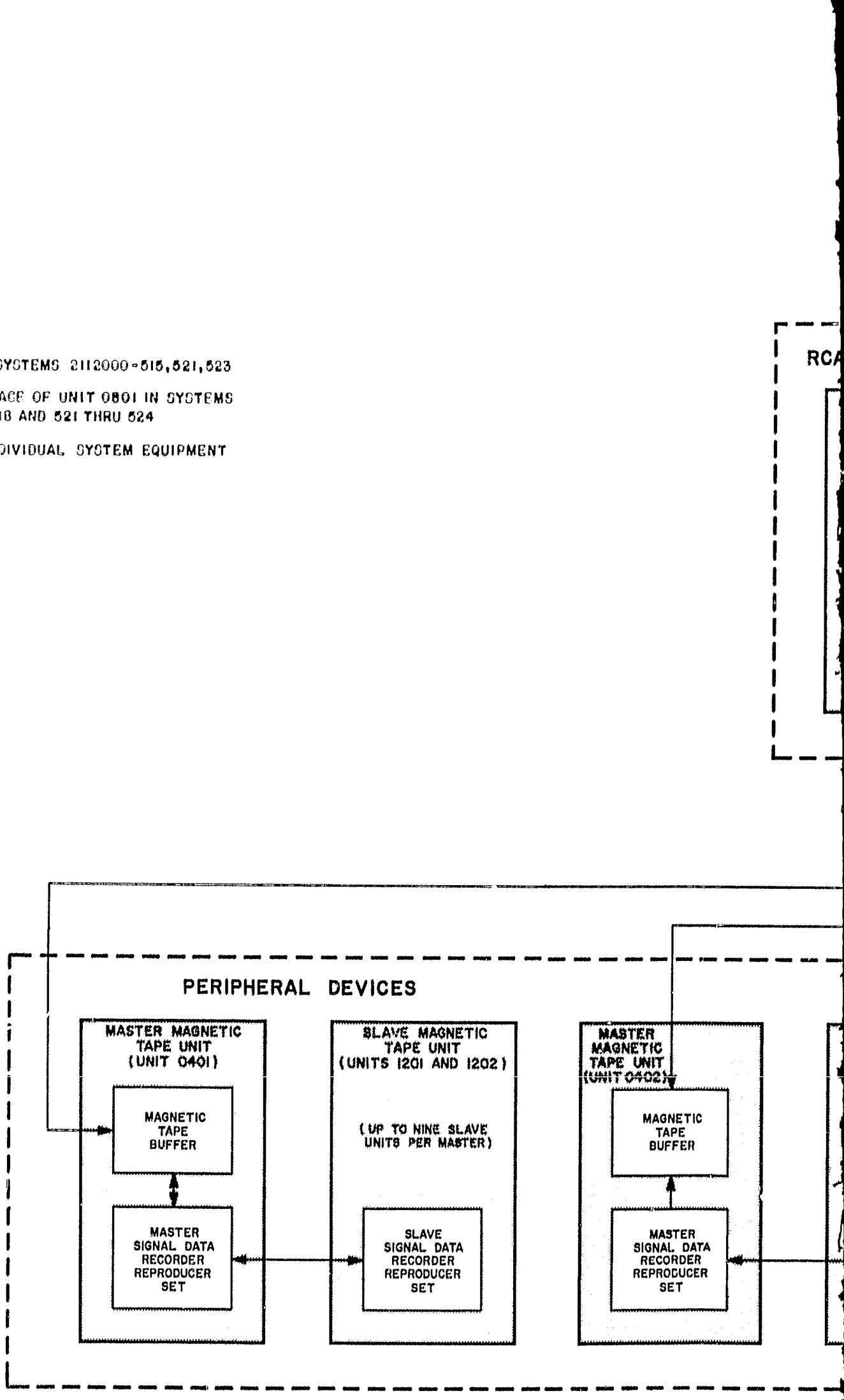
Figure 2-1. Typical Saturn Ground Computer System

NOTES:

* APPLICABLE ONLY TO SYSTEMS 2112000-515,521,523

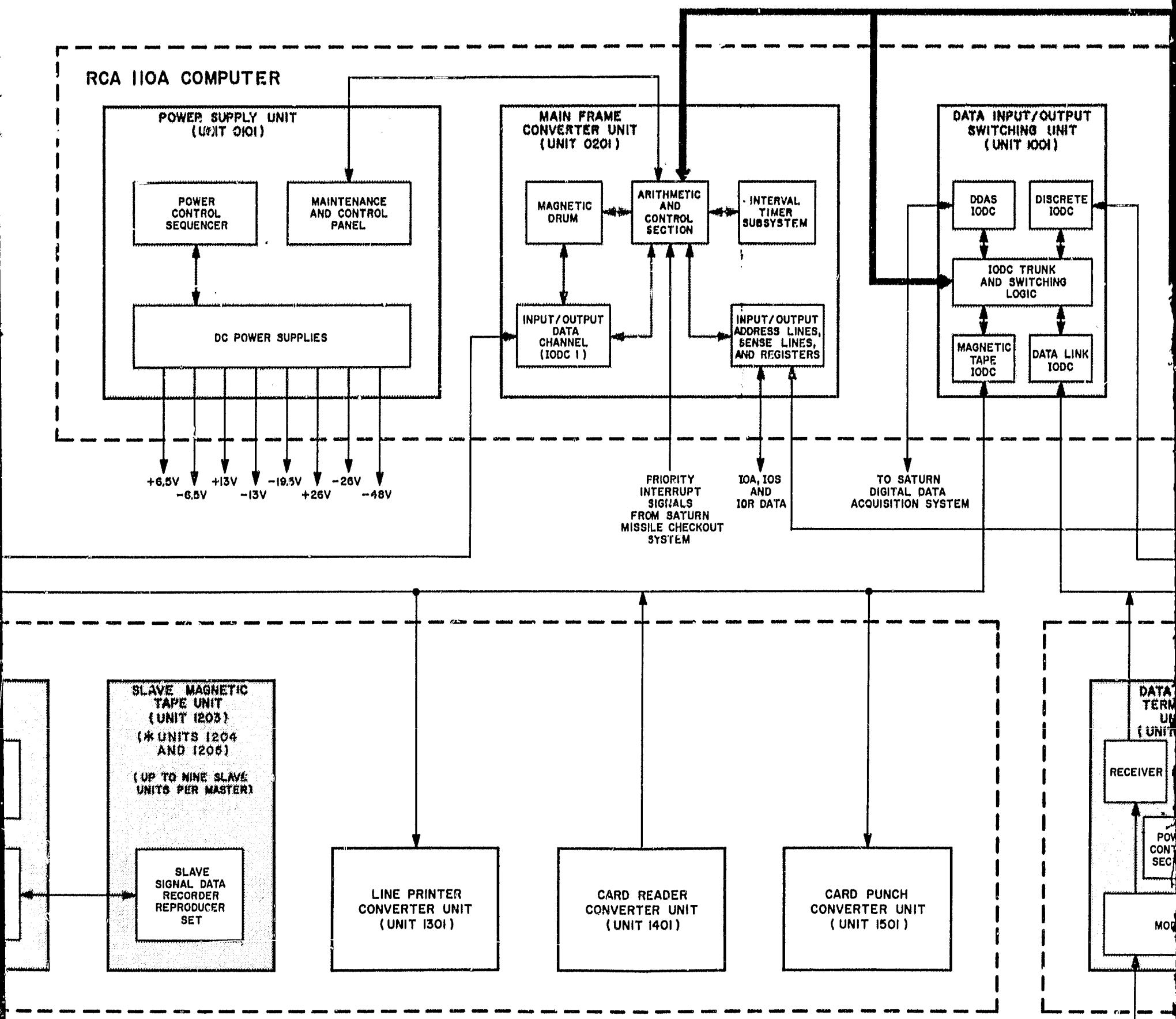
** UNIT 0702 USED IN PLACE OF UNIT 0801 IN SYSTEMS 2112000-513,515,517,518 AND 521 THRU 524

SEE TABLE 1-2 FOR INDIVIDUAL SYSTEM EQUIPMENT CONFIGURATION



1571-1

Foldout FRAME 1



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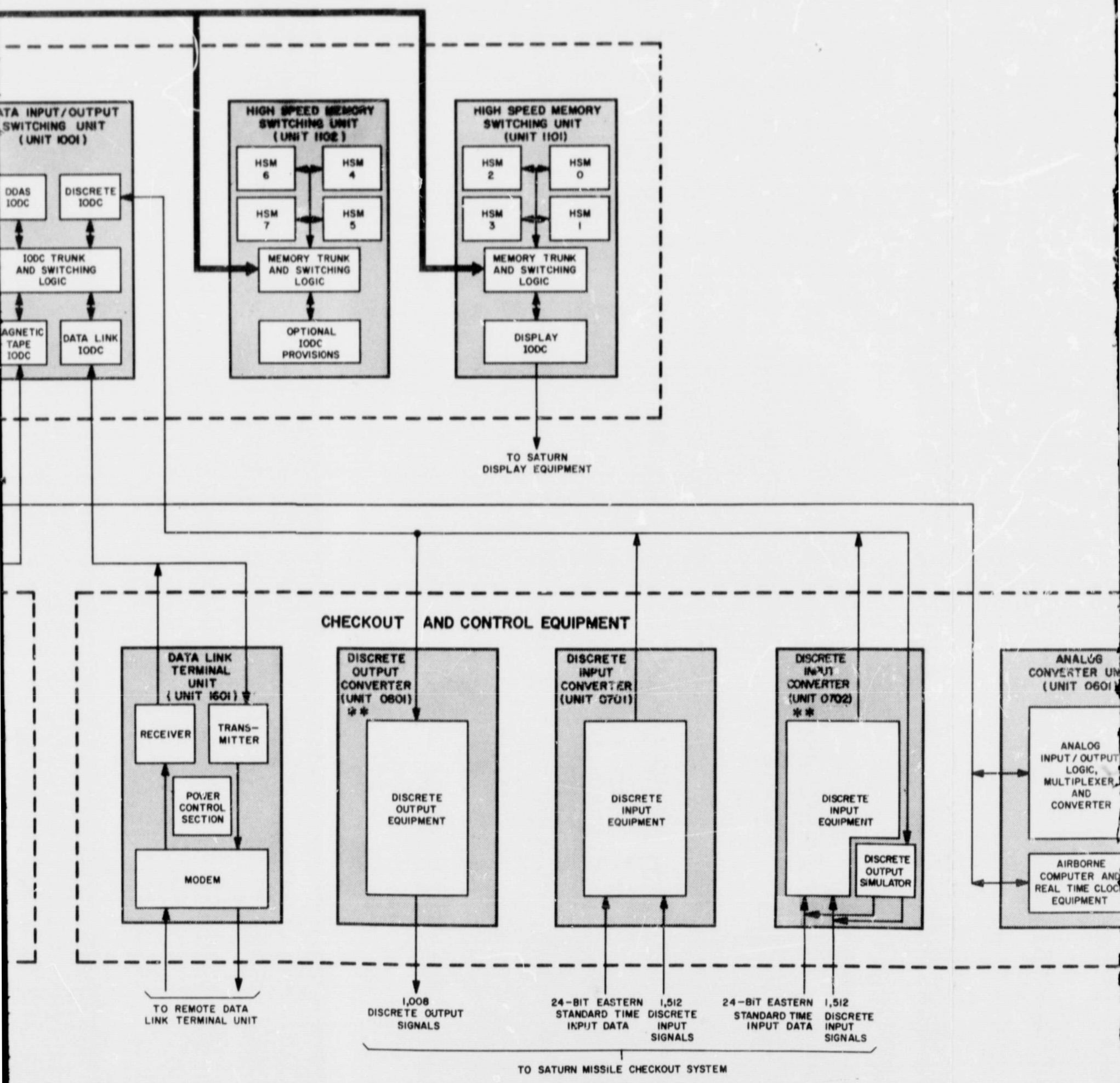

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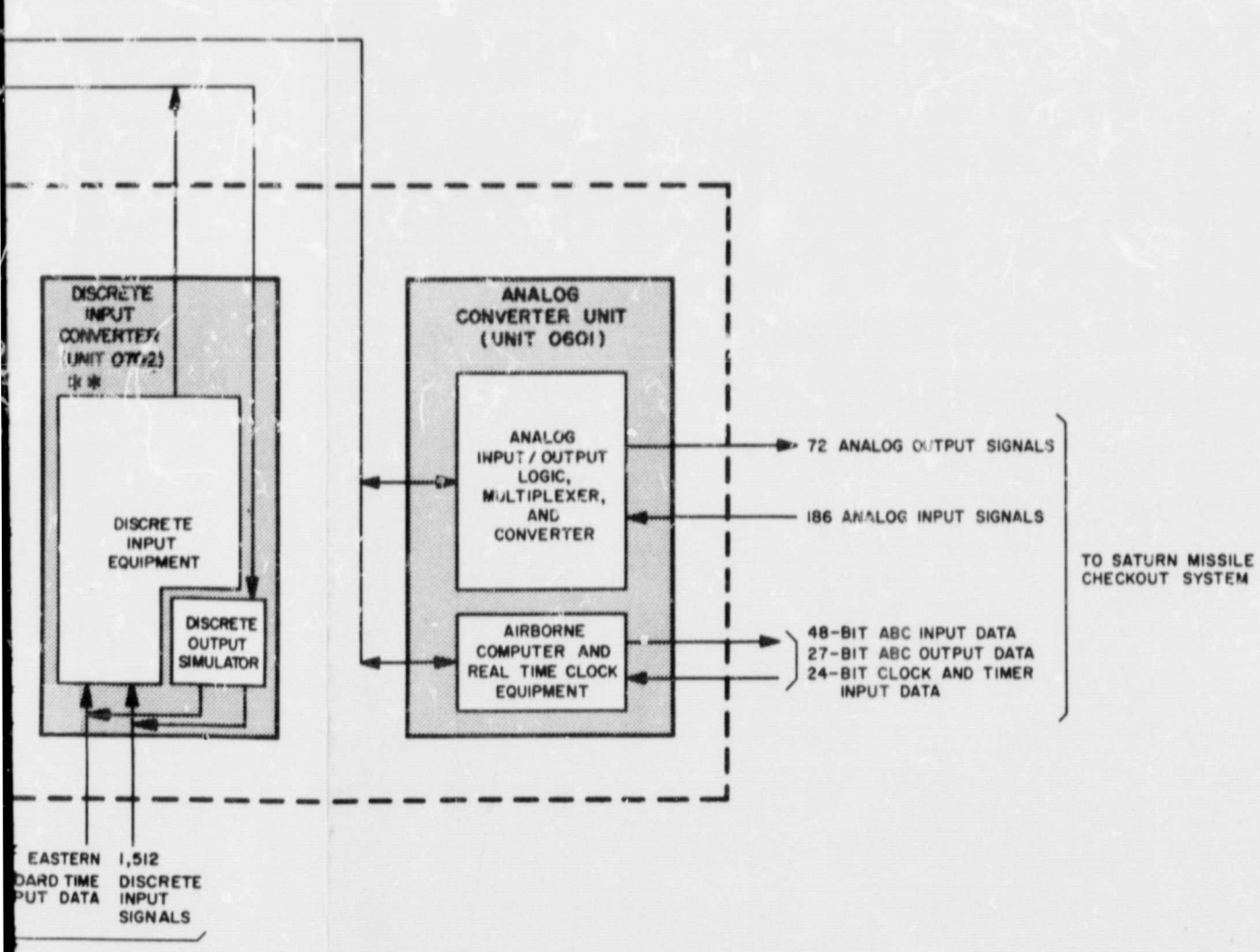

Figure 2-2. Saturn Ground Computer System, Block Diagram

FRAME 4

of eight core memory blocks of 4,096 words each. While direct addressing is possible within each memory block, any of the 32,768 words of core memory may be randomly accessed through indirect addressing.

The system clock rate is 936 kc with a 28.9 microsecond word time. The memory cycle time is 10.3 microseconds, enabling two memory cycles to be executed during each word time; one for arithmetic and control unit operations, and one for input/output operations. The arithmetic and control unit is assigned the highest memory access priority, but is restricted to the last memory cycle of each word time.

A computer word length is 24 bits plus a single odd parity bit. Data words provide a sign bit and 23 data bits for a precision greater than one part in eight million. Limited arithmetic operations may be performed on double-length words for even greater precision. The arithmetic section operates on fixed point two's complement data.

A four level priority interrupt feature permits real time control of the computer system. There are hardware provisions for two separate programs per interrupt level or eight separate programs within the interrupt system. Many more programs may be associated with the interrupt subsystem by means of effective software. Each level is assigned a different priority. When an interrupt occurs, the contents of critical registers and indicators are automatically stored in the core memory. The interrupting program returns control to the interrupted program with a single instruction that restores the contents of the critical registers and accumulators, permitting the interrupted program to resume at its point of interruption.

The computer program is also interrupted in the event of a power failure and may be conditioned by a manually pre-set switch to jump to a standard location if a core memory parity error or illegal instruction code is sensed. Interrupts caused by power failure automatically store critical registers and indicators and stop the computer clock. Upon re-application of power, computer operation may be resumed at the point of interruption.

2.1.2 Peripheral Input/Output Devices

Input/output data transfers between the RCA 110A computer and external devices are accomplished through input/output registers, address lines, and sense lines, and through the input/output data channels. The general-purpose input/output registers are standard 24-bit buffer registers located in the mainframe unit which provide for data transfers to the remote computer, payload, and telemetry subsystems. Each register utilizes its own synchronization logic. The input/output address and sense lines are also contained in the mainframe unit and provide additional data transfer paths for the computer system. The address lines are primarily used to transmit control signals to external devices (such as set-up signals for the various subsystems), while the sense lines are used to detect the status of these devices and to receive their responses. The input/output registers, address lines, and sense lines are operated under direct program control. The input/output complement of the computer system includes 8 input/output registers, 192 address lines, and 192 sense lines.

Additional synchronized registers, contained in the analog and discrete cabinets, permit data communications with the launch vehicle digital computer subsystem and the external support equipment time sources. The real-time clock registers enable the programmer to read any one of three time inputs: countdown clock, eastern standard time, or interval timer. The synchronized registers for the launch vehicle computer and the external time sources are also operated under program control.

The input/output data channels (IODC's) perform buffered data transfers, but unlike the input/output registers, these data transfers are not under direct program control and may be accomplished simultaneously with normal computer operations. There are eight data channels available from which the normal computer system complement of seven are selected:

- The central input/output data channel controls the input/output operations of the drum memory, and up to ten magnetic tape stations.

- The magnetic tape IODC controls the operations of the card reader, the card punch, the line printer, and up to ten magnetic tape stations.
- The DDAS IODC provides buffering and control for data transfers between the computer and the digital data acquisition system.
- The discrete IODC controls the activity of the discrete signal converters described above.
- The data link IODC and any one of three display IODC's provide buffering and control for data transfers between the data link terminals, the respective display subsystems, and the RCA 110A computer. The three display IODC's are similar in general operation and design but each was developed to accommodate one of the three different display subsystems currently in use at various vehicle checkout installations.

Intercommunication between two RCA 110A computers is provided by the data link terminals, one terminal being required at each computer site. The computer sites may be separated by up to seven miles. Each data link terminal has the capability of simultaneous transmission and reception, and thus permits the time-shared two-way exchange of both data and command messages. Each data link terminal operates under control of its associated input/output data channel.

2.1.3 Analog and Discrete Subsystems

In an analog signal loop, a digital data word is transferred to the output section of the analog converter unit. This unit in turn performs the digital-to-analog conversion required to provide stimuli for the vehicle electrical support equipment (ESE). The analog response of the ESE is received by the input section of the analog converter unit and converted back to digital form for processing by the central control computer. Analog signals are handled by the computer system at a rate of 2,000 signals per second.

The discrete signal loop provides for the generation of 28-volt command signals at operational speeds of up to 15,000 signals per second. These signals are supplied as stimuli to the vehicle ESE by the discrete output converter unit under control of its associated data channel. The discrete output converter unit can provide up to 1,008 independently controlled signals. The discrete responses of the ESE are received by the discrete input/output data channel. A total of 1,512 discrete inputs can be connected to the input converter. The converter, in turn through its signal selector circuits processes the inputs in 24-signal groups (corresponding to the 24-bit computer system data word) in any one of four operating modes. In the single scan mode, the 1,512 discrete input lines are each sensed once and their conditions are stored in the high-speed memory. In the continuous scan mode, the input lines are sensed continuously and their latest conditions are stored in the high-speed memory. In the monitor mode they are sensed continuously and their conditions are compared with their previous conditions. When a difference is detected, the discrete word and a relative time word is stored in the high-speed memory. In the monitor mode with selectable priority interrupt, the 1,512 discrete input lines are monitored in the same manner as the monitor mode, except that priority interrupt signal is sent to the computer system if a difference is detected in any preselected discrete input word.

The discrete subsystem may be expanded in increments of 1,512 input lines and 1,008 output lines to a maximum capacity of 9,072 discrete inputs and 6,048 discrete outputs.

2.1.4 Display/Control Subsystem

The two-way transmission of information between test personnel and the computer system is the primary purpose of the display/control subsystem. Test programs, messages, and results can be requested, composed, edited, and displayed on a direct view storage tube in either tabular or graphic format. Tabular format provides for a display area 50 characters wide by 32 lines high. Each character is approximately 0.19 inch high. In graphic format, maximum matrix area is 168 "X" increments wide by 217 "Y" increments high. A graphic increment is approximately equal to a quarter-character.

2.2 MECHANICAL DESCRIPTION

A standard Saturn SV Ground Computer System cabinet measures 80 inches high by 32 inches wide by 32 inches deep. Forced air cooling blowers, each with a built-in airvane switch, are mounted in the base of each cabinet. The airvane switches provide alarm signals when the respective blowers are inoperative. Air intakes for the blowers are located in the base of each cabinet (bottom air entry), and exhaust vents are located at the top of each cabinet. A thermostatic switch, mounted in the exhaust vents of each cabinet, is connected in parallel with the blower airvane switches. When the cabinet temperature exceeds a predetermined level, the thermostatic switch generates temperature alarm signals.

Each cabinet is equipped with front and rear doors for access. The rear module boards are mounted on a fixed frame of the cabinet and are removed and replaced from the rear of the cabinet. A horizontal row of 27-module boards comprises a full module nest. As many as 12-module nests can be mounted in the fixed frame or the hinged swinging frame. The hinged swinging frame, when opened, provides access to both front and rear module jacks and wiring for maintenance.

Interface connectors are provided for external equipment. The connectors are located near the base of each cabinet for bottom entry cabling. The internal cabling runs vertically in plastic panduits and fans out horizontally for module wiring. A wire mesh gasket attached to the door frames provides electrical connection between the doors and frame for radio frequency shielding and grounding.

A description of each individual cabinet is presented in the following paragraphs.

2.2.1 Power Supply Unit (Unit 0101)

The power supply unit (figures 2-3 and 2-4) provides dc power for all units of the Saturn SV Ground Computer System with the exception of the slave magnetic tape units (units 1201, 1202, 1203, 1204 and 1205), line printer, card reader, and card punch

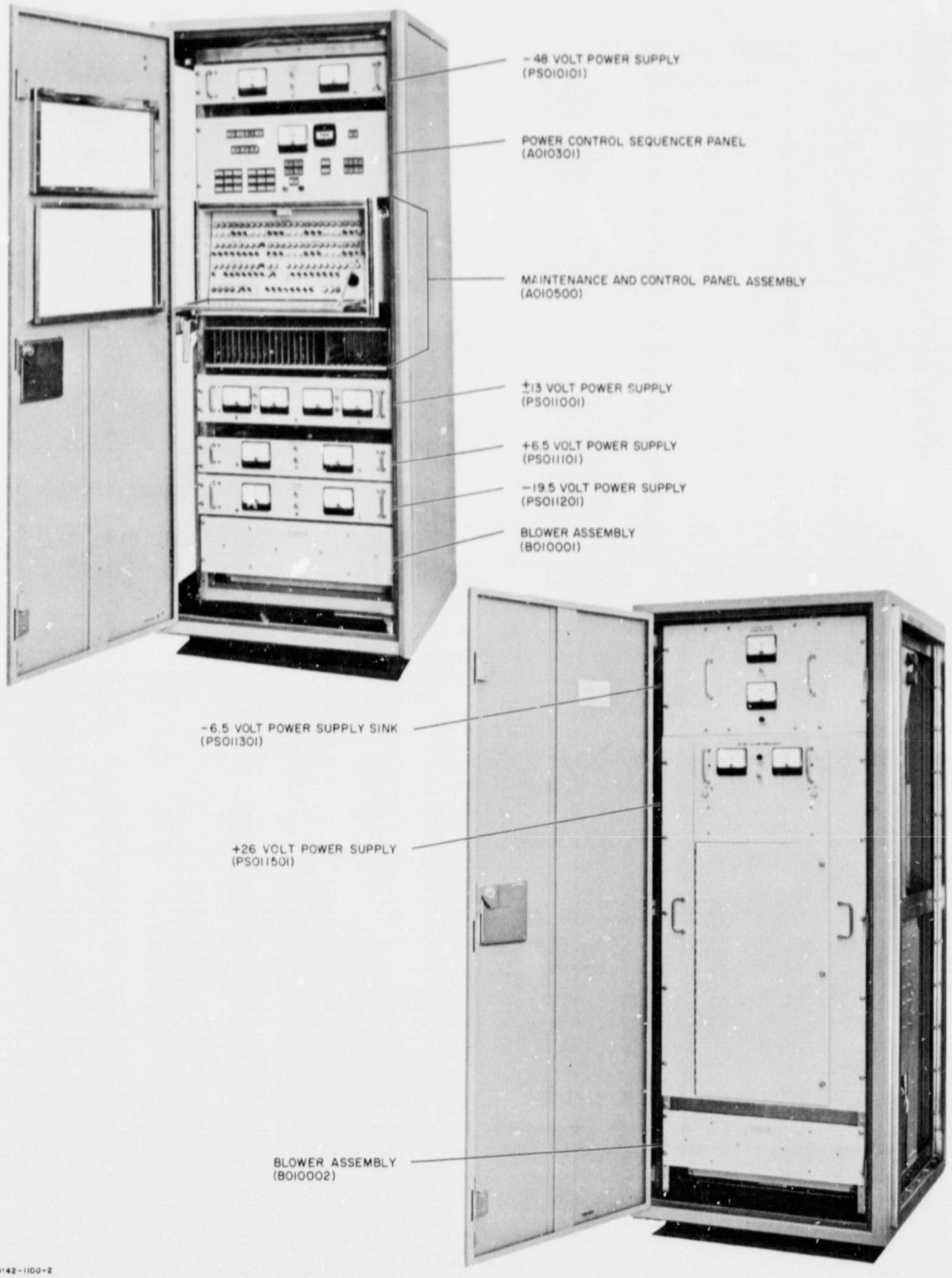

Figure 2-3. Power Supply Unit, Cabinet 01, Location of Assemblies

Figure 2-4. Power Supply Unit, Cabinet 05, Location of Assemblies

converter units (units 1301, 1401, and 1501, respectively). The power supply unit consists of the power distribution assembly (cabinet 01) and the power supply assembly (cabinet 05) connected together as a single assembly. The power supply unit also contains the Maintenance and Control Panel (the computer system operating controls and indicators) and the power control and monitoring circuitry.

