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FAMILIARIZATION MANUAL

MISSION CONTROL CENTER HOUSTON

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PREPARED BY

PHILCO Ford

WESTERN DEVELOPMENT LABORATORIES
HOUSTON OPERATIONS
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PREFACE

This manual serves to familiarize the reader with the purpose and operation of the National Aeronautics and Space Administration (NASA) Mission Control Center-Houston (MCC-H) located near Houston, Texas. The manual is primarily an orientation/indoctrination guide and, in addition, furnishes a reference source for information pertinent to the MCC-H systems, subsystems, and major components.

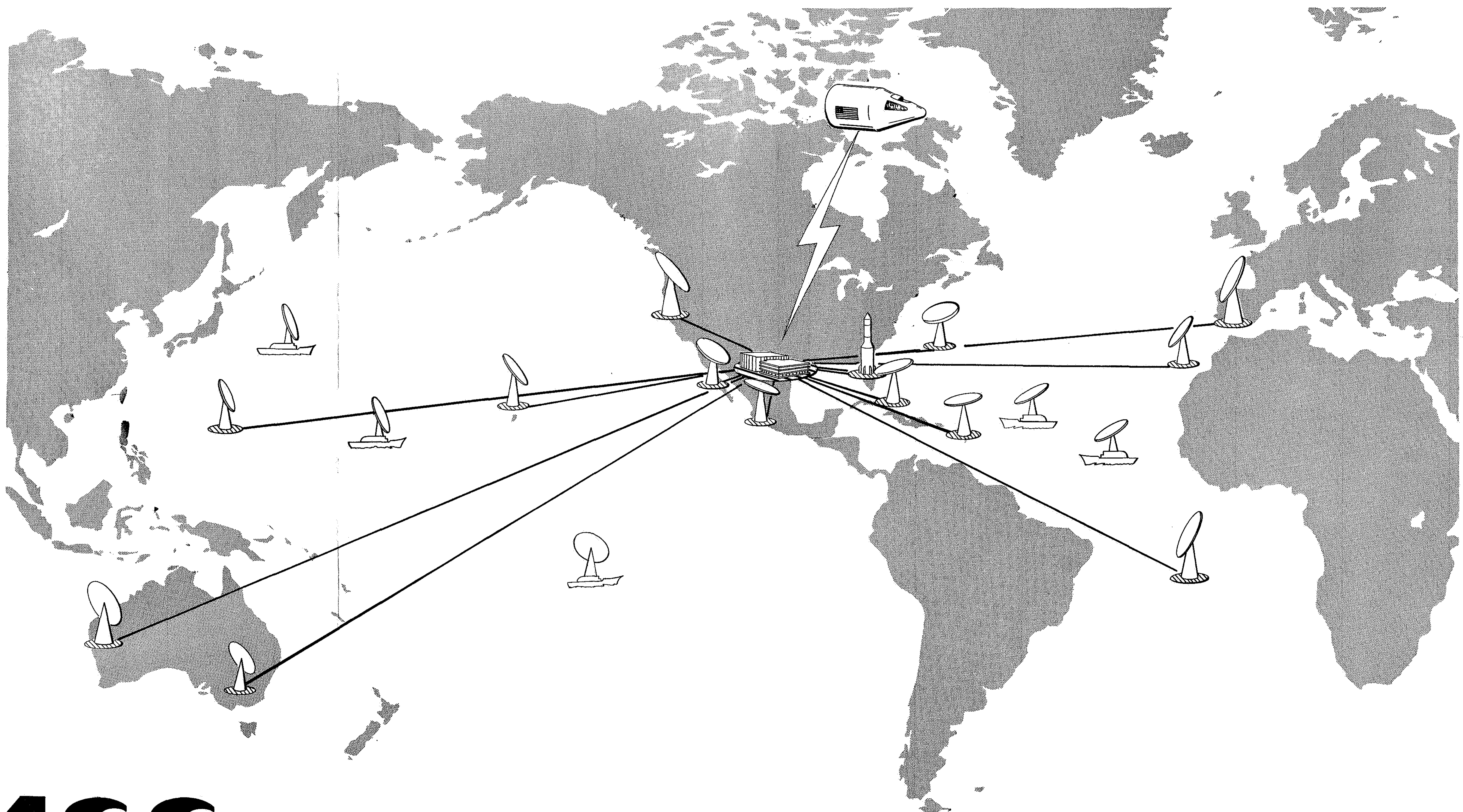
The manual discusses the MCC-H in general terms, avoiding detailed technical descriptions, but with sufficient detail to convey a clear understanding of the purpose and operation of the MCC-H. A listing of support manuals that provide detailed technical coverage of the MCC-H systems and interfaces is included as a ready reference for anyone desiring increased coverage of a particular area.

The manual is divided into five sections: General Description, Functional System Equipment, Functional System Operation, Support Facilities, and Manning. Three appendices are included with the manual: MCC-Houston Support Manuals, General Description of Manned Spaceflight Network, and General Description of Apollo Simulation, Checkout, and Training System (ASCATS). A glossary of abbreviations used throughout this manual is presented below:

CCATS	Communications, Command, and Telemetry System
GOSS	Ground Operational Support Systems
GSFC	Goddard Space Flight Center
KSC	Kennedy Space Center
MBOA	Mission Briefing and Observation Auditorium
MCC-H	Mission Control Center-Houston
MOCR	Mission Operations Control Room
MOW	Mission Operations Wing
MSC	Manned Spacecraft Center
NASA	National Aeronautics and Space Administration
OSW	Operations Support Wing
RCR	Recovery Control Room
RTCC	Real Time Computer Complex
SSR	Staff Support Room
ASCATS	Apollo Simulation, Checkout, and Training System

This manual was prepared by Philco-Ford Education and Technical Services Division, Technical Documentation, Houston, under subcontract to Philco-Ford Western Development Laboratories, Houston Operations.

This manual is revised to include technical changes resulting from all approved and completed modifications that have occurred from the date of original publication to 30 June 1967.



MCC

–HOUSTON

CENTRALIZED CONTROL OF NASA
MANNED SPACEFLIGHT MISSIONS

SECTION I
GENERAL DESCRIPTION

This section provides a general description of the National Aeronautics and Space Administration (NASA) manned spaceflight Mission Control Center-Houston (MCC-H) located near Houston, Texas. The purpose of the MCC-H is first defined and then the MCC-H physical plant, functional systems, and overall operation during a typical mission are described. This discussion is followed by a brief description of the purpose and function of the Apollo Simulation, Checkout, and Training System (ASCATS).

1-1. PURPOSE OF MCC-HOUSTON

The MCC-H provides centralized control of NASA manned spaceflight missions. The MCC-H is supported in this role by the Manned Spaceflight Network (reference appendix B), a world-wide network of tracking and voice-data communications stations. The MCC-H Manned Spaceflight Network combination is referred to by the collective title of Manned Spaceflight Ground Operational Support Systems (GOSS). MCC-H functions include full mission control from launch through recovery, and technical management in the areas of vehicle systems, flight dynamics, life systems, flight crew activities, recovery support, and GOSS operations. Figure 1-1 breaks down the MCC-H functions for each phase of a typical mission, including premission and postmission activities.

1-2. PHYSICAL PLANT

The MCC-H physical plant comprises buildings 30 and 48 of the NASA Manned Spacecraft Center (MSC). (See figure 1-2.) Building 30 is referred to as the MCC-H building. Building 48 is the emergency power building. An underground utility tunnel, an extension of the MSC central tunnel system, connects buildings 30 and 48. A site plan for buildings 30 and 48 is shown in figure 1-2-1. This illustration is keyed to the floor plans of the MCC-H, shown in figures 1-2-1-1 through 1-2-1-8.

The three-story MCC-H building consists of a Mission Operations Wing (MOW), an Operations Support Wing (OSW), and an interconnecting lobby wing. The MOW contains all the technical equipment and facilities required to support the mission control and monitoring functions of the MCC-H. The MOW is equipped with two Mission Operations Control Rooms (MOCR's), associated Staff Support Rooms (SSR's), and a Recovery Control Room (RCR). These rooms provide the proper environment for the comprehensive data displays and analyses required for detailed mission control. The OSW contains office, laboratory, and technical support areas, and a Mission Briefing and Observation Auditorium (MBOA) for the NASA-MSC Flight Operations Directorate. The lobby wing interconnects the MOW and OSW and contains several offices, dormitory facilities, and technical support areas.

The single-story emergency power building houses all standby electrical power, air conditioning, and ventilation facilities for exclusive use by the MOW. An electrical power substation pad, cooling towers, and a diesel fuel and oil storage area are located adjacent to the emergency power building.

1-3. FUNCTIONAL SYSTEMS

All MCC-H equipments that contribute directly to the mission control capabilities of the MCC-H are grouped into three functional systems: Communications, Command, and Telemetry System, Display/Control System, and a data processing system called the Real Time Computer Complex (RTCC) System. These three systems incorporate all the technical equipment in the MOW with the exception of telephone termination and distribution equipment. The systems interface with the flight crew trainers in building 5, ASCATS in building 422, and the Mission Operations Support Laboratory (MOSL) in the OSW.

The functional systems, composed of complex electronic or electromechanical equipment, enable the MCC-H to communicate with spacecraft and the Manned Spaceflight Network, initiate commands, and display large quantities of data in numerous formats. The equipments in each system are further grouped into subsystems as shown in figure 1-3.

1-4. OPERATIONS

The MCC-H is the focal point for the world-wide Manned Spaceflight Network. During the course of a manned spaceflight mission, this network feeds enormous quantities of information in various forms into the MCC-H. In return, the MCC-H feeds a large amount of information back to the network. The primary reason for this data exchange is to maintain cognizance over the current status of the spacecraft and flight crews involved in the mission. A byproduct of the exchange is the compilation of data for historical purposes and postflight analyses.

A manned spaceflight mission consists of several consecutive phases: launch, earth orbit, translunar, etc., depending upon the mission objectives. The MCC-H flight controllers must know during all phases of the mission the location of the spacecraft involved and how the spacecraft and their crews are withstanding the changing environment imposed upon them. The Manned Spaceflight Network functions as a remote arm of the MCC-H, constantly collecting the data that will provide this required information to the MCC-H. (See figure 1-4.)

From the moment of lift-off, as a spacecraft is being launched, the personnel in control of the mission must be supplied with information regarding acceleration, speed, and direction of the spacecraft to enable them to make an almost immediate decision as to whether or not a satisfactory trajectory is being maintained. To accomplish this, high-speed data lines carry radar tracking data from Bermuda and Kennedy Space Center (KSC) to the RTCC at the MCC-H. The RTCC, in turn, causes displays of the spacecraft trajectory parameters to be plotted only a few seconds behind the actual spacecraft position. The predicted impact point of the spacecraft is also displayed during this time so that recovery forces can quickly converge on the spacecraft landing area in the event of an abort.

During the launch phase, the condition of the spacecraft crew and critical vehicle systems, and the status of critical mission events, must also be known. This data is telemetered from the spacecraft, received at several data acquisition stations, applied to data transmission equipment at KSC, and routed over wide band data lines to the MCC-H. At the MCC-H, the data is used to produce event status displays, biomedical data displays, and other pertinent displays required for immediate evaluation.

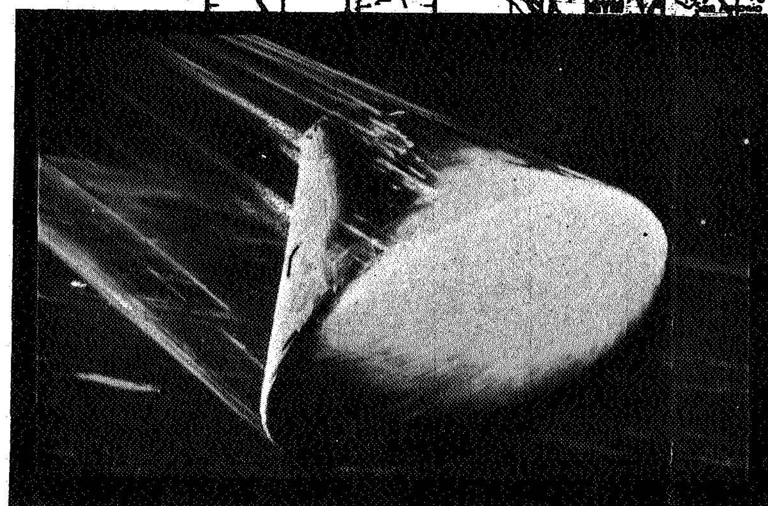
After the spacecraft has been successfully launched, the RTCC system is used to determine the spatial position of the spacecraft. If the next phase is an earth orbit, the RTCC will establish the orbital track of the spacecraft utilizing tracking data coming from the Manned Spaceflight Network. The RTCC maintains a plot of the spacecraft position, predicts where it will be at any predetermined time in the future, and sends out acquisition messages to each tracking station that tell the station where to point its tracking antenna and at what time the station can expect to acquire the spacecraft. The RTCC also causes predicted impact points to be displayed throughout the orbital phase of the mission so that recovery forces will have maximum reaction time in the event of an abort.

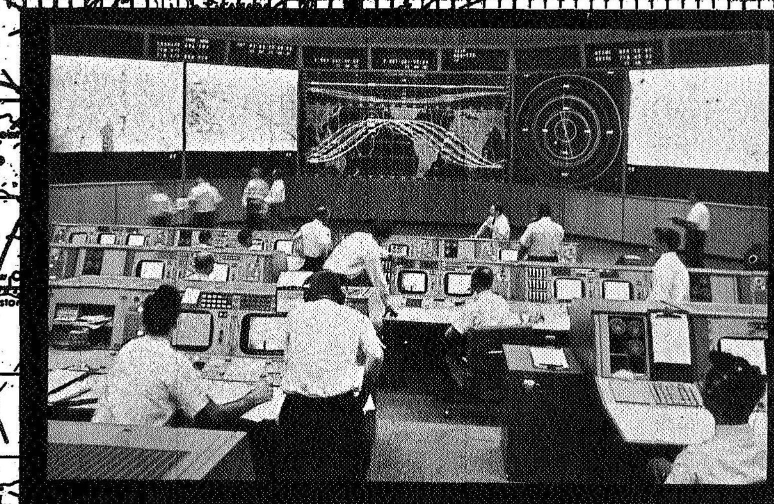
Throughout the mission, the physical well-being of the flight crew is monitored via telemetry data and voice communications. Telemetry data also enables the performance of the spacecraft and related equipment to be evaluated.

1-5. APOLLO SIMULATION, CHECKOUT, AND TRAINING SYSTEM

The Apollo Simulation, Checkout, and Training System (ASCATS) is a self-supporting facility that provides the interfacing equipment and data for supporting simulated mission exercises. The ASCATS, located primarily in building 422, is used for training the spacecraft flight crews, the MCC-H flight controllers, and the remote site flight controllers. Refer to appendix C for further details related to the ASCATS.

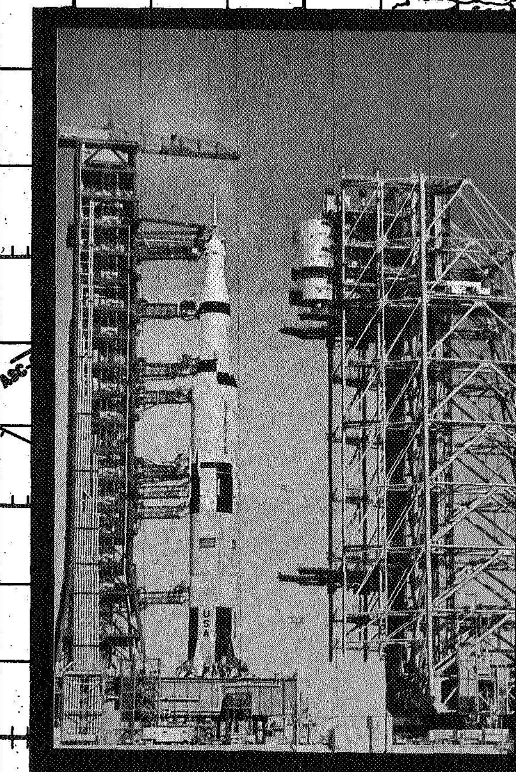
FLIGHT CONTROL READINESS AND PREPARATION





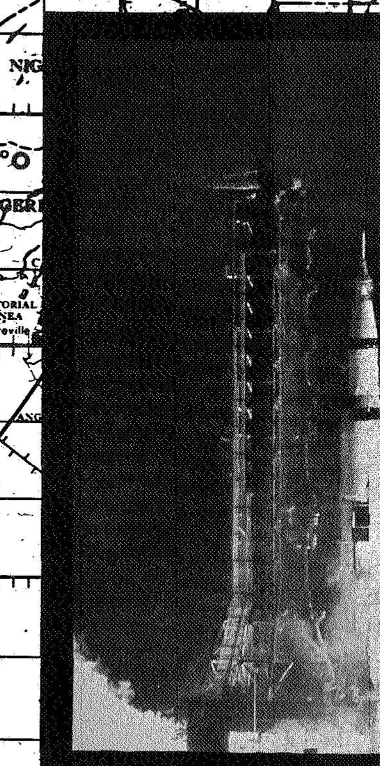
- FINALIZE MISSION PROCEDURES AND DOCUMENTATION
- RESOLVE ANY OPERATIONAL PROBLEMS
- PARTICIPATE IN SIMULATED MISSIONS
- SUPPORT VEHICLE PAD TESTS
- SUPPORT NETWORK TESTS
- VERIFY MISSION READINESS

PRELAUNCH



- SUPPORT AND CONTROL LAUNCH AND NETWORK COUNTDOWNS
- UPDATE NETWORK FLIGHT CONTROL TEAMS
- EVALUATE ALL NETWORK SUPPORT EQUIPMENT
- SCHEDULE AND CONTROL ANY REQUIRED SIMULATIONS
- UPDATE COMPUTER PROGRAMS AND DISPLAY EQUIPMENT
- REVIEW WEATHER AND RECOVERY STATUS
- REVIEW NETWORK STATUS
- MONITOR AND EVALUATE ALL VEHICLE SYSTEMS

LA



- EXERCISE CONTROL OF MISSION
- EVALUATE PERFORMANCE OF SPACECRAFT AND LAUNCH VE
- RECOMMEND AND TAKE NECESSARY ABORT ACTION IF REQ
- COORDINATE RECOVERY FORCES FOR RETRIEVAL IN ANY LANDING AREA
- MONITOR AND EVALUATE ALL TELEMETRY, RADAR, AND V
- ADVISE FLIGHT CREW OF ANY GROUND-INITIATED OR AIRBO CONTINGENCY ACTION
- COORDINATE AND UPDATE ALL COMPUTER PROGRAMS AND
- GO / NO-GO DECISION FOR INSERTION

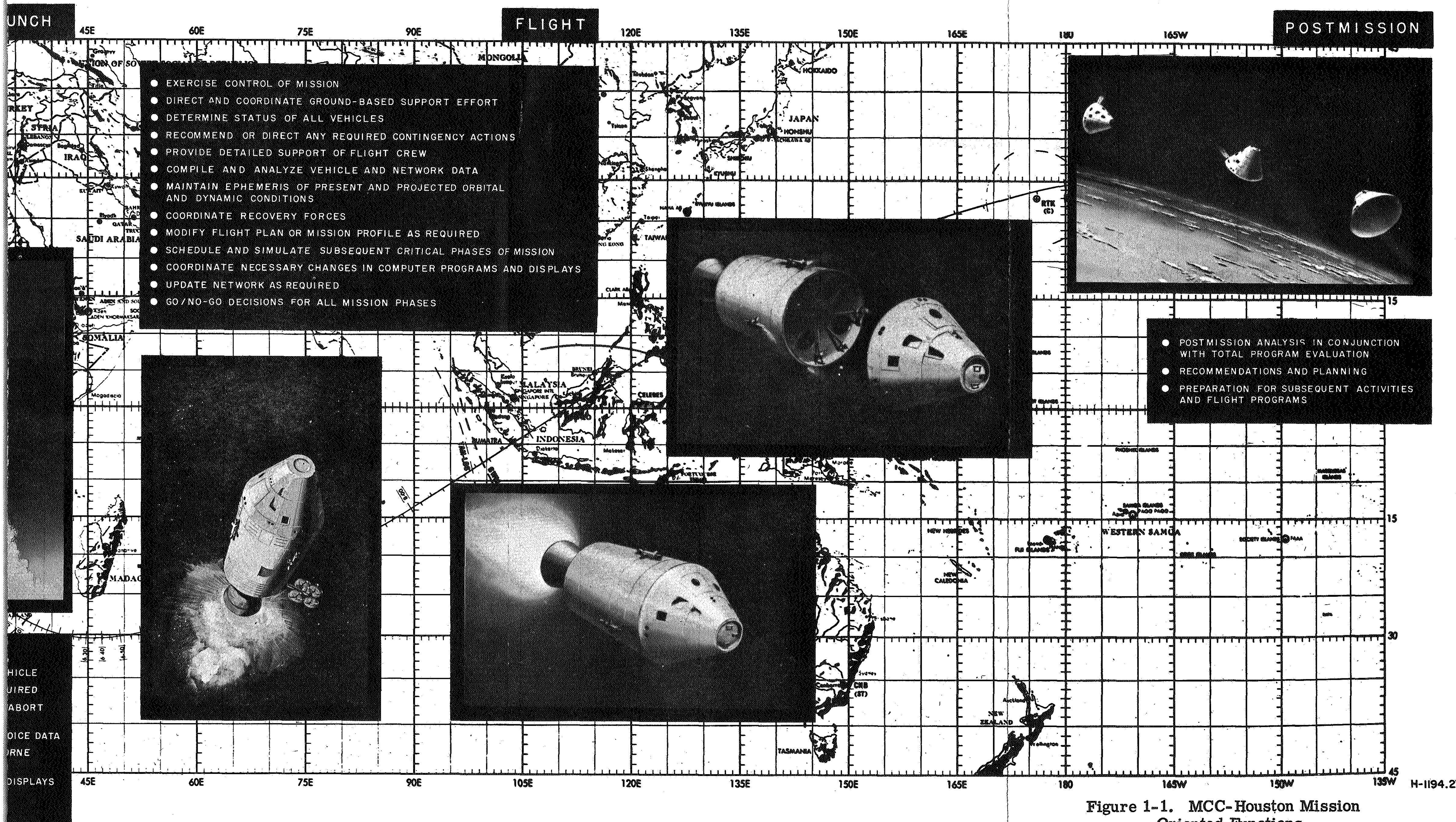


Figure 1-1. MCC-Houston Mission Oriented Functions

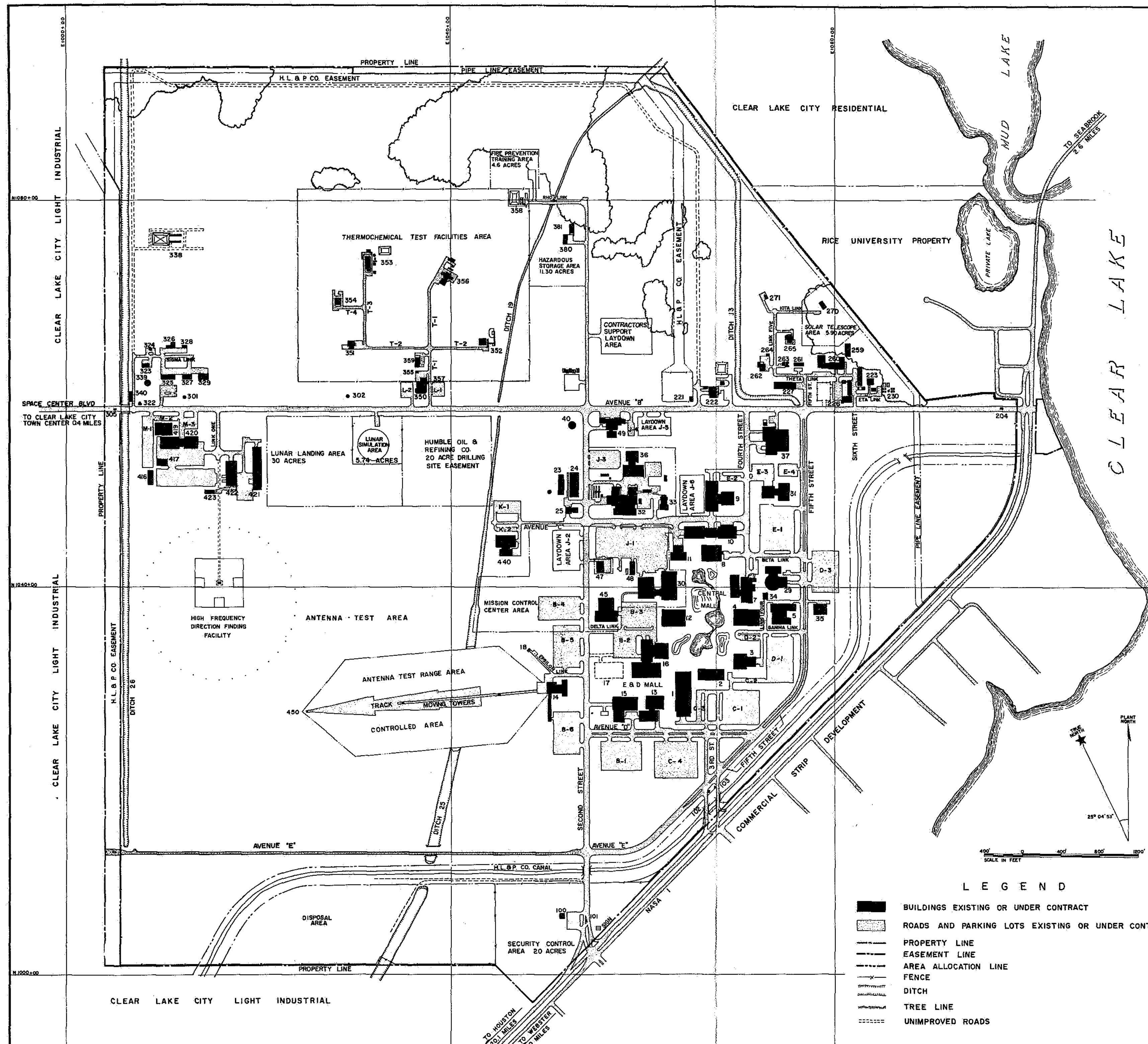


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Figure 1-2. NASA Manned Spacecraft Center, Site Plan

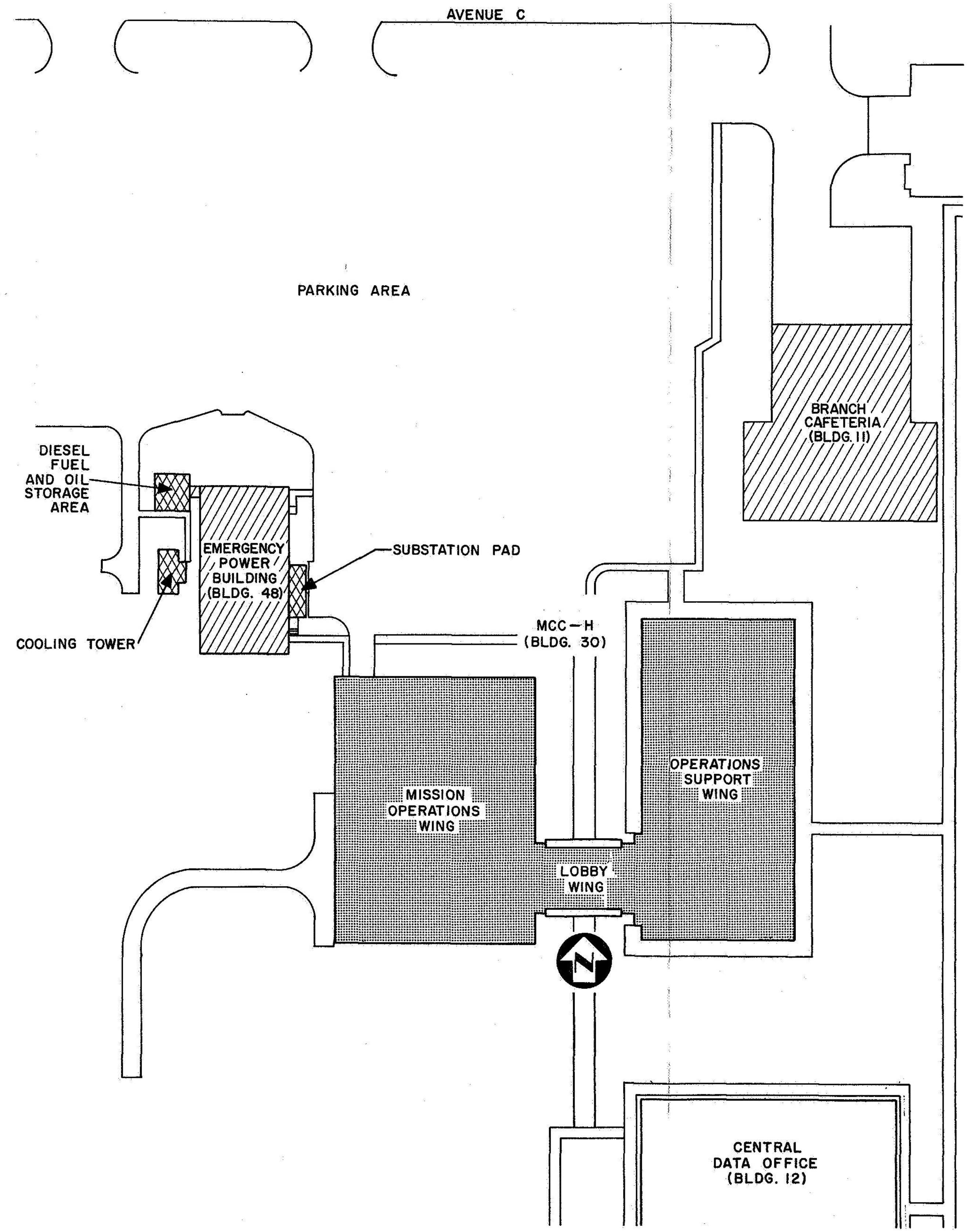
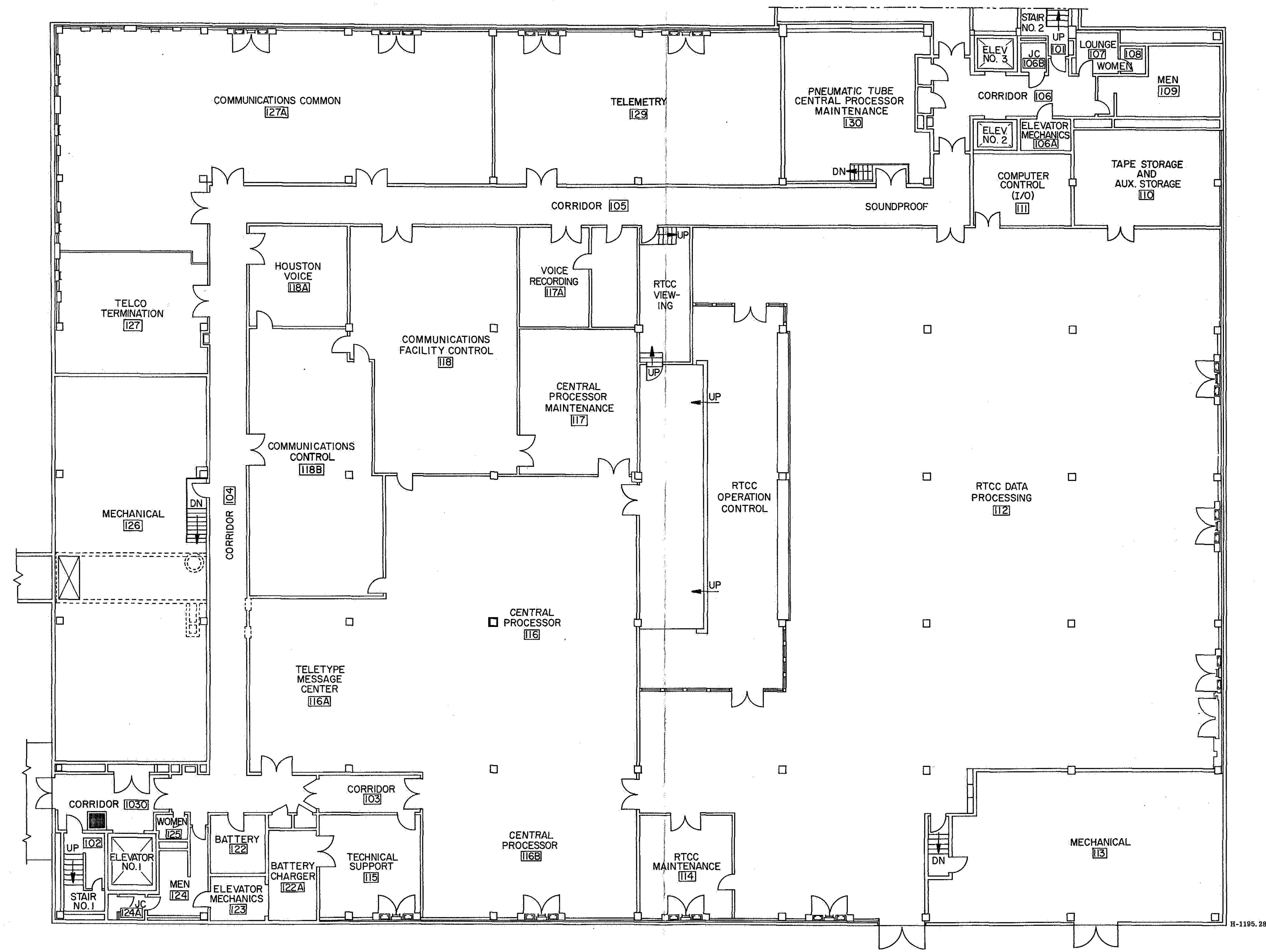


Figure 1-2-1. MCC-Houston, Site Plan



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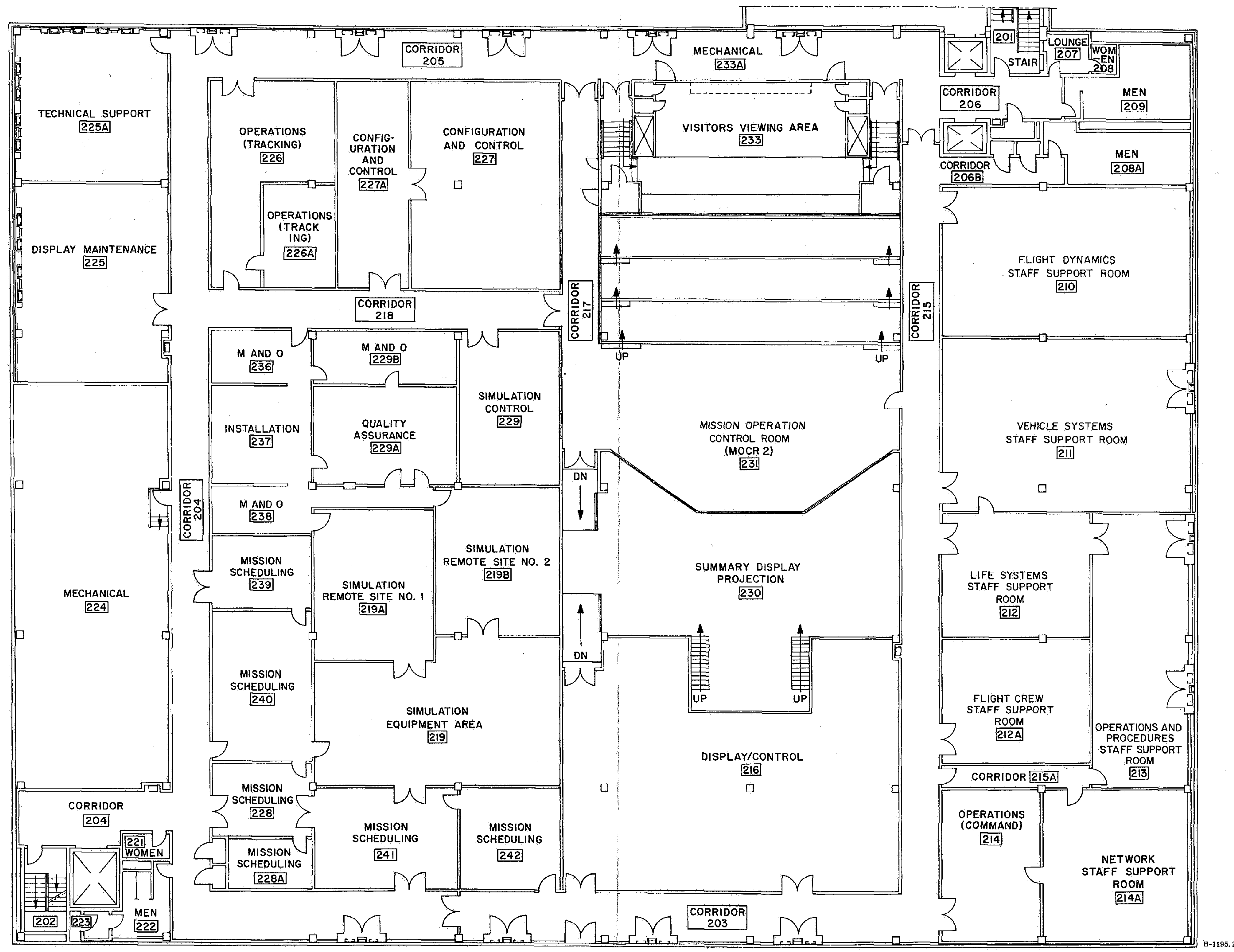

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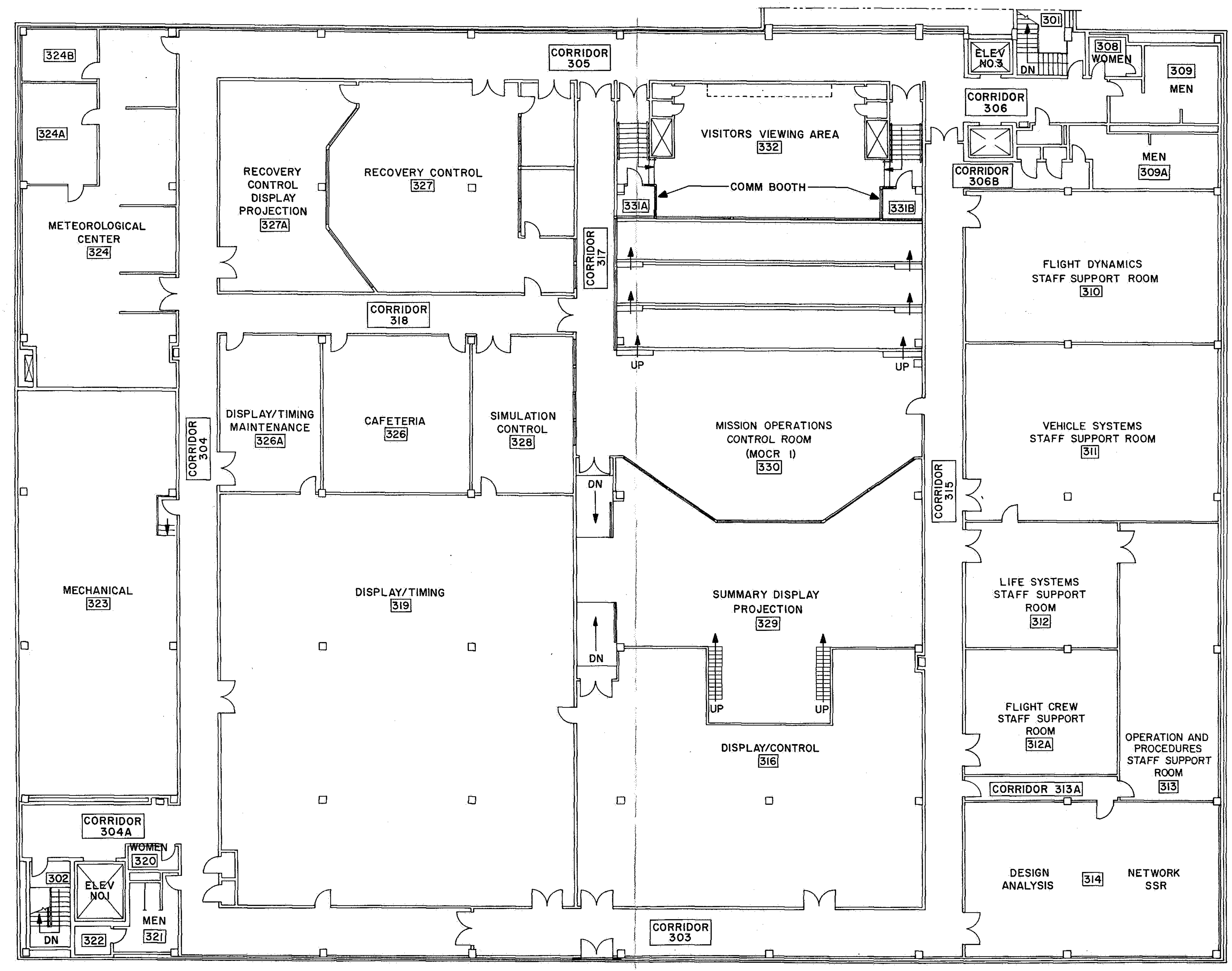

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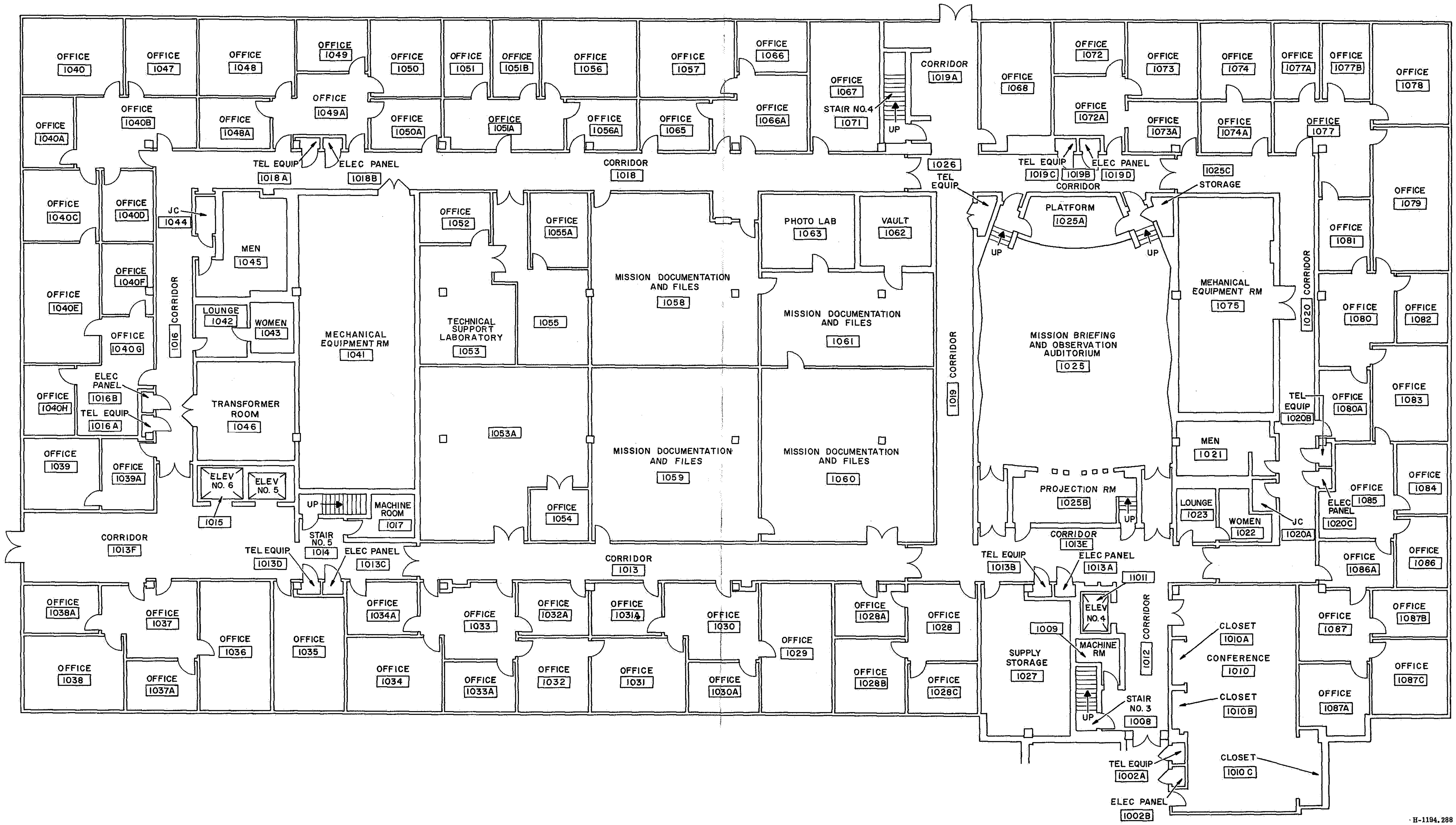

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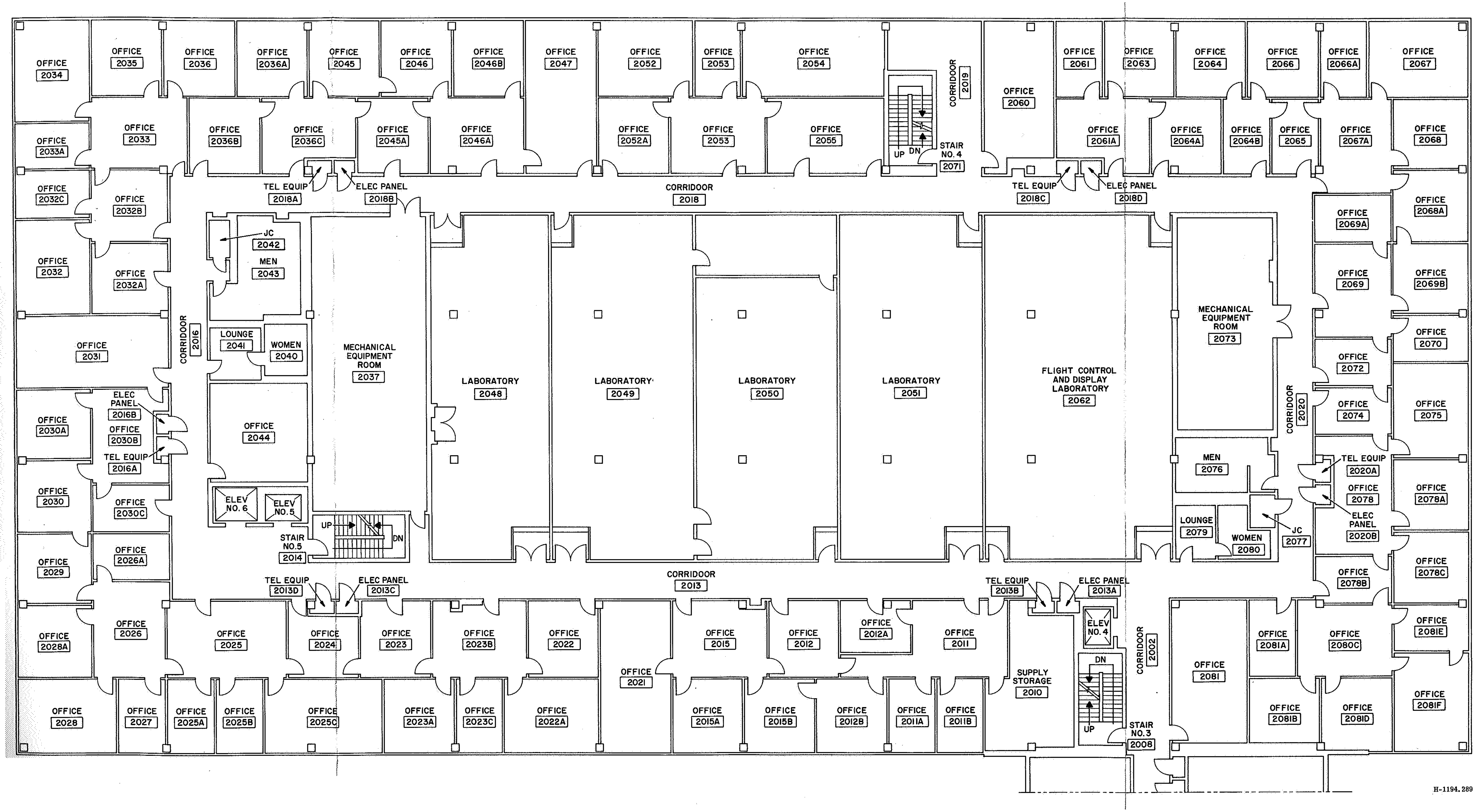

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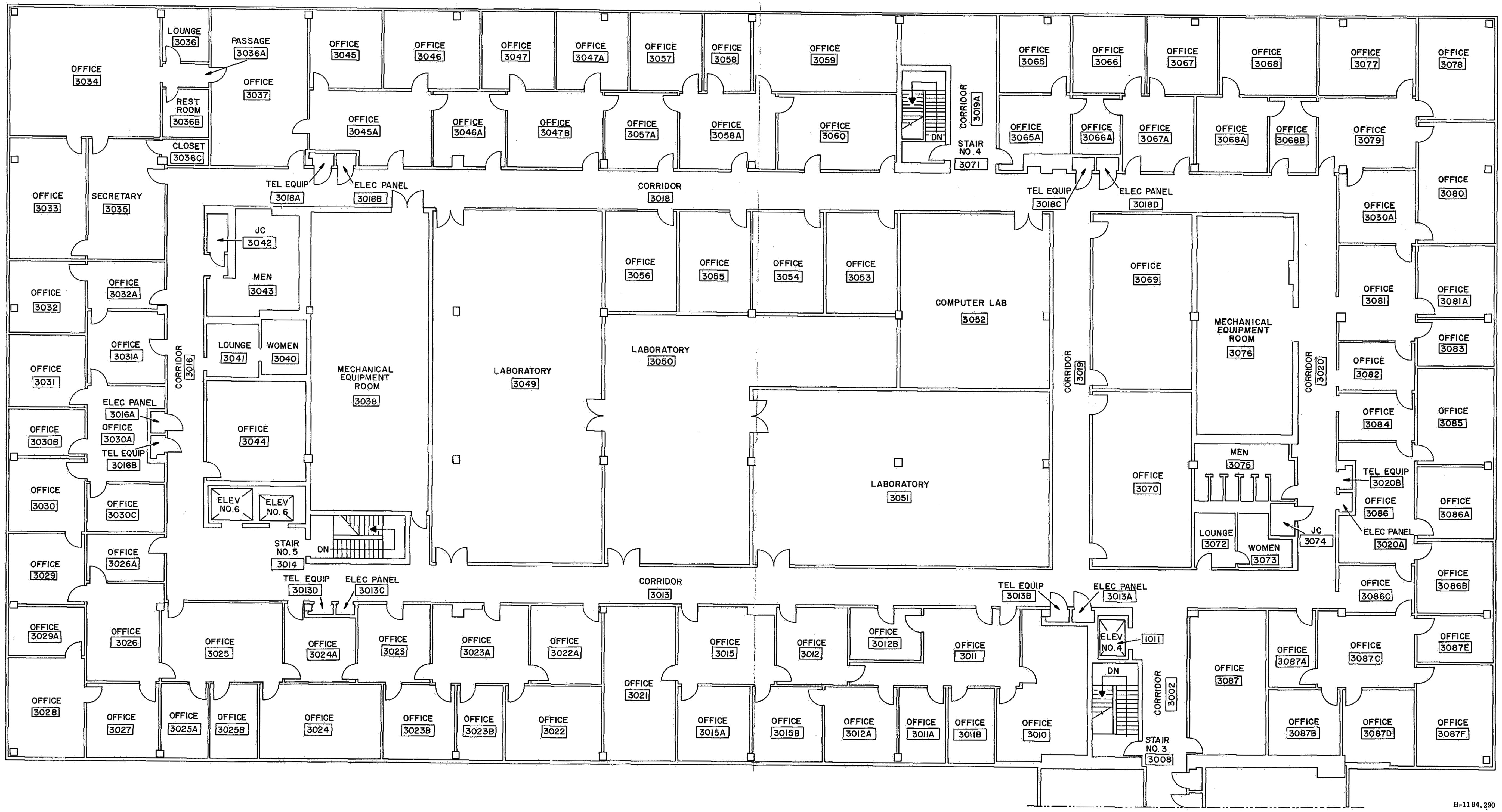

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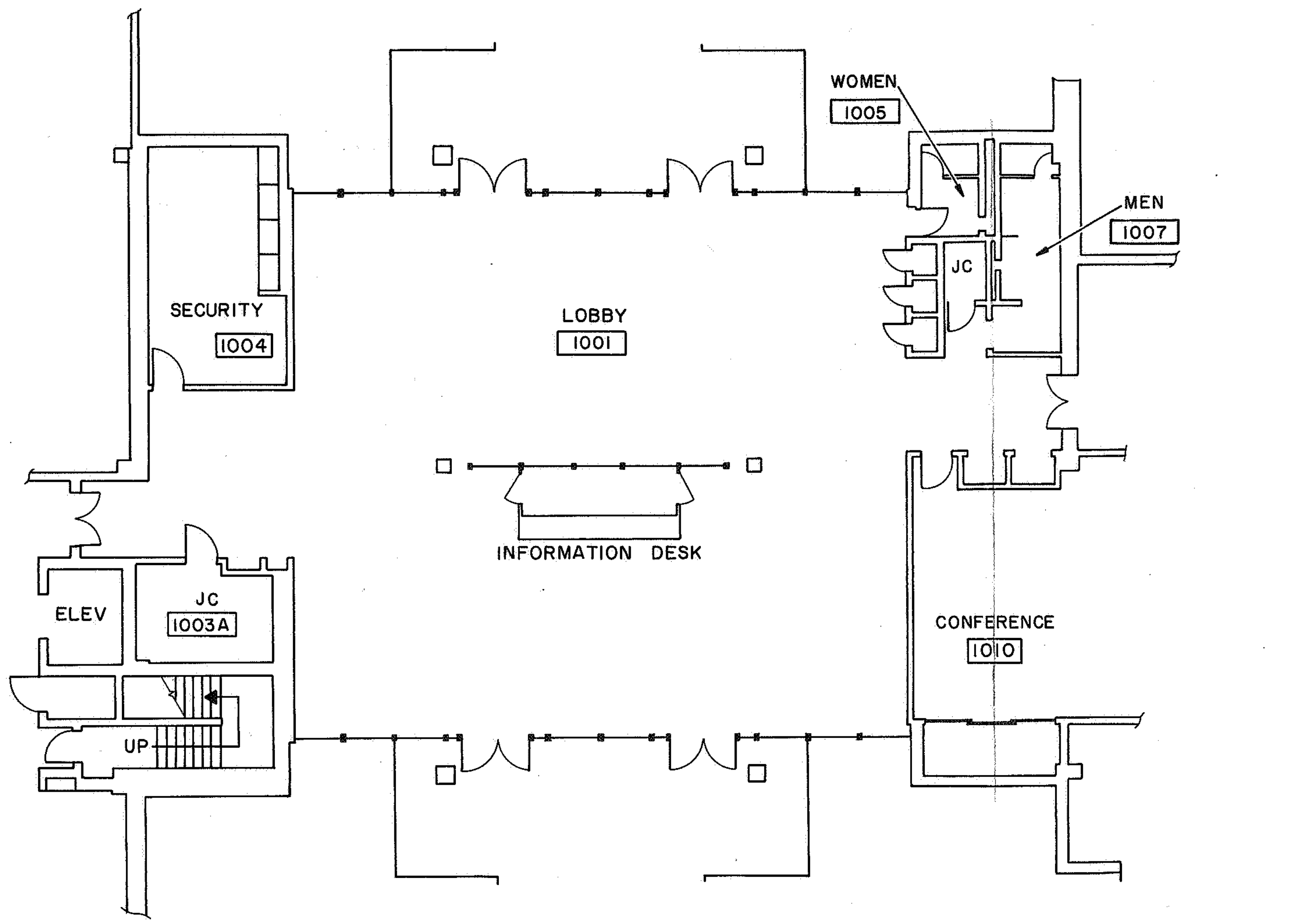
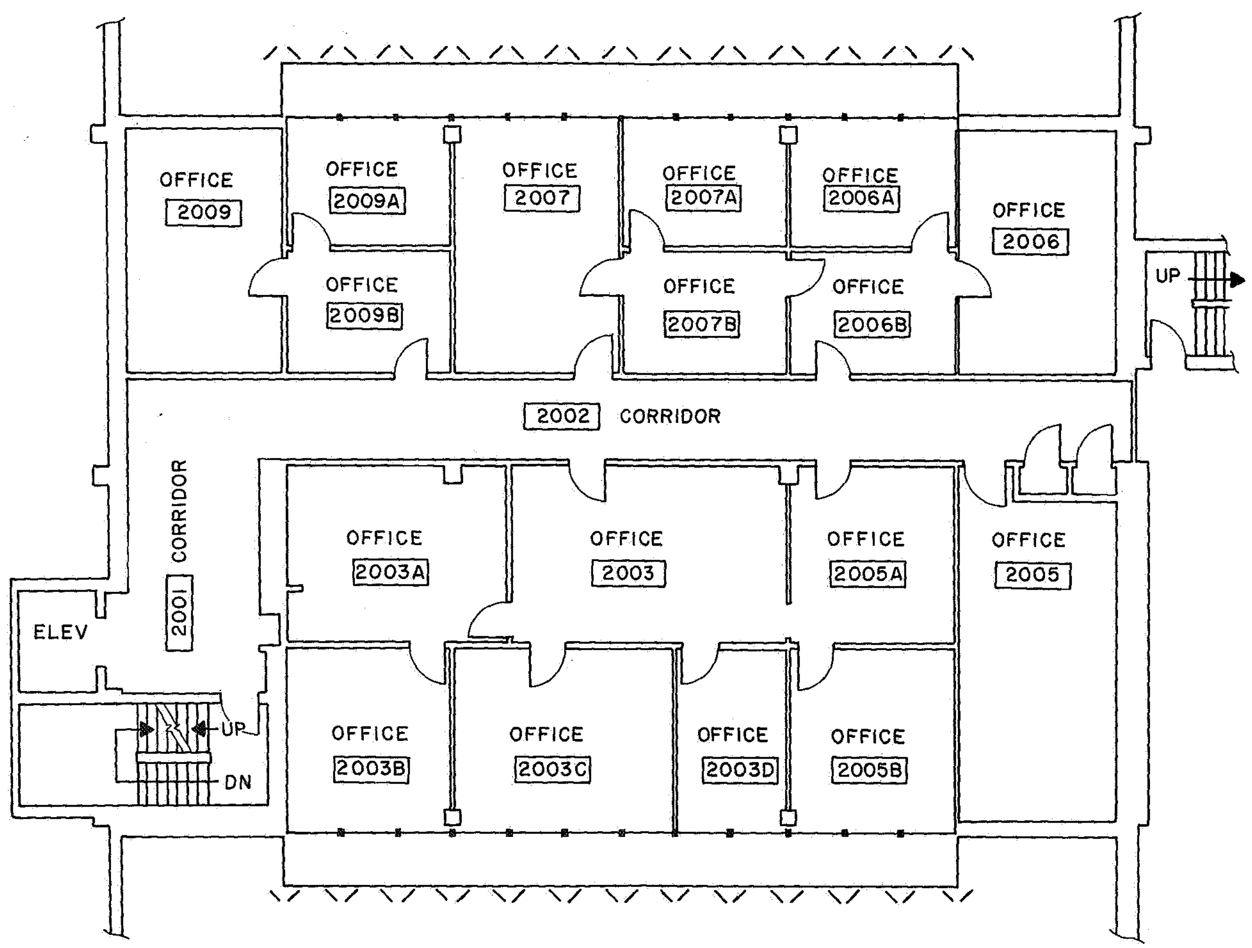
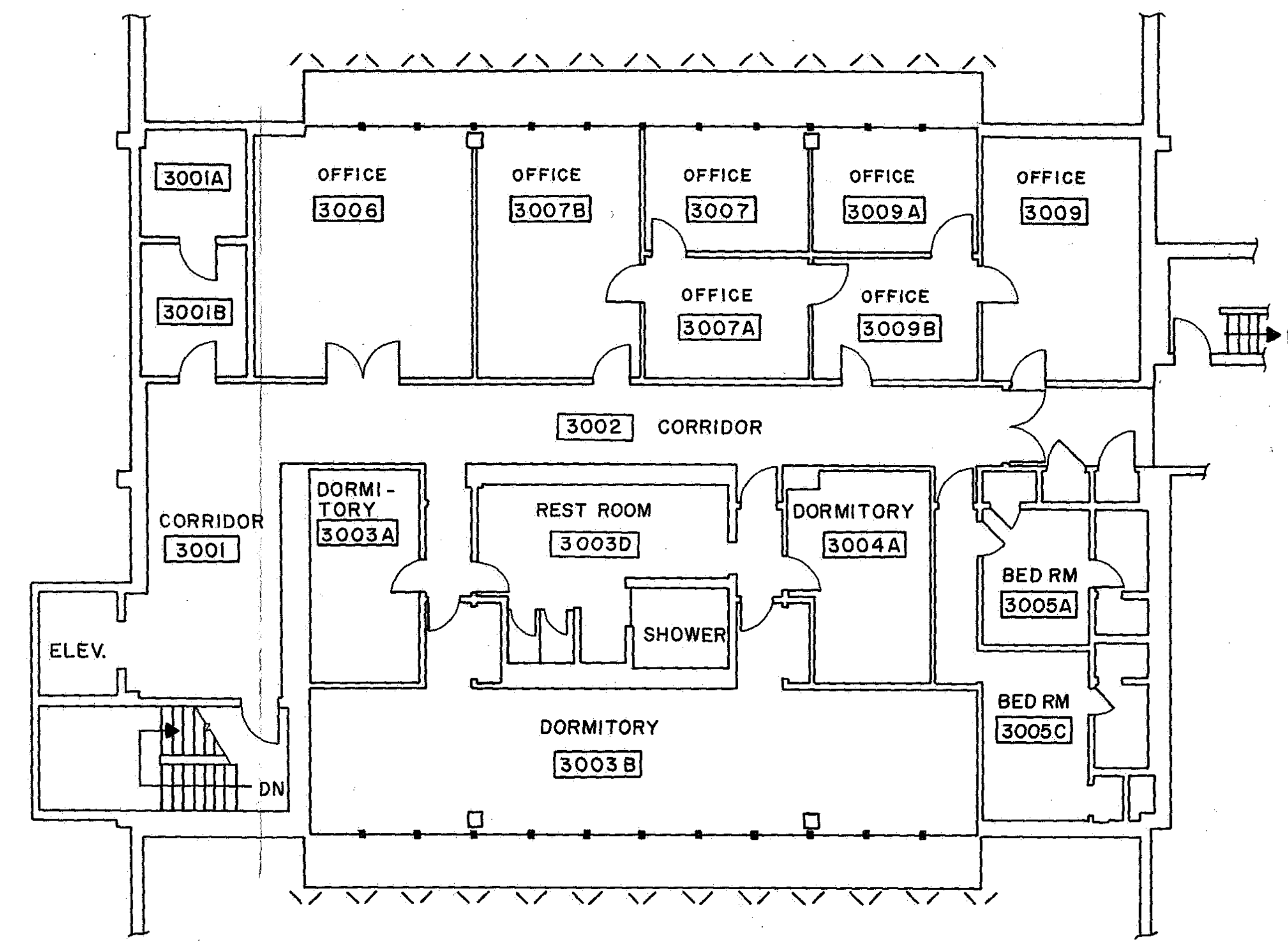


FIRST FLOOR PLAN



SECOND FLOOR PLAN



THIRD FLOOR PLAN

Figure 1-2-1-7. Lobby Wing, Floor Plans

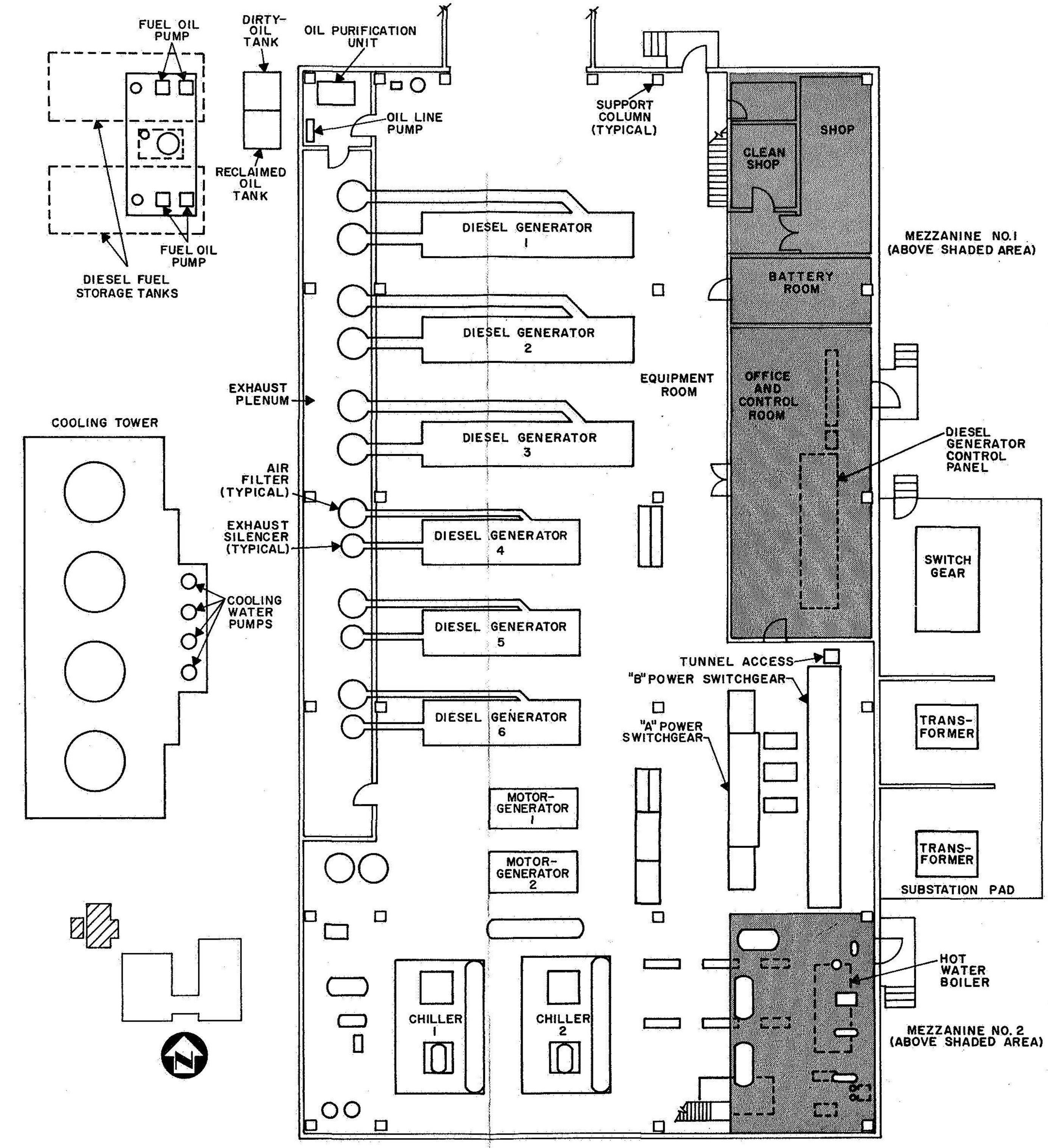


Figure 1-2-1-8. Emergency Power Building, Floor Plan

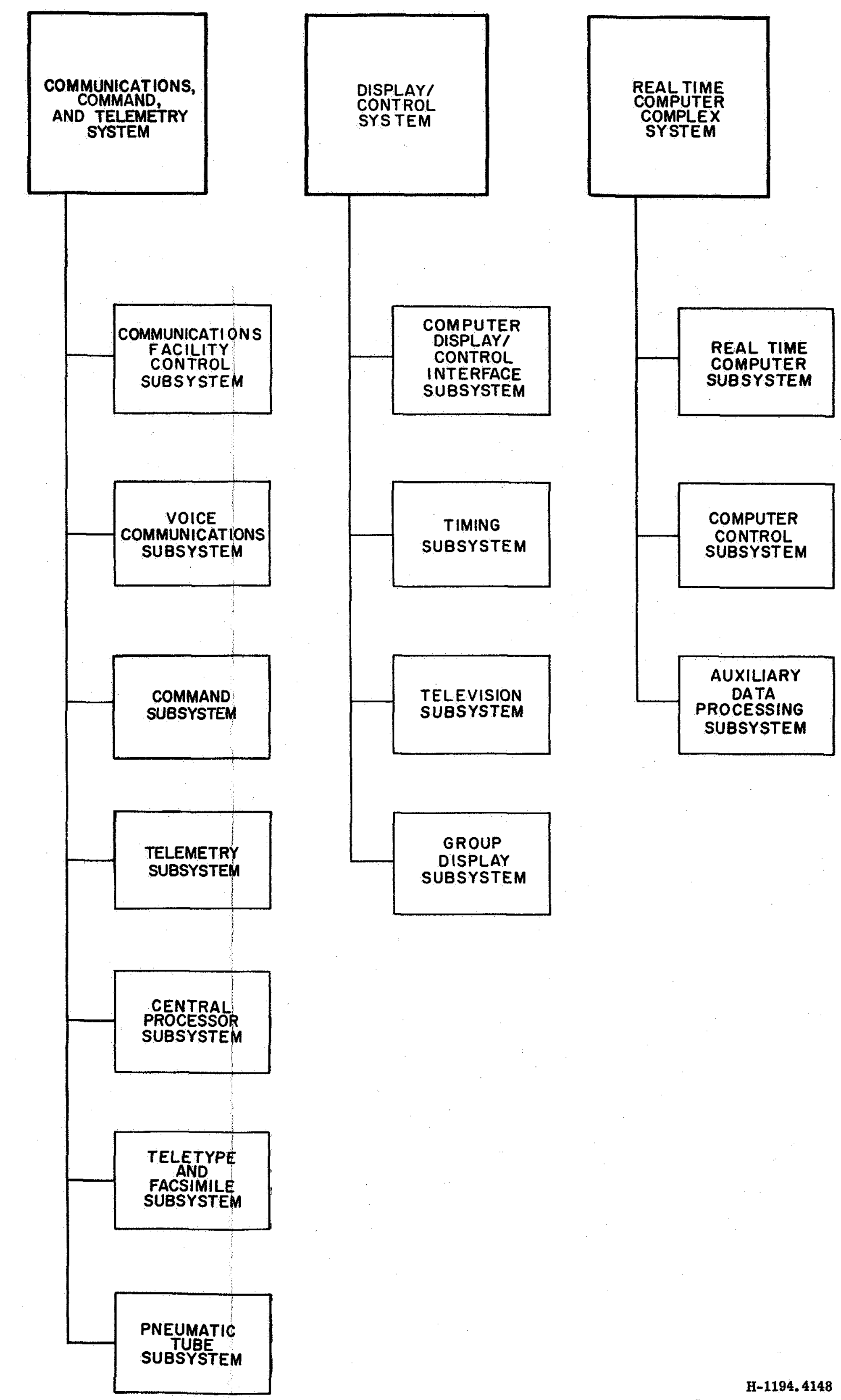


Figure 1-3. MCC-Houston, Functional Systems

MANNED SPACEFLIGHT NETWORK

ACQUISITION AIDS

PROVIDE CAPABILITY TO ACQUIRE AND TRACK SPACECRAFT AND ALSO PROVIDE ANGLE TRACKING DATA TO OTHER ONSITE ANTENNA SYSTEMS.

TRACKING SYSTEMS

DETERMINE POSITION AND VELOCITY OF SPACECRAFT.

VOICE COMMUNICATIONS SYSTEMS

PROVIDE CAPABILITY FOR CONDUCTING VOICE INTERCHANGES BETWEEN FLIGHT CREWS AND FLIGHT CONTROLLERS.

TELEMETRY SYSTEMS

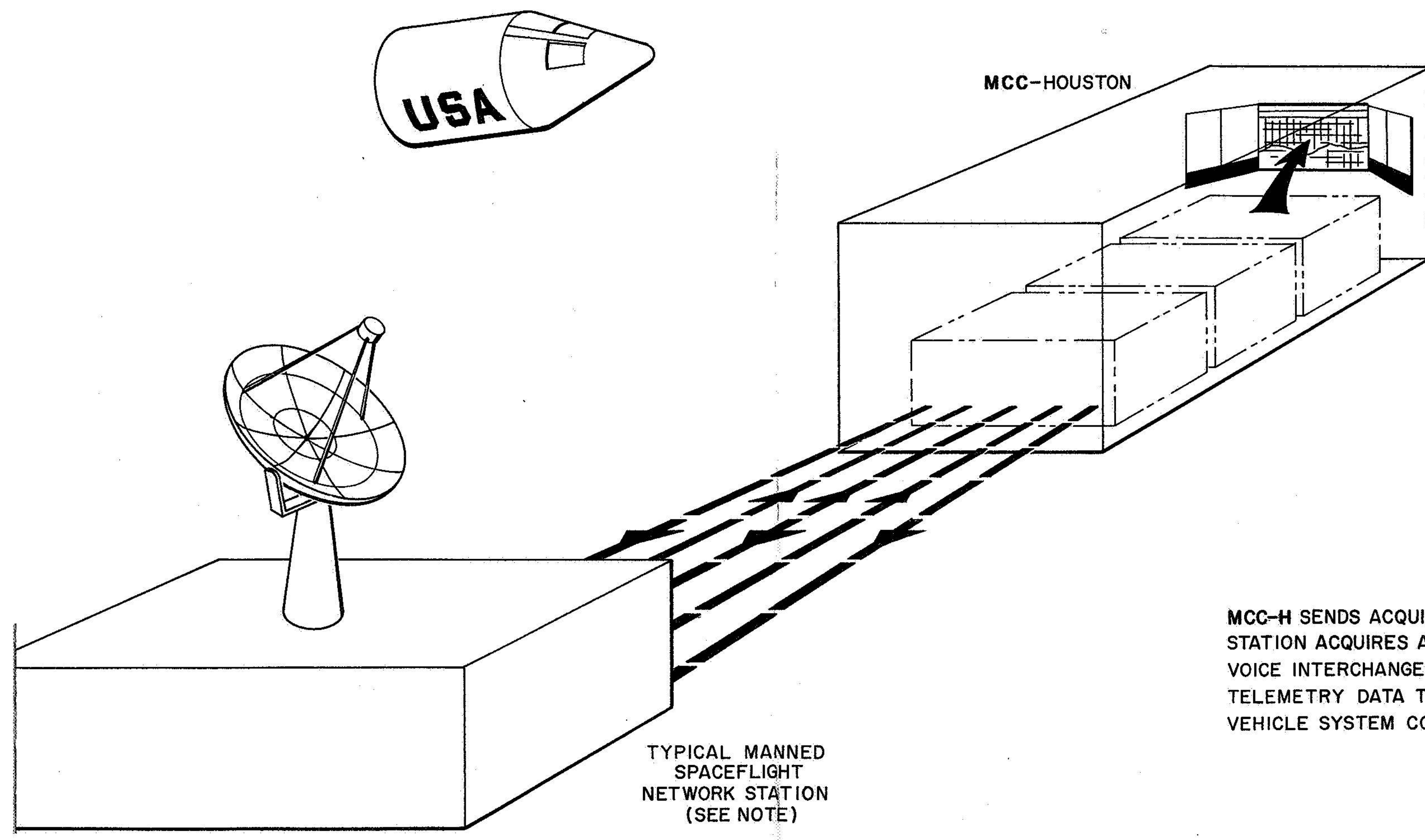
MONITOR VEHICLE SYSTEMS PERFORMANCE AND CONDITION OF FLIGHT CREW.

REMOTE SITE DATA PROCESSORS

PROVIDE CAPABILITY FOR SELECTING MOST PERTINENT OR CRITICAL TELEMETRY DATA TO EFFECTIVELY UTILIZE COMMUNICATIONS LINES TO MCC-H.

DIGITAL COMMAND SYSTEMS

UPDATE ONBOARD SPACECRAFT COMPUTERS,
COMMAND REAL TIME FUNCTIONS,
DISPLAYS REAL TIME DATA FOR FLIGHT CREWS.