2.2.2 Main Frame Converter Unit (Unit 0201)

The main frame converter unit (figures 2-5 and 2-6) contains the processing and control logic and the internal bulk storage for the Saturn SV Ground Computer System. The main frame converter unit consists of the logic converter (cabinet 02) and the mass memory converter (cabinet 03) connected together as a single assembly. The logic converter contains 24 module nests of logic while the mass memory converter contains 18 module nests and a 32,768-word data storage magnetic drum. Included in the mass memory converter logic is an input/output data channel, IODC No. 1, and an interval timer subsystem which enables the computer system to perform accurate, programmed, time interval measurements.

The magnetic drum provides internal bulk storage for the RCA 110A Computer and has a capacity of 32,768 25-bit words. Data is stored in 256 tracks of 128 words each and is transferred serially under control of IODC No. 1. The drum rotates at a nominal speed of 3600 revolutions per minute and has a bit-transfer rate of 214 kc, producing a maximum access time of approximately 17 milliseconds. Average access time is approximately 8.5 milliseconds.

The interval timer subsystem enables the Saturn SV Ground Computer System to perform accurate, programmed, time interval measurements. Under program control, each of the three timers contained in subsystem may be activated to measure intervals of up to 262,143 milliseconds (approximately 4 minutes, 22.1 seconds).

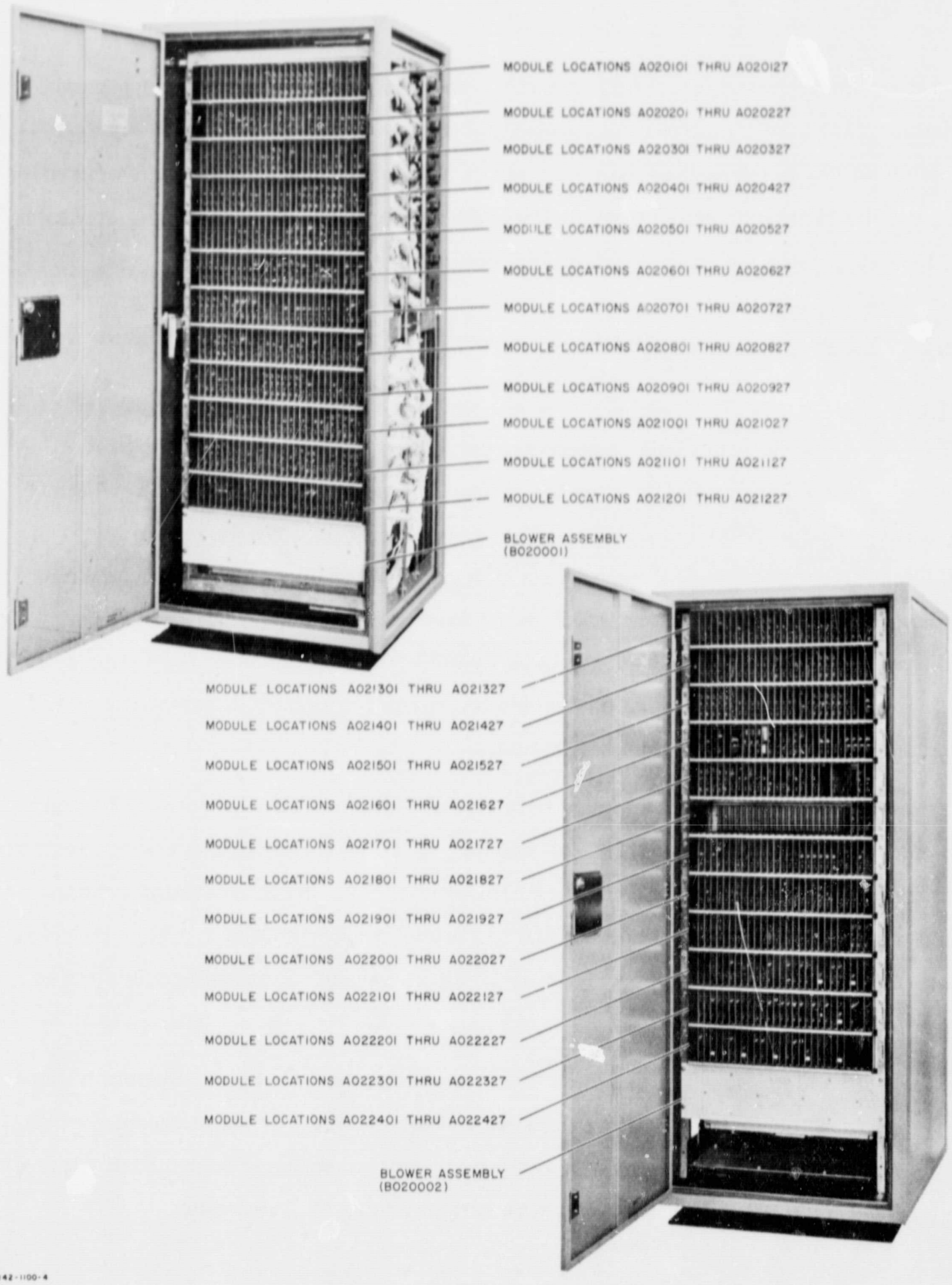

Figure 2-5. Main Frame Converter Unit, Cabinet 02, Location of Assemblies

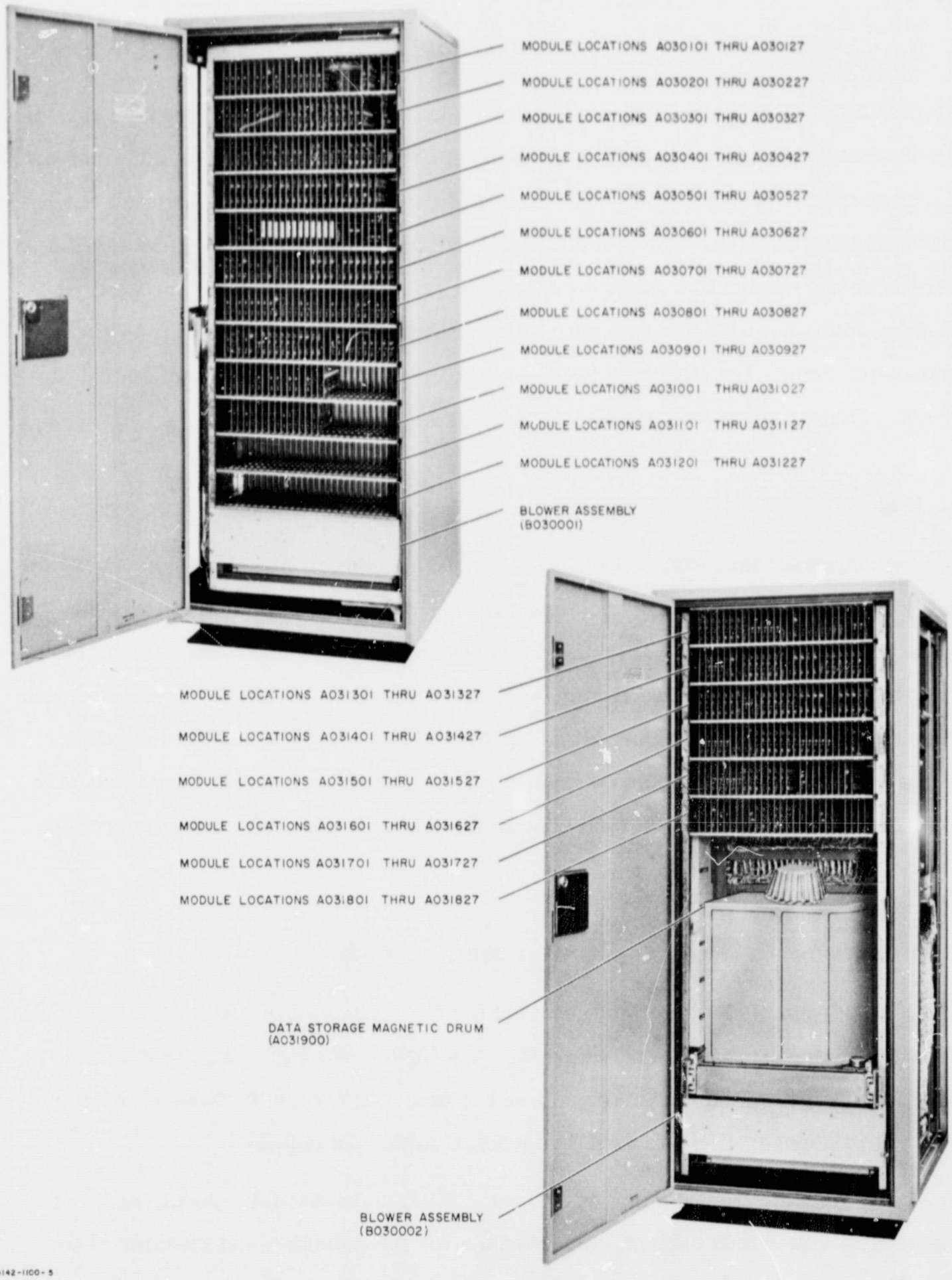

Figure 2-6. Main Frame Converter Unit, Cabinet 03, Location of Assemblies

2.2.3 Master Magnetic Tape Units (Units 0401 and 0402)

The master magnetic tape unit (figure 2-7) provides auxiliary bulk storage at a rate of 15,000 characters (6-bits plus parity) per second on half inch tape. The unit consists of a data recorder-reproducer set and seven module nests of buffering logic all housed in a free-standing cabinet. The master signal data recorder-reproducer set contains the electrical and mechanical magnetic tape assemblies necessary to record and retrieve data, interface with the buffering logic, and control a maximum of nine slave magnetic tape units. The buffering logic provides distribution of data and control signals from an input/output data channel to the master magnetic tape unit.

2.2.4 Analog Converter Unit (Unit 0601)

The analog converter unit (figure 2-8) consists of an analog processing and conversion assembly and eight module nests containing the analog conversion control logic all housed in a standard cabinet. This unit converts ac and dc analog voltages into equivalent digital data for processing and storage, and also converts stored digital data into equivalent ac and dc analog output voltages. In addition to analog conversion control logic, the eight module nests contain input and output circuits for communication with the airborne computer and input logic circuits for receiving signals from the special clock.

2.2.5 Discrete Input Converter Unit (Units 0701 and 0702)

There are two types of discrete input converter units (figures 2-9 and 2-10): unit 0701 and unit 0702. Unit 0701 is the standard discrete input converter unit. Unit 0702 is the modified discrete input converter unit and is designed for use in those computer systems with which the discrete output converter unit is not supplied.

The standard discrete input converter unit (unit 0701) consists of 17 module nests of logic housed in a standard cabinet, and provides for the selection and transfer of the discrete input signals. Twenty-four individually distinct input signals from a group of 1,512, are addressed and sensed at one time for storage, processing or monitoring operations. The standard discrete input converter unit logic also includes a relative

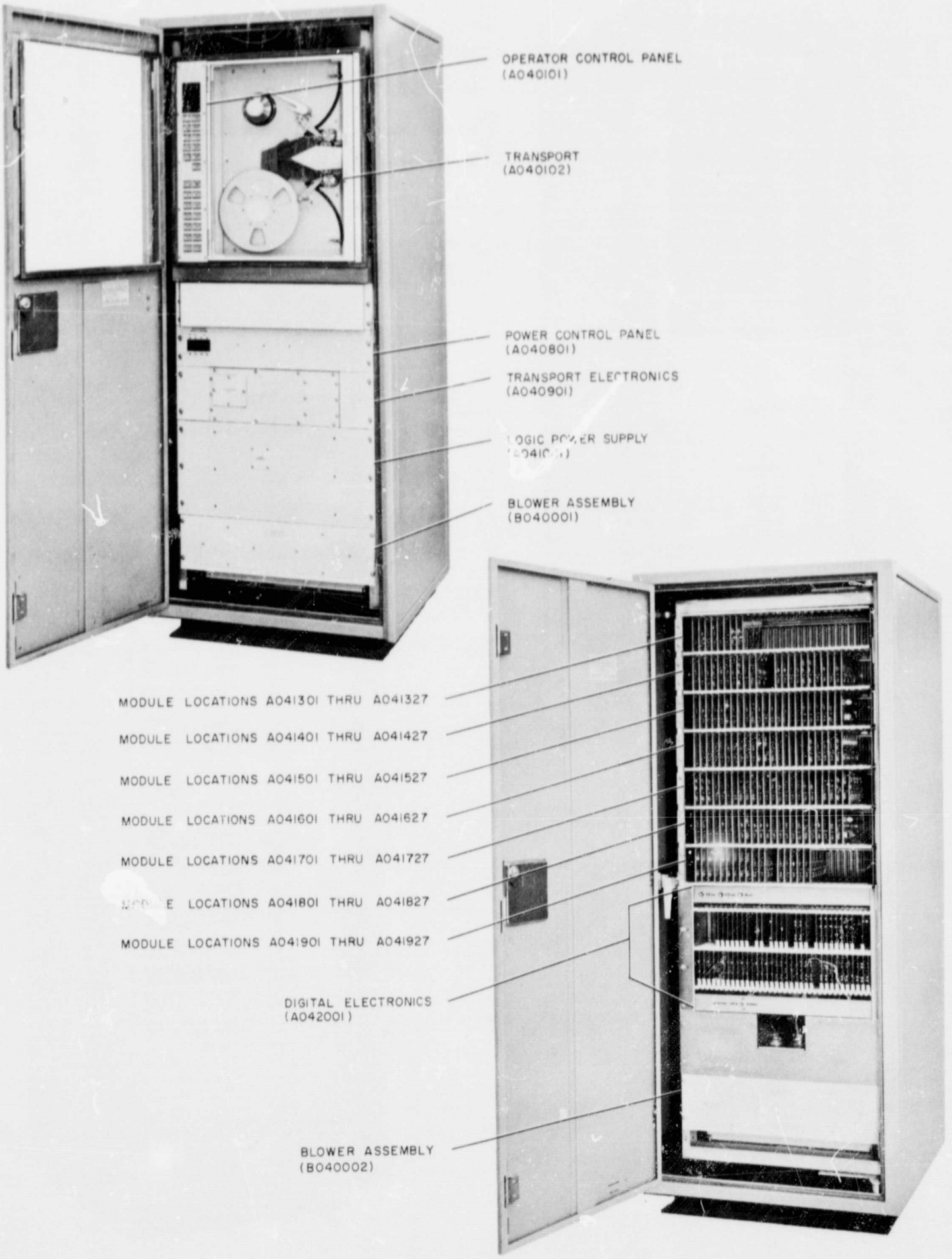

Figure 2-7. Master Magnetic Tape Unit, Location of Assemblies

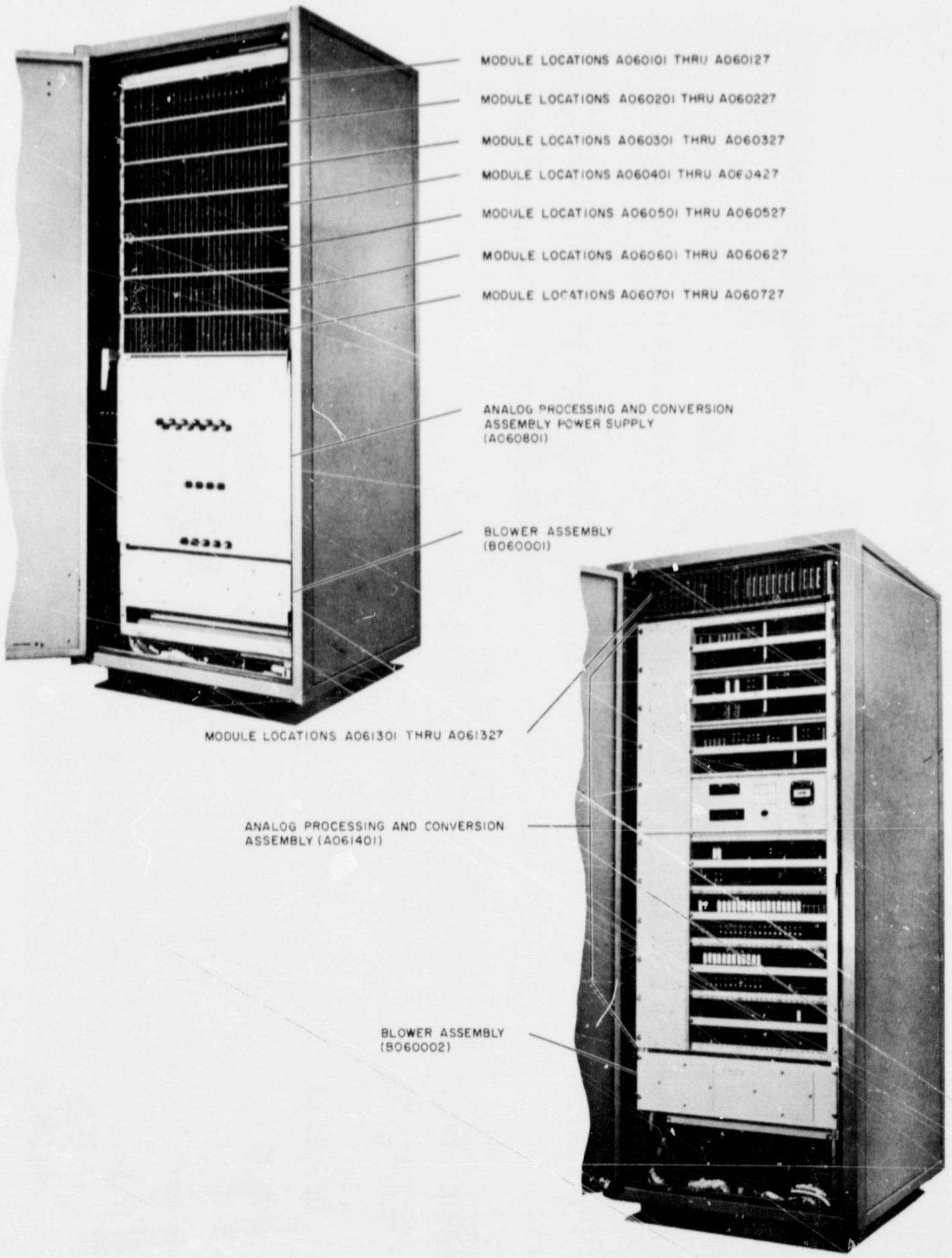

Figure 2-8. Analog Converter Unit, Location of Assemblies

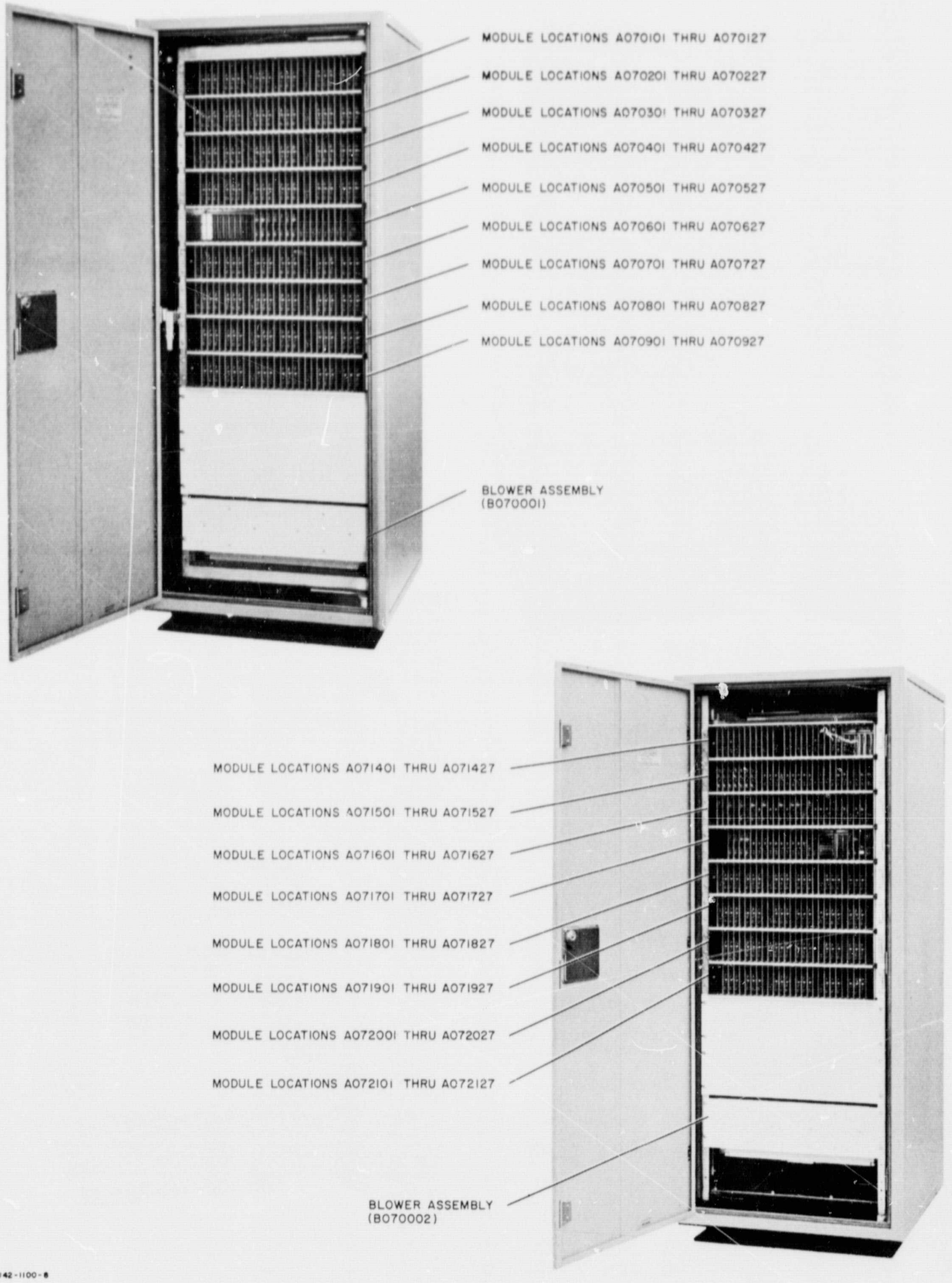

Figure 2-9. Discrete Input Converter Unit (Unit 0701), Location of Assemblies

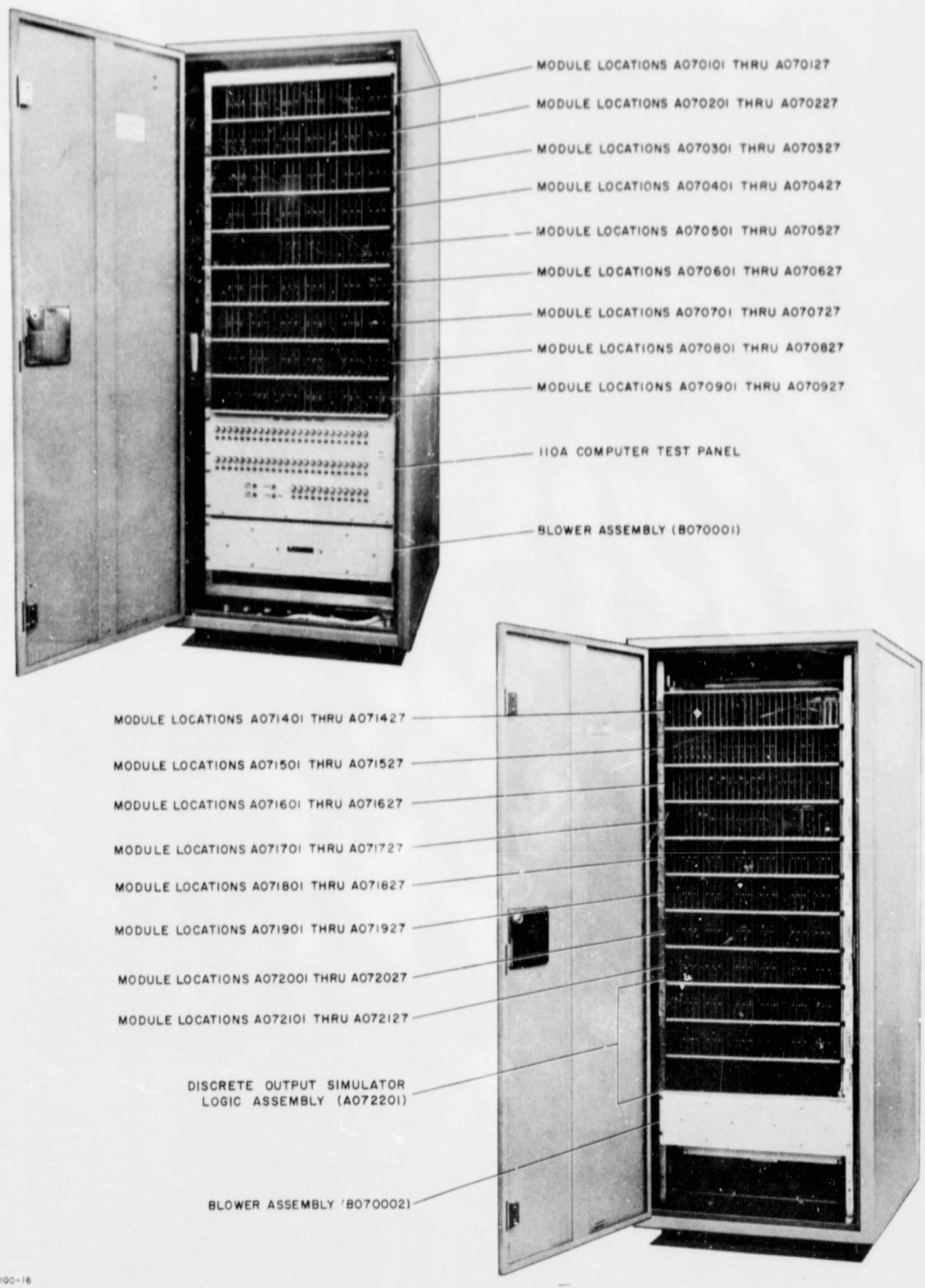

Figure 2-10. Discrete Input Converter Unit (Unit 0702), Location of Assemblies

time counter used for regulating real-time monitoring operations, and a parallel parity generator which provides odd-parity for the data words supplied to the discrete IODC.