MCC-HOUSTON

COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM
INTERFACES MCC-H WITH MANNED SPACEFLIGHT NETWORK,
TRANSMITS OUTGOING DATA TO RESPECTIVE STATIONS,
PROCESSES AND DISTRIBUTES INCOMING DATA TO RESPECTIVE DESTINATIONS.

REAL TIME COMPUTER COMPLEX SYSTEM
COMPUTES ACQUISITION DATA AND ROUTES TO RESPECTIVE STATIONS VIA COMMUNICATIONS SYSTEM,
ACCEPTS INCOMING DATA AND PERFORMS COMPUTATIONS AS NECESSARY,
DISTRIBUTES DATA TO DISPLAY AND CONTROL SYSTEM.

DISPLAY/CONTROL SYSTEM
RECEIVES DATA FROM REAL TIME COMPUTER COMPLEX SYSTEM,
DISTRIBUTES DATA TO RESPECTIVE DISPLAY DEVICES,
PERMITS INITIATION OF VEHICLE SYSTEMS COMMANDS AS NECESSARY.

MCC-H SENDS ACQUISITION DATA TO STATION.
STATION ACQUIRES AND TRACKS SPACECRAFT SENDING POSITIONAL DATA TO MCC-H.
VOICE INTERCHANGES CONDUCTED BETWEEN SPACECRAFT AND MCC-H VIA STATION
TELEMETRY DATA TRANSMITTED FROM SPACECRAFT TO STATION AND THEN ROUTED TO MCC-H.
VEHICLE SYSTEM COMMANDS TRANSMITTED TO SPACECRAFT TO PERFORM REQUIRED FUNCTIONS.

NOTE:
SEE FIGURE B-I FOR SPECIFIC CAPABILITIES OF EACH MANNED SPACEFLIGHT NETWORK STATION.

H-1194.4149

Figure 1-4. MCC-Houston/Manned Spaceflight Network, Simplified Information Flow

SECTION II
FUNCTIONAL SYSTEM EQUIPMENT

This section describes the equipment complement of each MCC-H functional system. The equipment composition and location is first given for each subsystem. This is followed by a brief statement of the function or purpose of each equipment grouping or major component.

2-1. COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM

The Communications, Command, and Telemetry System (CCATS) processes and distributes all signals, except television, entering and leaving the MCC-H and provides internal communication capabilities for the MCC-H. The system is divided into seven subsystems: Communications Facility Control, Voice Communications, Command, Telemetry, Central Processor, Teletype and Facsimile, and Pneumatic Tube.

2-1-1. Communications Facility Control Subsystem

The Communications Facility Control Subsystem, located in room 118, centralizes quality control and maintenance for all wide band and high-speed data circuits, all audio frequency communications circuits, and most of the teletype circuits that enter and leave the MCC-H. The U.S. Weather Bureau teletype circuits interface directly with the telephone company facilities. Room 118 contains wide band data and high-speed data transfer and test equipment, a wide band data and high-speed data recording facility, teletype test and patch equipment, audio test and patch equipment, and a countdown and status receiver. Figure 2-1-1 shows a composite photograph of the subsystem equipment.

2-1-1-1. Wide Band Data and High-Speed Data Transfer and Test Equipment

The wide band data and high-speed data transfer and test equipment consists of test bays, patch bays, modulator-demodulator units, data control units, high-speed teleprinter equipment, transfer switch equipment, checkout equipment, and line driver-terminator units. This equipment is used to monitor and maintain the quality of wide band and high-speed data circuits.

2-1-1-2. Wide Band Data and High-Speed Data Recording Facility

The wide band data and high-speed data recording facility consists of magnetic tape recorders and reproducers, and a digital time display unit. This equipment is used to record and make available for playback all wide band and high-speed data signals that enter or leave the MCC-H.

2-1-1-3. Audio Test and Patch Equipment

The audio test and patch equipment consists of patch and test bays. This equipment is used to monitor, test, and maintain all audio circuits. The patch bays also provide voice circuit status signals to the communications line switching console in room 118A.

2-1-1-4. Teletype Test and Patch Equipment

The teletype test and patch equipment consists of patch bays, a test bay, and a monitor console. The equipment is used to monitor, test, and maintain the quality of most teletype circuits that enter or leave the MCC-H.

2-1-1-5. Countdown and Status Receiver

The countdown and status receiver consists of a switching unit, a control panel, input/output logic, and patching and output relays. This equipment is used to receive and demultiplex for distribution the countdown and status data messages from the countdown and status transmitting equipment at the KSC.

2-1-2. Voice Communications Subsystem

The Voice Communications Subsystem enables voice communications between personnel within the MCC-H and, also, between the MCC-H and the MSC flight crew trainer facility, the Manned Spaceflight Network, and the spacecraft. The subsystem is composed of voice intercom equipment situated throughout the MCC-H and the flight crew trainer facility, a communication line switch console located in room 118A, public address equipment situated throughout the MCC-H, private automatic branch exchange equipment in the telephone central exchange building and room 118A, and a voice recording facility located in room 117A. A composite photograph of the subsystem equipment is shown in figure 2-1-2.

2-1-2-1. Voice Intercommunication Equipment

The basic element of the voice intercom equipment is a station keyset unit. This unit (in various configurations according to usage requirements) is mounted in consoles, on desks, walls, or pedestals, and on equipment racks situated throughout the MCC-H and the flight crew trainer facility. Special lamp supply generators, which provide code-type signaling to the keysets and other equipment in the form of a wink, flash, or flutter presentation, are located in room 127A. Supervisory and signaling control circuits, line circuits, and interconnecting networks for the keysets are also located in room 127A. This room also contains test and patch circuits necessary for proper maintenance and operation of the equipment. The keyset units, along with their associated control and interconnection circuitry, provide an internal communications network for the MCC-H and a voice communications capability between the MCC-H and the flight crew trainer facility.

2-1-2-2. Communication Line Switch Console

The communication line switch console consists of a two-position, manually operated switchboard, which provides for control and termination of voice communication lines between the MCC-H and the Manned Spaceflight Network. Line switching is accomplished by utilizing a four-color illuminated keyboard and a communication line switching matrix, which is an integral part of the console. The multicolor key lamps present a steady, flashing, or winking indication. The combination of lamp color and coded signaling indicates the operational status of any input communication line. Interconnection circuitry and certain equipments necessary for operation of the console are located in room 127A.

2-1-2-3. Air/Ground Control Equipment

The air/ground control equipment consists of tone transmitters, tone receivers, and a logic sequencer. This equipment turns on ground-to-air radio transmitters at remote sites, allowing voice communications between the spacecraft and the MCC-H.

2-1-2-4. Public Address Equipment

The public address equipment is composed primarily of audio amplifiers, located in room 127A, loudspeakers and microphones that allow access to the public address network, and the public address key position on the voice intercom keyset units. This equipment provides for total voice broadcast coverage of the MCC-H. Voice circuitry, selection and switching equipment, and speaker muting and keying circuitry used in control and operation of the public address network are located in room 127A. The OSW auditorium has a separate, independent public address system consisting of a microphone, a 35-watt power amplifier, and six ceiling-mounted speakers. This public address system is used only in the auditorium for briefings and debriefings.

2-1-2-5. Private Automatic Branch Exchange Equipment

The private automatic branch exchange equipment consists of communication line circuitry arranged for voice communications outside the MCC-H and an intercept switchboard for operator control of selected circuits. This equipment provides access to the MSC telephone dial system. The communication lines are tied into the voice intercom keyset units for signaling and ringing at each station on incoming calls and for dialing on outgoing calls.

2-1-2-6. Voice Recording Facility

Various magnetic tape recorder/reproducers and associated patch and monitor circuitry comprise the voice recording facility. This equipment provides a means of recording and playback of selected voice communications and biomedical (FM/FM) data.

2-1-3. Command Subsystem

The Command Subsystem processes command data for transmission from MCC-H to the Apollo command and service module, the lunar excursion modules, or the Saturn launch vehicle. The subsystem utilizes the hardware of the CCATS, RTCC, and Display/Control Systems.

2-1-4. Telemetry Subsystem

The Telemetry Subsystem equipment is located primarily in room 129 with additional processing equipment in rooms 216 and 316. The subsystem receives wide band pulse-code-modulation (PCM) telemetry data from CCATS via the Communications Facility Control Subsystem, provides independent operational and dynamic standby processing of the received data for up to two simultaneous missions, and distributes the processed data to the two MOCR's, SSR's and CCATS display equipment. The subsystem also receives frequency modulation (FM) biomedical data from the Voice Communications Subsystem, provides independent processing of the received biomedical data for up to two simultaneous missions, and distributes the data representing the astronauts' heartbeat and respiration to the life systems analysts. The subsystem is composed of pulse-code-modulation telemetry equipment, telemetry monitor and processing equipment, frequency modulation equipment, biomedical processing equipment, output transfer switch equipment, and telemetry analog and event distribution equipment. A composite photograph of the subsystem equipment is shown in figure 2-1-4.

2-1-4-1. Pulse-Code-Modulation Telemetry Ground Station Equipment

The pulse-code-modulation (PCM) telemetry equipment consists of four PCM telemetry ground stations, a telemetry event decoder, a PCM telemetry signal simulator, and a PCM telemetry patch board. The four PCM telemetry ground stations provide independent, operational and dynamic standby data processing for the two MOCR's, SSR's, and CCATS display equipment. Each ground station contains serial-to-parallel converters, decommutation synchronization logic, a data format program memory, digital-to-analog converters, and various output registers. The PCM telemetry ground stations receive pulse-coded input signals and associated clock signals. The ground stations process the pulse-coded input signal and apply data, data identification, and decommutation synchronization and status signals to the output transfer switch equipment.

The telemetry event decoder consists of two similar event decoding sections. Each event decoding section processes data from an operational PCM telemetry ground station and furnishes additional event data for the associated MOCR, SSR, and CCATS display equipment. The PCM telemetry signal simulator generates PCM telemetry test input signals and associated clock signals for the four PCM telemetry ground stations. In addition, the signal simulator is capable of performance testing the PCM telemetry ground stations.

The PCM telemetry patch board provides the means for selecting input data and clock signals to the PCM telemetry ground stations.

2-1-4-2. Telemetry Monitor and Processing Equipment

The telemetry monitor and processing equipment monitors the operation of the pulse-code-modulation telemetry ground stations and the output transfer switch equipment. The equipment consists of telemetry supervisor console, logic equipment, and chart (analog) and event recorders.

2-1-4-3. Frequency Modulation Equipment

Frequency modulation (FM) ground stations and associated patch boards make up the frequency modulation equipment. FM ground stations are composed, almost entirely, of subcarrier discriminators, which receive and segregate the telemetered biomedical information by vehicle and type into specific channels. A separate discriminator is included as a backup or testing unit for the operational discriminator channels.

2-1-4-4. Biomedical Processing Equipment

The biomedical processing equipment consists of biomedical preprocessing equipment, biomedical computer processing equipment, delay-loop recorder/reproducer, and biomedical patch boards. Preprocessing equipment consists of pneumotachometers and cardiotachometers, which convert the analog respiration and heartbeat waveforms into digital form to drive remote digital displays and the computer processing equipment. The computer processing equipment consists entirely of cardiotachometer/pneumotachometer computer input buffers (cardio/pneumo CIB). The buffers simultaneously sample the individual heartbeat and breathing rates, combine the rates with data tags from the remote control equipment, and then transmit the data in high-speed format to the Communications Facility Control Subsystem. Delay-loop recorder/reproducers and associated patching equipment provide for post and/or present (30-second delay) analysis of individual astronaut heart and respiration conditions. Patch boards are used to manually select the specific data channels for use by the biomedical processing equipment.

2-1-4-5. Output Transfer Switch Equipment

The output transfer switch equipment routes decommutated telemetry data through patching, switching, and driver equipment to the chart (analog) and event recorders and to the Computer Display/Control Interface Subsystem for MOCR, SSR, and CCATS displays. The equipment is composed of relay switching, logic switching, patch panels, and output relays and drivers.

2-1-4-6. Telemetry Analog and Event Distribution Equipment

The telemetry analog and event distribution equipment is composed of telemetry event driver equipment that routes bilevel event signals to the consoles in Computer Display/Control Interface Subsystem for MOCR, SSR, and CCATS displays. The telemetry analog and event distribution equipment also contains the subchannel data distributor (SDD) and digital display driver (DDD) equipments. The subchannel data distributor controls the distribution of digital data to the digital display driver equipment for bilevel event displays on modules and chart recorders in the MOCR, SSR, and CCATS display areas.

2-1-5. Central Processor Subsystem

The Central Processor Subsystem receives, processes, and distributes all incoming and outgoing data at the MCC-H. The subsystem comprises three computers, communications interface equipment, storage and recording equipment, transfer switching equipment, and monitor and control equipment, all located in rooms 116 and 116B. A composite photograph of the Central Processor Subsystem is shown in figure 2-1-5.

2-1-5-1. Computers

The three computers are stored program, high-speed digital processors utilizing an internal memory and 18 input/output channels to process large amounts of data on a real time basis. A clock is associated with each computer to automatically time stamp each message and to provide synchronization signals for the computers.

2-1-5-2. Communications Interface Equipment

The communications interface equipment consists of communications line terminals, communications multiplexers, polynomial buffered terminals, channel scanners, central processor/RTCC adapters, computer input multiplexer/subchannel data distributor adapters, and output inhibit switching circuitry. This equipment permits the Central Processor Subsystem to accept numerous data communications, and to route the data to the assigned destination.

2-1-5-3. Storage and Recording Equipment

The storage and recording equipment associated with each computer consists of two magnetic core memory units, a magnetic drum, four magnetic tape units, and a card processor. These units provide message storage and rapid retrieval capabilities, printing out information at any time on an as-requested basis.

2-1-5-4. Transfer Switching Equipment

The transfer switching equipment consists of an electronic transfer switch and a system configuration unit.

The electronic transfer switch provides rapid switching between components with no loss of data. The system configuration unit provides computer-to-peripheral-unit configuration through use of programmed patch boards.

2-1-5-5. Monitor and Control Equipment

The monitor and control equipment consists of a computer control console for each computer and a communications and configuration console. The computer control consoles are used to control the operation and to insert program changes into the computer. The communications and configuration console is used to establish the operational configuration of the Central Processor Subsystem and to monitor its operation.

2-1-6. Teletype and Facsimile Subsystem

The Teletype and Facsimile Subsystem transmits and receives teletype and meteorological data between the MCC-H and the U.S. Weather Bureau, and between the MCC-H and the Manned Spaceflight Network. The subsystem is composed of teletype and facsimile equipment located in the meteorological center, and teletype equipment located throughout the MCC-H. A composite photograph of the subsystem equipment is shown in figure 2-1-6.

2-1-6-1. Teletype Equipment

The teletype equipment includes automatic send-receive sets, receive-only typing reperforator units, receive-only page printer units, transmitter distributor units, silent receive-only page printers, a teletype loop patch panel, and a teletype loop switchboard. With the exception of the teletype loop patch panel and the teletype loop switchboard, this equipment is used to print out and transmit all incoming or outgoing teletype messages. The teletype loop patch panel is used in the Recovery Control Room (RCR) to provide teletype equipment flexibility and the teletype loop switchboard is used in the meteorological center for switching U.S. Weather Bureau teletype circuits between the teletype equipment in the meteorological center.

2-1-6-2. Facsimile Equipment

The facsimile equipment includes a facsimile transmitter, facsimile receiver/recorder, and a call director. The facsimile equipment is used to transmit and receive U.S. Weather Bureau meteorological data in support of the meteorological center located in room 324. The call director is used to select the facsimile circuits for interfacing with the facsimile equipment.

2-1-7. Pneumatic Tube Subsystem

The Pneumatic Tube Subsystem enables rapid hard-copy message routing throughout the MCC-H. The subsystem is composed of automatic and manual message routing equipments located in various areas of the MOW. A composite photograph of the subsystem equipments, excluding pneumatic tube runs, is shown in figure 2-1-7.

2-1-7-1. Automatic Message Routing Equipment

The automatic message routing equipment is divided into two independent networks capable of routing hard-copy messages between an MOCR, the corresponding SSR's, the RTCC, and other areas. Each network includes send and receive stations located in various areas of the MOW, a rejected message receive and retransmit station in the MCC-H message center (room 116A), pneumatic tube runs that connect all stations through a central exchanger located in room 130, cylindrical message carriers that are inserted into the pneumatic tube runs to carry messages between stations, a control panel located in room 130, and automatic deflection fittings and other accessories that are located as required throughout the pneumatic tube runs. Pneumatic tube runs to and from these stations contain Y-switch units (deflection switches) for diverting message carriers to selected stations. A supervisory panel located in room 116A is also common to both automatic message routing networks. This panel provides the same indicators as on the control panel in room 130.

2-1-7-2. Manual Message Routing Equipment

The manual message routing equipment consists of 12 send and receive stations located in various areas of the MOW, pneumatic tube runs, and message carriers. This equipment provides a point-to-point message routing capability between the MCC-H message center and send and receive stations in the MOCR's, operations and procedures SSR's, and between room 229A and the third floor simulation control area (room 328).

2-2. DISPLAY/CONTROL SYSTEM

The Display/Control System displays selected data and enables control of various command functions. The system is divided into four subsystems: Computer Display/Control Interface, Timing, Television, and Group Display.

2-2-1. Computer Display/Control Interface Subsystem

The Computer Display/Control Interface Subsystem interfaces the RTCC System and the Communications, Command, and Telemetry System with the Display/Control System to accomplish data request, data display, and control functions. The subsystem is composed of computer request equipment, encoder-multiplexer equipment, slide file equipment, digital-to-television converter equipment, digital display driver equipment, event and analog driver equipment, and an MOCR switch unit. Some of the computer request, encoder-multiplexer, digital-to-television converter, and converter slide file equipments are used to support the dynamic standby computer in the RTCC System. Those components that are used exclusively in this manner are grouped together as auxiliary display equipment. The majority of the equipment comprising the subsystem is located in rooms 216, 316, and 319. Additional equipment, such as console keyboards, is located in the MOCR's and associated SSR's, in the RCR, the RTCC, and rooms

118B, 227A, and 324. Figure 2-2-1 shows a composite photograph of the subsystem equipment.

2-2-1-1. Computer Request Equipment

The computer request equipment consists of console-mounted keyboards that permit mission control operators to request information from the RTCC and Central Processor Subsystem, and to perform control functions.

2-2-1-2. Encoder-Multiplexer Equipment

The encoder-multiplexer equipment is composed of computer request encoders, (in general, one for each computer request keyboard) and a computer input multiplexer. The encoders detect and encode into a digital format the requests initiated on the computer request keyboards. The computer input multiplexer transmits the encoded requests over a single line to the RTCC or Central Processor Subsystem on a controlled access basis.

2-2-1-3. Slide File Equipment

The slide file equipment consists of converter slide file data distributors, converter slide files, reference slide files, and a set of slide-making equipment. The data distributors control distribution of slide selection data to the slide files and control data to the video switching matrix of the Television Subsystem. The converter slide files permit random access to photographic slides, which provide background information for digital data that is included in composite video displays produced by the digital-to-television converter equipment. The reference slide files are identical to the converter slide files, except that the slides contain reference information which is converted directly into video signals without the addition of dynamic digital data. Generation of slides for the slide files is accomplished with the slide-making equipment located in room 212R of building 8.

2-2-1-4. Digital-to-Television Converter Equipment

The digital-to-television converter equipment includes digital-to-television converter data distributors, buffers, and display generators. The data distributors control the distribution of display data from the RTCC to the buffers. The buffers are storage devices that apply the display data, upon demand, to the display generators. The display generators produce composite video displays for television presentation consisting of converted digital data and converter slide images.

2-2-1-5. Digital Display Driver Equipment

The digital display driver equipment comprises digital display driver data distributors and digital display drivers. The data distributors control the distribution of computer generated time words to the Timing Subsystem and of digital data to the digital display drivers, which control computer driven lamps within the Computer Display/Control Interface, Group Display, and Television Subsystems.

2-2-1-6. MOCR Switch Unit

The MOCR switch unit permits various areas of the MOW that are common to both MOCR's (e.g., the communications controller facility) to operate with either MOCR. The switch unit consists of preprogrammed patch boards for each area. Switching from one MOCR to the other is accomplished by changing patch boards.

2-2-1-7. Auxiliary Display Equipment

The auxiliary display equipment consists of various computer request keyboards, a converter slide file and data distributor, a digital-to-television converter data distributor, a buffer, and a display generator. The auxiliary display equipment shares the encoder-computer input multiplexer. These components, similar to equipment previously described, handle dynamic standby data.

2-2-1-8. Console/Module Equipment

The console/module equipment consists of the consoles and the modules mounted on the various consoles to fulfill specific mission requirements. The consoles are grouped in five functional areas: mission command and control, mission command and control support, flight dynamics, systems operations, and public affairs information control consoles. The mission command and control consoles are located in the MOCR's. The mission command and control support consoles are located in the MOCR's, the network instrumentation control room, the operations and procedures SSR's, the network SSR, the RCR, and the meteorological center. The flight dynamics consoles are located in the MOCR's and the flight dynamics SSR's. The systems operations consoles are located in the MOCR's, the vehicle systems SSR's, the flight crew SSR's, and the life systems SSR's. A public affairs officer console is located in each MOCR. Another public affairs information control console is located in room 319 for use by the public affairs television editor.

2-2-1-8-1. Mission Command and Control Consoles

The consoles included within the mission command and control group are the operations director, flight director, assistant flight director, operations and procedures officer, and the network controller consoles. These consoles provide operational positions from which the following functions are performed: monitoring and analyzing mission status, implementing appropriate actions to support flight plans and mission objectives, and detailed directing and controlling of all major elements involved in a manned spaceflight mission.

2-2-1-8-2. Mission Command and Control Support Consoles

The mission command and control support consoles consist of the consoles located in the operations and procedures SSR, the network SSR, the meteorological center, the RCR, and the instrumentation control room. These consoles provide operational positions to lend detailed support to the personnel stationed at the mission command and control consoles.

2-2-1-8-3. Flight Dynamics Consoles

The flight dynamics consoles consist of the flight dynamics officer, retrofire officer, guidance officer, and flight dynamics SSR consoles. These consoles enable monitoring and evaluation of all aspects of powered flight concerning crew safety and orbital insertion, evaluation of orbital trajectories required to meet mission objectives, and continuous updating of retrofire information throughout a mission for both planned and contingency reentry situations.

2-2-1-8-4. Systems Operations Consoles

The systems operations consoles include the life systems officer, the booster system engineer, the electrical environmental communications engineer, the guidance navigation computer engineer, the vehicle systems SSR, and the flight crew SSR consoles. These consoles enable monitoring and evaluation of flight crew status; analyzing the performance of electrical, mechanical, and life systems; and initiation of vehicle systems commands.

2-2-1-8-5. Public Affairs Information Control Consoles

The public affairs information control consoles include the public affairs officer and public affairs television editor consoles. The personnel stationed at these consoles do not engage in mission command and control activities. Their purpose, during a mission, is to coordinate public affairs information with commercial news media and other interested groups. In this respect, the public affairs information control consoles enable the monitoring of voice and television communications and the controlled delivery of such, along with appropriate comments, to the MBOA and to a remote public affairs broadcast studio located in a separate building.

2-2-2. Timing Subsystem

The Timing Subsystem is the MCC-H timing standard and distributes timing data to all MCC-H functional systems. The subsystem is composed of master instrumentation timing equipment, an Atlantic missile range countdown processor, two sets of relative time accumulators, six sets of dual stop clock equipment, two serial decimal time converters, three timing signal distributors, time display and control modules, a timing interface unit, and wall clock equipment. The master instrumentation timing equipment, countdown processor, timing interface unit, and serial decimal time converter are located in room 319. One relative time accumulator set is in room 216, the other in room 316. One timing signal distributor is in room 118 and two are in room 117A, three sets of dual stop clock equipment are in each MOCR, the time display and control modules and wall clocks are located throughout the MCC-H. A composite photograph of the subsystem equipment is shown in figure 2-2-2.

2-2-2-1. Master Instrumentation Timing Equipment

The master instrumentation timing equipment is a dual master timer synchronized to the National Bureau of Standards radio station WWV. The master instrumentation timing equipment generates pulse rate signals and time code words for distribution throughout the MCC-H to time index and synchronize actual and simulated mission operations.

2-2-2-2. Atlantic Missile Range Countdown Processor

The Atlantic missile range countdown processor provides simulated countdown signals and processes countdown data from KSC for the relative time accumulators.

2-2-2-3. Relative Time Accumulators

Two identical sets of relative time accumulators are used to accumulate countdown, mission, and general purpose timing signals. One relative time accumulator serves equipment on the second floor of the MOW; the other serves equipment on the third floor.

2-2-2-4. Dual Stop Clock Equipment

The dual stop clock equipment provides manually controlled time-to-go or elapsed time presentation for any selected event. There are two dual stop clock equipments in each retrofire officer console and one in each spacecraft communicator console.

2-2-2-5. Serial Decimal Time Converter

The serial decimal time converter receives binary-coded-decimal Greenwich mean time signals from the master instrumentation timing equipment, converts the signals to pulse-coded-decimal Greenwich mean time, and distributes the signals to all chart recorders within the MCC-H.

2-2-2-6. Timing Signal Distributors

The timing signal distributors receive specially formatted Greenwich mean time signals from the master instrumentation timing equipment on unbalanced lines and distribute the signals to all magnetic tape recorders and to some time display units on balanced lines.

2-2-2-7. Timing Interface Unit

The timing interface unit receives binary-coded-decimal time signals from the master instrumentation timing equipment and converts the time signals into time words and synchronization signals for use by the Central Processor Subsystem.

2-2-2-8. Time Display and Control Modules

The time display and control modules display the various time-code words generated by the Timing Subsystem equipment. In addition, the modules provide control of certain time-code words generated by the subsystem.

2-2-2-9. Wall Clock Equipment

The wall clock equipment consists of a wall-mounted master control unit in room 319 and associated wall clocks spaced throughout the MCC-H. The master control unit is synchronized with radio station WWV and supplies correction signals for the wall clocks.

2-2-3. Television Subsystem

The Television Subsystem generates, distributes, records, and displays television video information with pictorial, graphic, or alphanumeric content. The subsystem is composed of the following major components of equipment groups: television camera equipment; television viewers; television converter equipment; landline interface equipment; standard resolution (525-line scanning rate) and high resolution (945-line scanning rate) synchronization, generation, and distribution equipment; television distribution equipment; television recording equipment; and television remote control equipment. The majority of the equipment comprising the subsystem is located in rooms 118, 216, 231, 316, 319, and 330. Additional equipment, such as opaque televisors, television viewers, cameras, and associated control devices are located throughout the MOW. Figure 2-2-3 shows a composite photograph of the subsystem equipment.

2-2-3-1. Television Camera Equipment

The television camera equipment consists of television camera, fixed focus lenses, zoom lenses and control panels, pan and tilt mechanisms and control panels, camera control units, remote control panels, matte televisors, and opaque televisors. This equipment provides for the controlled generation of closed-circuit video information within the MCC-H.

2-2-3-2. Television Viewers

The television viewers are composed of 5-inch, dual 8-inch, 10-inch, 14-inch, 17-inch, and 21-inch television viewers that are console-, cabinet-, wall-, or ceiling-mounted. The viewers provide displays of television video signals generated within and outside the MCC-H.

2-2-3-3. Television Converter Equipment

The television converter equipment is composed of television standard converters located in room 319 and an analog-to-television converter and time display converters located in rooms 216 and 316. The television standard converters accept video signals at one scanning rate and convert the video signals to a different scanning rate while maintaining a standard frame rate. The time display converters generate video signals from illuminated time display readout panels. Analog-to-television converter converts chart recorder information to television video signals.

2-2-3-4. Landline Interface Equipment

The landline interface equipment consists of a 14-inch television viewer, a video waveform monitor, video jack panels, video distribution amplifiers, equalizing amplifiers, and stabilizing amplifiers located in room 118. This equipment is used to monitor and manually switch standard resolution video signals that enter or leave the MCC-H.

2-2-3-5. Synchronization Generation and Distribution Equipment

The synchronization generation and distribution equipment is located in room 319 and is divided into two groups: standard resolution and high resolution. Both groups consist of dual synchronizing generators, switching facilities, pulse distribution amplifiers, and pulse delay units. These two groups of equipment generate television timing and synchronizing pulses and distribute the pulses to appropriate components of the television subsystem located throughout the MOW.

2-2-3-6. Television Distribution Equipment

The television distribution equipment is composed of high resolution video switching matrices and video distribution amplifiers in rooms 216 and 316, and standard resolution patch and distribution equipment in room 319. Each high resolution video switching matrix has 80 input channels and 160 output channels. Each matrix provides selected television signals to console-mounted television viewers and group display television projectors and also distributes selected television signals to recording and monitoring equipment. The standard resolution patch and distribution equipment supplies selected television signals to video tape recorders, television viewers, and to the landline interface equipment for distribution to areas outside the MOW.

2-2-3-7. Television Recording Equipment

The television recording equipment consists of a video tape recording facility in room 319 and hardcopy recording equipment in rooms 216 and 316. The video tape recording facility provides video tape recording and editing facilities for standard resolution video signals. The hardcopy recording equipment consists of video scanners and television hardcopy recorders. The equipment provides a hardcopy reproduction of selected televised images when manually requested.

2-2-3-8. Television Remote Control Equipment

The television remote control equipment consists of console-mounted control modules located throughout the MOW. The control modules provide remote controls for video distribution equipment and video recording equipment.

2-2-4. Group Display Subsystem

The Group Display Subsystem presents large-scale displays of selected data for group viewing. The subsystem is composed of components located in the two MOCR's, the SSR's, the RCR, the RTCC, room 319, and the MBOA. The components comprise six equipment groups: plotting display equipment, projection plotting display equipment, projection television display equipment, transparency projection display equipment, screens and mirrors, and group time and data display equipment. A composite photograph of the components included in the subsystem is shown in figure 2-2-4.

2-2-4-1. Plotting Display Equipment

The plotting display equipment includes plotting display data distributors and X-Y plotboards. The data distributors control the distribution of plotting data from the RTCC System to the X-Y plotboards and the projection plotting display equipment. The X-Y plotboards contain dual pen-and-arm assemblies to permit simultaneous plotting of two independent sets of data.

2-2-4-2. Projection Plotting Display Equipment

The projection plotting display equipment consists of various slide projectors and associated automatic and manual control devices. These equipments work in conjunction with one another to produce highly accurate wall-type displays in the MOCR's and the RCR of computer and manually generated data plotted against static backgrounds.

2-2-4-3. Projection Television Display Equipment

Large screen television projectors and console-mounted control modules comprise the projection television display equipment. This equipment projects selected video signals, as pictures, onto group viewing screens in the MOCR's, the RCR, and MBOA.

2-2-4-4. Transparency Projection Display Equipment

The transparency projection display equipment, which is located in the RCR, is composed of transparency projectors, data files, and transparency processors. This equipment permits rapid generation of transparencies, or rapid access to previously generated transparencies, and the display of same on group viewing screens in the RCR.

2-2-4-5. Screens and Mirrors

The screens and mirrors provide the image and reflection surfaces, respectively, for the MOCR's and the RCR projection displays. The screens are rear-projection viewing screens, which permit favorable illumination to be maintained in the control rooms. The mirrors optically fold projected images to achieve the optical throw distance required to display the images properly on the screens.

2-2-4-6. Group Time and Data Display Equipment

The group time and data display equipment consists of large-scale, alphanumeric readout assemblies and display drivers. The time displays present various types of reference timing and event indications to the MCC-H control areas. The data displays present information concerning telemetry, tracking, and command data to the MOCR's and the RTCC. A video channel indication for the MOCR projection television displays is also provided by this equipment group.

2-3. REAL TIME COMPUTER COMPLEX SYSTEM

The RTCC system performs operational mission real time computation tasks required by the MCC-H and generates test data in support of MCC-H checkout and training programs. The computer complex constitutes five, real time computing systems, each composed of the following subsystems: Real Time Computer, Computer Control, and Auxiliary Data Processing. The equipments for all three subsystems are located in room 112 of the MOW. One of the five computer systems is shown in figure 2-3-1.

2-3-1. Real Time Computer Subsystem

The Real Time Computer Subsystem receives incoming data, stores and records the data as necessary, performs computation and analyses on the data, and transmits the data to user equipment. The subsystem consists of five large-scale digital computers with large auxiliary core memories, real time input/output channels, and associated peripheral equipment. A system selector unit, common to all five computers, enables reliable and flexible switching of computer functions. The specific components included with each real time computer-peripheral equipment combination are a central processing unit, a data input/output multiplexer, a core storage unit, 2 data channels, 12 magnetic tape units, a disc storage unit, a printer, a card reader, a direct data channel (dual), a data communication channel, a core storage file, and a computer controller multiplexer unit. These components and the system selector unit are briefly described below.

2-3-1-1. Central Processing Unit

The central processing unit is a digital data computer that performs high-speed data processing on a real time basis.

2-3-1-2. Data Input/Output Multiplexer

The data multiplexer is an input/output switching device that controls the flow of data and instructions between the central processing unit, input/output channels, and the core storage unit.

2-3-1-3. Core Storage Unit

The core storage unit is a fast, random access, magnetic memory core. The unit serves the central processing unit and the input/output channels with the central processing unit controlling the storage access of both.

2-3-1-4. Data Channels

The data channels, under the programmed direction of the central processing unit, transfer data to and from the core storage unit and the card reader, printer, and magnetic tape units connected to the channels. The card reader permits manual entry of data in punched-card form into a data channel for subsequent processing by the central processing unit. The printer provides rapid printouts of output data from an associated data channel. The magnetic tape units record data on magnetic tapes and permit entry of prerecorded data into the data channels.

2-3-1-5. Direct Data Channel

The direct data channels connect the data multiplexer with the core storage file unit (input and output) and, through the system selector unit, with the Computer Display/Control Interface Subsystem.

2-3-1-6. Core Storage File

The storage file is a large capacity, random access, storage device that permits rapid recall of data into the core storage unit.

2-3-1-7. Data Communications Channel

The data communications channel is a multiplexing device that connects one data input/output multiplexer channel to several input and output data communications subchannels, a clock subchannel, and an interval timer subchannel. The data communications subchannels serially receive and transmit data. The clock and interval timer subchannels provide selective signaling and program interruptions at predetermined times.

2-3-1-8. Computer Controller Multiplexer Unit

The computer controller multiplexer unit connects manual computer input/output equipment of the Computer Control Subsystem to subchannels of the data communications channel and performs format structure adaptation so that the subchannels are compatible with the manual input/output devices.

2-3-1-9. System Selector Unit

The system selector unit enables any of the five real time computers to perform any of the functional assignments (modes of operation) that may be assigned to the RTCC. (In general, the modes of operation are mission operations, dynamic standby, checkout and training, and "off-line".)

2-3-2. Computer Control Subsystem

The Computer Control Subsystem enables RTCC operating personnel to monitor computer performance and manually control mission programs and data selection. The subsystem consists of two control areas with associated plotting displays and manual entry devices. In addition, a control area junction unit, standby digital driver unit, and system status display unit are included with the subsystem. These units are common to both control areas.

2-3-2-1. Control Area Operating Positions

Each of the two control areas incorporates the following consoles: complex supervisor, tracking data selection processing controller, flight dynamics processing controller, network and command processing controller, telemetry processing controller, and checkout systems processing controller. These consoles provide operating positions for monitoring and controlling the real time computers. An RTCC director/maintenance and operations supervisor console serves both control areas. This two-position console provides operating positions for the RTCC Director and the RTCC Maintenance and Operations Supervisor to perform their respective duties, which are primarily administrative.

2-3-2-2. Plotting Displays

Four X-Y plotboards, physically arranged and cabled so that from one to four plotboards may be used with either control area, are used to monitor plotting display control data.

2-3-2-3. Manual Entry Devices

The manual entry devices are teletype send-receive units. These units are used by the operators in the control areas to manually enter data and control information into or receive computer generated responses from the real time computers.

2-3-2-4. Control Area Junction Unit

The control area junction unit provides a central junction point between the Real Time Computer Subsystem and manual computer input/output devices within the Computer Control Subsystem.

2-3-2-5. Standby Digital Driver Unit

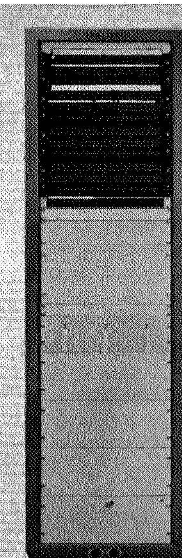
The standby digital driver unit is a combination decoder and driver unit that accepts selected outputs from the real time computer operating in the dynamic standby mode. The unit then decodes the outputs and routes them to control area console-mounted displays to allow a comparison to be made between the operational and the standby outputs.

2-3-2-6. System Status Display Unit

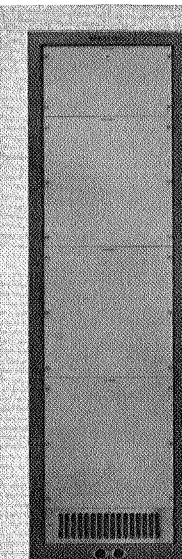
The system status display shows the functions assigned to each real time computer and the status of the subsystem that provides inputs to or receives outputs from the computers.

2-3-3. Auxiliary Data Processing Subsystem

The Auxiliary Data Processing Subsystem prepares computer input data and records the data on magnetic tapes for high-speed input to the Real Time Computer Subsystem. Two identical groups of data processing equipment comprise the subsystem. Each group includes a central processing unit, a console printer, a card read-punch unit, printers, and magnetic tape units.

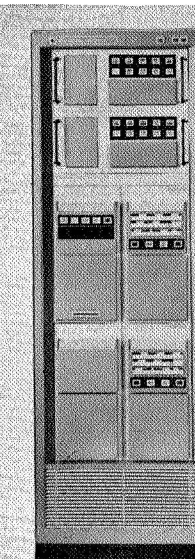


HSD VF PATCH BAY
PHO-OA1380



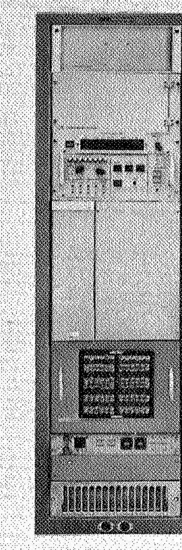
MODEM BAY

HSD/WBD MODEM EQUIPMENT



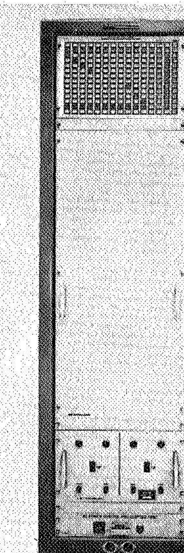
DATA CONTROL UNIT

DATA CONTROL UNITS



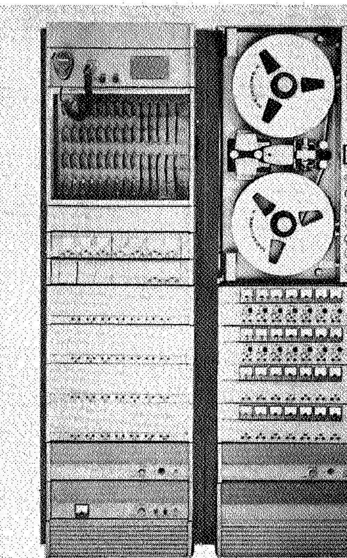
COUNTDOWN AND
STATUS RECEIVER

CASR EQUIPMENT



WBD TRANSFER SWITH

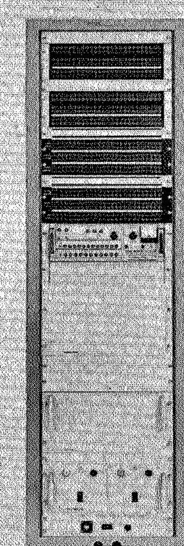
WBD TRANSFER SWITCH EQUIPMENT

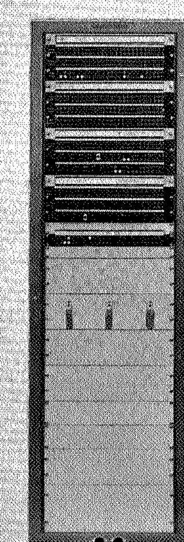


MAGNETIC TAPE
RECORDER/REPRODUCER
PHO-OA1451

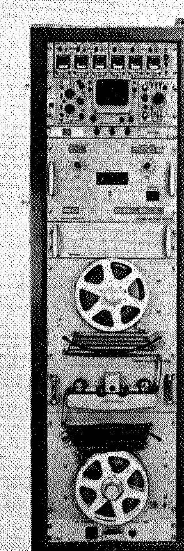
WB
PH

WBD RECORDI



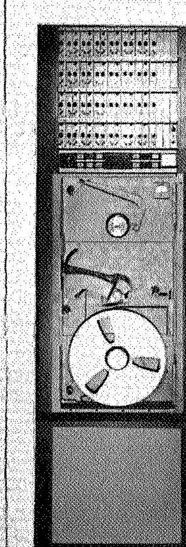


HSD PATCH BAYS
NO. 1 PHO-OA1115
NO. 2 PHO-OA1139

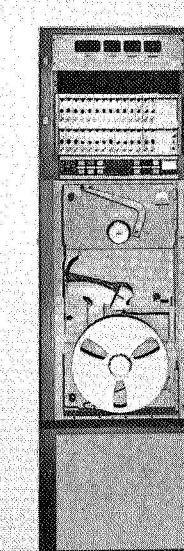


HSD TEST BAY
PHO-OA1140

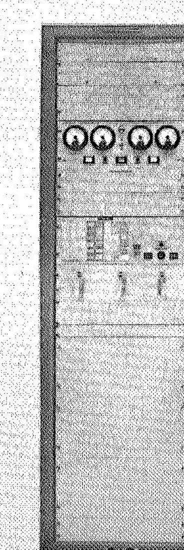
HSD TEST AND PATCH EQUIPMENT



HSD
RECORDER/REPRODUCER A

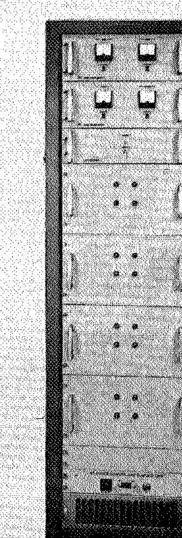


HSD
RECORDER B



HSD
TRANSFER CONTROL

HSD RECORDING FACILITY
PHO-OA1254



HIGH-SPEED TELEPRIN
INTERFACE EQUIPME
PHO-OA1474

HIGH-SPEED T
EQUIPM

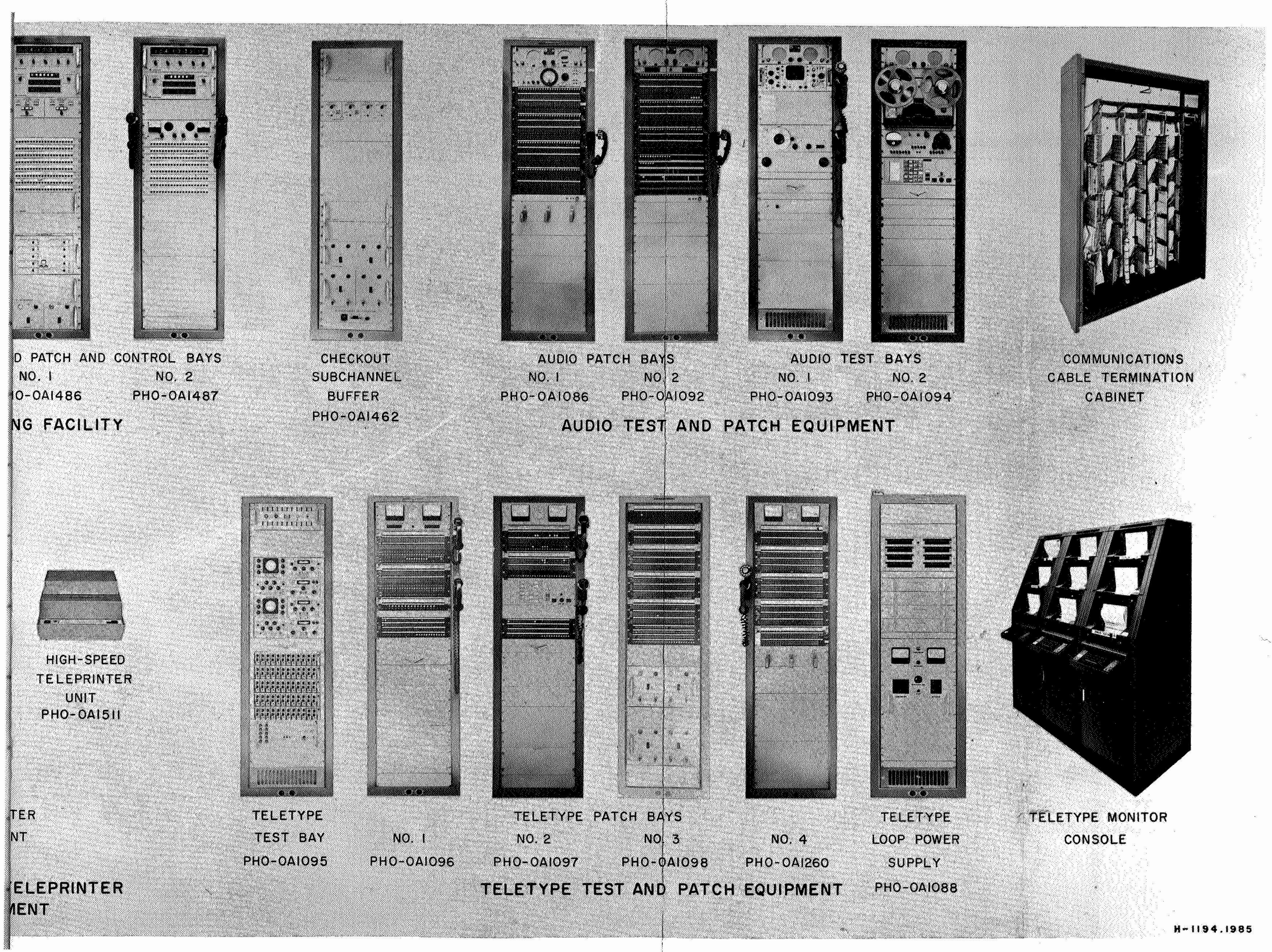


Figure 2-1-1. Communications Facility Control Subsystem

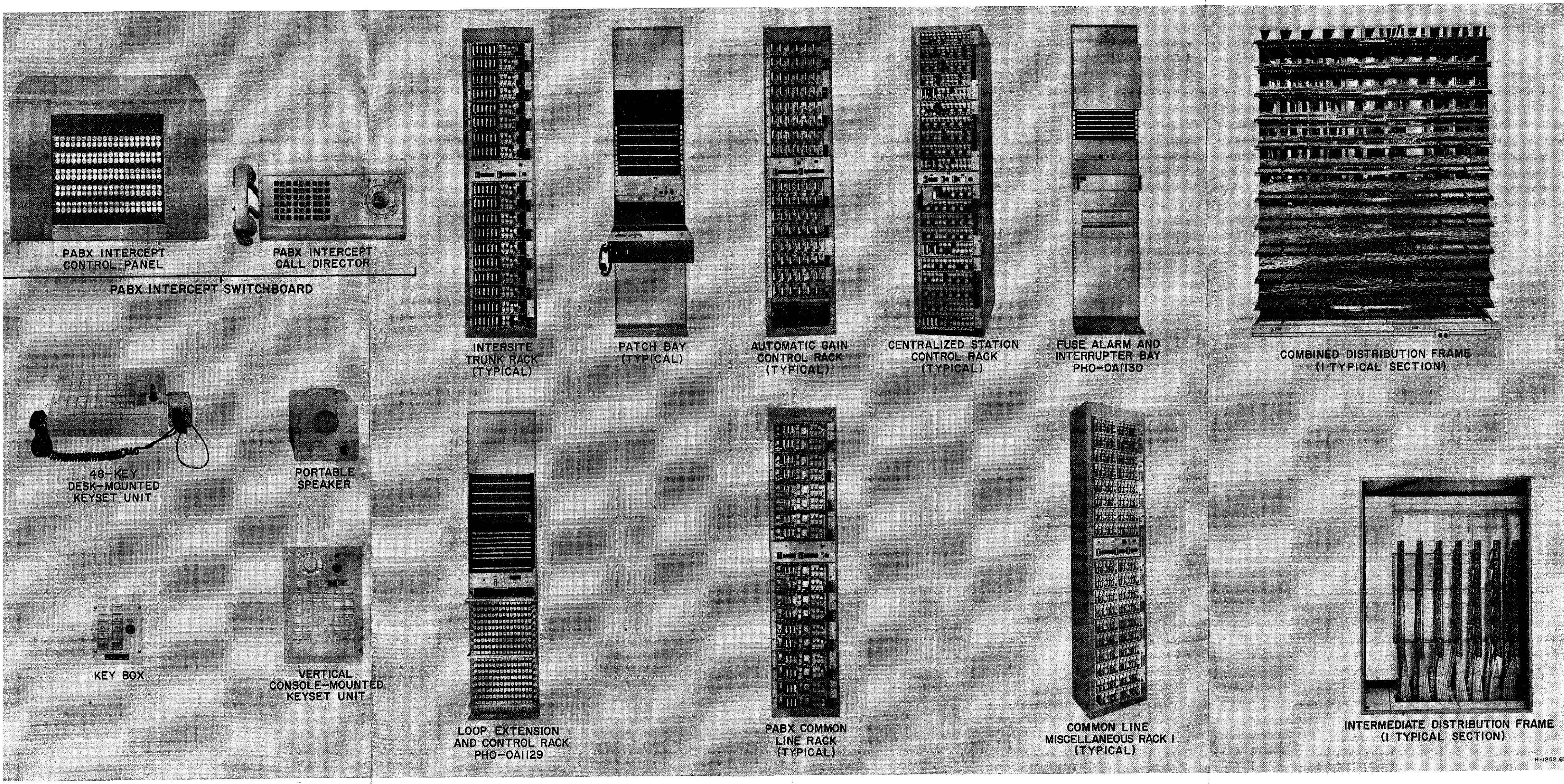


Figure 2-1-2. Voice Communications Subsystem (Sheet 1 of 3)

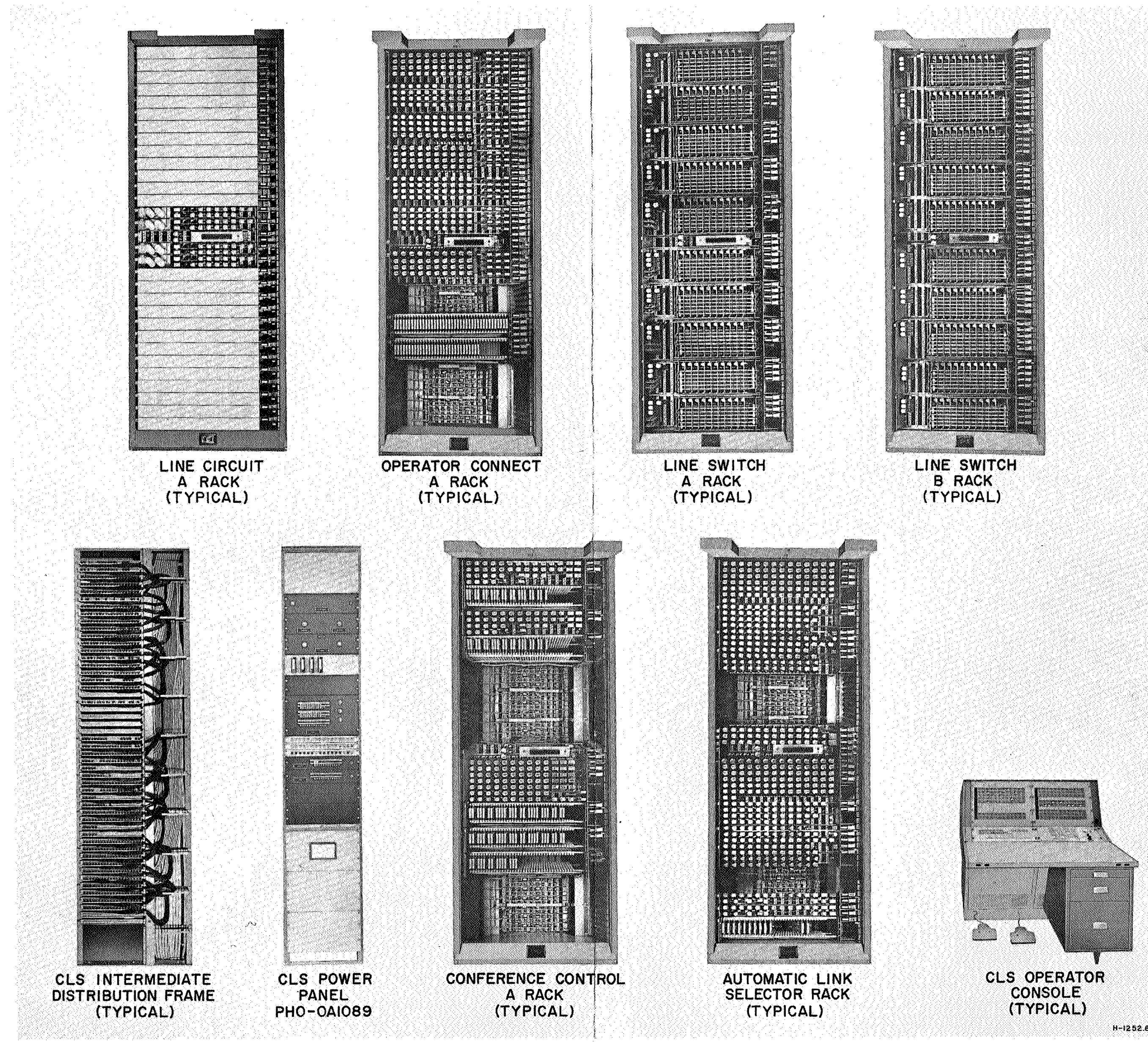
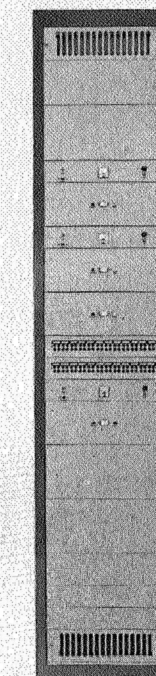
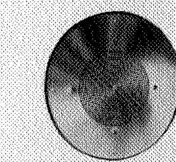


Figure 2-1-2. Voice Communications Subsystem (Sheet 2 of 3)

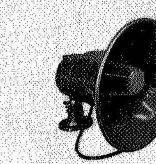


PUBLIC ADDRESS
EQUIPMENT
PHO-OA1246
CABINET B



SPEAKER
ASSEMBLY
PHO-LS1004
AND PHO-LS1005

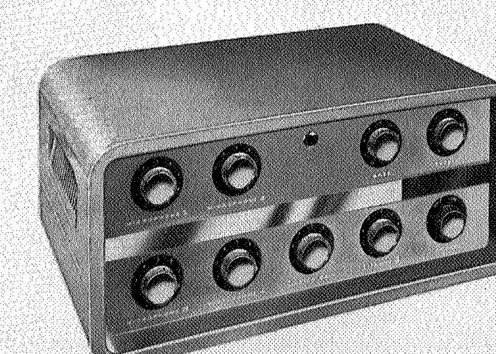
MICROPHONE / PREAMPLIFIER
ASSEMBLY
PHO-YM1001



HORN SPEAKER
ASSEMBLY
PHO-AS1007

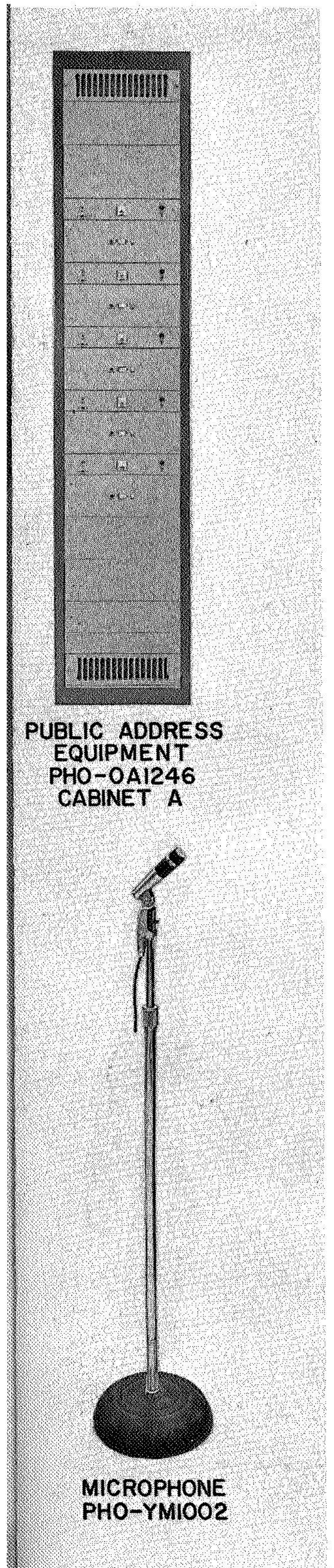
PHOTOGRAPH
NOT
AVAILABLE
AT TIME OF
PUBLICATION

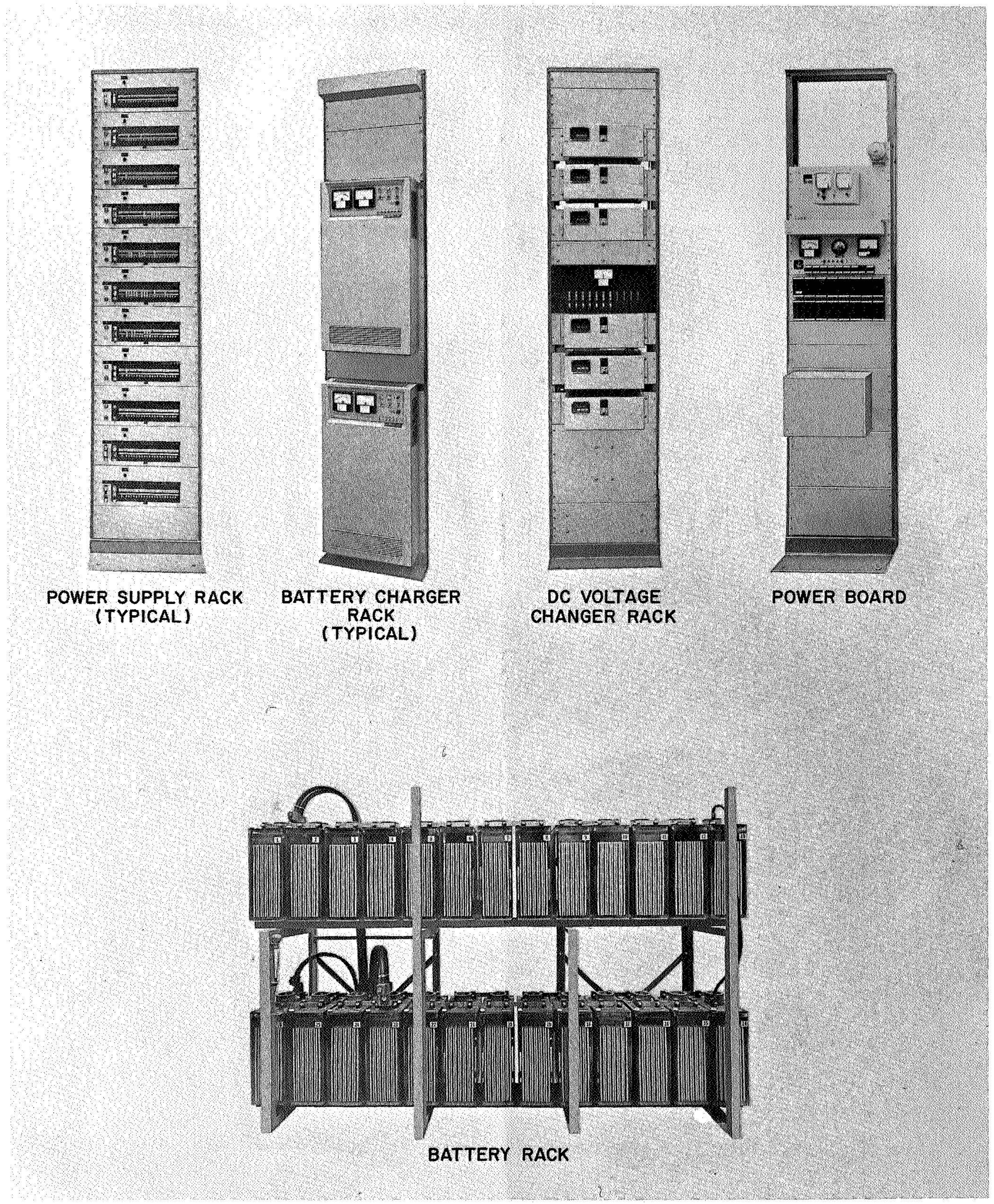
AIR-TO-GROUND
CONTROL EQUIPMENT



35-WATT POWER
AMPLIFIER
PHO-AM1035

PUBLIC ADDRESS AND AIR-TO-GROUND CONTROL





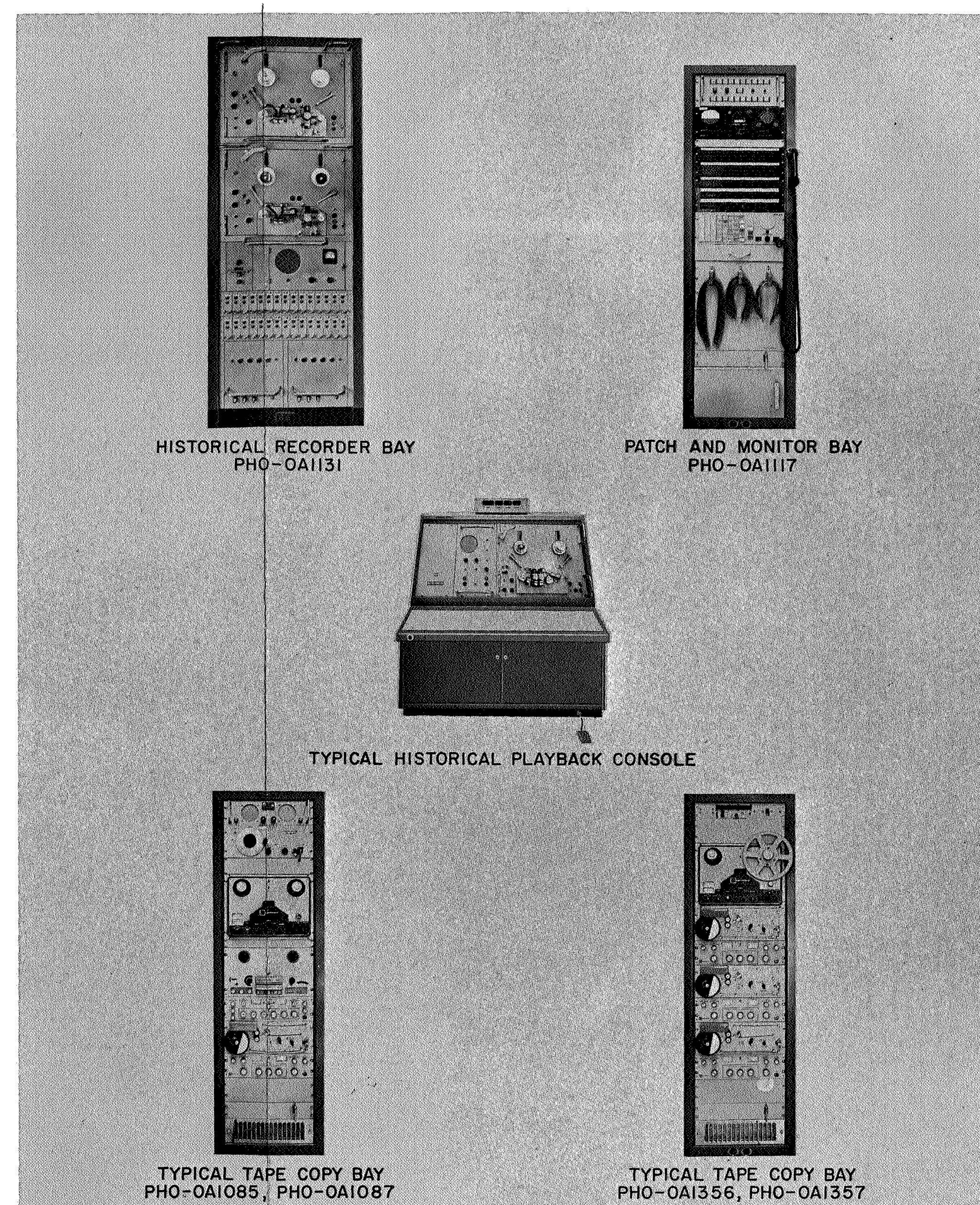


Figure 2-1-2. Voice Communications Subsystem (Sheet 3 of 3)

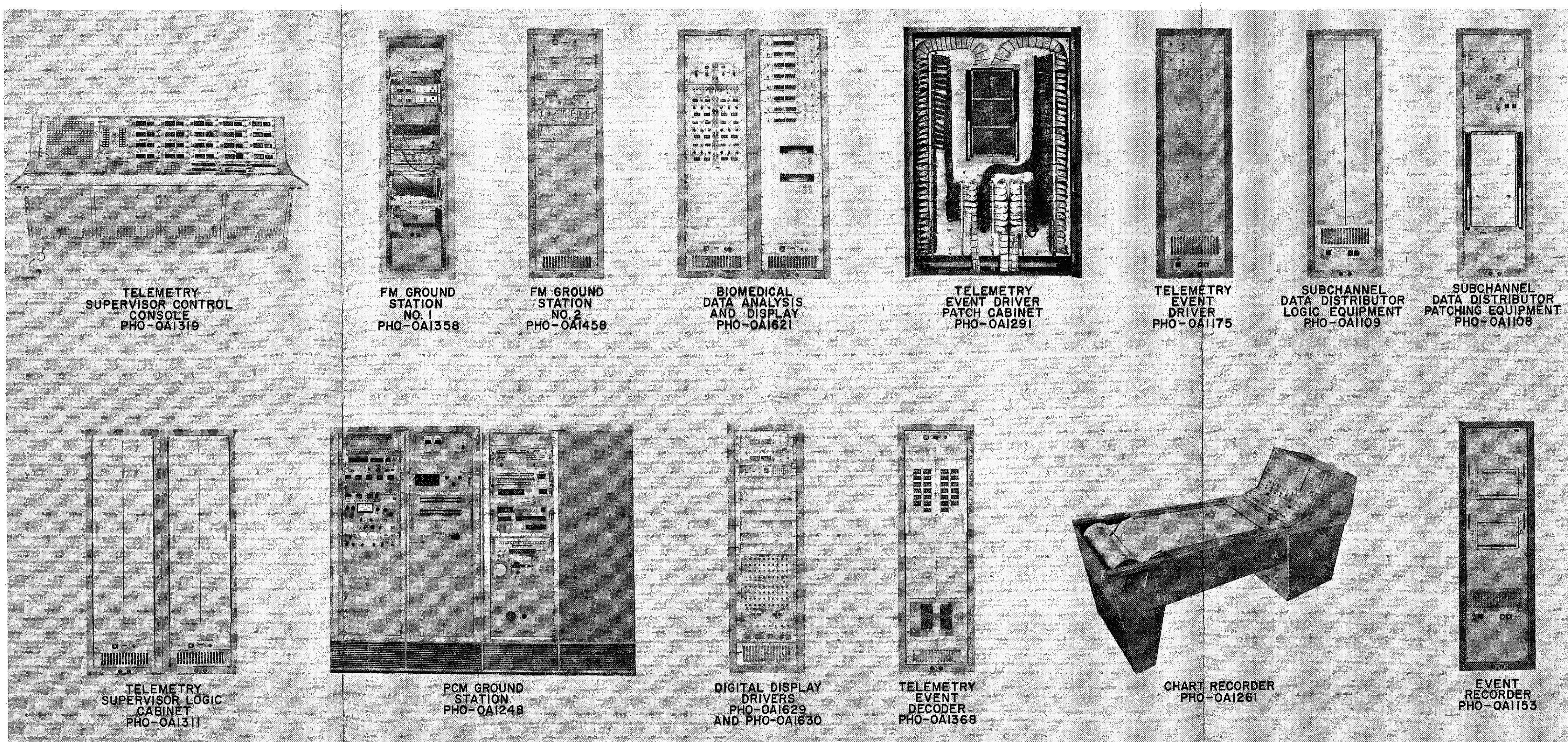


Figure 2-1-4. Telemetry Subsystem
(Sheet 1 of 2)

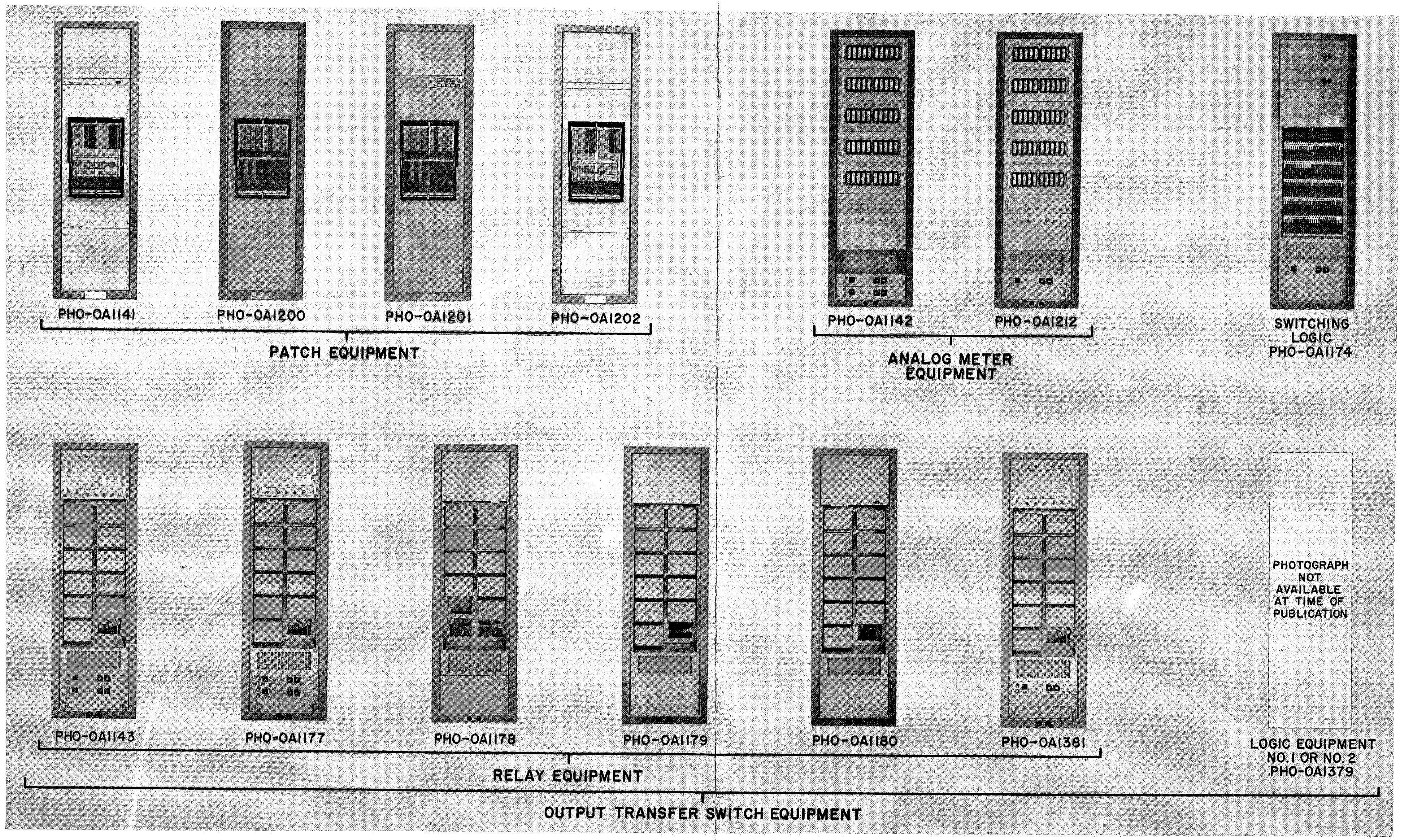
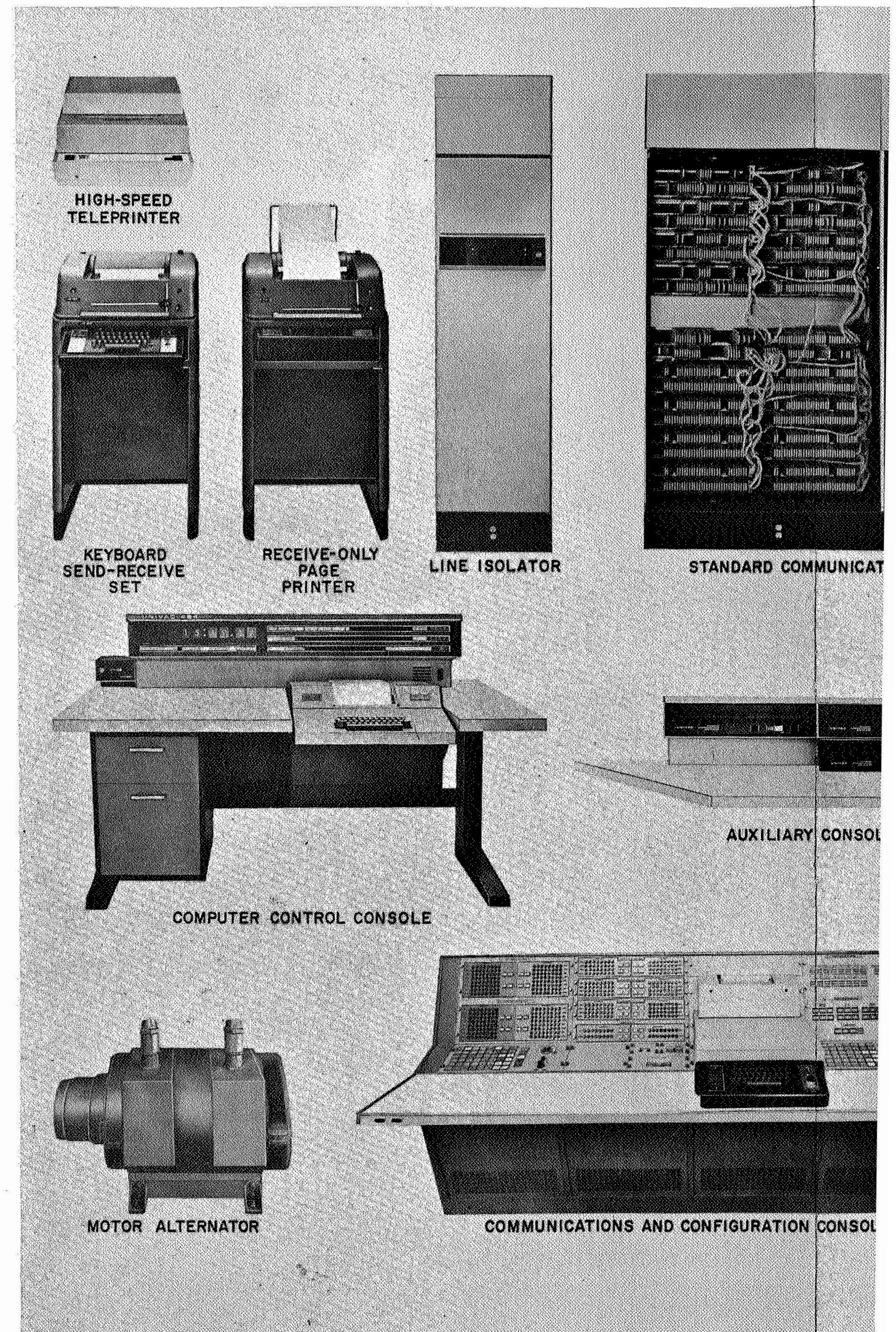


Figure 2-1-4. Telemetry Subsystem
(Sheet 2 of 2)


HIGH-SPEED TELEPRINTER
KEYBOARD SEND-RECEIVE SET
RECEIVE-ONLY PAGE PRINTER
LINE ISOLATOR
STANDARD COMMUNICAT
COMPUTER CONTROL CONSOLE
AUXILIARY CONSOL
MOTOR ALTERNATOR
COMMUNICATIONS AND CONFIGURATION CONSOL