The modified discrete input converter unit (unit 0702) is similar to the standard unit (0701) but additionally contains a discrete output simulator consisting of a 3-nest logic assembly and a modified 110A computer test panel. The discrete output simulator provides the test signals normally supplied by the discrete output converter unit during loop test operations.

The discrete input equipment contained in the discrete converter units (units 0701 and 0702) provides for the sensing of 1,512 discrete input signals that are either 0 or +28 volts and scales these signals to the -6.5 and 0 volt levels required by the computer system. Circuits for the transfer of Eastern Standard Time (EST) and relative time signals to the computer system, and a discrete output simulator (unit 0702 only) are also supplied by the discrete input equipment. The operation of the discrete input equipment is controlled by the discrete input/output data channel (discrete IODC) and all signals developed by the discrete signal section are gated to the computer system by the IODC.

Four monitoring modes are used by the IODC to sense the 1,512 discrete inputs. The monitoring modes are as follows:

- Single scan mode — The 1,512 discrete input lines are sensed once and their conditions are stored in high-speed memory.
- Continuous scan mode — The 1,512 discrete input lines are sensed continuously and their latest conditions are stored in high-speed memory.
- Monitor mode — The 1,512 discrete input lines are sensed continuously and their conditions are compared with their previous conditions. When a difference is detected, the discrete word and a relative time word is stored in high-speed memory.

- Monitor mode with selectable priority interrupt — The 1,512 discrete input lines are monitored in the same manner as the monitor mode. In addition, a priority interrupt signal is sent to the computer system if a difference is detected in one or more pre-selected discrete input words.

2.2.6 Discrete Output Converter Unit (Unit 0801)

The discrete output converter unit (figure 2-11) consists of 18 module nests of logic and an integrated test panel. The discrete output converter unit provides, in the form of dc ground returns for relay coils, up to 1,008 discrete output signals in addressable groups of 24 signals each. These signals may be supplied to the discrete input converter unit for loop-testing of the discrete equipment with data selection and visual monitoring capability being provided by the integrated test panel.

The discrete equipment contained in the discrete output converter unit generates signals to select and activate 1008 discrete output circuits in the Saturn missile checkout system. These signals provide dc ground returns to 28-volt dc relays in the missile checkout system and are selected in groups of 24 signals each. Under control of the computer system program and the discrete input/output data channel (discrete IODC), a 24-bit data word is transmitted to 24 of the 1,008 missile checkout circuits through one of the 42 discrete output registers. The specific discrete output register is selected by a 22-bit address word which is supplied with the command word through the IODC under program control.

2.2.7 Data Input/Output Switching Unit (Unit 1001)

The data input/output switching unit (figure 2-12) contains four pluggable input/output data channels and a trunk switch assembly, all housed in a standard cabinet. The trunk switch consists of two module nests of logic and provides interface between the individual data channels and the data distribution logic of the main frame converter unit. These input/output data channels (IODC's) provide buffering and control for data

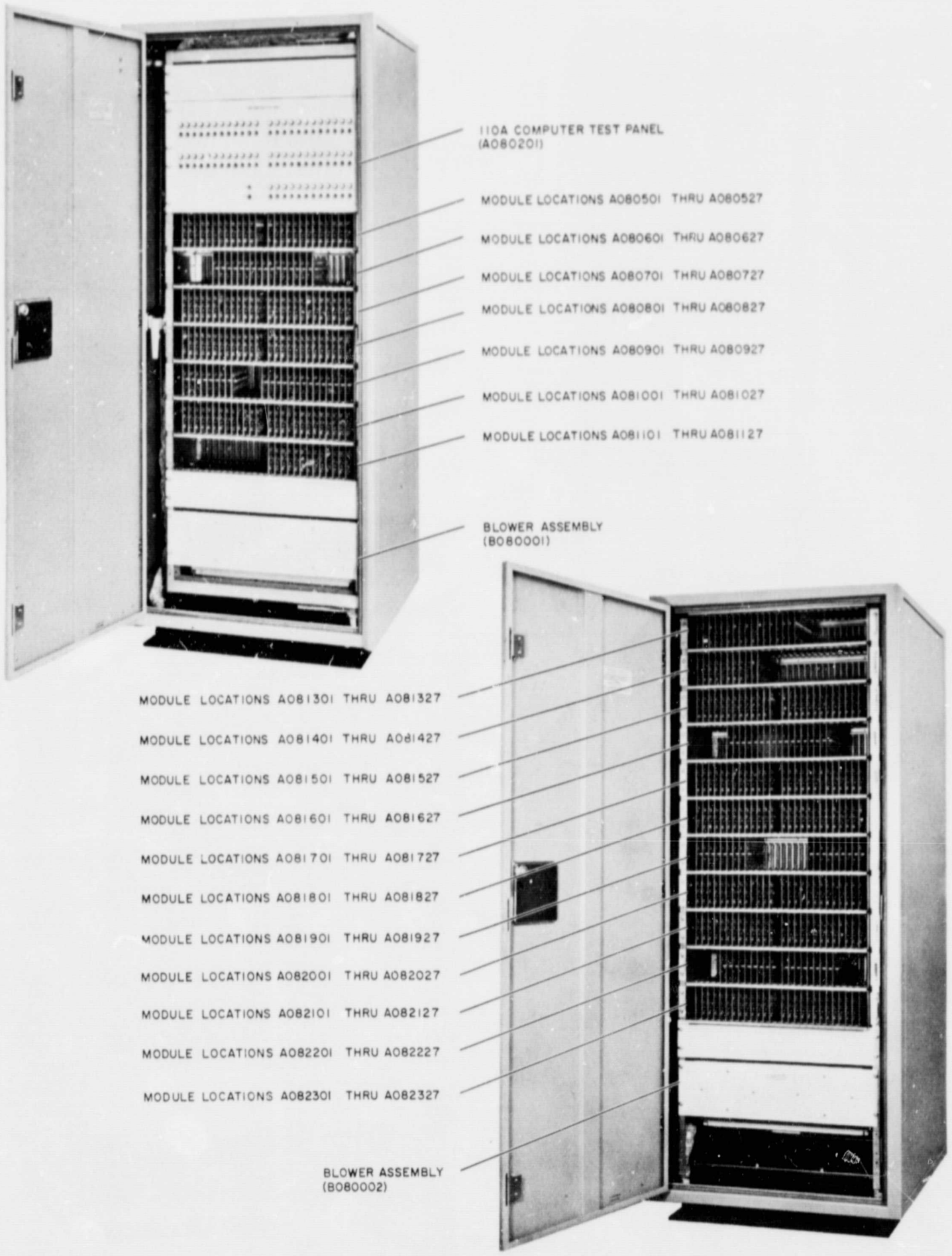

Figure 2-11. Discrete Output Converter Unit, Location of Assemblies

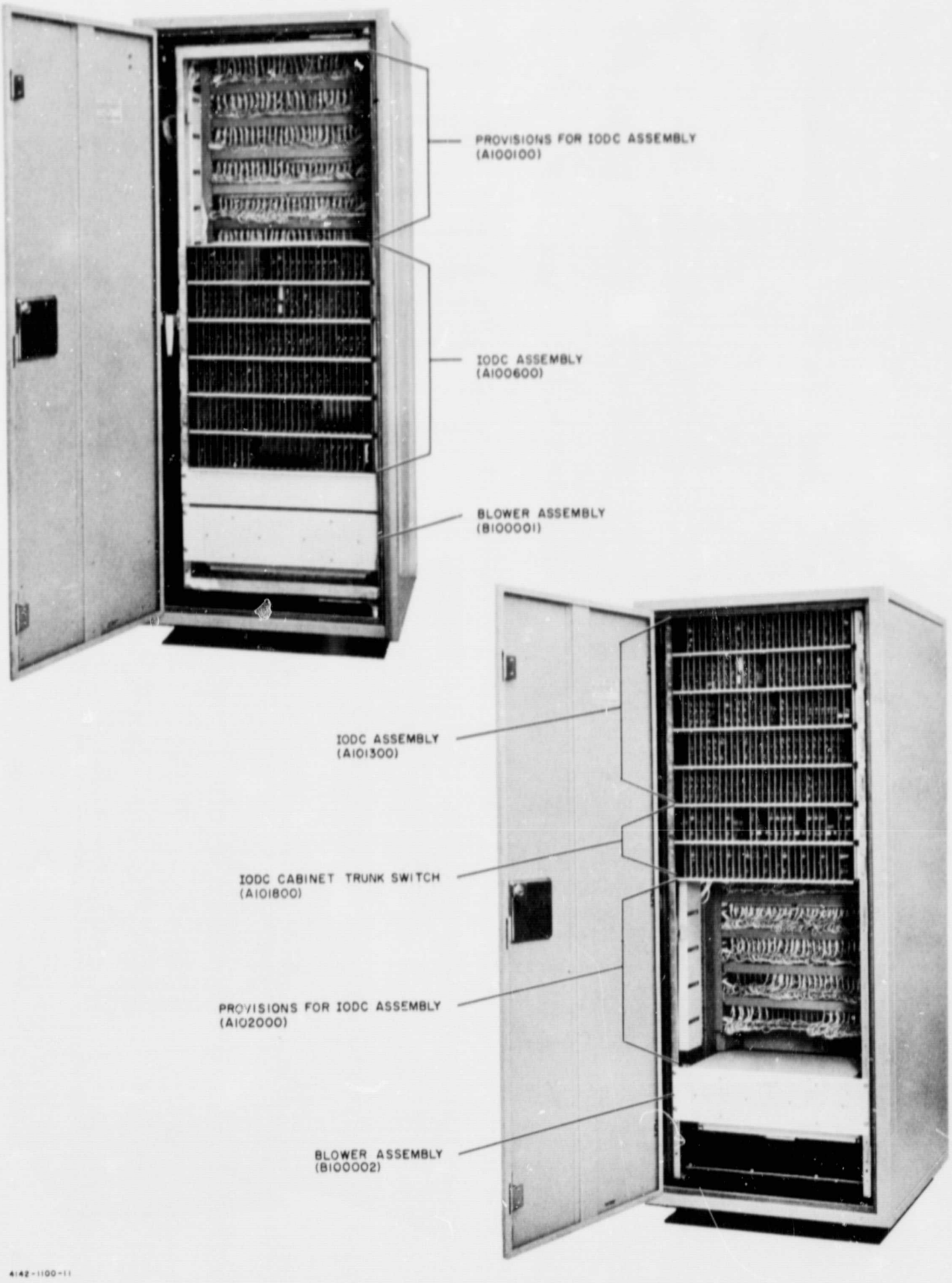

Figure 2-12. Data Input/Output Switching Unit, Location of Assemblies

transfers between the high speed memory and external devices. The IODC's which may be housed in this Unit are as follows:

- Data Link IODC No. 4
- Digital Data Acquisition System (DDAS) IODC No. 3
- Discrete IODC No. 5
- Magnetic Tape IODC No. 2

2.2.8 High Speed Memory Switching Unit (Units 1101 and 1102)

The high speed memory switching unit (figure 2-13) provides high-speed, random-access storage for up to 16, 384, 25-bit words of data. Each high speed memory switching unit concains four high-speed coincident-current magnetic-core memory assemblies and a memory switch and trunk assembly, all housed in a standard cabinet. This unit may also contain a display or an additional discrete IODC in some systems. Each memory assembly is a pluggable, self-contained unit (except for operating power) capable of storing 4, 096 words. Memory selection and data transfer operations are accomplished through the memory switch and trunk assembly which distributes data and control signals between the high speed memory switching unit and the rest of the system.

2.2.9 Slave Magnetic Tape Units (Units 1201, 1202, 1203, 1204, and 1205)

The slave magnetic tape unit (figure 2-14) contains a slave signal data recorder-reproducer set in a free-standing cabinet and is similar to the master magnetic tape unit except that the slave magnetic tape units do not contain buffering logic.

2.2.10 Line Printer Converter Unit (Unit 1301)

The line printer converter unit (figure 2-15) is housed in a free-standing console containing power supplies, buffering logic, and a mechanical high-speed printer.

The line printer, under control of the magnetic tape IODC, prints 120 characters per line of an alphabet comprised of 46 alphanumeric characters and symbols, at a maximum rate of 1, 000 lines per minute.

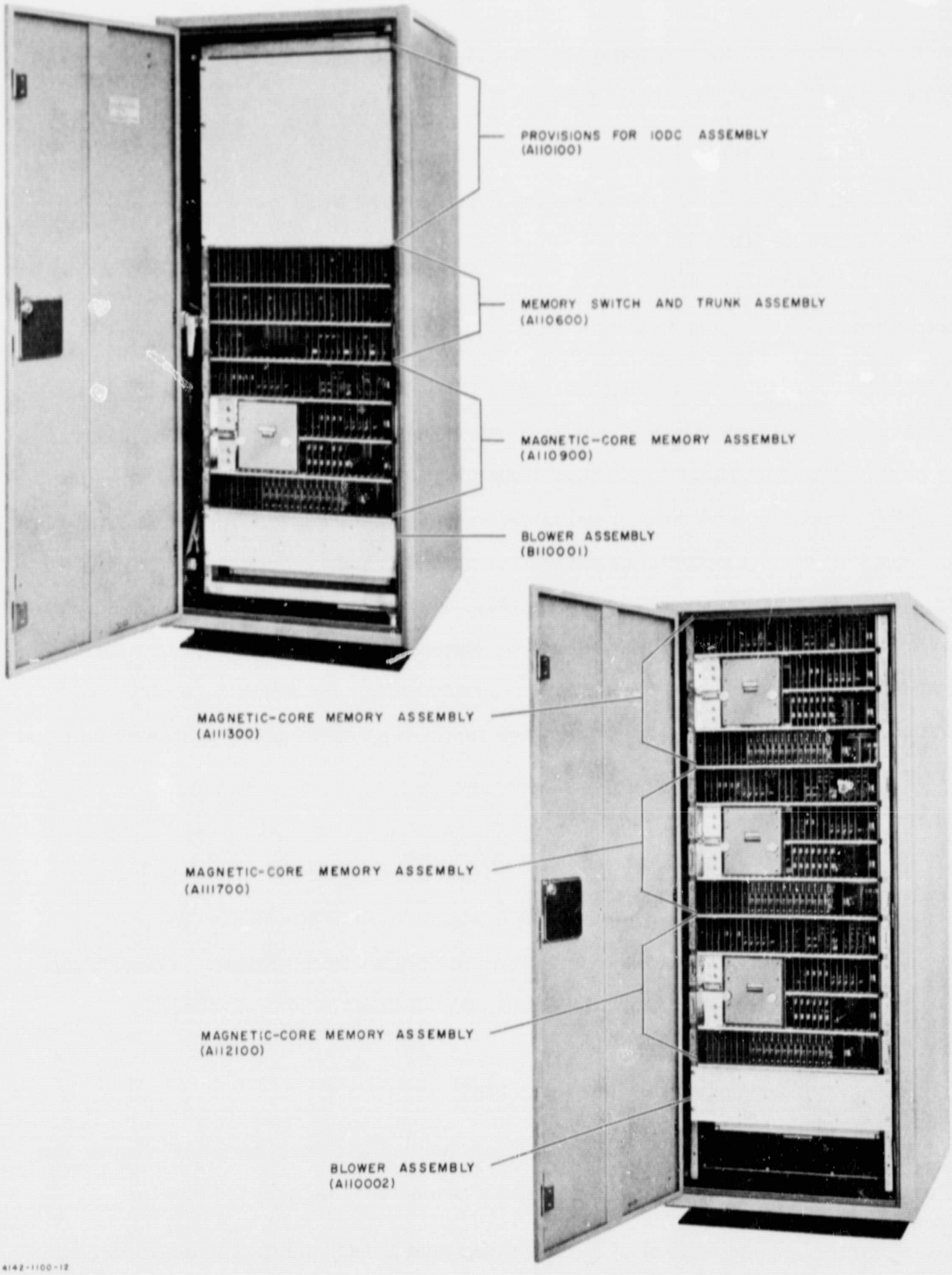

Figure 2-13. High Speed Memory Switching Unit, Location of Assemblies

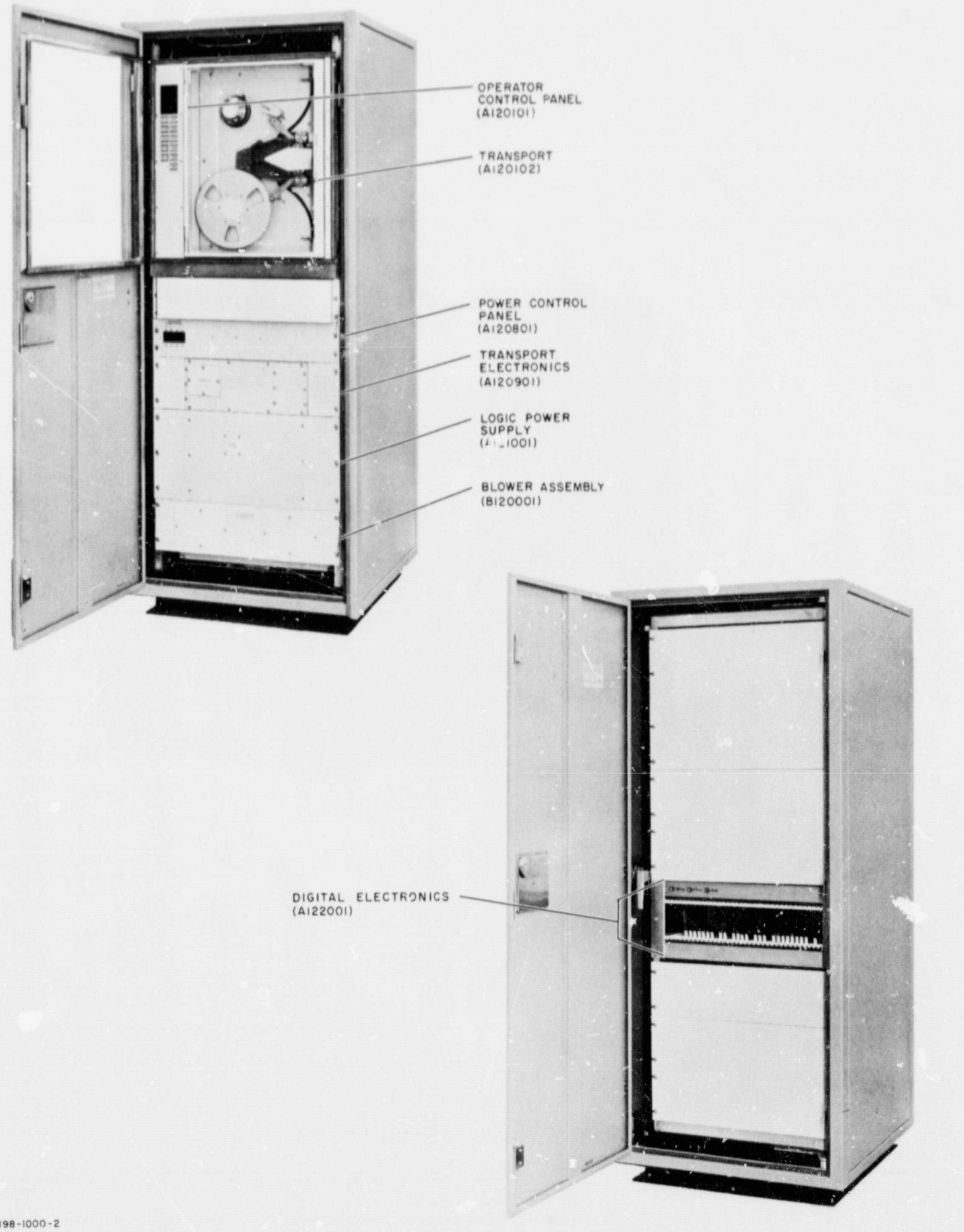

Figure 2-14. Slave Magnetic Tape Unit, Location of Assemblies

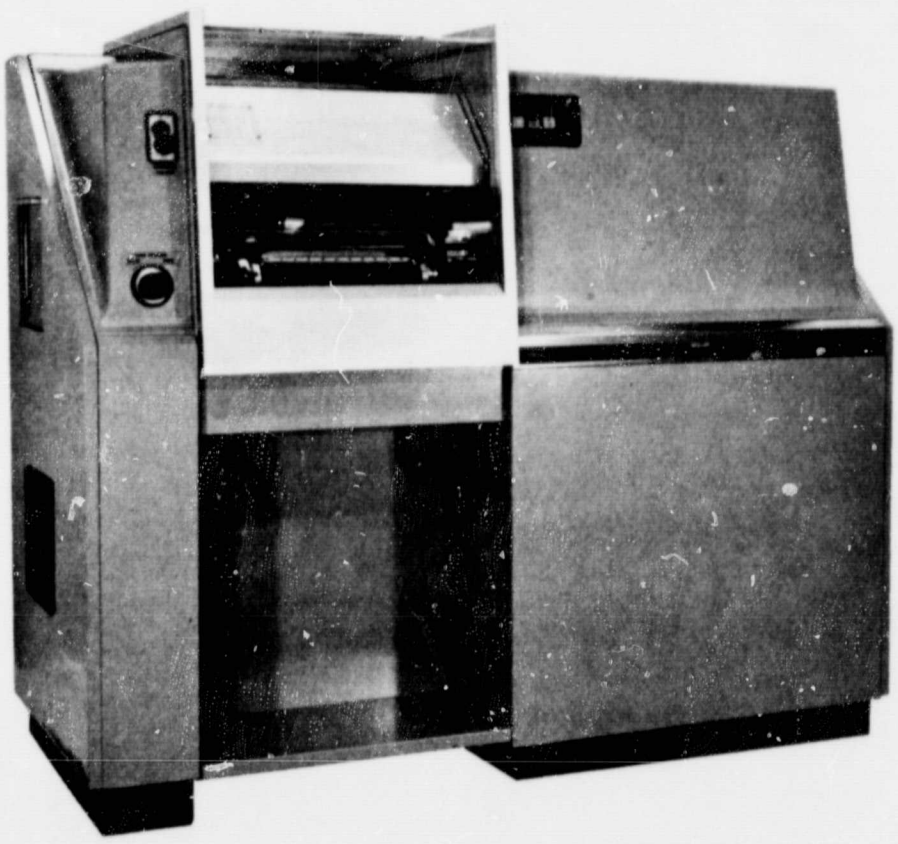

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Figure 2-15. Line Printer Converter Unit

2.2.11 Card Reader Programmer Unit (Unit 1401)

The card reader programmer unit (figure 2-16) is housed in a free-standing console containing power supplies, control logic, error detecting logic, card reader mechanism, and card reading and timing logic.

The card reader, under control of the magnetic tape IODC, reads standard 12-row 80-column or 51-column EAM cards, column-by-column at a maximum rate of 800 cards per minute. The card reader is capable of reading both binary and Hollerith card codes.

2.2.12 Card Punch Programmer Unit (Unit 1501)

The card punch programmer unit (figure 2-17) is housed in a free-standing console that includes all necessary power supplies, control logic, translation logic, drive motors, punch head, and control circuits.

The card punch, under control of the magnetic tape IODC, punches standard 12-row 80-column EAM cards, column-by-column, at a maximum rate of 450 cards per minute and 12-row 51-column cards at a rate of 650 cards per minute. The card punch is capable of punching in both the binary and Hollerith card codes, and with either continuous or single-column advancement.

2.2.13 Weights and Dimensions

The total weight of a typical Saturn SV Ground Computer System is 35, 200 pounds. The weights and dimensions of the individual cabinets are given in table 2-1. The weights of miscellaneous assemblies are given in table 2-2. Equipment outline dimensions are recommended working area clearances are shown in figures 2-18 through 2-21.