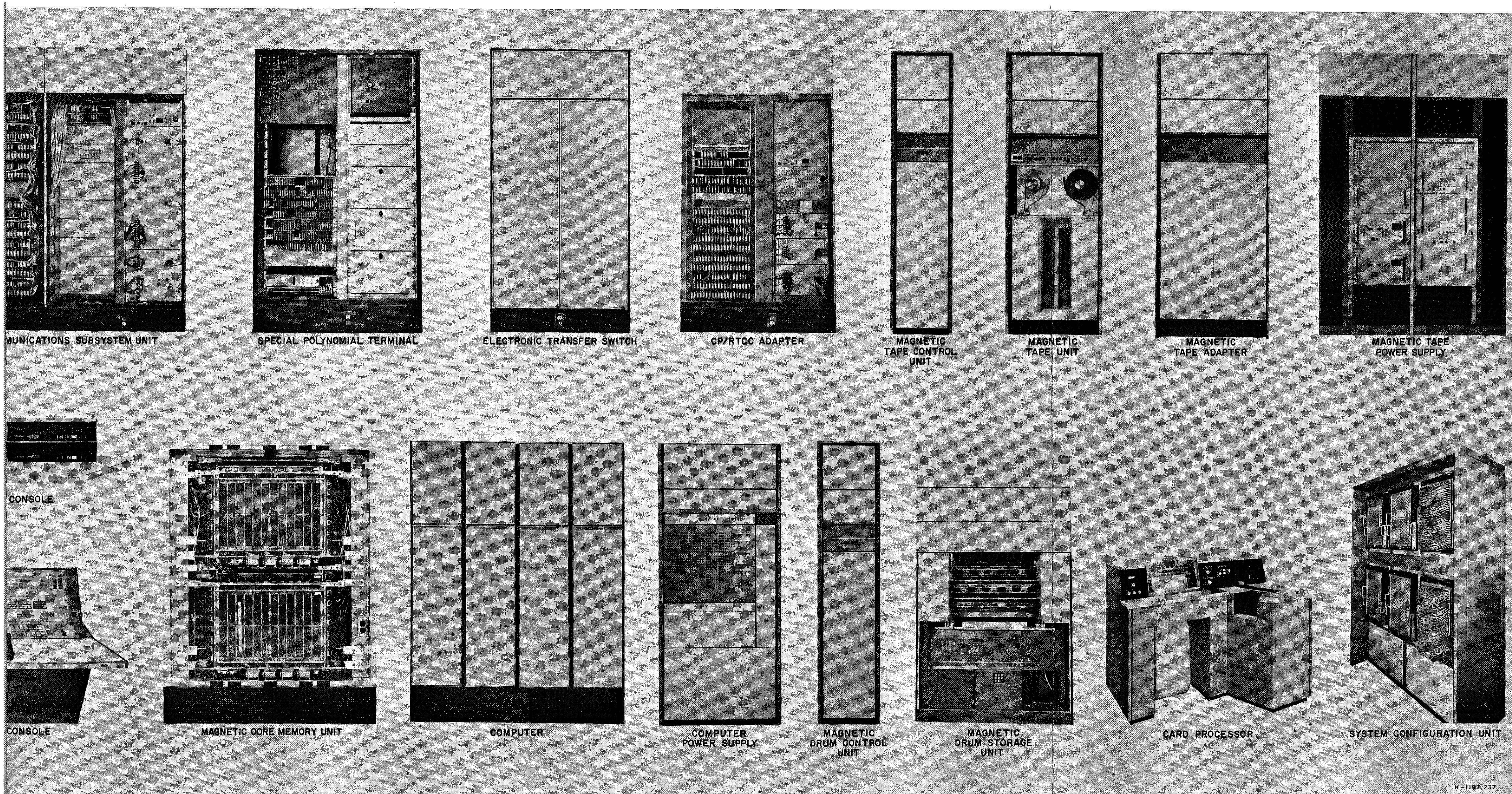


Figure 2-1-5. Central Processor Subsystem

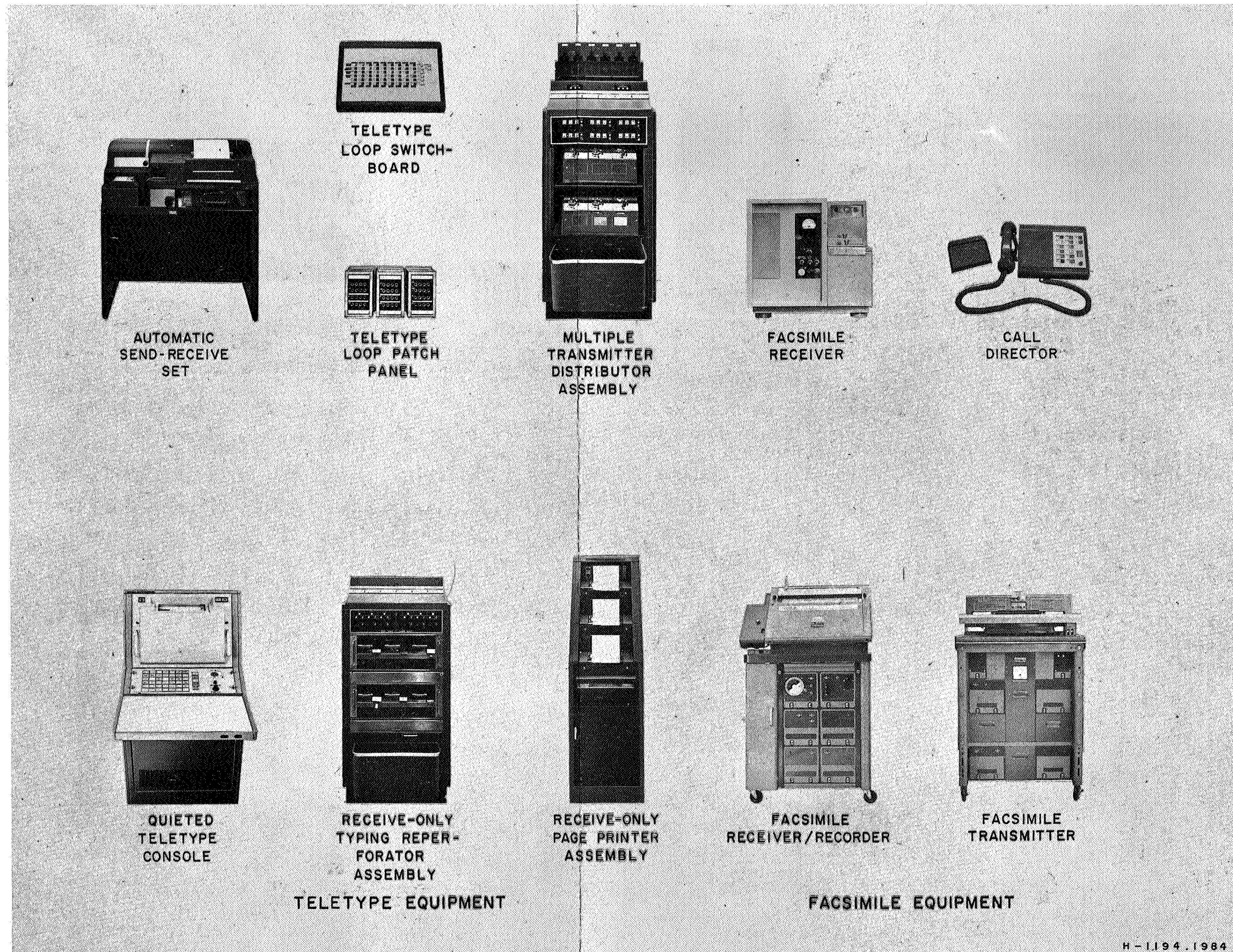


Figure 2-1-6. Teletype and Facsimile Subsystem

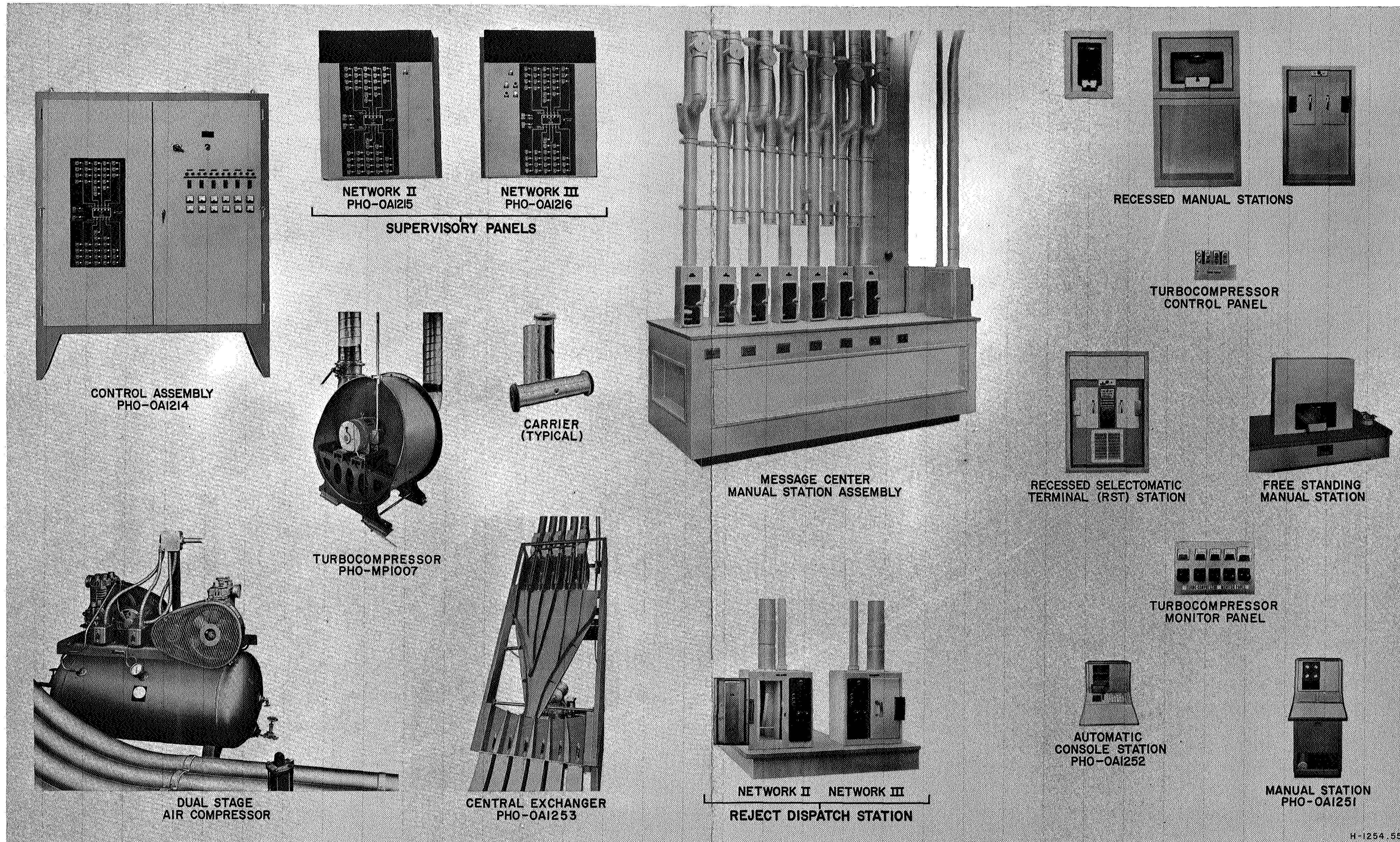


Figure 2-1-7. Pneumatic Tube Subsystem

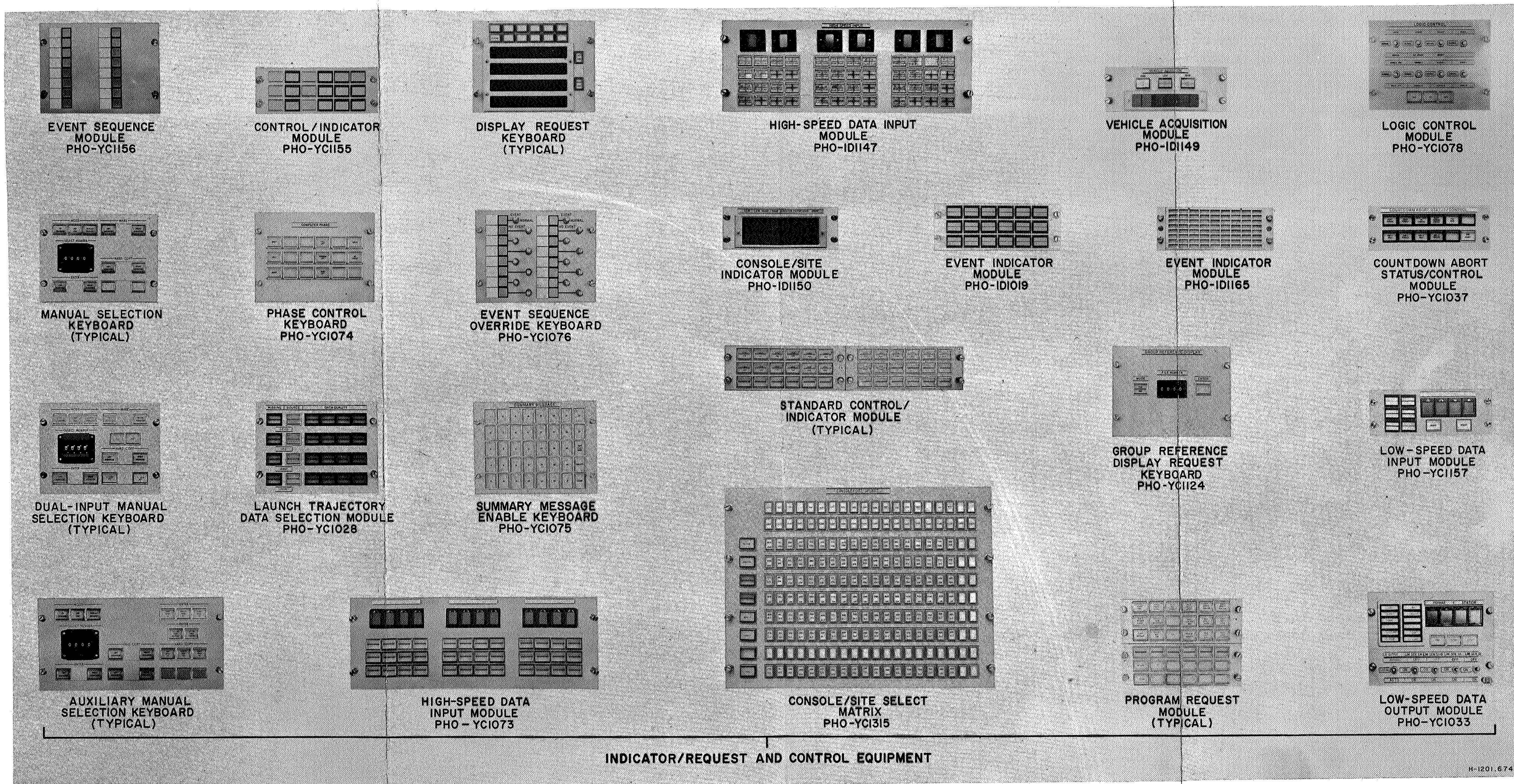


Figure 2-2-1. Computer Display/Control Interface Subsystem (Sheet 1 of 5)

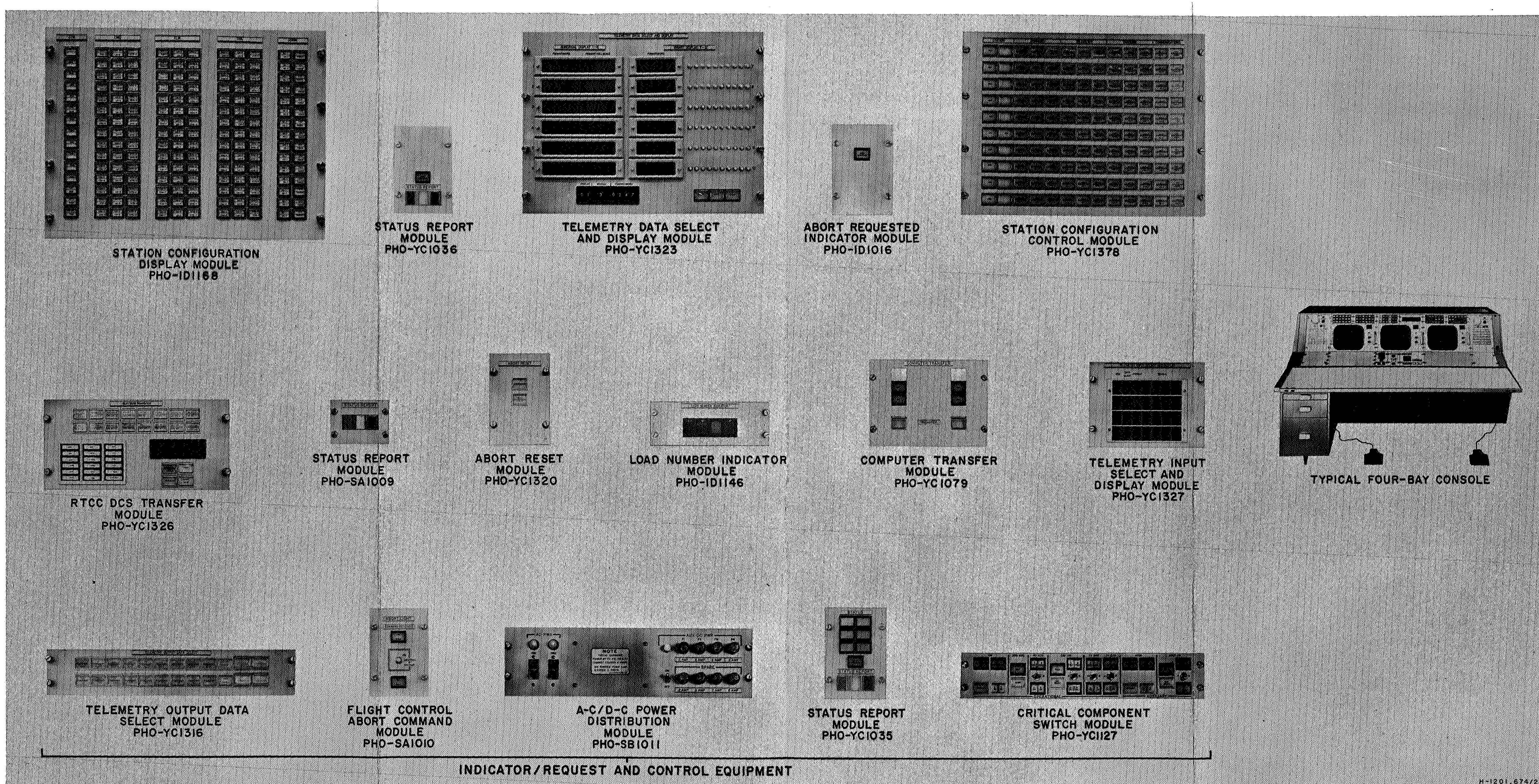


Figure 2-2-1. Computer Display/Control Interface Subsystem (Sheet 2 of 5)

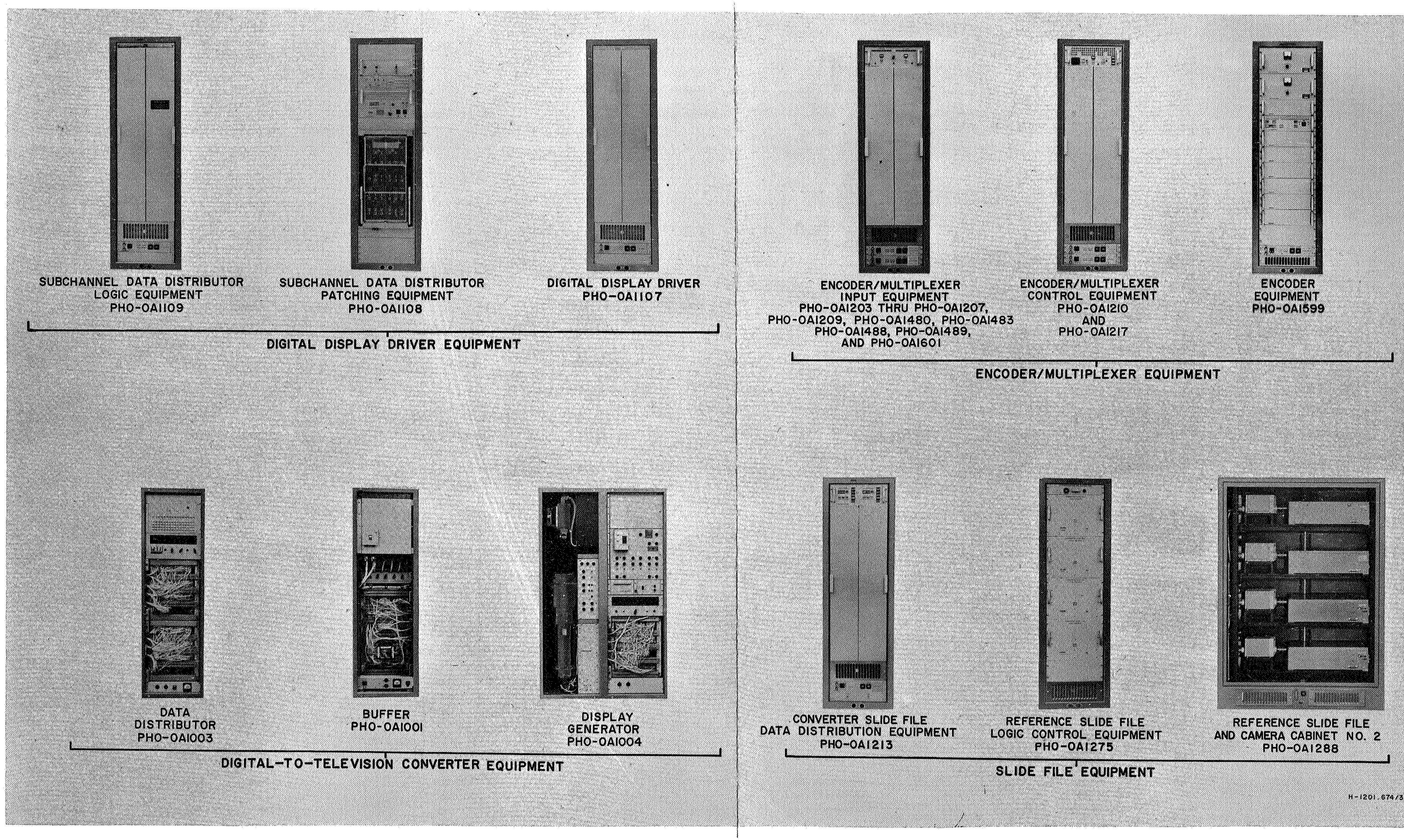


Figure 2-2-1. Computer Display/Control Interface Subsystem (Sheet 3 of 5)

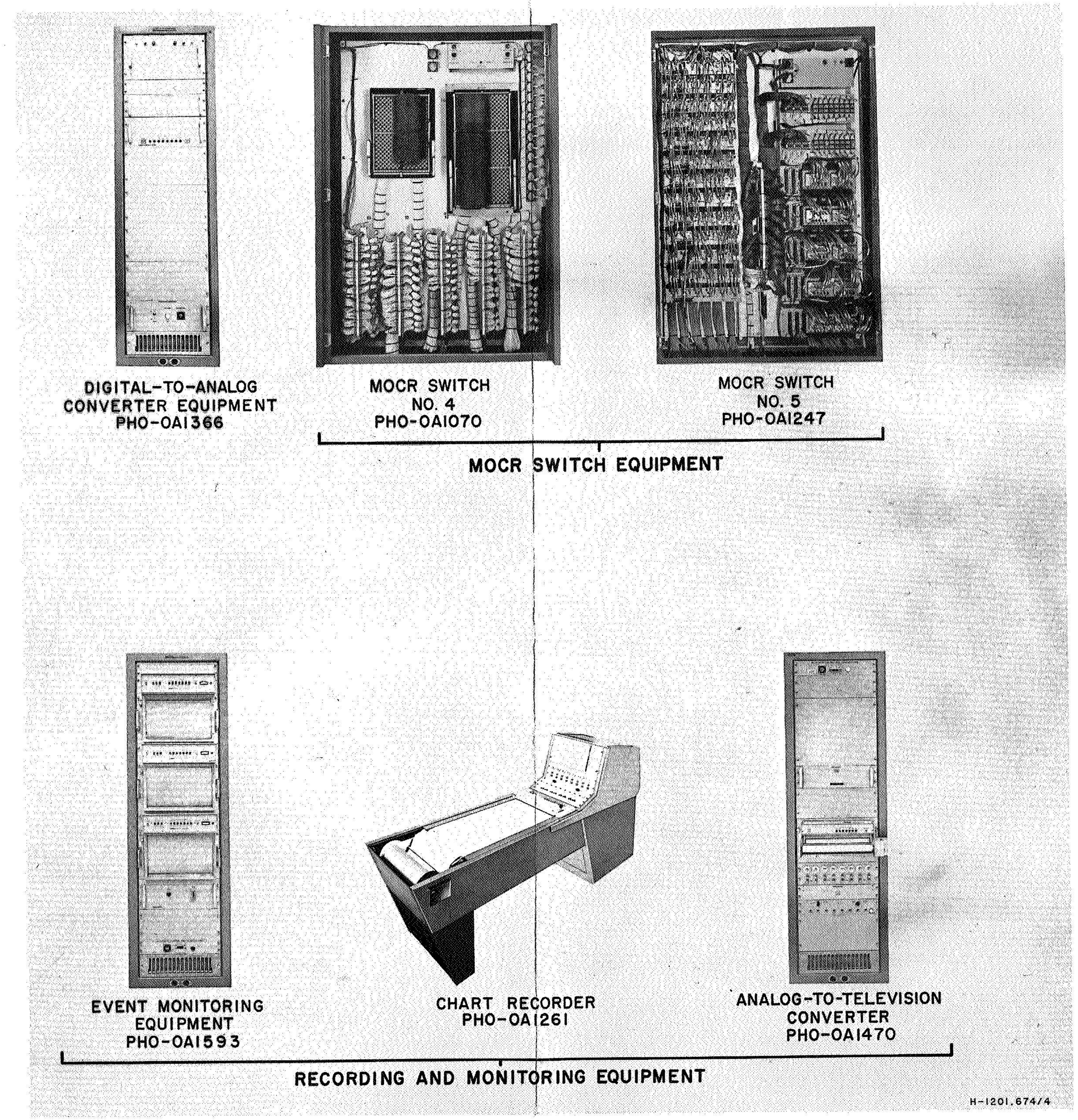
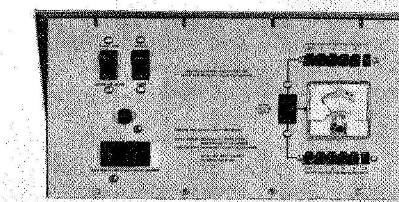
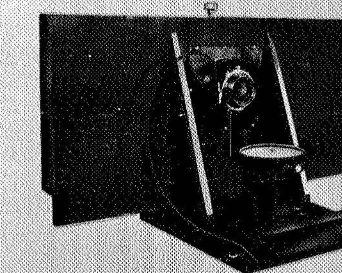


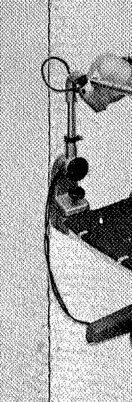
Figure 2-2-1. Computer Display/Control Interface Subsystem (Sheet 4 of 5)



REFLECTION LIGHT SOURCE

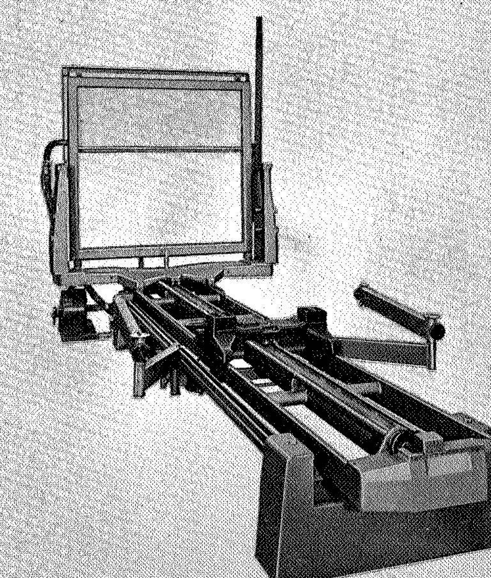


CAMERA

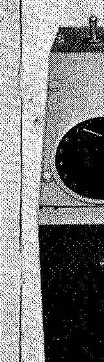


DRK CAME

PROJECTION
LIGHT SOURCE



CAMERA AND CARRIAGE



RETICL

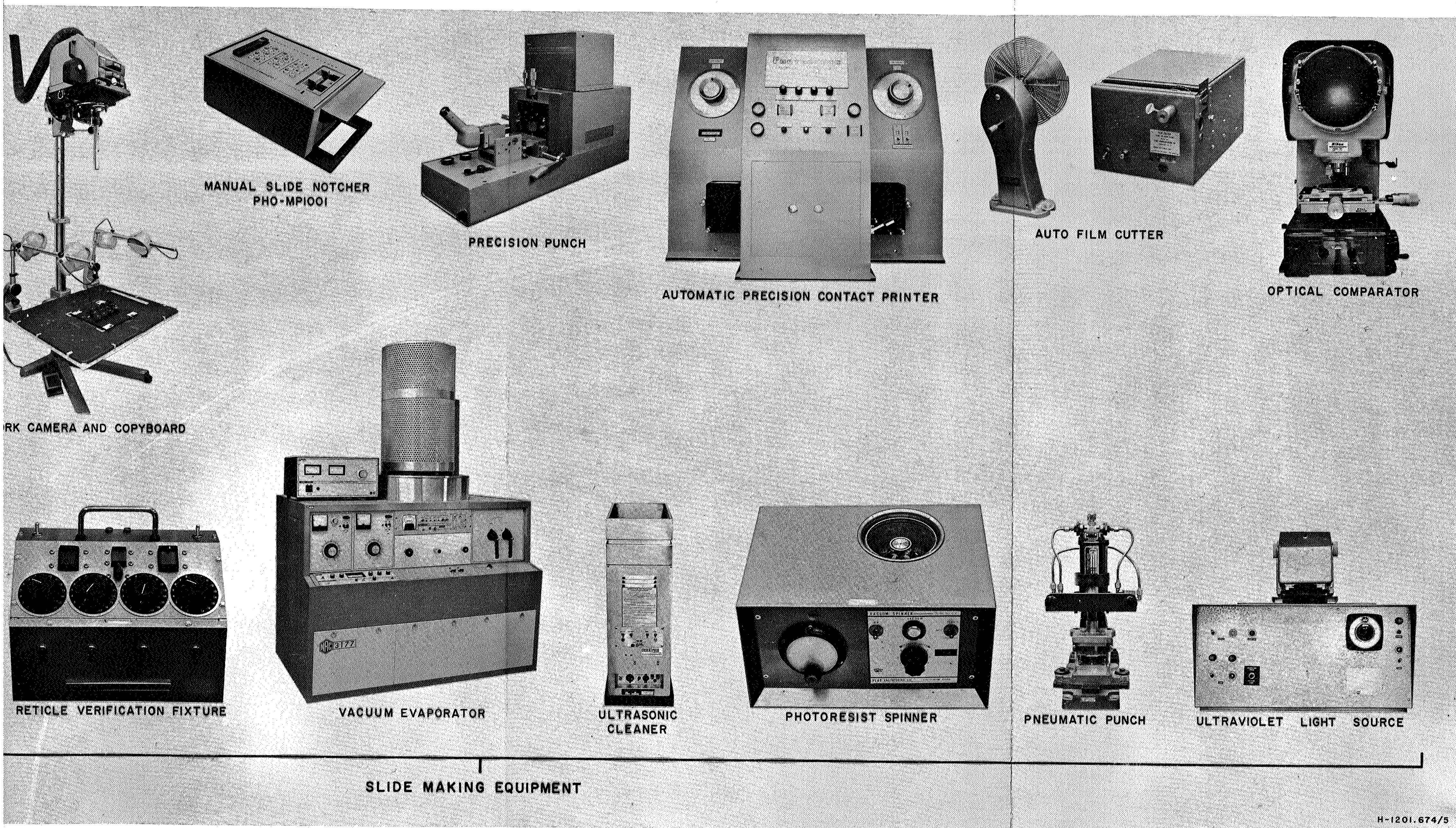


Figure 2-2-1. Computer Display/Control Interface Subsystem (Sheet 5 of 5)

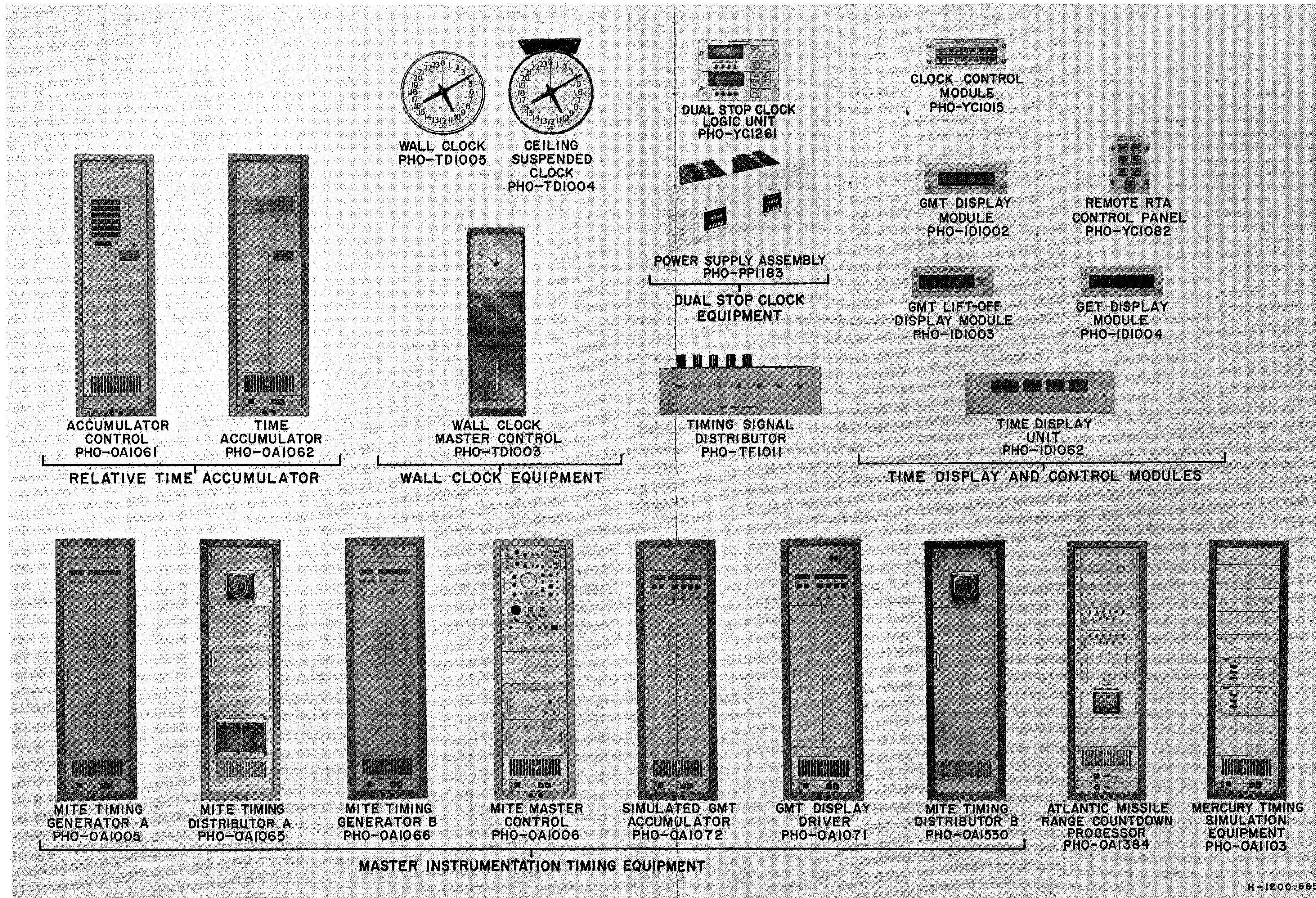
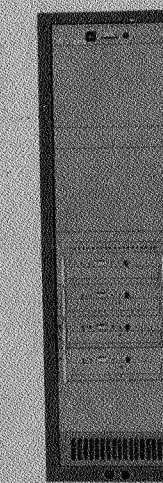
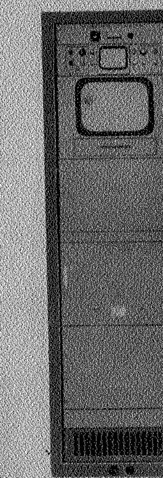


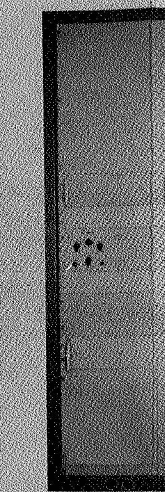
Figure 2-2-2. Timing Subsystem



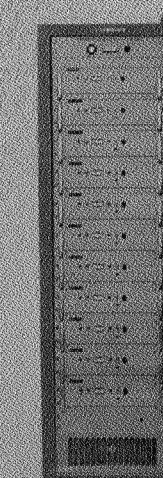
RECOVERY RSF CAMERA
AND CONTROL CABINET
PHO-OA1195



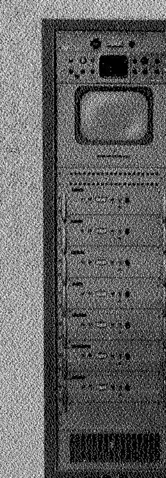
RECOVERY RSF LOGIC
AND MONITOR CABINET
PHO-OA1194



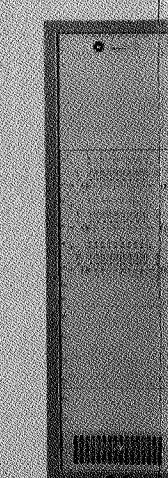
MATTE
TELEVISOR
PHO-OA1348



TELEVISION CAMERA
CONTROL NO.1
PHO-OA1076



TELEVISION CAMERA
CONTROL AND MONITOR
CABINET
PHO-OA1077



TELEVISION CAM
CONTROL AND AMPL
CABINET
PHO-OA1543

TELEVISION

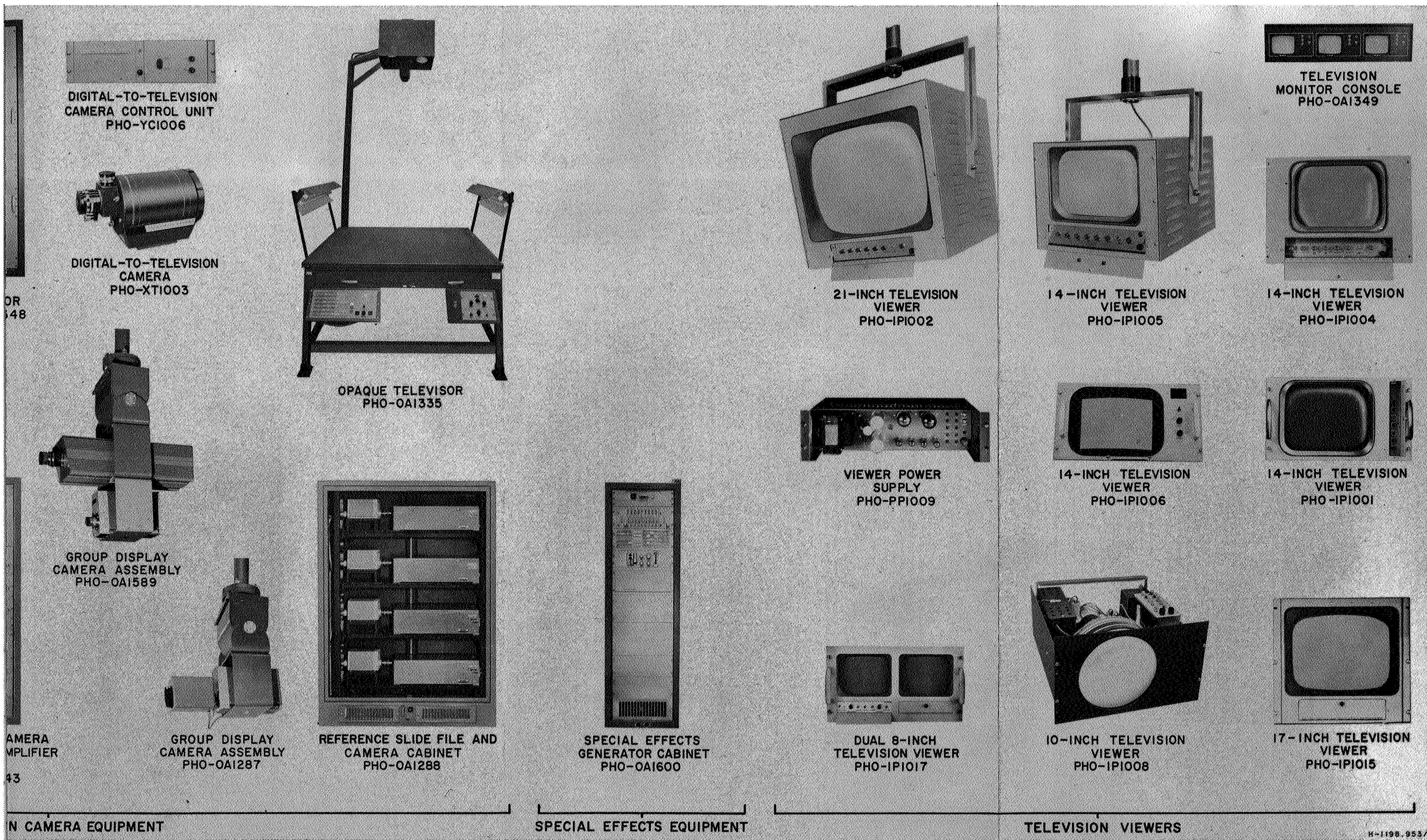
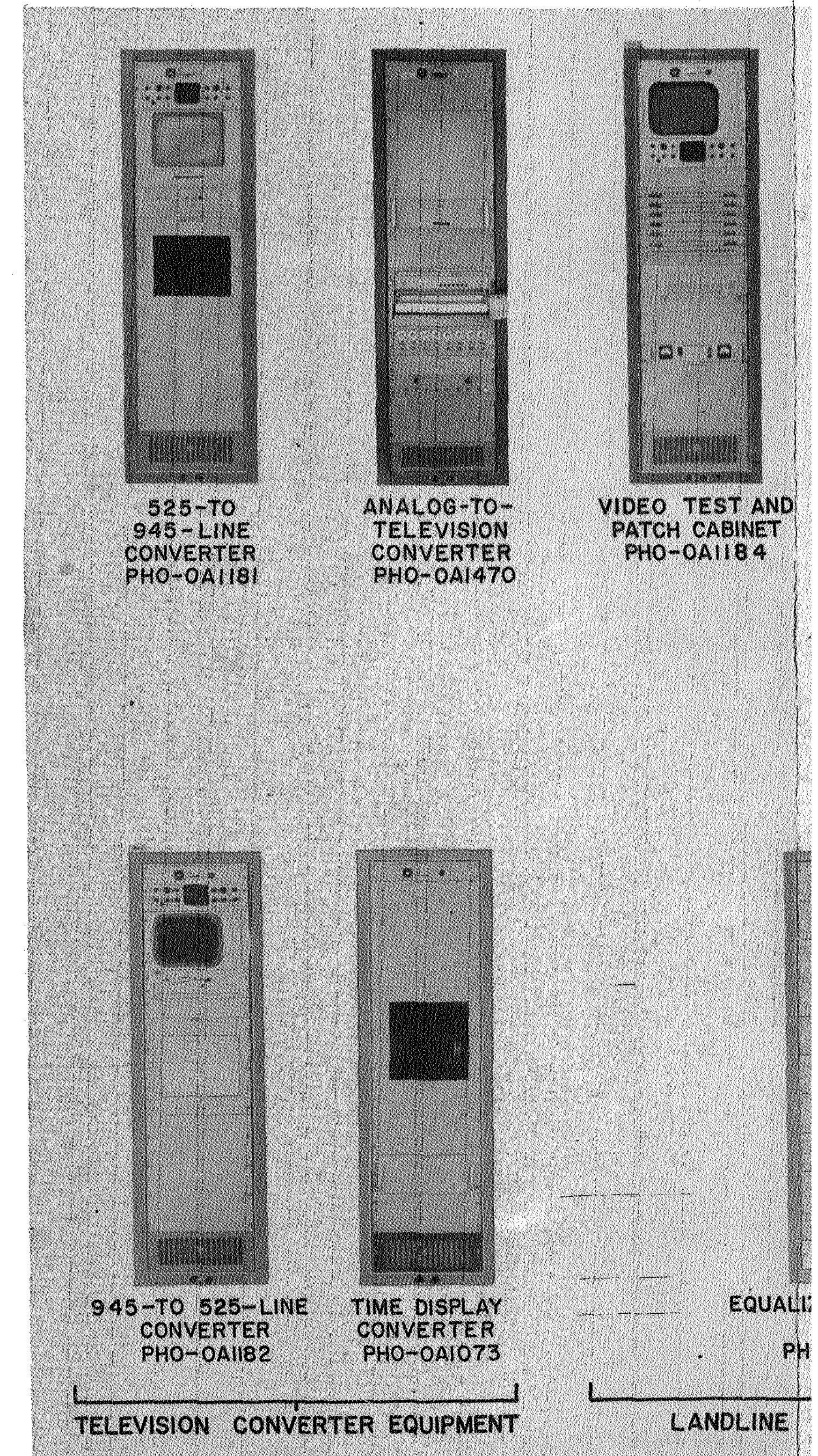


Figure 2-2-3. Television Subsystem
(Sheet 1 of 3)


525-TO 945-LINE CONVERTER PHO-OA1181
ANALOG-TO-TELEVISION CONVERTER PHO-OA1470
VIDEO TEST AND PATCH CABINET PHO-OA1184
945-TO 525-LINE CONVERTER PHO-OA1182
TIME DISPLAY CONVERTER PHO-OA1073
TELEVISION CONVERTER EQUIPMENT
LANDLINE

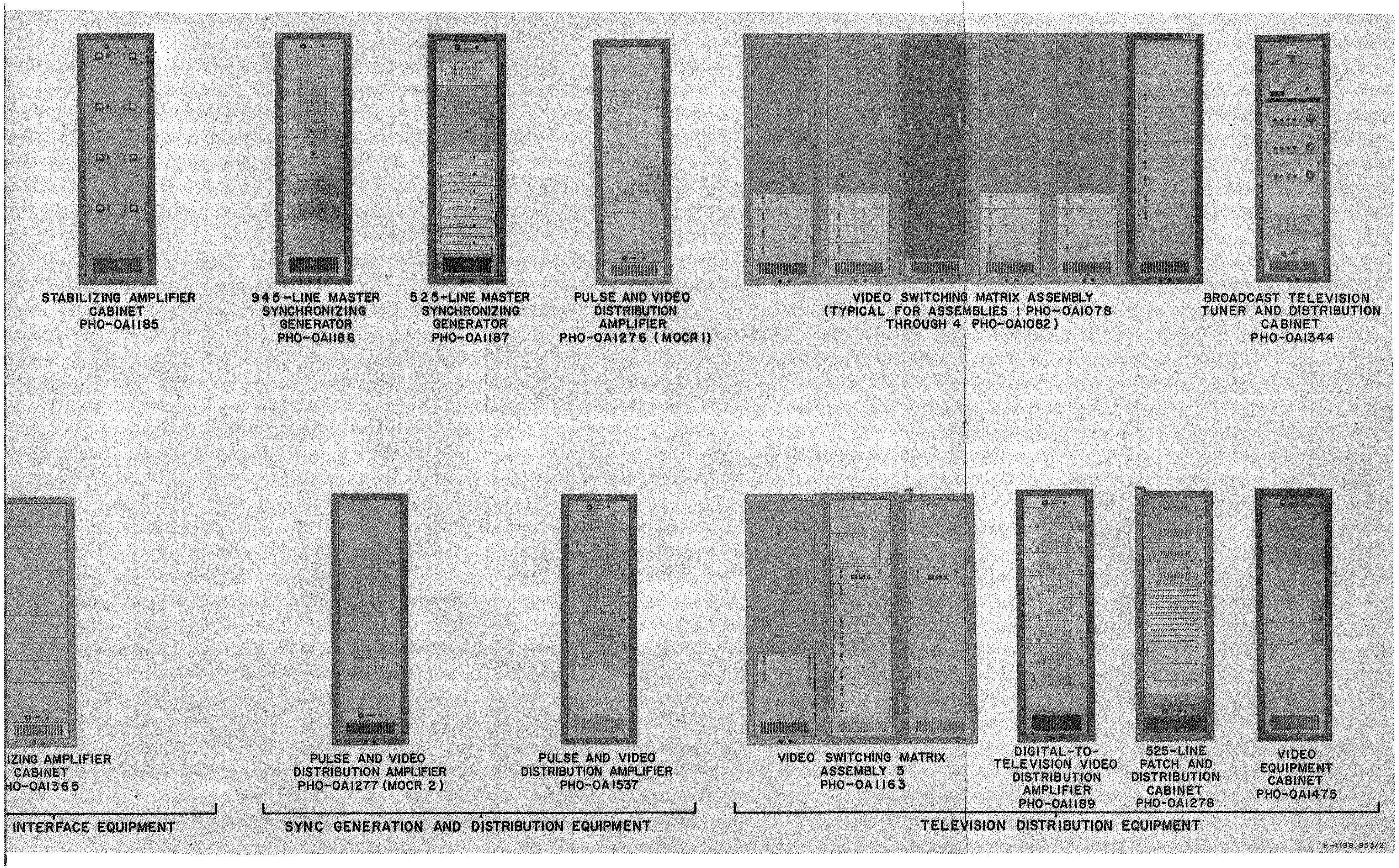
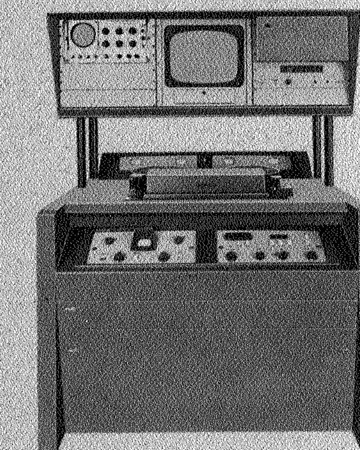
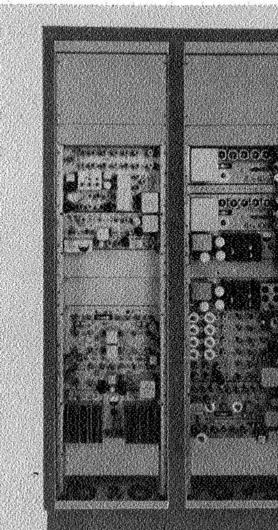


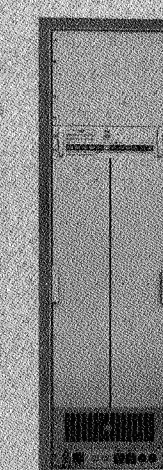
Figure 2-2-3. Television Subsystem
(Sheet 2 of 3)



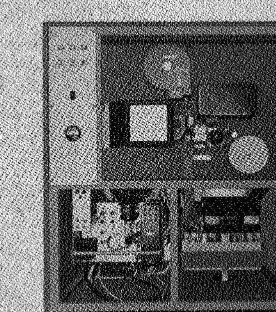
MONITOR BRIDGE ASSEMBLY
PHO-OA1264
AND VIDEO TAPE RECORDER CONSOLE
PHO-OA1265



VIDEO TAPE RECORDER
ELECTRONICS ASSEMBLY
PHO-OA1266



VIDEO SCANNER
CONTROL
PHO-OA1211



HARDCOPY RECORDER
PHO-OA1272

TELEVISION RECORDING EQUIPMENT

94

5

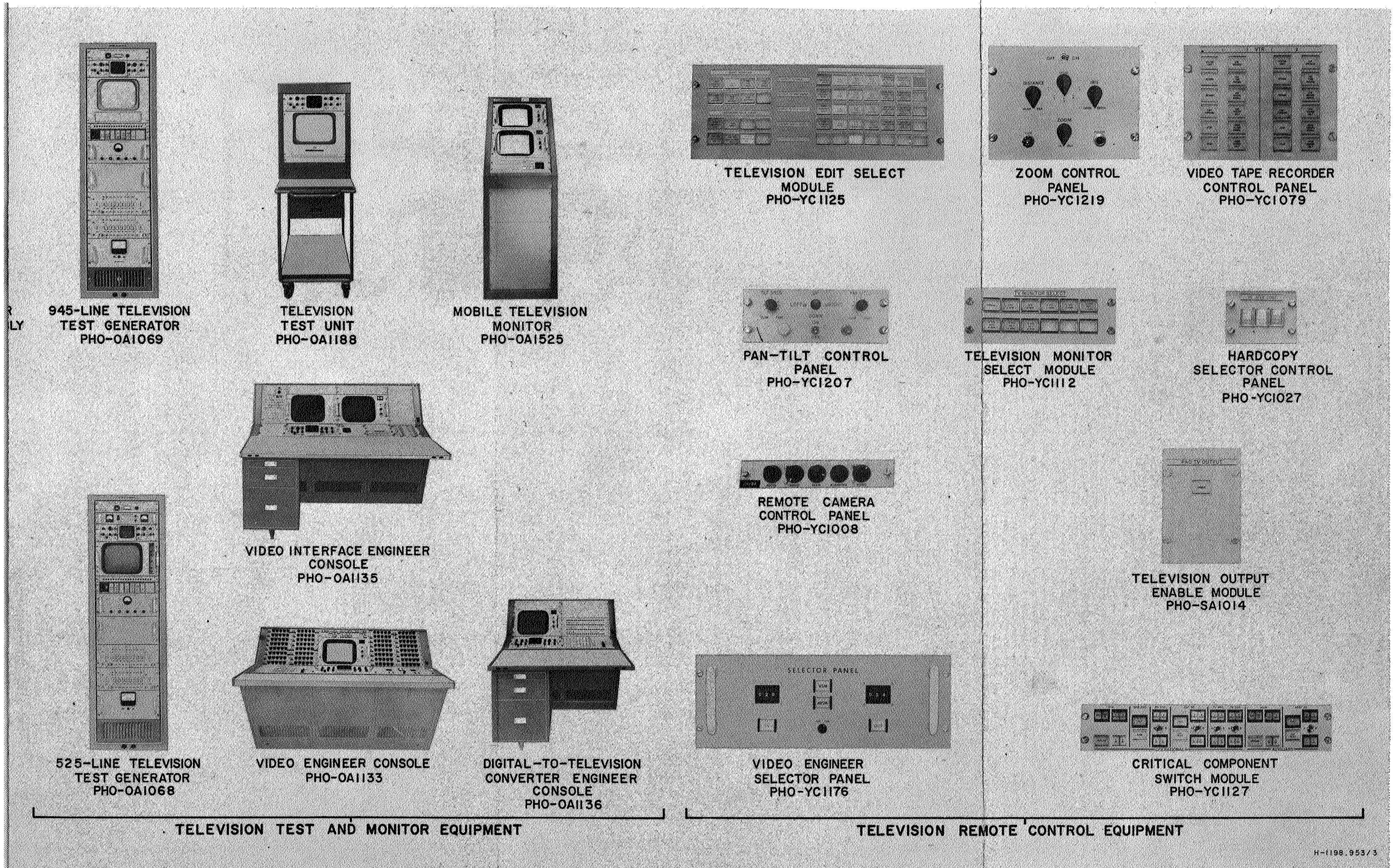
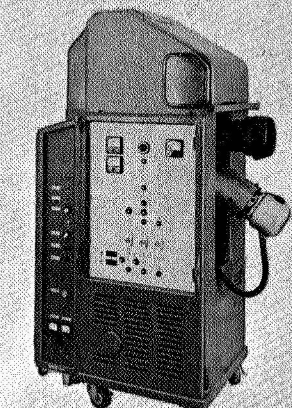
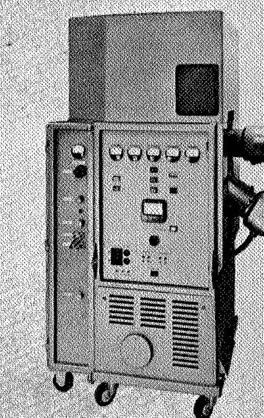
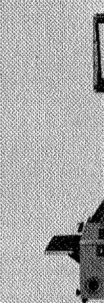
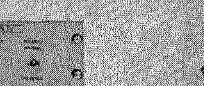


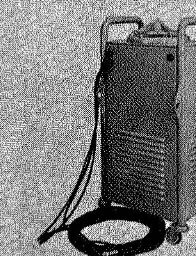
Figure 2-2-3. Television Subsystem
(Sheet 3 of 3)

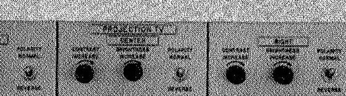

TELEVISION PROJECTOR

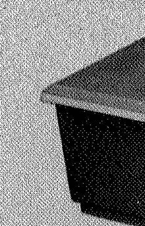

DUAL LINE RATE
TELEVISION PROJECTOR


TRANSP
PROJE


RECOVERY
CONTROL ROOM
PROJECTION
TELEVISION
CONTROL MODULE
PHO-YC1083


XENON LAMP
POWER SUPPLY
PHO-PP1105


PROJECTION TELEVISION
CONTROL MODULE
PHO-YC1084



PROJECTION TELEVISION DISPLAY GROUP

TRANSPA

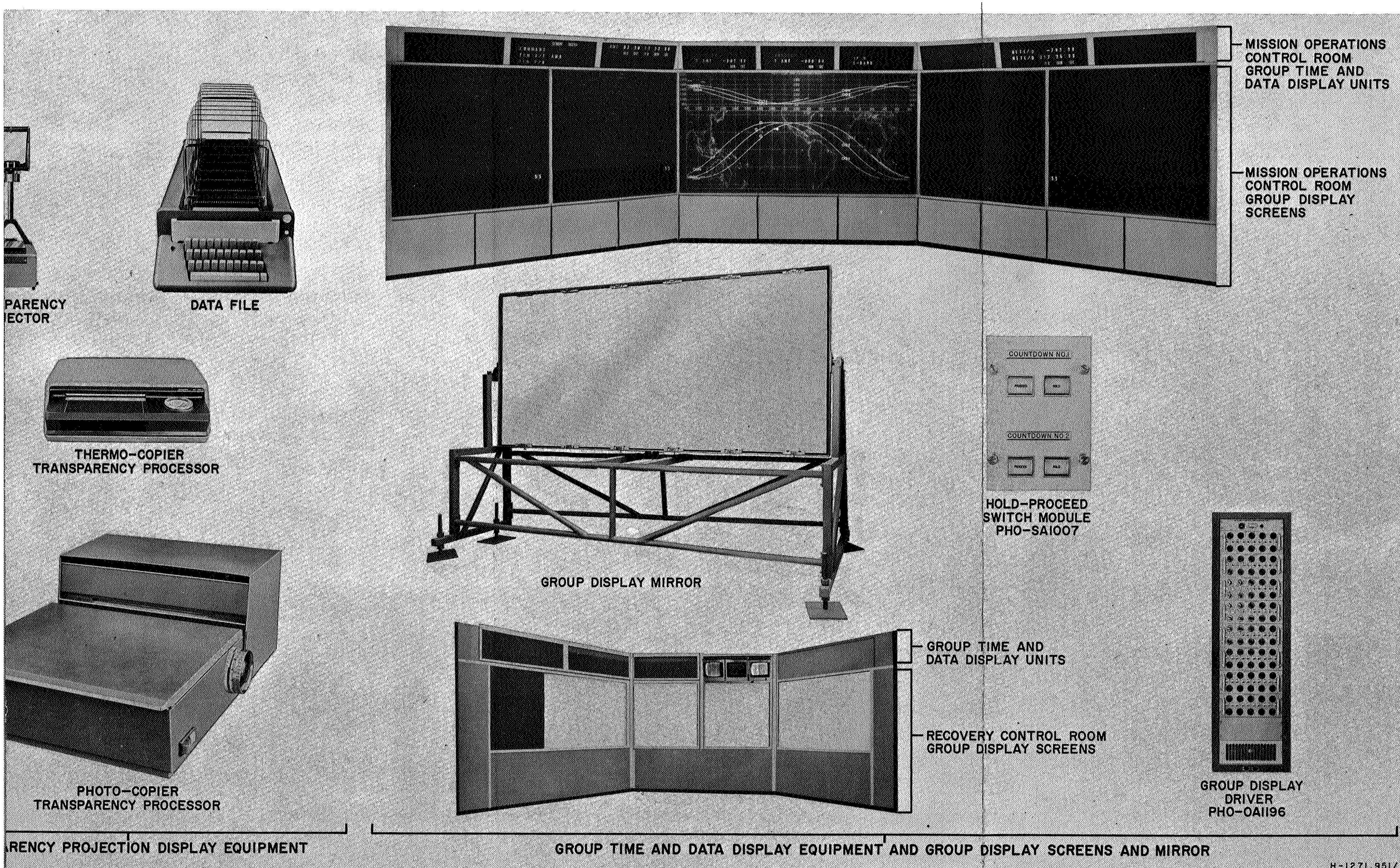


Figure 2-2-4. Group Display Subsystem (Sheet 1 of 2)

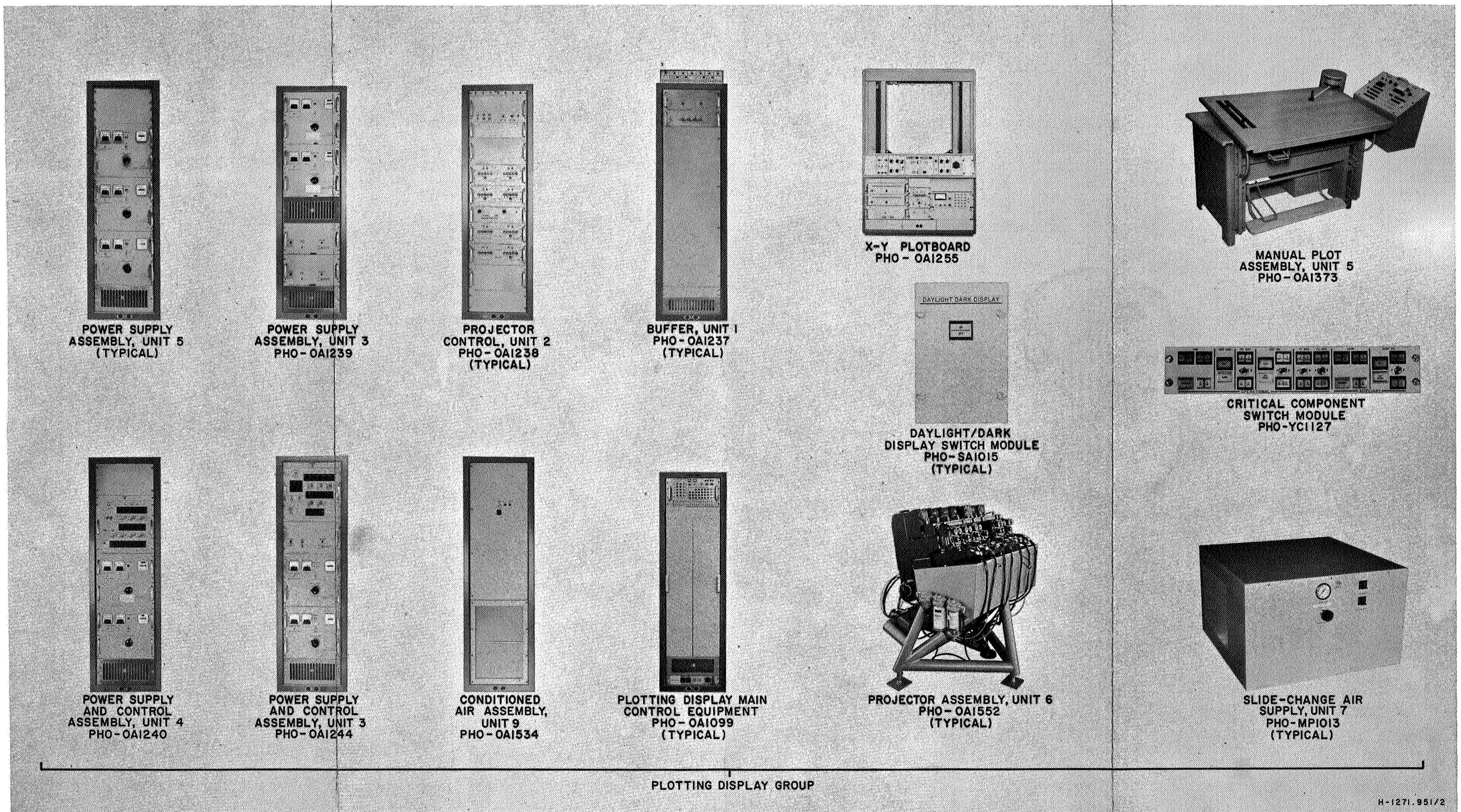


Figure 2-2-4. Group Display Subsystem (Sheet 2 of 2)

Figure 2-3-1. Real Time
Computer System

SECTION III
FUNCTIONAL SYSTEM OPERATION

This section describes the operation of the MCC-H functional systems. The systems are first discussed as they apply to the complete mission control configuration. Following this, each system is discussed and a functional analysis of the major component or equipment group level is presented for each subsystem.

3-1. GENERAL

All information enters and leaves the MCC-H over commercial common carrier communications lines. The communications lines are classed in five categories: wide band data, high-speed data, teletype, video, and audio. (See figure 3-1.) The wide band data lines handle the transmission and reception of command, tracking, and acquisition data between the MCC-H and GSFC and simulation data between ASCATS in building 422 and MCC-H. An additional set of wide band data lines bring the Apollo Launch Data System data into the MCC-H from KSC. The high-speed data lines carry ephemeris and Saturn IV B data from the MCC-H to KSC and Impact Predictor data from KSC to the MCC-H. Teletype data consists primarily of radar acquisition data and textual message traffic. The video lines carry television signals only. The audio lines mainly handle voice communication interchanges between the MCC-H, the Manned Spaceflight Network, and the spacecraft. Specially assigned audio lines carry meteorological data to and from facsimile machines at the MCC-H and the National Meteorology Center at Suitland, Maryland. Other specially assigned audio lines transmit biomedical data to the MCC-H. Direct audio lines are available from the MCC-H to the Department of Defense and the Department of State to carry priority voice communiques when necessary. All communications lines from sources external to the MSC that interface with the MCC-H come through the MSC telephone central exchange building to the MCC-H telephone termination and distribution equipment room and then, with two exceptions, converge on the Communications, Command, and Telemetry System. The two exceptions are video transmission lines and private telephone lines. Video transmission lines are routed directly to the Display/Control System. Private telephone lines are routed to the individual telephone sets situated throughout the MCC-H. Some of these private lines are routed through the Communications, Command, and Telemetry System during missions so that incoming calls may be intercepted and delayed, if desired. Also, if required, the Communications, Command, and Telemetry System can tie into the private telephone system during periods of emergency operations.

The Communications, Command, and Telemetry System monitors all incoming or outgoing voice and data signals for quality, records and processes the signals as necessary, and routes these signals to their assigned destinations. The system is the terminus for all incoming voice communications, facsimile messages, and teletype textual message traffic and provides for internal voice and hardcopy communications. All other incoming communications are routed to other systems for generation of data displays. Incoming telemetry data is processed through the Communications, Command, and Telemetry System and transferred to the RTCC for data display and message generation. Some of the processed data (such as analog, event, and biomedical data) is routed directly to the Display/Control System for direct monitoring by various flight controllers and medical specialists. Incoming tracking data is sent to the RTCC for generation of dynamic display data and to aid in the computation of acquisition data. All outgoing voice communications, facsimile messages, and teletype messages, and most command data originate within the Communications, Command, and Telemetry System. The remaining outgoing communications are routed through the Communications, Command, and Telemetry System for conversion to the proper format and assignment to an outgoing line.

The Display/Control System presents large-scale and individual console data displays and provides a data display and control capability to mission control and support personnel. The system also generates timing pulses that are distributed within the system and to other systems for time-correlation and synchronization purposes. In addition, the system provides edited public affairs television outputs for group receiving in the MBOA and for broadcasting via commercial television networks. Data is presented via digital readout display devices, wall-type projection displays, and individual console television monitors. The system generates data displays upon receipt of display/control data from the RTCC or upon receipt of selected telemetry data from the Communications, Command, and Telemetry System. The display/control data from the RTCC System is received only after request initiation except for digital readout display data which is transferred automatically from the RTCC at a specific, preprogrammed time.

The RTCC System performs real time processing of incoming data and applies display/control data on request to the Display/Control System. The RTCC System also computes acquisition, ephemeris, and certain command data for transmission to the Manned Spaceflight Network. Like all other functions of the MCC-H, the RTCC System is equipped to simultaneously support a dual mission.

3-2. COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM

The Communications, Command, and Telemetry System (figure 3-2) integrates the MCC-H with the real time and remote sites of the Manned Spaceflight Network. The system enables the MCC-H to communicate with all elements of the network and the occupants of manned spacecraft, and in general, provides all the two-way communication capabilities required between the MCC-H and external agencies and between personnel within the MCC-H. The system handles all signals that enter and leave the MCC-H except television signals, which are applied directly to the Television Subsystem of the Display/Control System. The subsystems comprising the system specialize in transmitting, processing, recording, and storing the various types of signals that are handled by the system. The system receives tracking, telemetry, and supervisory message traffic from the Manned Spaceflight Network, and transmits prelaunch, telemetry summary, digital command, and other data to the network. In addition, the system provides the MCC-H with teletype and facsimile links to external agencies. The system receives and transmits all data over commercial common carrier lines. Internal MCC-H communications include wide band data and high-speed data transfer, teletype, voice intercommunications, hardcopy message delivery, and also historical recording and reproduction of all wide band data, high-speed data, and voice communications.

3-2-1. Communications Facility Control Subsystem

The Communications Facility Control Subsystem (figure 3-2-1) centralizes operational control, monitor, and test access to all wide band data, high-speed data, teletype, and audio communication lines (except for a few end-to-end secure circuits) entering and leaving the MCC-H. The subsystem ensures dependable performance of each critical circuit by providing interconnection flexibility and monitor and test access.

3-2-1-1. Wide Band Data and High-Speed Data Transfer and Recording

The Communications Facility Control Subsystem monitors the performance of wide band, high-speed, and teletype data between the MCC-H and the GSFC on the manned spaceflight communications network, and wide band data between the MCC-H and the KSC on the Apollo Launch Data System (ALDS) communications network.

The wide band data transfer and test equipment includes the modulator-demodulator units, transfer switching equipment, a test message generator/receiver, and the checkout subchannel buffer. The wide band data enters the MCC-H through telephone lines, which terminate in modulator-demodulator units referred to as modems. The modems route the data to the transfer switching equipment. From this point the data is routed to the Central Processor Subsystem. Simultaneously, the data is also routed to the recording facility and recorded on magnetic tape, providing historical records for postmission playback and analysis. Output data from the MCC-H is processed in a similar manner from the Central Processor Subsystem to the transfer equipment. The data is then sent to the recording facility and to the modems after which it is placed on telephone lines for transmission to the network. The transfer switching equipment is also used to route the output of the test message generator/receiver through the transfer switching equipment for checkout purposes. The checkout subchannel buffer is used to provide a testing interface between the Central Processor Subsystem and the RTCC System, and between the network (via the transfer switch) and the RTCC System for checkout of data and software.

High-speed data being processed by the MCC-H consists of Impact Predictor and Countdown and Status data arriving from the KSC, and Saturn IV B telemetry data transmitted to KSC. High-speed data signals entering the MCC-H terminate in high-speed data modems. The modems demodulate the carrier signal and apply the data to data control units which identify the received data, detect transmission errors, if any, in each data message, and route the data to the Central Processor Subsystem. The countdown and status high-speed data is fed through the high-speed data test and patch equipment to the countdown and status receiver that demultiplexes the incoming data for distribution to the Timing Subsystem and the Computer Display/Control Interface Subsystem. Outgoing high-speed data is transmitted from the Central Processor Subsystem through high-speed data patch bays and modems onto telephone lines.

Prior to demodulation in the receive modem, each high-speed data signal is recorded on magnetic tape by the recording facility. The recorder/reproducers also record the output of each transmit modem, and the time-correlation signals originated by the Timing Subsystem. These recordings provide historical records and postmission playback and analysis.

The teletype test and patching equipment provides cross-patching, monitoring, and testing access to all receive, send, and internal teletype circuits within the MCC-H, except for certain end-to-end secure circuits. Most teletype data is routed to the Central Processor Subsystem except for special traffic, such as weather data, which is routed directly to equipment in the MCC-H meteorological center.

The high-speed teleprinters print out selected data derived from low-speed, high-speed, and wide band data processed by the Central Processor Subsystem.

3-2-1-2. Audio Patching and Monitoring

The audio test and patch equipment permits monitoring of external and internal MCC-H voice communications circuits that are patched through the audio patch bays. The audio patch bays also provide cross-patching flexibility and house equipment for testing all contained audio circuits. The audio test and patch bays interface with the telephone company termination facility and the Voice Communications Subsystem. The audio patch bays also contain a tape recorder for recording selected voice signals. The audio patch bays also transmit voice line status signals to the communications line switch, and distribute timing signals to the wide band and high-speed data recording facility. Biomedical data inputs are received through the audio patch bays, on specially assigned circuits, from the Manned Spaceflight Network. These are frequency-modulated subcarrier multiplex inputs that contain telemetered biomedical data and are routed through the Voice Communications Subsystem to the Telemetry Subsystem.

3-2-2. Voice Communications Subsystem

The Voice Communications Subsystem (figure 3-2-2) performs the following functions: internal voice communications (voice intercom), communication line monitoring and switching, local verbal announcement broadcasting, tying into private telephone network on an as-required basis, and recording and playing back selected voice communications. The voice intercom area of responsibility includes the keying of remote ground-to-air transmitters for MCC-H spacecraft voice transmission.

3-2-2-1. Internal Voice Communications

The voice intercom equipment constitutes an internal voice communications network with operational control provided by station keyset units. These units are operated by pushbutton keys, which provide connections to local conference loops or intersite loops. The keyset unit can provide talk/listen or monitor only circuits, public address system, and the capability of recording specific loops or keysets.

The voice intercom network is divided into five major groups, each group operationally independent of the others. With the exception of minimal interfacing with communication control equipment, each group is electronically isolated from the others. The major groups are as follows: local loops, intersite trunks, private automatic branch exchange, public address system, and the test and patch bay. The local loop provides communications within MCC-H only, but may be patched to another local loop or an intersite trunk on the test and patch bay. Each keyset is connected to the local loop by operation of the proper talk/listen key on the keyset unit. The intersite trunk is basically a local loop, in function, with additional facilities to allow interface to another intersite trunk or a remote location over a landline or radio link voice channel. The private automatic branch exchange lines provide keyset unit access to private telephone network circuits through a telephone central exchange for those keysets equipped for dial service to outside communications. The public address loop is a two-wire, transmit-only circuit providing talk access to public address system. The test and patch bay provides testing facilities for testing the local loops, intersite trunks, and the communication line switch. The test and patch bay also provides a patching facility for local loops, intersite trunks, and the communication line switch. Within the test and patch bay is the extension loop switching panel, which furnishes switching capability on various loops providing communications for MOCR 1 and MOCR 2. By the use of the switch, a loop may be switched to either MOCR 1 or MOCR 2.

Major special circuits include Public Affairs Officer, Flight Crew Trainer, and Air-to-Ground Control. These are special configurations of standard equipment. The Public Affairs Officer circuits provide the capability of releasing specific internal loops onto the Public Affairs Officer release loop. This circuit interfaces with lines going to KSC press-site and the press-site of MCC-H. The loop being released can also be put through a delay-loop recorder for the purpose of editing releases. The Flight Crew Trainer circuits provide communications that simulate real time communication to the spacecraft. These also have communication interfaces with the training consoles. The air-to-ground control circuit allows certain keyset units to be connected to control the air-to-ground unit. This unit makes provision for keying remote transmitters from certain keyset units.

An intercom loop similar to the local conference loop having jack-only positions is assigned as a maintenance loop for internal communications between maintenance personnel. The difference between this loop and the local conference loop having jack-only positions is that selective signaling from the master station to other stations within the loop is provided in the form of one-digit dialing. This is the only signaling capability furnished for the maintenance loop; however, a push-to-talk capability between stations is provided for all stations within the loop.

3-2-2-2. Communication Line Monitoring and Switching

The communication line switch is an automatic, manually operated switchboard that has the following interconnect capabilities: single party voice circuits within the MCC-H, conference circuits within the MCC-H, and longline circuits from the Manned Spaceflight Network stations. The console is capable of simultaneous and independent control of a real mission operation and a checkout and training operation.

The basic function of the communication line switch is to establish communication to simulation and real time mission. This is accomplished with a cross-bar type switching matrix. There are two console switchboard positions that are multipled to provide independent line access from either position to the switching matrix. Control and supervision of the switchboard is provided by illuminated pushbutton keys. The switching capabilities of the switchboard include a conferencing ability. This is accomplished by the use of ten 10-party conference keys. The conference connections provided by the switchboard allow lines to be added or dropped from an established conference without affecting other lines on the conference circuit. All conference lines are identified on the switchboards. Automatic ring-off is not provided on the console; therefore, manual ring-off is necessary to release longline circuits and internal circuits.

Biomedical telemetry data from the Communications Facility Control Subsystem is fed into the communication line switch console for assignment to specific audio lines. The data is then routed to the Telemetry Subsystem for processing, recording, and monitoring.

3-2-2-3. Internal Announcement Broadcasting

Total voice broadcast coverage of the MCC-H is provided by a public address network comprised of audio amplifiers, ceiling-mounted loudspeakers, control circuitry, and voice input components. The audio amplifiers receive verbal inputs either from station keyset units or microphones. The audio inputs are amplified and distributed by the amplifiers to the loudspeakers, which are located in various zones throughout the MCC-H. Speaker selection, keying, and muting circuits comprise the controlling circuitry for the public address network. Broadcasting access to the public address network is provided at specific console positions and keyset units. Receive and monitor capabilities, not broadcast, are extended to the two visitors viewing areas on the MOW second and third floors.

3-2-2-4. Private Automatic Branch Exchange

Tying into the MSC private telephone network on an as-required basis is a function of the private automatic branch exchange equipment. The private automatic branch exchange circuits are routed from the MSC telephone central exchange to the station keyset units of the voice intercom network. Any private automatic branch exchange station can be connected to any other private automatic branch exchange station by means of dial circuitry. These stations also have access to stations external to the MSC telephone central exchange anywhere within range of commercial switching. Sixty of the private automatic branch exchange circuits are fed through an intercept switchboard, which affords operator control of selected external lines. The switchboard is a one-position, desk-mounted, cordless board arranged for plug-in headset or handset, allowing operator control on an individual basis for each station line. The primary function of the intercept position is to provide a capability of intercepting incoming calls or allowing uninterrupted completion to the called station. On an interrupted call, the operator can converse with the calling party and determine if the call should be connected to the affected station.

3-2-2-5. Voice Communications Recording

Voice recorder/reproducers and associated equipment provide a central voice recording facility for permanently recording conversations from selected loops of the voice intercom network. The voice recorder/reproducers accomplish continuous historical recording of selected MCC-H loops, playback recorded tapes for stenographic transcription and direct copying, and delay public affairs information for 5 seconds to allow real time editing. Biomedical (FM/FM) data is recorded for historical analysis and post-pass playback. Timing pulses are always recorded along with the voice information for time-correlation purposes.

3-2-3. Command Subsystem

The Command Subsystem provides a means of transmitting data and other information necessary for command purposes from MCC-H through Goddard Space Flight Center and remote site(s) to the vehicles. The Command Subsystem is a complex network of computer centers interlinked to form a continuous data chain from MCC-H to the receiving vehicle. (See figure 3-2-3.) The command chain consists of four fundamental sites: the Manned Spacecraft Center in Houston, Texas; the Goddard Space Flight Center in Greenbelt, Maryland; the remote sites; and the receiving vehicles. It should be noted that a remote site is fully automatic in operation and is controlled from MCC-H. The subsystem utilizes the hardware contained in the CCATS, RTCC, and Display/Control Systems at MCC-H.

Information of a command category is routed from the flight controller command modules at MCC-H through the CCATS computers, the GSFC, the remote sites to the vehicle. The command information is grouped into command load, execute command request, and computer execute function types. The command load information is data that is generally used by the vehicle onboard computer. The execute command request information is instructions sent from the flight controllers at MCC-H to the remote site directing the transmission of command load or real time command information to the vehicle. The computer execute function information is instructions sent from MCC-H to the remote site directing that a certain function is to be performed by the remote site command computer. The computer execute function information does not cause initiation of uplink commands.

When the flight controller requests a command load generation, the remote site or sites are specified to which the load is to be sent, the type of load, and any other detail that the computer command controller in the RTCC or CCATS requires for the generation of the load. In the regeneration of the command load, the computer command controller may use data generated by subroutines of the RTCC System command program. The command load includes any additional quantities that are required for the teletype translation message. The data is routed to CCATS and formulated in the Central Processor Subsystem and transmitted by teletype to the remote sites.

After the command load generation is complete by the RTCC System, the computer command controller and the flight controller request a display of the command load data. When the command load data is approved by the flight controller, the computer command controller transfers the command load to CCATS.

The command load input routine in CCATS Central Processor Subsystem checks for any errors in the load. The Baudot coded load message is formatted by a teletype translation routine and converted to a load message. The command load is converted by the high-speed output routine to a 5-bit key code for the command and service module and lunar excursion module commands. The 8-bit key code for the Saturn launch vehicle commands does not require conversion. The data is error checked and if the data is not valid, the command load is dumped and an error printed out on a high-speed teleprinter at the command load controller position. If the data is valid, the command load is then transmitted through wide band data communications line terminal at a 40.8 Kbps rate on wide band data lines to GSFC. Approximately 1 second after command load transmission, the command load is retransmitted. The CCATS waits approximately 5 seconds for a command analysis pattern validation message from the remote site. If the site has not returned a validation message within 5 seconds, CCATS will again transmit two more command load messages approximately 1 second apart and again CCATS will wait approximately 5 seconds for a validation message. This process will repeat the cycle once more and, if the validation message is not received following this transmission, the sequence stops. The load message is routed through a low-speed communications line terminal to GSFC on teletype transmission lines. The entire sequence may be restarted by manual action on the part of the CCATS command load controller.

The GSFC error checks the command load data, reformats the data, and transmits the data at a 2.4 Kbps rate to the designated remote site. The command load data is processed by the remote site command computer. The high-speed command load subroutine validates the data and notifies MCC-H of all input data validated as command analysis pattern (CAP) messages. If an error exists, a message is printed out on a high-speed teleprinter to the CCATS command load controller and the command load message is discarded. If an error is not detected, the CCATS Central Processor Subsystem sends a command load acceptance message to the RTCC indicating that the command load received is in proper format. The command data is sent to CCATS by way of the high-speed data and teletype lines. The data is then stored in the remote site command computer to be uplinked to the vehicle when requested.

When the command load contains errors, the remote site command computer waits for the next command load transmission approximately 5 seconds later. If the command load still contains errors after two more transmissions, the load is retransmitted by CCATS to the remote site command computer or the remote site station controller is directed to load the teletype command load tape into the remote site command computer.

The execute command request or computer execute function information messages are also transmitted from MCC-H to the remote site command computer. The execute command request information causes a command load or a real time command stored in the remote site command computer to be uplinked to the vehicle. The computer execute function request information directs the remote site command computer to perform a specific computer function or routine. The execute command request or computer execute function messages originate from the flight controller command modules in the MOCR's or CCATS area at MCC-H. For either type of information, the message is selected on the command module, converted into a digital data word by the encoder-multiplexer equipment, also known as the CIM, and routed to CCATS Central Processor Subsystem. The CCATS command program formats the information. The data is transmitted to GSFC where the information is reformatted and transmitted to the appropriate remote site on a 2.4 Kbps data line. The remote site command computer error checks the data and, if the data is valid, a command analysis pattern message is sent to MCC-H by way of the GSFC.

The command acceptance pattern message for any of the three types of information messages from the remote site command computer is transmitted on a 2.4 Kbps data line three times in successive telemetry frames to the GSFC which, in turn, reformats and routes the data to MCC-H on a 40.8 Kbps data line. The command acceptance pattern message information is transmitted by the telemetry processor to the command processor in the CCATS Central Processor Subsystem. The data is then driven by the CCATS digital display drivers to light the appropriate indicators on the console modules in the MOCR and/or CCATS area. The data is also sent from the CCATS Central Processor Subsystem to a high-speed teleprinter in the CCATS command control area.

3-2-4. Telemetry Subsystem

The Telemetry Subsystem (figure 3-2-4) provides independent operational and dynamic standby processing of wide band pulse-code-modulation (PCM) telemetry data received from the Communications Facility Control Subsystem for up to two simultaneous missions. The subsystem also provides independent processing of frequency modulation (FM), multiplexed biomedical data received from the Voice Communications Subsystem for up to two simultaneous missions. The processed data is routed for display in the appropriate MOCR, SSR, and CCATS flight controller areas.

3-2-4-1. PCM Telemetry Data Processing

The pulse-code-modulation telemetry ground station equipment receives serial digital telemetry data and associated clock from the Central Processor Subsystem by way of the Communications Facility Control Subsystem. The serial data and clock signals are connected to the appropriate ground station by PCM Telemetry Patch Board. The serial data and clock signals are transmitted at a maximum rate of 40.8 Kbps NRZ. Each ground station automatically synchronizes to the serial input data format and output data is provided to the user equipment. Each ground station contains a program memory that is set up to process incoming data with given formats. The program memory controls the decommutation process.

As indicated in the preceding paragraph, the pulse-code-modulated input signal to each ground station is serial data (1's and 0's). This serial data is generated by commutation equipment at the data source. The commutation equipment takes a given number of data signals and feeds them sequentially online. Periodically, the commutation equipment inserts synchronization and data identification patterns (1's and 0's) between appropriate and specific groups (words) of data bits. The combination of data, synchronization, and identification bits are transmitted to the selected ground station in a predetermined format.

When the synchronization circuits recognize the synchronization patterns, commands from the program memory transfer associated data words to the ground station output circuits. Certain data words, which contain signals that have high fluctuation rates, are converted into analog or bilevel (on-off) event signals. Other data words undergo no further processing in the ground stations.

As each data word is shifted from serial to parallel and transferred to output circuits by the decommutation logic, the program memory unloads an identification word that accompanies the associated data word. In addition, the decommutation logic generates transfer command signals that accompany individual or groups of data words and other signals that indicate the operating status of the synchronization logic circuitry.

Data multiplex and analog signals from the ground stations are monitored for quality by the telemetry supervisor console and logic equipment. The data multiplex signals are then converted by the telemetry event decoder to a maximum of 100 event signals and sent to the output transfer switch equipment.

Each ground station can process and route 100 analog and 125 bilevel event signals, control, and synchronization signals to the output transfer switch equipment. Therefore, each ground station and associated event decoder equipment can process 100 analog and 225 bilevel event signals for routing to the output transfer switch and finally to the MOCR, SSR, and CCATS display equipment. A pulse-code-modulation telemetry signal simulator is provided with the subsystem for generating test signals to exercise the pulse-code-modulation telemetry ground stations.

3-2-4-2. Biomedical Data Processing

The frequency modulation ground station is the main artery for incoming biomedical data that has been telemetered from the astronauts to a Manned Spaceflight Network station. The station receives biomedical telemetry data from the Voice Communications Subsystem over specifically assigned audio lines. The equipment demodulates the incoming data and processes the individual astronaut's heart and respiration analog waveforms into the formats required by the digital display equipment and the Central Processor Subsystem. The analog waveforms are also recorded to provide the postanalysis of the individual astronaut's well-being. The recorded analog waveforms are also available to chart recorders in the remote display equipment. The chart recorder data can be delayed by 30 seconds to provide the life systems analysts (rooms 212 and 312) with a data recall feature. This feature allows the analyst to obtain an analog recording of an abnormal (or normal) heartbeat or breathing rate reading reflected by the remote digital displays.

The biomedical data is contained in subcarriers of the 3-kilohertz, frequency-modulated (FM) carrier signal from the Voice Communications Subsystem. One carrier is assigned for the astronauts of each mission. Each subcarrier contains heart or respiration analog data for a particular astronaut in the command service module, or the lunar excursion module. The frequency modulation ground station separates the subcarriers by discriminator action, then demodulates or extracts the analog data from the subcarriers. The patch boards are manually configured, to mission requirements, by connecting the appropriate discriminator/demodulator channel output to the preprocessing equipment and delay-loop recorder/reproducers.

Preprocessing is performed by cardiotachometers and pneumotachometers, which use the individual analog waveforms to generate rate data in digital, binary, and analog forms. Formatting of the data is performed by cardio/pneumo CIB's in the computer processing equipment before the digital data can be accepted by the Central Processor Subsystem. The cardio/pneumo CIB's receive instantaneous heartbeat rate digital data from the cardiotachometers and average breathing rate digital data from the pneumotachometers. The individual rate signals are sampled and buffered, data tags are added from the remote control equipment, and the composite data is routed, in high-speed format, to the Central Processor Subsystem by way of the Communications Facility Control Subsystem.

The delay-loop recorder/reproducer receives and individually records the electrocardiogram analog waveforms output from the frequency modulation ground stations. The recorder/reproducer can be manually operated in the record, erase, reproduce, or normal continuous-loop mode. The normal mode, providing record and 30-second delay reproduction of the data, is also controlled from the remote control equipment. When the normal mode is selected in the remote control area, the desired analog waveforms, starting with the one recorded 30 seconds previously, will be reproduced and sent to a chart recorder at the selection source.

3-2-4-3. Data Distribution

The output transfer switch equipment routes analog data from the pulse-code-modulation telemetry ground stations and biomedical data (analog) from the biomedical processing equipment to indicating devices on consoles and recording equipment in the Computer Display/Control Interface Subsystem. The output transfer switch also routes event data from the PCM telemetry ground stations and associated telemetry event decoder to the telemetry event driver (TED) equipment for distribution to console-mounted indicators in the Computer Display/Control Interface Subsystem. Telemetry bilevel event parameters from the Central Processor Subsystem are processed by the subchannel data distributor (SDD) equipment. The SDD output signals are driven by digital display driver (DDD) equipment as bilevel event signals to console indicating devices and event recorders. Biomedical and telemetry data is sent from the Central Processor Subsystem to the Real Time Computer Complex System. The computers perform engineering unit conversion and provide digital data for the digital-to-television converter and digital display driver equipment in the Computer Display/Control Interface Subsystem.

The biomedical remote control equipment is contained in the Computer Display/Control Interface Subsystem and provides the life systems analysts with the capability of verifying that the cardiotachometers and pneumotachometers are calibrated. Readouts provided by the remote display devices are in digital form as follows: instantaneous and average heartbeat rates, three digital indicators; average breathing rates, two digital indicators; and out-of-limits heartbeat rates, red warning indicators. The remote control equipment interfaces with the recorder/reproducer and biomedical preprocessing equipment. The remote control equipment also enables the life systems analysts to insert vehicle, astronaut, and astronaut activity identification data tags into the individual rate streams applied to the Central Processor Subsystem. The activity data tags identifies the astronaut activity: sleeping, extra vehicular activity, suited or unsuited, etc.

3-2-5. Central Processor Subsystem

The Central Processor Subsystem (figure 3-2-5) processes, error checks, and automatically routes all MCC-H incoming and outgoing communications (except video, direct voice, weather, and military communications) to the proper destination in real time or as near to real time as possible. The subsystem accomplishes this message routing, using a store-and-forward technique. This means that if a message is received for a specific address and the addressed line is in use, the message is stored and then forwarded as the individual line becomes available. The messages sent to a specific address are consecutively numbered to ensure receipt of all messages. All messages are recorded; therefore, a lost message can be retrieved and retransmitted.

3-2-5-1. Message Routing

To accomplish its message routing functions, the Central Processor Subsystem interfaces with the Communications Facility Control Subsystem, the RTCC, and the Computer Display/Control Interface Subsystem. These interfaces provide six basic routes either into or out of the Central Processor Subsystem for operational exercises.

The first circuit provides routing for command, telemetry, tracking, and checkout and training data to the RTCC where it is processed and sent to users as necessary. The second circuit routes low-speed teletypes to and from the teletype and facsimile equipment in the Communications Facility Control Subsystem. The third circuit routes RTCC generated commands, ephemeris, acquisitions, and telemetry summary data to the Communications Facility Control Subsystem, which routes the data to outgoing lines to GSFC for distribution to the Manned Spaceflight Network. The fourth circuit is used for data exchange between the RTCC and the Central Processor Subsystem computers. The fifth route is used for input requests from selected console input devices to determine message routing and flight control real time execute commands. The sixth circuit provides a route for computer acknowledgements back to the selected console module equipment.

The interface peripheral equipment in the Central Processor Subsystem prepares received data for entry into the computer and transmits the processed data to the designated destinations. The Standard Communication System (SCS) and polynomial buffered terminals (SPOTS) provide terminal connections between the telephone and telegraph lines of the Communications Facility Control Subsystem and a computer input/output channel via communications multiplexers and channel scanner units. The communications multiplexers and channel scanners enable a number of lines to be terminated into a single input/output computer channel. Scanner selector units and high-speed adapters perform the same functions between the Central Processor Subsystem and the RTCC, and between the Central Processor Subsystem and the Computer Display/Control Interface Subsystem.

3-2-5-2. Message Processing and Recording

One control computer is operational at all times while the other functions as a dynamic standby, processing the same data as the operational computer but with the output inhibited. Dual input provisions are therefore provided by the peripheral, configuration, and switching equipment for all incoming messages but only one output for the processed message.

Each computer is a stored-program, binary computer with a magnetic core memory, associated control and arithmetic circuitry, and several input/output channels over which data is received or transmitted in a continuous data processing program. All messages coming into the Central Processor Subsystem are deposited in the core memory of each processor. If the output line to which a message is addressed is busy, the message is transferred to one of the magnetic drums for temporary storage. At the appropriate time (when the addressed output line is no longer busy), the message is transferred from the drum back to the computer core memory and then forwarded to its destination. If the addressed line is not busy, the message is fed on through the computer to its destination.

The storing and recording equipment temporarily stores messages, permanently records messages for recall at any time, and prints out individual messages. The magnetic drum storage units temporarily store messages as indicated in the preceding paragraph. The magnetic tape units record and store all messages for any required period of time and permit rapid retrieval and retransmission of a message upon request. All messages are transferred from the magnetic drums to the tape units at prescribed intervals. The resultant messages may be subsequently introduced into the computers for periodic traffic analysis reports. Card processors are available for entering program information from cards directly into the computer or to print out specific information requested of the computer. Control and synchronizer units are linked with the magnetic drum and tape storage units to regulate the input/output functions of these components. These control and synchronizer units convert the data to and from the storage and recording equipment to make it compatible with equipment capability.

In the event data becomes degraded within the subsystem, electronic transfer switching provides rapid change-over capability from one processing component to the standby component. An uninterrupted flow of data is therefore preserved.

3-2-5-3. Control and Monitoring

The communications and configuration console enables the status and the configuration of the Central Processor Subsystem to be monitored and controlled from one central location. Additionally, a manual entry device contained in the console provides a means of operator control over the computer program functions.

3-2-6. Teletype and Facsimile Subsystem

The Teletype and Facsimile Subsystem (figure 3-2-6) provides, in clear text, page-printed copy of teletype messages received from the Manned Spaceflight Network, major military relay centers, U. S. Weather Bureau, military weather networks and commercial telegraph outlets; transmits teletype messages back to these locations; supports checkout and training program; receives meteorological data (e. g., weather maps) from the National Meteorology Center at Suitland, Maryland; and transmits meteorological data back to the center.

3-2-6-1. Teletype Message Receive and Transmit

The various teletype components include receive-only page printers, transmitter-distributor units, receive-only typing reperforators, automatic send-receive sets, and teletype loop switchboards, physically grouped in various areas of the MOW. Since the automatic send-receive sets include components similar to the other components mentioned (except the teletype loop switchboards), the operation of these sets will be described prior to discussing the operating aspects of the physical grouping of the teletype components.

The basic components of each automatic send-receive set are a page printer with a manual control keyboard, a tape punch, and a tape reader. The page printer and keyboard provide for automatic printout of received messages and for manual coding of teletype message tapes for transmission. The tape punch (perforator) provides the mechanical action that drives punch pins for coded perforation of a teletype message tape as directed from the manual control keyboard. A typing wheel, incorporated in a printing mechanism, prints an individual character on the teletype tape at the same time that the code for the character is being perforated on the tape. Thus, a message inserted into an automatic send-receive set for transmission by an operator at the manual control keyboard is simultaneously printed out as clear text and converted into coded perforations on the same teletype tape. This enables any errors in the typed-out message to be detected prior to transmission. A tape punch unit with this capability is called a typing perforator. The addition of a receiving selector mechanism to the tape punch unit permits perforation of tape corresponding to received messages to be simultaneously printed out and code perforated. This enables the destination of each incoming message to be determined by reading the address directly off the tape; hence, alleviating the necessity for a skilled code-reading operator. A tape punch unit with this capability is called a typing reperforator. The tape reader is a transmitter-distributor unit, which controls the automatic transmission of messages. The transmitter-distributor effectively reads the message on a punched teletype tape and converts the coded perforations to electrical impulses, or line signals, and distributes these signals in sequential form to communication lines for online transmission or forwards them as parallel outputs for operation of similarly wired machines.

The majority of the tape punch units included with the automatic send-receive sets and individual receive-only typing reperforators do not actually perforate the teletype message tapes. Instead, they only partially perforate the tape resulting in coded indentations rather than perforations. Teletype tape coded in this manner is called chadless tape because it leaves no punched-out waste or chad. Messages coded on chadless tape appear as raised dots instead of punched holes, as is the case with fully perforated tape. The operational aspects of the teletype equipment grouping are discussed in the following paragraphs.

The teletype message center contains automatic send-receive sets with auxiliary receive-only typing reperforators, transmitter-distributor units, receive-only typing reperforators, and receive-only page printers. The automatic send-receive sets are used for message preparation and editing, and as backup equipment. The transmitter-distributor units have their output loops fed to the Central Processor Subsystem via the Communications Facility Control Subsystem. Receive-only typing reperforator/page printer combinations are used to monitor radar and telemetry data, terminate receive-only teletype loops that contain messages addressed to the teletype message center, and to intercept teletype messages containing garbled or otherwise unrecognizable headings. The remaining receive-only page printers are used to monitor outgoing operational message traffic, monitor real and simulated digital command messages, intercept invalid high-speed data messages received from remote stations, copy outgoing advisory messages relating to invalid high-speed data messages, and to monitor all traffic on either the second or third floor SSR teletype loops.

The MOCR's and associated SSR's contain receive-only page printers, which receive teletype messages from the Central Processor Subsystem via the Communications Facility Control Subsystem. One teletype loop terminates in receive-only page printers in the assistant flight director console and the operations and procedures officer console in MOCR 1; another loop terminates at identical consoles in MOCR 2. Two loops terminate in receive-only page printers in each SSR. Two loops are designated as the primary loops and the others as over-flow loops. Two additional circuits provide for internal MCC-H originated traffic and network postlaunch traffic to the SSR's. The network postlaunch traffic, under computer control, is also sent to building 45 when appropriately tagged. The printers in the operations and procedures SSR's copy all traffic received on the loops. The printers in the other SSR's are specially equipped to provide selective traffic delivery, which allows individual printer operation on a common loop.

The RCR teletype equipment includes a teletype loop switchboard, receive-only typing reperforators, transmitter-distributor units, and automatic send-receive sets. One of the automatic send-receive sets (with an auxiliary receive-only typing reperforator) handles cryptographic message traffic and terminates an end-to-end secure circuit from the MSC communications center. Other automatic send-receive sets (with and without auxiliary receive-only typing reperforator) function as backup equipment and terminate circuits from the Communications Facility Control Subsystem teletype patch board. The other components, respectively, terminate full-duplex and half-duplex circuits from the Defense Communications Agency switching center at Fort Detrick, Maryland and the KSC launch control center. These circuits are not routed through the Central Processor Subsystem, but are routed directly to the telephone termination and distribution equipment (room 127) via the Communications Facility Control Subsystem teletype patch board. All the teletype circuits tied into the teletype loop switchboard are patchable at the switchboard as well as at the Communications Facility Control Subsystem teletype patch board.

The meteorological center contains a teletype loop switchboard, a call director, an automatic send-receive set, receive-only page printers, and a transmitter-distributor unit. The automatic send-receive set, which includes an auxiliary receive-only typing reperforator, is included only for preparation of message tapes. The automatic send-receive set and the majority of receive-only page printers are equipped with standard weather symbol keyboards, typing wheels, and type boxes for exchange of weather information. One full-duplex circuit extends from the Communications Facility Control Subsystem teletype patch board to the teletype loop switchboard to function as a backup loop. All circuits are patchable at both the teletype loop switchboard and the Communications Facility Control Subsystem teletype patch board.

Three circuits provide for administrative and coordination traffic between the teletype center and buildings 2 and 45 and Huntsville, Alabama. Two circuits, under computer control, provide selected vector data to engineering study and analysis groups in Huntsville, Alabama, and to the Houston-auxiliary computer room (H-ACR). The flight crew and flight operations circuits (two) adequately tie in the MCC-H with KSC and the network during checkout and training programs.

3-2-6-2. Facsimile Receive and Transmit

Facsimile equipment is used in the meteorology center to transmit and receive meteorological data. The equipment and associated circuits are a part of end-to-end service. The facsimile machines terminate, via the call director, a spaceflight meteorology circuit and a national meteorology center circuit. The spaceflight meteorology circuit is a four-party combination voice and facsimile circuit connecting the MCC-H meteorological center with meteorological centers in Washington D. C., Miami, Florida, and at Cape Kennedy. The national meteorology circuit connects the MCC-H meteorological center with the national meteorological center in Suitland, Maryland. The call director permits the facsimile machines to be switched to different on-line and off-line configurations.

3-2-7. Pneumatic Tube Subsystem

The Pneumatic Tube Subsystem (figure 3-2-7) is a self-contained subsystem, which provides an automatic and manual hardcopy message routing capability between send and receive pneumatic tube stations located throughout the MOW. The messages are carried in cylindrical message carriers that are vacuum propelled through the pneumatic tubing.

3-2-7-1. Automatic Message Routing

The automatic pneumatic tube stations are linked to central exchangers, which automatically route the messages to their selected destinations. Each console-mounted, send-receive control panel enables station selection by means of station-designated push-buttons, which, when pressed, cause the dispatch door of the panel to open, permitting the insertion of a message carrier into the dispatch tube associated with the panel. Each wall-mounted, send-receive control panel enables station selection by means of dual-digit dialing using two rotary knobs and a two-digit indicator unit. After the desired station is selected by dialing its number, a send button on the panel is pressed to cause the dispatch door of the panel to open. Lights are provided on the send-receive control panels to indicate the arrival of a message carrier.

Operation of the send or receive portion of each station is in the no-air mode, i. e., no air is applied to a pneumatic tube run when either the dispatch or receive door of its associated send-receive panel is open. This is accomplished in the dispatch line by pneumatically operated slidegates and windgates. The slidegate is installed in the station dispatch line and the windgate in the main tube airflow line. The slidegate is normally closed and the windgate normally open. When the dispatch door is closed, the slidegate opens and the windgate closes, applying airflow (vacuum) to the message carrier in the dispatch line causing the carrier to be dispatched. In the down-receive wall stations, the carrier is deflected out of the main line by a pneumatically operated, horizontal deflection switch. The carrier is gravity dropped to the receiving chamber compressing dead air ahead of the carrier and cushioning the carrier fall. The air is prevented from entering the receiving chamber by a valve installed in the deflection switch. In the up-receive stations, an arrangement of air valves and microswitches allow the carrier to be drawn up into the receiving chamber; the air is cut off prior to the carrier coming to rest in the chamber, but the carrier momentum provides sufficient forward movement to complete the receiving cycle.

Turbocompressors provide air pressure to the pneumatic tubing for message carrier transmission. Air lines from the compressors are connected to the dispatch and receive lines at appropriate locations to provide sufficient air to maintain an average carrier velocity of 25 feet per second. Another compressor provides operating air to the pneumatically operated deflection switches, slidegates, and windgates. A separate tube network using smaller tubing than the message transmission tubing connects this compressor to the appropriate components. Each central exchanger contains an air compressor for its exclusive use.

All carrier traffic passes through the central exchangers enroute to a station. Dispatching tubes terminate at the exchangers and receiving tubes originate at the exchangers. The exchangers receive inbound message carriers, hold the carriers (thereby spacing them to a proper time interval), release them one at a time in sequence, and shuttle them to their outbound destination loops. The control panels receive and store station selection signals from the automatic station send-receive control panels, control message carrier routing and activity, and indicate the presence and flow of all carriers through the pneumatic tube runs with color-coded lights. The selection of a station at the send-receive control panels causes telephone type switching relays to be actuated at the control panels that set up the sequence of message carrier operation required to direct each carrier to its selected destination in turn. The supervisory control panel provides the same status indications as the control panels.

The central exchangers, which consist of storage, spacer, loop selection, and reset sections, are capable of processing 720 message carriers an hour. Each exchanger processes the carrier in four stages, starting with the storage section, which is located in the tubing directly above and connected to the exchanger. The carriers are deflected from the main tube runs by deflection switches and gravity dropped into the storage section. Line limit switches, located in the tubing above the exchanger, are activated by carrier passage and, after a carrier enters the storage section, signal the control panel associated with the exchanger. The control panel places the affected inbound dispatch tube in a no-operation mode until the exchanger processes the carrier. In this condition, a second carrier placed in the dispatch tube at a send-receive station is held there until the exchanger has cleared the storage section of the first carrier. As a carrier drops into the storage section, it comes to rest on ejector arms and makes contact with a limit switch that initiates an electrical sequence in the control panel, which takes control at this point and directs the carrier. The air-operated ejector arm holding the carrier is retracted and the carrier drops to a shoulder in the spacer section. At the end of its back stroke, the ejector arm contacts a limit switch that reverses the airflow to a piston that drives the arm to its original position and pushes the carrier into the loop selector section. The loop selector mechanism, an air-operated hopper, moves the correct outbound loop as the ejector arm retracts and the carrier is deflected directly to the outbound loop. As the carrier leaves the loop selector section and enters the outbound loop, it trips a reset switch, resetting the exchanger for subsequent carrier operation for that particular loop.

Each exchanger has five input loops and six outgoing loops. One of the outbound exchanger loops is used for a reject loop. Two reject stations, one for each central exchanger, are located at the central desk in the message center. If for any reason, the selected outgoing loop from the exchanger is inoperative, or after a predetermined time delay, the exchanger hopper directs the carrier into the reject loop. At the central desk, a dispatch station (one for each exchanger) may be used for redispatching the carrier.

3-2-7-2. Manual Message Routing

Message carriers are dispatched, transmitted, and received through the manual message routing network similarly to the automatic message routing network stations. However, since the manual stations are directly linked by pneumatic tube runs, no interchange action is required on messages routed through these tube runs. Also, the manual stations require only a single pushbutton to open the dispatch door and, since the manual stations are directly linked, no station-selection pushbuttons are required at their respective control panels.

3-3. DISPLAY/CONTROL SYSTEM

The Display/Control System (figure 3-3) utilizes various display devices (plotting, television, and digital) to present two basic types of displays: dynamic and reference. Dynamic displays present real time or near real time information (vehicle systems data, biomedical data, tracking data, etc.) that permits flight controllers to stay abreast of dynamic mission situations as they occur. Reference displays present reference information (mission rules, operational procedures, performance histories, etc.) that enables flight controllers to make reliable decisions concerning the progress of a mission. The information is made available to specific areas or, as desired, to several areas for combined evaluation. Selection of the desired information and the resultant presentation require minimum operator action and interpretation, thus unencumbering the data evaluation and decision-making roles of the flight controllers. In addition to providing information displays employing each of its five subsystems, the system also provides a timing standard for the MCC-H and operating positions for all mission controllers and associated specialists.

3-3-1. Computer Display/Control Interface Subsystem

The Computer Display/Control Interface Subsystem (figure 3-3-1) functions in conjunction with the RTCC and the Central Processor (CP) Subsystem to automatically carry out requests initiated by mission control and support personnel during either actual missions or checkout and training programs. In this capacity, the subsystem detects, encodes, and transmits operator requests to the computer systems, generates displays in response to the requested data received from the computers, and provides distribution facilities to supply the display information to the desired display equipment.

3-3-1-1. Computer Requests

Operator requests of specific display formats for presentation on specific display equipment are initiated on computer request keyboards located on mission control and support consoles. These keyboards permit requests for viewing selected data on individual console television displays, automatic X-Y coordinate plotboards, and large-scale projection displays. In addition, the keyboards provide status indications of selected data parameters and permit manual switching of the RTCC operational computer program subroutine during different phases of a mission. The tasks to be performed by an operator determine the types of keyboards located on a console and the availability of computer requests.

Requests initiated on the computer request keyboards are applied to associated encoders, transformed into digital codes, detected by a computer input multiplexer, and transmitted over a single line at 2400 bits per second to the RTCC. The computer input multiplexer sequentially scans the encoders. Upon detection of a request, the scanning operation is inhibited and the multiplexer locks on to the data lines of the encoder holding the request until the request is completely transferred to the multiplexer. Address information designating the originator of the request is assembled with the coded request into a uniform data word by the multiplexer, which then transmits the data word to the RTCC. Afterwards, the multiplexer resumes scanning the encoders, starting at the next sequential position. The RTCC processes the data words received from the multiplexer and releases the data required to fulfill each request to the appropriate data distributor (either the plotting display, converter slide file, digital-to-television converter, or digital display data distributor).

The manual selection keyboards and associated encoders communicate operator requests to the RTCC and television hardcopiers. These keyboards allow an operator to request any available display format by dialing the display format number (obtained from a premission prepared display index) and selecting the method of display. Hardcopy controls on the keyboards permit operators to request hardcopy prints of selected television images. This request is communicated directly to the Television Subsystem hardcopy control equipment to initiate hardcopy operation.

The display request keyboards and associated encoders allow an operator to quickly select up to 384 displays. The display requests are made by pressing the switch containing the name of the desired display and then pressing the switch containing the name of the desired display device.

Manual switching of the RTCC computer program subroutine during different phases of a mission is accomplished by the phase control keyboard located on certain mission control operator consoles. When the time arrives during a mission to switch the operational computer from one mission phase program subroutine to another, the proper control on the phase control keyboard is operated. This immediately causes the selected mission phase control lamp on the keyboard to light. The control switch closures are detected, encoded, and communicated to the RTCC by the encoder-multiplexer equipment. The RTCC then performs the requested computer switchover operation.

Summary message enable keyboards are employed to permit returning certain portions of telemetered data to remote stations, in the form of summary messages, for transmission validation. The selection of a specific summary message is communicated to the RTCC, which, in turn, strips out the required telemetry data for communication to remote stations. At this time, the RTCC also sends digital display data to the digital display driver equipment to extinguish the summary message request light on the summary message enable keyboard, thus indicating completion of the request.

Telemetry event status (early, on-time, and late) during various mission phases are indicated by event sequence modules. If a specific mission event occurs during a programmed time, the computer generates digital display data to cause an associated event indicator to light green. If the event signal is not received before the programmed time is exceeded, the computer causes the indicator to light red.

A special encoder, included with the encoder-multiplexer equipment, receives status inputs from the digital-to-television converters, converter slide files, and reference slide files. The encoder senses any change in the operational status of the equipment and generates a coded message, which is transmitted via the computer input multiplexer to the RTCC. By knowing the status of the equipment, the RTCC is able to route display data accordingly.

3-3-1-2. Command Transmission

Command transmission from the MCC-H involves the initiation of a command from a particular flight command control module, the transfer of this command initiation through encoder-multiplexers to the appropriate computer, and the execution or command data transmission from the computer to the spacecraft via

GSFC and a remote site. The commands can be classed in two general categories: real time commands and command loads.

Real time commands are initiated from flight control modules in either the MOCR's or room 118B of the MOW. Commands initiated from these modules are applied to encoder-multiplexers and transmitted to the Central Processor Subsystem. The Central Processor Subsystem formats the command and transfers it via the Communications Facility Control Subsystem to GSFC, where it is routed to the appropriate Manned Spaceflight Network remote site. A message acceptance is returned from the remote or remoted site and transferred back through the same route to the Central Processor Subsystem. The Central Processor Subsystem sends an acknowledgment of reception back to the control module.

Command loads refer to data that has been previously loaded from the RTCC into the remote site data processor. Requests for uplinking these commands to the spacecraft are initiated from flight command control modules and cause the Central Processor Subsystem to send out an execute command. Acknowledgment of spacecraft reception signals are received at the command control module by way of the CCATS digital display driver equipment.

3-3-1-3. Plotting Display Data Distribution

The plotting display data distributor receives control data signals from the RTCC that are necessary to generate large-scale plotting displays on X-Y coordinate plotboards or group display viewing screens. The plotting display data distributor then distributes display control data to X-Y plotboards in the flight dynamics SSR's and to projection plotting display control electronics in the MOCR's and the RCR.

The X-Y plotboards perform digital-to-analog conversion of the binary data received from the plotting display data distributor. The resultant analog signals control the plotboard X-Y coordinate plotting pens to produce a visual display of flight dynamics data.

Control-data signals (projector selection, slide selection, and plotting data), in the form of selection and position commands, are distributed to the Group Display Subsystem plotting display control electronics to control projection plotting displays on wall-type viewing screens. This permits display controllers in the MOCR's and the RCR to select specific data for group display and also to select a specific viewing screen to display the data on. For example, if the Assistant Flight Director wishes to view, on one of the MOCR projection plotting display viewing screens, the progress of an earth orbiting spacecraft in relation to its geographical position, he merely selects the desired viewing screen and inserts the request code for the desired display format into a manual selection keyboard mounted on his console for that purpose. The encoder-multiplexer equipment detects the request, encodes it, and transmits it to the RTCC. The RTCC processes the coded request to determine the data, and the destination of the data, required to generate the display. The RTCC then shifts the necessary control data out to the plotting display data distributor. The data distributor temporarily stores the data, if necessary, and distributes the data to the projection plotting display control electronics. The control electronics convert the digital control data into analog signals that cause the projectors associated with the selected viewing screen to respond and produce the requested display. This entire process is illustrated in figure 3-3-4-1.

3-3-1-4. Television Display Data Distribution

The converter slide file data distributor and the digital-to-television converter data distributor receive control data signals from the RTCC that are necessary to generate individual console television displays and large-scale projection television displays. These distributors are connected in parallel to the same RTCC direct data channel. The address coding structure of the computer data allows selective data transfer to the distributors.

The converter slide file data distributor routes slide selection data from the RTCC to reference slide files and converter slide files. The distributor also distributes control signals to a video switching matrix (part of the Television Subsystem) to connect an input video channel with an output television viewer or projector channel.

The slide selection data signals routed to the reference slide files cause requested reference slides to be selected out of storage. After a slide is retrieved from storage, it is transported to a gate at the end of the slide file where it is locked in-place between a light source and a television camera. In this position, the slide is transilluminated and viewed by the television camera, which converts the reference slide image into video signals and applies them to the Television Subsystem video switching matrix. The video switching matrix receives input-to-output connection commands and routes the video signals to the television viewer located on the console from which the request for the reference data originated or to a television projector for group display, if desired.

The slide selection data signals routed to the converter slide files are acted upon in the same manner as the data routed to the reference slide files. However, the slides contained in the converter slide files are not intended to be displayed alone. Instead, they provide format or pictorial-type reference backgrounds for dynamic television displays produced by digital-to-television display generators. For this reason, the transilluminated slide images are not viewed directly by television cameras, but projected to optical lens assemblies attached to the cameras that mix the background slide images with dynamic data images displayed on character print-out cathode ray tubes in the display generators. Television cameras in the display generators pick up the mixed images and convert them to video signals.

The digital-to-television converter data distributor routes digital display generation data to the buffers. The data is stored in the buffers and applied, upon demand to the addressed display generators on a time-shared basis. The display generator then converts the digital display data into alphanumeric and vector displays for conversion into video signals. Conversion of the digital data into video signals is accomplished by the display generators in the following manner: the digital display data signals are first decoded into analog voltages and then applied to the appropriate elements of a character print-out (shaped-beam) cathode ray tube to control the deflection of the electron beam inside the tube. The electron beam is first deflected through the character, designated by the display data signals, of a letter, numeral, and symbol matrix located between the cathode and screen of the tube. After deflection through the matrix, the electron beam is again deflected so as to strike the phosphorous screen of the shaped-beam tube at the proper point. The resultant display image on the face of the tube is optically mixed with the converter slide file image and viewed by a television camera, which converts the mixed images into video signals. These video signals are distributed in the same manner as the video output of the reference slide files.

A miniature version of the typical projection plotting display shown in figure 3-3-4-1 may be generated by the digital-to-television converters when desired for display on individual console television monitors. This would be desirable, for example, if a flight controller wanted to view only one spacecraft involved in a particular mission while the large viewing screen was displaying all the spacecraft involved in the mission. This display would be created by rapidly printing out a dot symbol by the shaped-beam tube, in conjunction with incoming control data, to produce a moving vector or plot line. This dynamic plot line would then be superimposed on a static background map of the world (projected by the converter slide file) to produce a composite television display similar to the large-scale projection plotting display.

All video signals generated within the MCC-H, or entering the MCC-H from remote sources, are connected to input channels of the Television Subsystem video switching matrix. Individual console television viewers (part of the Television Subsystem) and television projectors (part of the Group Display Subsystem) are connected to output channels of the matrix. Access to any of the video output channels to view a television display is permitted by a television channel select mode on the manual selection keyboards. For example, if a projection television display of a space vehicle launching is desired in the MOCR on the left projection television screen, either the Assistant Flight Director or the Operations and Procedures Officer will select the desired viewing screen and insert the code of the video switching matrix channel to which the desired video information is being applied into a manual selection keyboard. This display request is then encoded and transmitted to the RTCC by the encoder-multiplexer equipment. The RTCC, in turn, channels an input-to-output connection command through the converter slide file data distributor to the video switching matrix. The video switching matrix decodes the command and connects the video input channel to the output channel that feeds the television projector associated with the left projection television screen. The television projector then converts the video signals from the matrix into the requested television display. Figure 3-3-4-2 illustrates this entire process from selection to presentation. If a console-mounted television viewer had been selected to display the televised space vehicle launching instead of the group display viewing screen, the video switching matrix input-to-output connection command would have caused the matrix to route the video signals to the selected television viewer instead of the television projector.

3-3-1-5. Digital Display Data Distribution

The digital display data distributor receives computer generated digital time words and other digital display data from the RTCC and distributes this data to the Timing Subsystem and digital display drivers. The timing data routed to the Timing Subsystem is used to control the general purpose relative time accumulators of that subsystem. Control data routed to the digital display drivers selects a specific driver to control a single projection lamp in digital readout displays of the Television, Group Display, and Computer Display/Control Interface Subsystems. The display drivers directly control all the readout devices except those of the Group Display Subsystem.

The Group Display Subsystem readout devices require a high-power level due to their numerous display lamps that must be illuminated simultaneously. Display drivers, included in the Group Display Subsystem, effectively step up the power level of control signals from the digital display drivers to drive the digital readout group displays in the MOCR's, RCR, and RTCC.

3-3-1-6. Telemetry Events Distribution

Certain significant telemetry events and analogs are displayed on mission control and support consoles and recorders. Signals to control these displays are routed from the Central Processor Subsystem through the Telemetry Subsystem to the event/analog driver equipment. The amplified outputs of the drivers are applied to applicable event indicators and recorders and analog meters and recorders.

3-3-1-7. Data Switching Between MOCR's

The MOCR switch unit permits various areas of the MOW that are common to the MOCR's to switch operations from one MOCR to the other. The MOW rooms that are considered MOCR common areas are the RTCC, display and timing equipment room, and the RCR. The switch unit contains distribution and patching facilities to interface the keyboards and digital readout displays located in MOCR common areas and in the RCR with the rest of the Computer Display/Control Interface Subsystem.

3-3-2. Timing Subsystem

The Timing Subsystem (figure 3-3-2) functions as the timing standard for the MCC-H. The subsystem generates, distributes, and displays Greenwich mean time in various formats and timing pulses at numerous pulse rates. These timing signals are used for synchronization, time correlation, and other purposes by each functional system in the MCC-H. The subsystem also generates general purpose time, normally under control of the RTCC, for distribution to various time display devices. In addition to generating timing signals, the subsystem accepts launch countdown time from KSC via the Communications Facility Control Subsystem and supplies the countdown timing signals to various display devices during the countdown phase of a mission. At the countdown conclusion, the subsystem supplies ground elapsed time (mission time) to the same display devices previously displaying countdown time. The subsystem also provides dual stop clock display, on console-mounted equipment, and central standard time and Greenwich mean time displays on wall clocks located throughout the MCC-H.

3-3-2-1. Greenwich Mean Time/Pulse Rate Signals/ Status Signals Generation, Distribution, and Display

The master instrumentation timing equipment handles the majority of specialized timing requirements of the MCC-H. The equipment utilizes an ultrastable oscillator and associated timing generators synchronized with the National Bureau of Standards radio station WWV to generate Greenwich mean time and a quantity of pulse rate signals. Status signals are sent from the equipment to the relative time accumulators to denote the operating status of the equipment.

Decimal, binary-coded-decimal, and specially formatted Greenwich mean time signals are generated by the master instrumentation timing equipment and distributed to various individual and group time displays, the serial decimal time converter, the timing interface unit, and the timing signal distributors. The time displays convert the timing signals to decimal readout for direct viewing or conversion to video signals. The serial decimal time converter converts binary-coded-decimal inputs to pulse-coded-decimal outputs, and applies them to chart recorders (part of the Computer Display/Control Interface Subsystem) for visual display. The timing interface unit converts Greenwich mean time to serial time data for the Central Processor Subsystem. Specially formatted Greenwich mean time signals are applied through timing signal distributors to recording equipment of the Communications Facility Control and Voice Communications Subsystems and recorded along with data signals for time-correlation purposes.

Timing pulses are generated at numerous pulse rates by the master instrumentation timing equipment and distributed to user equipment, such as X-Y plotboards, through the MCC-H. The timing pulses function as clock pulses in some cases to step up time accumulators and in other cases (e.g., X-Y plotboards) are displayed along with dynamic data.

3-3-2-2. Launch Countdown Time/Ground Elapsed Time Generation, Distribution, and Display

The Atlantic missile range countdown processor receives, via the Communications Facility Control

The Atlantic missile range countdown processor receives, via the Communications Facility Control Subsystem, countdown timing signals or a lift-off signal from the KSC launch control center and simulates countdown signals for processing to the relative time accumulators. If desired, a manual lift-off signal to override the countdown signals can be applied to the countdown processor from the Computer Display/ Control Interface Subsystem. The relative time accumulators distribute the launch countdown timing signals, at the proper power level, to various display devices up to the moment of vehicle lift-off. At lift-off, a signal is transmitted from the launch site through the countdown processor to the relative time accumulators. The lift-off signal inhibits the relative time accumulator countdown outputs and enables mission time counter outputs. Additional mission time signals are generated from the vehicle as telemetry signals processed by the Telemetry Subsystem and applied to the relative time accumulators to start the counting cycle. Mission time is then displayed on the display devices.

The mission time displays may be started and stopped manually from a relative time accumulator remote control panel mounted on the network controller console in each MOCR.

The relative time accumulators provide a lift-off signal in Greenwich mean time to a display module mounted on the network controller console in each MOCR. This signal is obtained by storing Greenwich mean time in lift-off drivers that are continuously updated until a lift-off signal is received from the countdown processor. When this occurs, the lift-off drivers are locked-up (prevented from being updated); thus, making the exact time of lift-off available in Greenwich mean time until the drivers are reset by remote control.

3-3-2-3. General Purpose Time Generation and Distribution

General purpose time displays, for the most part, consist of specially computed times under control of the RTCC through the digital display data distributor (part of the Computer Display/Control Interface Subsystem) and the relative time accumulators. The RTCC causes a mnemonic label to light adjacent to each computer controlled, general purpose time display to identify the time that is being displayed (e.g., GMTNMI indicates that the time being displayed is the Greenwich mean time at which the next maneuver for a particular spacecraft is to occur). The general purpose time displays may also be started and stopped manually from the relative time accumulator remote control panels.

3-3-2-4. Dual Stop Clock Time Display and Control

An accurate time-to-go indication for certain events is provided by dual stop clock equipments mounted on the retrofire officer console and the spacecraft communicator console in each MOCR. These equipments are used to start and stop a countdown or countup digital readout display, which is a part of each equipment.

3-3-2-5. Greenwich Mean Time/Central Standard Time Wall Clock Display

Wall clocks, displaying Greenwich mean time and central standard time, are slaved to the wall clock master control unit. The master control unit, in synchronization with radio station WWV, sends time correction signals to all wall clocks once each hour. An accurate time presentation is thus ensured throughout the MCC-H at all times.

3-3-3. Television Subsystem

The Television Subsystem (figure 3-3-3) generates, distributes, displays, and records standard resolution (525-line per frame scanning rate) and high resolution (945-line per frame scanning rate) video information. The subsystem also generates and distributes synchronization pulses required by television equipment included within the subsystem and other subsystems.

Video information to be distributed and displayed by the television subsystem includes live video from the Manned Spaceflight Network or from commercial television networks; dynamics computer generated numeric, symbolic, or vectoral information combined with static background slide file information; and reference data or textual information selected from a file of reference slides. All the video information, except that from the Manned Spaceflight Network and commercial television broadcasts, is generated within the MOW either by television cameras viewing selected images or the playing back of previously recorded video signals. The video is distributed through video patch panels and computer or manual controlled video switching matrices and displayed by television viewers and large-screen projection television displays.

3-3-3-1. Video Generation

Video information is generated in the MOW by television cameras viewing group displays, and by cameras located in opaque televisors, matte televisors, analog-to-television converters, time display converters, digital-to-television display generators, reference slide files, and television standard converters. The display generators and the reference slide files are part of the Computer Display/Control Interface Subsystem.

The group display cameras are divided into three groups, one group for each MOCR and one group for both MOCR's. The cameras televise network status, plotboards displays, projection plotting displays, and scheduling information. The cameras are supplied with remotely controlled pan-tilt mechanisms and zoom lenses. The remote control module for each camera is located on a console near the camera. Video information from the cameras associated with each MOCR is routed directly to the main video switching matrix associated with the MOCR. Video information from RCR and scheduling group display cameras is routed to both video switching matrices.

The opaque televisors are also divided into three groups, one group for each MOCR and one group in the RCR and meteorological center that supplies information to both MOCR's. The opaque televisors televise artwork such as maps and drawings. Video information from the opaque televisors associated with each MOCR is routed directly to the MOCR main video switching matrix and to nearby monitors. Video information from opaque televisors in the RCR and meteorological center is routed directly to both video switching matrices.

The time display converters receive Greenwich mean time, countdown or mission time, and general purpose time signals from the Timing Subsystem. These time signals are displayed on an illuminated readout panel that is viewed by television cameras. The resultant video signals are routed to fixed display viewers and the appropriate video switching matrices.

The television standard converters accept video signals at one scanning rate and convert the video signals to a different scanning rate. The television standard converters are divided into two types: the 945-line to 525-line and the 525-line to 945-line. The 945-line to 525-line standard converters receive video signals from either video switching matrix and supply the converted video signals to a video patch panel for distribution to the standard resolution switching matrix. The 525-line to 945-line standard converters receive video signals from a television receiver and selected landline interface inputs or outputs and supply the converted video signals to a video patch panel for distribution to either of the two main video switching matrices.

3-3-3-2. Video Distribution

Two similar sets of high resolution video switching matrix equipment (one for each MOCR) and one standard resolution video switching matrix are included with the Television Subsystem. These matrices switch a number of video sources to selected output channels for distribution to various television viewers, television projectors, and recording equipment.

Each set of high resolution video switching matrix equipment includes four switching matrices: the main video switching matrix, auxiliary video switching matrix, video engineer switching matrix, and the video scanner switching matrix. Each main video switching matrix connects selected video input signals to selected output channels for distribution to console-mounted and ceiling-suspended television viewers, television projectors, and television standard converters. Each auxiliary video switching matrix connects input video signals to television viewers only. The selection of the video input signals for television display is accomplished by entering a display request into a console-mounted keyboard, part of the Computer Display/Control Interface Subsystem. The display request is sent to the RTCC, which applies an input-to-output connection command through the Computer Display/Control Interface Subsystem to the main or auxiliary video switching matrix depending upon the input video selected for viewing. The appropriate switching matrix decodes the command and connects the selected video input signals to the selected output television display equipment (either a television viewer, projector, or standard converter). This entire selection, distribution, and display process using a television projector as the selected output equipment is illustrated in figure 3-3-4-2.

Digital readout driver circuits are associated with the main and auxiliary video switching matrices. These circuits operate in conjunction with readout panels located on console-mounted television viewers to enable console operators to identify the switching matrix input channel connected to each viewer.

The video engineer switching matrix, in conjunction with a selector panel located on the video engineer console, permits the Video Engineer to select any of the main or auxiliary video switching matrix video input or output signals for display on a console-mounted television viewer.

The video scanner switching matrix receives video input signals from the main and auxiliary video switching matrices and supplies these video signals to the hardcopy control equipment for hardcopy recording.

The standard resolution video switching matrix consists of three functional sections: television viewer switcher, video tape recorder input switcher, and video output switcher. The video input signals to the television viewer switcher are video tape recorders input and output signals and landline interface video signals. The switcher supplies selected video signals to console-mounted standard resolution television viewers. These viewers are located in public affairs information control consoles and in the video interface engineer console. The video input signal desired on a particular viewer is selected at a video select module on the appropriate console. The video tape recorder input switcher receives video signals from the television standard converters, time display converters, television broadcast receivers, group display cameras, and the landline interface equipment and distributes the selected input signals to the video tape recorders. Control of the switcher is provided by remote control panels. The video output switcher receives video input signals from the television standard converters, time display converters, television broadcast receivers, group display cameras, landline interface equipment, and the video tape recorders. The switcher distributes selected input signals to the landline interface equipment. The switcher is controlled by remote control panels.

The landline interface equipment is used to monitor, adjust, and manually switch standard resolution video signals that enter or leave the MOW. The equipment receives video inputs supplied to the MOW from the KSC launch control center, Manned Spaceflight Network, and MSC public affairs studio. Video signals generated within the MOW (television test generator signals, television standard converter signals, and video tape recorder signals) are supplied to the landline interface equipment from the standard resolution video switching matrix. The equipment supplies video signals to the KSC launch control center, MSC public affairs studio, and the MSC headquarters.

3-3-3-3. Video Display

Video information for individual and group viewing is displayed by television viewers and television projectors (part of the Group Display Subsystem). Television viewers are used by console operators and support personnel to view the video signals generated within the MOW (closed circuit) and the video signals generated by external sources. Various sizes of both the standard and high resolution television viewers are included with the Television Subsystem.

The 14-inch, high resolution viewers are console-mounted, cabinet-mounted, and ceiling-suspended. The console-mounted viewers, located in various consoles throughout the MOW, accept video input signals from either the main video switching matrix or the auxiliary video switching matrix. As indicated previously, video displays are selected for viewing with a manual selection keyboard. After a selected video display is connected to the appropriate viewer, the video switching matrix input channel number is displayed on a readout panel on the front of the viewer. The cabinet-mounted viewers, used for alignment and testing of the high resolution television equipment, receive video signals from the particular cabinet in which they are mounted. The ceiling-suspended viewers are used as special purpose viewers to monitor video signals from the opaque televisors.

The 14-inch, standard resolution viewers are console-mounted and cabinet-mounted. The console-mounted viewers receive video signals from the standard resolution video switching matrix. The cabinet-mounted viewers are used for alignment and testing of the standard resolution television equipment and receive video signals from the particular cabinet in which they are mounted.

The 21-inch, standard and high resolution viewers are ceiling-suspended and are used as general purpose viewers by groups of observers. The viewers receive video signals from television standard converters, time display converters, and selected video signals from the video switching matrices.

3-3-3-4. Video Recording and Editing

Two types of video recording equipment are included with the Television Subsystem: hardcopy recording equipment and video tape recording equipment.

The hardcopy recording equipment consists of hardcopy control equipment and hardcopy recorders. Requests for hardcopy reproductions are initiated from manual selection keyboards. When the hardcopy control equipment receives a hardcopy request, the hardcopy control equipment selects the appropriate video channel from the video scanner switching matrix and routes the selected video signals to one of the hardcopy recorders. The hardcopy control equipment also supplies control signals to the hardcopy recorder to initiate the recording action and supplies a two-digit requester identification code to identify the hardcopy reproduction. Greenwich mean time is supplied to the hardcopy recorders from the Timing Subsystem so that the time of request can be recorded along with the video information and requester identification code. The hardcopy reproduction is routed to the requester through the Pneumatic Tube Subsystem.

Video tape recording is accomplished by two remote-controlled video tape recorders. The two video tape recorders provide a means of recording and editing standard resolution video signals for distribution to areas external to the MOW. The edited video signals from each video tape recorder are supplied through the standard resolution video switching matrix to the landline interface equipment.

3-3-3-5. Synchronization Generation and Distribution

The synchronization generation and distribution equipment is divided into two groups: standard resolution and high resolution. These two groups of equipment generate mixed blanking, horizontal drive, vertical drive, and mixed synchronizing pulses and distribute the pulses to the television cameras and viewers. High resolution vertical drive pulses are also applied to the Computer Display/Control Interface Subsystem where they are used to synchronize the digital-to-television converter storage buffer operations with the scanning rate of the television cameras in the display generators.

3-3-4. Group Display Subsystem

The Group Display Subsystem (figure 3-3-4) provides flight dynamics, mission status information, and reference data in readily recognizable form on large-scale displays in the three control areas of the MCC-H. The subsystem also provides mission status displays to the RTCC and enhances the information display capability of the MBOA.

The group displays in each MOCR are identical and consist of projection plotting displays, projection television displays, and alphanumeric readout displays. The projection viewing screens are divided into five display areas: four 10- by 10-foot areas and one 10-by 20-foot area. Three of the 10- by 10-foot areas are used for projection television displays. The remaining areas are used for projection plotting displays. All viewing screens use rear projection techniques with folded optics so that the optical throw distance required for quality projections can be achieved without having to resort to long, straight-line, light projection raceways such as those commonly found in movie theatres. The most beneficial aspect of this is that a high degree of illumination may be maintained in the MOCR's, thus contributing to favorable working conditions, without sacrificing required detail from the displays. Also, more efficient utilization of floor space is realized in this manner. Group time and data displays (digital readouts) are located directly above the viewing screens.

RCR group display consist of a projection plotting display with provisions for manual inputs and daylight and darkness indications, a projection television display, transparency projection displays, and alphanumeric readout displays. Four viewing screens are used to display the projections. A 6- by 12-foot screen is used for the projection plotting display. Two 6- by 6-foot screens are used to display sheet transparencies generated during, or just prior to, a mission. A 6- by 8-foot screen is used to display television projections of reference data obtained from the television subsystem. As in the MOCR's, all projection equipments are located behind the viewing screens. Optical fold mirrors are used with each display except the manually generated data display, which does not require a lengthy optical throw distance. Group time and data displays, which are similar to the MOCR's, but somewhat abbreviated in both size and quantity of displays, are mounted on the wall above the viewing screens.

Two data source displays, each identical to data source displays in the MOCR's, are mounted above the X-Y plotboards on each side of the RTCC. These displays are the only components of the Group Display Subsystem located in the RTCC.

A television projector similar to MOCR and RCR television projectors is located in the MBOA projection room to add a television projection capability to the MBOA information display facilities. This projector is used for direct front screen projection and employs a long light projection path; thus, no mirrors are required for optical folding. The front projection screen in the MBOA is used for various viewing applications, in addition to displaying the television projections, and is not considered part of the Group Display Subsystem.

3-3-4-1. Projection Plotting Display

The presentation of projection plotting displays is controlled by either the Assistant Flight Director or the Operations and Procedures Officer in the MOCR's and by the Recovery Display Controller in the RCR. To select a specific display format, a display selection code is manually inserted into a projection display select keyboard mounted on their respective consoles. This keyboard is actually a manual selection keyboard similar to those discussed with the Computer Display/Control Interface Subsystem. This initiates a fully automated sequence of operations, which causes selection and position commands to be fed into the control electronics associated with each projection plotting display. These commands control the characteristics required for the selected display format (color, background, etc.) and position the plots and symbols on the plotboards selected for the display. An added feature of the RCR projection plotting display is that it can combine manually generated plots with selected displays and also project daylight and darkness patterns whenever a world map background is shown on the summary display plotboards. A typical projection plotting display, including selection, data processing, and presentation, is shown in figure 3-3-4-1.

3-3-4-2. Projection Television Display

The projection display select keyboards on the assistant flight director and the operations and procedures officer consoles are also used to select video information for display by the MOCR projection television displays. Any video information available through the Television Subsystem video switching matrix may be selected for group viewing in the MOCR's. After a display selection is made, the routing of video signals to the appropriate television projector is an automatic function. Video signals are fed into the television projector and subsequently projected, as pictures, onto the selected television display screen. A projection television control module, mounted on the network controller console, enables remote control of the polarity, brightness, and contrast of the MOCR television projections. A typical projection television display is shown in figure 3-3-4-2.

Video information to be displayed via the MBOA television projector is routed through a video patch panel (part of the Television Subsystem) and controlled by a television editor. These television projections supplement other information displays (i. e., motion pictures) in the MBOA and do not necessarily portray the same real time or reference data being viewed in the MOCR's.

The RCR television projector receives video information from a reference slide file or the video switching matrix. A video select module on the recovery display controller console permits selection of video from either source. The reference slide file contains a large quantity of premission-prepared and filed-reference slides. A reference slide select keyboard, mounted on the recovery display controller console, is used to select reference data slides for display. After a selected slide is moved into position, a television camera, an integral part of the reference slide file, converts the image into video signals, which are then applied to the television projector. After conversion of the signals, the television projector projects an enlarged image of the selected reference slide onto the display screen. Other video from the Television Subsystem is routed directly to the projector via the video select module and displayed in the same manner as the MOCR projections. A projection television control module mounted on the recovery display controller console permits remote control of the television projection presentation (polarity, brightness, and contrast).

3-3-4-3. Transparency Projection Display

The manually generated data display in the RCR displays reference data in the form of sheet transparencies. Control of the display is effected at the transparency projectors. Transparency-making equipment and a random access data file, provided as ancillary components, enable rapid generation of transparencies from hardcopy data and permit quick location of any transparencies filed before or during a mission. To display specific reference data, the display operator must first generate a transparent copy of the hardcopy reference data or, if the transparency has already been generated and filed, must retrieve the transparency from the data file. After the transparency has been secured, the operator places it on the staging area of one of the transparency projectors and turns on the projector lamp. The transparency is then illuminated, causing the reference data to be projected onto the viewing screen.

3-3-4-4. Group Time and Data Display

Some of the group time displays, and all the group data display input signals, require power amplification to drive the desired displays. These signals are fed into display drivers, which then feed a voltage output at the correct power level to the designated display device. Those timing signals requiring no power amplification are routed directly to the applicable timing display.

Countdown timing, various types of reference timing (Greenwich mean time, accumulated mission time, etc.), and indications of certain mission events (countdown hold or proceed and switchover to spacecraft onboard guidance) are presented in the MOCR's as group displays. The RCR group time display does not consist of as many units as the MOCR time displays, but presents all of the same information except the switchover indication during the launch phase of a mission. The switchover signal indicates that the launch vehicle guidance system has switched over to the spacecraft onboard guidance system. The timing readout drive signals are fed into the applicable group time display devices and converted directly into large-scale alphanumeric displays.

The MOCR group data display consists of two units, each providing two specific data indications. The command enable status display indicates when commands can be transmitted to a spacecraft, the station which will transmit the commands, and the best time for transmission. The display also indicates when real time or playback telemetered instrumentation data is being processed by the RTCC from a particular spacecraft and the real time telemetry acquisition source. The data source display indicates the tracking data source being used by the RTCC to generate flight dynamics displays. This display also indicates orbit insertion go/no-go recommendations for a spacecraft as determined for each data source. Two data source displays, each identical to the MOCR data source display, comprise the RTCC group data display. Data readout drive signals are fed into the applicable group data display devices from the display drivers and converted directly into large-scale alphanumeric displays.

Projection television channel indicators are adjacent to each MOCR projection television display to identify the specific channel of the video switching matrix furnishing video signals to each television projector.

3-4. REAL TIME COMPUTER COMPLEX SYSTEM

The RTCC System (figure 3-4) performs high-speed processing of all computable data supporting actual missions and checkout and training programs. During a mission, the communications lines of the Manned Spaceflight Network constantly bring a vast array of data into the RTCC via the Communications, Command, and Telemetry System. The data is absorbed and translated by the RTCC into recognizable data displays that enable mission controllers and associated specialists to evaluate current mission situations and initiate appropriate actions.

The Real Time Computer (RTC) Subsystem comprises the bulk of the RTCC. Five large-capacity, digital computers provide the subsystem with sufficient computer capacity to support single or dual mission operations and, at the same time, allow continuation of program development, or permit scheduled validation maintenance. Each real time computer may be functionally assigned as a mission operations computer (MOC), dynamic standby computer (DSC), validation testing and maintenance computer, or be taken off-line and electrically isolated from the rest of the RTCC. One MOC and one DSC are required to execute real-mission programs for each mission. All required outputs for a given mission are provided by the MOC; however, the DSC does provide a few local monitoring outputs and can be manually switched into the on-line MOC configuration when desired. Various configurations of the MOC and DSC are required to perform all types of validation testing and maintenance. The types of validation testing are preventive maintenance inspections, operational readiness and confidence testing, and MCC-H/network validation. Prevailing mission requirements establish the number and configurations of the computer(s) needed and the type(s) of programs required. Operational readiness and confidence testing (ORACT) test programs are required for ORACT testing. Mission operational programs (MOP) and ORACT test programs are required for MCC-H/network validation testing. The off-line computer receives no data, is isolated from the remainder of the RTCC, and is used for program compilation or loop testing.

The Computer Control Subsystem provides displays and operating positions for monitoring and controlling the real time computers. Normally, the computers are grouped into two complexes (A and B) with each complex assigned to a control area of the Computer Control Subsystem. One complex works in conjunction with MOCR 1 while the other operates with MOCR 2. Depending upon the type of mission being conducted, each complex may comprise at different times from two to three computers. The basic configurations are a two-computer, single operational mission (one MOC and one DSC), a four-computer, dual operational mission (two MOC's and two DSC's), and a nonoperational mission (validation testing). Several variations of the nonoperational mission configurations are required to facilitate preventive maintenance inspections and validation testing. Specific configurations are established through selective patching and switching at the Computer Control Subsystem and the system selector unit in the Real Time Computer Subsystem.

The Auxiliary Data Processing Subsystem prepares data for insertion into the real time computers via magnetic tape units and provides printed or punched card outputs of data previously placed onto magnetic tapes by the computers. The subsystem also provides a means for project accounting, scheduling, and maintenance applications.

3-4-1. Real Time Computer Subsystem

The Real Time Computer Subsystem (figure 3-4-1) interfaces with the Communications, Command, and Telemetry and the Display/Control Systems to receive incoming data and, after processing, to distribute the data as necessary to support actual missions or checkout and training programs. The incoming data is computed, sorted, and converted and the results disseminated for timely utilization at the MCC-H, Manned Spaceflight Network, and spacecraft. Processing includes preparing information for each phase of flight, acceptance and distribution of feedback control information, and any additional work required for conveying necessary control data.

3-4-1-1. Communications Interface

The RTCC communicates with the Manned Spaceflight Network through the Central Processor and Communications Facility Control subsystems. The Central Processor Subsystem controls the message processing and switching to input or output lines. All data is serially transmitted between the Central Processor Subsystem and the RTCC at 40.8 bits per second over demand-response interconnections.

The Central Processor Subsystem routes four output lines to the RTCC via the system selector unit to each real time computer according to the functional assignment of the computer. The number of outputs that are actually routed to a computer and their functions depends on the type of mission or checkout and training program being conducted. The inputs to the computers are through high-speed serial input subchannels of the data communication channels. Each data communication channel provides two high-speed serial output subchannels to the Central Processor Subsystem (one for each message processing computer). The system selector unit routes the outputs to each message processing computer so that each output goes to the proper input according to the assigned mode of operation. The system selector unit terminates similar outputs generated by the dynamic standby computer.

Messages may be transmitted from any real time computer via the system selector unit, through the Central Processor Subsystem, to any output of the subsystem (including another real time computer). Inputs to the Central Processor Subsystem from the Manned Spaceflight Network are routed to the appropriate real time computer according to their message labels. The system selector unit sets up the proper equipment relationship and the Central Processor Subsystem is programmed accordingly to enable any desired message routing.

3-4-1-2. Display Interface

Data required for display in the MOCR's, SSR's, and MOCR common areas are of a varied nature and are presented in such a manner as to require minimum interpretation. Control of the data for presentation is fully automated so that the selection of desired information requires minimum operator action and can be made rapidly. Console operators request specific displays by manually selecting them through the use of keyboards located on their respective consoles. The encoded keyboard data is applied to the RTCC and interpreted by the appropriate computer program, which then generates the output data necessary to provide the requested display. Other manual data, entered into the RTCC in a similar manner, allows mission controllers to signal the appropriate computer program to alter the sequence of mission events, to generate specific telemetry summary messages, and to change from one mission phase to another. Input data concerning the status of digital-to-television converters, converter slide files, and reference slide files is applied to the RTCC automatically or whenever the RTCC requests an equipment status readout. Computer input data originating from the keyboards and encoders of the Computer Display/Control Interface Subsystem is serially transmitted at a 2400 bit per second rate to the RTCC by the computer input multiplexers in the subsystem. The multiplexers interface through the system selector unit with serial input subchannels of the data communications channels. When a dynamic standby computer is used in a mission, the system selector unit routes the computer input data into respective subchannels of the operational and standby computers.

The system selector unit receives the computer request and equipment status indications and distributes them to the appropriate real time computers. The computers, in turn, feed required display data back to the Computer Display/Control Interface Subsystem through the system selector unit. The display data includes plotting, television, and digital display control data.

The plotting display control data includes X-Y plotboards control data and projection plotting display control data. The X-Y plotboard control data largely consists of positional commands for the plotting pens of the X-Y plotboards. The projection plotting display control data consists of positional commands, slide selection commands, and other control data. Both sets of data are transmitted from high-speed serial output subchannels via the system selector unit to plotting display data distributors in the Computer Display/Control Interface Subsystem. The system selector unit also makes both sets of data available simultaneously to the X-Y plotboards of the Computer Control Subsystem. The system selector unit routes operational computer outputs to the Computer Display/Control Interface Subsystem but inhibits standby outputs. Both outputs, however, are routed to the Computer Control Subsystem X-Y plotboards for monitoring.

The television display control data, which includes digital-to-television quantities, slide selection data, and video switching matrices input-to-output connections commands, is routed from the direct data channels via the system selector unit to digital-to-television converter and converter slide file data distributors in the Computer Display/Control Interface Subsystem.

The digital display control data is used to control various indicator lamps and digital indicators located throughout the MOW. The indications thus produced include mission events, mission phases, input data sources, acknowledgment of manual data insertion, and numerical quantities that represent display format numbers, television channel numbers, etc. The digital display control data also includes computer generated time words, which are used to control the Timing Subsystem general purpose relative time accumulators. The digital display outputs generated by both the mission operations computer and the dynamic standby computer are transmitted by high-speed serial output subchannels to the system selector unit. The operational outputs are routed to the digital display data distributors of the Computer Display/Control Interface Subsystem standby digital driver unit, which displays selected data on digital display modules mounted on the Computer Control Subsystem consoles. These displays correspond to indicators driven by the operational program, thus allowing a direct comparison to be made between the two programs and associated equipment.

The Timing Subsystem of the Display/Control System provides timing pulses directly to the multiplexer line adapter where they are available for distribution to the RTCC equipment requiring them. Timing pulses are applied to the clock and interval timer subchannels of each data communications channel, a clock in each data communications channel, a clock in each data input-output multiplexer, and to the X-Y plotboards of the Computer Control Subsystem. For increased reliability, the timing signals used by the dynamic standby computer come from a section of the Timing Subsystem master instrumentation timing equipment other than those used by the operational computer.

3-4-1-3. Data Processing

The central processing unit processes data internally in a fixed word length of 36 binary bits. Information is transferred to or from the core storage unit in full word, parallel form. The computer cycle time, or the time required to perform one logical arithmetic or transfer operation, is 1.4 microseconds. A 36-bit data word (one unit of information) can be read into, or out of, any one of the 32,768 core storage locations in 1.4 microseconds, or one computer cycle time. The core storage serves both the central processing unit and the input/output data channels with the central processing unit controlling the storage access of both.

Two data channels, one dual-direct data channel and one data communications channel, use five input/output channels of the data input/output multiplexer. Each of these channels operates as an independent unit to transfer data to and from the core storage unit via the multiplexer; however, each data transfer must be initiated by and under the direction of the program in the central processing unit. Once set into operation by the program, the channels proceed without any further program action until the data transfer operation is complete. The channels transfer data to and from storage in full word form. Each data channel connects a bank of magnetic tape units to the control processing unit. In addition, one of the channels connects a card reader and a printer to the central processing unit. The direct data channel occupies two data multiplexer channels while providing interface connections to the different units. One channel with both input and output capabilities is connected to the core storage file. The other channel, with output capabilities only, is connected to data distributors in the Computer Display/Control Interface Subsystem. The data communication channel connects 1 data multiplexer channel to 11 separate subchannels. These subchannels include four input and five output data communication subchannels, one clock subchannel, and one interval timer subchannel. The input data communication subchannels receive data serially from external equipment and buffer the data into 36-bit data words for parallel transfer to storage. Similarly, the output subchannels accept 36-bit words from storage and transmit them serially to the external equipment. Each subchannel, after once being set into operation by the central processing unit program, normally transfers a complete data message before it requires further action by the program. The clock and interval timer subchannels do not transfer data. The interval timer subchannel provides a means of signaling or interrupting the computer program when a predetermined interval of time has elapsed. The clock subchannel interrupts the program at unit intervals of time at a program-selected rate.

The core storage file unit provides random access storage for 524,000 data words. The computer program stores data within the file or retrieves data from the file at a rate of 250,000 words per second. The core file is connected to the central processing unit through the direct data channel and an input/output channel of the data multiplexer.

The computer controller multiplexer unit connects manual input and output equipment of the Computer Control Subsystem to the central processing unit. The manual data is buffered and transferred by means of one input and one output subchannel of the data communication channel. Data transferred between the manual devices via the system selector unit and the computer controller multiplexer unit is transferred serially and in parallel and varies in format structure; however, the same data is transferred between the computer controller multiplexer unit and the data communication channel in serial 36-bit words.

Functional assignments for the real time computers, and consequently, the routing and distribution of input and output data is accomplished by the system selector unit. The system selector unit permits any of the real time computers to perform any of the RTCC functional assignments. The unit also provides the capability to rapidly exchange functional assignments between operational and dynamic standby computers. The switchover between these computers is a combined system selector unit and computer programming function. When switchover action is taken, the system selector unit signals the program in both computers to suspend its output operations until switchover has occurred. Incomplete or erroneous data transmissions are thus prevented by ensuring that the switchover does not occur during transmission of processed data.

3-4-2. Computer Control Subsystem

The Computer Control Subsystem (figure 3-4-2) provides the facilities for monitoring and controlling the RTCC computers.

3-4-2-1. Computer Monitoring

Personnel within the control area operating positions monitor the performance of the mission and dynamic standby computers via television displays, digital displays, and plotting displays. A system status display unit, common to both control areas, permits the personnel to monitor the functional assignment of each real time computer as well as that of interfacing components. The television displays are provided by the Television Subsystem. The computer controllers may select any display obtainable through the Television Subsystem for viewing. Operational digital displays are provided by the Computer Display/Control Interface Subsystem, which drives digital indicators mounted on the control area consoles. Selected digital display control data from the dynamic standby computer is applied through the standby digital driver unit to digital indicators also located on the consoles. All plotting display control data is applied to the control area X-Y plotboards for selective monitoring.