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Figure 2-16. Card Reader Programmer Unit

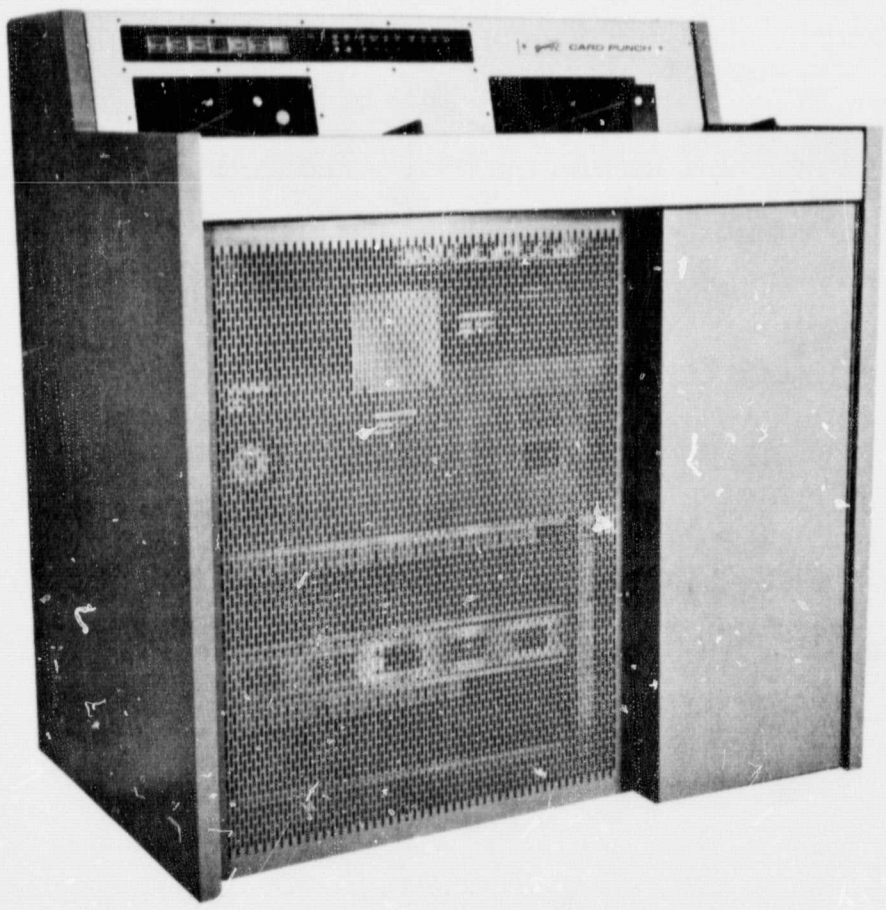

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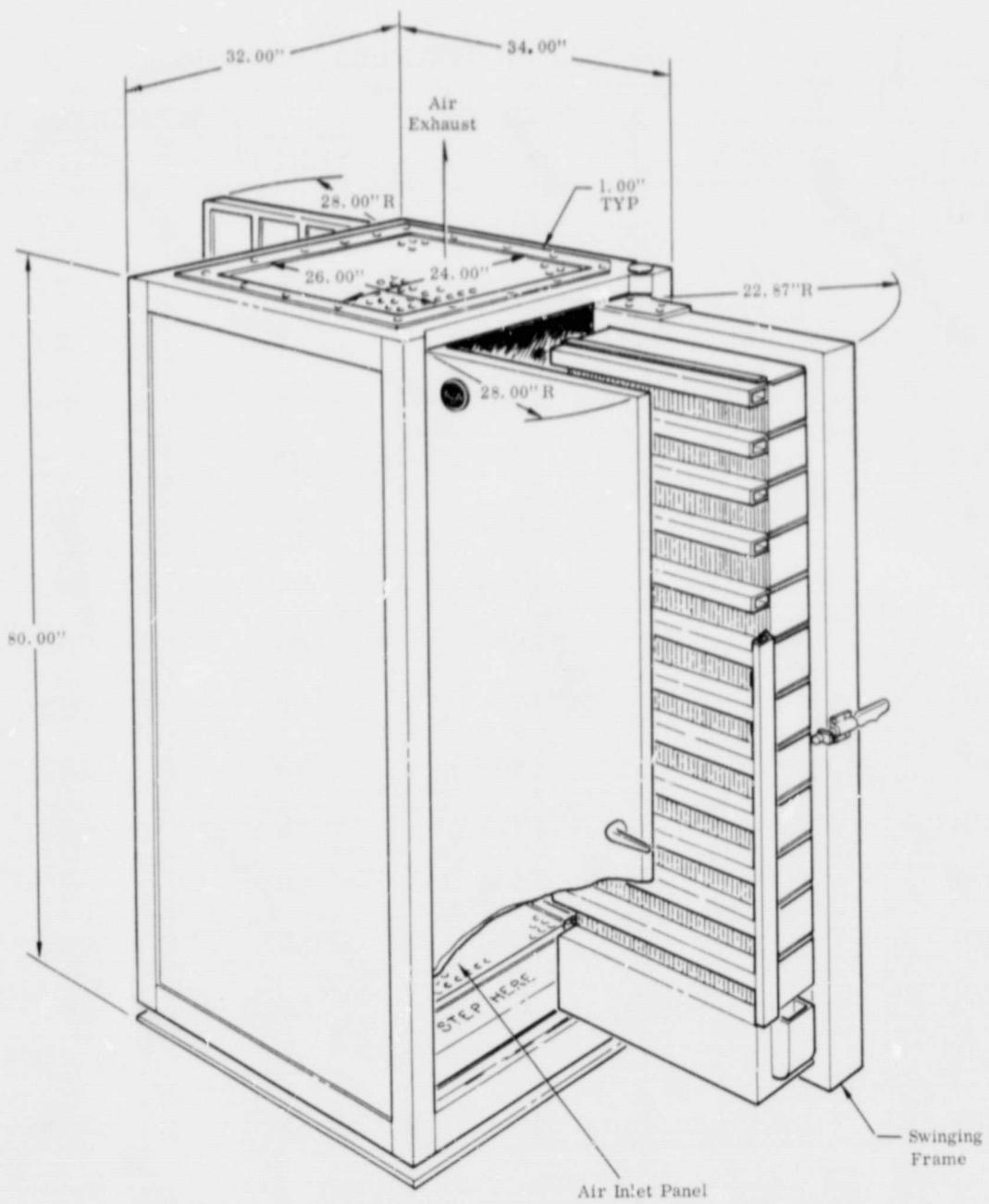
Figure 2-17. Card Punch Programmer Unit

Table 2-1. Weights and Dimensions

UNIT	CABINET	WEIGHT (LBS)	DIMENSIONS (INCHES)		
			HEIGHT	WIDTH	DEPTH
0101	01	2175	80	32	34
	05	2000	80	32	34
0201	02	1600	80	32	34
	03	1750	80	32	34
0401	04	1800	80	32	34
0601	06	1800	80	32	34
0701	07	1800	80	32	34
0702	07	1850	80	32	34
0801	08	1800	80	32	34
1001	10	1800	80	32	34
1101	11	1800	80	32	34
1201	12	1600	80	32	34
1301	13	2300	55	64	29
1401	14	925	50.5	48	28
1501	15	985	44.5	43	28
1601	16	2000	80	32	34

Table 2-2. Weights of Miscellaneous Items

ITEM	WEIGHT (LBS)
Magnetic Drum Unit	190
Magnetic Core Memory Unit	125
IODC Assembly	200
Magnetic Tape Unit, Tape Transport Assembly	260
Power Supply, 26v, 250A	500
Con-Ducts and Risers	375
Con-Duct Bus Bar Assembly	500
Ground Plane	350
Shielded Cables	500
AC Filters (Unit 0101), Each	100
AC Filters (Unit 1301, 1401, 1501) Each	35



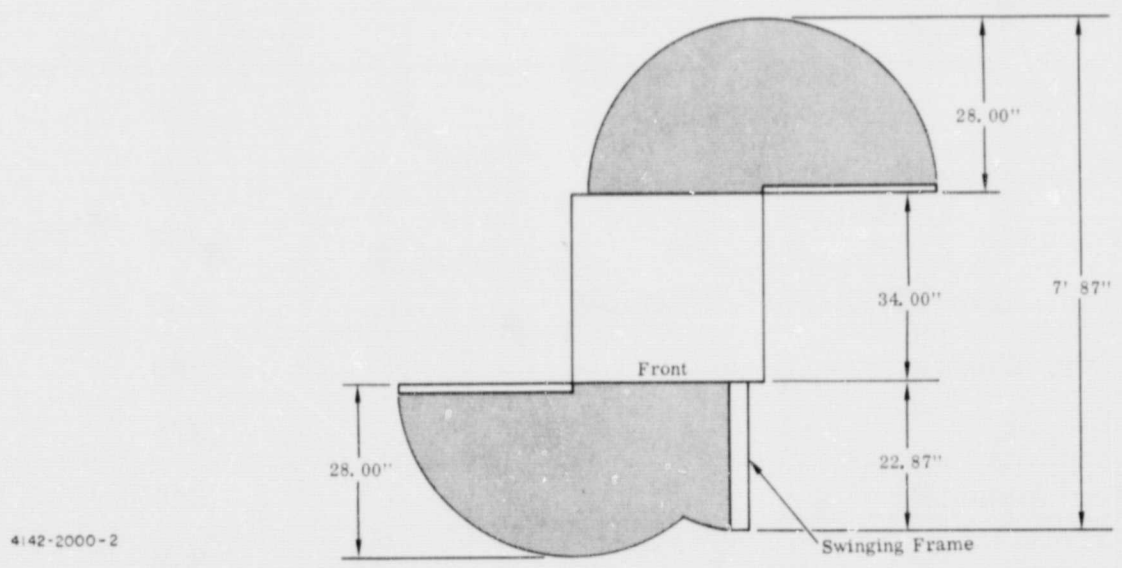


Figure 2-18. Outline and Installation Dimensions, Standard Saturn Ground Computer System Cabinet

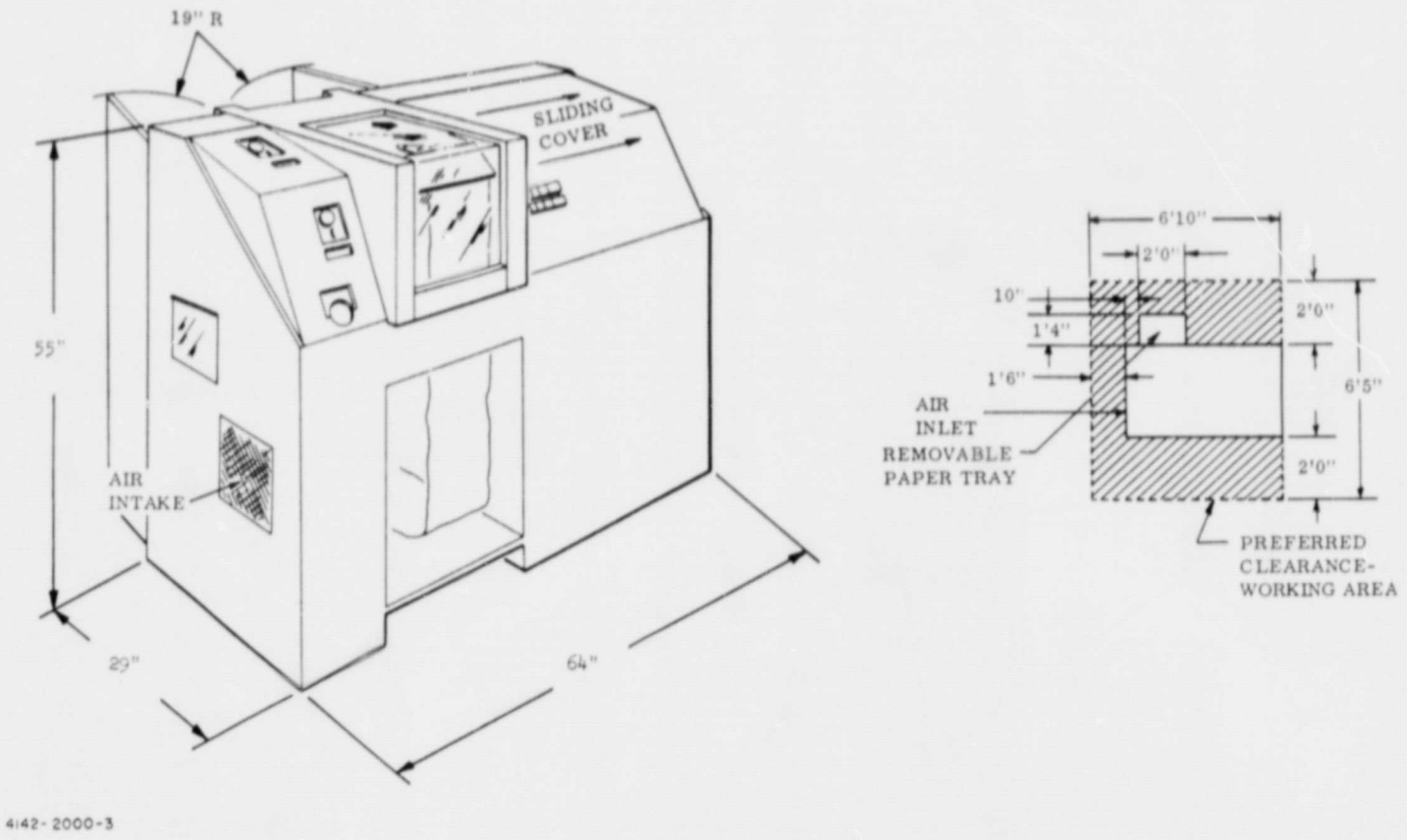


Figure 2-19. Outline and Installation Dimensions, Line Printer Converter Unit (Unit 1301)

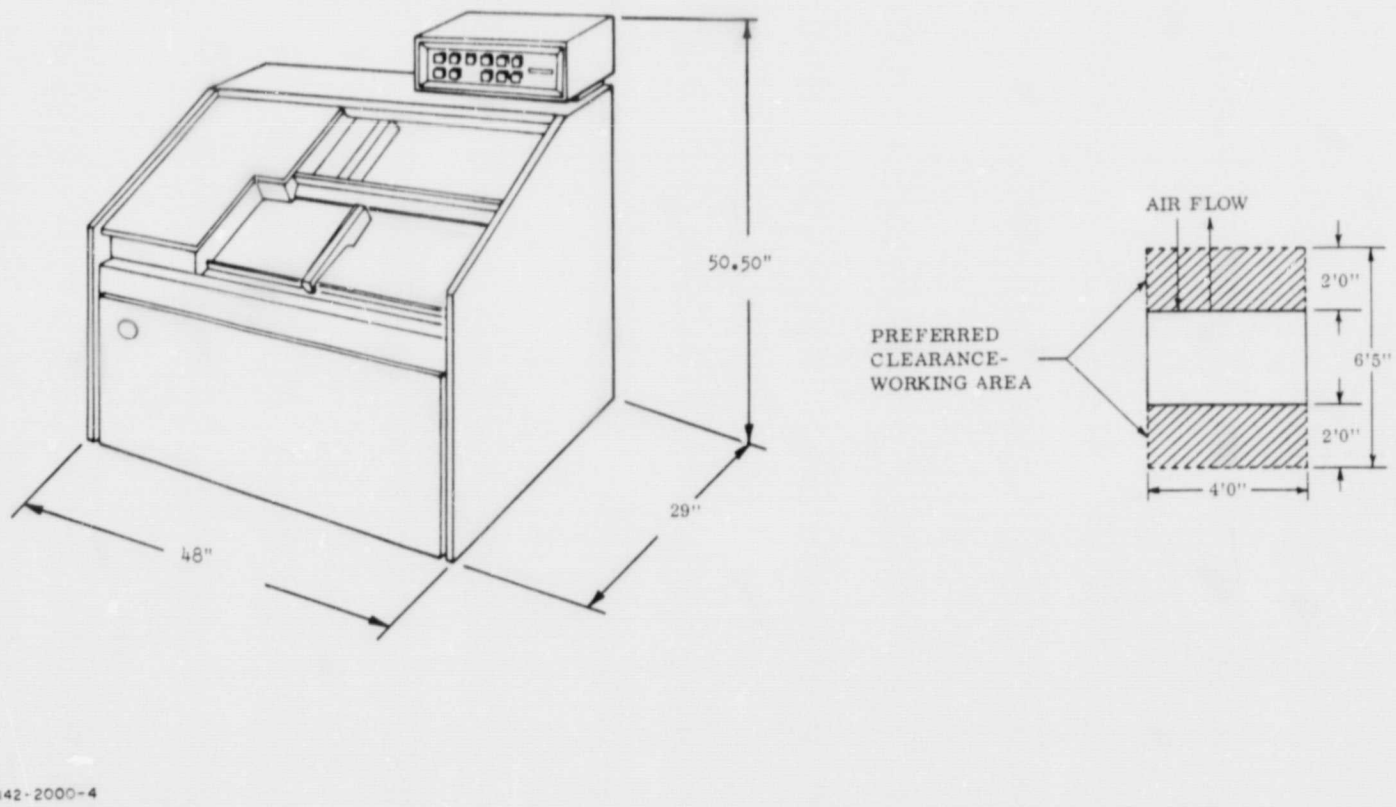
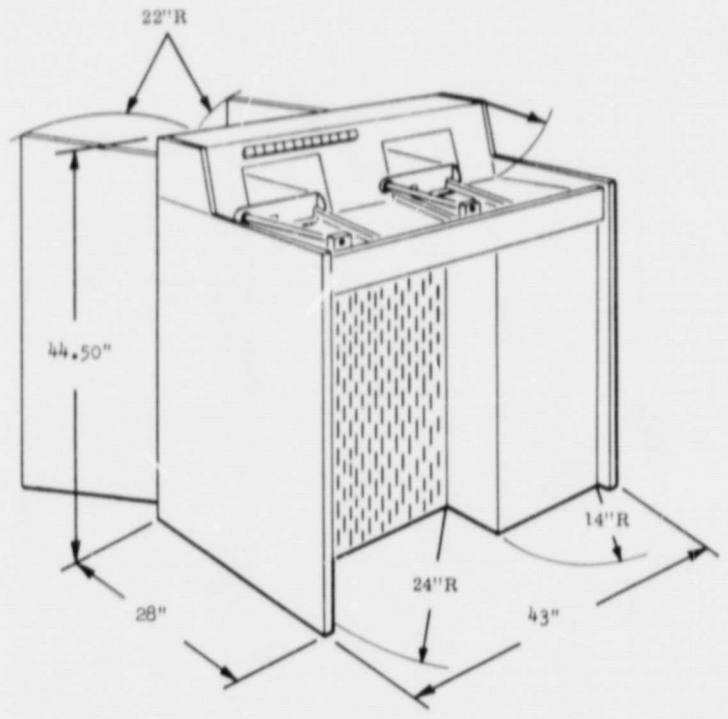


Figure 2-20. Outline and Installation Dimensions, Card Reader Converter Unit (Unit 1401)



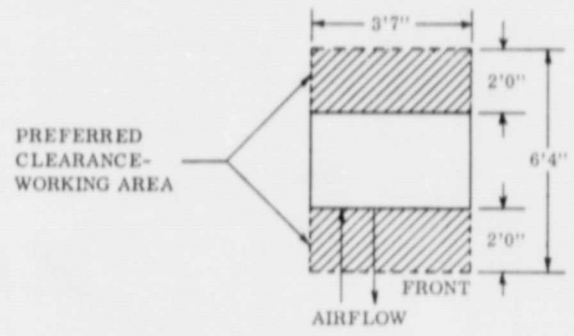


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Figure 2-21 Outline and Installation Dimensions, Card Punch Converter Unit (Unit 1501)

SECTION 3

PROGRAM MILESTONES

Contract NAS8-13007 was awarded to RCA, West Coast Division, Van Nuys, California in August 1964. Fabrication of the contracted SV computer systems followed a smooth transition from the SIB computer system fabrication. The period of performance of the contract extended through August 1967. The original contract called for fabrication of 19 systems; later in the program this was modified to 17 systems. The program milestones, system allocations, and completion schedule are outlined in the following paragraphs.

3.1 SYSTEM NO. 1, MICHOUD NO. 1

This system was scheduled for initial testing to begin in January 1965, and installation at allocated site to begin in February 1965 with checkout being completed in March 1965. Initial system testing and demonstration to Air Force QC and NASA at the RCA Van Nuys plant was completed in April 1965, and equipment was shipped to the allocated site in May 1965. The installation, checkout, and sell-off to NASA was also completed in May 1965.

3.2 SYSTEMS NO. 2 AND NO. 3, VLF 34/LCC AND VLF 34/AGS

These systems were scheduled for initial testing to begin in January 1965, and installation at allocated site in March 1965 with checkout being completed in March 1965 for VLF 34/LCC and April 1965 for VLF 34/AGS. Initial system testing and demonstration to Air Force QC and NASA at the RCA Van Nuys plant was completed in May 1965, and equipment was shipped to allocated sites in June 1965. These systems were installed, checked out, and sold-off to NASA at KSC in June 1965.

3.3 SYSTEM NO. 4, MSFC TEST

This system was scheduled for initial testing to begin in February 1965, and installation at allocated site in March 1965 with checkout being completed in May 1965. System demonstration to Air Force QC for provisional acceptance was completed and the equipment was shipped to allocated site in June 1965. Installation, checkout, and sell-off to NASA was completed and the system became operational in July 1965.

3.4 SYSTEM NO. 5, MICHOUD NO. 2

This system was scheduled for initial testing to begin in February 1965, and installation at allocated site in March 1965 with checkout completed in April 1965. System demonstration to Air Force QC for provisional acceptance was completed and the equipment was shipped to allocated site in June 1965. Installation, checkout, and sell-off to NASA was completed and the system became operational in July 1965.

3.5 SYSTEM NO. 6, SV BB/LUT

This system was scheduled for initial testing to begin in March 1965 and installation at allocated site in April 1965 with checkout completed in May 1965. System demonstration to Air Force QC for provisional acceptance was completed and equipment was shipped to allocated site in July 1965. Installation, checkout, and sell-off to NASA was completed and the system became operational in August 1965.

3.6 SYSTEM NO. 7, 500 FS

This system was originally designated system 10 and as such was scheduled for site installation and checkout to be completed August 1965. This system was demonstrated to the Air Force QC for provisional acceptance and equipment was shipped to allocated site in August 1965. Installation, checkout, and sell-off to NASA was completed and the system became operational in September 1965.

3.7 SYSTEM NO. 8, KSC LAB

This system was originally designated system 7 and as such was scheduled for site installation and checkout to be completed June 1965. Demonstration to the Air Force QC for provisional acceptance was completed in September 1965. Since the KSC Lab facility was not available for installation this system was placed in storage at complex 39 in September 1965. During the period of storage parts were removed from this system to support the SA-201 launch, and the system was removed from storage and installed at the allocated site in December 1965. Checkout of the system could not be initiated at time of installation until a complete inventory was taken and refurbishment completed. The system was refurbished, checked out, and sold-off to NASA in April 1966.

3.8 SYSTEM NO. 9, VLF 39/LCC NO. 1

This system was originally designated system 8 and as such was scheduled for site installation and checkout to be completed in July 1965. Demonstration to the Air Force QC for provisional acceptance was completed and the equipment was shipped to allocated site in September 1965.

This system was installed and ready for checkout at site in October 1965, but facility power was not available to operate the system. The system checkout and demonstration to NASA was completed and the system became operational in November 1965.

3.9 SYSTEM NO. 10, VLF 39/LUT NO. 1

This system was originally designated system 11 and as such was scheduled for site installation and checkout to be completed in October 1965. Demonstration to the Air Force QC for provisional acceptance was completed and the equipment was shipped to allocated site in October 1965. The system was installed and ready for checkout in November 1965, but facility power was not available to operate the system. The system checkout and demonstration to NASA was completed and the system became operational in December 1965.

3.10 SYSTEM NO. 11, MTF NO. 1

This system was reallocated many times during the fabrication period and finally returned to the original system designation. The system was originally scheduled for installation and checkout to be completed in October 1965. This system was used by RCA engineering during December 1965 to investigate core memory problems. Demonstration to Air Force QC was completed and shipped to allocated site in January 1966. Installation and checkout as site was also completed in January 1966. Sell-off demonstration to NASA was completed and the system became operational in February 1966.

3.11 SYSTEM NO. 12, VLF 37/AGS

This system was originally scheduled for installation and checkout at allocated site in November 1965. The system was demonstrated to Air Force QC for provisional acceptance in December 1965. The installation kit was installed at site and equipment was emplaced in December 1965. System checkout and sell-off to NASA was completed in January 1966.

3.12 SYSTEM NO. 13, VLF 37/LCC

This system was reallocated many times during the course of manufacture. After system preliminary testing at RCA plant was completed this was used for the First Article Configuration Testing (FACT) required by contract modification 27. After completion of the FACT program the system was demonstrated to Air Force QC for provisional acceptance in November 1965. The system was then placed in storage until January 1966 when it was shipped to the allocated site. Emplacement and checkout was accomplished in January 1966, and sell-off to NASA was completed in February 1966.

3.13 SYSTEM NO. 14, VLF 39/LCC NO. 2

This system was originally scheduled for installation and checkout at allocated site in May 1966. Preliminary system testing was completed in January 1966 and the system was held at RCA to carry out the "Verification Plan for Solder Fracture Corrective Action Approach" program. Later the module boards from this system were used to support the Module Board Rework program. After completion of the Module Board Rework program this system was updated to configuration of latest modifications and demonstrated to Air Force QC in September 1966. The system was shipped and emplaced at site in September 1966, and final sell-off to NASA was completed in October 1966.

3.14 SYSTEMS NO. 15 AND NO. 16, VLF 39/LUT NO. 3 AND VLF 39/LCC NO. 3

Modules from these systems were used in the Module Board Rework program and the systems were rescheduled for site installation in April 1967 and June 1967. These systems were demonstrated to Air Force QC in April and May 1967 and shipped to allocated sites. The final sell-off to NASA was also affected in April and May of 1967.

3.15 SYSTEM NO. 17, VLF 39/LUT NO. 2

This system was initially scheduled for completion in August 1966. After a reallocation the system was installed at Qualification Lab 500 FS, Huntsville, Alabama in November 1964. The system was then removed and reinstalled at Douglas Aircraft Company facility at Huntington Beach, California in March 1965. In January 1966 the system was removed from Huntington Beach and reinstalled in Complex VLF 39/LUT No. 2 and finally sold-off in February 1966.

SECTION 4

PROBLEM AREAS AND RESOLUTIONS

During the course of Contract NAS 8-13007 several problem areas arose. These problems and their resolutations are described in the following paragraphs:

- In September 1965 reports were received that wet electrolytic tantalum capacitors (family designation CL65) were showing signs of discoloration and corrosion. The units affected displayed a brownish appearance in the vicinity of the capacitor anode and/or corrosion in the vicinity of the anode weld joint. Investigations definitely established that leaking of acid fumes trapped by conformal coating can be the source of electrical malfunctions. A short term plan to support the AS-201 launch was proposed which entailed replacing module boards in systems 2112000-509 and -510 with boards reworked to remove the conformal coating from the anode end of the capacitor. This plan was satisfactorily implemented and, in addition, was extended to the 2112000-507 system. The long term plan, proposed concurrently with the short term plan, recommended the replacement of all CL65 type capacitors. This plan was subsequently modified to utilize the short term method for the rework of module boards with the CL65 type capacitors.

- Several months after the first 110A Saturn Ground Computer Systems were sold off in the field, reports received by RCA indicated high speed memory parity errors occurring. The randomness of the errors made troubleshooting extremely difficult and these random occurrences caused serious problems in running long programs. The results of the investigation conducted to isolate the cause of the high speed memory parity errors revealed that the technique of adjusting the drive currents was inadequate. A technique using relative type measurements, as opposed to magnitude type measurements, was developed and implemented. The new technique improved the parity error performance but did not completely eliminate the problem.

- In its investigation of the high speed memory parity error problem, RCA established a correlation between fractured solder joints and parity errors. Under magnification, solder fractures could be seen (particularly on the joints associated with the TO-5 transistors). Solder fractures resulted from the incompatibility of NASA specifications for conformal coating and contour soldering of printed circuit boards. Stresses were set up in the conformal coating which, when added to the normal solder joint stresses, exceeded the amount tolerable with the minimal amount of solder used in the contour soldering process. Correction of the problem was effected by reworking module boards using the "tubelet" technique. This consisted of slipping copper tubelets over the clinched transistor lead and then filling the tube with solder and soldering it to the pad. New module boards were built with stress relieved transistors. On both types of boards (reworked and new build) a heavier application of solder than previously specified by NASA was used.

- The combined effect of the resolution of the above problems was a marked improvement in system performance and the elimination of these problems as causes for high speed memory parity errors.

- Early in the production cycle RCA started to experience failures in the Soroban Card Punch Head assembly. These failures were exhibited as feed and data errors. Working closely with the Soroban technical personnel, RCA engineers isolated areas of probable failure and several changes were made to the punch head design. Several punch heads incorporating design changes were forwarded to RCA for life testing. During these tests a number of failures occurred, and the heads were returned to Soroban for further rework. An expanded acceptance procedure was developed to test the quality of the heads by punching 200,000 cards. As subsequent higher quality punch heads were tested, RCA established that a 25,000 card test would provide the same information and the test was modified accordingly. This reduced the test time and expedited reworked punch heads to help relieve a critical field shortage. Through the series of investigations and resolutions of the specific problems as they occurred, RCA in conjunction with Soroban evolved a configuration and a reliability standard that was suitable and insured reliable field operation. These changes were incorporated in an ECP to bring all units to the correct configuration which provides a solution to the known problems.

- Throughout the production cycle, RCA was able to support delivered systems only through the shifting of Librascope drums from production to field support as a high rate of field failures occurred. Investigations by RCA engineers revealed that the failures were due to a head to rotor gap closure and bad bearings. Indications were that the head to rotor gap closure was caused by subjecting the drum to thermal shock conditions causing unequal contraction of the parts. Bearing failures were caused, in part, by contaminants in the grease and an electrical potential across the bearing, causing pitting in the bearing race. As an interim measure, instructions were issued containing operating precautions relative to subjecting the drum to thermal shock. These instructions required that if a drum had been turned off for a period greater than ten minutes it remain off line for a period of four hours to permit stabilization. Closer in-process quality control was invoked to assure contaminant free grease in the bearings, and tests showed that the addition of a grounding brush effectively removed the electrical potential across the bearings and would eliminate the pitting. Realizing that the four hours' waiting period was not a satisfactory solution to operational conditions, RCA engineers continued their investigations and tests to eliminate the effects of thermal shock. These investigations were satisfactorily concluded by increasing the head to rotor gap without degrading the performance of the drum or the system. The recommendations of RCA were accepted by NASA, and the solution to the head to rotor gap closure and faulty bearing problems was implemented by an ECP.

SECTION 5

CONFIGURATION MANAGEMENT

5.1 CONFIGURATION MANAGEMENT PROCEDURES

At the start of the Saturn V Program under Contract NAS8-13007, Configuration Management procedures based on RCA's normal practices, were invoked. These practices consisted primarily of change control procedures, utilizing a Change Control Board, that provided the following:

a) Review of proposed changes for compliance with NASA requirements prior to implementation.

b) Accessment of the impact of proposed changes on the delivery schedule prior to implementation.

c) Accessment of the impact of proposed changes on the reliability goal prior to implementation.

d) Assurance that all necessary change details were included in drawing hardware changes.

e) Control of equipment identification and marking.

f) Establishment of the proper cut-in of changes and maintenance of configuration records.

The controls and procedures that were implemented to accomplish the above are described in Section 7 of RCA TP1213, Volume 1, dated 30 April 1964, which is the Program Plan submitted by RCA for overall management of the Saturn V Program.

Though the foregoing program was operating satisfactorily, NASA, in early 1965, invoked the requirement for implementation of NPC 500-1, Apollo Configuration Management Manual. This requirement was invoked via Modification No. 27 to Contract NAS8-13007.

5.2 COMPLIANCE TO NPC 500-1

RCA's system of change control at the time of receipt of Modification 27 was in general agreement with that required by NPC 500-1. The major impact of the new requirement came in area of specifications and documentation (Configuration Identification Status Accounting).

RCA's complete response to the requirements of Modification No. 27 were documented in RCA TP1314, Volume 1. This document was submitted to NASA in June of 1965 and subsequently

accepted by NASA under Modification No. 65 to Contract NAS8-13007. RCA's performance to the specified contract exhibits is described in the following paragraphs.

5.2.1 Exhibit II - Preparation of Prime Equipment Specifications

Under this Exhibit, RCA initially prepared twenty-three (23) prime equipment specifications (Part II only). Table 5-1 lists these specifications. In addition, one overall system specification was prepared. This specification was titled "System Requirements and Acceptance Specification" and was assigned RCA Drawing number, 2186699.

These specifications were initially submitted to NASA in August/September 1965. During, and subsequent to, the First Article Configuration Inspection held in October 1965, comments were received from NASA relative to content and format. The specification drafts were revised and re-submitted for approval in January 1966. Approval of these specifications was received by letter of 7 June 1967 from the Contracting Officer.

In addition to the initial twenty three prime equipment specifications listed in table 5-1, thirteen (13) prime equipment specifications were generated and submitted during the course of the program. These specifications, shown in table 5-2, were required as the result of ECP actions wherein all existing units of the contract end items affected were not approved for the change action. Such limited approvals resulted in the creation of new prime equipment specifications under the interpretation of NPC 500-1. As noted in table 5-2, four (4) of these specifications were not approved by NASA as of this report preparation. The remainder were approved by Contracting Officers letter of June 7, 1967.

Table 5-1. Prime Equipment Specifications

TITLE OF SPECIFICATION	SPEC ID NO.	CONTRACT END ITEM
Power Supply Unit (Unit 0101)	CPV12001	112001A
Power Supply Unit (Unit 0101)	CPVA2001	112001B
Power Supply Unit (Unit 0101)	CPV12369	112001C
Converter Unit, Main Frame (Unit 0201)	CPV12002	112002A
Converter Unit, Main Frame (Unit 0201)	CPVA2002	112002B
Magnetic Tape Unit, Master (Cab. 04)	CPV12004	112004A
Converter Unit, Analog (Cab. 06)	CPV12012	112013A
Converter Unit, Discrete Input (Cab. 07)	CPV12014	112014A
Converter Unit, Discrete Input (Cab. 07)	CPV12018	112014B

Table 5-1. Prime Equipment Specifications (Cont)

TITLE OF SPECIFICATION	SPEC ID NO.	CONTRACT END ITEM
Converter Unit, Discrete Output (Cab. 08)	CPV12015	112015A
Switching Unit, Data Input /Output (Cab. 10)	CPV12008	112008A
Switching Unit, Data Input /Output (Cab. 10)	CPVA2008	112008B
Switching Unit, High Speed Memory (Cab. 11)	CPV12005	112005A
Switching Unit, High Speed Memory (Cab. 11)	CPVA2005	112005B
Switching Unit, High Speed Memory (Cab. 11)	CPV12017	112005C
Switching Unit, High Speed Memory (Cab. 11)	CPV11767	112005D
Magnetic Tape Unit, Slave (Cab. 12)	CPV12007	112007A
Magnetic Tape Unit, Slave (Cab. 12)	CPV34002	112007B
Converter Unit, Line Printer (Cab. 13)	CPV85462	185462A
Recorder Set-Punched Card Reader (SV)(Cab. 14)	CPV85464	185464A
Card Punch (Cab. 15)	CPV85466	185466A
Card Punch (Cab. 15)	CPVA5466	185466B
Terminal Unit, Data Link (Cab. 16)	CPV10221	110221A

Table 5-2. Prime Equipment Specifications - Addition

TITLE OF SPECIFICATION	SPEC ID NO.	CONTRACT END ITEM
Power Supply Unit (Unit 0101)	CPV34523	112001D
Power Supply Unit	CPV34524	112001E
Converter Unit, Main Frame (Unit 0201)	CPV34537	112002C
Converter Unit, Main Frame	CPV34538	112002D
Switching Unit, High Speed Memory	CPVB2005	112005E
(Cabinet 11)	CPV34464	112005F
Switching Unit, High Speed Memory	CPV34578	112005G*
Switching Unit, Data Input /Output (Cab. 10)	CPV34466	112008C
Switching Unit, Data Input /Output	CPV34543	112008D
Switching Unit, Data Input /Output	CPV34577	112008E*
Converter Unit, Discrete Input (Cab. 07)	CPV34575	112014C*
Converter Unit, Discrete Input	CPV34576	112014D*
Converter Unit, Discrete Output (Cab. 08)	CPV34541	112015B

*Unapproved specifications as of July 1967.

5.2.2 [illegible]ation Specifications

Under this Exhibit, R[illegible] identification specifications. Table 5-3 lists these specifications. As [illegible] equipment specifications, drafts of these specifications were submitted, r[illegible]nts, and resubmitted for approval in early 1966. As noted in table 5-3, approval of th[illegible]ations was received in two increments - June 1966 and June 1967. One specification, [illegible]3 remained unapproved.

5.2.3 Exhibit VI - Preparation of Critical Component Specifica[illegible]

Under this Exhibit, RCA selected forty-four (44) RCA-designed assemblies and one hundred sixty five (165) vendor-designed assemblies as Logistic Critical items. The selections were submitted as part of TP1314, and subsequently were approved by NASA for preparation of specifications. The specifications were prepared and submitted incrementally between September 1965 and June 1966. To-date, only those noted in table 5-4 have been approved by NASA.

In addition to the vendor assembly specifications, RCA prepared in excess of 450 Specification Control Drawings for vendor-used piece parts. This requirement was warranted by the inability or unwillingness of RCA's major vendors to comply with the requirements of NPC 500-1, thus leaving little assurance that the piece parts being procured as spares would always be to the original acceptance and configuration criterias.

5.2.4 Exhibit VII - Specification Maintenance

In accordance with this Exhibit, RCA maintained control of all specifications prepared by:

a) Preparation and submittal of Specification Change Notices (SCN's) against all specifications affected by Engineering Change Proposals.

b) Preparation and submittal of Specification Change Log sheets.

c) Preparation and maintenance of a Configuration Chart for each specification.

To date, no specifications have been revised, as such action is only allowed when specifically directed by the procuring activity.

5.2.5 Exhibit IX - Preparation of Engineering Change Proposals for Contract End Items

In accordance with this Exhibit, RCA prepared and submitted approximately eighty (80) Engineering Change Proposals (ECP's) against Contract NAS8-13007. This quantity represents those ECPs generated from the invocation of NPC 500-1 in May 1965 through mid-1966 when contractual direction was received to submit all ECP's against contract NAS8-15496. All contractual actions required for the ECP's submitted under NAS8-13007 has been completed.

Table 5-3. Item Identification Specifications

TITLE OF SPECIFICATION	SPEC ID NO.	DRAWING NO.	CONTRACT END ITEM
Installation Kit, RCA 110A Computer-Launcher-Umbilical Tower Complex 39, LUT 1-Saturn V	CDV33956 ①	2133956-501	133956A
Installation Kit, RCA 110A Computer-Launcher-Umbilical Tower Complex 39, LUT 2-Saturn V	CDV33957 ①	2133957-501	133957A
Installation Kit, RCA 110A Computer-Launcher-Umbilical Tower Complex 39, LUT 3-Saturn V	CDV33958 ①	2133958-501	133958A
Installation Kit, RCA 110A Computer, DAC Facility 500FS	CDV33959 ①	2133959-501	133959A
Installation Kit, RCA 110A Computer-MILA Test SPT Area Complex 39, Saturn V	CDV33960 ①	2133960-501	133960A
Installation Kit, RCA 110A Computer-S-1C Checkout, Michoud, Room 2	CDV33961 ①	2133961-501	133961A
Installation Kit, RCA 110A Computer-S-1C Checkout, Michoud, Room 1	CDV33962 ①	2133962-501	133962A
Installation Kit, RCA 110A Computer-Blockhouse, Complex 34	CDV33964 ①	2133964-501	133964A
Installation Kit, RCA 110A Computer-AGCS Building, Complex 34	CDV33965 ①	2133965-501	133965A
Installation Kit, RCA 110A Computer-Test Lab., Saturn V	CDV33966 ①	2133966-501	133966A
Installation Kit, RCA 110A Computer-Saturn V System Dev. B/B Facility-LUT Saturn V	CDV33967 ①	2133967-501	133967A
Installation Kit, RCA 110A Computer-Blockhouse, Complex 37, Saturn 1B	CDV33968 ①	2133968-501	133968A
Installation Kit, RCA 110A Computer-AGCS Building, Complex 37, Saturn 1B	CDV33969 ①	2133969-501	133969A
Installation Kit, RCA 110A Computer-Firing Room 1, Complex 39, Saturn V	CDV33970 ①	2133970-501	133970A
Installation Kit, RCA 110A Computer-Firing Room 2, Complex 39, Saturn V	CDV33971 ①	2133971-501	133971A

① Approved by Contracting Officers letter 15 June 1966
② Approved by Contracting Officers letter 7 June 1967

Table 5-3. Item Identification Specifications (Cont)

TITLE OF SPECIFICATION	SPEC ID NO.	DRAWING NO.	CONTRACT END ITEM
Installation Kit, RCA 110A Computer-Firing Room 3, Complex 39, Saturn V	CDV33972 ①	2133972-501	133972A
Installation Kit, RCA 110A Computer-S-1C Test Cont. Ctr., Miss. Test Facility, Saturn V	CDV33973 ①	2133973-501	133973A
Tool Set	CDV85170 ②	2185170-502	185170A
Data Link Cable Simulator	CDT13389 ②	8613389-501	613389A
Saturn V Demonstration Test Program, Executive Routine	CDV86600 ①	2186600	186600A
Saturn V Demonstration Test Program,Core	CDV86601 ①	2186601	186601A
Saturn V Demonstration Test Program, Instruction	CDV86602 ①	2186602	186602A
Saturn V Demonstration Test Program, Drum	CDV86603 ①	2186603	186603A
Saturn V Demonstration Test Program, Typewriter	CDV86604 ①	2186604	186604A
Saturn V Demonstration Test Program, Priority Interrupt	CDV86605 ①	2186605	186605A
Saturn V Demonstration Test Program, Magnetic Tape	CDV86606 ①	2186606	186606A
Saturn V Demonstration Test Program, Line Printer	CDV86607 ①	2186607	186607A
Saturn V Demonstration Test Program, Interval Time	CDV86608 ①	2186608	186608A
Saturn V Demonstration Test Program, Card Punch and Reader	CDV86609 ①	2186609	186609A
Saturn V Demonstration Test Program, Paper Punch and Reader	CDV86610 ①	2186610	186610A
Saturn V Demonstration Test Program, Discrete Input/Output - Cabinet 7 & 8	CDV86611 ①	2186611	186611A
Saturn V Demonstration Test Program, Discrete Input/Output - Monitor Mode	CDV86612 ①	2186612	186612A
Saturn V Demonstration Test Program, Input/Output Registers (IOR)	CDV86613 ①	2186613	186613A

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Table 5-3. Item Identification Specifications (Cont)

TITLE OF SPECIFICATION	SPEC ID NO.	DRAWING NO.	CONTRACT END ITEM
Saturn V Demonstration Test Program, Display IODC	CDV86614 ①	2186614	186614A
Saturn V Demonstration Test Program, Analog Input/Output	CDV86615 ①	2186615	186615A
Saturn V Demonstration Test Program, Data Link - Special Test Mode	CDV86616 ①	2186616	186616A
Saturn V Demonstration Test Program, Data Link Acceptance	CDV86617 ①	2186617	186617A
Saturn V Demonstration Test Program, Data Link - Two Computer Demonstration	CDV86618 ①	2186618	186618A
Saturn V Demonstration Test Program, DDAS IODC	CDV86619 ①	2186619	186619A
Saturn V Demonstration Test Program, Simultaneous IODC Demonstration	CDV86620 ①	2186620	186620A
Saturn V Demonstration Test Program, 110A Computer Test Panel	CDV86621 ①	2186621	186621A
Saturn V Demonstration Test Program, Display IODC - Saturn V	CDV86622 ①	2186622	186622A
Saturn V Demonstration Test Program, Discrete Input Test - Cabinet 7	CDV86623 ①	2186623	186623A
Test/Maintenance & Utility Routine, Sense Switch Test	CDV86624 ①	2186624	186624A
Test/Maintenance & Utility Routine, Program & Data Punch	CDV86625 ①	2186625	186625A
Test/Maintenance & Utility Routine, Program & Data Loader	CDV86626 ①	2186626	186626A
Test/Maintenance & Utility Routine, Binary to Decimal	CDV86627 ①	2186627	186627A
Test/Maintenance & Utility Routine, Decimal to Binary	CDV86628 ①	2186628	186628A
Test/Maintenance & Utility Routine, Decimal Memory Dump	CDV86629 ①	2186629	186629A
Test/Maintenance & Utility Routine, Octal Memory Dump	CDV86630 ①	2186630	186630A

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Table 5-3. Item Identification Specifications (Cont)

TITLE OF SPECIFICATION	SPEC ID NO.	DRAWING NO.	CONTRACT END ITEM
Test/Maintenance & Utility Routine, Post Mortem Compare Print	CDV86631 ①	2186631	186631A
Test/Maintenance & Utility Routine, Display Console Debug Program	CDV86632 ①	2186632	186632A
Test/Maintenance & Utility Routine, Trace	CDV86633	2186633	186633A
Mathematical Subroutine, Sine/Cosine	CDV86634 ②	2186634	186634A
Mathematical Subroutine, Square Root	CDV86635 ②	2186635	186635A
Mathematical Subroutine, Exponential (2, e, 10)	CDV86636 ②	2186636	186636A
Mathematical Subroutine, Arctangent	CDV86637 ②	2186637	186637A
Mathematical Subroutine, Log X (2, e, 10)	CDV86638 ②	2186638	186638A
Mathematical Subroutine, Binary Coded Decimal to Floating Point Binary	CDV86639 ②	2186639	186639A
Mathematical Subroutine, Floating Point Binary to BCD Floating Format	CDV86640 ②	2186640	186640A
Mathematical Subroutine, Floating Point Add or Subtract	CDV86641 ②	2186641	186641A
Mathematical Subroutine, Floating Point Multiplication	CDV86642 ②	2186642	186642A
Mathematical Subroutine, Floating Point Divide	CDV86643 ②	2186643	186643A
Mathematical Subroutine, Floating Point Square Root	CDV86644 ②	2186644	186644A
Mathematical Subroutine, Floating Point Sine or Cosine	CDV86645 ②	2186645	186645A
Mathematical Subroutine, Floating Point Arctangent	CDV86646 ②	2186646	186646A
Mathematical Subroutine, Floating Point Common Logarithm or Natural Logarithm	CDV86647 ②	2186647	186647A
Mathematical Subroutine, Floating Point Exponential, E^X	CDV86648 ②	2186648	186648A

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Table 5-3. Item Identification Specifications (Cont)

TITLE OF SPECIFICATION	SPEC ID NO.	DRAWING NO.	CONTRACT END ITEM
Mathematical Subroutine, Floating Point Tangent or Cotangent	CDV86649 ②	2186649	186649A
Mathematical Subroutine, Double Precision Divide	CDV86650 ②	2186650	186650A
SLAP 2 System	CDV86651 ②	2186651	186651A

Table 5-4. Critical Components Specifications

RCA PART NUMBER	DESCRIPTION	SPEC NO.
2110011-504	Module Assembly-Filter	LCV10011
2110012-504	Module Assembly-Lamp Driver	LCV10012
2110029-504	Module Assembly-Power Gate B	LCV10029
2110032-504	Module Assembly-Diode Board B	LCV10032
2110041-504	Module Assembly-Clock	LCV10041
2110042-504	Module Assembly-Clock Amplifier	LCV10042
2110043-504	Module Assembly-Write Drive	LCV10043
2110044-504	Module Assembly-Read Amplifier	LCV10044
2110045-504	Module Assembly-Diode Board C	LCV10045
2110046-504	Module Assembly-Matrix Row	LCV10046
2110047-504	Module Assembly-Matrix Column	LCV10047
2110048-504	Module Assembly-Pulse Shaper	LCV10048
2110049-504	Module Assembly-Squaring ①	LCV10049
2110050-504	Module Assembly-Pulse Amplifier	LCV10050
2110064-504	Module Assembly-Voltage ①	LCV10064

① Approved by Contracting Officers letter 15 June 1966
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Table 5-4. Critical Components Specifications (Cont)

RCA PART NUMBER	DESCRIPTION	SPEC NO.
2110073-504	Module Assembly-Tape Oscillator	LCV10073
2110074-504	Module Assembly-Tape Oscillator	LCV10074
2110119-503	Printed Wiring Board ①	LCV10119
2110121-504	Module Assembly-Clock	LCV10121
2110122-504	Module Assembly-Relay ①	LCV10122
2110123-503	Module Assembly-Relay	LCV10123
2110124-504	Module Assembly-Terminating ①	LCV10124
2110125-504	Module Assembly-High Speed ①	LCV10125
2110126-504	Module Assembly-Gate A	LCV10126
2110127-504	Module Assembly-Inverter ①	LCV10127
2110128-504	Module Assembly-Gate B, Type ①	LCV10128
2110129-504	Module Assembly-Power Gate A ①	LCV10129
2110130-504	Module Assembly-Flip Flop Shift ①	LCV10130
2110131-504	Module Assembly-Flip Flop ①	LCV10131
2110132-504	Module Assembly-Diode Board A ①	LCV10132
2110133-504	Module Assembly-Power Gate C ①	LCV10133
2110134-504	Module Assembly-Flip Flop ①	LCV10134
2110135-504	Module Assembly-Relay Board ①	LCV10135
2110225-501	Cable Assembly, Special Purpose ①	LCV10225
2133930-502	Regulator Chassis Assembly	LCV33930
2133931-502	Power Supply Assembly-18 VDC ①	LCV33931
2163347-501	Cable Assembly, Special Purpose ①	LCV63347
2164086-503	Over/Under Voltage Detector ①	LCV64086
2164086-504	Over/Under Voltage Detector ①	LCVA4086

① Approved by Contracting Officers letter 15 June 1966
② Approved by Contracting Officers letter 7 June 1967

Table 5-4. Critical Components Specifications (Cont)

RCA PART NUMBER	DESCRIPTION	SPEC NO.
2164103-502	Over Current Detector Assy	LCV64103
2164109-502	Differential Amplifier Assembly ①	LCV64109
2164112-502	Blocking Oscillator Assembly ①	LCV64112
2164135-502	Differential Amplifier Assembly	LCV64135
2164141-502	Pre-Shunt Regulator Assy ①	LCV64141
ANELEX PART NUMBER	DESCRIPTION	SPEC NO.
30348G1	DC Sens CD Assy	LCV30348
49001	1N1476	LCV49001
49002	A NOR 5	LCV49002
49003	A NOR 10	LCV49003
49004	B NOR 5	LCV49004
49005	C NOR 5	LCV49005
49006	C NOR 10	LCV49006
49007	C NOR 20	LCV49007
49008	Register	LCV49008
49009	One Shot Short	LCV49009
49010	One Shot Long	LCV49010
49011	CD 200	LCV49011
49012	CD 400	LCV49012
49013	CD Load	LCV49013
49014	P. A. Gate Gen	LCV49014
49015	Hd Gate Driver	LCV49015
49016	P. B. Lamp Dr	LCV49016
49017	Pulser	LCV49017

① Approved by Contracting Officers letter 15 June 1966
② Approved by Contracting Officers letter 7 June 1967

Table 5-4. Critical Components Specifications (Cont)

ANELEX PART NUMBER	DESCRIPTION	SPEC NO.
49018	SW to D. C.	LCV49018
49019	L. D. T.	LCV49019
49020	C. E. F.	LCV49020
49021	R. W. Sense Amp	LCV49021
49022	Hammer Dr Assy	LCV49022
49023	Comp Gt Amp Assy	LCV49023
49024	Comp Trig Assy	LCV49024
49025	Paper Out Detec	LCV49025
49026	Rib Control Assy	LCV49026
49027	Paper Fd Pul Dr	LCV49027
49028	Paper Fd Hd Dr	LCV49028
49029	Pho Stb Rec Assy	LCV49029
49030	Pho Data Rec Assy	LCV49030
51651G1	P/F Dr and F/Assy	LCV51651
51684G1	Seq Assy	LCV51684
68671	Power Supply Assy	LCV68671
68673	Power Supply	LCV68673
SOROBAN PART NUMBER	DESCRIPTION	SPEC NO.
B-11829-P3	Printed Circuit Card-SOR-210	LCV9-PS3
D-14198-P3X	Control Panel Assembly	LCV8-PS3
D-15058-P19	Printed Circuit Card-SOR-CD12	LCV-P1S9
D-15058-P20	Printed Circuit Card-SOR-CD12	LCV-P2S0
D-15123-P5	Printed Circuit Card-SOR-DL-10	LCV3-PS5
D-15141-P27	Printed Circuit Card-SOR-SS8	LCV-P2S7

Table 5-4. Critical Components Specifications (Cont)

SOROBAN PART NUMBER	DESCRIPTION	SPEC NO.
D-15141-P28	Printed Circuit Card-SOR-SS8	LCV-P2S8
D-15250B-P2	Printed Circuit Card-SOR-CD12	LCVB-PS2
D-15280-P13	Printed Circuit Card-SOR-CAL	LCV-P1S3
D-15403-P5	Printed Circuit Card-SOR-CA2	LCV3-SP5
D-15422-P10	Printed Circuit Card-SOR-408	LCV-P1S0
D-15465-P3	Printed Circuit Card-SOR-FF4M	LCV-P3S
D-15465-P4	Printed Circuit Card MOD	LCV5-PS4
D-15173A-P3	Printed Circuit Card-SOR-CD4	LCVA-PS3
D-15476-P3	Printed Circuit Card-SOR-SG14	LCV6-PS3
D-15481-P3	Printed Circuit Card-SOR-ST-8	LCV1-PS3
D-31256A-P2	Resistor Panel Assy	LCVA-PS2
X-13528A	Card Punch Head	LCVN-1S6
PS 47712	Power Supply 28 Volts 25 Amp	LCV771S2
SIB		
SIB		

AMPEX PART NUMBER	DESCRIPTION	SPEC NO.
3102629-10	Dashpot Assy	*
3107655-10	Reel Motor Assy	LCV765A5
3107707-10	Capstan Drive Assy	LCV770A7
3112020-10	Photo Amp	LCV202A0
3112022-10	Input Buffer	LCV202A2
3112023-10	Input Buffer (Invert)	LCV202A3
3112025-10	Echo Clipper	LCV202A5
3112027-10	Pre Amp	LCV202A7
3112029-10	Line Drive, B	LCV202A9

Table 5-4. Critical Components Specifications (Cont)

AMPEX PART NUMBER	DESCRIPTION	SPEC NO.
3112031-10	Write Permit	LCV203A1
3112035-10	NAND Power Gate, P	LCV203A5
3112037-10	NAND, P	LCV203A7
3112039-10	Diode Output	LCV203A9
3112041-10	Lamp/Relay/Line Driver	LCV204A1
3112043-10	Line Driver, P	LCV204A3
3112045-10	Single Shot	LCV204A5
3112046-10	Single Shot	LCV204A6
3112048-10	PNP Non-Invert Power Gate	LCV204A8
3112050-10	NPN Non-Invert Power Gate	LCV205A0
3112052-10	Voltage Amp	LCV205A2
3112054-10	Clipping Level	LCV205A4
3112056-10	Flip Flop, B	LCV205A6
3112058-10	Line Terminator	LCV205A8
3112060-10	Flip Flop, P	LCV206A0
3112062-10	Line Driver, C	LCV206A2
3112064-10	BCD Decoder	LCV206A4
3112066-10	NREM Head Driver	LCV206A6
3112068-10	Unique Select	LCV206A8
3112070-10	Act. Driver	LCV207A0
3112072-10	Peak Detector	LCV207A2
3112089-10	Time Delay	LCV208A9
3112120-10	Power Control Chassis	LCV212A0
3112122-10	Logic Power Supply	LCV212A2
3112130-10	Board Assy	LCV213A0
3112132-10	Board Assy	LCV213A2

Table 5-4. Critical Components Specifications (Cont)