3-4-2-2. Computer Control

The control area operating positions are provided with manual entry devices and switch modules that have direct input/output connections with the Real Time Computer Subsystem. A common path for the data to and from these manual entry devices is provided by the control area junction unit. Data to and from the manual entry devices is passed through the junction unit and the system selector unit to the computer controller multiplexer unit. Switch module data is received by the unit from several switch modules and is forwarded to the Real Time Computer Subsystem on a common bus. This bus includes duplicate sets of data for operational and standby computer inputs. The computer input multiplexer (CIM) interfaces some of the switch modules with the Real Time Computer Subsystem.

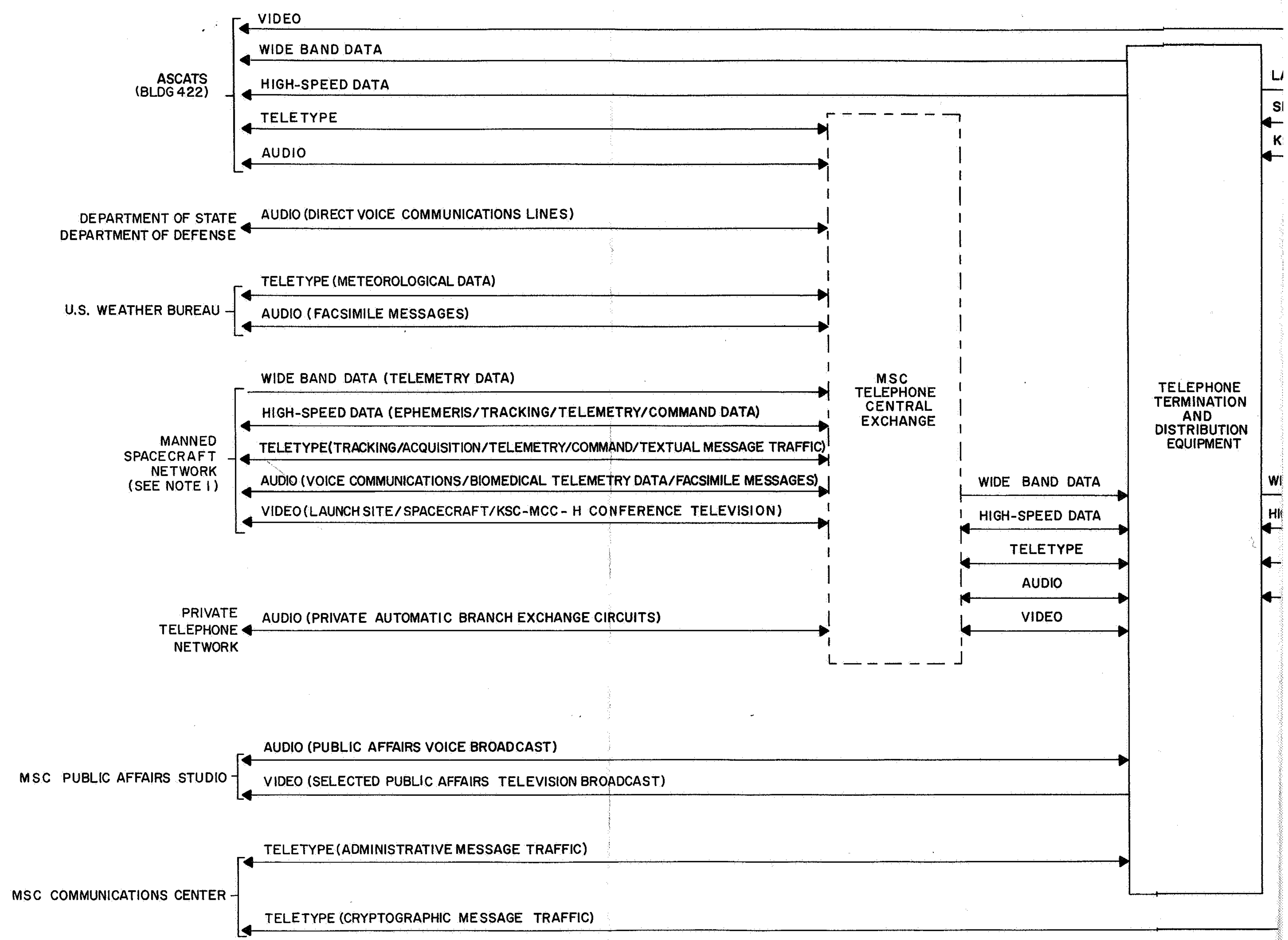
3-4-2-3. Time Generation

Accurate timing signals are supplied to the RTCC by the Timing Subsystem. All RTCC timing is connected directly to the multiplexer line adapter.

3-4-3. Auxiliary Data Processing Subsystem

The Real Time Computer Subsystem places data onto magnetic tapes, which are inserted into the Auxiliary Data Processing Subsystem magnetic tape units and processed by the subsystem to provide output data in printed or punched-card form. By reversing the process, input data is prepared and placed on magnetic tapes by the Auxiliary Data Processing Subsystem for high-speed entry into the real time computers.

The Auxiliary Data Processing Subsystem (figure 3-4-3) performs no real or checkout and training functions. Instead, it enables more effective utilization of the Real Time Computer Subsystem for program development and other nonoperational applications.


ASCATS (BLDG 422)
VIDEO
WIDE BAND DATA
HIGH-SPEED DATA
TELETYPE
AUDIO
DEPARTMENT OF STATE
DEPARTMENT OF DEFENSE
AUDIO (DIRECT VOICE COMMUNICATIONS LINES)
U.S. WEATHER BUREAU
TELETYPE (METEOROLOGICAL DATA)
AUDIO (FACSIMILE MESSAGES)
MANNED SPACECRAFT NETWORK (SEE NOTE 1)
WIDE BAND DATA (TELEMETRY DATA)
HIGH-SPEED DATA (EPHEMERIS/TRACKING/TELEMETRY/COMMAND DATA)
TELETYPE(TRACKING/ACQUISITION/TELEMETRY/COMMAND/TEXTUAL MESSAGE TRAFFIC)
AUDIO (VOICE COMMUNICATIONS/BIOMEDICAL TELEMETRY DATA/FACSIMILE MESSAGES)
VIDEO (LAUNCH SITE/SPACECRAFT/KSC-MCC-H CONFERENCE TELEVISION)
PRIVATE TELEPHONE NETWORK
AUDIO (PRIVATE AUTOMATIC BRANCH EXCHANGE CIRCUITS)
MSC TELEPHONE CENTRAL EXCHANGE
WIDE BAND DATA
HIGH-SPEED DATA
TELETYPE
AUDIO
VIDEO
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT
MSC PUBLIC AFFAIRS STUDIO
AUDIO (PUBLIC AFFAIRS VOICE BROADCAST)
VIDEO (SELECTED PUBLIC AFFAIRS TELEVISION BROADCAST)
MSC COMMUNICATIONS CENTER
TELETYPE (ADMINISTRATIVE MESSAGE TRAFFIC)
TELETYPE (CRYPTOGRAPHIC MESSAGE TRAFFIC)

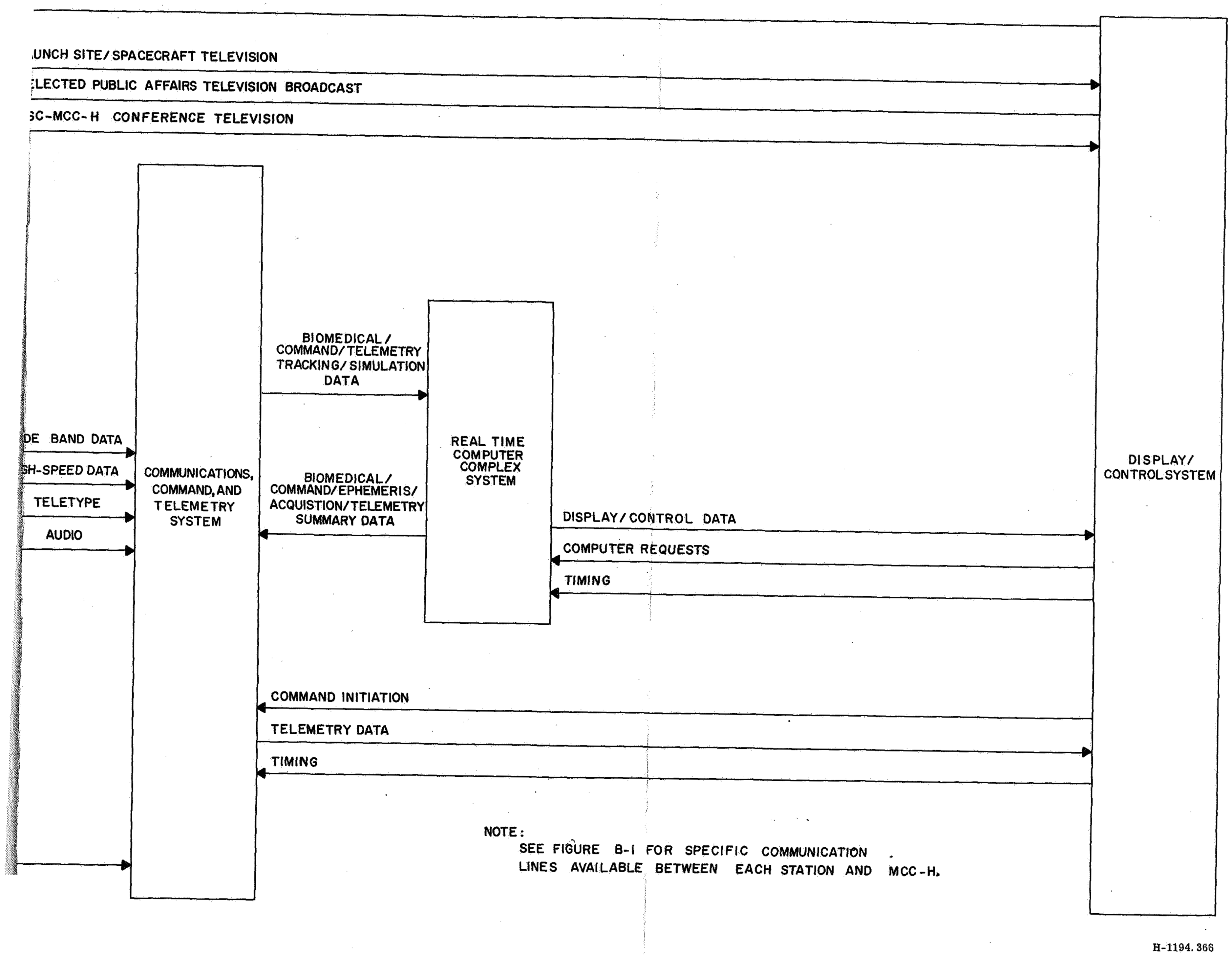


Figure 3-1. MCC-Houston Functional Data Flow, Block Diagram

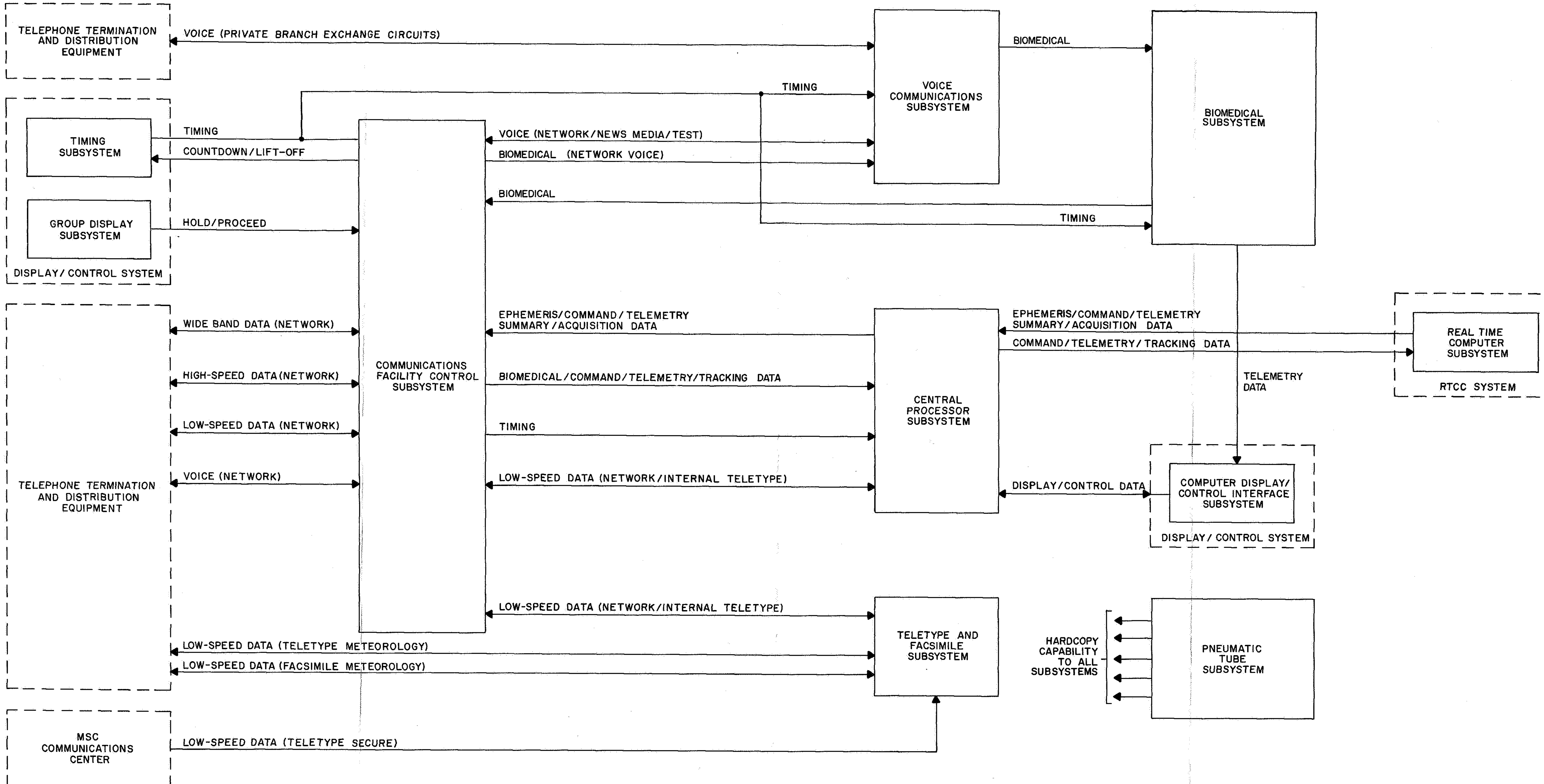
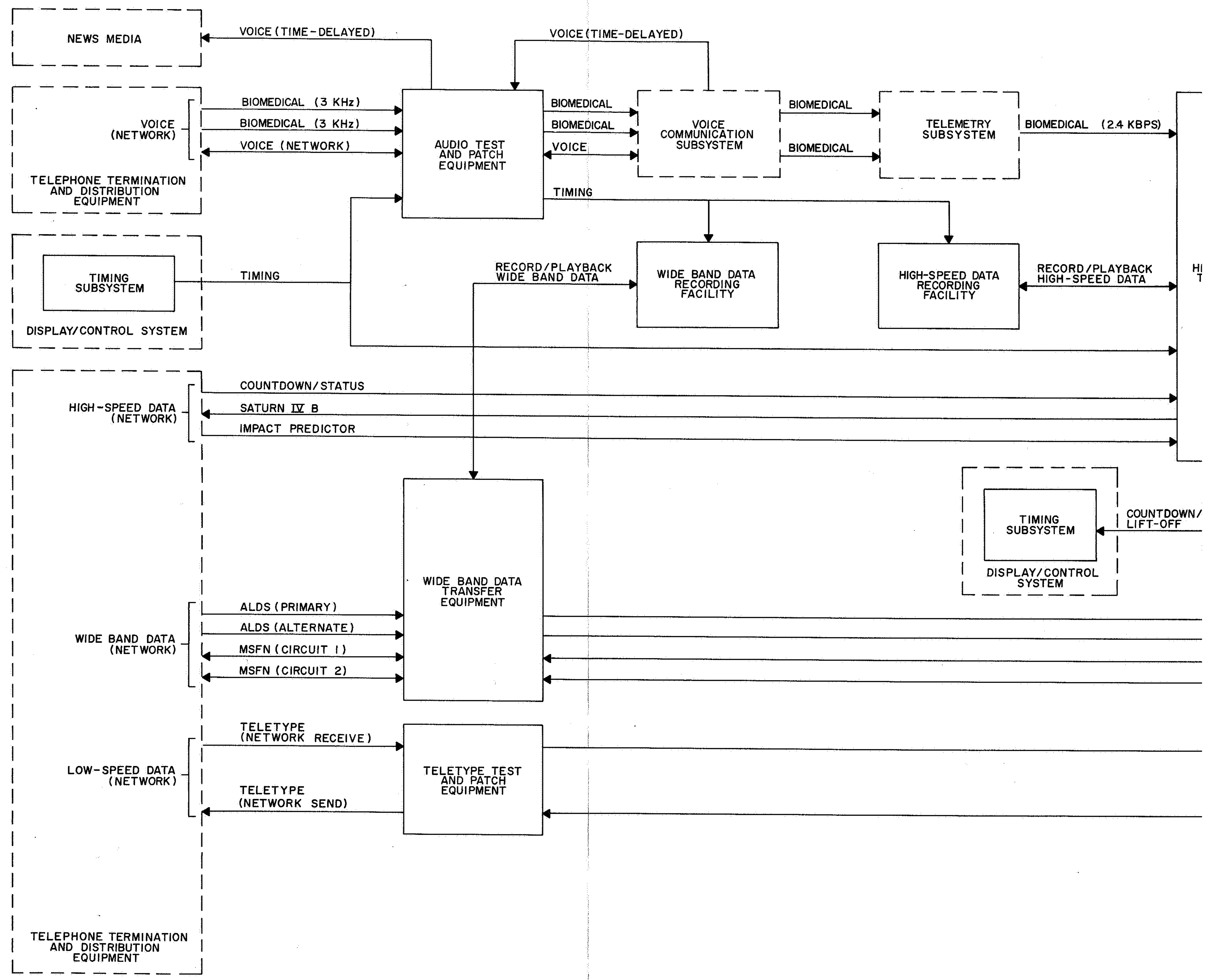


Figure 3-2. Communications, Command, and Telemetry System, Block Diagram


NEWS MEDIA
VOICE (TIME-DELAYED)
VOICE (TIME-DELAYED)
VOICE (NETWORK)
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT
BIOMEDICAL (3 KHz)
BIOMEDICAL (3 KHz)
VOICE (NETWORK)
AUDIO TEST AND PATCH EQUIPMENT
BIOMEDICAL
BIOMEDICAL
VOICE
TIMING
VOICE COMMUNICATION SUBSYSTEM
BIOMEDICAL
BIOMEDICAL
TELEMETRY SUBSYSTEM
BIOMEDICAL (2.4 KBPS)
TIMING SUBSYSTEM
DISPLAY/CONTROL SYSTEM
TIMING
RECORD/PLAYBACK WIDE BAND DATA
WIDE BAND DATA RECORDING FACILITY
HIGH-SPEED DATA RECORDING FACILITY
RECORD/PLAYBACK HIGH-SPEED DATA
HIGH-SPEED DATA (NETWORK)
COUNTDOWN/STATUS
SATURN IV B
IMPACT PREDICTOR
TIMING SUBSYSTEM
DISPLAY/CONTROL SYSTEM
COUNTDOWN/ LIFT-OFF
WIDE BAND DATA TRANSFER EQUIPMENT
WIDE BAND DATA (NETWORK)
ALDS (PRIMARY)
ALDS (ALTERNATE)
MSFN (CIRCUIT 1)
MSFN (CIRCUIT 2)
LOW-SPEED DATA (NETWORK)
TELETYPE (NETWORK RECEIVE)
TELETYPE (NETWORK SEND)
TELETYPE TEST AND PATCH EQUIPMENT
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT

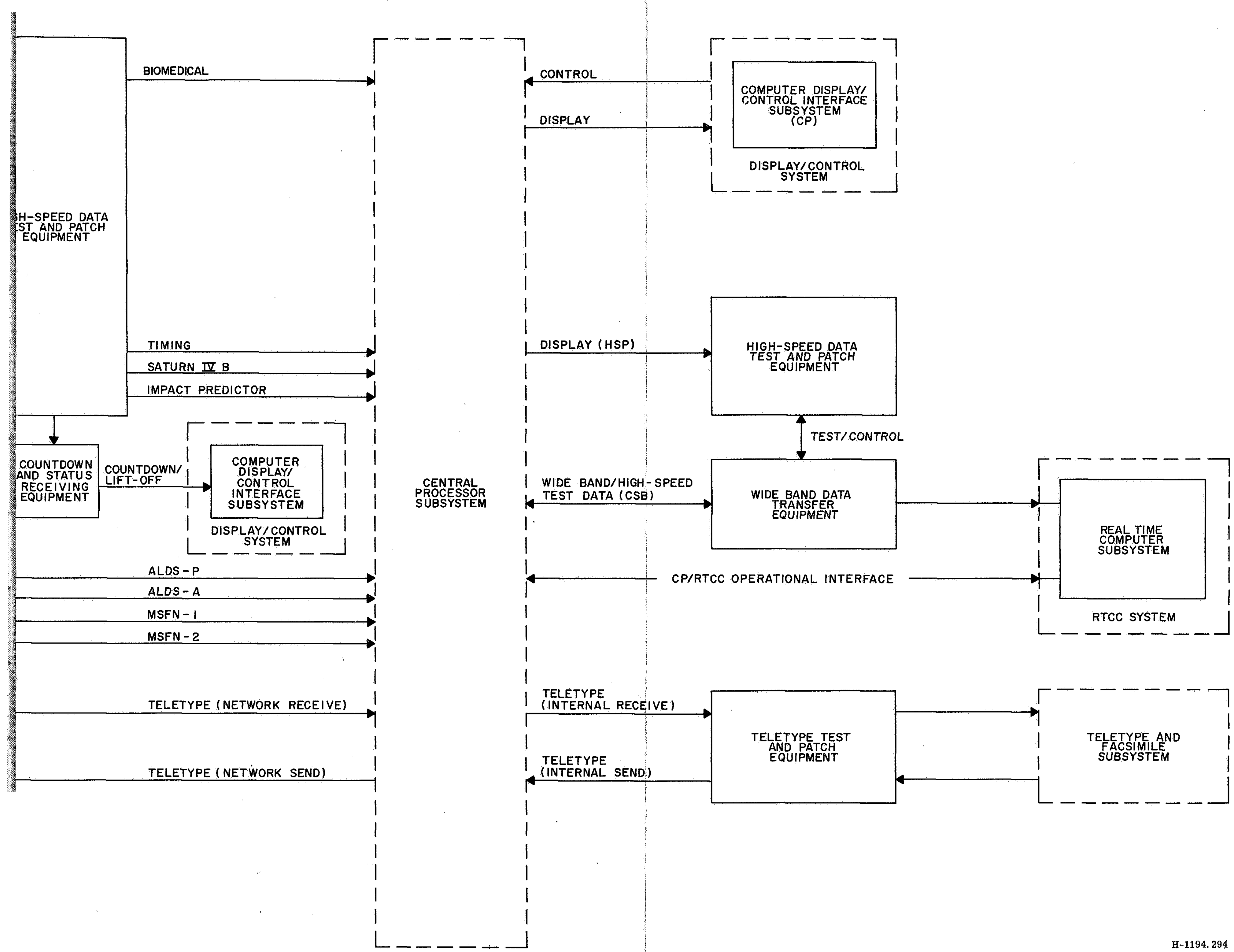


Figure 3-2-1. Communications Facility Control Subsystem, Block Diagram

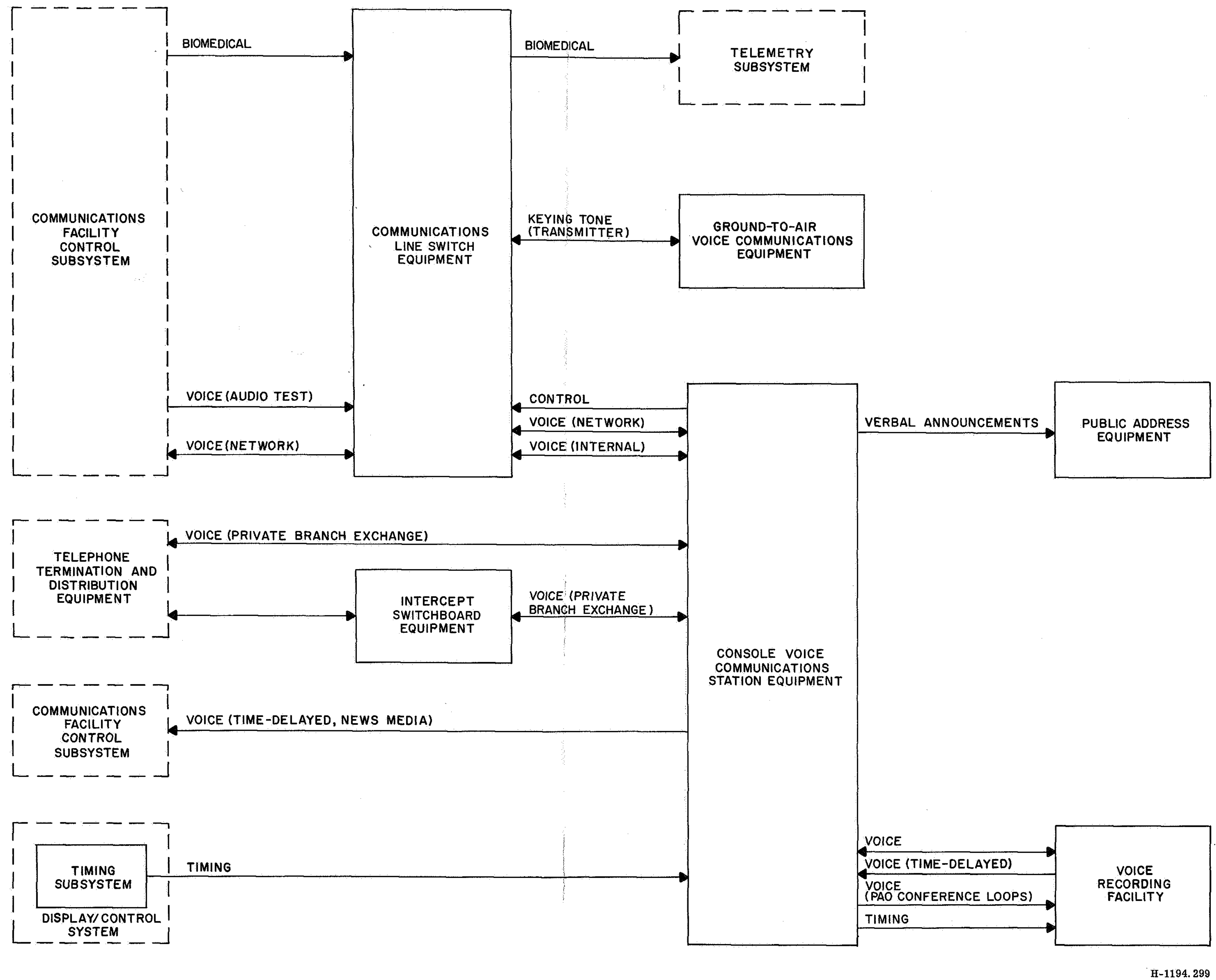
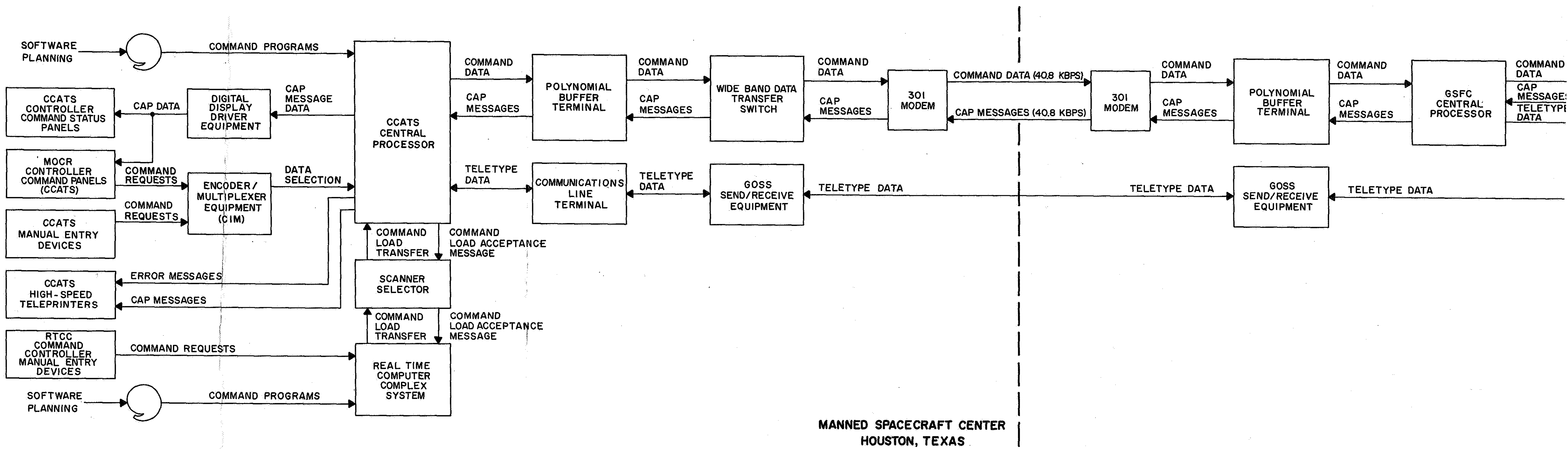
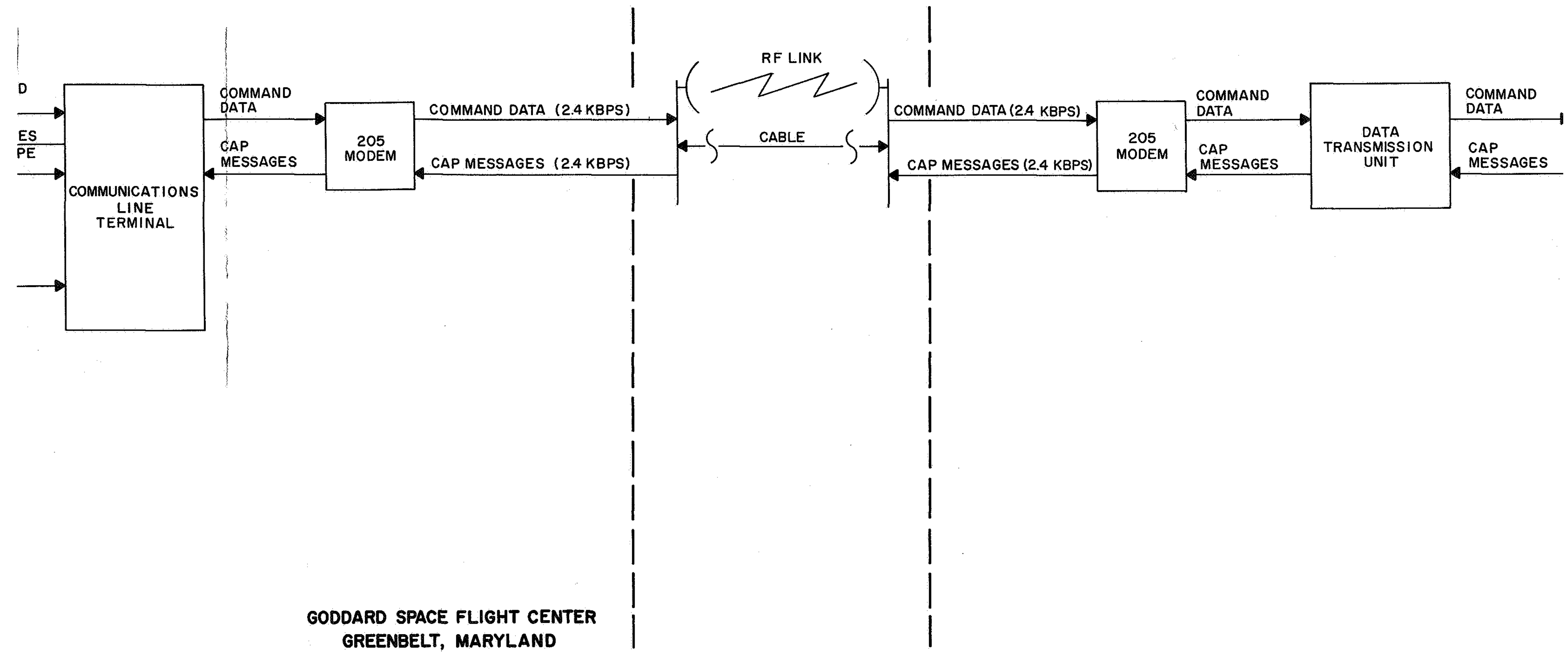


Figure 3-2-2. Voice Communications Subsystem, Block Diagram


SOFTWARE PLANNING
COMMAND PROGRAMS
CCATS CONTROLLER COMMAND STATUS PANELS
CAP DATA
DIGITAL DISPLAY DRIVER EQUIPMENT
CAP MESSAGE DATA
MOCR CONTROLLER COMMAND PANELS (CCATS)
COMMAND REQUESTS
ENCODER/ MULTIPLEXER EQUIPMENT (CIM)
DATA SELECTION
CCATS MANUAL ENTRY DEVICES
COMMAND REQUESTS
CCATS HIGH-SPEED TELEPRINTERS
ERROR MESSAGES
CAP MESSAGES
RTCC COMMAND CONTROLLER MANUAL ENTRY DEVICES
COMMAND REQUESTS
SOFTWARE PLANNING
COMMAND PROGRAMS
CCATS CENTRAL PROCESSOR
COMMAND LOAD TRANSFER
COMMAND LOAD ACCEPTANCE MESSAGE
SCANNER SELECTOR
COMMAND LOAD TRANSFER
COMMAND LOAD ACCEPTANCE MESSAGE
REAL TIME COMPUTER COMPLEX SYSTEM
COMMAND DATA
CAP MESSAGES
POLYNOMIAL BUFFER TERMINAL
TELETYPE DATA
COMMUNICATIONS LINE TERMINAL
COMMAND DATA
CAP MESSAGES
WIDE BAND DATA TRANSFER SWITCH
TELETYPE DATA
GOSS SEND/RECEIVE EQUIPMENT
COMMAND DATA
CAP MESSAGES
301 MODEM
COMMAND DATA (40.8 KBPS)
CAP MESSAGES (40.8 KBPS)
TELETYPE DATA
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
301 MODEM
COMMAND DATA
CAP MESSAGES
POLYNOMIAL BUFFER TERMINAL
TELETYPE DATA
GOSS SEND/RECEIVE EQUIPMENT
COMMAND DATA
CAP MESSAGES
GSFC CENTRAL PROCESSOR
TELETYPE DATA
COMMAND DATA



GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

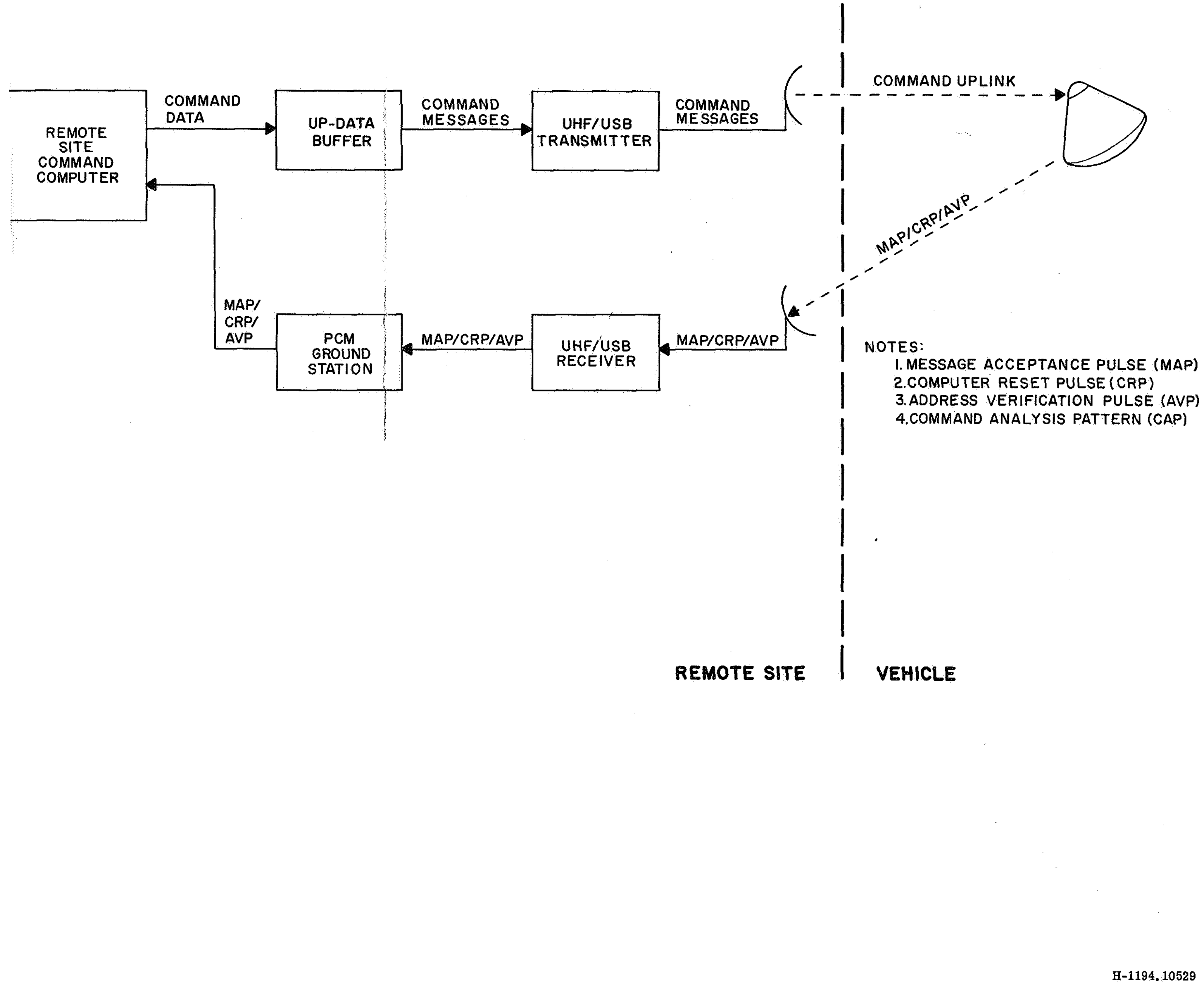
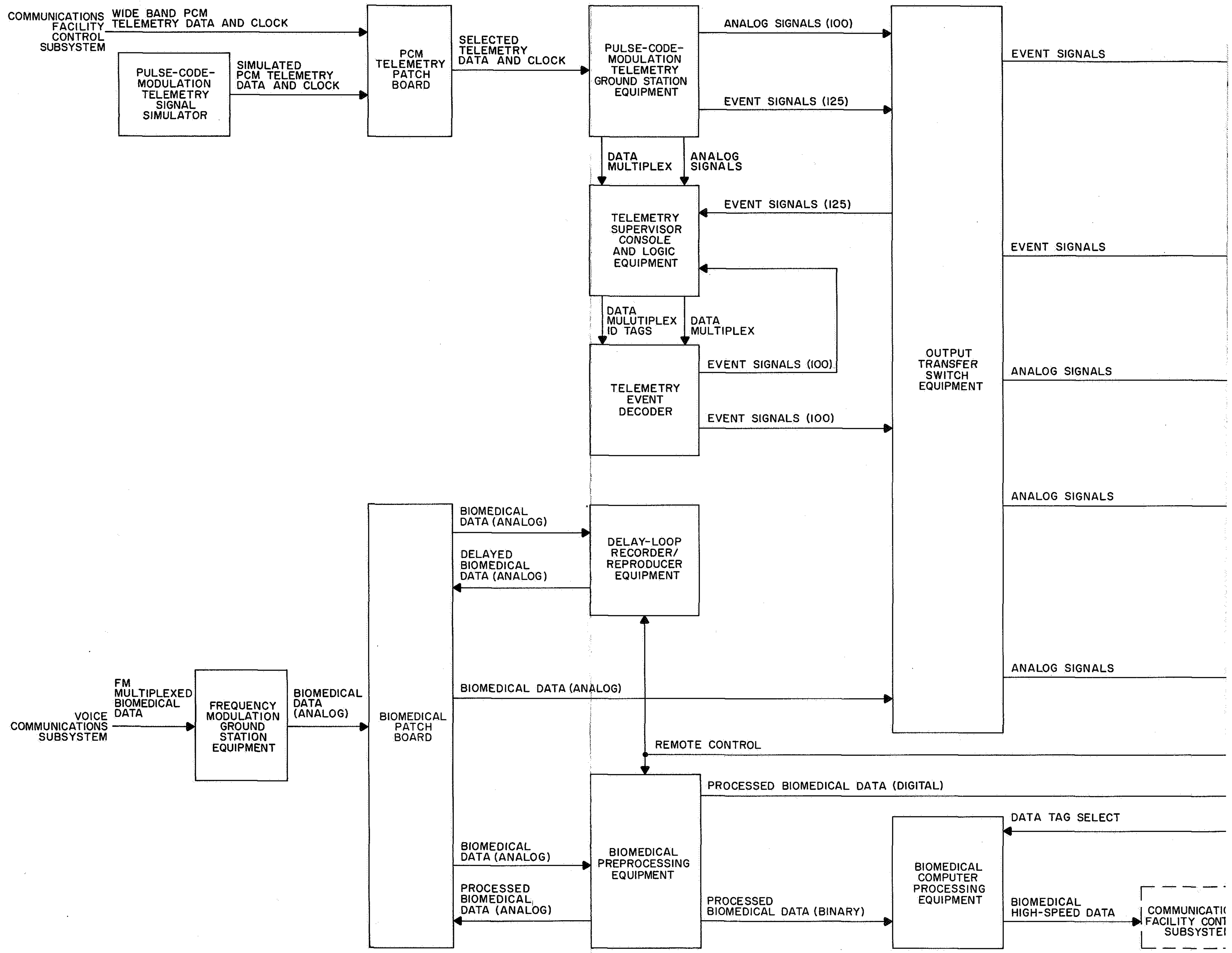


Figure 3-2-3. Command Subsystem, Typical Data Flow, Block Diagram


COMMUNICATIONS FACILITY CONTROL SUBSYSTEM
WIDE BAND PCM TELEMETRY DATA AND CLOCK
PULSE-CODE-MODULATION TELEMETRY SIGNAL SIMULATOR
SIMULATED PCM TELEMETRY DATA AND CLOCK
PCM TELEMETRY PATCH BOARD
SELECTED TELEMETRY DATA AND CLOCK
PULSE-CODE-MODULATION TELEMETRY GROUND STATION EQUIPMENT
ANALOG SIGNALS (100)
EVENT SIGNALS (125)
DATA MULTIPLEX
ANALOG SIGNALS
TELEMETRY SUPERVISOR CONSOLE AND LOGIC EQUIPMENT
EVENT SIGNALS (125)
DATA MULUTIPLEX ID TAGS
DATA MULTIPLEX
TELEMETRY EVENT DECODER
EVENT SIGNALS (100)
EVENT SIGNALS (100)
OUTPUT TRANSFER SWITCH EQUIPMENT
EVENT SIGNALS
EVENT SIGNALS
ANALOG SIGNALS
ANALOG SIGNALS
ANALOG SIGNALS
VOICE COMMUNICATIONS SUBSYSTEM
FM MULTIPLEXED BIOMEDICAL DATA
FREQUENCY MODULATION GROUND STATION EQUIPMENT
BIOMEDICAL DATA (ANALOG)
BIOMEDICAL PATCH BOARD
BIOMEDICAL DATA (ANALOG)
DELAYED BIOMEDICAL DATA (ANALOG)
DELAY-LOOP RECORDER/ REPRODUCER EQUIPMENT
BIOMEDICAL DATA (ANALOG)
REMOTE CONTROL
PROCESSED BIOMEDICAL DATA (DIGITAL)
BIOMEDICAL DATA (ANALOG)
PROCESSED BIOMEDICAL DATA (ANALOG)
BIOMEDICAL PREPROCESSING EQUIPMENT
PROCESSED BIOMEDICAL DATA (BINARY)
BIOMEDICAL COMPUTER PROCESSING EQUIPMENT
DATA TAG SELECT
BIOMEDICAL HIGH-SPEED DATA

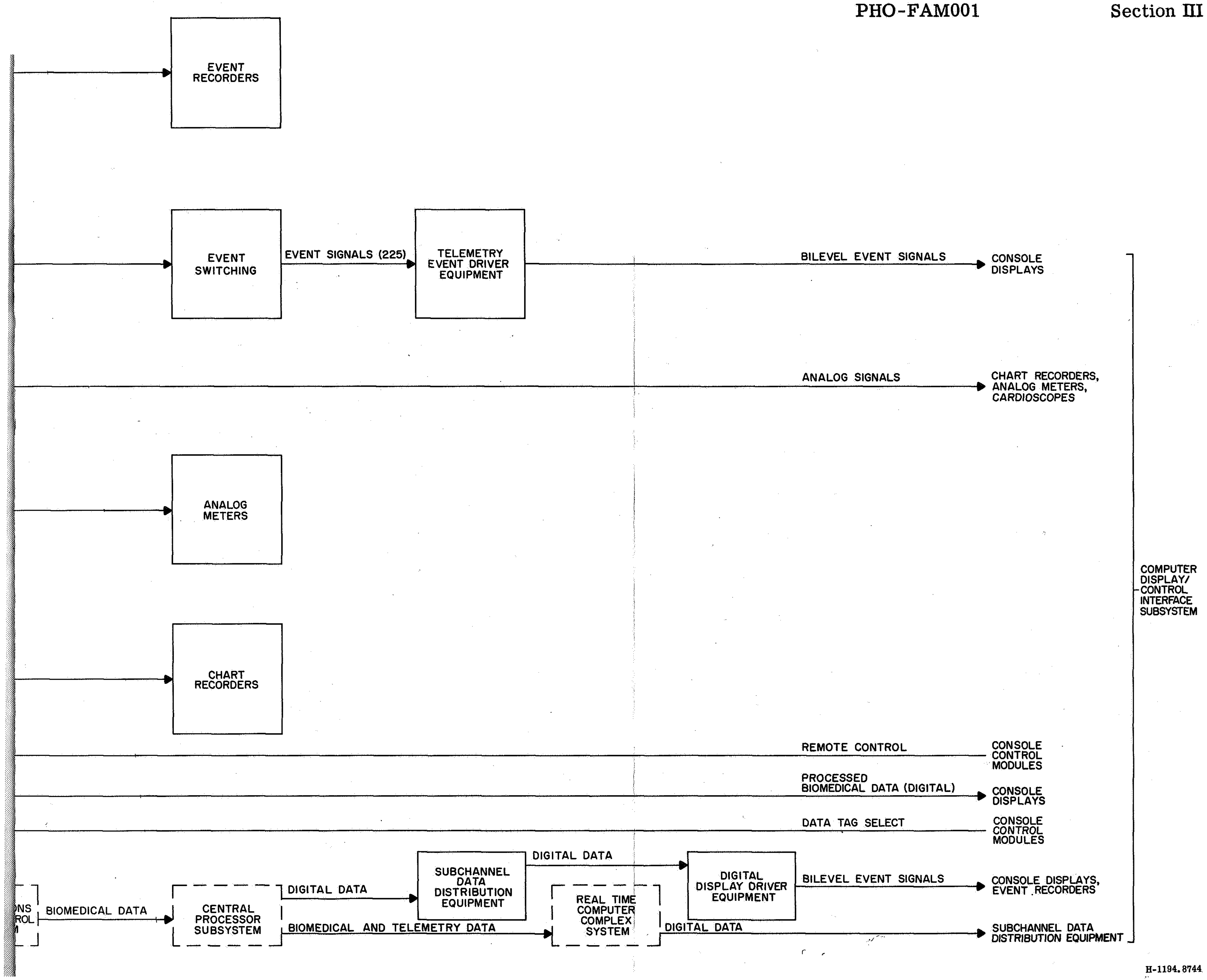
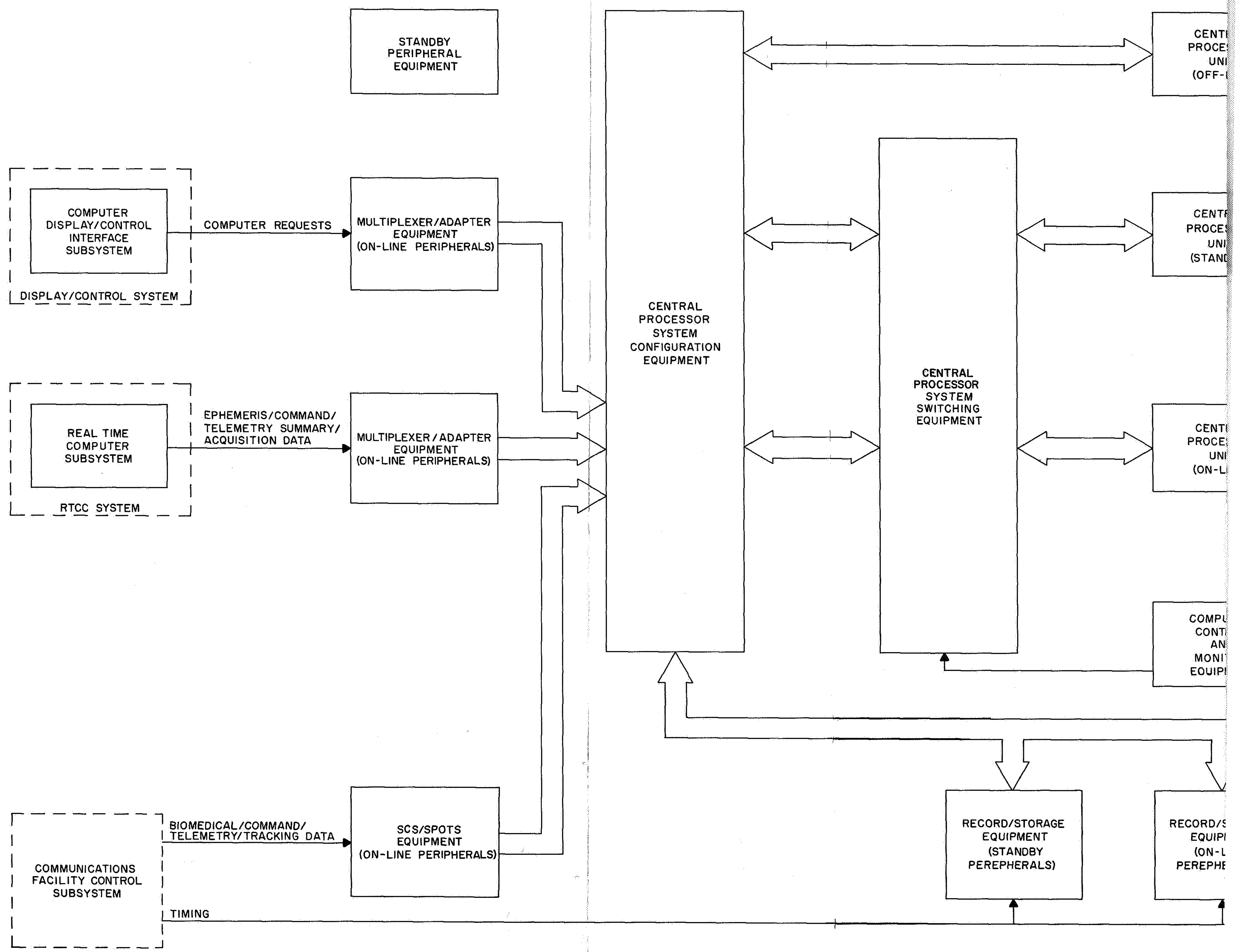


Figure 3-2-4. Telemetry Subsystem Block Diagram

181



STANDBY PERIPHERAL EQUIPMENT
COMPUTER DISPLAY/CONTROL INTERFACE SUBSYSTEM
DISPLAY/CONTROL SYSTEM
COMPUTER REQUESTS
MULTIPLEXER/ADAPTER EQUIPMENT (ON-LINE PERIPHERALS)
REAL TIME COMPUTER SUBSYSTEM
RTCC SYSTEM
EPHEMERIS/COMMAND/ TELEMETRY SUMMARY/ ACQUISITION DATA
MULTIPLEXER/ADAPTER EQUIPMENT (ON-LINE PERIPHERALS)
COMMUNICATIONS FACILITY CONTROL SUBSYSTEM
BIOMEDICAL/COMMAND/ TELEMETRY/TRACKING DATA
SCS/SPOTS EQUIPMENT (ON-LINE PERIPHERALS)
TIMING
CENTRAL PROCESSOR SYSTEM CONFIGURATION EQUIPMENT
CENTRAL PROCESSOR SYSTEM SWITCHING EQUIPMENT
RECORD/STORAGE EQUIPMENT (STANDBY PEREPHERALS)

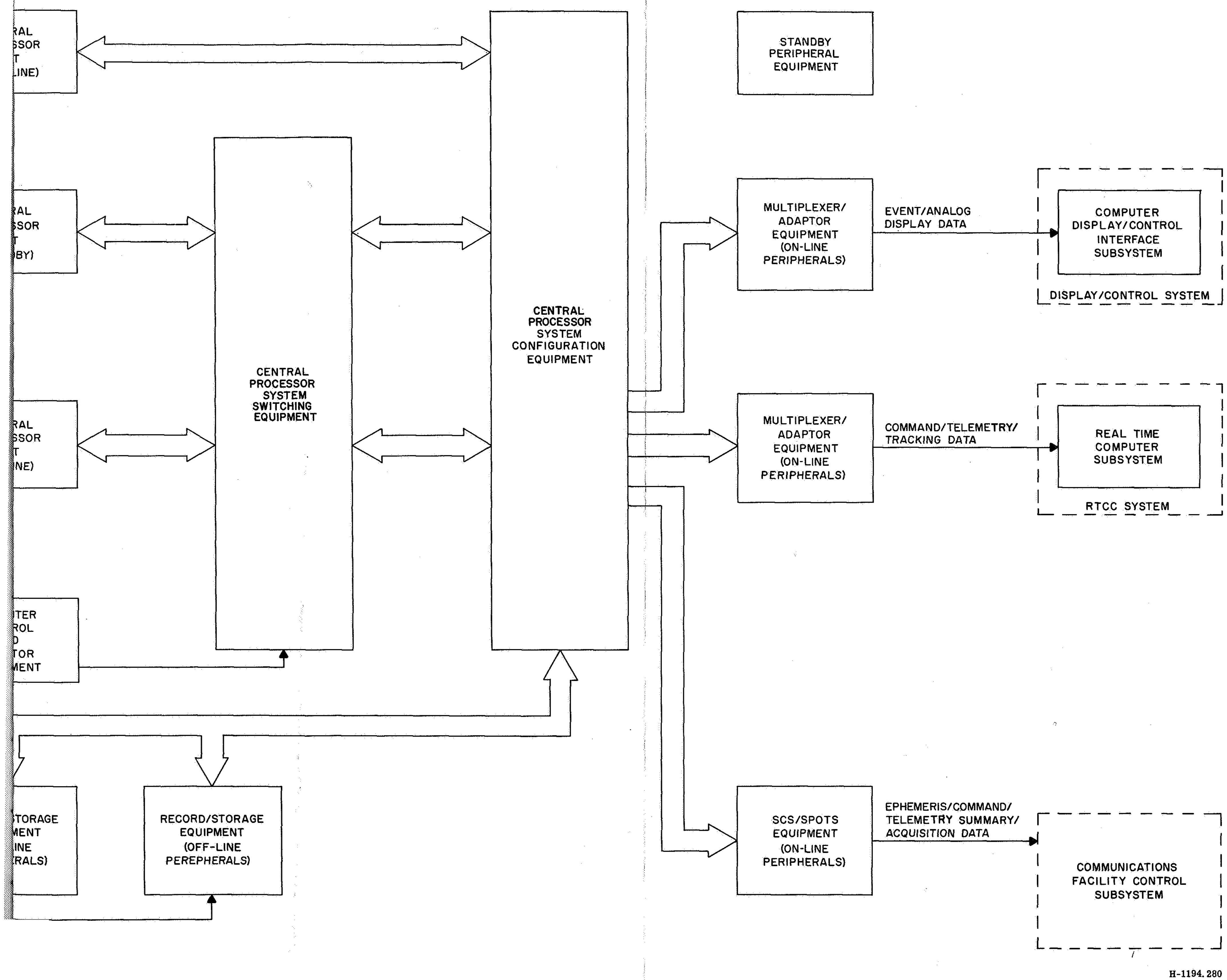


Figure 3-2-5. Central Processor Subsystem, Block Diagram

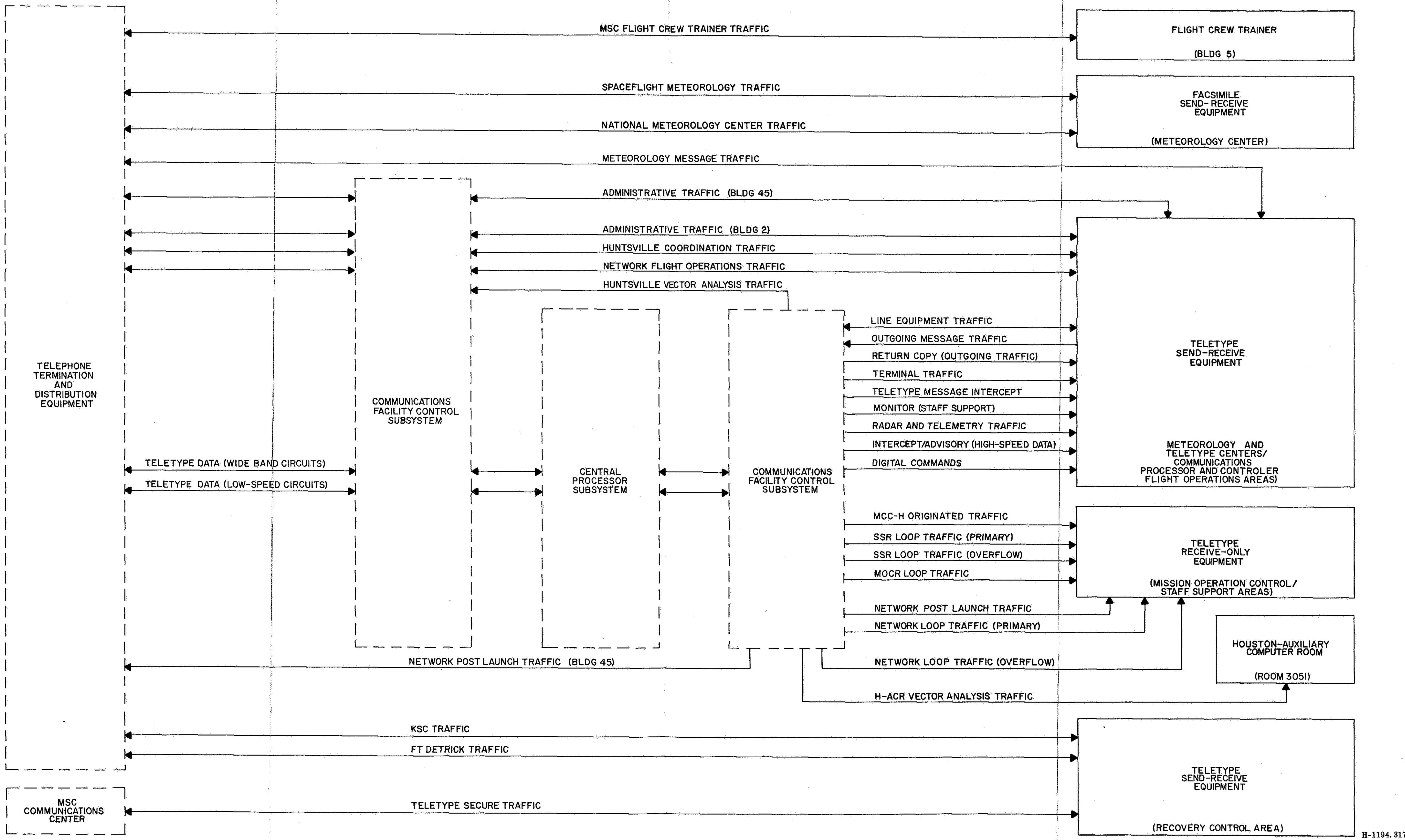


Figure 3-2-6. Teletype and Facsimile Subsystem, Block Diagram

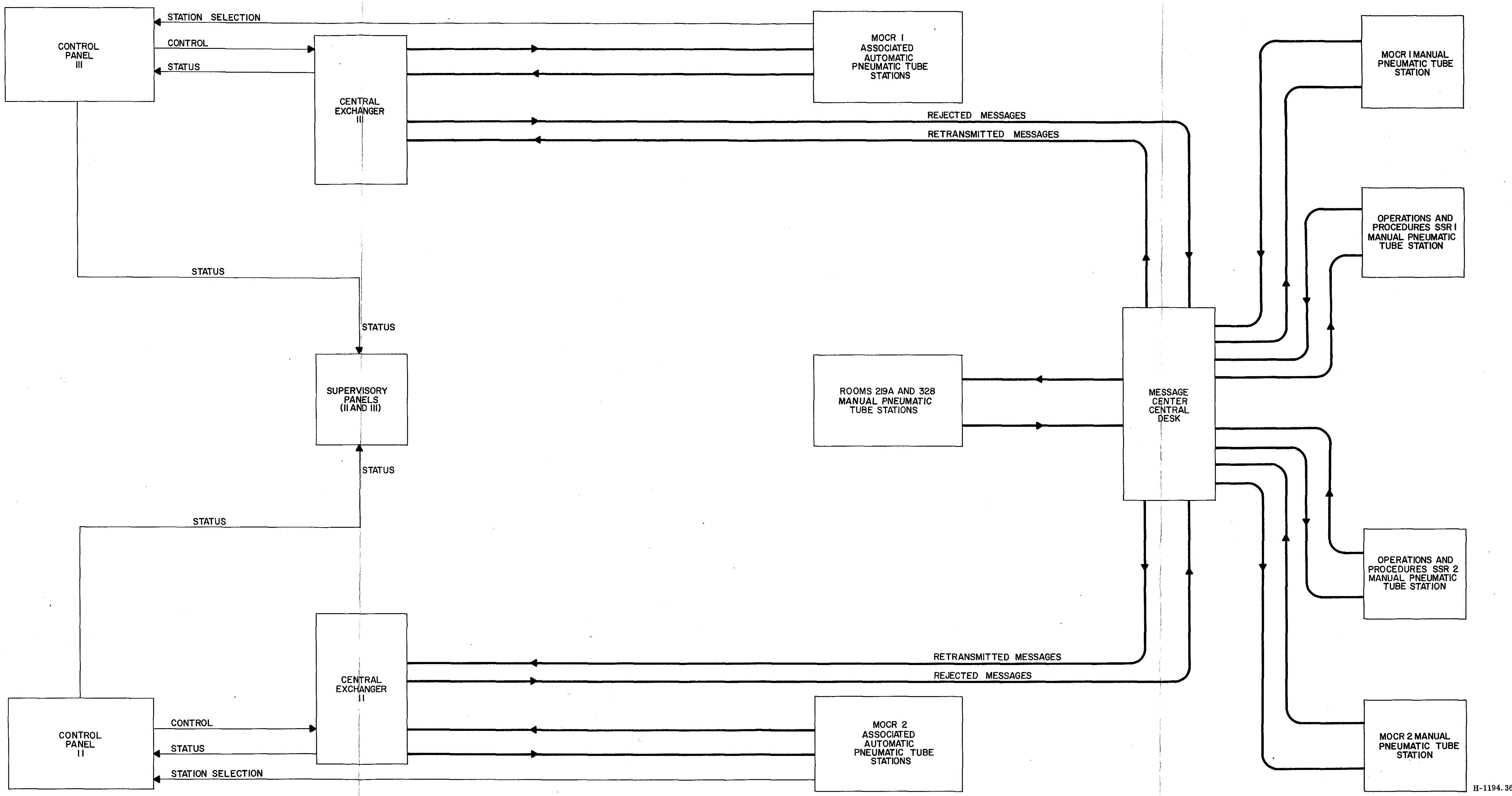
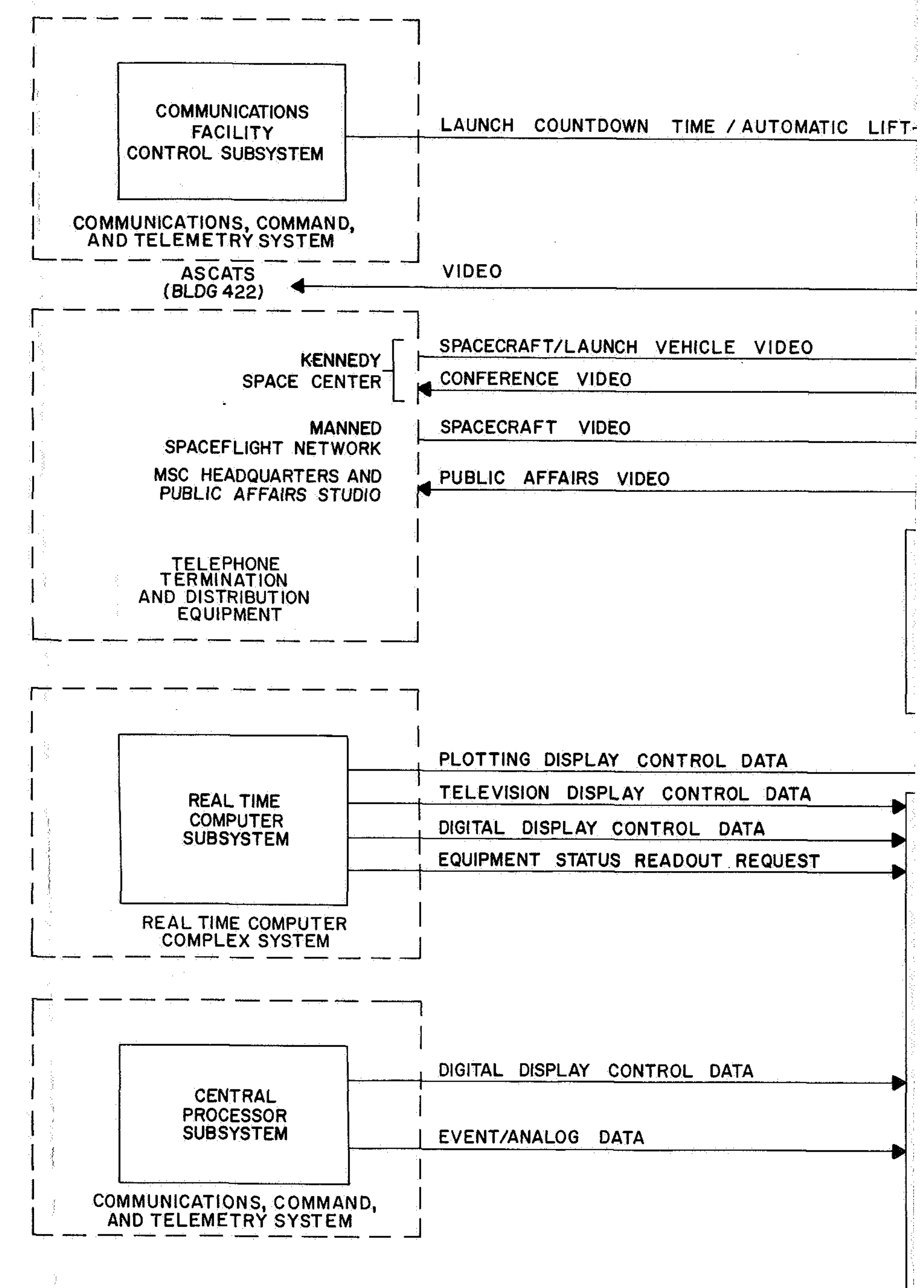


Figure 3-2-7. Pneumatic Tube Subsystem, Block Diagram


COMMUNICATIONS FACILITY CONTROL SUBSYSTEM
COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM
LAUNCH COUNTDOWN TIME / AUTOMATIC LIFT-
ASCATS (BLDG 422)
VIDEO
KENNEDY SPACE CENTER
SPACECRAFT/LAUNCH VEHICLE VIDEO
CONFERENCE VIDEO
MANNED SPACEFLIGHT NETWORK
SPACECRAFT VIDEO
MSC HEADQUARTERS AND PUBLIC AFFAIRS STUDIO
PUBLIC AFFAIRS VIDEO
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT
REAL TIME COMPUTER SUBSYSTEM
PLOTTING DISPLAY CONTROL DATA
TELEVISION DISPLAY CONTROL DATA
DIGITAL DISPLAY CONTROL DATA
EQUIPMENT STATUS READOUT REQUEST
REAL TIME COMPUTER COMPLEX SYSTEM
CENTRAL PROCESSOR SUBSYSTEM
DIGITAL DISPLAY CONTROL DATA
EVENT/ANALOG DATA
COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM

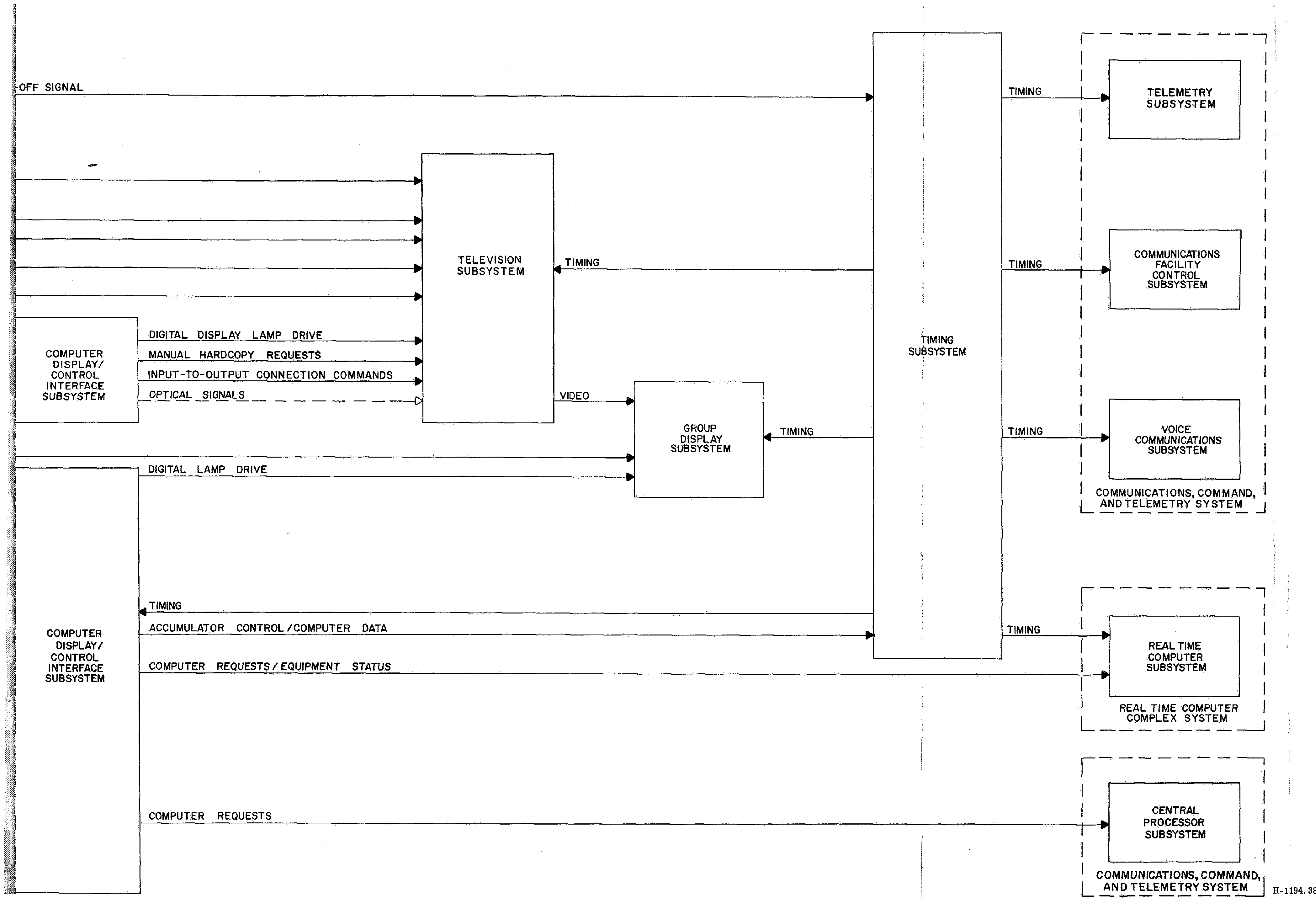
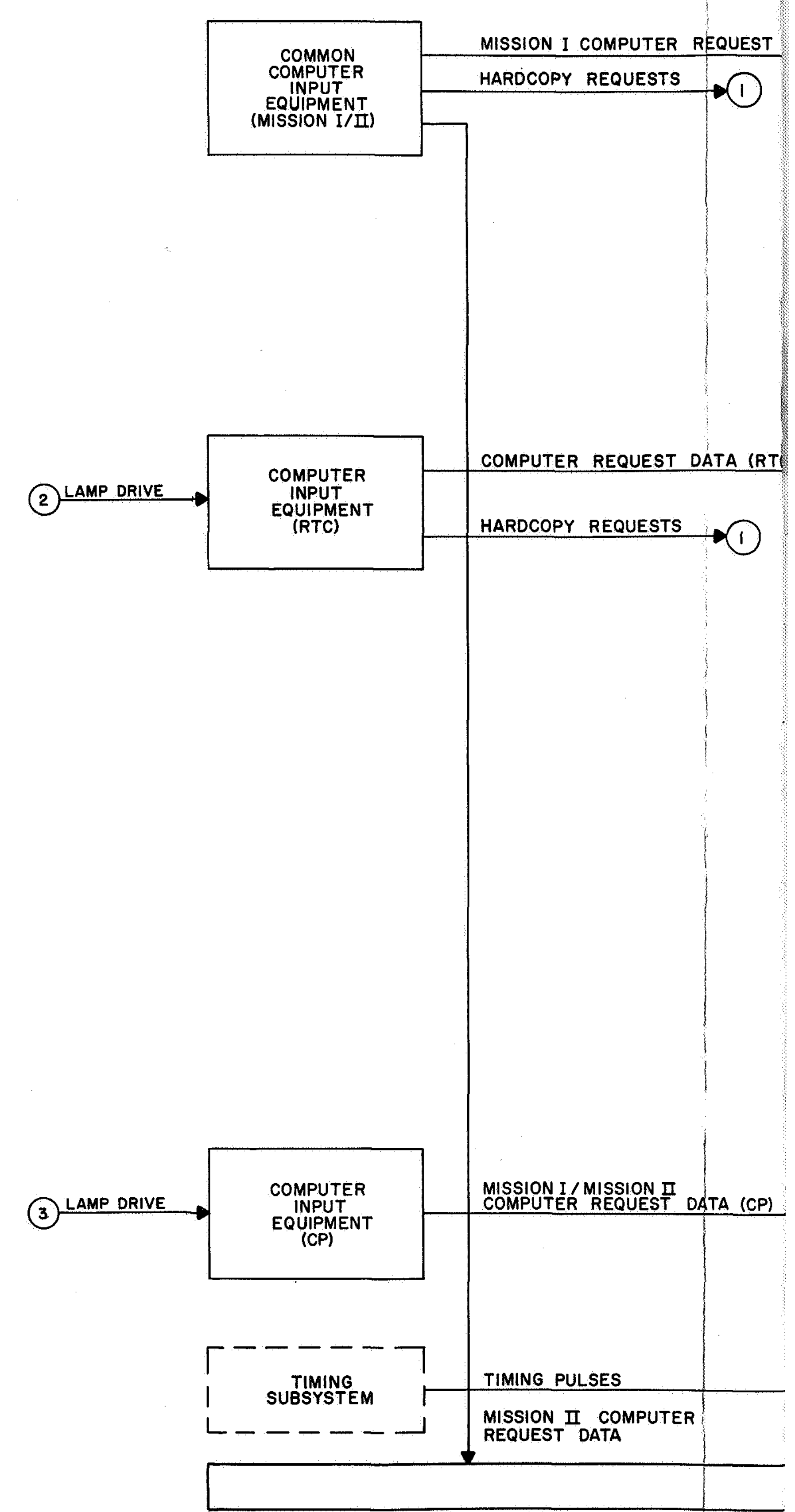


Figure 3-3. Display/Control System, Block Diagram


COMMON COMPUTER INPUT EQUIPMENT (MISSION I/II)
MISSION I COMPUTER REQUEST
HARDCOPY REQUESTS
1
2
LAMP DRIVE
COMPUTER INPUT EQUIPMENT (RTC)
COMPUTER REQUEST DATA (RT
HARDCOPY REQUESTS
1
3
LAMP DRIVE
COMPUTER INPUT EQUIPMENT (CP)
MISSION I / MISSION II COMPUTER REQUEST DATA (CP)
TIMING SUBSYSTEM
TIMING PULSES
MISSION II COMPUTER REQUEST DATA

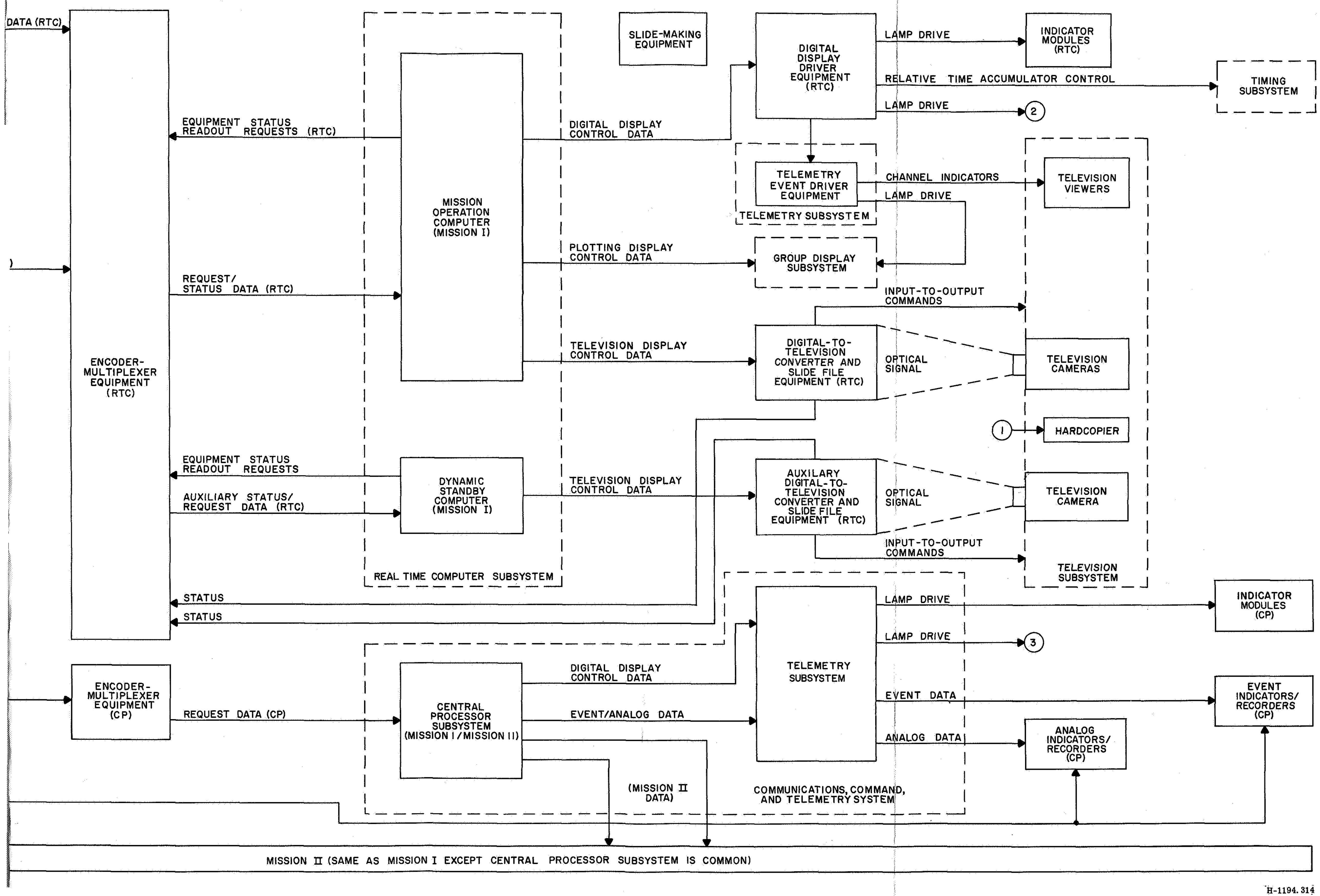
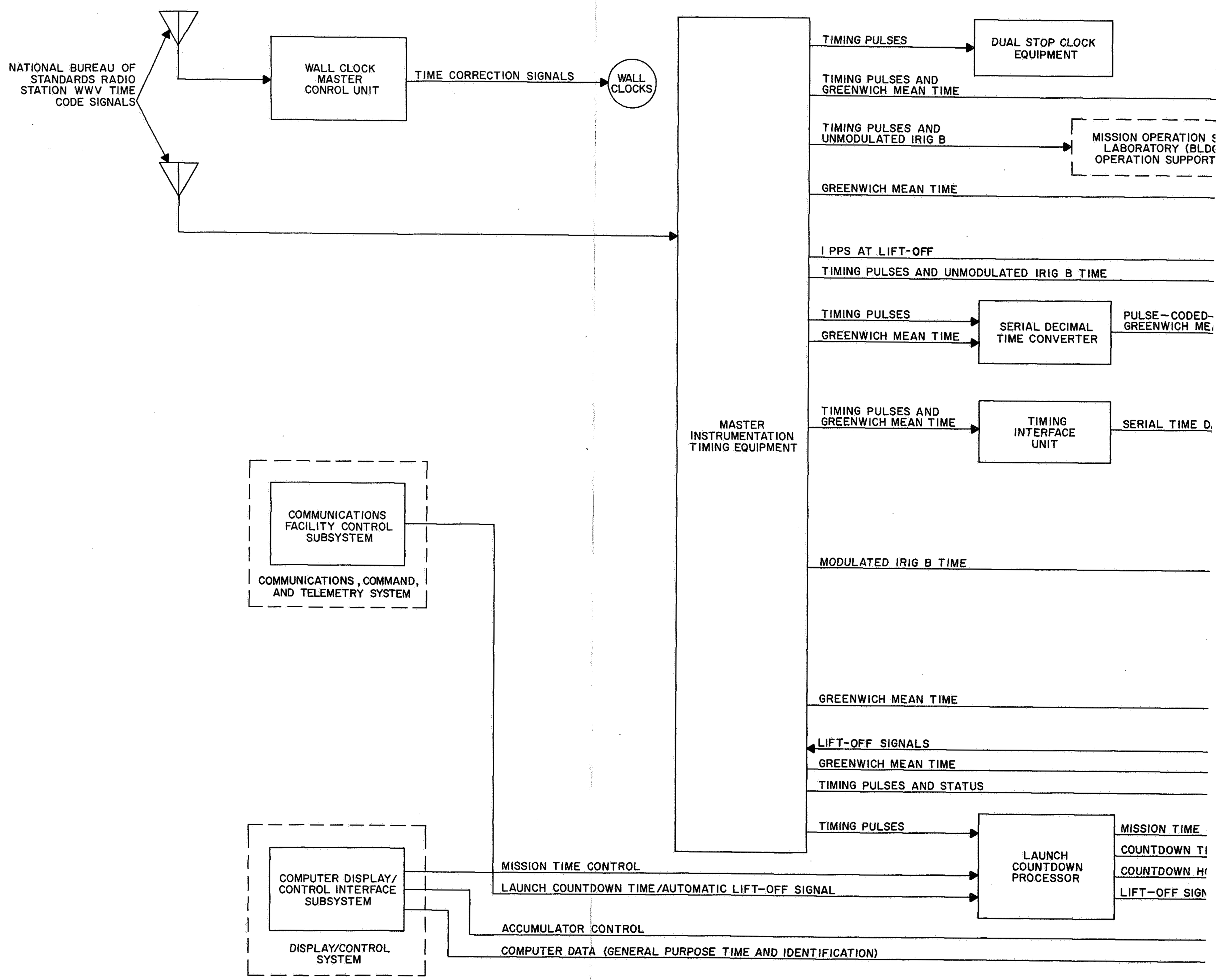


Figure 3-3-1. Computer Display/Control Interface Subsystem, Block Diagram


NATIONAL BUREAU OF STANDARDS RADIO STATION WWV TIME CODE SIGNALS
WALL CLOCK MASTER CONROL UNIT
TIME CORRECTION SIGNALS
WALL CLOCKS
MASTER INSTRUMENTATION TIMING EQUIPMENT
TIMING PULSES
DUAL STOP CLOCK EQUIPMENT
TIMING PULSES AND GREENWICH MEAN TIME
TIMING PULSES AND UNMODULATED IRIG B
GREENWICH MEAN TIME
I PPS AT LIFT-OFF
TIMING PULSES AND UNMODULATED IRIG B TIME
TIMING PULSES
GREENWICH MEAN TIME
SERIAL DECIMAL TIME CONVERTER
TIMING PULSES AND GREENWICH MEAN TIME
TIMING INTERFACE UNIT
MODULATED IRIG B TIME
GREENWICH MEAN TIME
LIFT-OFF SIGNALS
GREENWICH MEAN TIME
TIMING PULSES AND STATUS
TIMING PULSES
LAUNCH COUNTDOWN PROCESSOR
MISSION TIME
COMMUNICATIONS FACILITY CONTROL SUBSYSTEM
COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM
COMPUTER DISPLAY/ CONTROL INTERFACE SUBSYSTEM
DISPLAY/CONTROL SYSTEM
MISSION TIME CONTROL
LAUNCH COUNTDOWN TIME/AUTOMATIC LIFT-OFF SIGNAL
ACCUMULATOR CONTROL
COMPUTER DATA (GENERAL PURPOSE TIME AND IDENTIFICATION)

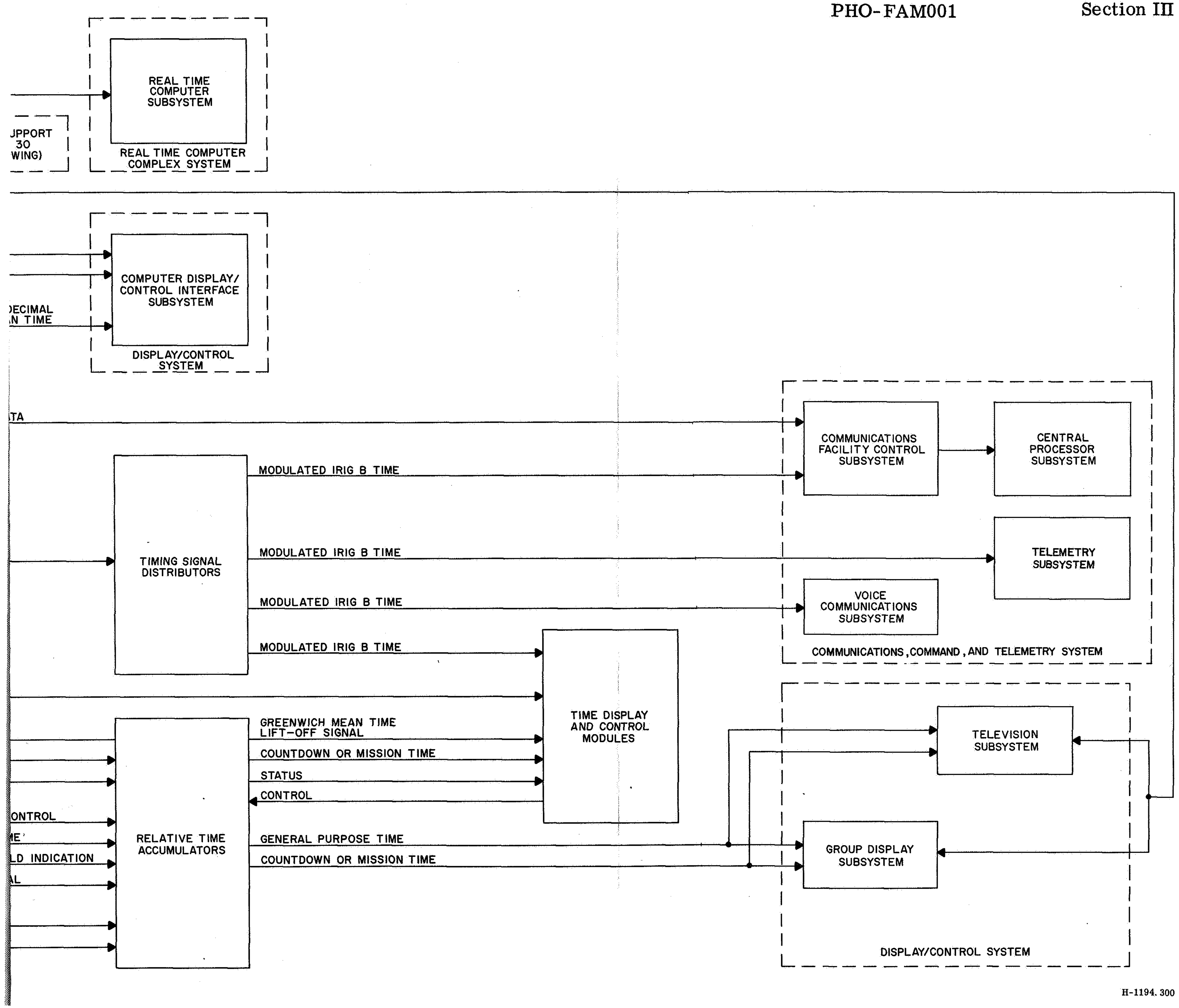
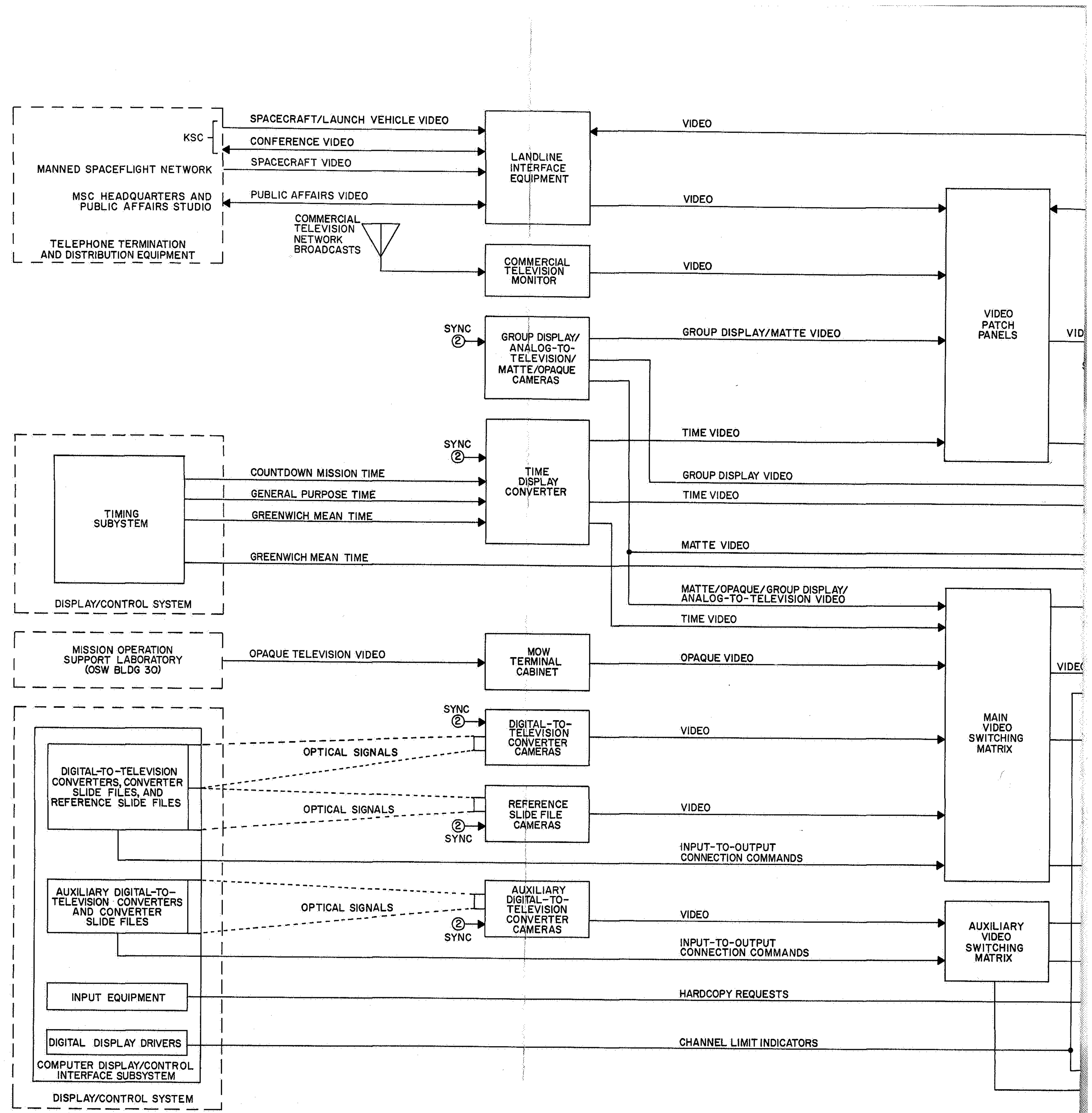


Figure 3-3-2. Timing Subsystem, Block Diagram



KSC
MANNED SPACEFLIGHT NETWORK
MSC HEADQUARTERS AND PUBLIC AFFAIRS STUDIO
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT
SPACECRAFT/LAUNCH VEHICLE VIDEO
CONFERENCE VIDEO
SPACECRAFT VIDEO
PUBLIC AFFAIRS VIDEO
COMMERCIAL TELEVISION NETWORK BROADCASTS
LANDLINE INTERFACE EQUIPMENT
COMMERCIAL TELEVISION MONITOR
SYNC
GROUP DISPLAY/ ANALOG-TO- TELEVISION/ MATTE/OPAQUE CAMERAS
TIMING SUBSYSTEM
COUNTDOWN MISSION TIME
GENERAL PURPOSE TIME
GREENWICH MEAN TIME
GREENWICH MEAN TIME
DISPLAY/CONTROL SYSTEM
TIME DISPLAY CONVERTER
MISSION OPERATION SUPPORT LABORATORY (OSW BLDG 30)
OPAQUE TELEVISION VIDEO
MOW TERMINAL CABINET
DIGITAL-TO-TELEVISION CONVERTERS, CONVERTER SLIDE FILES, AND REFERENCE SLIDE FILES
OPTICAL SIGNALS
OPTICAL SIGNALS
DIGITAL-TO-TELEVISION CONVERTER CAMERAS
REFERENCE SLIDE FILE CAMERAS
AUXILIARY DIGITAL-TO-TELEVISION CONVERTERS AND CONVERTER SLIDE FILES
OPTICAL SIGNALS
AUXILIARY DIGITAL-TO-TELEVISION CONVERTER CAMERAS
INPUT EQUIPMENT
DIGITAL DISPLAY DRIVERS
COMPUTER DISPLAY/CONTROL INTERFACE SUBSYSTEM
DISPLAY/CONTROL SYSTEM
VIDEO
VIDEO
VIDEO
GROUP DISPLAY/MATTE VIDEO
TIME VIDEO
GROUP DISPLAY VIDEO
TIME VIDEO
MATTE VIDEO
MATTE/OPAQUE/GROUP DISPLAY/ ANALOG-TO-TELEVISION VIDEO
TIME VIDEO
OPAQUE VIDEO
VIDEO
VIDEO
INPUT-TO-OUTPUT CONNECTION COMMANDS
VIDEO
INPUT-TO-OUTPUT CONNECTION COMMANDS
HARDCOPY REQUESTS
CHANNEL LIMIT INDICATORS
VIDEO PATCH PANELS
MAIN VIDEO SWITCHING MATRIX
AUXILIARY VIDEO SWITCHING MATRIX
VID
VIDE

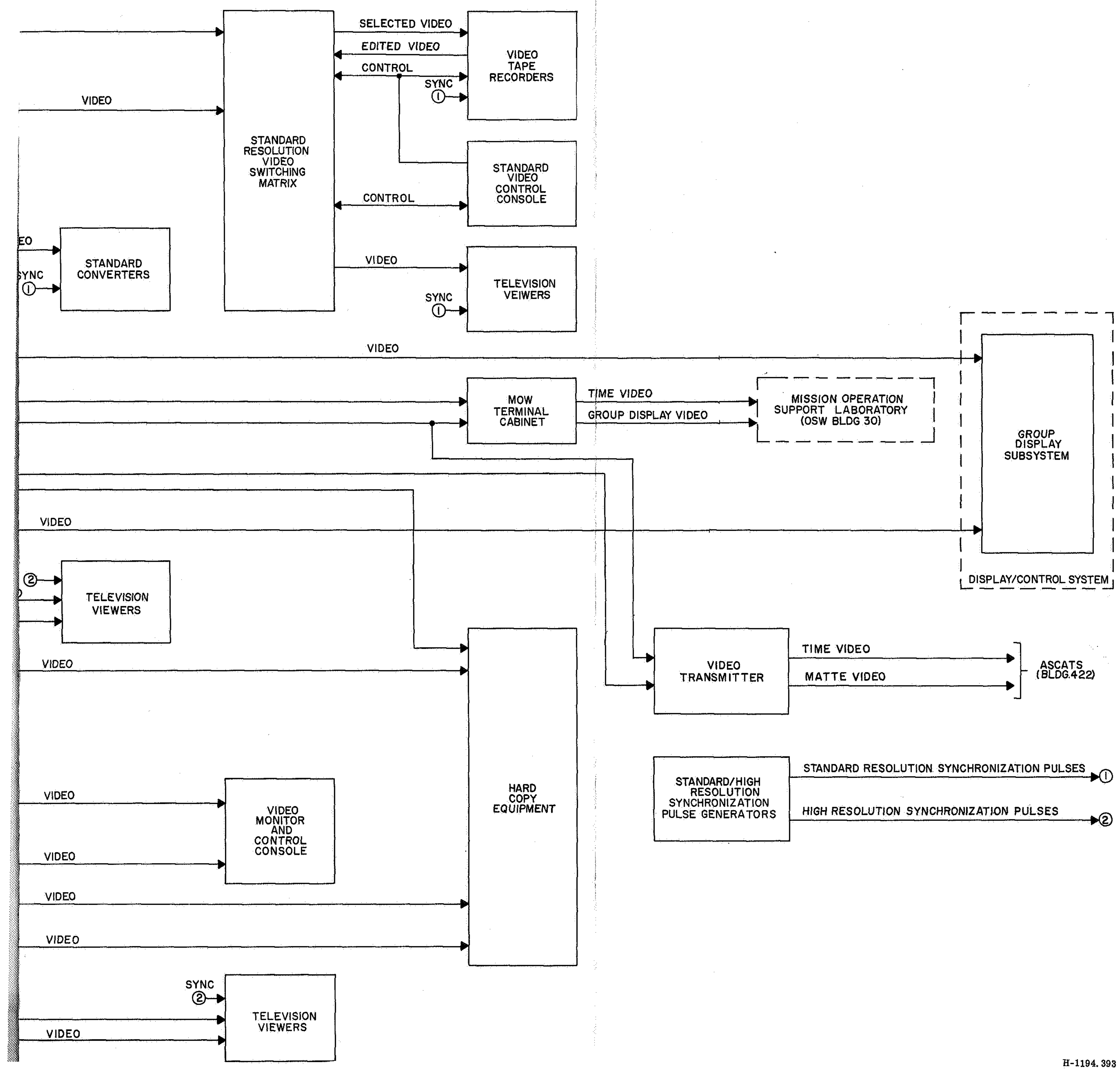
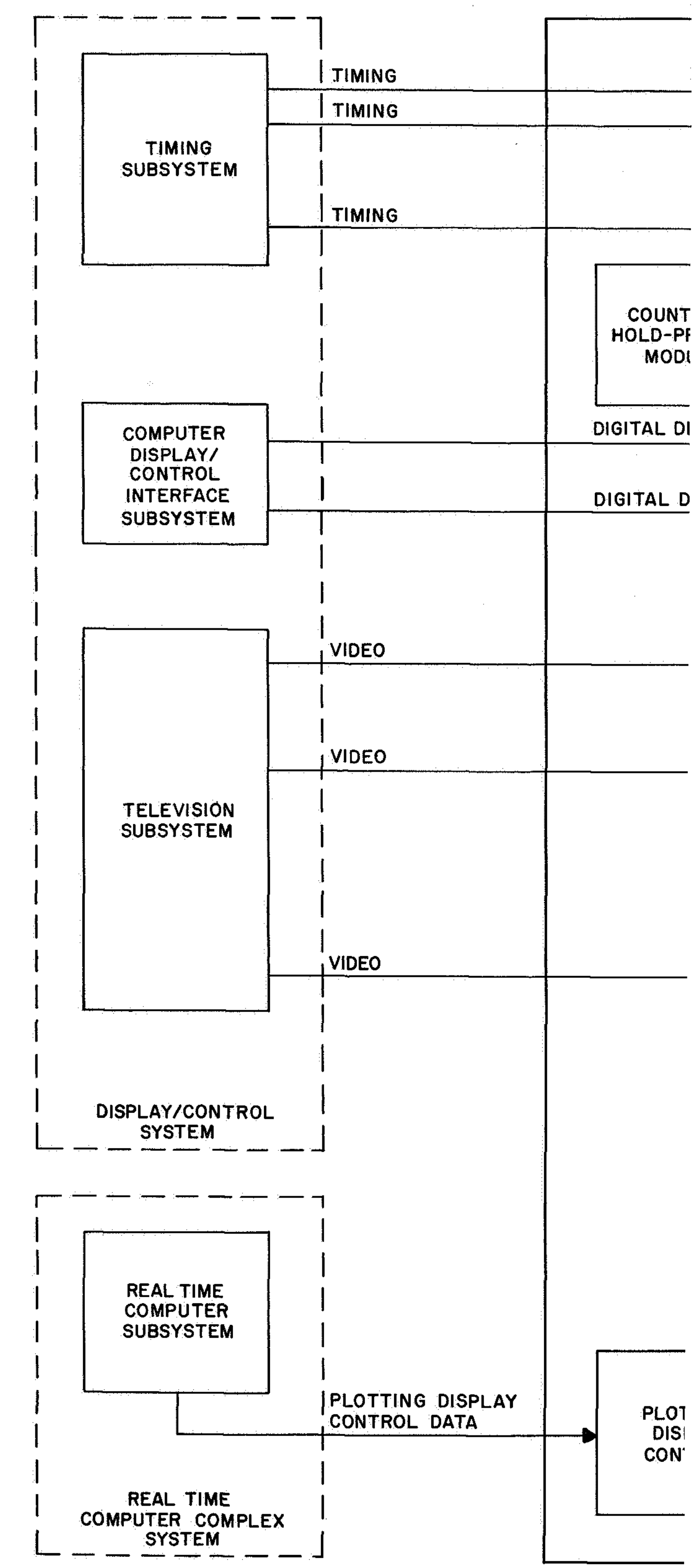


Figure 3-3-3. Television Subsystem, Block Diagram


TIMING
TIMING
TIMING
TIMING SUBSYSTEM
COMPUTER DISPLAY/ CONTROL INTERFACE SUBSYSTEM
VIDEO
VIDEO
VIDEO
TELEVISION SUBSYSTEM
DISPLAY/CONTROL SYSTEM
REAL TIME COMPUTER SUBSYSTEM
PLOTTING DISPLAY CONTROL DATA
REAL TIME COMPUTER COMPLEX SYSTEM

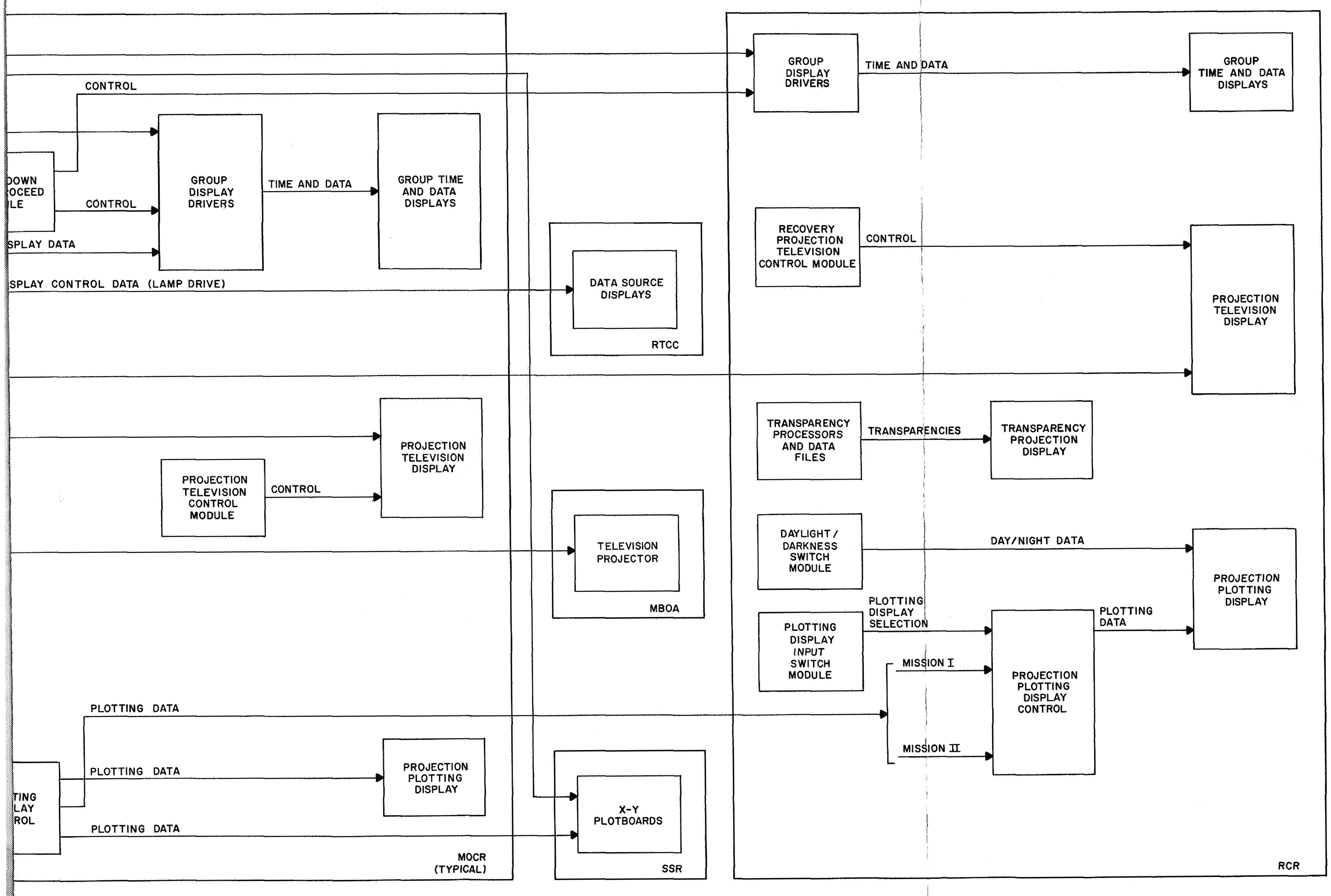


Figure 3-3-4. Group Display Subsystem, Block Diagram

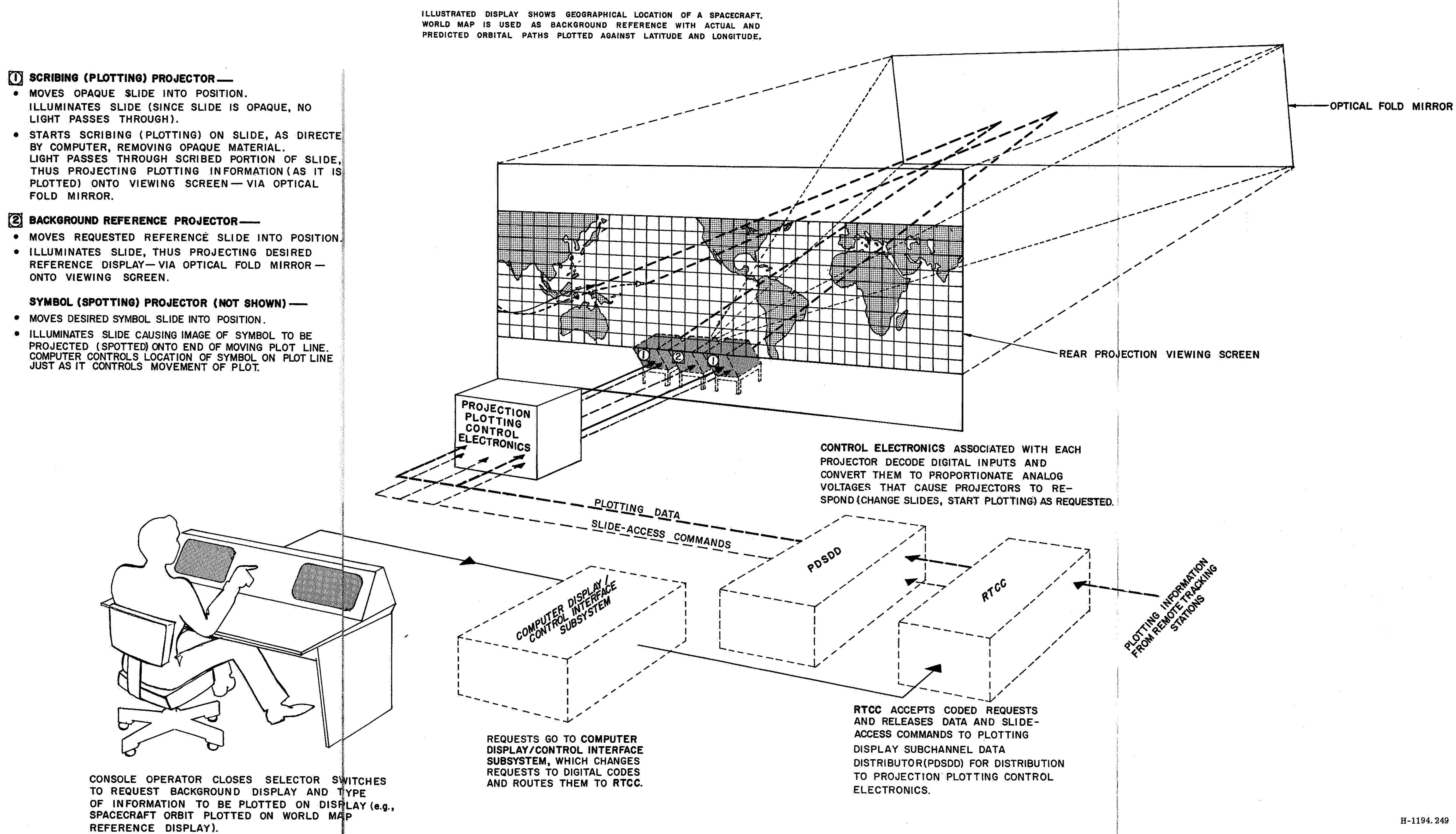


Figure 3-3-4-1. Typical Projection Plotting Display

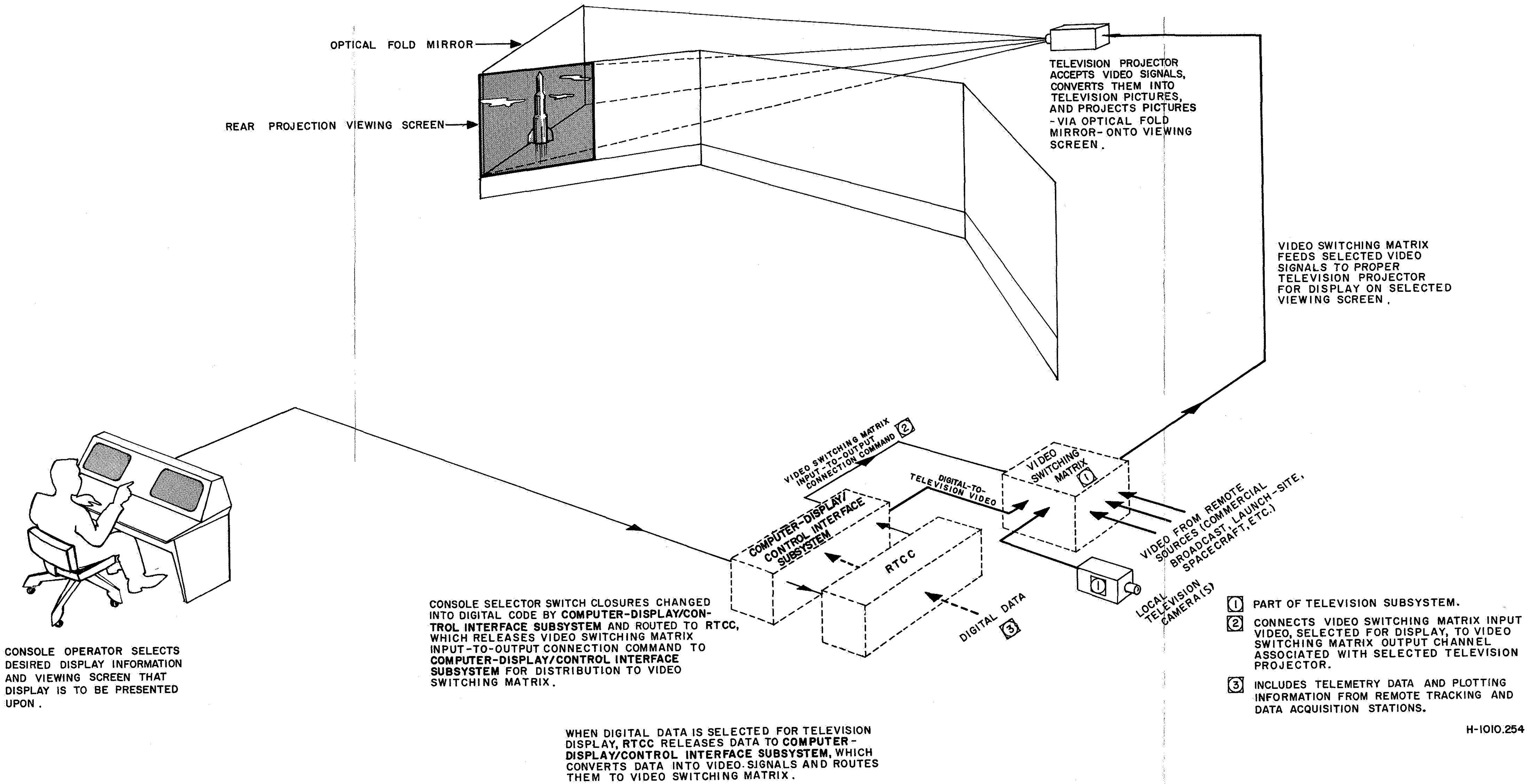


Figure 3-3-4-2. Typical Projection Television Display

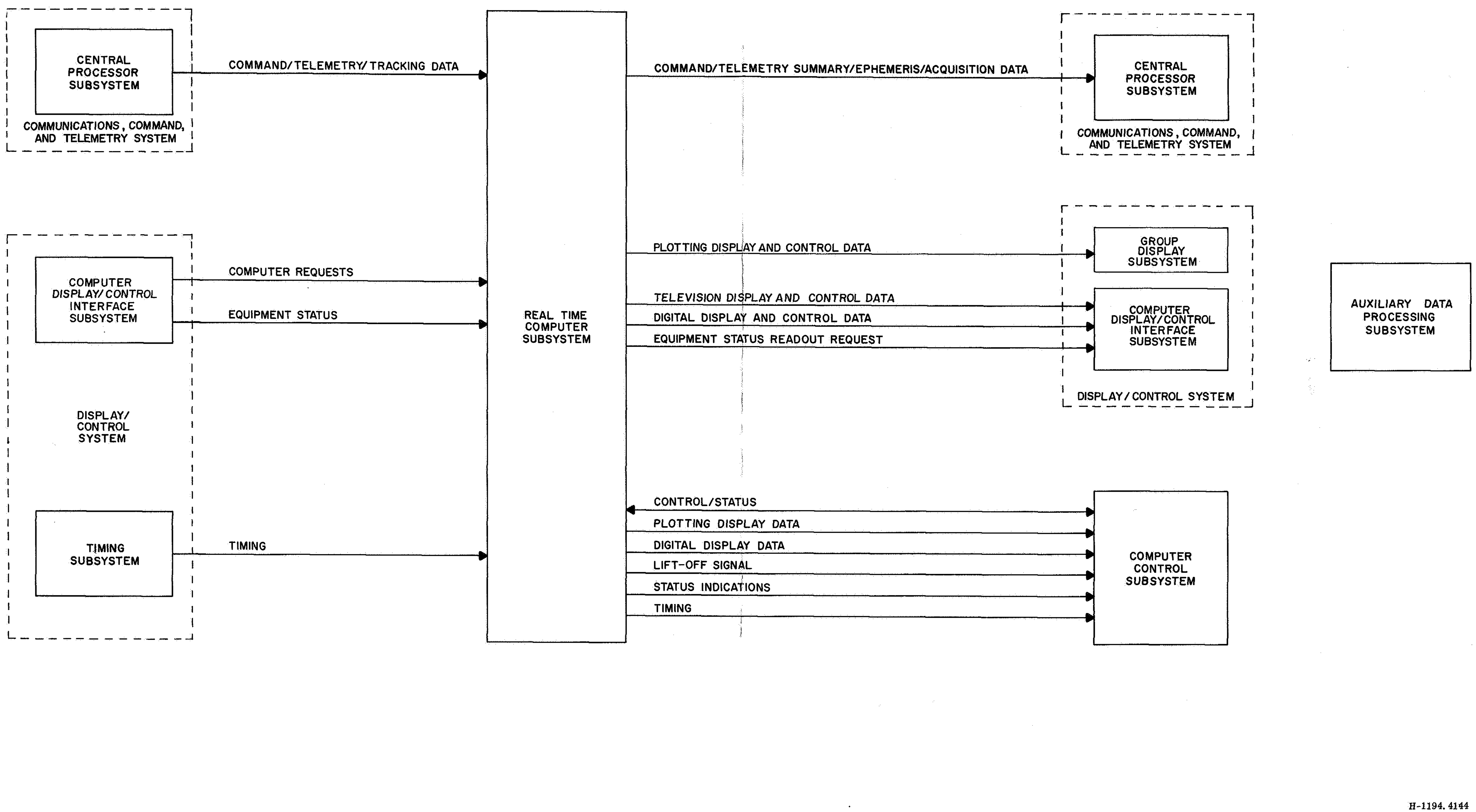
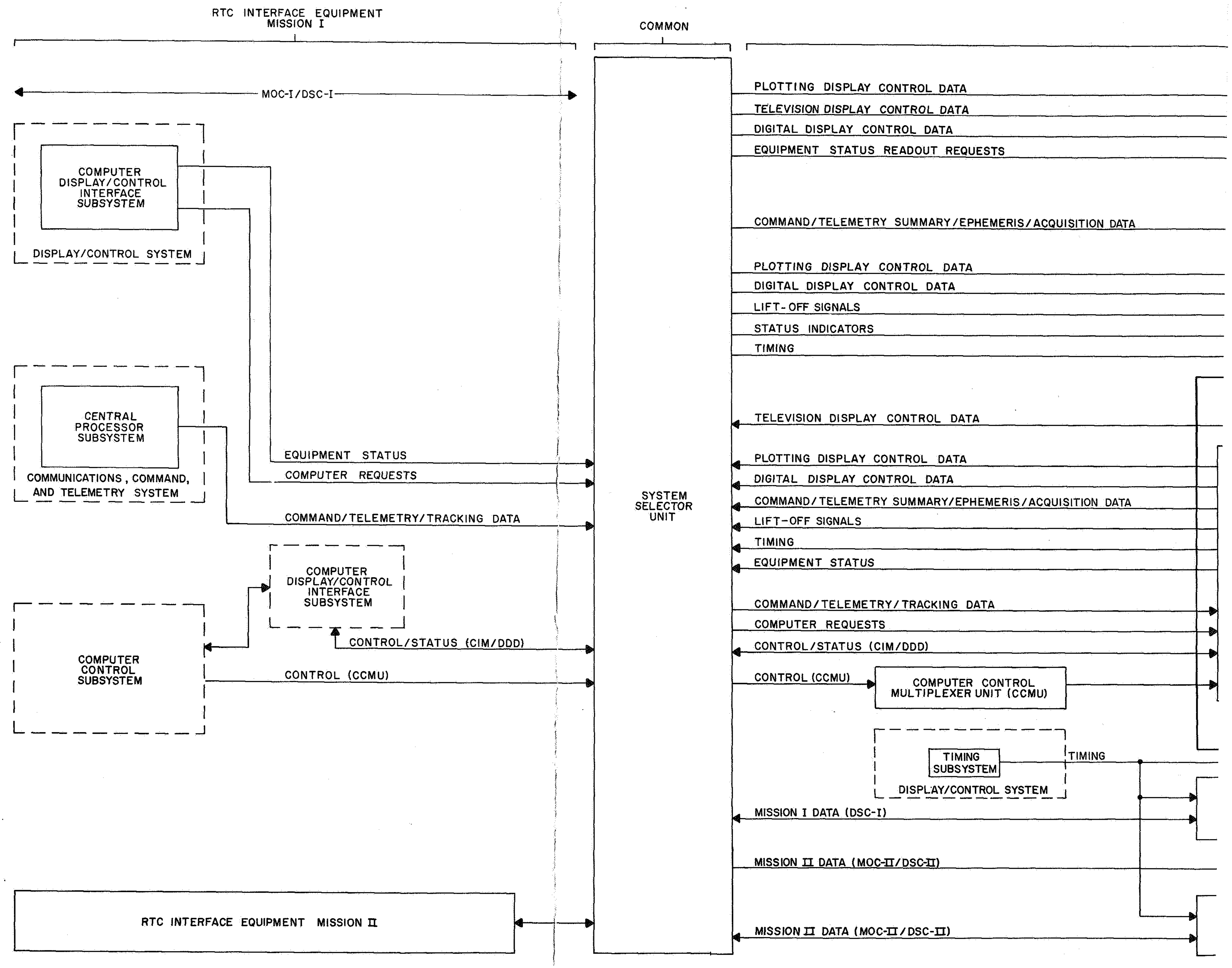


Figure 3-4. Real Time Computer Complex System, Block Diagram



RTC INTERFACE EQUIPMENT MISSION I
COMMON
MOC-I/DSC-I
COMPUTER DISPLAY/CONTROL INTERFACE SUBSYSTEM
DISPLAY/CONTROL SYSTEM
CENTRAL PROCESSOR SUBSYSTEM
COMMUNICATIONS, COMMAND, AND TELEMETRY SYSTEM
EQUIPMENT STATUS
COMPUTER REQUESTS
COMMAND/TELEMETRY/TRACKING DATA
COMPUTER DISPLAY/CONTROL INTERFACE SUBSYSTEM
CONTROL/STATUS (CIM/DDD)
COMPUTER CONTROL SUBSYSTEM
CONTROL (CCMU)
RTC INTERFACE EQUIPMENT MISSION II
SYSTEM SELECTOR UNIT
PLOTTING DISPLAY CONTROL DATA
TELEVISION DISPLAY CONTROL DATA
DIGITAL DISPLAY CONTROL DATA
EQUIPMENT STATUS READOUT REQUESTS
COMMAND/TELEMETRY SUMMARY/EPHEMERIS/ACQUISITION DATA
PLOTTING DISPLAY CONTROL DATA
DIGITAL DISPLAY CONTROL DATA
LIFT-OFF SIGNALS
STATUS INDICATORS
TIMING
TELEVISION DISPLAY CONTROL DATA
PLOTTING DISPLAY CONTROL DATA
DIGITAL DISPLAY CONTROL DATA
COMMAND/TELEMETRY SUMMARY/EPHEMERIS/ACQUISITION DATA
LIFT-OFF SIGNALS
TIMING
EQUIPMENT STATUS
COMMAND/TELEMETRY/TRACKING DATA
COMPUTER REQUESTS
CONTROL/STATUS (CIM/DDD)
CONTROL (CCMU)
COMPUTER CONTROL MULTIPLEXER UNIT (CCMU)
TIMING SUBSYSTEM
TIMING
DISPLAY/CONTROL SYSTEM
MISSION I DATA (DSC-I)
MISSION II DATA (MOC-II/DSC-II)
MISSION II DATA (MOC-II/DSC-II)

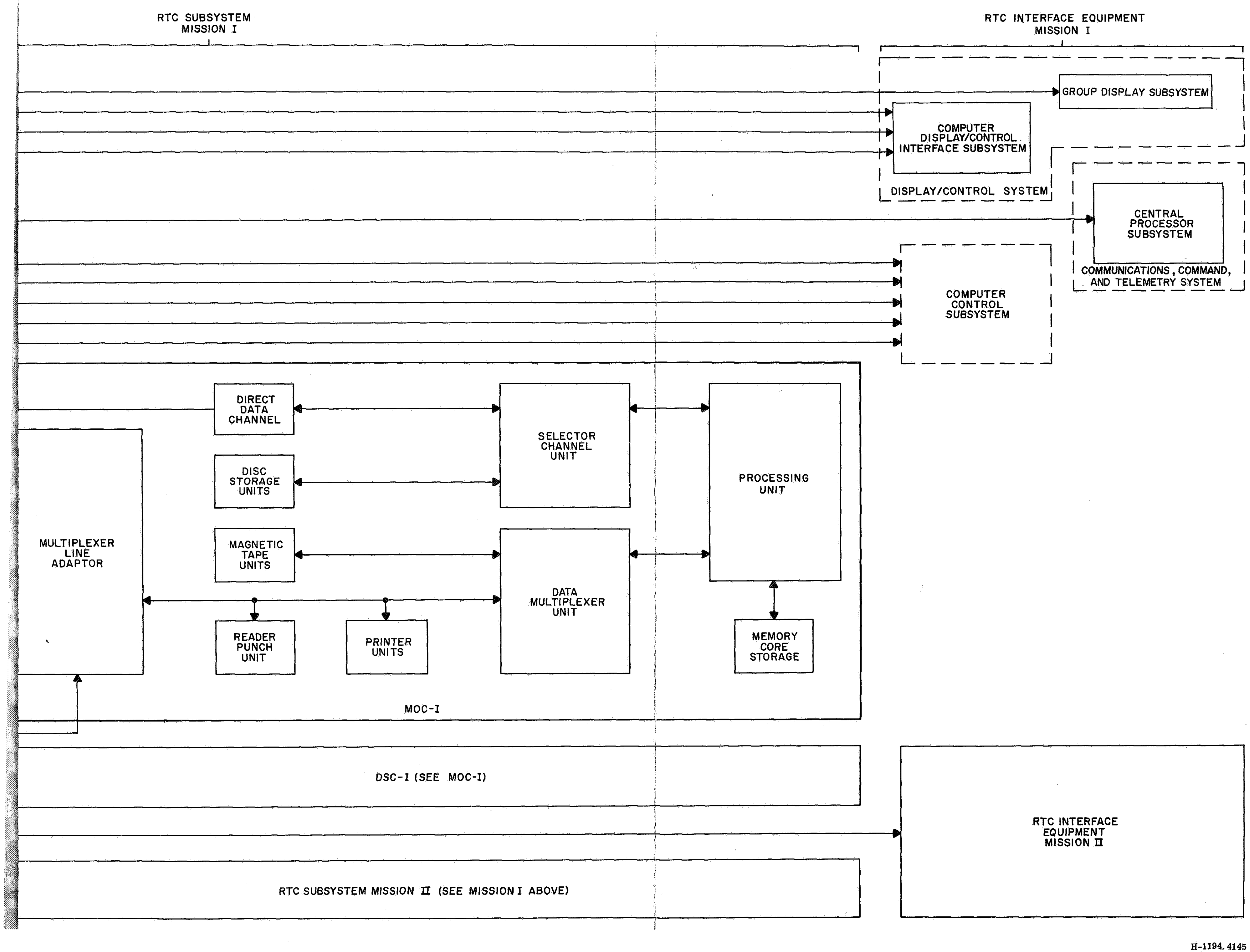


Figure 3-4-1. Real Time Computer Subsystem, Block Diagram

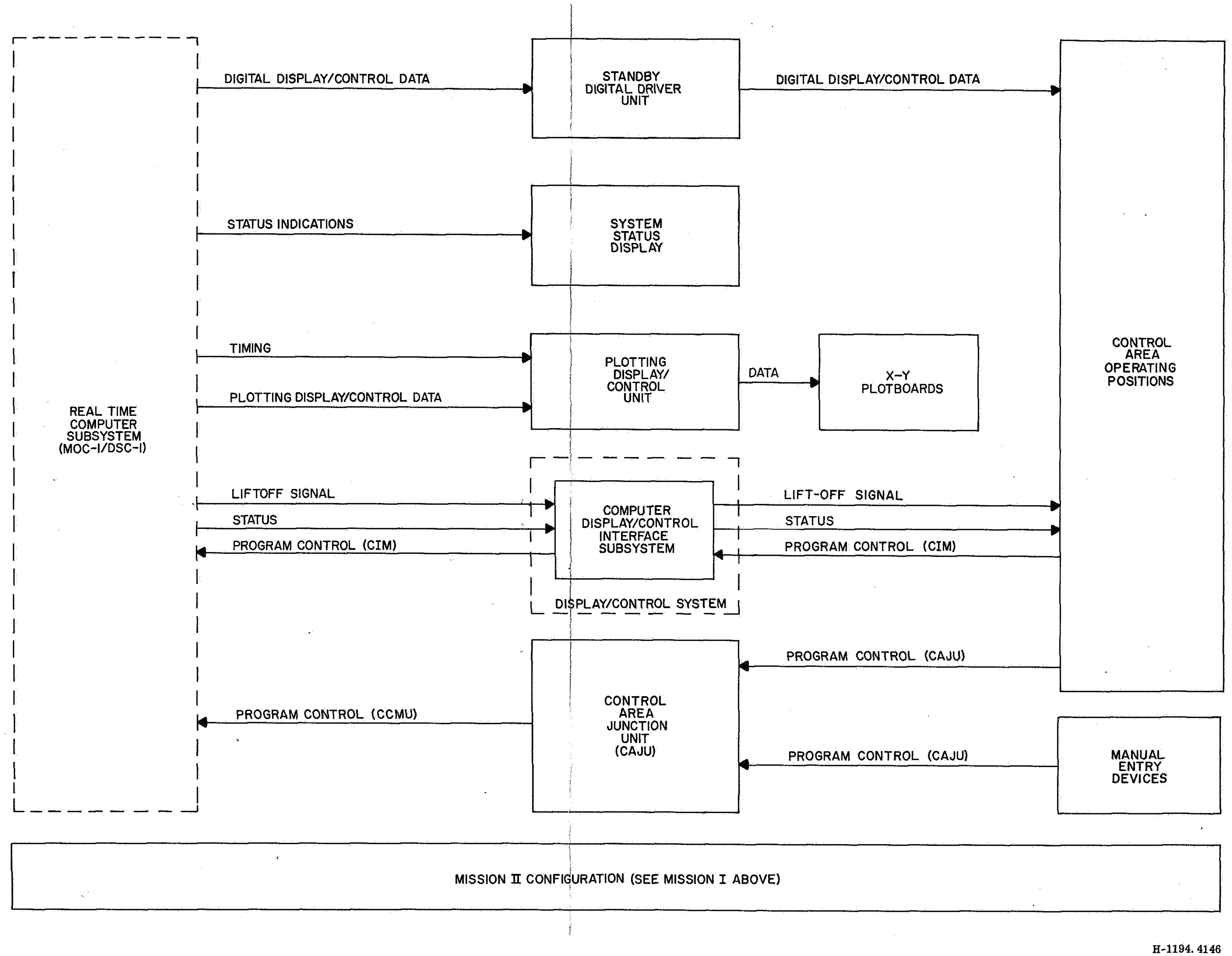


Figure 3-4-2. Computer Control Subsystem, Block Diagram

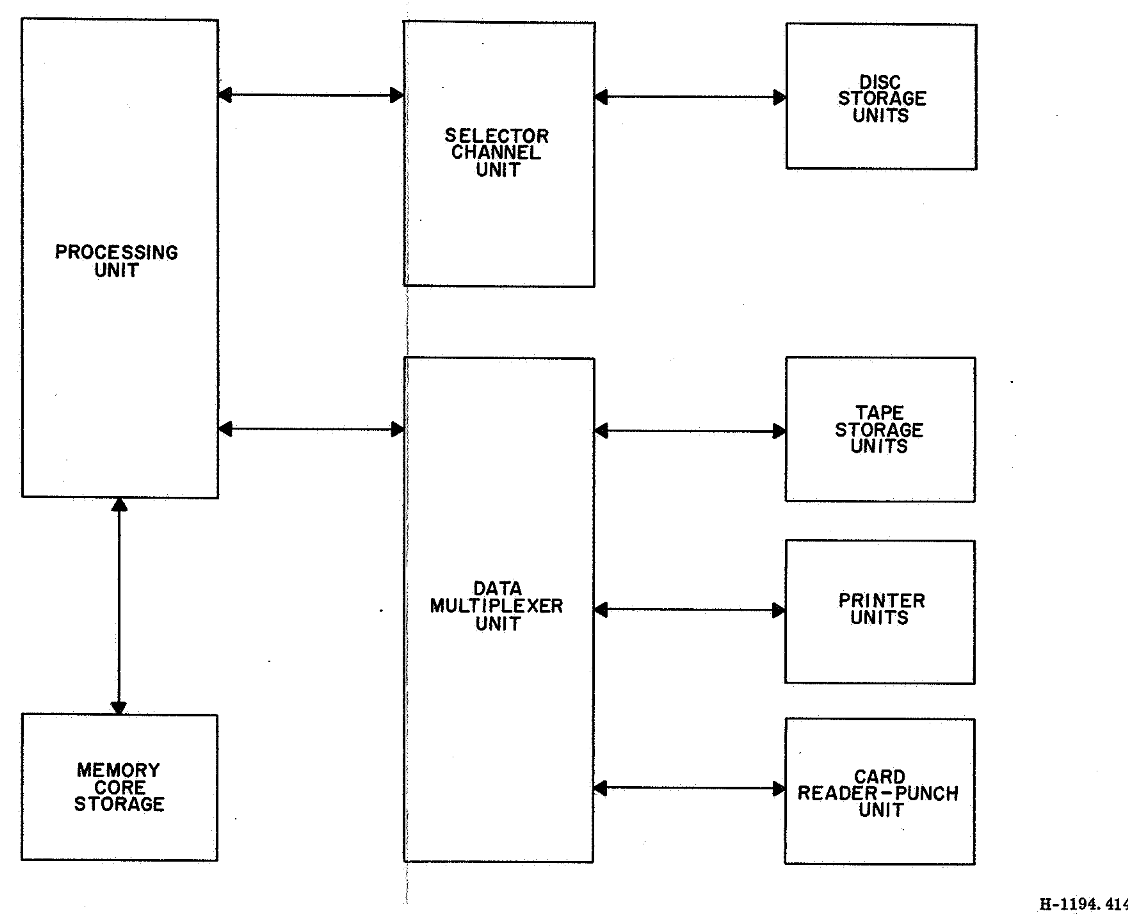


Figure 3-4-3. Auxiliary Data Processing Subsystem, Block Diagram

SECTION IV
SUPPORT FACILITIES

This section describes the utility systems and special features required to support MCC-H operations.

4-1. GENERAL

Various facilities are required to support mission operations within the MCC-H. These facilities include the electrical power distribution system (figure 4-1), lighting system, air conditioning system, fire detection and alarm system, and telephone system. The functions of the MOW, OSW, lobby wing, and emergency power building are different; thus it follows that electrical power, lighting, air conditioning, etc., requirements vary to a certain extent for each part of the MCC-H. A higher degree of complexity is demanded for the MOW support facility systems than those of the rest of the MCC-H. This is true because the MOW systems must include backup equipment for emergency operation. The OSW, lobby wing, and emergency power building support facilities are standard public utility systems.

4-2. ELECTRICAL POWER DISTRIBUTION SYSTEM

Commercial electrical power is routed through high-voltage transmission lines from a priority feeder network to the MSC electrical substation, building 21. Two circuit breakers at the substation are assigned to the MCC-H. From each of these circuit breakers, a power cable is routed through the MSC central tunnel system to switchgear on the substation pad outside the emergency power building. One of the cables is used as a spare to ensure against any long interruption of power at the MCC-H due to cable failure. Feeder circuits are connected from the switchgear to stepdown transformers on the substation pad and in the OSW transformer room (1046). All power, except that supplied to critical equipments, is distributed to the MOW and the emergency power building from the substation pad transformers. Critical equipments are those that could hamper the mission control capabilities of the MCC-H if they became inoperative for even a few seconds. Power is distributed throughout the OSW from the transformers in room 1046.

Electrical power is distributed to the MOW through one of two systems: category A or category B. Category A is uninterruptible power generated within the emergency power building that continually serves critical loads (e.g., data processing and timing equipment) in the MOW during mission periods plus certain lighting fixtures. Two motor generator sets (used for electrical isolation) and three diesel generators (two on-line, one standby) generate category A power. Category B is 20-second interruptible power that supplies all power to the MOW and the emergency power building except power supplied to critical components by the category A power system. Normally, commercial power is distributed to the noncritical loads through the category B system. However, when a commercial power failure occurs, the category B emergency power system assumes the load. Three diesel generators, two on-line and one standby, in the emergency power building provide all category B power approximately 20 seconds after a commercial power failure occurs. The normal and emergency aspects of supplying electrical power to the MOW are described in the following paragraphs.

4-2-1. Normal Operation

During normal operation, the commerical power system is intact and supplies all loads except those which are supplied by the category A distribution system. The normal mode of operation for each power distribution system is given below.

Category A power is obtained from two electric motor generators and three diesel generators during normal operation. One motor generator and one diesel generator operate in parallel to supply power to bus A1 through the category A power switchgear. Another motor generator/diesel generator combination supplies power to bus A2. Each generator handles half the load for the appropriate A-bus and is capable of assuming the entire load, if necessary. The third diesel generator acts as a standby generator capable of being substituted for any of the other generators in the A-power generating system.

Category B power is received from the commercial power system through the substation pad stepdown transformers during normal operation and then fed to each B-bus through the category B power switchgear.

4-2-2. Emergency Operation

A malfunction occurring in either the commercial power system or one of the MCC-H internal distribution systems (category A or B) will precipitate an emergency operation condition. Two modes of emergency operation are provided for both the category A and the category B distribution systems.

The two emergency operation modes for the A-power distribution system occur when (1) commercial power is not available to the MCC-H or (2) one of the B-power buses providing power to the A-power electric motor generators becomes nonoperative.

When commercial power service is interrupted, both electric motor generators cease to operate and the A-power diesel generators temporarily assume the full load for the category A power system. As soon as the category B power system generators have started, the A-power motor generators are manually restarted and operationally powered by the B-power diesel generators.

When one of the B-buses associated with the A-power motor generators is not functioning, the motor generator receiving power from this bus ceases to operate, thereby shifting the full load to the on-line diesel generator. The standby A power diesel generator then operates in parallel with the operational diesel generator to provide uninterruptible power to the A-bus.

The two emergency operation modes for category B power distribution occur when (1) commercial power is not available to the MCC-H or (2) when one of the emergency power building substation pad transformers becomes nonoperative.

When commercial power is interrupted, the B-buses are tied together through bus-tie circuit breakers and the entire category B power system load is supplied from two diesel generators. Each generator is capable of starting and synchronizing with the other generator and supplying full system power to the B-buses within approximately 20 seconds. A third diesel generator acts as a standby capable of being substituted for either one of the other two B-bus diesel generators in the emergency power generating system.

When one of the subsystem pad transformers becomes inoperative, the B-buses are tied together and power is supplied from the remaining transformer and one diesel generator operating in parallel. If one of the B-buses is out of service, the load on that bus may be manually transferred to the other B-buses and the entire category B power load supplied from the remaining operational transformer and one diesel generator operating in parallel.

4-3. LIGHTING SYSTEM

While certain areas of the MCC-H have specialized lighting requirements, the only lighting criteria for most of the MCC-H is that minimum illumination be maintained for favorable working conditions. The MOW, OSW, lobby wing, and emergency power building lighting requirements are described below.

4-3-1. Mission Operations Wing

The critical MOW, which has no windows, requires a special lighting system that has provisions for emergency operation. Both fluorescent and incandescent light fixtures are provided in the MOW. Utility power is distributed from the category B power switchgear in the emergency power building to the MOW light fixtures. Utility power is fed directly to the fluorescent light fixtures while stepdown transformers, located in electrical equipment closets on each floor of the MOW, step down the utility power voltage for use by the incandescent light fixtures. All fluorescent fixtures are equipped with radio-frequency noise suppressors.

A battery-powered emergency lighting system is provided for the safety of MOW personnel in the event a complete failure of the MCC-H internal power distribution systems extinguishes the emergency lighting fixtures tied onto the category A power system. If a power failure of this nature occurs, the emergency lighting system will automatically switch on-line and supply power to light fixtures strategically located in each area and corridor. These are recessed, ceiling-mounted fixtures and are normally off at all times. The emergency lighting system will also furnish electrical power to all exit lights and wall clock outlets. Batteries, switching gear, and battery charging equipment for the system are located in the emergency power building.

4-3-2. Operations Support Wing and Lobby Wing

The lighting system in the OSW and lobby wing consists primarily of fluorescent light fixtures, which are supplied electrical power from the transformers in room 1046. Incandescent lights are supplied power from the same transformers through various stepdown transformers.

4-3-3. Emergency Power Building

The lighting system for the emergency power building is similar to that of the OSW and lobby wing.

4.4. AIR CONDITIONING SYSTEM

The air conditioning system for the MOW, OSW, lobby wing, and emergency power building is described in the following paragraphs.

4-4-1. Mission Operations Wing

Special requirements are imposed on the MOW air conditioning system. The large concentration of electronic equipment in the MOW, particularly in the RTCC area, necessitates a highly reliable air conditioning system to provide the proper environment for the equipment, and also for personnel, since mission operations must continue in the MOW under all but the most extreme emergency conditions.

A dual-duct, high-velocity air system utilizing pneumatic control devices is used to air condition the MOW. Steam and chilled water is normally piped from the heating and cooling plant, building 24. If the heating and cooling plant system fails, the MOW is provided warm and cool water from the emergency power building for emergency air conditioning to permit mission operations to continue. Compressed air for the pneumatic air conditioning control devices is also supplied from the heating and cooling plant. Backup air pressure to the control devices is provided by an air compressor located in mechanical equipment room 113. Although cooling, heating, and ventilating equipments are controlled at the areas served within the MOW, a control panel is provided in the emergency power building as a precautionary measure to monitor and reset the equipments. Mixed air and discharge plenums are acoustically lined and constructed to withstand the high air pressure generated by the high-velocity air supply system. Return air plenums are also lined and contain vertical sound baffles to confine fan noise within the mechanical equipment room.

Each MOW mechanical equipment room contains air conditioning units that draw return air from ceiling plenums and fresh air from outside air processing units containing air filters, preheating and precooling coils, humidifiers, and control dampers. The air is discharged through heating and cooling coils and filter sections of the air conditioning units to the high-velocity duct system. The high pressure dual-duct system delivers air from the hot and cold decks of the discharge plenums to constant volume mixing boxes (air valves) above the suspended ceilings on each floor. The mixing boxes mix cool and warm air to produce the environment desired for each area. Thermostats control motorized dampers that regulate the quantities of cool and warm air to be mixed in the boxes. The mixed air is fed to low pressure ducts for distribution to air diffusers located in each area. In general, the air diffusers are located on the ceiling-mounted fluorescent lighting fixtures. Each diffuser includes volume control dampers and adjustable air deflectors. Conventional ceiling air diffusers are located in the MOCR's. Return air in most areas is drawn through slots in the lighting fixture frames and routed back to the mechanical equipment rooms through the low pressure ceiling plenums. Return air from the MOCR's and visitors viewing areas is drawn through grills, located under the leading edge of the stepped floor, to special charcoal filter units installed under the visitors viewing areas. These filters remove excessive tobacco smoke and odors from the air before conveying the air back to the mechanical equipment rooms through the ceiling plenums.

The high cooling load of the RTCC equipment is handled by an underfloor air supply system. Duplicate fans, coils, filters, and controls are installed in mechanical equipment room 113 for the system, which uses no outside air. The system supplies air to the RTCC areas of highest heat gain through strategically situated floor grills. The lighting and personnel cooling load of the RTCC area is handled by the regular overhead air distribution system.

As indicated earlier, emergency water heating and cooling facilities are located in the emergency power building to backup the heating and cooling plant that supplies warm and cool water to the MOW. Water pumps in the emergency power building circulate warm and cool water through the air conditioning coils in the MOW mechanical equipment rooms. A 5-minute change-over period is required to switch from the MSC heating and cooling plant loop to the emergency backup system. As an added measure to ensure continuous operation, each MOW mechanical equipment room contains dual air handling equipment including supply fan, heating and cooling coils, air filters, and controls.

Ventilation exhaust fans collect exhaust air and discharge it outside the building. Exhaust fans are provided for each mechanical equipment room, projection room, battery room, and for each toilet area.

4-4-2. Operations Support Wing and Lobby Wing

The air conditioning system for the OSW and lobby wing is designed primarily for human comfort. Equipment cooling requirements are of secondary importance since these wings essentially form an office building with technical support areas located in the inner sections of each OSW floor.

A conventional dual-duct, high-velocity air supply system, similar in operation to the MOW system, is used to air condition these wings. Two mechanical equipment rooms are included on each floor of the OSW to distribute conditioned air to the four sections of each floor. The third floor of the lobby wing receives conditioned air from OSW mechanical equipment room 3076 and from a separate air handling unit located in mechanical equipment room 3001A of the lobby wing. The unit in room 3001A is provided to air condition the lobby wing dormitory area exclusively.

Ventilation fans are provided to exhaust air from toilet areas, mechanical equipment rooms, and the auditorium projection room.

4-4-3. Emergency Power Building

The office, shop, and control rooms of the emergency power building are air conditioned to maintain comfort as specified for the OSW and lobby wing. An air conditioner using chilled water from the tunnel supply system and water from the emergency power building heat exchangers is furnished for this purpose. Heaters maintain a comfortable temperature in all other areas of the building during the winter when the diesel engines are not operating. Also, roof ventilators draw air through wall louvers for ventilation during the summer or at other times as required. Manually operated dampers adjust the louvers for the desired amount of air.

4-5. FIRE DETECTION AND ALARM SYSTEM

The automatic fire detection and alarm system for the MCC-H consists of two independent systems. A special multizoned system is provided for the MOW and a conventional zoned system is provided for the OSW, lobby wing, and emergency power building.

4-5-1. Mission Operations Wing

The special multizoned automatic fire detection and alarm system in the MOW is independent of the system in the OSW and lobby wing. The special system has three major zones (one for each floor) terminating in the special master fire alarm equipment group in the lobby wing security office. Each major zone is divided into minor zones that provide fire detecting and alarm coverage for each minor zone area.

Each minor zone is further divided into subzones containing combustion detector units capable of detecting smoke, or fire. When indication of a fire or a hazardous condition within the areas covered by the special system is received at the master fire alarm equipment, an alarm is automatically transmitted to the MSC fire station, building 25.

4-5-2. Operations Support Wing and Lobby Wing

The conventional system in the OSW and lobby wing consists of one zone for each floor and terminates in the conventional master fire alarm equipment group in the lobby wing security office. When smoke or fire is detected, alarms will be sounded and a coded signal transmitted to the MSC fire station by the master fire alarm equipment.

4-5-3. Emergency Power Building

The fire detection and alarm system for the emergency power building is identical to the OSW and lobby wing system and is keyed to the central fire alarm equipment at the MSC fire station.

4-6. TELEPHONE SYSTEM

Telephone service lines for private conversation enter the MSC telephone facility building (47) along with Manned Spaceflight Network communication lines. All lines are routed from the telephone building through the utility tunnel to MOW room 127. From there, the private telephone lines branch out to telephone equipment closets on each floor of the MCC-H. Individual circuits then spread out to personal telephone units. The MCC-H Communications System can be connected into the private telephone network, if required, during emergency operations.

4-7. SPECIAL FEATURES

The special features necessary for the type of operations conducted within the MCC-H include an electrical grounding system, provisions for equipment cabling access and routing, internal fire protection, noise attenuation, a vacuum cleaning system, elevators to service each floor, and shoe cleaners to cut down on surface dirt brought into the MOW.

The MCC-H main grounding system consists of a copper, ground-grid loop buried 18 inches below grade. Numerous ground rods are attached to the ground-grid to establish a low resistance ground. Ground cables extend from the main grounding system to various locations throughout the MCC-H. A technical grounding system extends throughout the MOW for the exclusive use of functional system equipments.

Various provisions are made in the MCC-H to ensure rapid access to equipment interconnection cabling. This could be important when a cable-associated malfunction occurs or when accomplishing equipment modifications. A raised modular floor system containing removable floor panels for easy cable access is installed over the major portion of the MOW floor structures. A similar floor system is also installed in several rooms of the OSW. Cable access between floors of the MOW is accomplished by utilizing vertical cable riser cabinets located in the periphery of the building. Permanent personnel ladders are located between the cable trays of each cabinet. Hinged doors provide ready access to the vertical cable trays and personnel ladders and completely conceal them when closed. One vertical cable riser cabinet is located in the OSW to provide cable access between second and third floor laboratories.

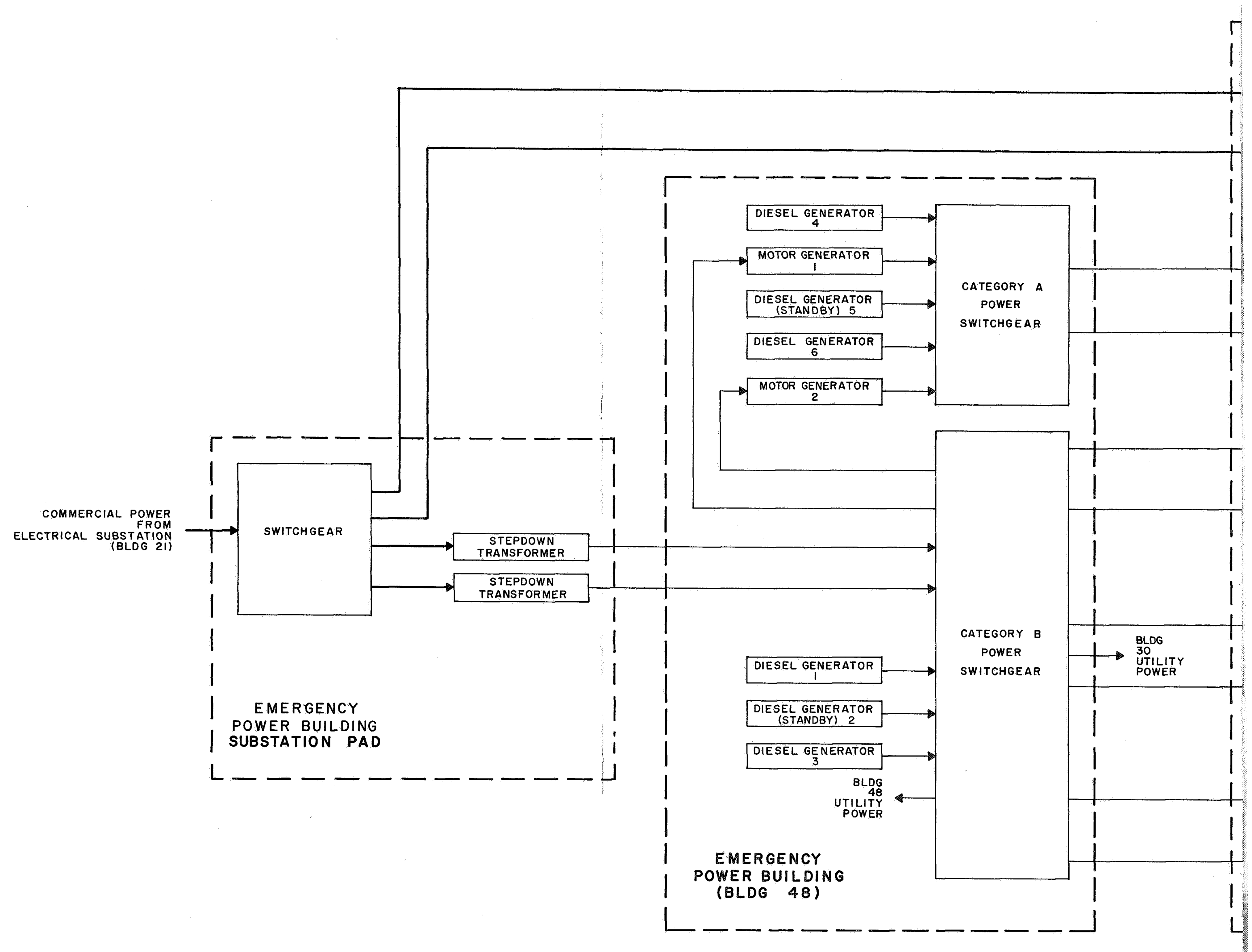
In addition to the automatic fire detection and alarm system previously discussed, portable fire extinguishers are located throughout the MCC-H for internal fire protection. Also, a cart-type unit is stored on each floor of the MOW and a dry standpipe system is provided. A wet standpipe system with fire hose cabinets is distributed throughout the OSW. An emergency smoke-purging system employing two roof-mounted exhaust fans is installed to permit rapid removal of smoke from the MOW. Fire dampers, operated automatically by fuses, are provided in all ducts passing through fire walls except in the MOW where manually operated dampers are provided. This deviation from normal safety practices is accepted due to the overriding priority that mission operations will continue during all, but the most severe, emergencies.