REDCOR PART NUMBER	DESCRIPTION	SPEC NO.
700005-1	Module Assy	LCV05-R1
700005-2	Module Assy	LCV05-R2
700030	Module Assy	LCV003R0
700036	Module Assy	LCV003R6
700045-1	Module Assy	LCV45-R1
700045-2	Module Assy	LCV45-R2
700050	Module Assy	LCV005R0
700065	Module Assy	LCV006R5
700080	Module Assy	LCV008R0
700085	Module Assy	LCV008R5
700090	Module Assy	LCV009R0
700095-1	Module Assy	LCV95-R1
700095-2	Module Assy	LCV95-R2
700095-3	Module Assy	LCV95-R3
700101	Module Assy	LCV010R1
700105	Module Assy	LCV010R5
700110	Module Assy	LCV011R1
700115-2	Module Assy	LCV15-R2
700122-1	Module Assy	LCV22-R1
700122-2	Module Assy	LCV22-R2
700129-1	Module Assy	LCV29-R1
700129-2	Module Assy	LCV29-R2
700135	Module Assy	LCV013R5
700145	Module Assy	LCV014R5

Table 5-4. Critical Components Specifications (Cont)

REDCOR PART NUMBER	DESCRIPTION	SPEC NO.
700170	Module Assy	LCV017R0
700175	Module Assy	LCV017R5
700180	Module Assy	LCV018R0
700185	Module Assy	LCV018R5
700195	Module Assy	LCV019R5
700205	Module Assy	LCV020R5
700222	Module Assy	LCV022R2
700225-1	Module Assy	LCV25-R1
700225-2	Module Assy	LCV25-R2
700230	Module Assy	LCV023R0
700235	Module Assy	LCV023R5
700240	Module Assy	LCV024R0
700250	Module Assy	LCV025R0
700260	Module Assy	LCV026R0
700295	Module Assy	LCV029R5
700360	Module Assy	LCV036R0
700455	Module Assy	LCV045R5
700470-1	Module Assy	LCV70-R1
700470-2	Module Assy	LCV70-R2
700470-3	Module Assy	LCV70-R3

Table 5-4. Critical Components Specifications (Cont)

RCA PART NUMBER	DESCRIPTION	SPEC NO.
1605989-501	Module Assy ①	LCN05989
1605990-501	Module Assy	LCN05990
1605991-501	Module Assy	LCN05991
1605992-501	Module Assy	LCN05992
1605993-501	Module Assy	LCN05993
1605994-501	Module Assy	LCN05994
1605995-501	Module Assy ①	LCN05995
1605996-501	Module Assy	LCN05996
1605997-501	Module Assy	LCN05997
1605998-501	Module Assy ①	LCN05998
1605999-501	Module Assy ①	LCN05999
1605962-501	Module Assy	LCN05962
1601659-501	Sub-Module SU3008	LCN01659
1601660-501	Sub-Module SU3009	LCN01660
1601661-501	Sub-Module SU3010	LCN01661
1601662-501	Sub-Module SU3011	LCN01662
1601663-501	Sub-Module SU3012	LCN01663
1601664-501	Sub-Module SU3013	LCN01664
1601665-501	Sub-Module SU3014	LCN01665
1601666-501	Sub-Module SU3015	LCN01666
NA 2162	Core Stack	LCNA2162
2110052-504	Module Assy - Line Amplifier	LCV10052
2110055-504	Module Assy - Phase Detector	LCV10055
2110056-504	Module Assy - Input Coupler	LCV10056

① Approved by Contracting Officers letter 15 June 1966
② Approved by Contracting Officers letter 7 June 1967

Table 5-4. Critical Components Specifications (Cont)

RCA PART NUMBER	DESCRIPTION	SPEC NO.
2110057-504	Module Assy - Locked	LCV10057
2110058-504	Module Assy - Master	LCV10058
2110059-504	Module Assy - Cable①	LCV10059
2110060-504	Module Assy - Preamplifier	LCV10060
LIBRASCOPE PART NUMBER	**DESCRIPTION**	**SPEC NO.**
L200018052	Head Assy	LCV805L2
L408000504	Motor Assy	LCV050L4

① Approved by Contracting Officers letter 15 June 1966
② Approved by Contracting Officers letter 7 June 1967

5.2.6 Exhibit X - Standard Configuration Identification Numbers

Assignment and control of identification numbers was carried out in accordance with Section 10 of TP1314.

5.2.7 Exhibit XI - Identification and Acceptance of Equipments, Aerospace Facilities, Technical Orders, Engineering Data and Contract Documents

Engineering documentations, and drawings as applicable, were revised and/or generated to conform to the requirements of this Exhibit as interpreted in TP1314. One of the major elements associated with this Exhibit was the generation of engineering drawings for each deliverable computer program. Fifty-one (51) such drawings were prepared and released.

5.2.8 Exhibit XII - Engineering Release Record Requirements

The Engineering Release Record system in use prior to invocation of NPC 500-1 was modified to comply with the requirements of this Exhibit. A contract end item (CEI) and drawing tree index was prepared for each of sixteen (16) sites (as requested by NASA); Parts Application Records (PAR's) were expanded to define part numbers in terms of CEI numbers; Assembly Parts Lists (APL's) were generated to define part number of CEI's in terms of subordinate part numbers; additional miscellaneous reports and records were generated and maintained such as:

- Engineering Change Notice (ECN) Status Reports
- Serialization Records for CEI's and Serialized Assemblies

- Specification Identification Number Assignment Log
- Specification Change Notice and Log Maintenance
- ECP Status Records
- Field Change Records

5.2.9 Exhibit XIII - Requirements for Verifying the Incorporation of Class I Engineering Changes

In response to this Exhibit, RCA instituted additional procedures and controls to those already in effect for compliance with NPC 200-3, to complete the physical and documentation verification requirements of incorporation. The controls and procedures invoked are described in detail in Section 13 of TP1314.

5.2.10 Exhibit XIV - Formal Configuration Management Reviews, Inspections and Demonstrations

A First Article Configuration Inspection (FACI) was held in October 1965 at the RCA, Van Nuys facility in accordance with this Exhibit. No major discrepancy or problem areas were noted as a result of this review. As noted earlier, the Part II CEI specifications were revised and resubmitted following the review. The Product Configuration Baseline of the computer systems was established at the Review, and has been used as the basis for change documentation.

5.2.11 Exhibit XV and XVI - Configuration Identification and Accounting Reports Requirements and Configuration Management Data Requirements

Manually generated and maintained reports and records were compiled in accordance with the requirements of these two Exhibits. Subsequent contractual actions in mid-1966 directed RCA to compile and produce machine-generated configuration reports in accordance with MSFC-PROC-459. RCA initiated the necessary programs to compile the following reports on RCA's in-house 301 computer:

1. Configuration Identification Index Record (CIIR)
2. Configuration Status Accounting Report #1 (CSAR #1)
3. Configuration Status Accounting Report #2 (CSAR #2)
4. Configuration Status Accounting Report #3 (CSAR #3)
5. Configuration Status Accounting Report #4 (CSAR #4)
6. Configuration Status Accounting Report #5 (CSAR #5)

Of the above, only items 1, 2, 5, and 6 were actually compiled for delivery; programs for items 3 and 4 were developed in case of eventual need. These reports are currently submitted to NASA on a monthly basis under Contract NAS 8-15496.

SECTION 6

RELIABILITY PROGRAM

NPC 250-1, Reliability Program Provisions for Space Systems Contractors, was invoked on contract NAS 8-13007. In accordance with this document a reliability program plan was prepared to serve as the master planning and control document for the reliability program. This plan detailed the approach and stepwise procedure by which RCA would insure compliance with the provisions of NPC 250-1 and with the specific requirements of the contract. The plan was approved by NASA as section 4 of document TP1213-A, volume 3 in January 1965 and became part of the contract. With the inclusion of applicable requirements of contract Modification 13, the program plan was reissued as TP1213-B and approved by NASA on January 29, 1965.

The following paragraphs summarize the reliability program effort.

6.1 PARTS AND MATERIALS PROGRAM

This task was established as a continuation and up-dating of the program provided on the proceeding and over-lapping Saturn S1B contract. Parts already on the approved Master Parts List (RCA drawing No. 1004628A) formed the baseline for the SV Ground Computer System high reliability program. The primary continuation effort was the periodic review of part qualification data and new qualification or requalification as required by passage of time or equipment changes.

6.2 MAJOR VENDOR ASSEMBLIES

Revision 'A' of the Reliability Program plan (TP1213) carried over the same quality and workmanship specifications for major vendor assemblies as were invoked on the previous S1B contract. Modification 13 to contract NAS 8-13007, dated January 1965, authorized further upgrading of these requirements, on an individual basis, for each of the 14 major assembly contractors.

To implement subsequent review and control, the initial base lines of the application of these requirements was detailed in Section Seven (7.0) of each of the assembly specification control drawings. These base lines established those provisions applied, those provisions for which MSFC has approved substitutes or deviation and those provisions which were not applicable to the particular product. TP1213 was updated to Revision 'B' and the base-line sections for each of the 14 specification control drawings was incorporated into the Program Plan.

6.3 RELIABILITY ASSESSMENT

The reliability prediction models for the 110-A Ground Computer System were developed and submitted under contracts NAS 8-5423 and NAS 8-11582. These were identified as TP1256-A and TP1307 respectively. They were based upon failure rate data from the MSFC handbook "Components Failure Physics Analysis," dated 15 May 1963, and utilized a NASA supplied 'mission profile' to identify launch critical equipment.

The first reliability assessment effort was documented in a special report identified as TP1295 and submitted to NASA in May 1965. This consisted primarily of Field Failure data from Saturn I equipment (110 computer) which was delivered to NASA on previous contracts.

The first complete reliability assessment report on the 110-A Ground Computer System was prepared and submitted in April 1966. This was based upon the Unsatisfactory Condition Reports (UCR's) written against the 110-A systems from time of sell-off in the field to December 31, 1965, and included approximately 35,000 computer hours. Subsequent assessment report issues were:

- Issue 2, dated July 1966, covering operation through March 31, 1966
- Issue 3, dated February 1967, covering operation through September 30, 1966
- Issue 4, dated May 1967, covering operation through December 31, 1966

110-A Systems had accrued 141,000 computer operating hours by December 1966. To direct the reliability assessment closer toward a measure of launch mission success, issue No. 4 utilized only failure data from the SV 110-A Computer Systems located at Kennedy Space Center (KSC), computer hours at that location totaled 24,500. The summary results from assessment No. 4 showed the following:

	110-A	Data Link
• Current MTBF	217 hrs.	3,920 hrs.
• Future expected MTBF based on 'in mill' corrective action	288 hrs.	6,400 hrs.
• Predicted MTBF from TP1256-A and TP1307	418 hrs.	6,600 hrs.

Current and future reliability assessment is continuing under Contract NAS 8-15496. The Reliability Program Plan, TP1213-B, has been invoked and remains the controlling specification for tasks and documentation.

6.4 FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION

Failure reports (UCR's) prepared in the field by equipment user personnel are utilized in a data control and analysis program as described in the program plan. Saturn program requirements in

the fall of 1965 introduced the requirement for a separate, documented analysis and problem closure for each failure report (UCR). This resulted in RCA completing a NASA Form 498 (CAR) for each UCR in contrast with previous effort which had dealt only with groups of failures and analysis of trends.

Highlights of failure analysis and corrective action were reported in the monly Reliability Progress Reports* along with UCR /CAR cumulative status. On 1 July 1967 this status was as follows:

- UCR's received to 1 July 1967 - 5, 914
- UCR's closed by CAR - 5, 583
- Open UCR's requiring closure - 331

6.5 DOCUMENTATION

The formal reporting to NASA existed as the required documentation specified in the program plan. Section 7 of this summary report records the history of transmittal of the required data which is peculiar to the reliability program. Figure 6-1 illustrates the reliability program data flow which was developed on this contract for performance and reporting of program plan tasks.

6.6 FOLLOW-ON EFFORT

The reliability program for contract NAS 8-13007 was designed to form a common program with those of prior related contracts (NAS 8-5423, 5433 and 11582. In addition, to provide the greatest assurance of achieving the desired operational reliability in future launch missions, the applicable tasks from this plan were continued in the follow-up contract NAS 8-15496. Reliability Program Plan TP1213-B, volume 3, therefore continues the Failure Analysis, Corrective Action, Assessment, and Maintenance of reliability history for the Saturn 110-A Ground Computer System performed on this program.

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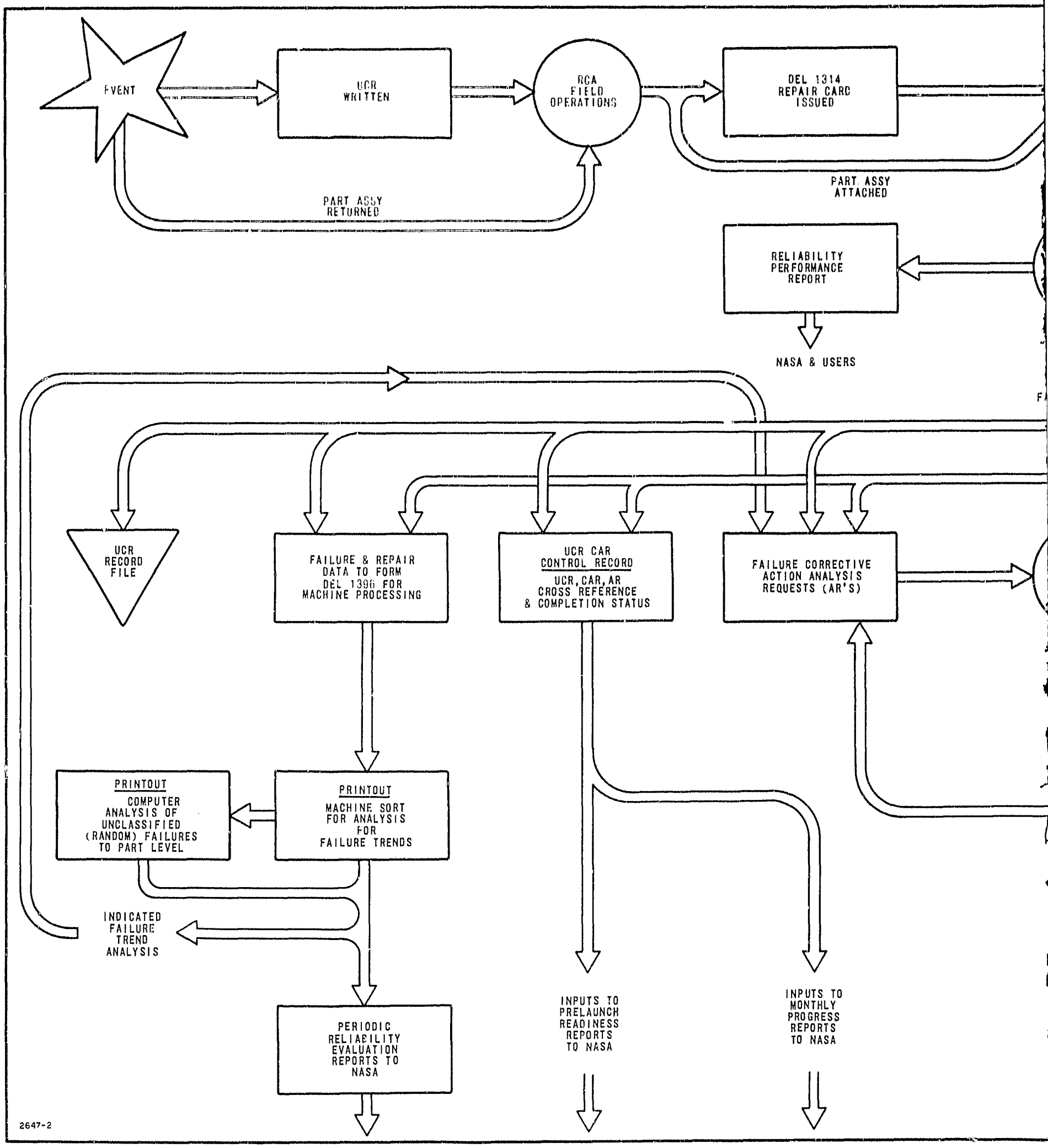
*From July 1966 the Monthly Reliability Progress Reports were addressed to Contract NAS 8-15496 in place of NAS 8-13007



Foldout Frame 1

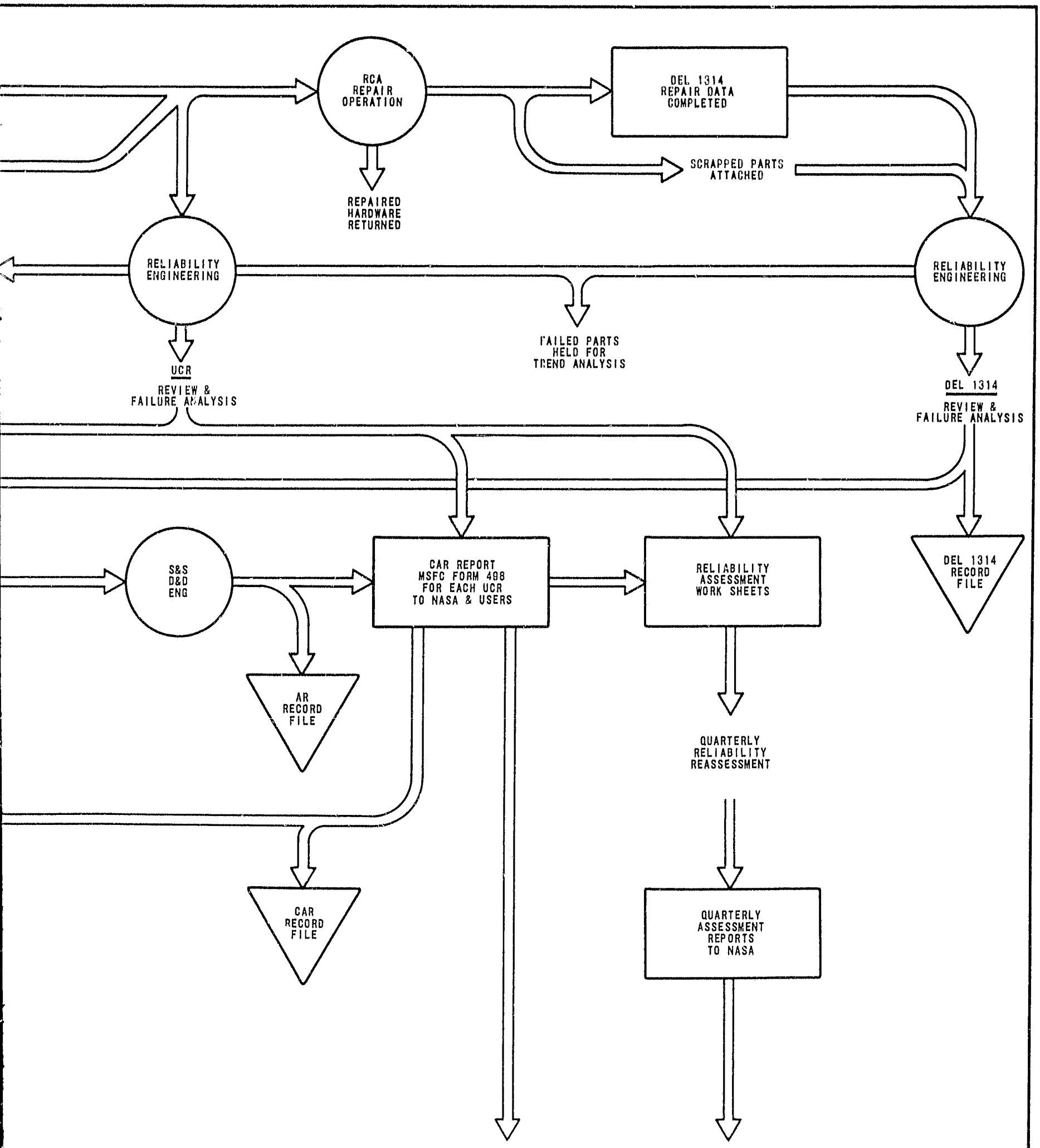


Figure 6-1. Reliability Program Data Flow

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SECTION 7

DOCUMENTATION

Documentation submitted under contract NAS8-13007 consisted of: monthly progress reports, reliability evaluation program reports, special technical reports, test procedures, technical manuals, and programming manuals. A list of drawings, test procedures, and manuals supplied is presented in table 7-1.

7.1 REPORTS AND REVIEWS

A Monthly Progress Report was submitted to NASA every month for the duration of the contract. In addition to these reports, other various contractually required reports and reviews were formally transmitted to NASA during the course of the subject contract.

7.2 TECHNICAL MANUALS

Four types of technical manuals were supplied to NASA under contract NAS8-13007. The manuals are defined as follows:

- Saturn Ground Computer System Instruction Manual
- Saturn Ground Computer System Illustrated Parts Breakdown
- Saturn Module Data Handbook
- Saturn Ground Computer System Programming Manuals

Table 7-1. Data Transmittal

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
1	1	Set-Saturn V Computer System drawings per shipping list 2101066 which includes the following: a) Power Distribution Schematics, both "D" and "B" size b) Logic Summaries, "A" size only c) Schematic Diagrams, both "D" and "B" size		

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
1	1	d) Wire Connection Lists, "A" size only e) Module Assembly Drawings "B" size only f) Module Schematic Drawings, "B" size only g) Specification Control Drawings, Vendor Assemblies "A" size only		
2	5	Set-Manuals (per below)		
		Saturn Data Link Terminal Instruction Manual		TP1241
		Saturn Data Link Terminal I. P. B.		TP1242
		RCA 110A Computer Mathematical Subroutines		TP1265
		RCA 110A Computer Test/Maintenance and Utility Routine		TP1266
		Saturn Ground Computer System Instruction Manual Volume 1 - Description, Installation, Operation Principles of Operation and Maintenance Volumes 2 & 3 - Circuit Diagrams		TP1270
		Saturn Ground Computer System Vendor Manuals Volumes 1 thru 6		TP1271
		RCA 110A Computer SV Module Tester Manual		TP1272
		Saturn Ground Computer System Illustrated Parts Breakdown		TP1261
		Saturn Module Data Handbook		TP1262
		RCA 110A Computer Programmers Reference Manual		TP1263
3	2	Card Deck-Saturn V Demonstration Test Program		
		Executive Routine	CDV86600	2186600
		Core	CDV86601	2186601

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
3	2	Instruction	CDV86602	2186602
		Drum	CDV86603	2186603
		Typewriter	CDV86604	2186604
		Priority Interrupt	CDV86605	2186605
		Magnetic Tape	CDV86606	2186606
		Line Printer	CDV86607	2186607
		Interval Timer	CDV86608	2186608
		Card Punch and Reader	CDV86609	2186609
		Paper Punch and Reader	CDV86610	2186610
		Discrete Input/Output - Cabinets 7 and 8	CDV86611	2186611
		Discrete Input/Output - Monitor Mode	CDV86612	2186612
		Display IODC	CDV86614	2186614
		Analog Input/Output	CDV86615	2186615
		Data Link - Special Test Mode	CDV86613	2186616
		Data Link Acceptance	CDV86617	2186617
		Data Link - Two Computer Demonstration	CDV86618	2186618
		DDAS IODC	CDV86619	2186619
		Simultaneous IODC Demonstration	CDV86620	2186620
		110A Computer Test Panel	CDV86621	2186621
		Display IODC - Saturn V	CDV86622	2186622
		Discrete Input Test - Cabinet 7	CDV86623	2186623
		IOR and TPC Register	CDV86675	2186675
		Discrete System Tests	CDV86676	2186676
4	2	Set-Saturn V Demonstration Test Program		
		Executive Routine		2186600
		Core		2186601
		Instruction		2186602
		Drum		2186603
		Typewriter		2186604
		Priority Interrupt		2186605
		Magnetic Tape		2186606
		Line Printer		2186607
		Interval Timer		2186608

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
4	2	Card Punch and Reader		2186609
		Paper Punch and Reader		2186610
		Discrete Input/Output - Cabinets 7 and 8		2186611
		Discrete Input/Output - Monitor Mode		2186612
		Display IODC		2186614
		Analog Input/Output		2186615
		Data Link - Special Test Mode		2186616
		Data Link Acceptance		2186617
		Data Link - Two Computer Demonstration		2186618
		DDAS IODC		2186619
		Simultaneous IODC Demonstration		2186620
		110A Computer Test Panel		2186621
		Display IODC - Saturn V		2186622
		Discrete Input Test - Cabinet 7		2186623
		IOR and TPC Register		2186675
		Discrete System Tests		2186676
5	1	Parts Application Record		2112138
6	2	System Requirements and Acceptance Specification for SV Ground Computer System		2186699
7	2	Card Decks - Program Libraries		
		Test/Maintenance & Utility Routine, Sense Switch Test	CDV86624	2186624
		Test/Maintenance & Utility Routine, Program & Data Punch	CDV86625	2186625
		Test/Maintenance & Utility Routine, Program & Data Loader	CDV86626	2186626
		Test/Maintenance & Utility Routine, Binary to Decimal	CDV86627	2186627
		Test/Maintenance & Utility Routine, Decimal to Binary	CDV86628	2186628
		Test/Maintenance & Utility Routine, Decimal Memory Dump	CDV86629	2186629
		Test/Maintenance & Utility Routine, Octal Memory Dump	CDV86630	2186630
		Test/Maintenance & Utility Routine, Post Mortem Compare Print	CDV86631	2186631

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
7	2	Test/Maintenance & Utility Routine, Display Console Debug Program	CDV86632	2186632
		Test/Maintenance & Utility Routine, Trace	CDV86633	2186633
		Mathematical Subroutine, Sine/Cosine	CDV86634	2186634
		Mathematical Subroutine, Square Root	CDV86635	2186635
		Mathematical Subroutine, Exponential (2, e, 10)	CDV86636	2186636
		Mathematical Subroutine, Arctangent	CDV86637	2186637
		Mathematical Subroutine, Log X (2, e, 10)	CDV86638	2186638
		Mathematical Subroutine, binary Coded decimal to floating point binary	CDV86639	2186639
		Mathematical Subroutine, Floating Point binary to BCD floating format	CDV86640	2186640
		Mathematical Subroutine, Floating Point add or subtract	CDV86641	2186641
		Mathematical Subroutine, Floating Point multiplication	CDV86642	2186642
		Mathematical Subroutine, Floating Point divide	CDV86643	2186643
		Mathematical Subroutine, Floating Point square root	CDV86644	2186644
		Mathematical Subroutine, Floating Point sine or cosine	CDV86645	2186645
		Mathematical Subroutine, Floating Point Arctangent	CDV86646	2186646
		Mathematical Subroutine, Floating Point common logarithm or Natural logarithm	CDV86647	2186647
		Mathematical Subroutine, Floating Point exponential, E^X	CDV86648	2186648
		Mathematical Subroutine, Floating Point tangent or contangent	CDV86649	2186649
		Mathematical Subroutine, double Precision divide	CDV86650	2186650
8	2	Programs - Program libraries Test/maintenance & utility routine, sense Switch test		2186624

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
8	2	Test /maintenance & utility routine, program & data punch		2186625
		Test /maintenance & utility routine, program & data Loader		2186626
		Test /maintenance & utility routine, binary to decimal		2186627
		Test /maintenance & utility routine, decimal to binary		2186628
		Test /maintenance & utility routine, decimal Memory dump		2186629
		Test /maintenance & utility routine, octal Memory dump		2186630
		Test /maintenance & utility routine, post Mortem compare print		2186631
		Test /maintenance & utility routine, display Console debug program		2186632
		Test /maintenance & utility routine, trace		2186633
		Mathematical subroutine, sine /cosine		2186634
		Mathematical subroutine, square root		2186635
		Mathematical subroutine, exponential (2, e, 10)		2186636
		Mathematical subroutine, arctangent		2186637
		Mathematical subroutine, Log X (2, e, 10)		2186638
		Mathematical subroutine, binary coded Decimal to floating point binary		2186639
		Mathematical subroutine, floating point Binary to BCD floating format		2186640
		Mathematical subroutine, floating point add or subtract		2186641
		Mathematical subroutine, floating point Multiplication		2186642
		Mathematical subroutine, floating point Divide		2186643
		Mathematical subroutine, floating point Square root		2186644
		Mathematical subroutine, floating point Sine or cosine		2186645
		Mathematical subroutine, floating point Arctangent		2186646

Table 7-1. Data Transmittal (Cont)

ITEM	QTY.	DATA DESCRIPTION	SPEC ID NO.	REFERENCE
8	2	Mathematical subroutine, floating point Common logarithm or natural logarithm		2186647
		Mathematical subroutine, floating point Exponential, E^x		2186648
		Mathematical subroutine, floating point tangent or cotangent		2186649
		Mathematical subroutine, double Precision divide		2186650
		SPEC for Saturn V Computer Programs		2186653
9	1	RCA 110A computer system preventative Maintenance check list		TP1321
		Packing design-best commercial practice or per specification ID number where applicable.		