Acoustical paneling is used on the ceilings of the MCC-H, and the walls of certain areas are specially treated for noise reduction. Also, certain areas, such as the MOCR's are carpeted to further absorb sound and reduce noise.

A built-in vacuum cleaning system, installed in the mechanical equipment rooms, facilitates cleaning the plenums and mechanical equipment. A 25-foot hose and other vacuum cleaning equipment are stationed near the vacuum duct inlet servicing each mechanical equipment room.

Six hydraulic elevators are installed in the MCC-H building. One elevator is located in the northwest corner of the MOW, two in the southeast corner of the MOW, two in the north end of the OSW, and one in the south end of the OSW. One of the elevators in the southeast corner of the MOW serves the lobby wing and the MOW.

Two shoe cleaners are provided in the first floor corridors of the MOW. The shoe cleaners operate automatically, whenever they are stepped upon, to remove dirt from the shoe soles of anyone entering the MOW. Additionally, a master ON-OFF control switch is wall-mounted immediately adjacent to each shoe cleaner.



COMMERCIAL POWER FROM ELECTRICAL SUBSTATION (BLDG 21)
SWITCHGEAR
STEPDOWN TRANSFORMER
STEPDOWN TRANSFORMER
EMERGENCY POWER BUILDING SUBSTATION PAD
DIESEL GENERATOR 4
MOTOR GENERATOR 1
DIESEL GENERATOR (STANDBY) 5
DIESEL GENERATOR 6
MOTOR GENERATOR 2
CATEGORY A POWER SWITCHGEAR
CATEGORY B POWER SWITCHGEAR
DIESEL GENERATOR 1
DIESEL GENERATOR (STANDBY) 2
DIESEL GENERATOR 3
BLDG 48 UTILITY POWER
BLDG 30 UTILITY POWER
EMERGENCY POWER BUILDING (BLDG 48)

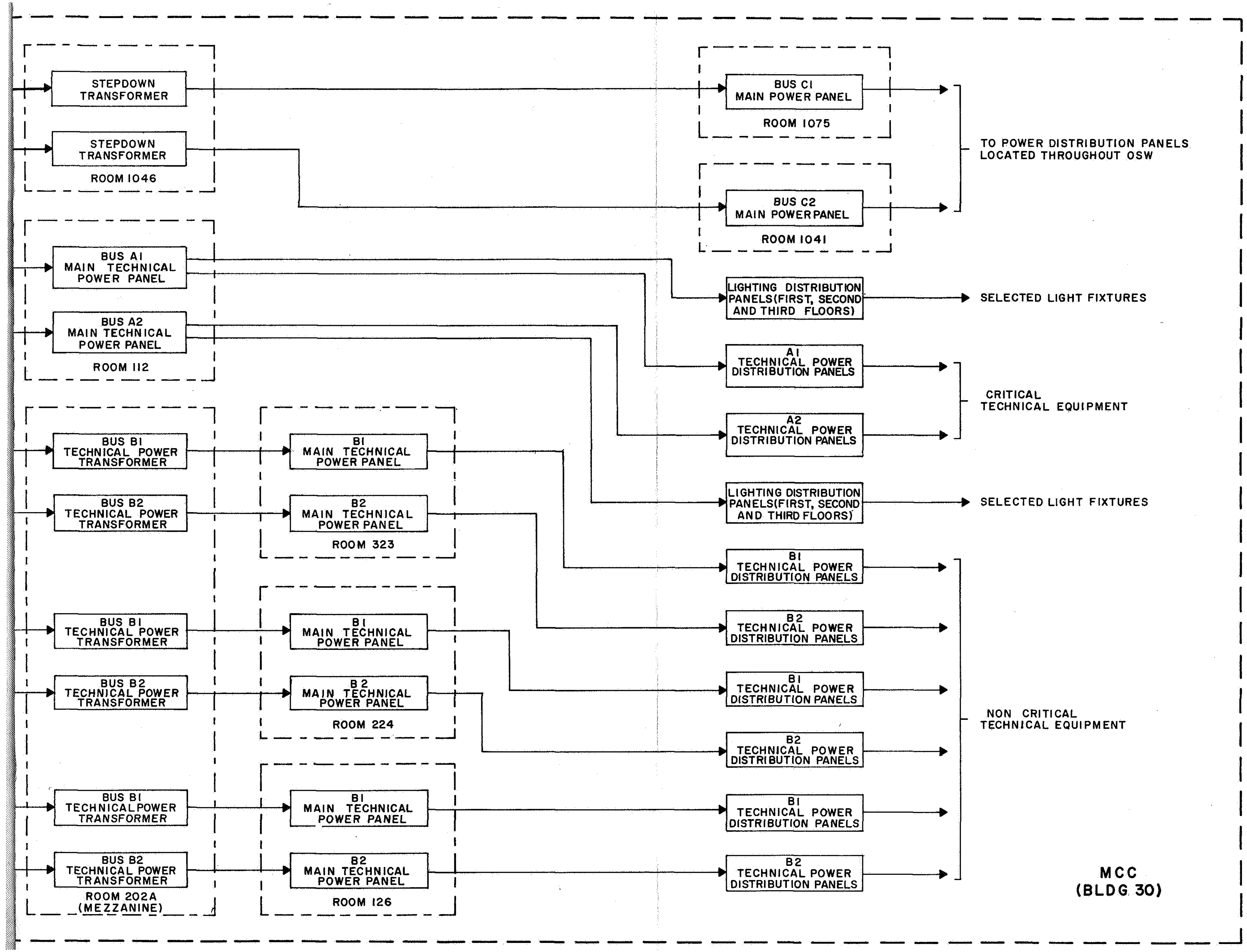


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Figure 4-1. MCC-Houston Electrical Power Distribution, Simplified Diagram

SECTION V
MANNING

This section describes the organizational groupings required to man the MCC-H Mission Operations Wing during actual and simulated mission operations.

5-1. GENERAL

The MCC-Houston personnel structure includes the mission director and six organizational groups that are required to perform active mission control and support functions: Mission Command and Control, Mission Command and Control Support, Flight Dynamics, Systems Operations, RTCC Computer Control, and Maintenance and Operations. (See figure 5-1.) The personnel structure includes one group, Public Affairs Information Control, that does not perform active mission control and support functions.

5-2. MISSION COMMAND AND CONTROL GROUP

The Mission Command and Control Group exercises detailed mission control from operating positions located in one of the MOCR's. The group monitors and analyzes mission status, implements appropriate actions to support flight plans and mission objectives, and provides detailed direction and control of all major system elements.

5-3. MISSION COMMAND AND CONTROL SUPPORT GROUP

The Mission Command and Control Support Group exercises detailed mission control from SSR's, the RCR, the meteorological center, and the communications control room. The group monitors and controls incoming and outgoing data, controls and coordinates recovery operations, and provides weather analysis and forecasts.

5-4. FLIGHT DYNAMICS GROUP

The Flight Dynamics Group personnel are primarily concerned with vehicle trajectories. The group monitors and evaluates all aspects of powered flight concerning crew safety and orbital insertion, evaluates and recommends modification of orbital trajectories to meet mission objectives, and continuously updates retrofire information for both planned and contingency reentry situations.

5-5. SYSTEMS OPERATIONS GROUP

The Systems Operations Group is responsible for monitoring and evaluating flight crew status and analyzing the performance of the electrical, mechanical, and life support systems aboard all vehicles involved in a manned or unmanned spaceflight mission. In addition, this group is responsible for issuing the vehicle systems commands, determining preventive and/or remedial actions if contingencies and malfunctions occur, and for conducting voice interchanges between the spacecraft and MCC-H.

5-6. RTCC COMPUTER CONTROL GROUP

The RTCC Computer Control Group monitors the performance of the RTCC computers, observes and evaluates computer-generated displays, provides direct consultation to MOCR and SSR personnel, and manually inserts data into the computers, as required, during mission periods.

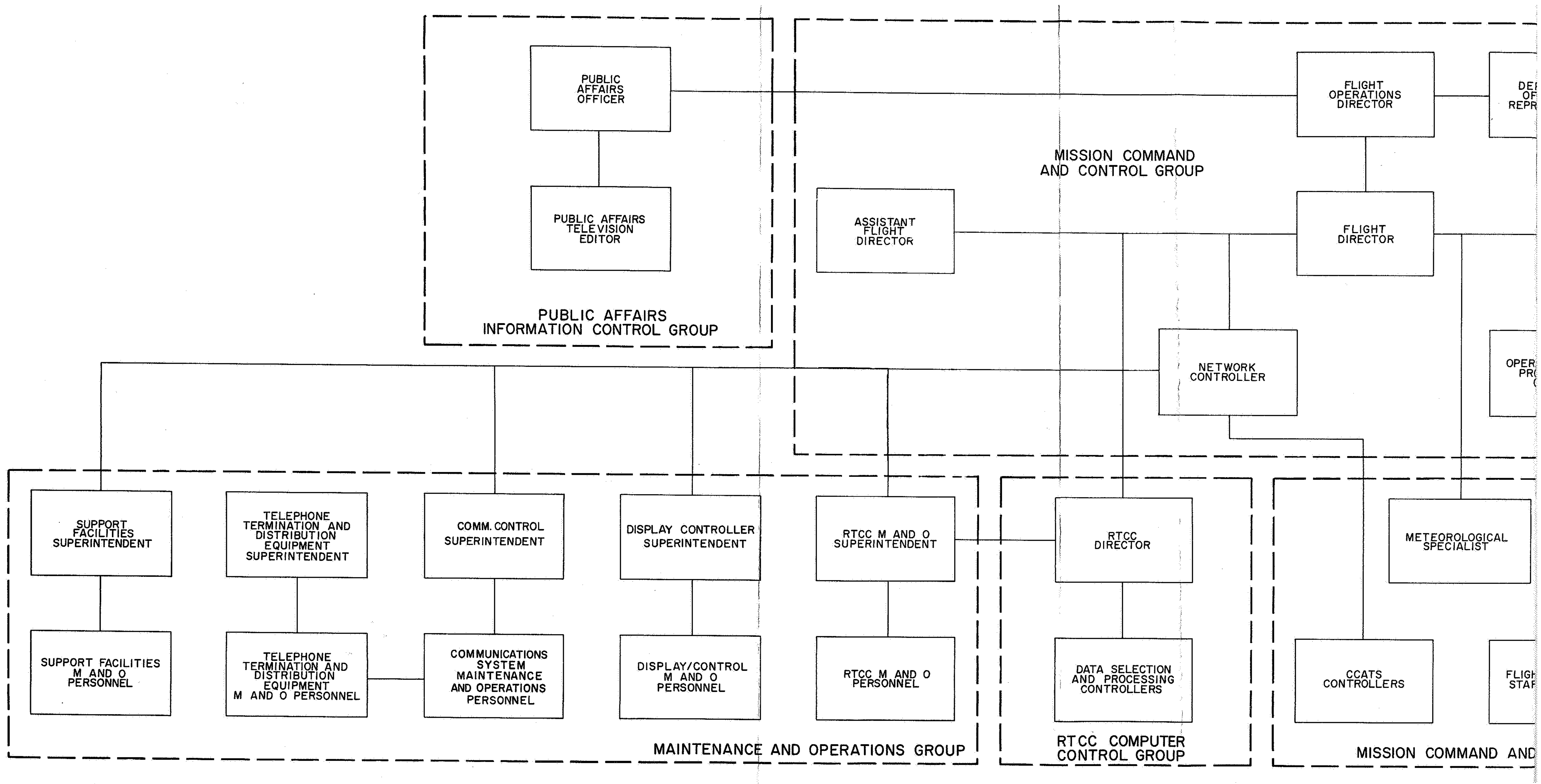
5-7. MAINTENANCE AND OPERATIONS GROUP

The Maintenance and Operations Group is responsible for the performance of MCC-H equipment and its ability to support a mission. During nonmission periods, the group accomplishes corrective and preventive maintenance on the MCC-H equipment as necessary to ensure optimum performance. During mission periods, the group operates specified equipment, monitors equipment performance, and performs critical maintenance as required.

The Maintenance and Operations Group is directed by the Network Controller who exercises operational control of all MCC-H equipment during mission periods.

5-8. PUBLIC AFFAIRS INFORMATION CONTROL GROUP

The Public Affairs Information Control Group coordinates public affairs information with commercial news media and other interested agencies. The group does not engage in mission control activities.


PUBLIC AFFAIRS OFFICER
PUBLIC AFFAIRS TELEVISION EDITOR
PUBLIC AFFAIRS INFORMATION CONTROL GROUP
MISSION COMMAND AND CONTROL GROUP
ASSISTANT FLIGHT DIRECTOR
FLIGHT OPERATIONS DIRECTOR
FLIGHT DIRECTOR
NETWORK CONTROLLER
SUPPORT FACILITIES SUPERINTENDENT
SUPPORT FACILITIES M AND O PERSONNEL
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT SUPERINTENDENT
TELEPHONE TERMINATION AND DISTRIBUTION EQUIPMENT M AND O PERSONNEL
COMM. CONTROL SUPERINTENDENT
COMMUNICATIONS SYSTEM MAINTENANCE AND OPERATIONS PERSONNEL
DISPLAY CONTROLLER SUPERINTENDENT
DISPLAY/CONTROL M AND O PERSONNEL
RTCC M AND O SUPERINTENDENT
RTCC M AND O PERSONNEL
MAINTENANCE AND OPERATIONS GROUP
RTCC DIRECTOR
DATA SELECTION AND PROCESSING CONTROLLERS
RTCC COMPUTER CONTROL GROUP
METEOROLOGICAL SPECIALIST
CCATS CONTROLLERS
MISSION COMMAND AND

B

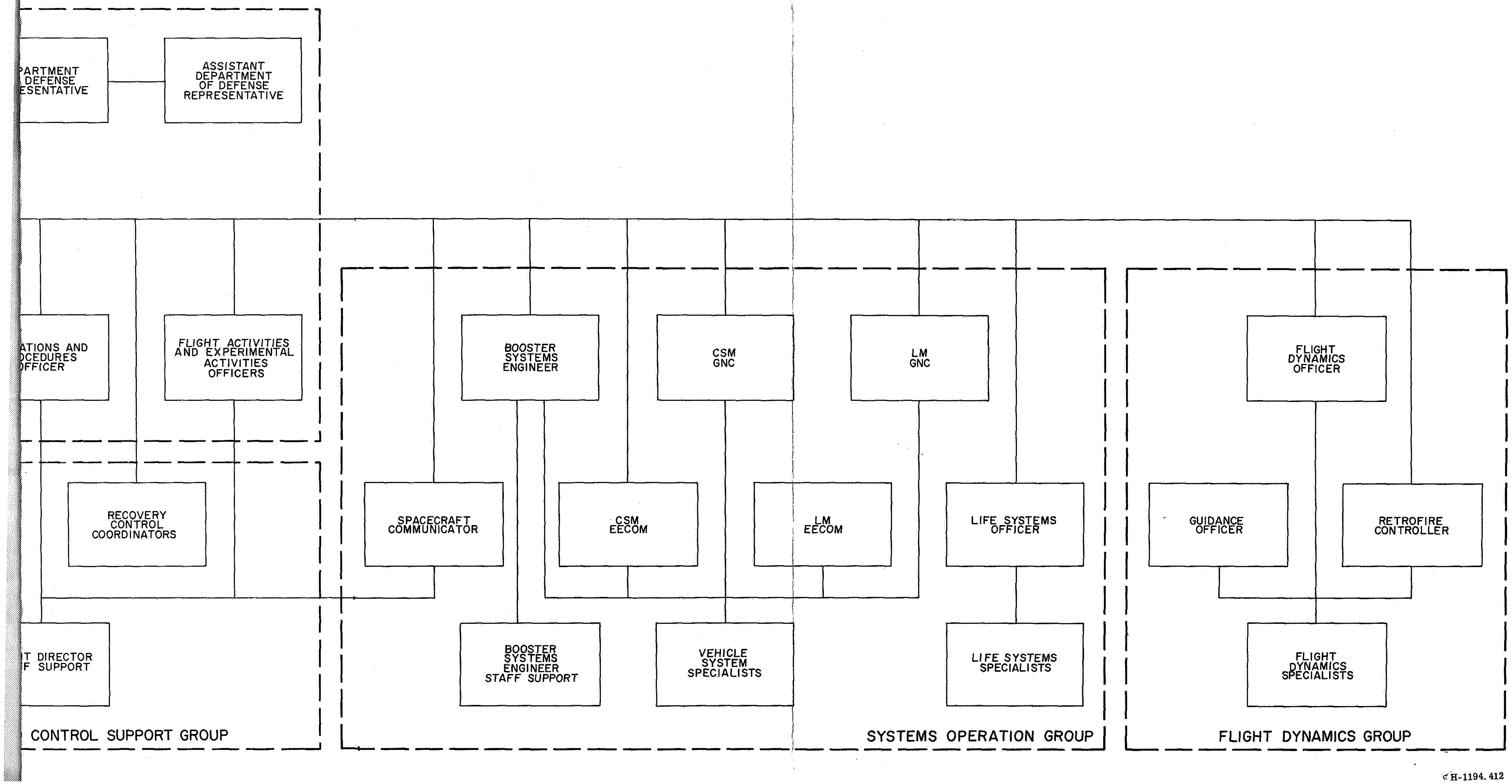
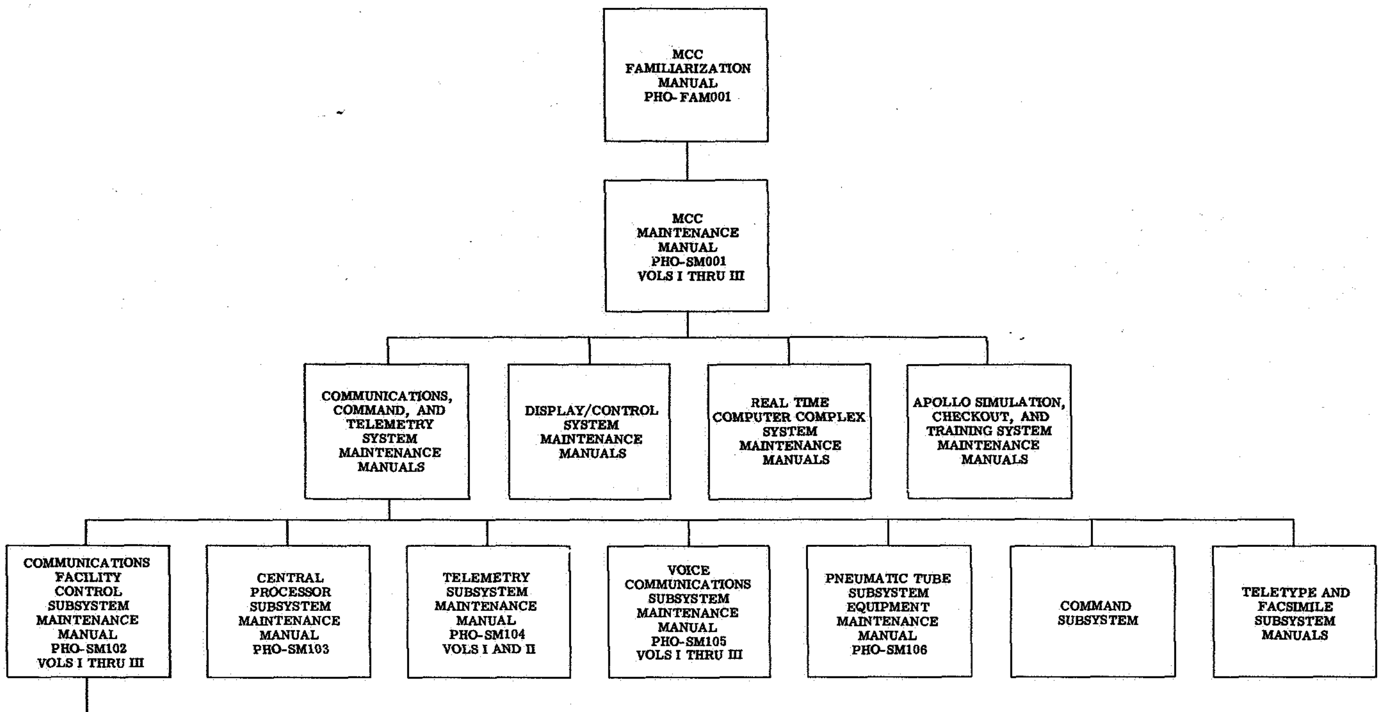


Figure 5-1. MCC-Houston, Organizational Chart

APPENDIX A
MCC-HOUSTON SUPPORT MANUALS

The support manuals, containing detailed technical descriptions of the MCC-H functional equipment, are listed in the system/subsystem family of manuals illustrations in figures A-1 through A-11. Each family of manuals illustration lists the three functional systems within MCC-H and, when applicable, all related subsystem and equipment maintenance manuals. Refer to appendix C for the ASCATS family of manuals.



PHO-EM001	STANDARD DIGITAL COMPONENTS
PHO-EM002	LOGIC CARD TESTER (VOLS I AND II)
PHO-EM114	HIGH-SPEED DATA TEST AND PATCH EQUIPMENT (VOLS I AND II)
PHO-EM115	HIGH-SPEED DATA RECORDING FACILITY (VOLS I AND II)
PHO-EM116	TELETYPE TEST AND PATCH EQUIPMENT
PHO-EM118	AUDIO TEST AND PATCH EQUIPMENT
PHO-EM122	MAGNETIC TAPE RECORDER/REPRODUCER PHO-OA1451 (VOLS I AND II)
PHO-EM129	SOUND RECORDER/REPRODUCERS PHO-RD1002 AND PHO-RD1003
PHO-EM130	SOUND RECORDER PHO-RP1001 (DUAL SPEAKER AMPLIFIER)
PHO-EM134	TELEDATA ANALYSIS SET PHO-SG1015 (VOLS I THRU III)
PHO-EM140	WIDE BAND DATA TRANSFER SWITCH EQUIPMENT
PHO-EM141	TAPE READER AND SPOOLER EQUIPMENT
PHO-EM142	CHECKOUT SUBCHANNEL BUFFER PHO-OA1462
PHO-EM143	HIGH-SPEED TRANSLATOR PHO-CV1024 AND HIGH-SPEED TELEPRINTER PHO-TT1016
PHO-EM144	HIGH-SPEED TELEPRINTER INTERFACE EQUIPMENT PHO-OA1474
PHO-EM145	DIGITAL DATA RECEIVER PHO-YR1010
PHO-EM146	WIDE BAND DATA PATCH AND CONTROL EQUIPMENT (VOLS I AND II)
PHO-EM147	OSCILLOSCOPE PHO-OA1017
PHO-EM236	DIGITAL DISPLAY INDICATOR PHO-ID1062 (TIME DISPLAY UNIT)
PHO-EM317	LINE TRANSMITTER/RECEIVER
PHO-EM625	MEMORY UNIT PHO-MU1006
PHO-SM404	STATUS AND VERIFICATION RECEIVING SUBSYSTEM EQUIPMENT
PHO-SM504	COUNTDOWN AND STATUS RECEIVING SUBSYSTEM EQUIPMENT
*RTCC 102	DATA CONTROL UNIT TYPES 1 THRU 8-VOLUMES I AND II (INTERNATIONAL BUSINESS MACHINES CORPORATION)
NASA	TELETYPE MONITOR CONSOLE (TELETYPE CORPORATION)
NASA	201A DATA SET (BELL SYSTEM)
NASA	201B DATA SET (BELL SYSTEM)
NASA	301B DATA SET (BELL SYSTEM)

*MANUFACTURERS HANDBOOK DESIGNATION

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Figure A-1. Communications Facility Control Subsystem Family of Manuals

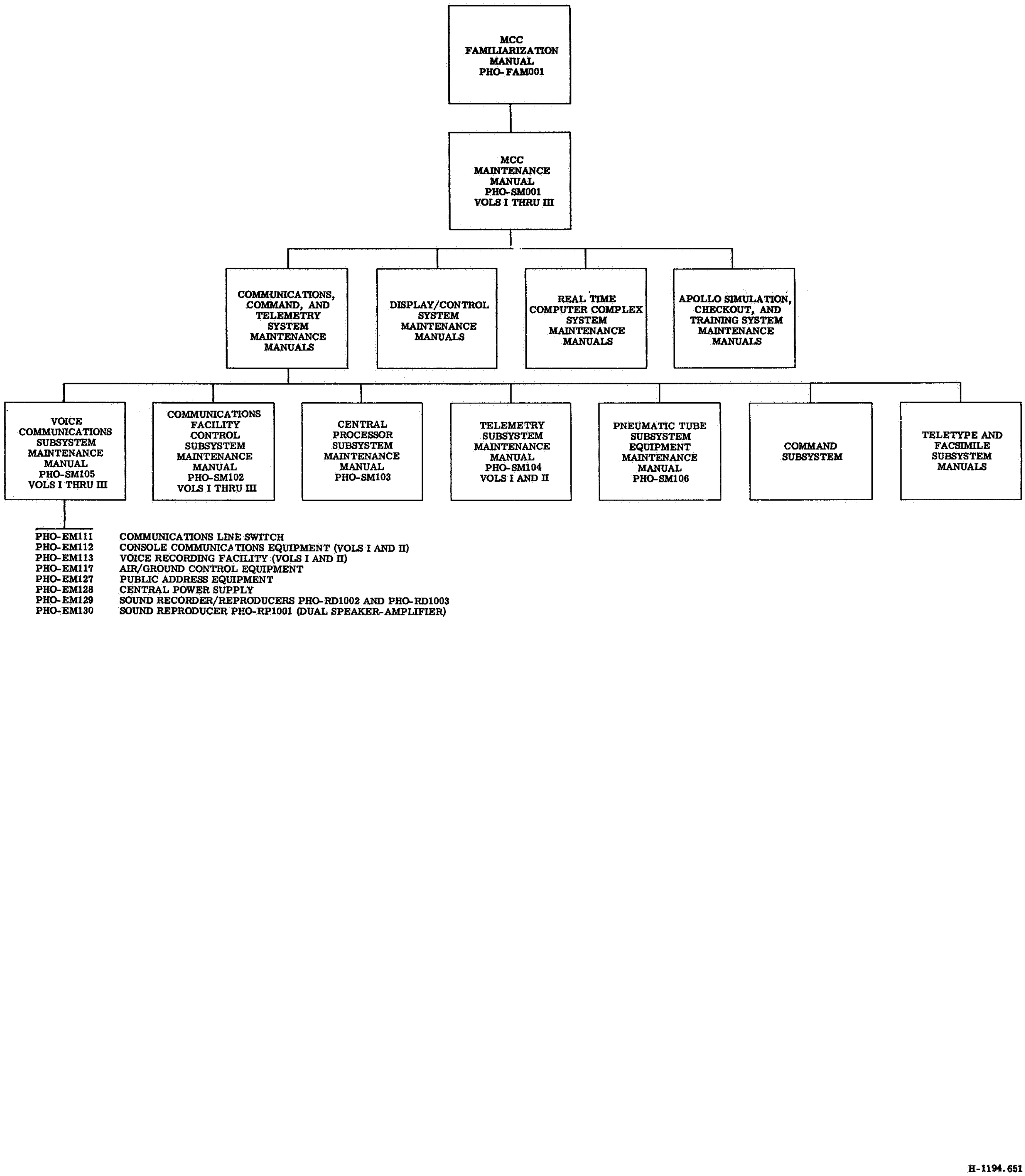
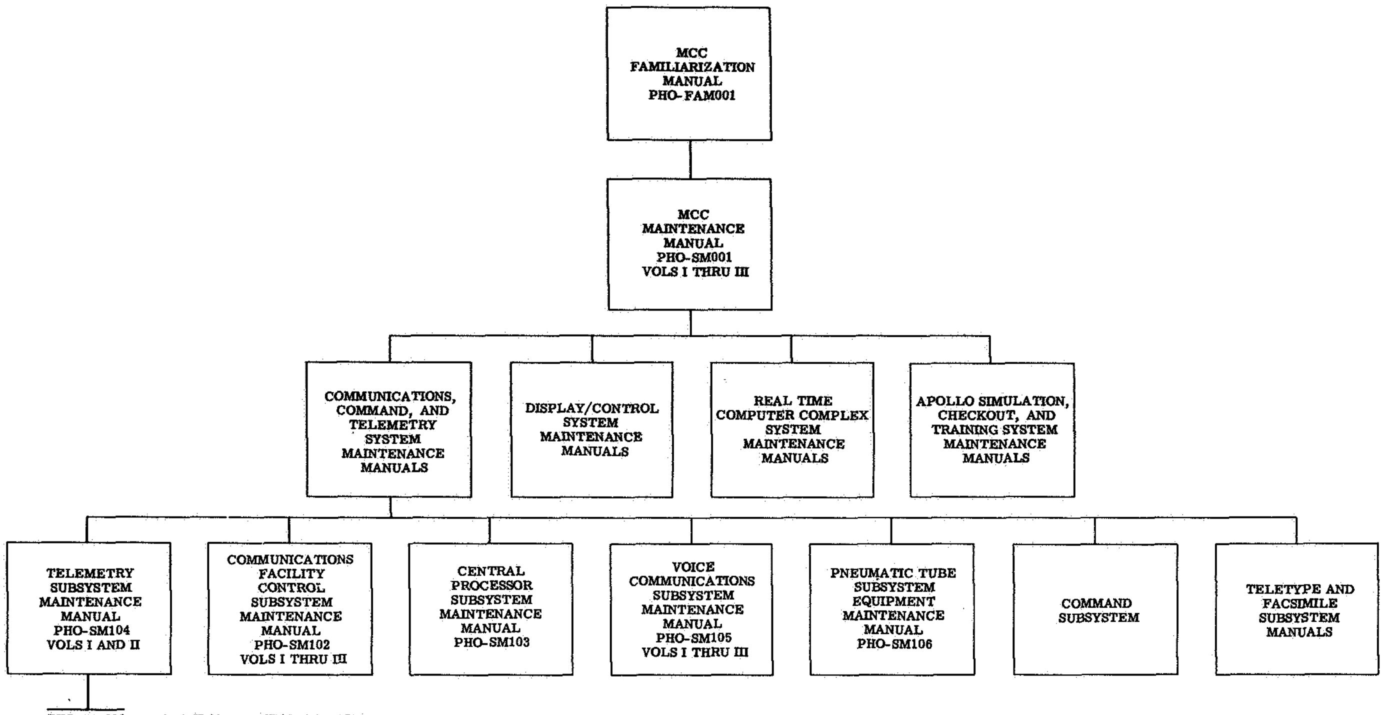


Figure A-2. Voice Communications Subsystem Family of Manuals



PHO-EM001 STANDARD DIGITAL COMPONENTS
PHO-EM002 LOGIC CARD TESTER (VOLS I AND II)
PHO-EM124 OUTPUT TRANSFER SWITCH EQUIPMENT
PHO-EM126 FM GROUND STATION EQUIPMENT (VOLS I AND II)
PHO-EM131 CHART RECORDER PHO-OA1261
PHO-EM132 EVENT RECORDER PHO-OA1153
PHO-EM133 TELEMETRY SUPERVISOR CONSOLE EQUIPMENT (VOLS I THRU III)
PHO-EM135 TELEMETRY EVENT DECODER EQUIPMENT
PHO-EM148 BIOMEDICAL DATA ANALYSIS AND DISPLAY EQUIPMENT PHO-OA1621
PHO-EM149 CHART RECORDER PHO-TS1051
PHO-EM223 DIGITAL DISPLAY DRIVER SUBCHANNEL DATA DISTRIBUTOR
PHO-EM245 TELEMETRY EVENT DRIVERS PHO-OA1175
PHO-EM257 CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
PHO-EM258 DIGITAL DISPLAY DRIVERS WDL-OA-623
PHO-EM311 PCM GROUND STATION PHO-OA1248 (VOLS I AND II)
PHO-EM331 PCM GROUND STATION LOGIC ELEMENTS

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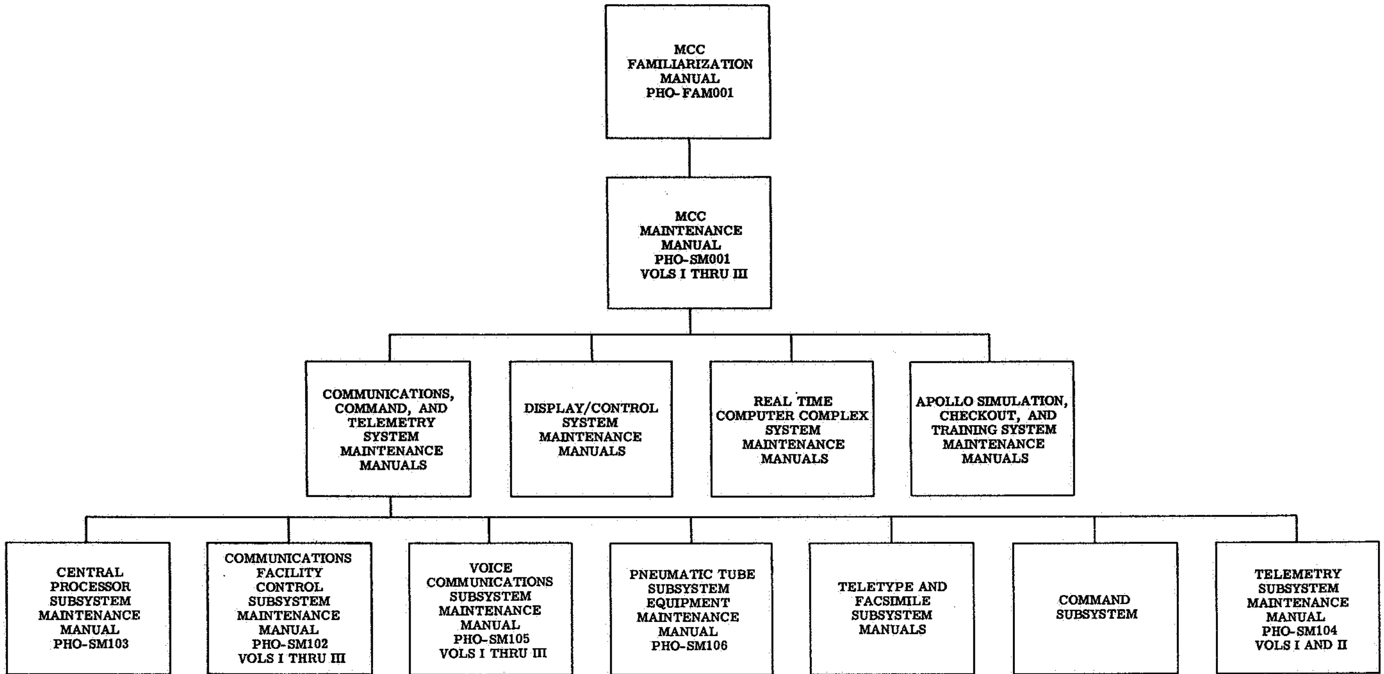
Figure A-3. Telemetry Subsystem Family of Manuals



PHO-EM143	HIGH-SPEED TRANSLATOR PHO-CV1024 AND HIGH-SPEED TELEPRINTER PHO-TT1016
PHO-EM257	CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
*HB1603	UNISERVO IIIC SUBSYSTEM (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1617	PERIPHERAL EQUIP. POWER DISTRIBUTION (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1642	CONTROL CONSOLE (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1652	ELECTRONIC TRANSFER SWITCHES (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1665	FH-880 DRUM SUBSYSTEM (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1667	U-494 CENT. PROCESSOR - VOLS I AND II (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1668	CORE MEMORY TYPE 7005-02 AND 7005-06 (UNIVAC DIVISION OF SPERRY RAND CORP.)
*HB1700	U-1004 MAINT. HANDBOOK - VOLS I AND II (UNIVAC DIVISION OF SPERRY RAND CORP.)
*MA1214	STANDARD COMM. SUBSYSTEM (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2043	UNISERVO IIIC TAC (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2218	LINE ISOLATOR - WIDE BAND (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2233	FH-880 DRUM CONTROL AND POWER (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2238	UNISERVO IIIC CONTROL AND POWER (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2440	UNISERVO IIIC (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2772	I/O TRANSFER SWITCHES (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2775	CONTROL CONSOLE (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX2785	FH-880 DRUM (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3076	U-494 MEMORY TYPE 7005-02 (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3079	U-494 MEMORY TYPE 7005-06 (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3088	U-494 CENT. PROCESSOR - VOLS I AND II (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3142	STANDARD COMM. SUBSYSTEM - LO SPEED (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3217	LINE ISOLATOR - HI SPEED (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3408	U-494/7094 HI SPEED ADAPTER (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3775	STANDARD COMM. SUBSYSTEM - HI SPEED (UNIVAC DIVISION OF SPERRY RAND CORP.)
*PX3901	SPECIAL POLYNOMIAL SUBSYSTEM (UNIVAC DIVISION OF SPERRY RAND CORP.)
GFE	MODEL 28 KEYBOARD SEND-RECEIVE SET (TELETYPE CORPORATION)

*MANUFACTURER'S HANDBOOK DESIGNATION

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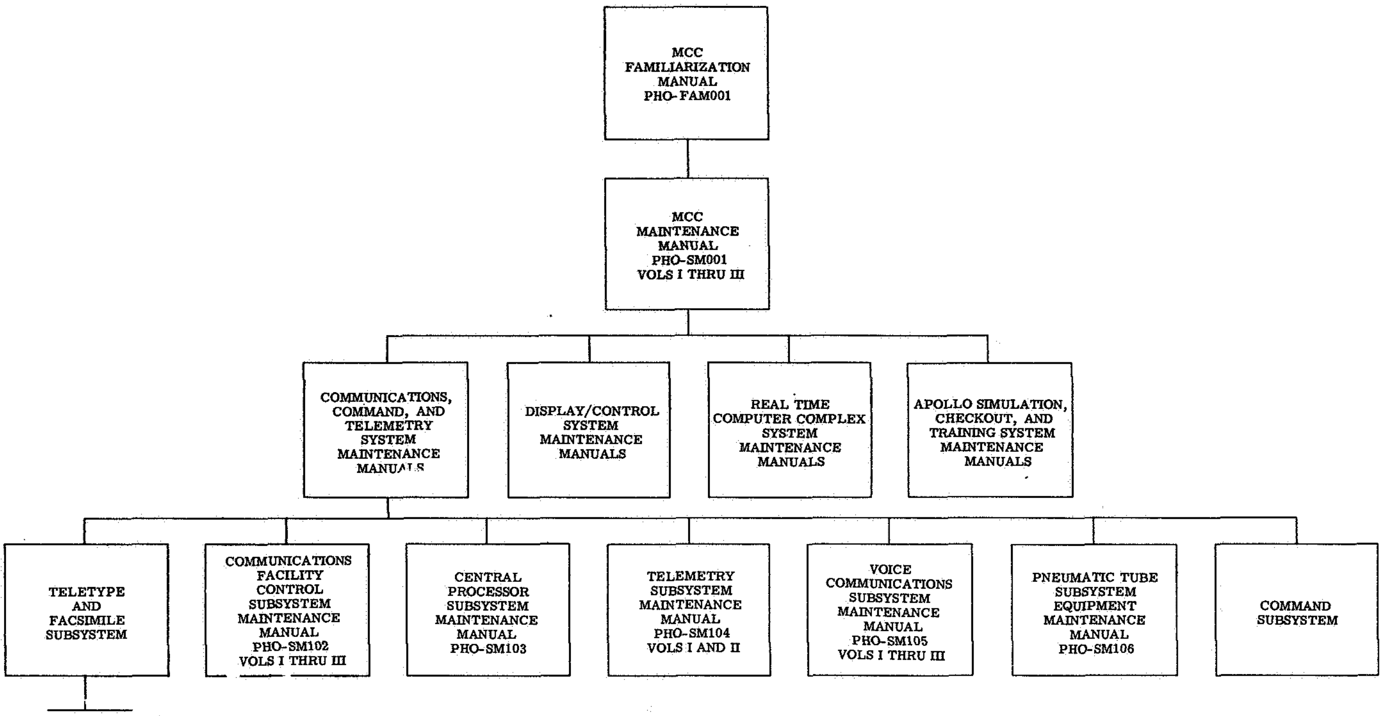
Figure A-4. Central Processor Subsystem Family of Manuals



NASA	MODEL R-759 (XC-2/GX) MODIFIED, FACSIMILE RECEIVER (WESTREX DIVISION OF LITTON SYSTEMS INCORPORATED)
NASA	MODEL 9244, FULLY AUTOMATIC CONTINUOUS FACSIMILE RECORDER (ALDEN ELECTRONIC AND IMPULSE RECORDING EQUIPMENT COMPANY)
NASA	MODEL 9208C, 11-INCH CONTINUOUS FLAT COPY SCANNER TRANSMITTER (ALDEN ELECTRONIC AND IMPULSE RECORDING EQUIPMENT COMPANY)
NASA	CALL DIRECTOR (BELL SYSTEM)
NASA-ME519	MODEL 28 PRINTER, GENERAL DESCRIPTION AND THEORY OF OPERATION (TELETYPE CORPORATION)
NASA-ME520	MODEL 28 PAGE PRINTER SET LP, LK, LB, LAC, ADJUSTMENTS AND LUBRICATION (TELETYPE CORPORATION)
NASA-ME522	MODEL 28 TRANSMITTER DISTRIBUTOR LXD, LXDB, LXDC, ADJUSTMENTS AND LUBRICATION (TELETYPE CORPORATION)
NASA-ME523	MODEL 28 TYPING REPERFORATOR SET LPR, LRB, LRC, LT, DESCRIPTION AND PRINCIPLES OF OPERATION (TELETYPE CORPORATION)
NASA-ME524	MODEL 28 TYPING REPERFORATOR SET, ADJUSTMENTS AND LUBRICATION (TELETYPE CORPORATION)
NASA-ME526	MODEL 28 PERFORATOR TRANSMITTER LAK, LPE, LAAC, DESCRIPTION AND THEORY OF OPERATION (TELETYPE CORPORATION)
NASA-ME527	MODEL 28 PERFORATOR TRANSMITTER LAK, LPE, LTPE, LAC, ADJUSTMENTS AND LUBRICATION (TELETYPE CORPORATION)
NASA-ME528	MODEL 28 TRANSMITTER DISTRIBUTOR LAXD, DESCRIPTION AND THEORY OF OPERATION (TELETYPE CORPORATION)
NASA-ME529	MODEL 28 TRANSMITTER DISTRIBUTOR LAXD, ADJUSTMENTS AND LUBRICATION (TELETYPE CORPORATION)
NASA-ME531	MODEL 28 TRANSMITTER DISTRIBUTOR LXD, LXDB, LXDC, DESCRIPTION AND PRINCIPLES OF OPERATION (TELETYPE CORPORATION)
NASA-ME541	MODEL 28 TRANSMITTER DISTRIBUTOR SET (28TD), FIXED HEAD SINGLE CONTACT TYPE, PARTS BREAKDOWN (TELETYPE CORPORATION)
NASA-ME544	MODEL 28 TYPING REPERFORATOR SET (LPR), PARTS BREAKDOWN (TELETYPE CORPORATION)
NASA-ME546	MODEL 28 AUTOMATIC SEND-RECEIVE SET (ASR), PARTS BREAKDOWN (TELETYPE CORPORATION)
NASA-ME548	MODEL 28 TAPE SPLICER (LTS), PARTS BREAKDOWN (TELETYPE CORPORATION)
NASA	MODEL R-759 (XC-2)/GX MODIFIED, FACSIMILE RECEIVER (WESTREX DIVISION OF LITTON SYSTEMS INCORPORATED)
NASA	MODEL 9244, FULLY AUTOMATIC CONTINUOUS FACSIMILE RECORDER (ALDEN ELECTRONIC AND IMPULSE RECORDING EQUIPMENT COMPANY)
NASA	MODEL 9208C, 11-INCH CONTINUOUS FLAT COPY SCANNER TRANSMITTER (ALDEN ELECTRONIC AND IMPULSE RECORDING EQUIPMENT COMPANY)
NASA	CALL DIRECTOR (BELL SYSTEM)
NASA	TELETYPE LOOP SWITCHBOARD (BELL SYSTEM)

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Figure A-5. Teletype and Facsimile Subsystem Family of Manuals

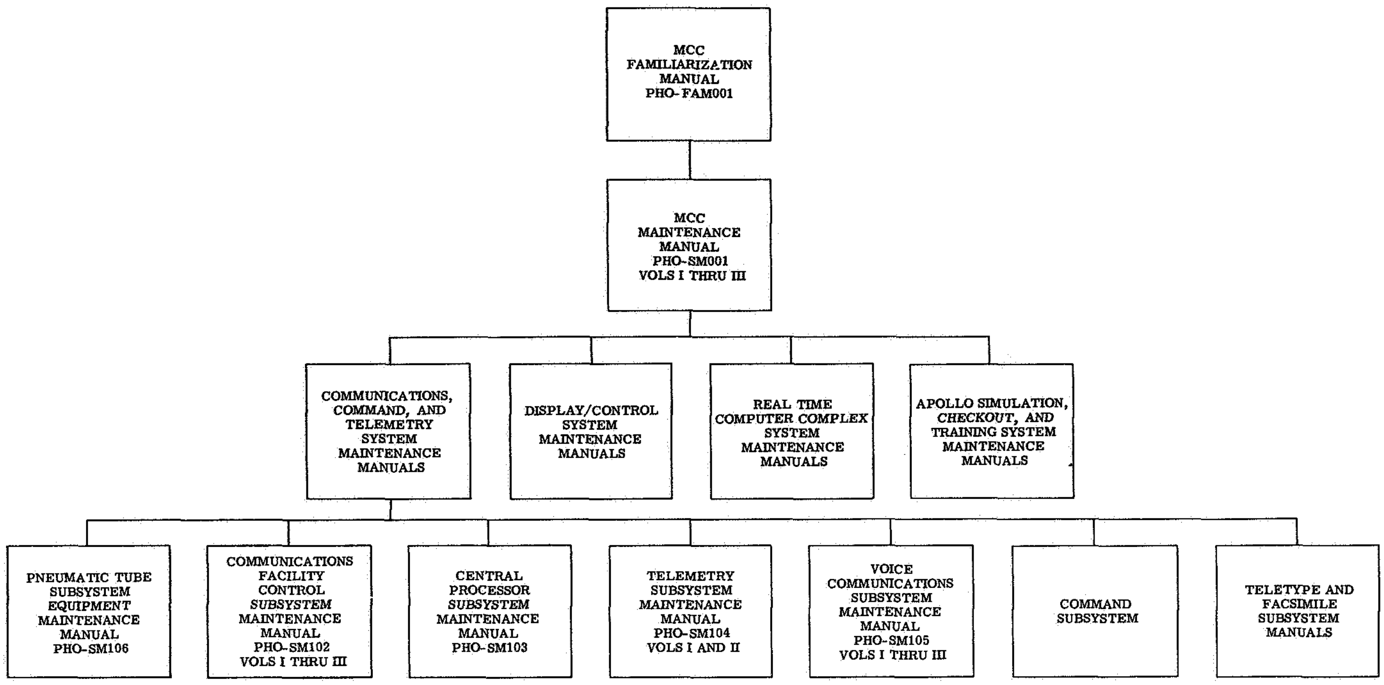
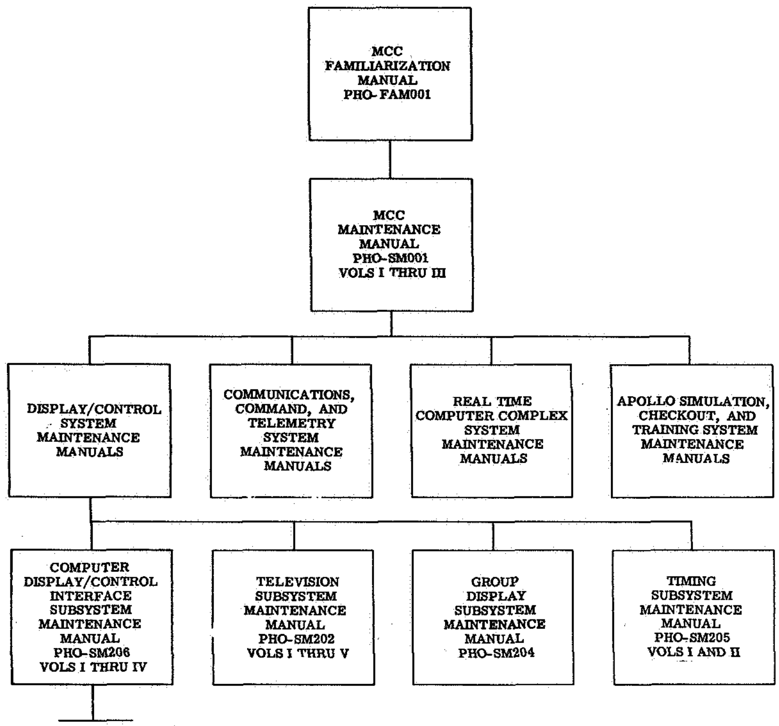


Figure A-6. Pneumatic Tube Subsystem Family of Manuals



PHO-EM001	STANDARD DIGITAL COMPONENTS
PHO-EM002	LOGIC CARD TESTER (VOLS I AND II)
PHO-EM211	DIGITAL-TO-TELEVISION CONVERTER (VOLS I AND II)
PHO-EM212	SLIDE FILE EQUIPMENT
PHO-EM217	DIGITAL-TO-TELEVISION CAMERA AND CONTROL EQUIPMENT
PHO-EM220	RTCC ENCODER/MULTIPLEXER EQUIPMENT (VOLS I THRU III)
PHO-EM221	DIGITAL DISPLAY DRIVER EQUIPMENT
PHO-EM223	DIGITAL DISPLAY DRIVER SUBCHANNEL DATA DISTRIBUTOR
PHO-EM224	CONVERTER SLIDE FILE DATA DISTRIBUTOR PHO-OA1213
PHO-EM227	FILE SLIDE MAKING EQUIPMENT
PHO-EM245	TELEMETRY EVENT DRIVERS PHO-OA1175
PHO-EM247	POWER SUPPLIES PHO-PP1012 AND PHO-PP1127
PHO-EM253	DIGITAL-TO-ANALOG CONVERTER EQUIPMENT PHO-OA1366
PHO-EM257	CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
PHO-EM262	DIGITAL-TO-ANALOG CONVERTER EQUIPMENT PHO-OA1612
PHO-EM263	ENCODER EQUIPMENT PHO-OA1599 (VOLS I THRU IV)
PHO-EM271	COMPUTER RESTART MODULE PHO-YC1417
PHO-EM272	CCATS ENCODER/MULTIPLEXER EQUIPMENT (VOLS I AND II)
PHO-EM330	EVENT MONITORING EQUIPMENT
NASA	FOUR-CHANNEL CARDIOSCOPE GEM3147571 (BENDIX-PACIFIC)
NASA	FOUR-CHANNEL CARDIOSCOPE REMOTE CONTROL PANEL GEM3147572 (BENDIX-PACIFIC)

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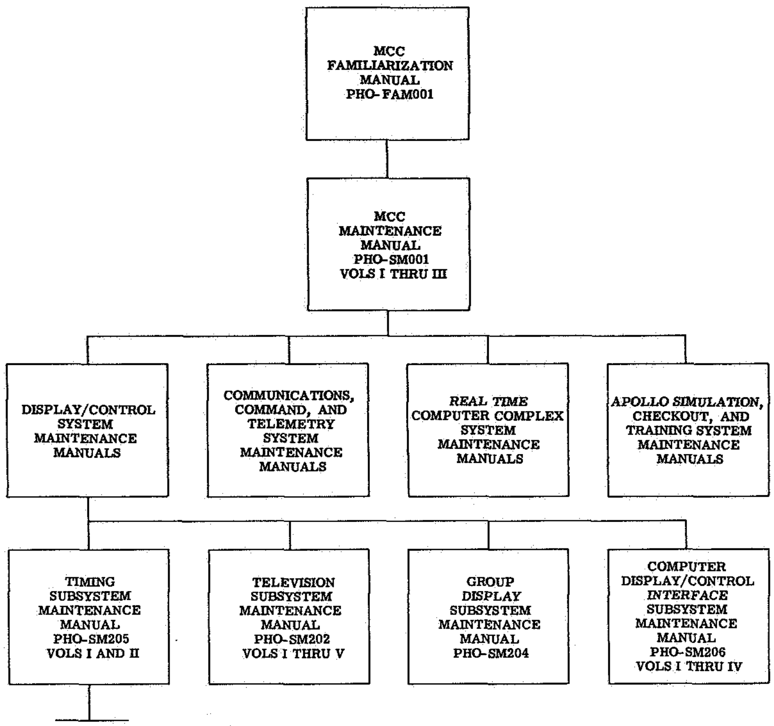
Figure A-7. Computer Display/Control Interface Subsystem Family of Manuals



PHO-EM001	STANDARD DIGITAL COMPONENTS
PHO-EM002	LOGIC CARD TESTER (VOLS I AND II)
PHO-EM218	MASTER INSTRUMENTATION TIMING EQUIPMENT (VOLS I AND II)
PHO-EM219	RELATIVE TIME ACCUMULATOR (VOLS I AND II)
PHO-EM225	SIGNAL DATA CONVERTER PHO-CV1002 (SERIAL DECIMAL TIME CONVERTER)
PHO-EM228	WALL CLOCK EQUIPMENT
PHO-EM229	ATLANTIC MISSILE RANGE COUNTDOWN PROCESSOR EQUIPMENT
PHO-EM230	STOP CLOCK EQUIPMENT
PHO-EM231	SIGNAL DATA CONVERTER PHO-CV1001 (MERCURY TIMING SIMULATOR)
PHO-EM236	DIGITAL DISPLAY INDICATOR PHO-ID1062 (TIME DISPLAY UNIT)
PHO-EM255	DUAL STOP CLOCK EQUIPMENT PHO-YC1261
PHO-EM256	TIMING INTERFACE UNIT
PHO-EM257	CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
PHO-EM261	EVENT RECORDER TIMING INTERFACE UNIT PHO-MX1440
PHO-EM270	TIME COINCIDENCE EQUIPMENT

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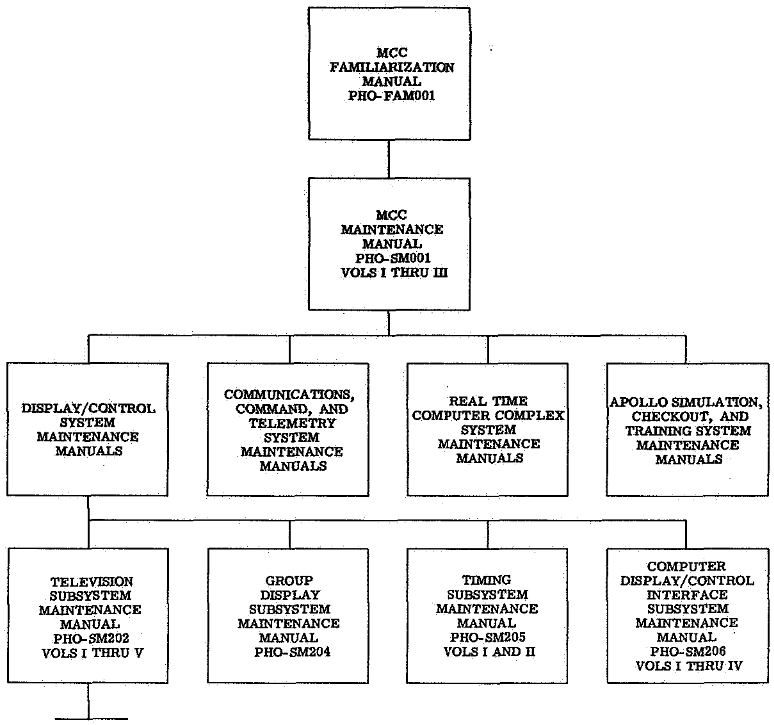
Figure A-8. Timing Subsystem Family of Manuals



PHO-EM001	STANDARD DIGITAL COMPONENTS
PHO-EM002	LOGIC CARD TESTER (VOLS I AND II)
PHO-EM213	TELEVISION CAMERA CHAIN EQUIPMENT
PHO-EM214	VIDEO SWITCHING MATRICES
PHO-EM215	TELEVISION VIEWERS PHO-IP1006, PHO-IP1007, AND PHO-IP1030
PHO-EM216	TELEVISION VIEWER PHO-IP1001
PHO-EM217	DIGITAL-TO-TELEVISION CAMERA AND CONTROL EQUIPMENT
PHO-EM237	VIDEO AND PULSE DISTRIBUTION EQUIPMENT
PHO-EM238	VIDEO TAPE RECORDER (VOLS I THRU V)
PHO-EM239	TIME ELEMENT COMPENSATOR
PHO-EM240	VIDEO SCANNER CONTROL PHO-OA1211
PHO-EM241	HARDCOPY RECORDER
PHO-EM242	TELEVISION TEST GENERATOR
PHO-EM243	ELECTRICAL SYNCHRONIZERS PHO-SN1002 AND PHO-SN1003 (TELEVISION SYNC GENERATORS)
PHO-EM244	TIME DISPLAY CONVERTER PHO-OA1073
PHO-EM246	STABILIZING AMPLIFIER PHO-AM1004
PHO-EM247	POWER SUPPLIES PHO-PP1012 AND PHO-PP1127
PHO-EM248	VIDEO WAVEFORM MONITOR PHO-OS1002
PHO-EM249	TELEVISION RECEIVER PHO-YC1249
PHO-EM250	TELEVISION VIEWER PHO-IP1008
PHO-EM251	TELEVISION VIEWERS PHO-IP1002, PHO-IP1003, PHO-IP1004, AND PHO-IP1005
PHO-EM252	TELEVISION EDITOR SWITCHING MATRIX PHO-YC1209
PHO-EM254	TELEVISION VIEWER PHO-IP1017
PHO-EM257	CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
PHO-EM259	VIDEO TRANSMITTER PHO-YT1006 AND VIDEO RECEIVER PHO-YR1007
PHO-EM264	TELEVISION SYNC GENERATOR
PHO-EM265	IMAGE ORTHICON CAMERA CHAIN EQUIPMENT
PHO-EM266	TELEVISION SUBSYSTEM MISCELLANEOUS COMPONENTS
PHO-EM267	VIDEO AND PULSE DISTRIBUTION EQUIPMENT (1000 SERIES)
PHO-EM268	TELEVISION VIEWER PHO-IP1024
PHO-EM269	SPECIAL EFFECTS GENERATOR
PHO-EM320	VIDEO AMPLIFIER PHO-AM1019

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Figure A-9. Television Subsystem Family of Manuals

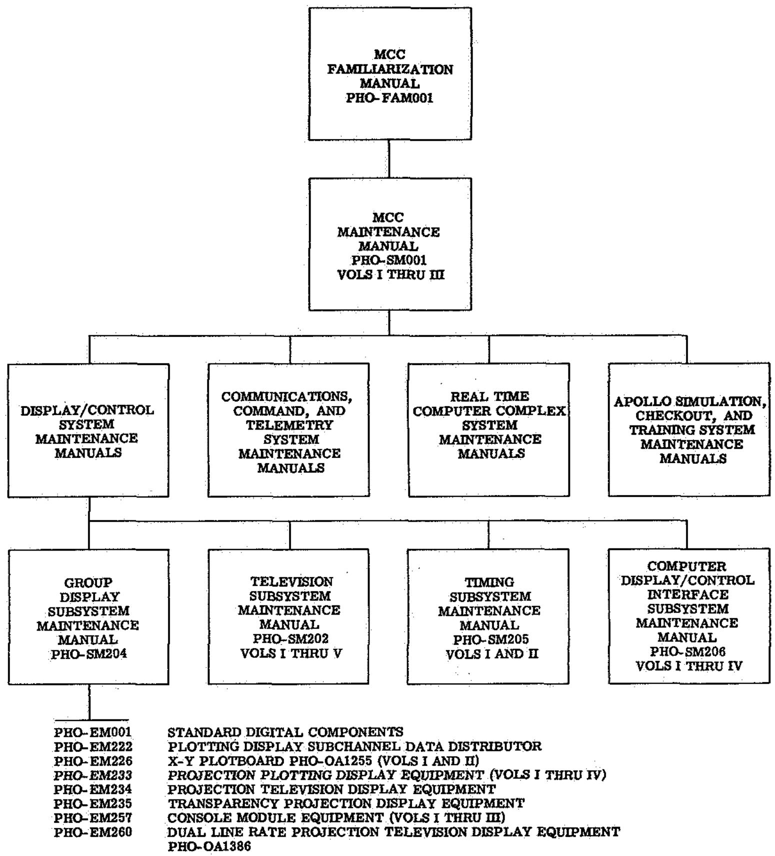

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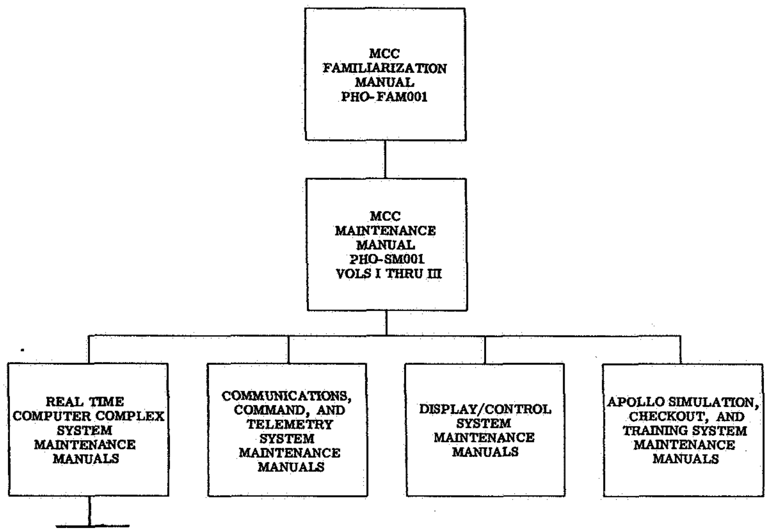
Figure A-10. Group Display Subsystem Family of Manuals



*RTCC-101	COMPUTER MONITOR AND CONTROL CONSOLE (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-102	DATA CONTROL UNITS (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-103	DYNAMIC TEST PATTERN GENERATOR (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-104	SYSTEM SELECTOR UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-105	COMPUTER CONTROLLER MULTIPLEXER UNIT AND CONTROL AREA JUNCTION UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-106	OPERATIONAL DATA RECORDER (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-107	X-Y RECORDER (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*RTCC-108	MANUAL ENTRY DEVICE (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A21-9026	CARD PROCESSOR (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A22-6864-1	DATA ADAPTER UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A22-6866	MAGNETIC TAPE UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A22-6869	CORE STORAGE UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A22-6877	CENTRAL PROCESSOR CONTROL CONSOLE AND PRINTER, KEYBOARD (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A22-6889-0	360/75 CENTRAL PROCESSOR UNIT AND CENTRAL PROCESSOR MEMORY UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A24-3073-3	PRINTER, KEYBOARD (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A24-3120	PRINTER, KEYBOARD (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A24-3312	CARD PROCESSOR, PRINTER CONTROL UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A26-3567	DISC STORAGE DRIVE UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)
*A26-5988-3	DISC STORAGE CONTROL UNIT (INTERNATIONAL BUSINESS MACHINES CORPORATION)

*MANUFACTURER'S HANDBOOK DESIGNATION

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Figure A-11. Real Time Computer Complex System Family of Manuals

APPENDIX B
GENERAL DESCRIPTION OF MANNED SPACEFLIGHT NETWORK

During operational missions, the Manned Spaceflight Network functions as a remote arm of the MCC-H. A discussion of the basic Manned Spaceflight Network/ MCC-Houston data interchange requirements follows.

The Manned Spaceflight Network is divided into two types of facilities: Deep Space Instrumentation and Near Space Instrumentation Facilities. Earth orbital missions are monitored and controlled by the Near Space Instrumentation Facilities. At such time as the spacecraft departs the earth orbit and starts its flight towards outerspace, the Deep Space Instrumentation Facilities will actively replace the Near Space Instrumentation Facilities in the monitor and control function. The Deep Space Instrumentation Facilities consist of 3 remote sites while the Near Space Instrumentation Facilities total 11. Additionally, there are five ships, three for the insertion and injection phase and two for the reentry phase. Further assisting the Manned Spacecraft Network are eight specially equipped JC-135A aircraft. Figure B-1 shows the geographical location (except for the aircraft and ships) and the capabilities of each station in the network.

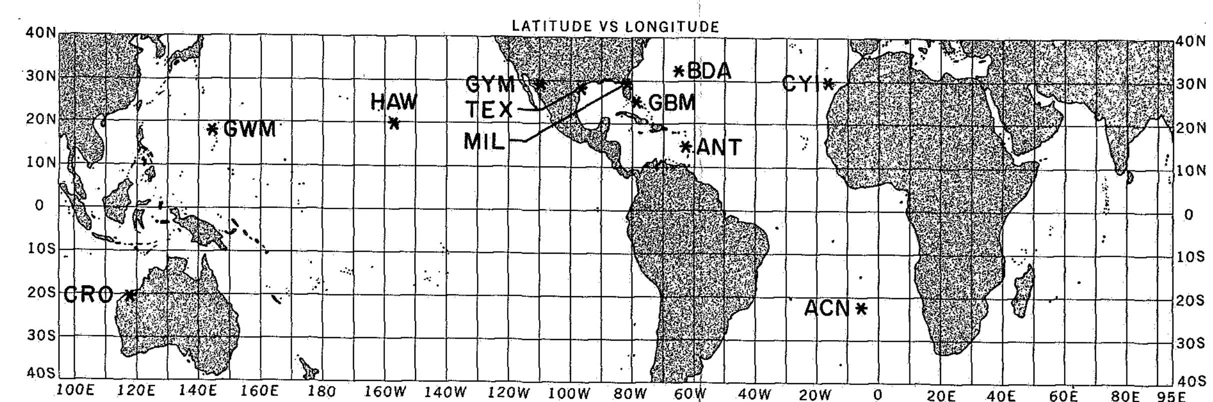
Five basic types of spacecraft data interchange between the MCC-H and the Manned Spaceflight Network are required: ephemeris, tracking, acquisition, telemetry, and command. Ephemeris data, which is required only during rendezvous and docking missions, giving the position of an orbiting target vehicle is transmitted to KSC prior to spacecraft launch. Launch vehicle guidance systems require this information so that proper trajectory can be achieved for orbital rendezvous. Tracking data is obtained by following the spacecraft with tracking antennas and noting its spatial position and velocity. In this way, the position of the spacecraft is known at all times and may be predicted in advance of a predetermined time. Acquisition data, giving the computed point at which a particular tracking station should pick up (acquire) and commence tracking the spacecraft, is sent to each tracking station. This data tells the station where to point its tracking antenna for initial pickup of the spacecraft. Telemetry data is obtained by making selected measurements on the spacecraft crew members, life support systems, and vehicle systems throughout a mission and transmitting (telemetering) the measured data to telemetry data receiving equipment. This data enables the MCC-H flight controllers and associated specialists to monitor and analyze the performance of the flight crew and spacecraft, since the normal value of each measurement is known and any abnormal deviation can be quickly detected. Some of the telemetered data is bilevel (on-off) event information that indicates the occurrence of events scheduled to occur at certain times during a mission. The flight controllers monitor the status (too early, too late, on time) of the events and initiate appropriate actions as necessary. At various times during a mission, it is necessary to issue command data to control certain vehicle system functions. The necessary command is initiated at the appropriate time by the responsible flight controller and transmitted to the spacecraft.

All data is exchanged between the MCC-H and the Manned Spaceflight Network in digital coded form except selected biomedical telemetry measurements, which are transmitted to the MCC-H in frequency-modulated form. All other telemetry measurements arrive at the MCC-H in pulse-code-modulated form. The basic difference between the two is that the frequency-modulated data is frequency divided (each measurement occupies a different frequency band) and the pulse-code-modulated data is time divided (each measurement occupies different intervals of time). In the first case, each measurement is allocated to a different frequency band and all measurements are multiplexed at the remote station onto a single audio line for transmission to the MCC-H. In the latter case, each measurement is allocated to different periods of time and binarily coded. The resultant time-multiplexed stream of 1's and 0's, which represent in binary notation the specific values of measured data, are applied to a single wide band data, high-speed data, or teletype line (depending upon the station) for transmission to the MCC-H.

The pulse-code-modulated data transmission technique is used to exchange all data, including biomedical data, between spacecraft and the Manned Spaceflight Network. Each station then picks out the biomedical data and routes it to the MCC-H in frequency-modulated form over specially assigned audio lines. All other data, as indicated in the preceding paragraph, is routed to the MCC-H in pulse-code-modulated (digital coded) form, whether it is routed over a wide band data, high-speed data, or teletype line.

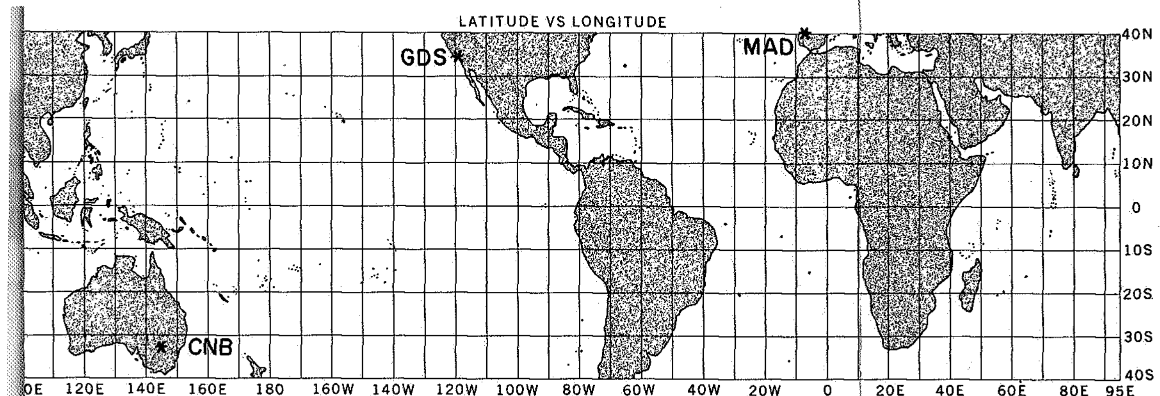
During the launch phase of a mission, televised images of the space vehicle are transmitted from KSC to the MCC-H. Also, a two-way television conference loop is available at this time and during other mission periods between KSC and the MCC-H. At certain periods during the mission, selected televised images are transmitted from the spacecraft (if it is equipped with this capability) via stations equipped for television reception to the MCC-H. The television signals are routed to and from the MCC-H over video lines.

To accomplish its assigned functions during a manned spaceflight mission, the MCC-H requires numerous types of information exchange with the Manned Spaceflight Network and with certain governmental agencies, in addition to spacecraft oriented data. This information includes meteorological data, network equipment status, and status of recovery forces. A great deal of this information is obtained through voice communications with the appropriate station or agency. Teletype and facsimile message traffic between the MCC-H and the appropriate station or agency satisfy all other information flow requirements.



NEAR SPACE INSTRUMENTATION FACILITIES (NSIF)

CODE	STATION	RADAR	REMOTE SITE COMPUTER	TELEMETRY	COMMUNICATIONS	UP-DATA
MIL	MERRIT ISLAND/CAPE AREA	YES	UNIVAC 642B	PCM, RECORD	VOICE, TTY, HSD, WBD, VOICE/DATA	
GBM	GRAND BAHAMA ISLAND	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD, WBD	DRUL
ANT	ANTIGUA	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD, WBD	DRUL
ACN	ASCENSION	YES	UNIVAC 642B	PCM, RECORD	VOICE, VOICE/DATA, TTY, HSD	
BDA	BERMUDA	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD	DRUL
CYI	CANARY ISLANDS	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD, SRI	DCS
CRO	CARNARVON	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD, SRI	DCS
GWM	GUAM	NO	UNIVAC 642B	PCM, RECORD	VOICE, VOICE/DATA, TTY, HSD	
HAW	HAWAII	YES	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD	DCS
GYM	GUAYMAS	NO	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD	DCS
TEX	TEXAS	NO	UNIVAC 642B	PCM, FM/FM, RECORD	VOICE, VOICE/DATA, TTY, HSD	DCS, DRUL
ARIA	APOLLO/RANGE INSTRUMENTED AIRCRAFT	NO	NONE	PCM DOWNLINK RECORD	TWO-WAY, AIRCRAFT-TO-GROUND, H-F VOICE, AND TTY	
INSERTION AND INJECTION SHIPS: VANGUARD, REDSTONE, MERCURY		YES	UNIVAC 642B	PCM, RECORD, FM	VOICE/DATA, TTY, HSD	DCS
REENTRY SHIPS: HUNTSVILLE, WATERTOWN		YES	NONE	PCM, RECORD	VOICE, TTY	



DEEP SPACE INSTRUMENTATION FACILITIES (DSIF)

CODE	STATION	TELEMETRY	COMMUNICATION	VOICE	REMOTE SITE COMPUTER
MAD	MADRID	PCM, RECORDER, FM/FM	USB (DUAL)	YES	UNIVAC 642B
CNB	CANBERRA	PCM, RECORDER, FM/FM	USB (DUAL)	YES	UNIVAC 642B
GDS	GOLDSTONE	PCM, RECORDER, FM/FM	USB (DUAL)	YES	UNIVAC 642B

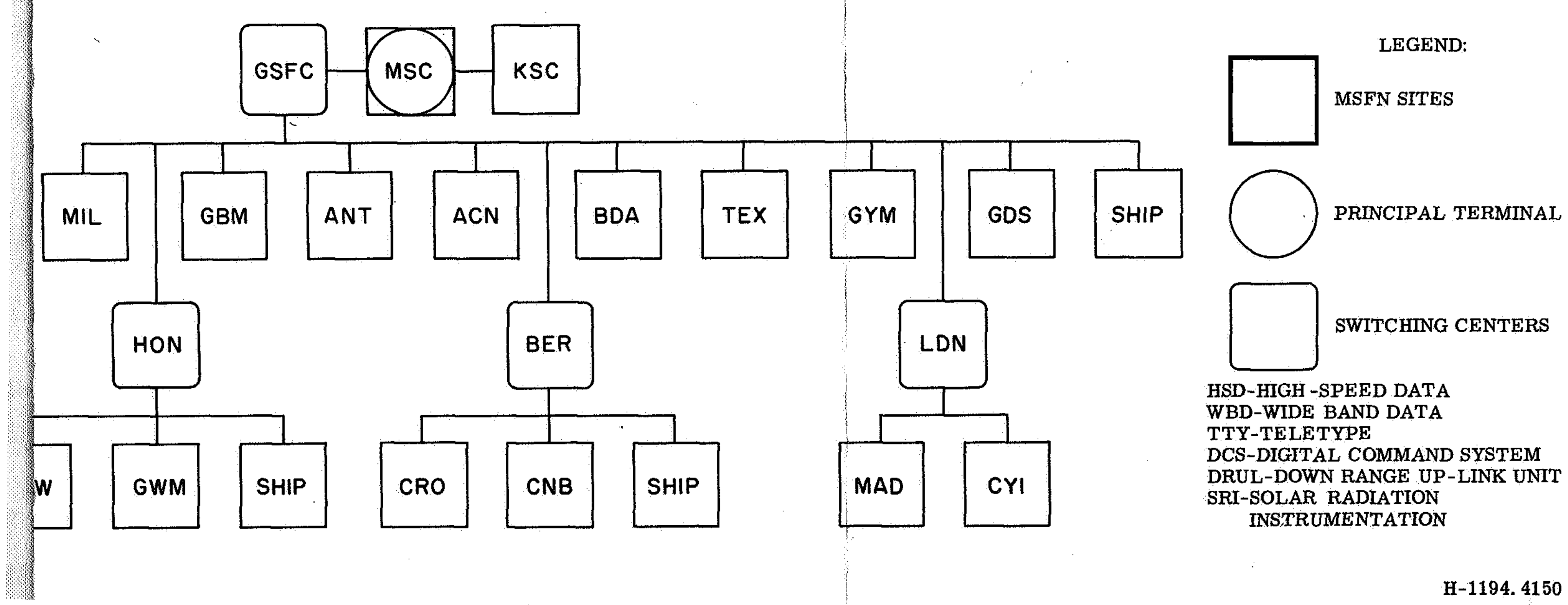


Figure B-1. Geographical Locations and Capabilities of Manned Spaceflight Network Stations

APPENDIX C
APOLLO SIMULATION, CHECKOUT, AND TRAINING SYSTEM

C-1. INTRODUCTION

This appendix discusses the Apollo simulation, checkout, and training system as to purpose of the system, description of equipment, functional description, and supporting manuals.