A brief description of the contents of the technical manuals is presented in the following paragraphs while a list of the specific technical manuals supplied under this contract is presented in table 7-2. Five copies of each manual were delivered with each Saturn SV Ground Computer System shipped to NASA.

Table 7-2. Technical Manuals

TP NUMBER	VOLUME	TITLE
1270	1	Saturn Ground Computer System Instruction Manual
1270	2	Saturn Ground Computer System Instruction Manual
1270	3	Saturn Ground Computer System Instruction Manual
1261	-	Saturn Ground Computer System Illustrated Parts Breakdown
1262	-	Saturn Module Data Handbook
1263	-	RCA 110A Computer Programmers Reference Manual
1264	1	RCA 110A Computer SLAP 2 System
1264	2	RCA 110A Computer SLAP 2 System

Table 7-2. Technical Manuals

TP NUMBER	VOLUME	TITLE
1265	-	RCA 110A Computer Mathematical Routines
1266	-	RCA 110A Computer Test/Maintenance and Utility Routines
1267	-	RCA 110A Computer SLAP 2 Programmers Reference Manual
1321		System Preventive Maintenance Checklists
1343		SLAP 2 Added Capabilities Programmers Reference Manual
1365		LAMBDA Power Supplies IM
1366		Soroban Paper Tape Perforator IM
1367		Ferranti Paper Tape Reader IM
1368		Librascope Data Storage Magnetic Drum IM
1369		Burroughs Punched Card Reader IM
1370		RCA Needham Core Memory Unit IM
1371	1	Ampex Tape Memory System IM
1371	2	Ampex Tape Memory System IM
1372		Soroban Card Punch IM
1373	1	Redcor Analog Processing and Conversion Assembly IM
1373	2	Redcor Analog Processing and Conversion Assembly IM
1374		ANelex Line Printer Converter Unit IM
1375		Card Reader (Hickok P/N 906-064) IM
1376		Positive High Voltage Power Supply (Transval P/N 517)
1377		Negative High Voltage Power Supply (Transval P/N 518)
1378		Direct Current Amplifier (Burr-Brown P/N 9587)
1379		Voltage Reference Power Supply (Viking P/N 151-2092-013)
1380		Keyboard (Invac P/N 50-38-002)

7.2.1 Saturn Ground Computer System Instruction Manual (TP1270)

The instruction manual contains a narrative description of equipment operation, a description of functional organization of the equipment, complete maintenance instructions for the Saturn SV Ground Computer System, instructions on special programming considerations and specific operating instructions. In addition, the instruction manual contains system operation information, with information peculiar to any equipment being provided only when required for clarity of the system instructions. Included are system turn-on, operation, turn-off, and system operator maintenance. Logic diagrams, schematic diagrams, power distribution diagrams, module locator charts, wire connection information, and cable configuration data are also supplied for each piece of equipment.

Information concerning each piece of commercial equipment used in the Saturn SV Ground Computer System is also contained in instruction manual.

7.2.2 Saturn Ground Computer System Illustrated Parts Breakdown (TP1261)

This publication lists, describes, and locates (by illustration) parts used in the Saturn SV Ground Computer System manufactured as Part No. 2112000-508 through -524 under contract NAS8-13007.

7.2.3 Saturn Module Data Handbook (TP1262)

This manual contains the description and circuit parameters of the modules used in the Saturn SV Ground Computer Systems. The manual specifies the type and number of each component for each circuit supplied in the system.

7.2.4 Programming Manuals

Five programming manuals were supplied. The technical publications (TP) numbers and titles of these manuals are listed in table 7-2.

7.2.4.1 RCA 110A Computer Programmers Reference Manual (TP1263)

The RCA 110A Computer Programmers Reference Manual contains information on the RCA 110A Computer programming including, input/output equipment programming considerations, definitions of the RCA 110A Computer organization, and the instruction repertoire. A complete explanation of operation techniques used in program loading and data loading is presented in the operation section of this manual. In addition, the manual also contains a complete description of the automatic priority interrupt system available on the RCA 110A Computer.

7.2.4.2 RCA 110A Computer SLAP 2 System (TP1264)

The RCA 110A Computer SLAP 2 System manual contains a complete description of the SLAP 2 Programming System including detailed flow charts and program listings.

7.2.4.3 RCA 110A Computer Mathematical Routines (TP1265)

The RCA 110A Computer Mathematical Routines manual contains mathematical subroutines which are used to assist both the RCA 110A Computer programmer and the machine operator in the writing and debugging of programs. Each subroutine includes a description flow chart, and a symbolic listing.

7.2.4.4 RCA 110A Computer Test/Maintenance and Utility Routines (TP1266)

The RCA 110A Computer Test/Maintenance and Utility Routines manual presents routines which are used to assist the RCA 110A Computer programmer and machine operator in the writing and

debugging of test programs and the identification of machine malfunctions. Complete instructions on the operating techniques necessary to use each routine are included in the manual.

7.2.4.5 RCA 110A Computer SLAP 2 Programmers Reference Manual (TP1267)

The RCA 110A Computer SLAP 2 Programmers Reference Manual describes the programming and operating characteristics of the RCA 110A SLAP 2 System. Information is presented to facilitate the preparation of symbolic programs, and to enable the programmer in assembling, debugging, loading, editing, and running these programs. Included in this manual are appendices which summarize the permissable instruction mnemonics, pseudo operations, and control cards.

7.2.5 Redline Manuals

In accordance with Contract Modification 56 addition instruction manuals, referred to as Redline manuals, were supplied. These manuals were supplied in quantity of two for each site, and were intended for use as master copies which would be used to record the designated site field changes and configuration. Before these manuals were released to the field they were reviewed and updated to include the latest equipment configuration in affect at the time indicated on the configuration control sheet included in each manual. In addition these manuals were updated and kept current as field changes dictated and were not permitted to lag behind the actual equipment configuration. Table 7-2 lists numbers and titles of manuals supplied.

SECTION 8

INSTALLATION

8.1 INSTALLATION PLANS AND EQUIPMENT ALLOCATIONS

An installation plan was prepared for each of the Saturn SV Ground Computer Systems and submitted to NASA. Each plan covered the equipment shipment and handling, and included the detailed requirements and schedule for installation of the systems. Each site was inspected for compliance with RCA drawing 2112021, Installation Specification, and any discrepancies were noted in the Installation Plan.

Equipment handling and emplacement at Huntsville, Alabama was sub-contracted to T. D. Little Co., and at Cape Kennedy, Florida Zero Manufacturing Co. Chechout of all installations was conducted by RCA.

Table 8-1 lists the pertinent drawings generated by RCA to define the system installations and includes the site inspection and computer system "sell-off" dates. There were no significant problems relating to the computer systems in regard to installation. Problems and delays were encountered in relation to the availability of electrical power and required cooling at some of the sites. These problems were corrected and the systems have been operating satisfactorily.

Due to the NASA program requirements, some system locations were changed and individual equipment cabinets and assemblies were diverted or exchanged. A summary of these changes follows:

a. System 2112000-517 was initially installed at Qualification Lab 500 FS Huntsville, Alabama in November 1964. This system was later removed and reinstalled at Douglas Aircraft Co. facility 500 FS at Huntington Beach, California in March 1965. The system was removed from Huntington Beach in January 1966 and reinstalled in

Table 8-1. Saturn SV Ground Computer System, Key Drawings and Installation Data

SGCS Site 2112000-	NASA Site		NASA Floor Layout MSFC Dwg No. 50M33777	Key Drawings & Data - Saturn Ground Computer System & Display Installations 30 Dec 65/ Rev 1					Site Inspected	Installation & S/O Complete
	Name	Loc	SH/ REV	Installation Kit Dwg. No	D. C. Power Distr Assy Dwg No.	A. C. Power Distr Assy Dwg No.	System Cable Distr-Sig & Test Dwg No.	Conduit Assy A. C. Distr Dwg No.		
-508	S-1C C/ O Michoud, Room 2 S-V	New Orleans	9/ A	2133961-501	2134151-501	2134137-501	2134155-501	2134133-507	2/ 65	6/ 65
-509	Blkhs Complex 34 (VLF 34/ LCC)	KSC	10/ A	2133964-501	2134151-501	2134138-501	2134155-503	2134133-506	4/ 65	6/ 65
-510	AGCS Bldg Complex 34	KSC	11/ A	2133965-501	2134151-501	2134138-501	2134155-503	2134192-505	5/ 65	6/ 65
-511	S-1C C/ O Michoud, Room 1 S-V	New	21/ 0	2133962-501	2134151-501	2134137-501	2134155-501	2134133-507	2/ 65	7/ 65
-512	Test Lab S-V, MSFC	HSVL	12/ 0	2133966-501	2134151-501	2134137-501	2134155-506	2134133-507	3/ 65	6/ 65
-513	S-V B/ B Lut (Bldg 4708, MSFC)	HSVL	6/ G	2133967-501	2134157-501	2134139-502	2134155-511	2134192-503	2/ 65	8/ 65
-514	Mila Test Spt Area Complex 39	KSC	13/ D	2133960-501	2134151-501	2134140-501	2134155-507	2134192-501	6/ 65	4/ 66
-515	Complex 39, F RM 1 (VLF 39/ LCC1)	KSC	16/ B	2133970-501	2134157-501	2134139-501	2134155-504	2134192-504	6/ 65	11/ 65
-516	Miss. Test Facility (Bldg. 4210, RM 113)	MISS.	18/ 0	2133973-501	2134151-501	2134137-501	2134155-508	2134133-508	10/ 65	2/ 66
-517	Complex 39, LUT #2 (VLF 39/LUT2)	KSC	19/ A	2133958-501	2134157-501	2134139-501	2134155-505	2134192-506	1/ 66	10/ 66
-518	Complex 39, LUT #1 (VLF39/LUT1)	KSC	19/ A	2133956-501	2134157-501	2134139-501	2134155-505	2134192-506	6/ 65	12/ 65

Table 8-1. Saturn SV Ground Computer System, Key Drawings and Installation Data (Cont)

SGCS Site 2112000-	NASA Site		NASA Floor Layout MSFC Dwg No. 50M33777	Key Drawings & Data - Saturn Ground Computer System & Display Installations 30 Dec 65/ Rev 1					Site Inspected	Installation & S/O Complete
	Name	Loc	SH/REV	Installation Kit Dwg No.	D. C. Power Distr Assy Dwg No.	A. C. Power Distr Assy Dwg No.	System Cable Distr-Sig & Test Dwg No.	Conduit Assy A. C. Distr Dwg No.		
-519	Blkhs Complex 37 (VLF 37/LCC)	KSC	14/ B	2133968-501	2134151-501	2134138-501	2134155-510	2134155-510	12/ 65	2/ 66
-520	Complex 37/ AGCS BLDG(VLF37/ AGCS)	KSC	15/ D	2133969-501	2134151-501	2134138-501	2134155-503	2134192-505	12/ 65	1/ 66
-521	Complex 39, F RM 2 (VLF 39/LCC 2)	KSC	16/ B	2133971-501	2134157-501	2134139-501	2134155-504	2134192-504	8/ 66	10/ 65
-522	Lab Support No. 2 ASTR Lab	HSVL	22/ A	2134491-501	2134157-501	2134139-502	2134155-505	2134192-509	1/ 66	2/ 66
-523	Complex 39, F RM 3 (VLF 39/LCC 3)	KSC	16/ B	2133972-501	2134157-501	2134139-501	2134155-504	2134192-504	1/ 67	5/ 67
-524	Complex 39, LUT #3 (VLF 39/LUT 3)	KSC	19/ A	2133957-501	2-34157-501	2134139-501	2134155-505	2134192-506	1/ 67	4/ 67

a. Complex VLF 39 LUT No. 2 at Kennedy Space Center where it was finally sold-off in February 1966.

b. Two Slave Tape Stations were added to systems 2112000-515, -521, and 523 installed at VLF 39/LCC No. 1, VLF 39/LCC No. 2, and VLF 39/LCC No. 3 respectively.

c. Tape stations at sites VLF 39/LUT No. 1, VLF 39/LUT No. 2, and VLF 39/LUT No. 3 were modified to provide front air delivery.

8.2 EQUIPMENT LAYOUT

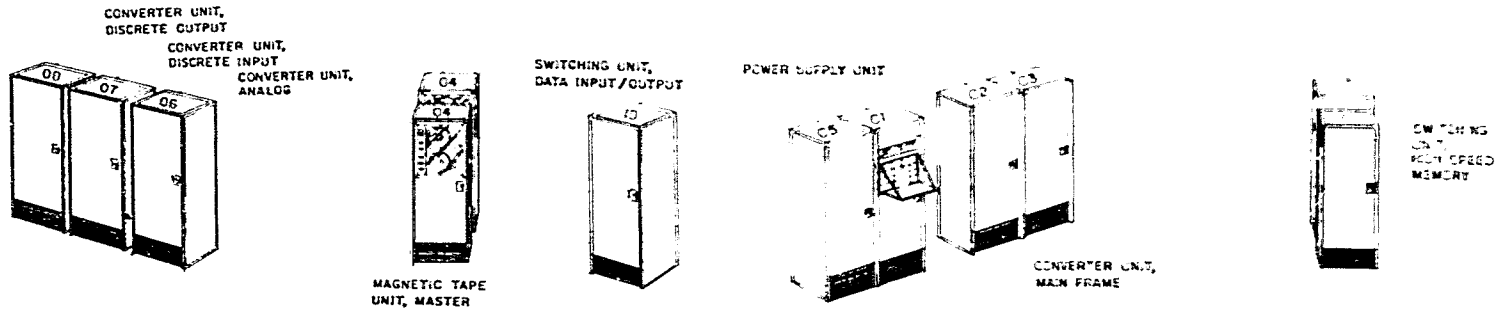
A typical Saturn SV Ground Computer System is shown in figure 8-1. Equipment complements for specific systems are given in table 1-2, Section 1.

Unit 0101 (power supply unit) and unit 0201 (main frame unit) each consists of two cabinets joined at their sides and having common internal cabling. The cabinets comprising each of these units may be separated, if necessary, during the initial equipment setup phases, but may not be separated or reversed in the final site configuration.

The maximum lengths of intercabinet cables provide significant restrictions to the relative placement of units 1201 through 1601. The standard and maximum intercabinet cable lengths are listed in table 8-2.

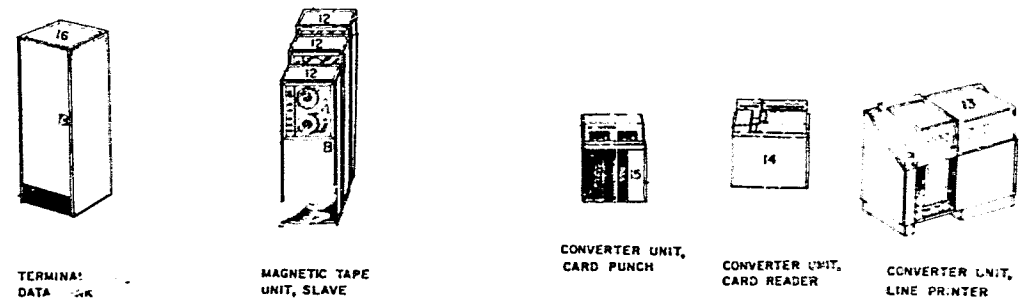
Table 8-2. Intercabinet Cable Lengths

FROM CABINET	TO CABINET	CABLE LENGTHS (FEET)	
		STANDARD	MAXIMUM
04	12	16	75 (TOTAL)
12	12	11	
10	13	20	30
10	14	20	30
10	15	20	30
10	16	30	100



UNIT 0801	UNIT 0701	UNIT 0601	UNIT 0402	UNIT 0401	UNIT 1001	UNIT 0101	UNIT 0201	UNIT 1101	UNIT 1102

UNIT 1601	UNIT 1203	UNIT 1202	UNIT 1201	UNIT 1501	UNIT 1401	UNIT 1301



Note:

Unit Numbers shown on type of configuration

*At sites where Unit [illegible] is not supplied, Unit [illegible] occupies that particular location

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Figure 8-1. Typical Saturn Ground Computer System

8.2.1 Power Requirements

The primary power requirements of the Saturn SV Ground Computer System are shown in table 8-3. The total power consumption of the system of the configuration shown in figure 8-1 is 76 kva (62 kw), 120/208 vac, 60 cps, 3 phase. Additional requirements are given below:

- Frequency variation should not exceed ±1 cps (1.67%).
- Voltage variations should not exceed 10% of the values specified in table 8-3.
- Harmonic distortion, line-to-line, should not exceed ±10%.
- Voltage phase angle unbalance, line-to-line, should not exceed ±3 degrees.
- The line-to-line amplitude of voltage unbalance should not exceed ±10%.

8.2.2 Con-Duct Distribution System

Intercabinet signals and dc power are distributed through an rf-shielded system of rectangular conduit duct modules, called con-ducts, which are sealed to each cabinet interface and suspended beneath the equipment room flooring (see figures 8-2 and 8-3). The modular design of the con-ducts permits the distribution system to be readily adapted to accommodate any of the different site layouts.

The main dc power levels (+26v, -26v, and -6.5v) are distributed through three electrically isolated, one-inch-square, copper bus bars contained in the con-duct assembly. Power is conducted to the busses by flexible cables from the connector interface of the power supply unit (unit 0101). The other dc operating power levels are distributed through flexible rf-shielded cables contained in the con-duct assembly. Intercabinet signals are distributed through unshielded cables which are also contained in the con-duct assembly.

8.2.3 AC Power Distribution System

The primary site power is connected to the computer system at a bank of ac filters located beneath the equipment room flooring (see figure 8-2). The filtered ac power is then distributed through standard, rigid-wall conduit, independent of the con-duct distribution system (see figure 8-4). Flexible, shielded conduit connects the rigid-wall conduit assembly to the cabinet connector interfaces through a conduit junction box located beneath each cabinet.

Table 8-3. System Primary Power and Cooling Requirements and Power Interface Locations

UNIT	NOMENCLATURE	REQ'D PRIMARY POWER	WALL BREAKER RECOMMEN-DATIONS	LINE FILTER LOCATION	HEAT LOAD REFRIG-ERATION	COOLING AIR REQUIRED
0101	Power Supply Unit	60 KVA, 49KW 208 VAC 60 CPS 3 Phase	Qty (1) 3 Pole 225 Amp	Under Cab 05	40 KW 11.36 tons	8,750 CFM
0201	Converter Unit, Main Frame					
0401	Magnetic Tape Unit, Master					
0402	Magnetic Tape Unit, Master					
0601	Converter Unit, Analog					
0701	Converter Unit, Discrete Input					
0801	Converter Unit, Discrete Output					
1001	Switching Unit, Data Input/Output					
1101	Switching Unit, Hi-Speed, Memory					
1102	Switching Unit, Hi-Speed, Memory					
1201	Magnetic Tape Unit, Slave	1.63 KVA, 1.5KW 120 VAC	1 Pole 20 Amp	Inside Cab. 12	1.0 KW 0.28 tons	350 CFM
1202	Magnetic Tape Unit, Slave	1 63 KVA, 1.5KW 120 VAC	1 Pole 20 Amp	Inside Cab. 12	1.0 KW 0.28 tons	350 CFM
1203	Magnetic Tape Unit, Slave	1.63 KVA, 1.5KW 120 VAC	1 Pole 20 Amp	Inside Cab. 12	1.0 KW 0.28 tons	350 CFM
1301	Converter Unit, Line Printer	2.00 KVA 1.5KW 120 208 VAC	3 Pole 15 Amp	Under Cab. 13	1.5 KW 0.43 tons	500 CFM (room air)
1401	Converter Unit, Card Reader	1.44 KVA 1.1KW 120 VAC	1 Pole 20 Amp	Under Cab. 14	1.1 KW 0.31 tons	600 CFM (room air)
1501	Converter Unit, Card Punch	4.00 KV A 2.8 KW 120 208 VAC	3 Pole 20 Amp	Under Cab. 15	2.8 KW 0.8[illegible] tons	500 CFM (room air)
1601	Terminal Unit, Data Link	3.45 KVA 2.6KW 120 VAC	1 Pole 40 Amp	Under Cab. 16	2.6 KW 0.74 tons	700 CFM
Totals for a Typical System as Shown in Figure 8-1		75.78 KVA 61.5 KW	Qty (8)	See Figure 8-2	51.0 KW 15.02 tons	12,100 CFM

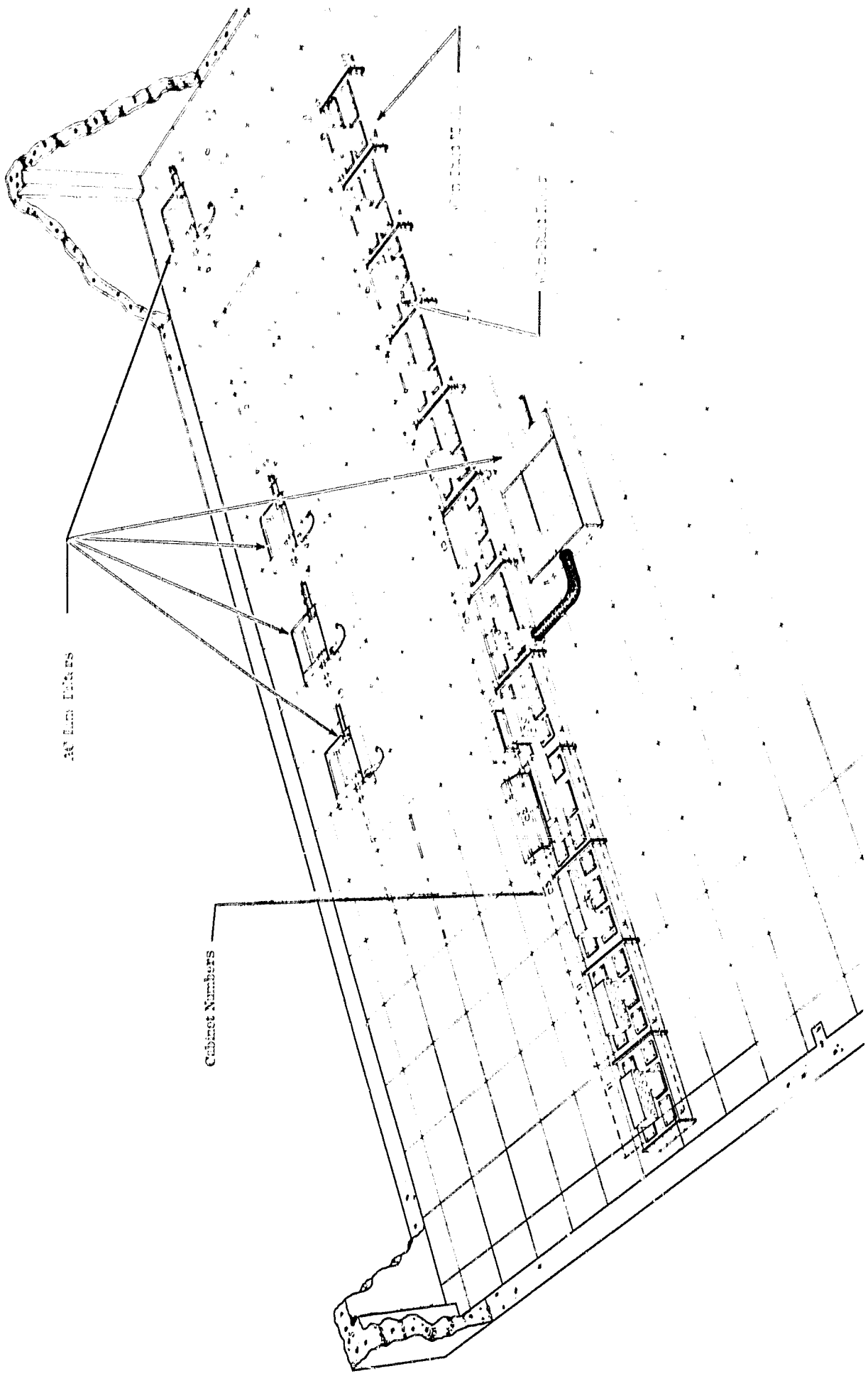


Figure 8-2. Typical Con-Duct, Riser and AC Filter Installation

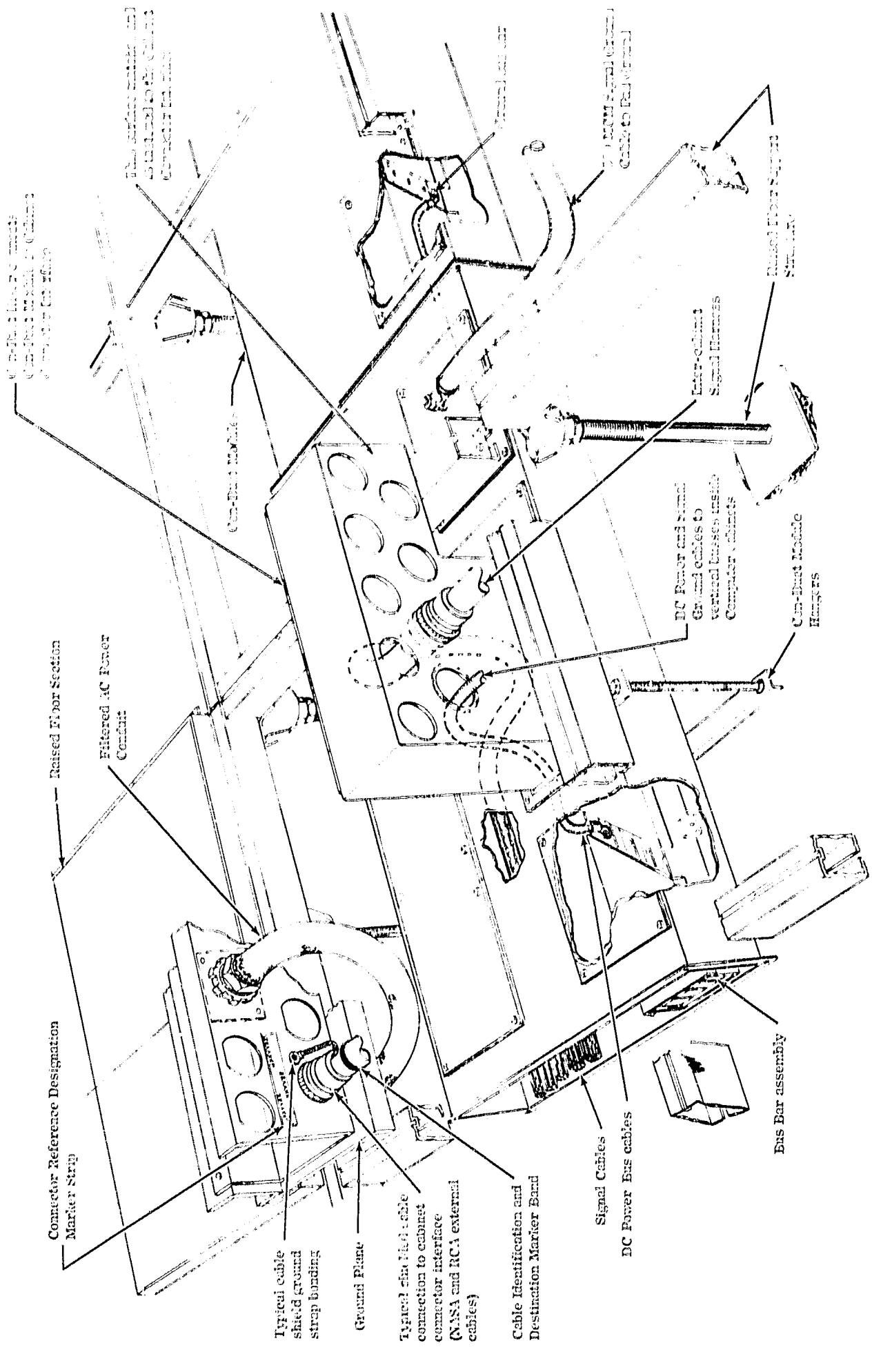


Figure 8-3. Typical Con-Duct Module

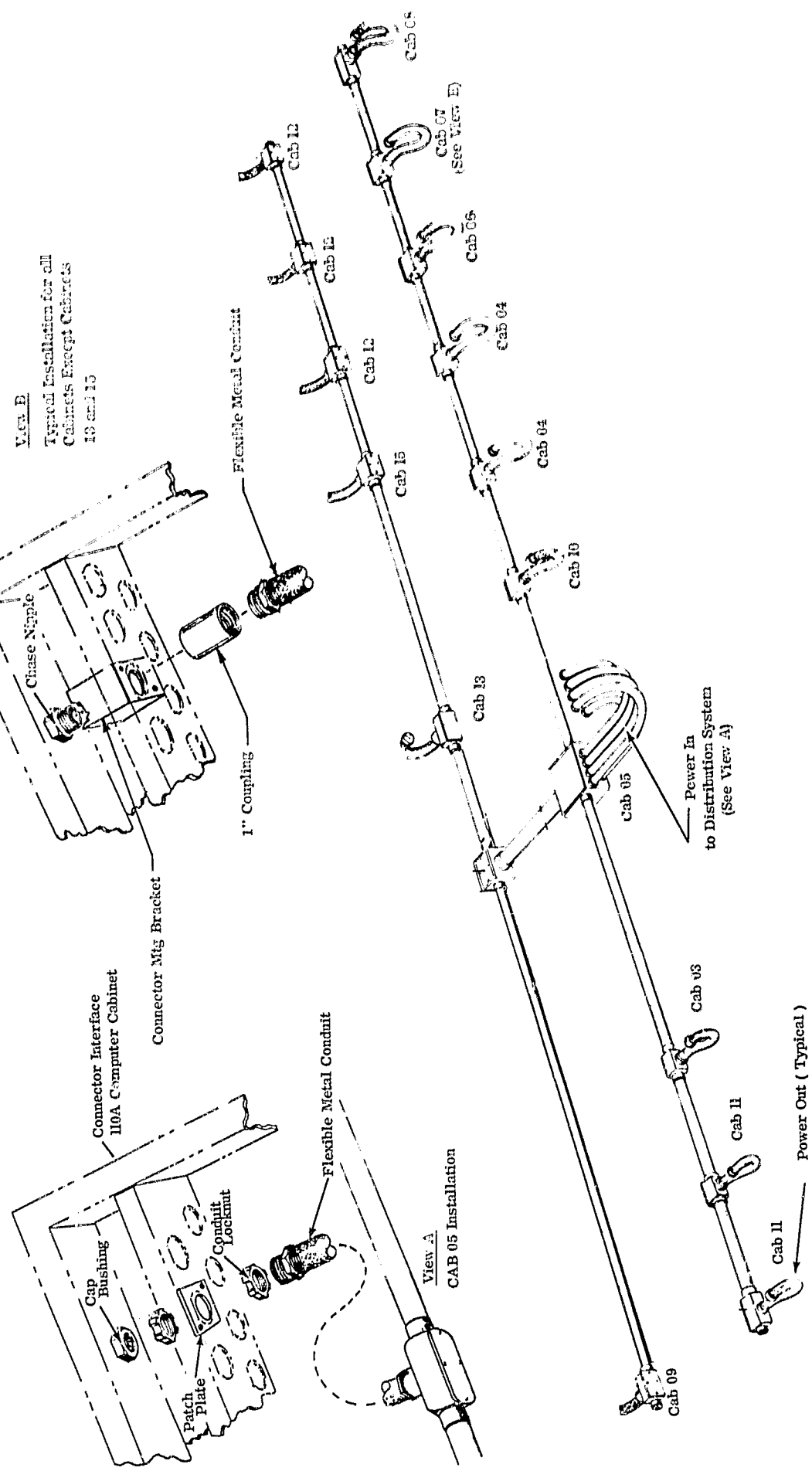


Figure 8-4. Typical AC Distribution System

8.2.4 Flooring Requirements

The bottom air and cable entries of the Saturn Ground Computer System cabinets required a raised-floor equipment room construction. The floor tile supporting structure provides support along all four sides of each tile rather than just supporting each corner. When the front and rear load-bearing areas of the equipment bases rest on solidly supported floor, no support is necessary under the sides of the equipment bases. Otherwise, additional supporting structures are required. See figure 8-5 for the required cabinet locations relating to floor tile support structures and other constraints on the support structure size.

8.3 NASA/RCA POWER INTERFACE

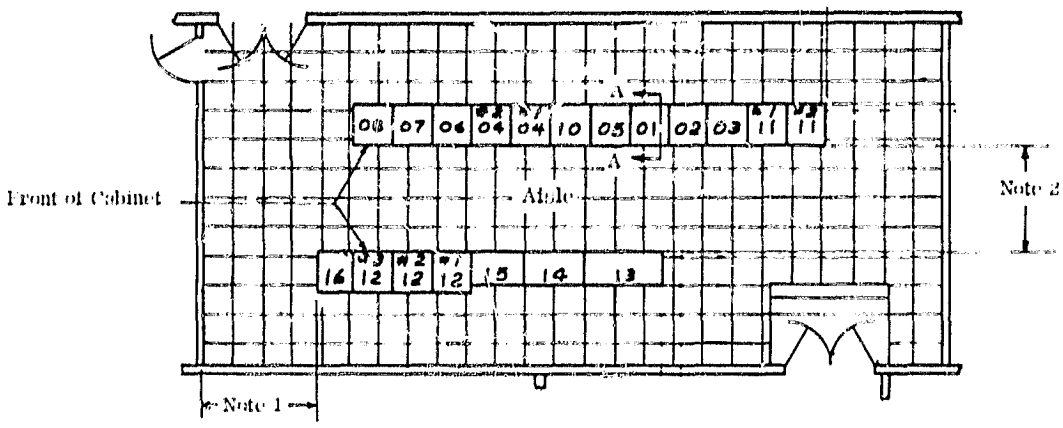
The input power wiring from the equipment room main circuit breaker panel to the computer system line filters is provided by NASA. The power is wired as outlined in the following paragraphs, 8.3.1 through 8.3.4.

8.3.1 Main Frame Power

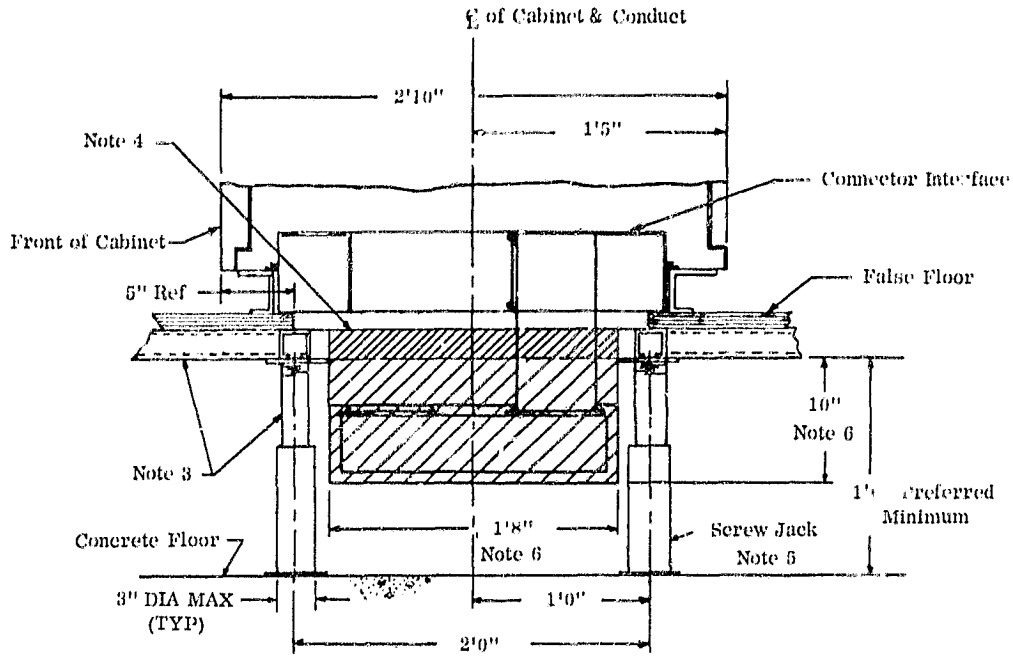
The main line filters of the computer system are located behind cabinet 05 (unit 0101) in an rf-shielded enclosure. Power to these filters is supplied with four AWG 4/0 type R of T cables installed in conduits (see detail A, figure 8-6). The cable terminations are 90 degree angle tongue lungs which fit the 3/8-inch line filter input terminal studs. Each phase leg and the neutral leg terminates at a separate filter (see figure 8-6). All power wiring from the filters to the computer system is provided by RCA.

8.3.2 Input/Output Equipment Power Interfaces

Power to units 1301, 1401, and 1501 is supplied in a manner similar to that described for the main frame unit input, except for the number of leads and wires sizes to each unit. See table 8-3 for power requirements for each of these units, figure 8-6 for line phasing, and detail B, figure 8-6 for the line filter terminations. RCA has provided all wiring from the filters to the equipment.



PLAN VIEW
Showing Location of Computer Cabinets



SECTION A-A
Typical Cross Section Thru CON-DUCT

NOTES:

1. The minimum side clearance required for end cabinets with swinging frame in front or rear is 1'2".
2. The minimum aisle dimension is 5'2" and may increase by 2'0" increments to 7'2".
3. False floor and sub-structure must be capable of supporting a load of 500 lbs/sq ft.
   Remove floor tiles under cabinets to permit cable access.
5. Screw jacks to be located at each corner of false floor tile.
6. Minimum clear cross-sectional area required for installation of CON-DUCT and riser.

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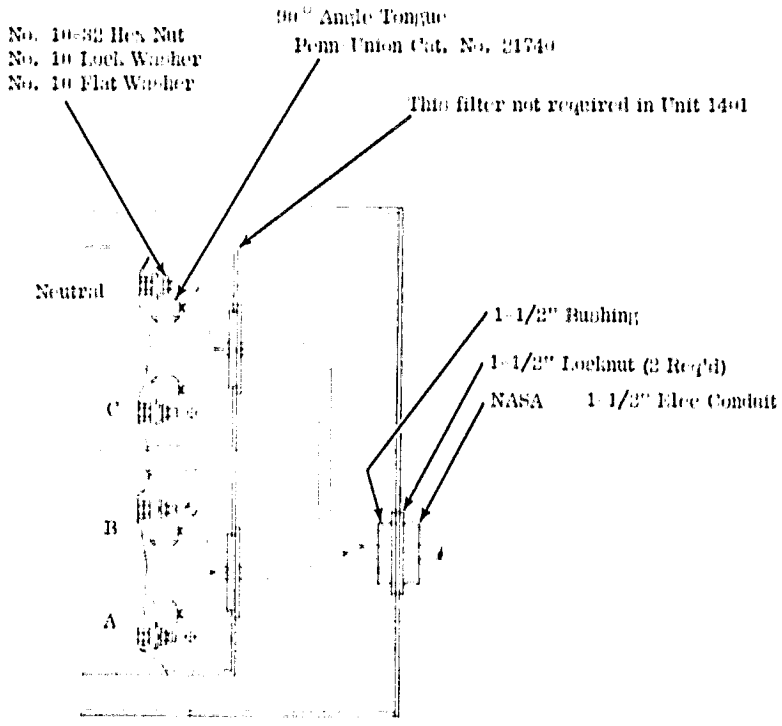
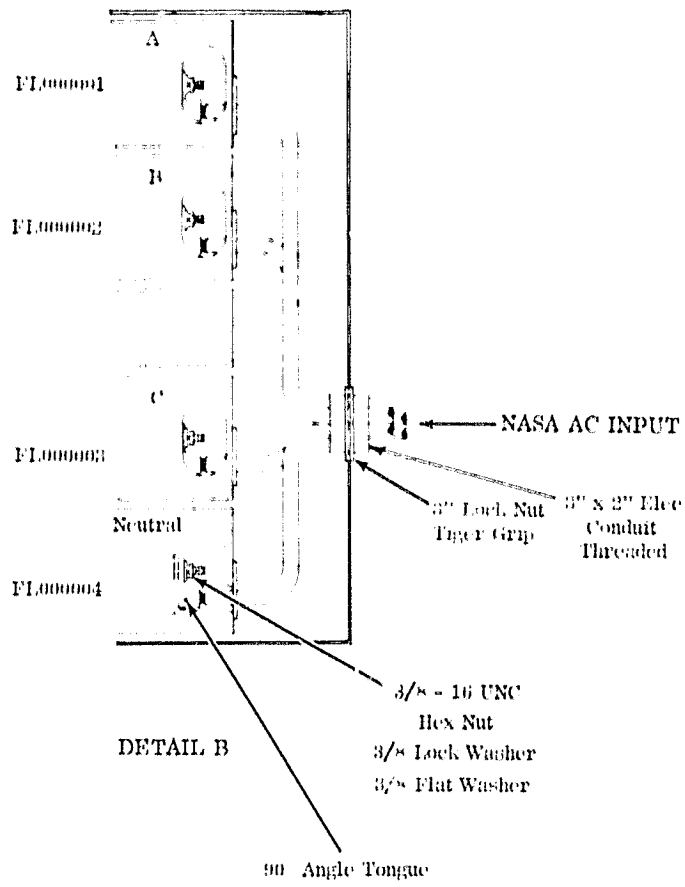
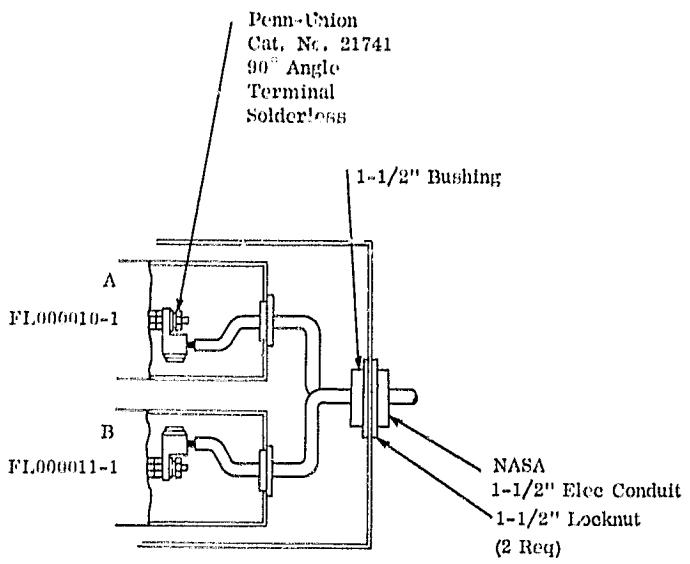
Figure 8-5. Typical Equipment Location



DETAIL A



DETAIL B



DETAIL C

Filter Phasing

Unit	Filter	No. of Phases	Terminal	Wire Size
0101	FL000001	3φ WYE	A	4/0
	FL000002		B	4/0
	FL000003		C	4/0
	FL000004		Neutral	4/0
1301	FL000005-1	3φ WYE	A	No. 10
	FL000005-2		B	No. 10
	FL000006-1		C	No. 10
	FL000006-2		Neutral	No. 10
1401	FL000007-1	1φ	Power (A)	No. 12
	FL000007-2		Neutral (B)	No. 12
1501	FL000008-1	3φ WYE	A	No. 10
	FL000008-2		B	No. 10
	FL000009-1		C	No. 10
	FL000009-2		Neutral	No. 10
1601	FL000010-1	1φ	Power (A)	No. 6
	FL000011-1		Neutral (B)	No. 6

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Figure 8-6. Power Interface

8.3.3 Slave Magnetic Tape Unit Power Interface

The line filters for the slave magnetic tape units (units 1201, 1202, and 1203) are located within the cabinets. Shielded power leads connect the filters to receptacles in the connector interfaces in the bottom of the cabinets. The RCA connector receptacle in the cabinet base is type MS3100E-16S-11P. The power cable to each slave unit is provided by NASA and terminates in the mating connector plug type MS3106E-16S-11S.

8.3.4 AC Convenience Outlets

Dual ac convenience outlets are provided between the bases, front and rear, of all adjacent cabinets. The outlets are factory-wired and are attached to the cabinets during system installation. Power inputs to the convenience outlets are provided by NASA and are 120 vac at 30 amps per dual outlet. The power input leads are stubbed beneath the flooring. Wall-mounted circuit breakers, separate from the main system power, are provided for the convenience outlets.

8.4 GROUNDING PROVISIONS

8.4.1 RFI Ground Plane

The Saturn SV Ground Computer System, including all peripheral equipment, is grounded to a low-impedance rfi ground plane which rests between the equipment and the equipment room flooring (see figure 8-7). The rfi ground plane consists of a thin (0.032-inch), tin-plated copper sheet which is mechanically bonded to the computer system equipment. The joining straps which connect the separate sections of the ground plane have a maximum length-width ratio of five to one.

The rfi ground plane is bonded to the facility ground. This connection is made as close to cabinet 05 as practicable to maintain the recommended length-to-width ratio of five to one for the connecting strap.

8.4.2 Pad Ground

A 500 MCM ground cable, supplied by NASA, connects the computer system ground bus to an external ground. This ground cable terminates on a 3/8 inch stud, labeled PAD GROUND,

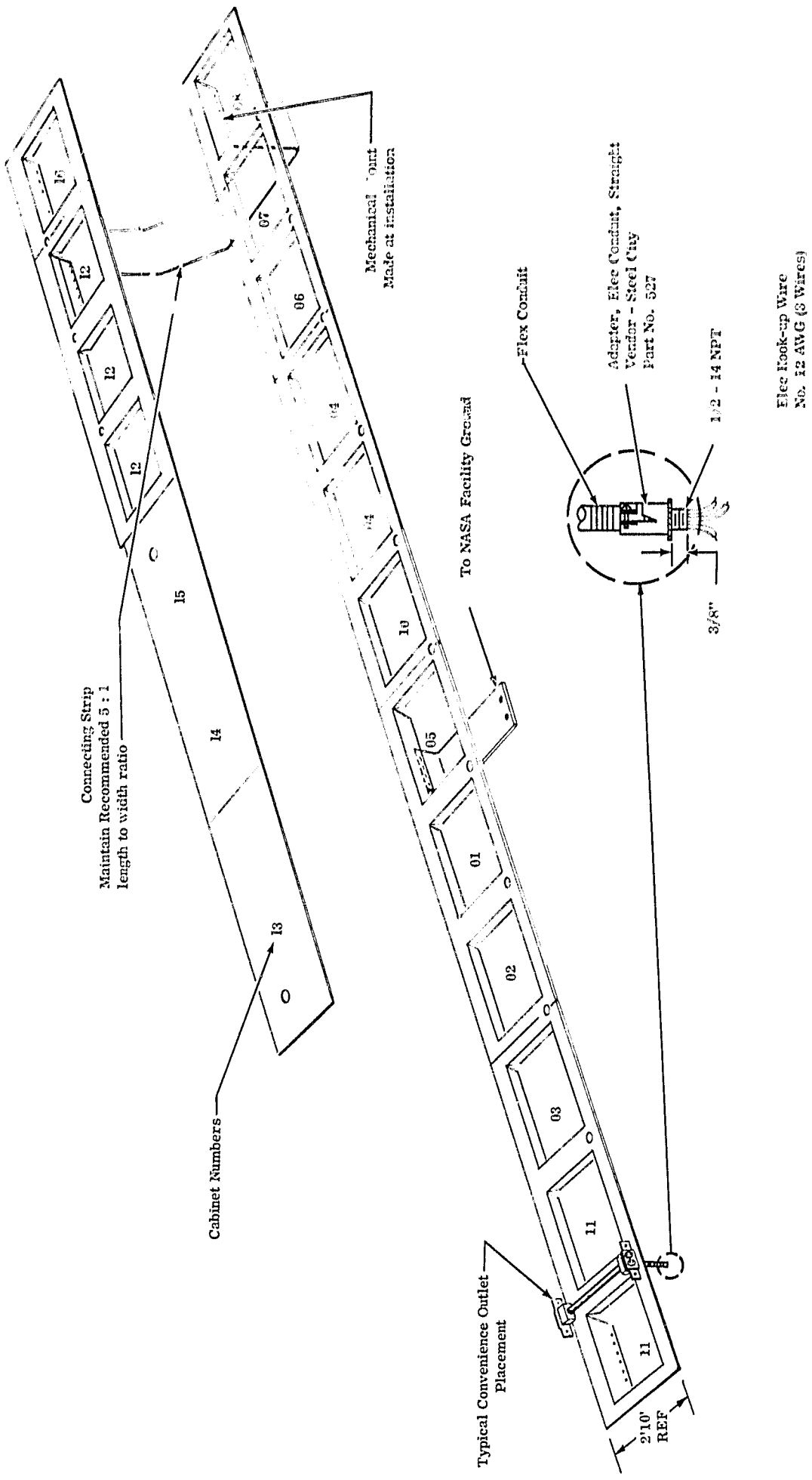

Figure 8-7. Ground Pl

which is located on the cover of the con-duct module beneath cabinet 05. Three other studs are provided on the cover for connecting the signal grounds of display and data link equipments to this common point. The studs are bussed inside the con-duct and the bus is connected to the computer system signal ground bus bar.

8.5 HEAT DISSIPATION AND AIR CONDITIONING REQUIREMENTS

The heat load and refrigeration and volumetric requirements of the typical installation shown in figure 8-1 are summarized in table 8-3. These values are for the computer system equipment only and do not include the thermal output of lighting equipment, test equipment, personnel, solar heat, or other external systems.

8.5.1 Air Conditioning Requirements

The typical facility air conditioning installation is capable of extracting the 51 kw (174 kBTU/hr) system heat load while maintaining a system intake air temperature 70 $\pm 10^{\circ}$F with 50 $\pm 30\%$ relative humidity.

8.5.2 Cooling Air Delivery Requirements

The cooling air requirements of the typical system shown in figure 8-1 are summarized in table 8-3. All units except 1301, 1401, and 1501 draw cooling air through rfi-shielded air-inlet panels on the bottom of the standard cabinets. Inlet air is filtered and internally distributed by blowers located at the bottom of each cabinet. Also tape stations of systems 2112000-517, 518, and 524 were modified for front air delivery.

8.5.2.1 Air Delivery Plenum

The bottom air entry of the standard Saturn cabinet requires a raised-floor equipment room construction with an air plenum formed by the solid underfloor and the raised floor. The cabinet blowers draw air in operational quantities with an air plenum static pressure of 0 inches H_2O (or greater). The computer cooling system is not designed to operate against a negative pressure head in the plenum. Air delivery into the plenum is to produce a reasonable balanced pressure and flow distribution. Internal computer air velocities are held below 1,200 fpm. The air plenum feed system is designed to hold plenum velocities below this value.

8.5.2.2 Air Delivery to Units 1301, 1401, and 1501

Units 1301, 1401, and 1501 draw cooling air from either the front, rear, or side of their respective consoles and discharge near the top. The 1600 cfm for these units therefore is taken from the room air.

8.5.3 Exhaust Air Ducting

The heated, exhaust air discharged from the tops of all standard cabinets is ducted out of the equipment room. Exhaust ducts fitted to the cabinet exhaust panels collect the heated air and deliver it back into the air conditioner inlet, thus minimizing moisture and contaminant extraction loads on the air conditioning unit. Exhaust duct static pressure must be 0 inches H_2O or less.