C-2. PURPOSE OF THE SYSTEM

The Apollo simulation, checkout, and training system (ASCATS) provides training of flight crews, remote site personnel, and flight controllers under conditions similar to those encountered during Apollo missions. The equipment in ASCATS processes simulated mission data using prerecorded data, flight crew trainer generated data, or computer generated data. Personnel in the ASCATS areas in building 422 insert faults into the data streams. These faults are similar to those encountered during operational missions and provide realistic problem solving conditions for the personnel undergoing training. The simulated data is displayed to the operators on console-mounted modules and group displays throughout the ASCATS area in building 422 and the Mission Control Center-Houston (MCC-H) of building 30. Remote site personnel training is accomplished by using the equipment located in building 422 only. Flight crew training requires the use of building 5 equipment in addition to building 422 equipment. Building 30 equipment is used in conjunction with building 422 equipment for training of flight controllers at MCC-H and the remote sites.

C-3. DESCRIPTION OF EQUIPMENT

The ASCATS equipment located in buildings 422 and 5 processes and distributes all data required for simulation of Apollo missions. The equipment is divided into eight functional groups: console, data processing, computer, display, interface, timing, communications, and teletype equipment. Figure C-3-1 shows a composite photograph of the ASCATS equipment. The ASCATS equipment is located in buildings 422 and 5. Building 422 equipment is contained in rooms 102, 104, 106, 107, and 108 as illustrated in figure C-3-2. Room 106 is a simulated remote site containing consoles and display equipment that present alphanumeric displays and event indications to remote site personnel undergoing training. Apollo simulation control area (ASCA) equipment in room 108 contains console and display equipment, that permit monitoring of a simulated mission activity, control of the simulated data, and data faulting. The Ground Support Simulation Computer (GSSC) and Apollo Process Control Unit (APCU) located in room 104 consist of two computer systems that generate simulated mission data and perform all calculations required during the simulated mission. The GSSC and APCU also establish mission parameters and provide for readout of data upon request from the simulated remote site or ASCA. The interface for data exchanged between equipments in building 422 and buildings 30 and 5 is performed by equipment in room 102. The equipment in room 102 also contains patching and termination equipment to permit rapid mission configuration, data processing equipment to supplement computer functions, and communication equipment that provides voice communications facilities throughout ASCATS. Teletype equipment located primarily in room 107 supplies a communications link between ASCATS and the spaceflight network.

Building 5 equipment is located in the flight crew trainer area. The equipment consists of interface equipment which interchanges data between the flight crew trainer and buildings 422 and 30 equipment.

C-3-1. Console Equipment

The console equipment consists of control consoles, monitor consoles, and a maintenance console. This equipment is used to control and monitor all simulated mission functions.

C-3-2. Data Processing Equipment

Data processing equipment consists of exchange control logic, a PCM telemetry output buffer, a multichannel demultiplexer and distributor, magnetic tape recorder/reproducers, interface adapters, a data control and generator, a data encoder unit, data control units, and memory and character generators. This equipment supplements computer functions, reformats data, and provides signal conversion required between equipments.

C-3-3. Computer Equipment

Computer equipment consists of a GSSC, an APCU, and a console computer interface adapter. This equipment generates preprogrammed mission data, processes all mission data in accordance with preprogrammed instructions, makes calculations, and performs operations requested by ASCA and simulated remote site equipment.

C-3-4. Display Equipment

The display equipment consists of wall-mounted group displays, television viewers, analog and event recorders, X-Y plotboards, high-speed teleprinters, maintenance monitors and slide projectors. This equipment allows monitoring of mission and maintenance data throughout the ASCATS area.

C-3-5. Interface Equipment

The interface equipment consists of a data routing cabinet, interface cabinets, cable termination cabinets, a patch equipment distribution cabinet, a decommutation system distribution unit located in building 422 and building 5 equipment consisting of the FCT selection patch cabinet and FCT interface equipment cabinet. This equipment provides a rapid and convenient method of configuring the equipment for the simulated missions, provides signal conversion for transmission of data over TELCO lines, and encodes and decodes data exchanged with building 30.

C-3-6. Timing Equipment

Timing equipment in ASCATS consists of the Apollo time distribution frame and central timing unit. This equipment receives WWV-L signals for synchronization and generates all timing used by the building 422 equipment.

C-3-7. Communications Equipment

The communications equipment contains pedestal-mounted keysets and key boxes, common equipment racks, conference loop racks, a power rack, a test rack, an amplifier rack, an amplifier and patch rack, a public address and air/ground rack, pedestal-mounted jack boxes, and a combined distribution frame. This equipment provides voice communications at each operator and maintenance position in ASCATS and amplifies signals exchanged with buildings 30 and 5.

C-3-8. Teletype Equipment

The teletype equipment consists of receive-only page printers, automatic send-receive sets, receive-only typing reperforators, and a teletype patch bay. This equipment allows monitoring of the spaceflight network teletype traffic and transmission of teletype data over circuits selected on the patch bay.

C-4. FUNCTIONAL DESCRIPTION

Mission simulations performed by ASCATS equipment are accomplished with one of three objectives: to train flight crews, flight controllers, or remote site personnel. Regardless of the objective, the basic functions performed by ASCATS are similar. (See figure C-4-1.)

Training of flight crews requires the operation of the flight crew trainer in building 5 or at Kennedy Space Center. During flight crew training, the simulation data is generated in the flight crew trainer and routed to building 422. Decisions made by operators and equipment in building 422 are transferred to the flight crew trainer. Flight controllers in building 30 may either monitor training exercises or actively participate in the exercise. In either event, flight controllers view displays that are a result of ASCATS data processing functions. Decisions made by the flight controllers actively engaged in the exercise are routed to ASCATS for processing. Remote site personnel training can be accomplished either in conjunction with the flight crew training or as a completely independent exercise. When remote site personnel are being trained independently, the GSSC and prerecorded data tapes are utilized as a data source. All functions (monitoring, data processing, commanding, etc.) are performed within building 422.

During training of the flight crews, data generated at either building 5 or the flight crew trainer at Kennedy Space Center (KSC) is routed to the ASCATS equipment in building 422 for processing. When the trainer at KSC is in operation, simulated trajectory data at a 40.8 Kbps rate is routed through TELCO, building 47, facilities to the mission operation wing data link equipment in building 422. Telemetry data is also generated at the flight crew trainer and routed to the Apollo launch data system (ALDS) telemetry subsystem for transmission to MCC building 30. Simulated manned space flight network (MSFN) data and simulated commands are received by the KSC flight crew trainer from ASCATS by way of the communications facility control subsystem. The command data received at the flight crew trainer instructs flight crew personnel of actions to be performed during the simulation. With the exception of commands, all data required by the flight crew trainer is routed from the communications facility control subsystem over the MSFN data lines.

The flight crew trainer in building 5 performs functions similar to those performed at the KSC flight crew trainer. During exercises utilizing the building 5 equipment, switching of the data lines from KSC to building 5 flight crew trainer is accomplished by a transfer switch in building 47 and patch equipment in the communications facility control subsystem in MCC. Simulated trajectory, MSFN data, and commands are exchanged with the flight crew trainer to perform the same functions as for the KSC trainer. The timing subsystem at MCC-H routes timing signals through the communications facility control subsystem to the flight crew trainer equipment for synchronization and conversion to a format that provides Greenwich mean time displays throughout the trainer. Time displays for building 422 are received from the building 30 television subsystem and applied on 21-inch television monitors throughout the ASCATS equipment areas. Matte television displays are received from building 30 in the same manner as time displays.

Flight controllers located throughout the mission operations wing of building 30 are trained using data from ASCATS equipment with specific faults entered into the data streams. The communications facility control and central processor subsystems, which are a part of Communications, Command, and Telemetry System (CCATS), performs the interfacing required with ASCATS. Simulated ALDS, impact predictor (IP), MSFN, and command data exchanged with ASCATS equipment is routed through the communications facility control subsystem to the CCATS central processor. Distribution of the data to flight control positions is performed by the CCATS central processor. Data generated or requested at the flight control positions is routed to ASCATS through the central processor and communications facility control subsystems.

Remote site personnel training is performed by using the equipment in ASCATS located at building 422. This training can be accomplished without connections to building 30 or the flight crew trainers (closed loop training within building 422). Data for the remote site training exercise is replayed from prerecorded data tapes and/or generated by the GSSC. Using the prerecorded data tapes as a telemetry data source, the data is routed through standardization logic, under control of the data control and generator equipment, to the mission operations wing data link (MOW D/L) patch panel. Patching of the telemetry data permits the data to be forwarded to the multichannel demultiplexer and distributor (MDD) or to be faulted in the MOW D/L equipment and then routed to the MDD. Reformatting and error checking of the data is accomplished in the MDD and the resulting telemetry data is routed to the GSSC and APCU. The GSSC generates simulated trajectory, and IP data from calculations made on the telemetry data. The resulting data from the computers is distributed in several forms to the Apollo simulated remote site (ASRS) and Apollo simulation control area (ASCA) equipment for display. Data distributed to the ASRS and ASCA consists of high-speed teleprinter data; display data; and GSSC and APCU data containing events, status, analog, and site assignment signals. High-speed teleprinter data is routed through console computer interface adapter (CCIA) equipment to high-speed teleprinters located in the ASRS and ASCA. Display data is routed to the ASRS and ASCA upon operator requests from console-mounted modules. The requests from the ASCA are routed to the serial simulation interface adapter (SSIA), which formats the requests into a computer word and sends the data to the GSSC or APCU. The ASRS display requests are routed through the CCIA to the APCU. Upon receipt of the requests, the GSSC or APCU routes display data through the memory character vector generator (MCVG) buffer to the memory and character generator (MCG) equipment. The data is converted from computer format to display format in MCG equipment and is then routed to CRT display units at the requesting console. The MCG equipment contains circuitry to store 12 different displays simultaneously.

The GSSC and APCU data routed to the SSIA contains events and digital readouts, status, analog, and site assignment signals. This data is continuously supplied to the SSIA, which strips out specific data according to address and routes the data to the ASCA, ASRS, and to the decommutation system distribution unit (DSDU). The site assignment of the ASRS and the status of the data being used in the simulation is routed to group displays in the ASRS and ASCA. Events and digital readouts are routed to console-mounted panels in the ASCA and ASRS according to the address accompanying the data from the computers. Analog data is applied to chart recorders and X-Y plotboards in the ASRS and ASCA. Certain event and status data signals from the SSIA is routed to the DSDU where patch boards permit a wide variety of signal distribution paths for the event and status signals. These signals are displayed on console-mounted panels in the ASRS. Additional event and analog signals are derived by the CCIA and distributed to the ASRS console-mounted panels. Simulated command and telemetry data is routed from the APCU through the ACIA to the CCIA. The CCIA is a small computer, which strips specific data from the command and telemetry data streams. The data stripped out is stored in the CCIA and routed to the ASRS upon request from the ASRS console modules. The patch distribution equipment receives various analog, event, and status signals from the MDD, PCM telemetry output buffer, and SSIA. The patch distribution equipment permits selection of signal destinations within the ASCA and ASRS, provides signal drive power, and performs signal conversion for the received signals. These signals are distributed to console-, wall-, and ceiling-mounted units in the ASCA and ASRS.

Timing for the ASCATS equipment is generated by a central timing unit and Apollo time distribution frame (ATDF) in building 422. The central timing unit receives synchronization signals from WWV-L and generates basic timing used by the GSSC, APCU, and ATDF, and through the ACIA to the CCIA. The timing signals from the ATDF are routed to the ASRS group wall display.

The use of computer control units and the GSSC/APCU control console allows rapid control of the GSSC and APCU to permit flexibility and monitoring of the computer functions and faulting of data during the mission. Flexibility of the computer functions allows the exercises to be changed as mission program requirements change. Faulting of data expands the training capability to include abnormal situations to be experienced as well as normal mission conditions.

The voice communications equipment provides intercommunications between operating positions and access to the public address system by assigned positions. The voice communications equipment consists of common equipment, conference loops, and telephone trunks. The operating positions are provided a keyset and headset with press-to-talk microphone. All power, control and supervision, and amplifier equipment is located in the Apollo simulation equipment area. Public address loudspeakers are ceiling-mounted throughout the ASCATS area. The keysets are console-, rack-, desk-, and pedestal-mounted. Jack stations for headset or handset operation are provided for maintenance coordination. The intersite trunk circuits provide voice communications between building 5, 422, and 30. All interbuilding trunk circuits are routed through telephone company (TELCO) equipment.

The common equipment consists of the operator, talk-pickup, monitor pickup, air-to-ground (A/G) control, signaling, transfer, jack common drop, muting, intersite trunk, amplifiers, and conference loop circuits. A combined distribution frame (CDF) is the common interface for all circuits. A test bay is provided for circuit testing, and one powerboard serves all voice communications equipment.

Operating positions for the conference loops are assigned to the loops on a functional basis. The local conference loop provides intercommunication between positions in the ASCATS area. An extension loop extends a local conference loop from building 422 to a similar loop in building 30. An intersite trunk circuit provides for signaling to and from a remote location.

The teletype circuits carry low-speed simulation data between building 422 and the MCC-H in building 30. Teletype signals enter and leave ASCATS by way of the TELCO facilities in building 47 and the simulation remote message center in building 422. Each send and receive circuit appears on normal-through jack circuits in the teletype patch bay in the simulation remote message center. Teletype loop current is supplied to all circuits that terminate or pass through the patch bay. In addition to send and receive circuits, internal ASCATS circuits are accessible at the patch bay. The internal circuits provide patching access to the ASCATS computer low-speed input/output channels.

C-5. SUPPORT MANUALS

The support manuals, containing detailed technical descriptions of the Apollo Simulation, Checkout, and Training System functional equipment are listed in figure C-5-1.

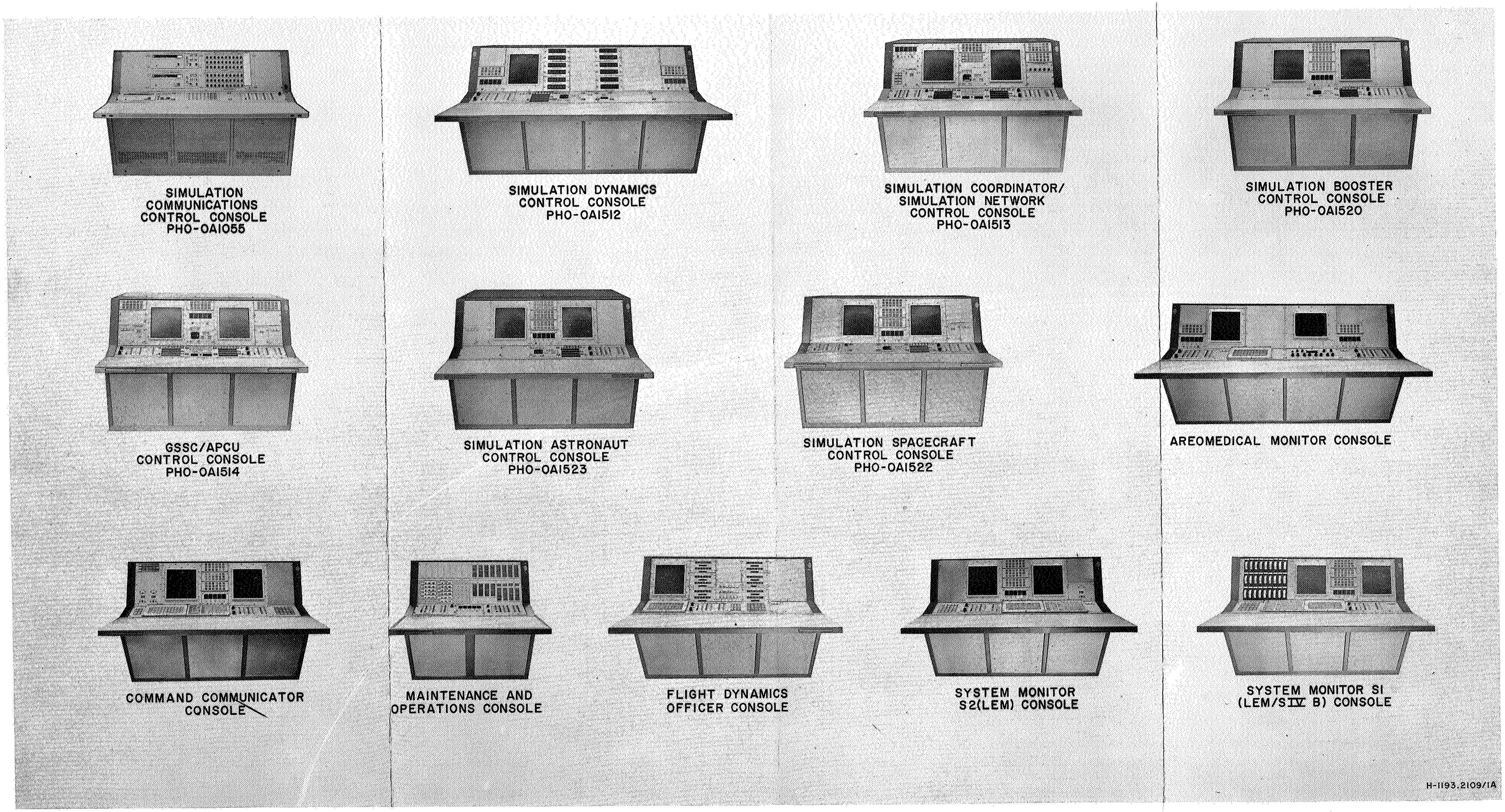


Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 1 of 6)

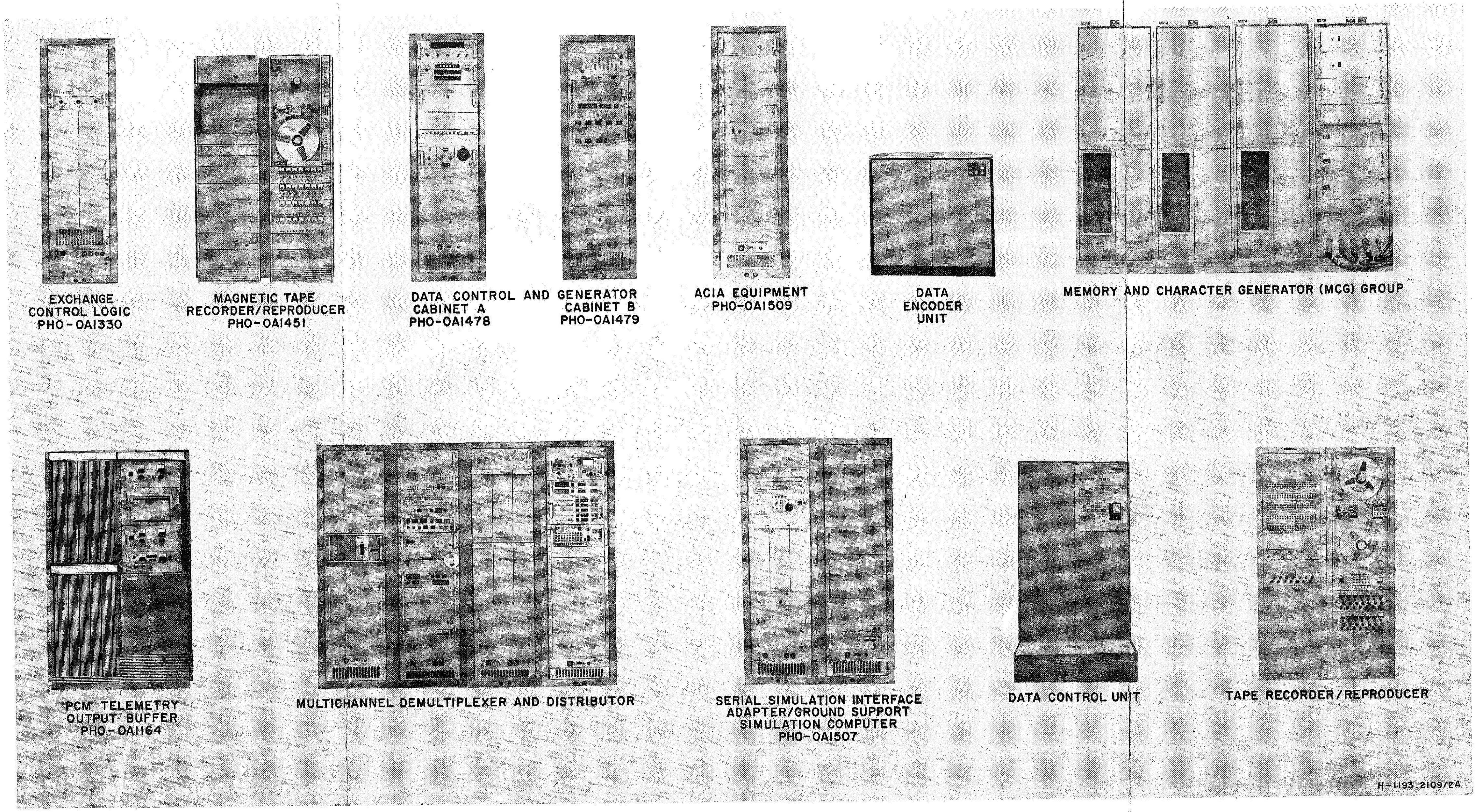


Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 2 of 6)

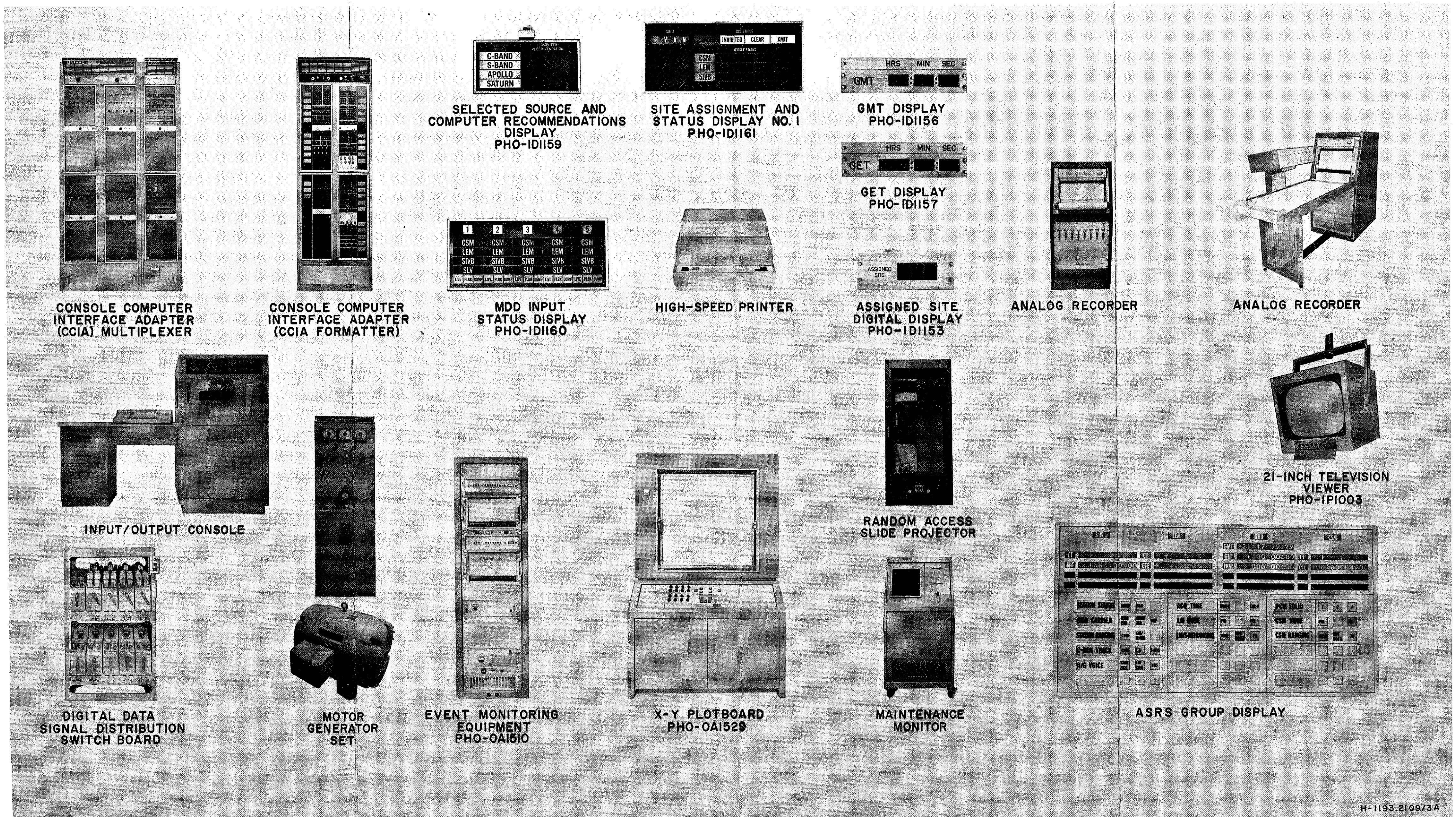


Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 3 of 6)

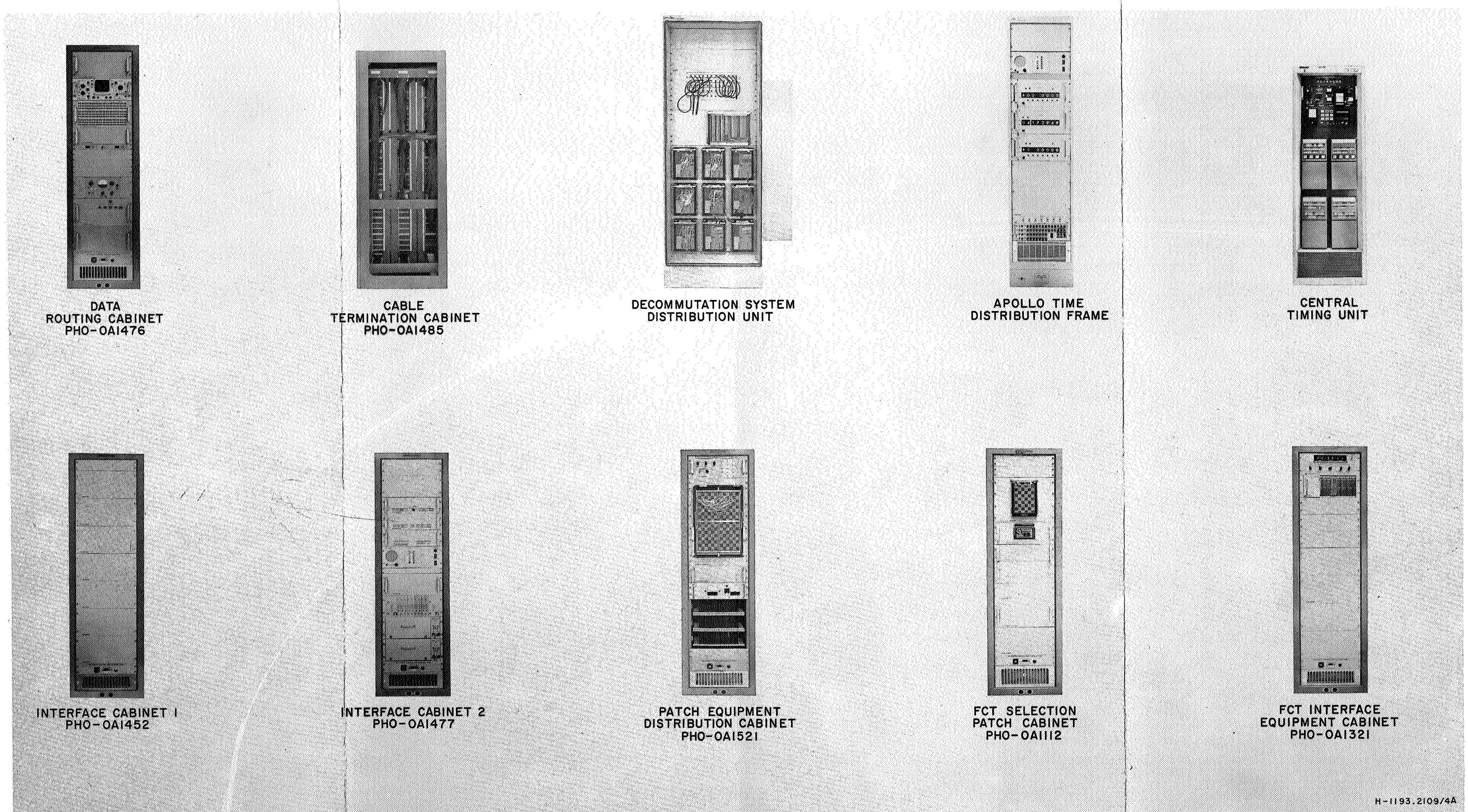


Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 4 of 6)

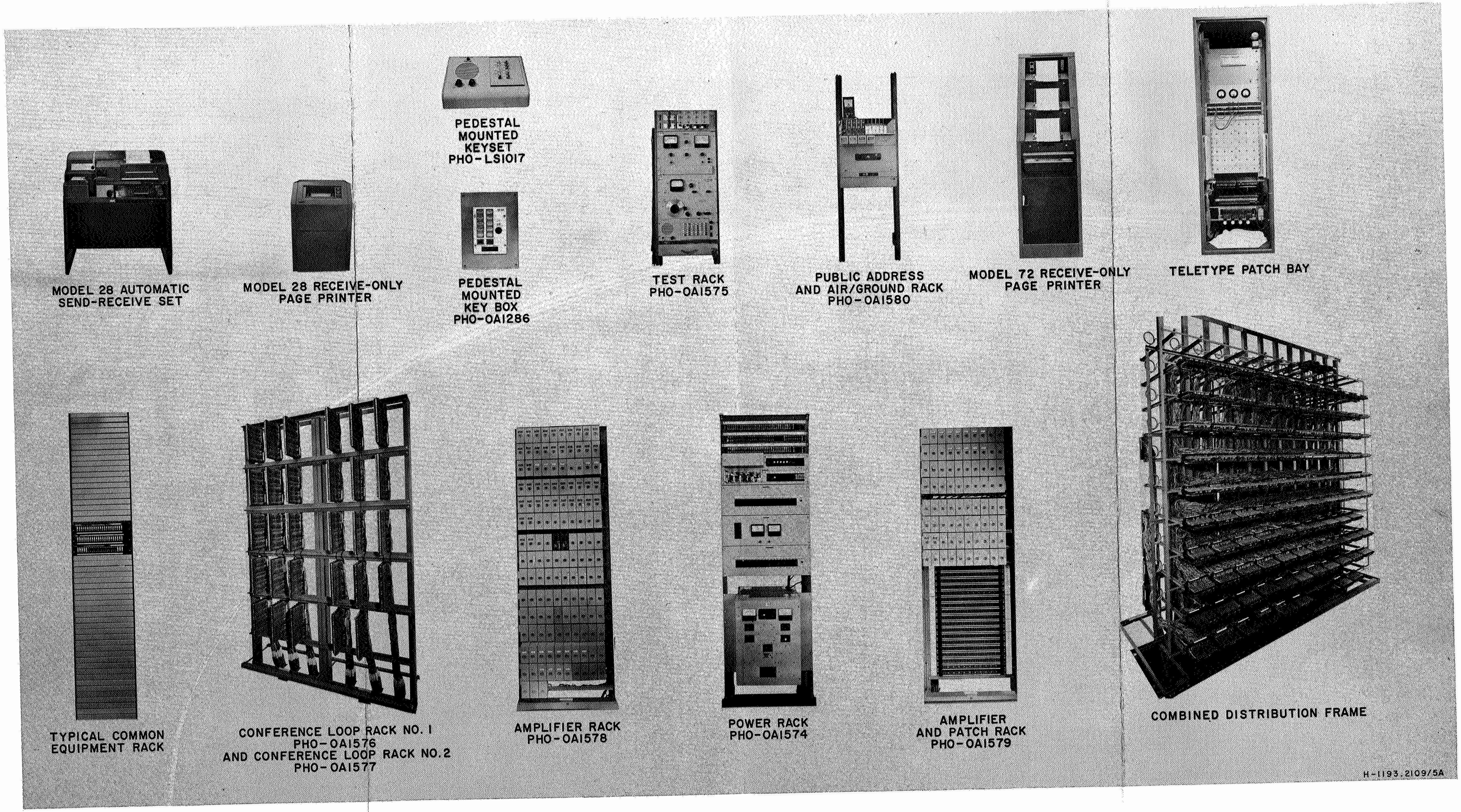
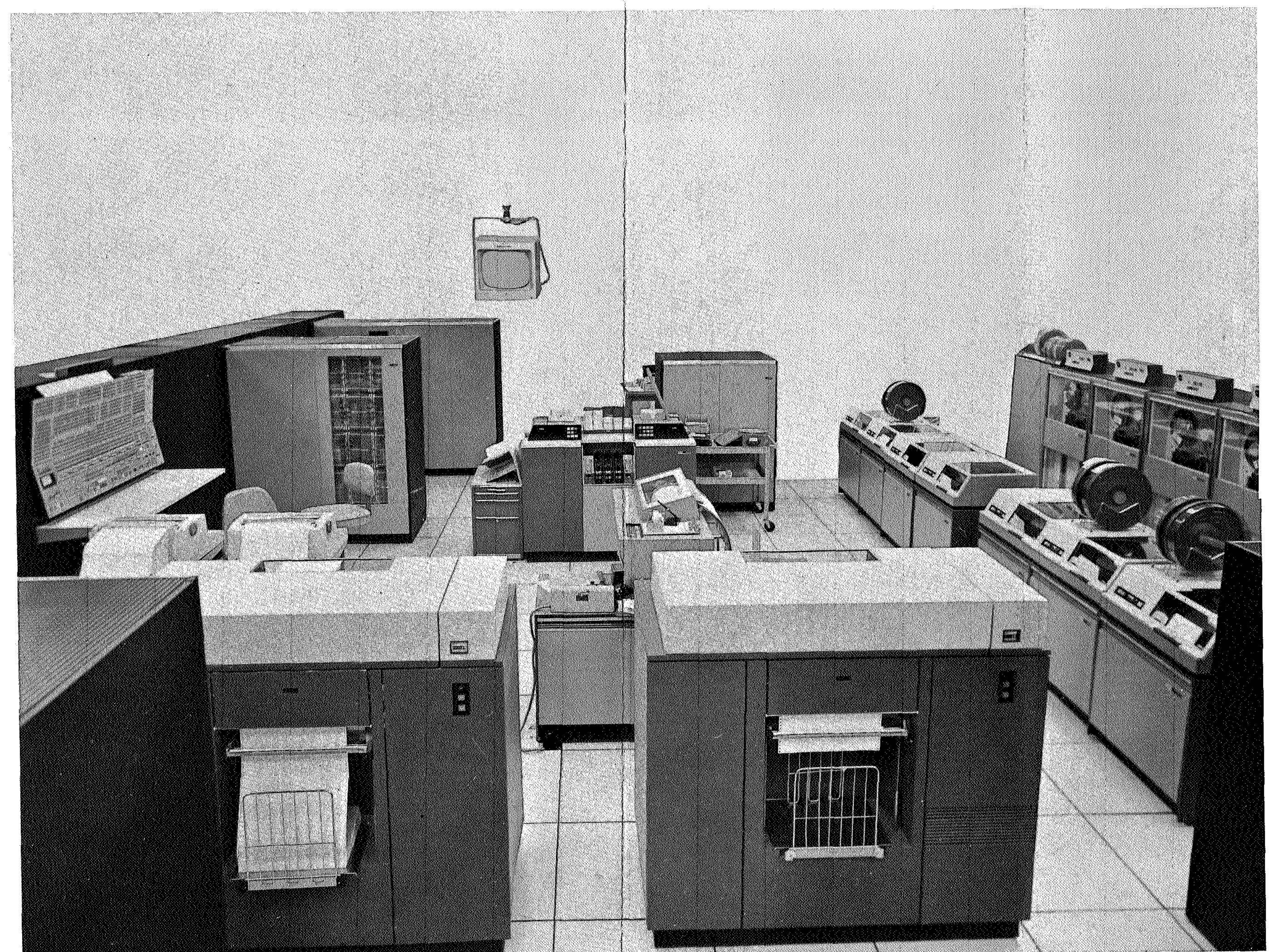
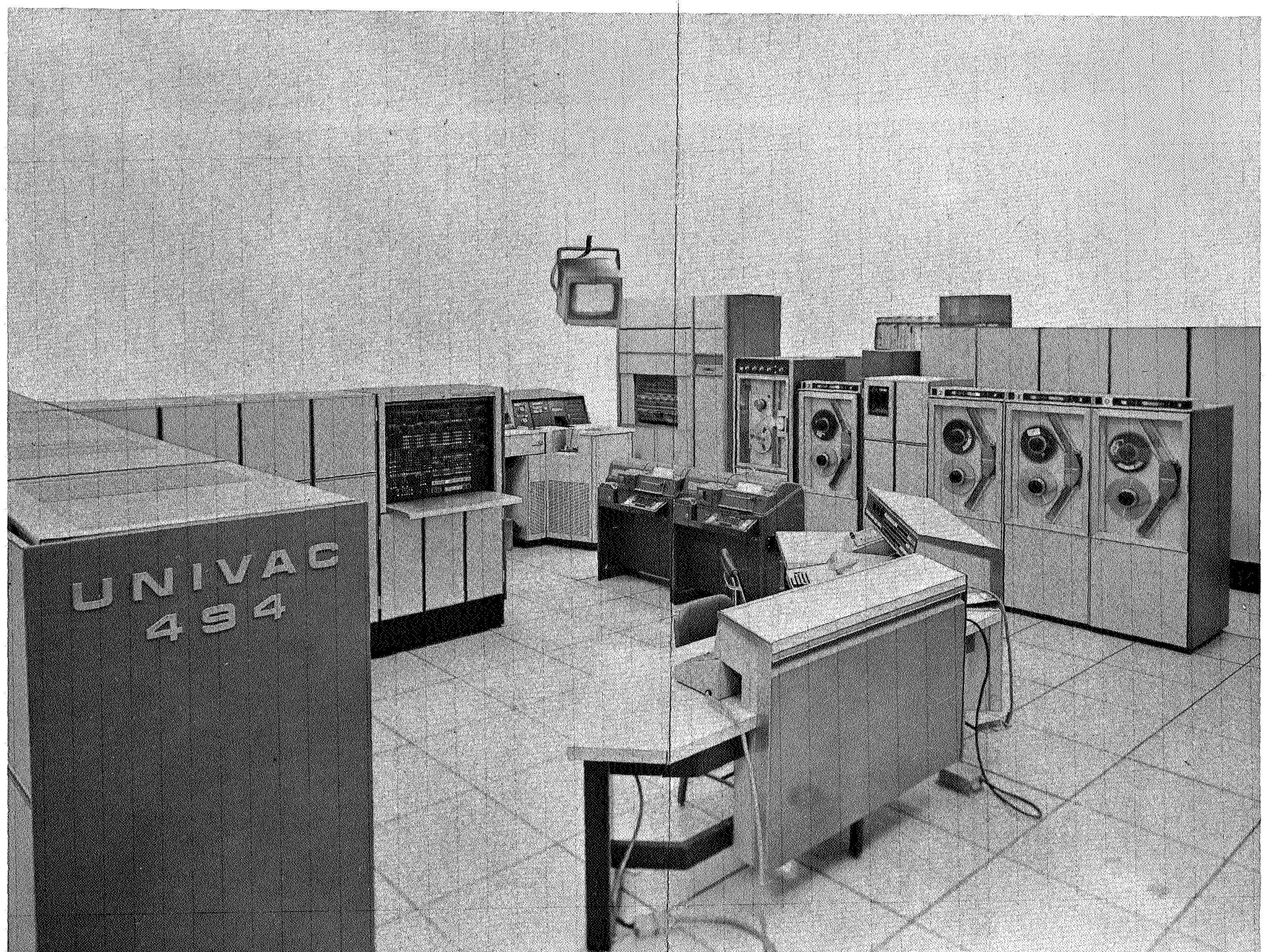


Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 5 of 6)



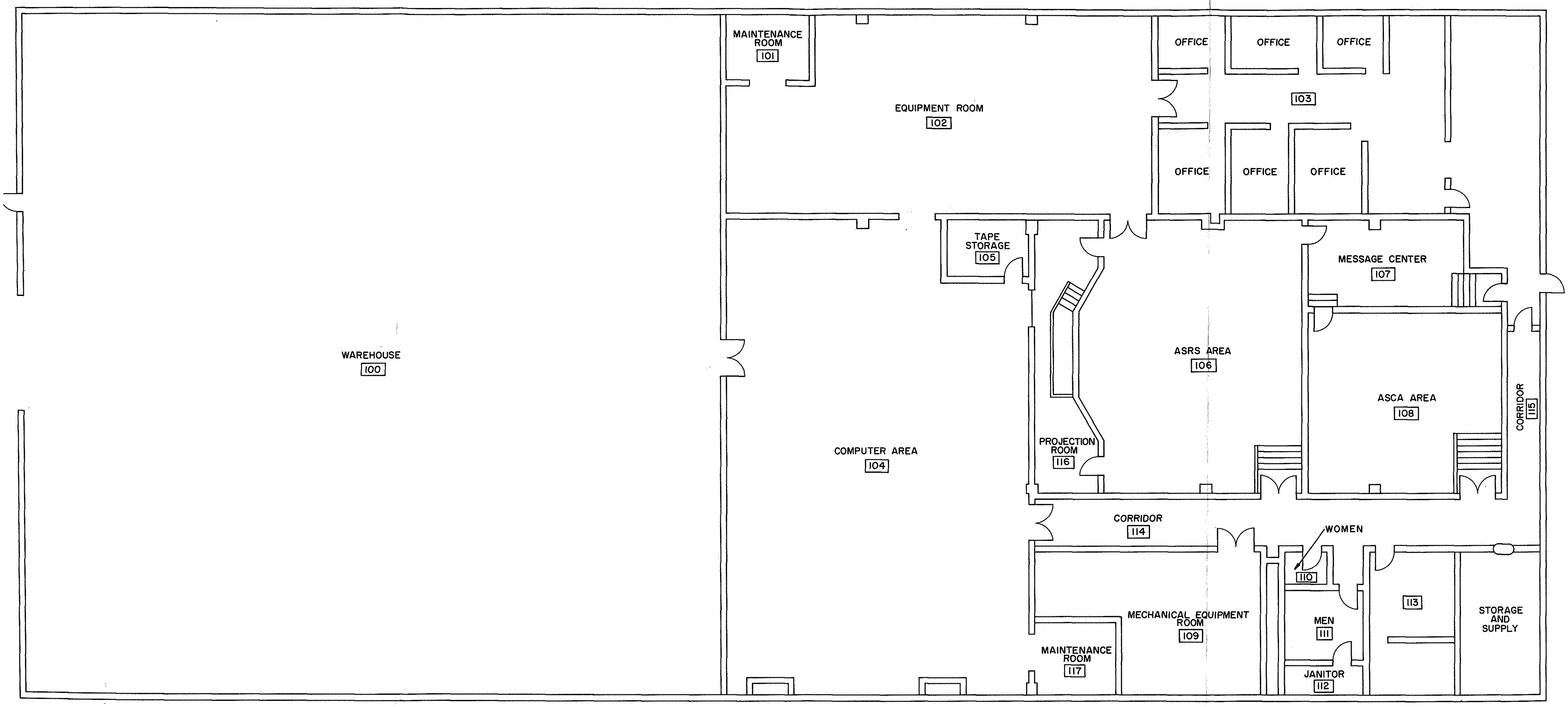
GROUND SUPPORT SIMULATION COMPUTER



APOLLO PROCESS CONTROL UNIT

H-1193.2109/6

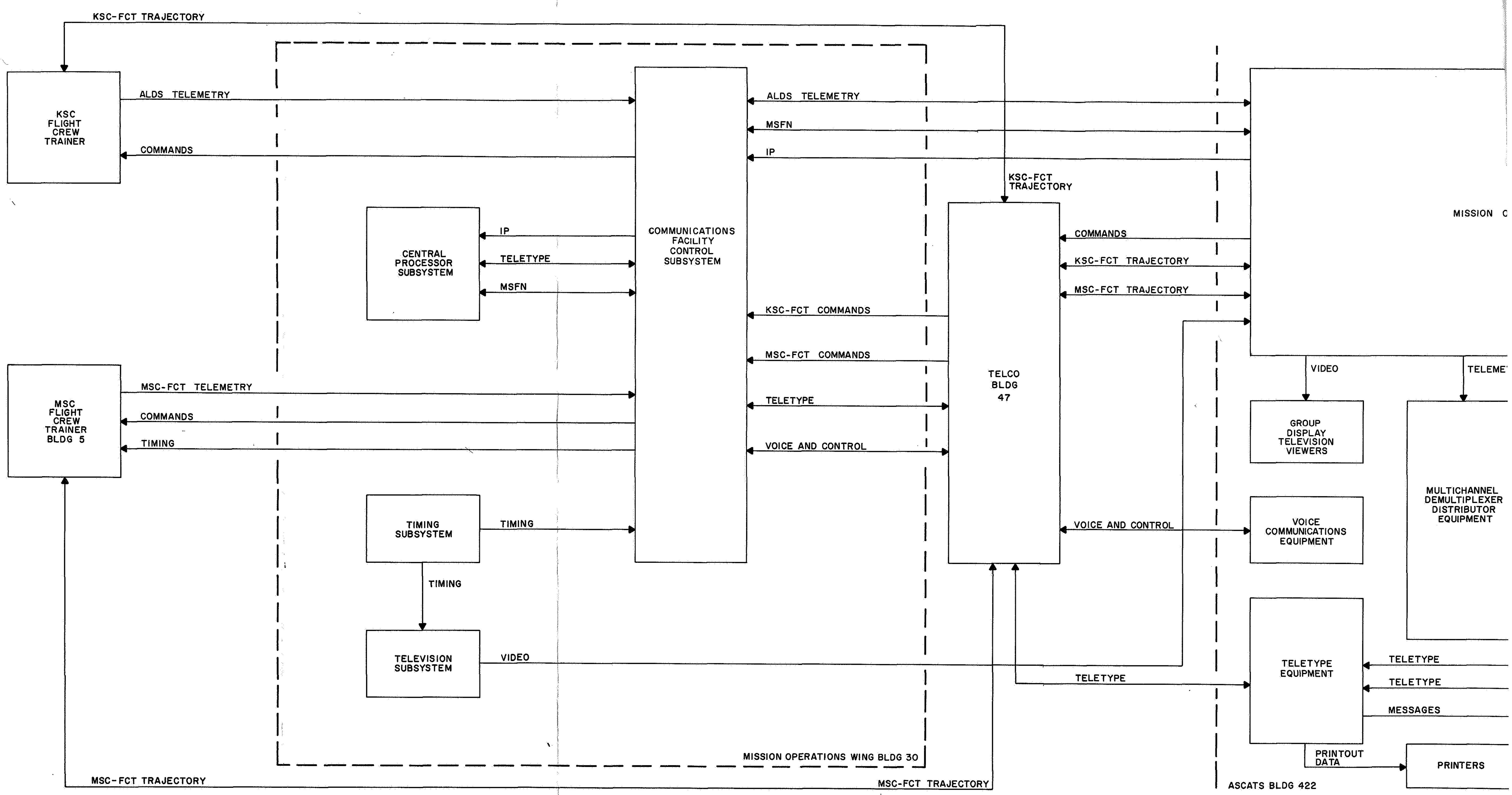
Figure C-3-1. Apollo Simulation, Checkout, and Training System (Sheet 6 of 6)



H-1371.10528

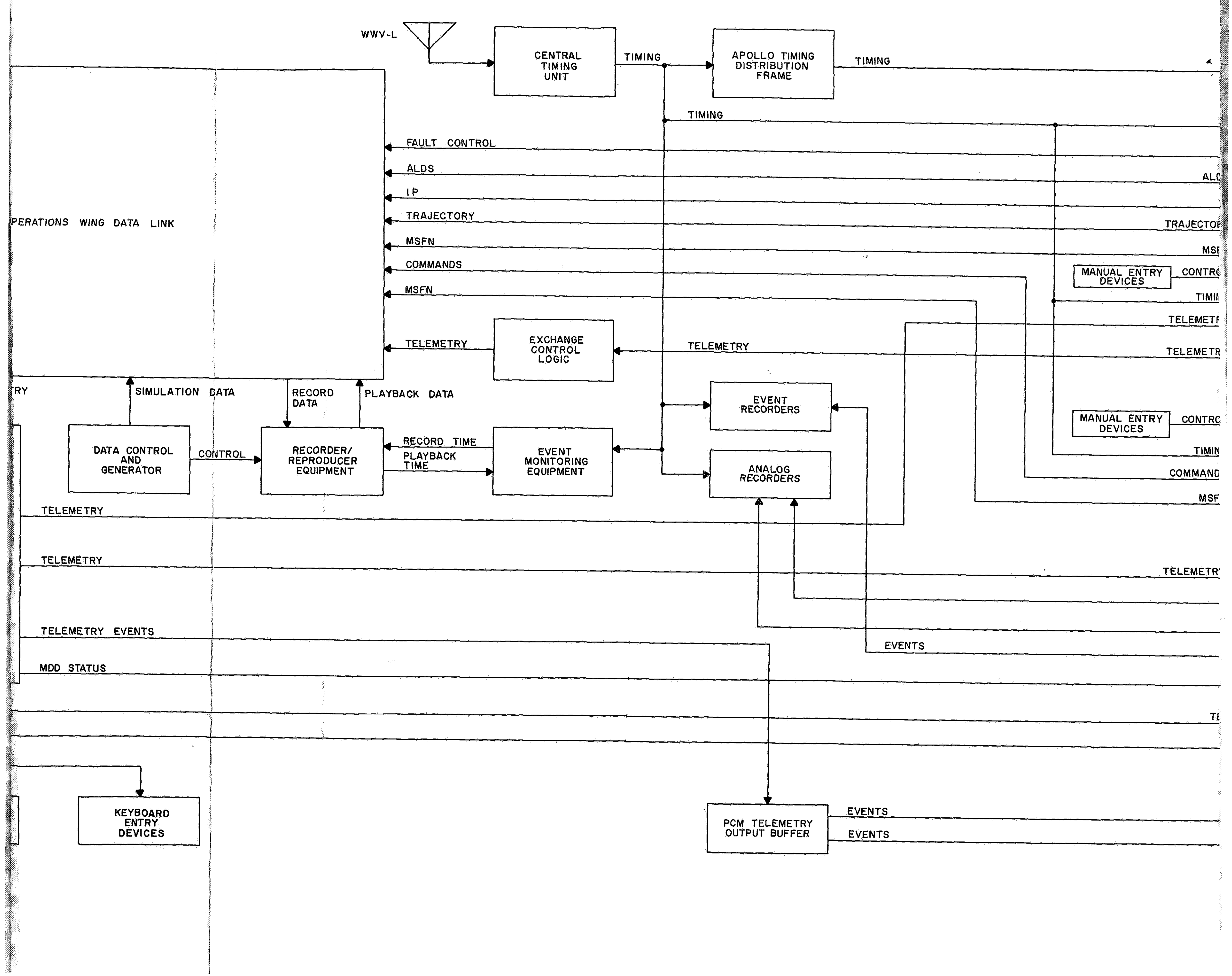
Figure C-3-2. Apollo Simulation, Checkout, and Training System, Building 422 Equipment Area Floor Plan

A



KSC-FCT TRAJECTORY
KSC FLIGHT CREW TRAINER
ALDS TELEMETRY
COMMANDS
CENTRAL PROCESSOR SUBSYSTEM
IP
TELETYPE
MSFN
COMMUNICATIONS FACILITY CONTROL SUBSYSTEM
ALDS TELEMETRY
MSFN
IP
KSC-FCT COMMANDS
MSC-FCT COMMANDS
TELETYPE
VOICE AND CONTROL
KSC-FCT TRAJECTORY
TELCO BLDG 47
COMMANDS
KSC-FCT TRAJECTORY
MSC-FCT TRAJECTORY
VOICE AND CONTROL
TELETYPE
MISSION C
VIDEO
TELEME
GROUP DISPLAY TELEVISION VIEWERS
MULTICHANNEL DEMULTIPLEXER DISTRIBUTOR EQUIPMENT
VOICE COMMUNICATIONS EQUIPMENT
TELETYPE EQUIPMENT
TELETYPE
TELETYPE
MESSAGES
PRINTOUT DATA
PRINTERS
ASCATS BLDG 422
MSC FLIGHT CREW TRAINER BLDG 5
MSC-FCT TELEMETRY
COMMANDS
TIMING
TIMING SUBSYSTEM
TIMING
TIMING
TELEVISION SUBSYSTEM
VIDEO
MISSION OPERATIONS WING BLDG 30
MSC-FCT TRAJECTORY
MSC-FCT TRAJECTORY

B



WWV-L
CENTRAL TIMING UNIT
TIMING
APOLLO TIMING DISTRIBUTION FRAME
TIMING
TIMING
FAULT CONTROL
ALDS
IP
TRAJECTORY
MSFN
COMMANDS
MSFN
TELEMETRY
EXCHANGE CONTROL LOGIC
TELEMETRY
PERATIONS WING DATA LINK
RY
SIMULATION DATA
RECORD DATA
PLAYBACK DATA
EVENT RECORDERS
ANALOG RECORDERS
DATA CONTROL AND GENERATOR
CONTROL
RECORDER/ REPRODUCER EQUIPMENT
RECORD TIME
PLAYBACK TIME
EVENT MONITORING EQUIPMENT
MANUAL ENTRY DEVICES
MANUAL ENTRY DEVICES
ALC
TRAJECTOF
MSF
CONTRC
TIMII
TELEMETF
TELEMETR
CONTRC
TIMIN
COMMAND
MSF
TELEMETRY
TELEMETRY
TELEMETR
TELEMETRY EVENTS
EVENTS
MDD STATUS
TI
KEYBOARD ENTRY DEVICES
PCM TELEMETRY OUTPUT BUFFER
EVENTS
EVENTS

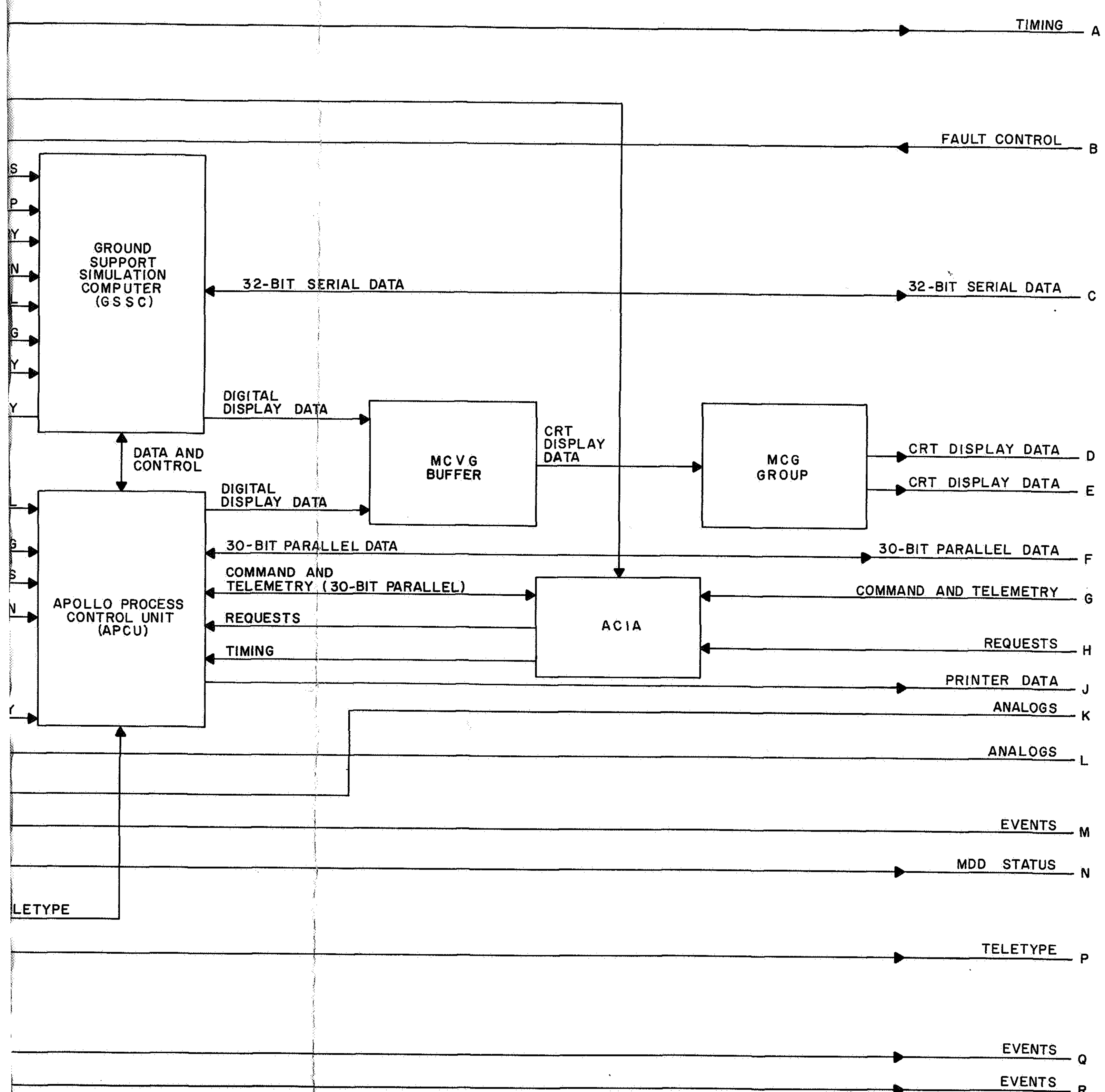
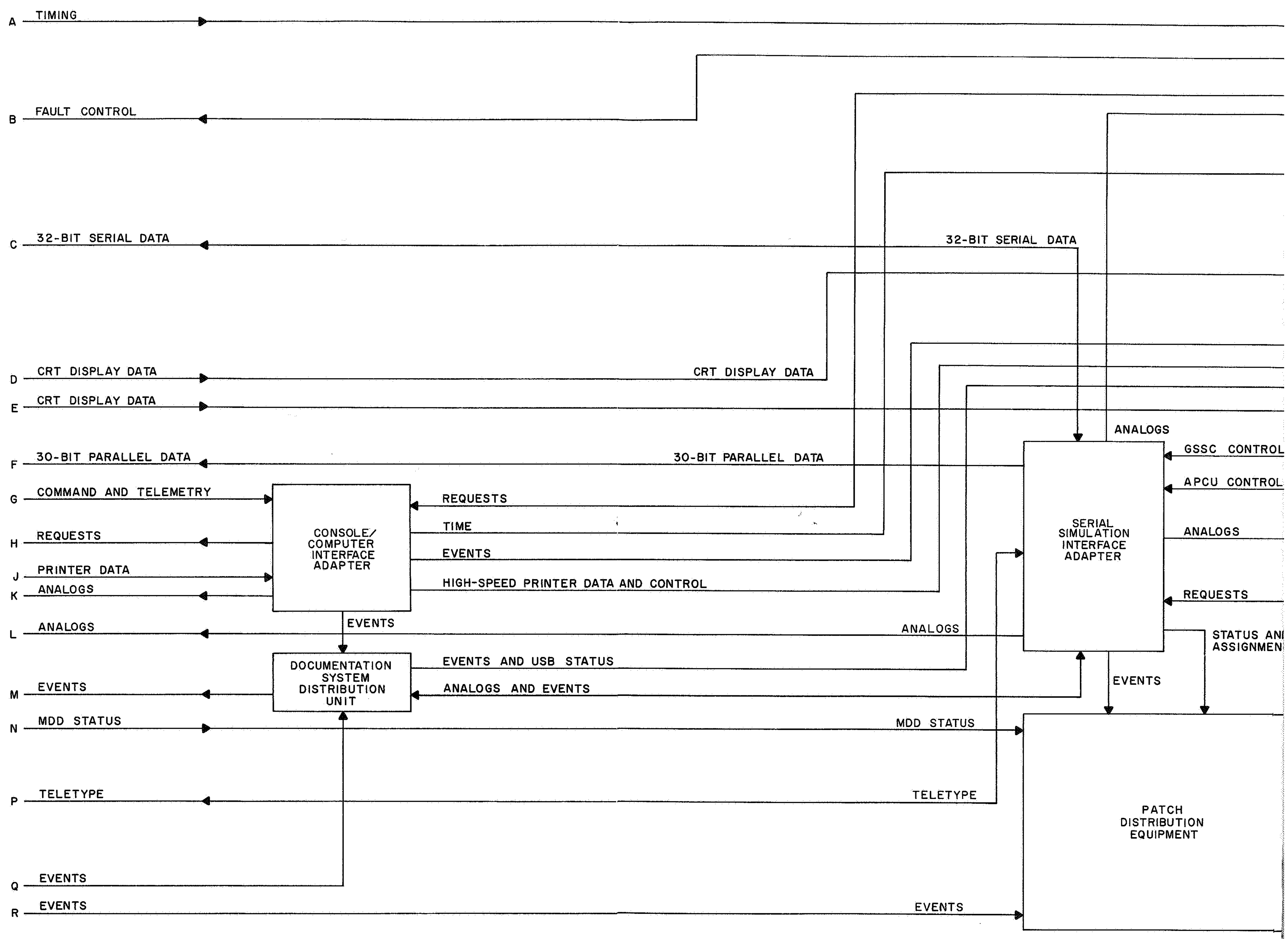


Figure C-4-1. Apollo Simulation, Checkout, and Training System, Functional Block Diagram (Sheet 1 of 2)

H-1193.10484/1

PART 1



A TIMING
B FAULT CONTROL
C 32-BIT SERIAL DATA
D CRT DISPLAY DATA
E CRT DISPLAY DATA
F 30-BIT PARALLEL DATA
G COMMAND AND TELEMETRY
H REQUESTS
J PRINTER DATA
K ANALOGS
L ANALOGS
M EVENTS
N MDD STATUS
P TELETYPE
Q EVENTS
R EVENTS
CONSOLE/ COMPUTER INTERFACE ADAPTER
DOCUMENTATION SYSTEM DISTRIBUTION UNIT
SERIAL SIMULATION INTERFACE ADAPTER
PATCH DISTRIBUTION EQUIPMENT
REQUESTS
TIME
EVENTS
HIGH-SPEED PRINTER DATA AND CONTROL
EVENTS
EVENTS AND USB STATUS
ANALOGS AND EVENTS
32-BIT SERIAL DATA
CRT DISPLAY DATA
30-BIT PARALLEL DATA
ANALOGS
MDD STATUS
TELETYPE
EVENTS
ANALOGS
GSSC CONTROL
APCU CONTROL
ANALOGS
REQUESTS
STATUS ANI
ASSIGNMEN
EVENTS

PART 2

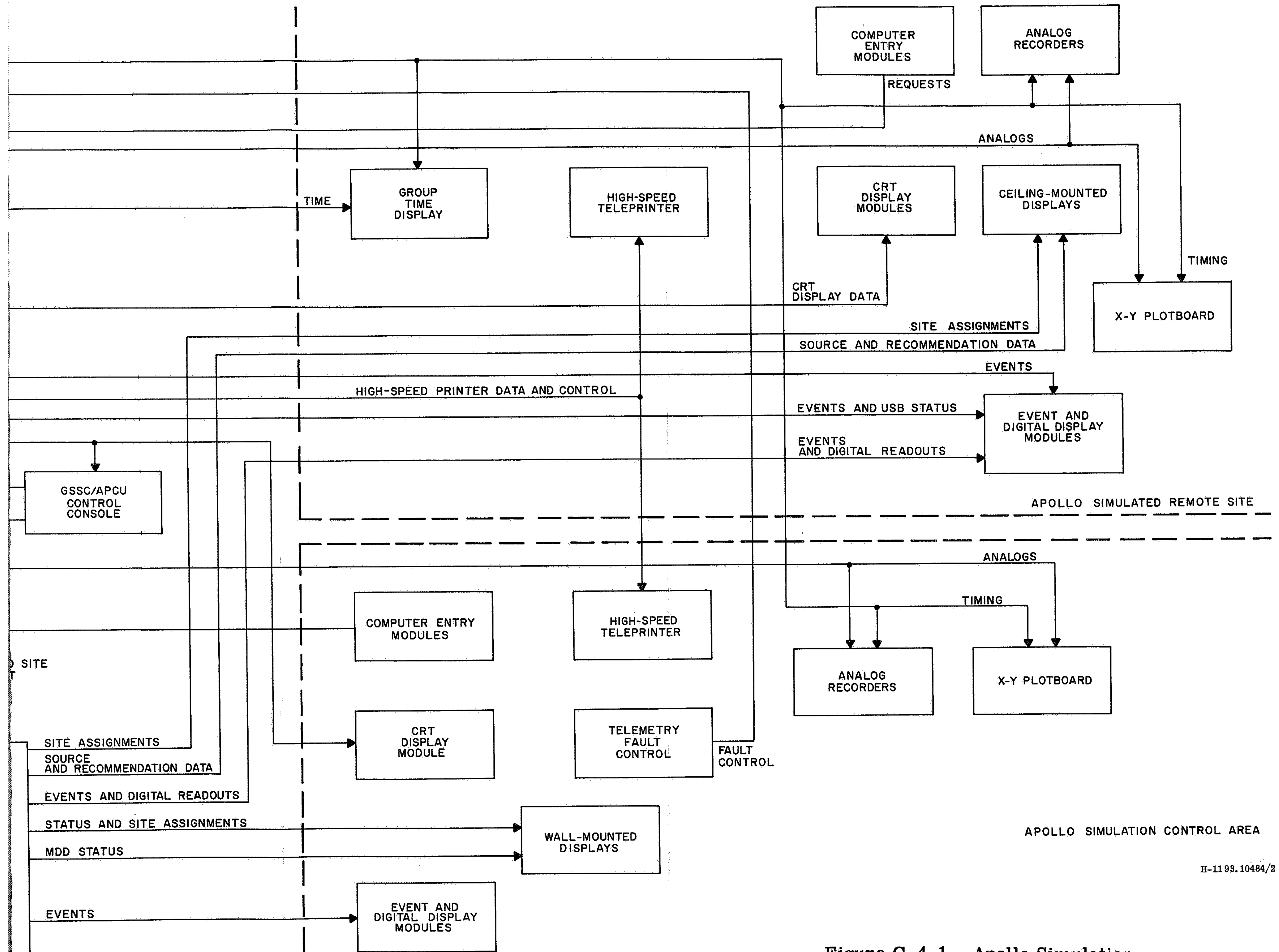
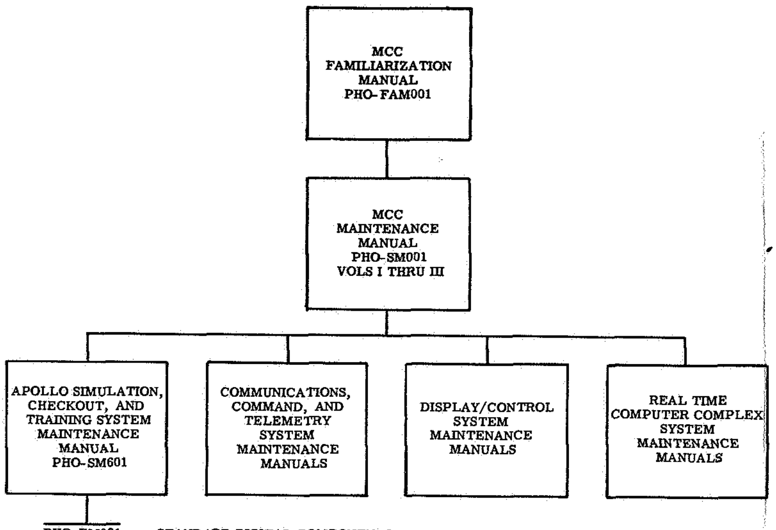


Figure C-4-1. Apollo Simulation, Checkout, and Training System, Functional Block Diagram (Sheet 2 of 2)



PHO-EM001	STANDARD DIGITAL COMPONENTS
PHO-EM002	LOGIC CARD TESTER (VOLS I AND II)
PHO-EM122	MAGNETIC TAPE RECORDER/REPRODUCER PHO-OA1451
PHO-EM141	TAPE READER AND SPOOLER EQUIPMENT
PHO-EM147	OSCILLOSCOPE PHO-OS1017
PHO-EM231	SIGNAL DATA CONVERTER PHO-CV1001 (MERCURY TIMING SIMULATOR)
PHO-EM237	VIDEO AND PULSE DISTRIBUTION EQUIPMENT
PHO-EM251	TELEVISION VIEWERS PHO-IP1002, PHO-IP1003, PHO-IP1004, AND PHO-IP1005
PHO-EM257	CONSOLE MODULE EQUIPMENT (VOLS I THRU III)
PHO-EM259	VIDEO TRANSMITTER PHO-YT1006 AND VIDEO RECEIVER PHO-YR1007
PHO-EM311	PCM GROUND STATION PHO-OA1248 (VOLS I AND II)
PHO-EM312	PCM TELEMETRY OUTPUT BUFFER PHO-OA1164 (VOLS I THRU IV)
PHO-EM319	SOUND RECORDER/REPRODUCER PHO-RD1006 AND PHO-RD1017
PHO-EM329	STANDARDIZATION LOGIC EQUIPMENT PHO-MX1196
PHO-EM330	EVENT MONITORING EQUIPMENT
PHO-EM331	PCM GROUND STATION LOGIC ELEMENTS
PHO-EM611	MULTICHANNEL DEMULTIPLEXER AND DISTRIBUTION EQUIPMENT
PHO-EM612	CENTRAL TIMING EQUIPMENT
PHO-EM613	APOLLO SIMULATION CONTROL AREA EQUIPMENT
PHO-EM614	MDD STATUS DRIVER PHO-MX1428
PHO-EM615	X-Y PLOTBOARD PHO-OA1529
PHO-EM616	DATA CONTROL AND GENERATOR EQUIPMENT
PHO-EM617	ASCATS CONSOLE COMMUNICATIONS EQUIPMENT
PHO-EM618	ASCATS PUBLIC ADDRESS EQUIPMENT
PHO-EM619	SERIAL SIMULATION INTERFACE ADAPTER EQUIPMENT
PHO-EM620	MOW DATA LINK EQUIPMENT
PHO-EM621	EXCHANGE CONTROL LOGIC EQUIPMENT PHO-OA1330
PHO-EM622	APCU/CCIA INTERFACE ADAPTER (ACIA) EQUIPMENT PHO-OA1509
PHO-EM623	MEMORY CHARACTER VECTOR GENERATOR BUFFER EQUIPMENT
PHO-EM624	DATA TEST AND TRANSFER EQUIPMENT
PHO-EM625	MEMORY UNIT PHO-MU1006
PHO-EM626	CASTS SIMULATION EQUIPMENT
PHO-TR283	MULTICHANNEL DEMULTIPLEXER AND DISTRIBUTOR PROGRAMMING INSTRUCTIONS

NASA-ME516	TELETYPE SIGNAL DISTORTION TEST SET (TELETYPE CORPORATION)
NASA-ME517	TELETYPE PORTABLE SIGNAL DISTORTION TEST SET (TELETYPE CORPORATION)
NASA-ME519	MODEL 28 PRINTER, GENERAL DESCRIPTION AND THEORY OF OPERATION (TELETYPE CORPORATION)
NASA-ME520	MODEL 28 PAGE PRINTER SET, AND LUBRICATION, LP, LK, LB, LAC, ADJUSTMENTS (TELETYPE CORPORATION)
NASA-ME521	MODEL 28-LD MULTIPLE WIRE DISTRIBUTOR, (TELETYPE CORPORATION)
NASA-ME1096	28-VOLT DC POWER SUPPLY, MODEL PS1393, TECHNICAL MANUAL (VALOR INSTRUMENTS)
NASA-ME1098	FOUR-CHANNEL CARDIOSCOPE, REMOTE SITES
NASA-ME1107	A/N KEYBOARD TYPE 7361 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1111	MODEL 35 PAGE PRINTER, (TELETYPE CORPORATION)
NASA-ME1113	MODEL 28 PAGE PRINTER, AND AUTO SEND RECEIVER SET (TELETYPE CORPORATION)
NASA-ME1387	WALL-MOUNTED GROUP DISPLAY
NASA-ME1388	TIME-OF-DAY DIGITAL CLOCK, MODEL D24LS-M10 (PARABAM INCORPORATED)
NASA-ME1389	COUNTDOWN/ELAPSED TIME DIGITAL CLOCK, MODEL D102HLS/CDU-MII (PARABAM INCORPORATED)
NASA-ME1394	DECOMMUTATION SYSTEM DISTRIBUTION UNIT, TYPE II, MODEL 410 (DYNATRONICS INCORPORATED)
NASA-ME1398	TIME DISTRIBUTION FRAME MODEL 440 (DYNATRONICS INCORPORATED)
NASA-ME1400	WIDE BAND TAPE RECORDER/REPRODUCER SYSTEM (MINCOM DIVISION OF MINNESOTA MINING AND MANUFACTURING COMPANY)
NASA-ME1462	ANALOG DATA RECORDER, MARK 200, MODEL 2222-1707-111-3645 (BRUSH INSTRUMENTS DIVISION OF CLEVITE CORPORATION)
NASA-ME1568	DIGITAL DATA SIGNAL DISTRIBUTION SWITCHBOARD, TYPE SB-1299 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1570	TIMING INTERFACE SYSTEM ADAPTER, TYPE 1000 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1572	MOTOR-GENERATOR SET, TYPE 1392, 1394 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1573	DIGITAL DATA COMPUTER, TYPE 1218, S/N 82 AND ABOVE-VOLS 1 AND 2 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1574	CONSOLE-COMPUTER INTERFACE ADAPTER MULTIPLEXER, VOLS 1 AND 2 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1575	PRINTER SYSTEM ADAPTER, TYPE 1222 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1576	TELEPRINTER, TP4000 SERIES
NASA-ME1577	PERIPHERAL COMMUNICATION SYSTEM TYPE 1502 (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1588	DIGITAL DATA COMPUTER, TYPE 1218, WIRE TABULATIONS (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1590	PRINTER SYSTEM ADAPTER, TYPE 1222, WIRE TABULATIONS (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1633	INPUT/OUTPUT CONSOLE, TYPE 1232A, MAINTENANCE TESTS (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1637	TIMING INTERFACE SYSTEM ADAPTER, TYPE 1000, MAINTENANCE TESTS (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1638	DIAGNOSTIC MAINTENANCE TEST FOR 1218 COMPUTER-WITH 4K MEMORY (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-ME1640	PRINTER SYSTEM, TYPE 1222, DIAGNOSTIC TROUBLESHOOTING
NASA-ME1693	RANDOM ACCESS 2 X 2 SLIDE PROJECTOR RA-500 (TELEPRO INDUSTRIES INCORPORATED)
NASA-MH1048	INPUT/OUTPUT CONSOLE TYPE 1232A (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-MH1050	DIGITAL DISPLAY SYSTEM-VOLS I THRU IV (RAYTHEON COMPANY, MICROWAVE AND POWER TUBE DIVISION, ADMINISTRATION BUILDING)
NASA-MH1051	CONSOLE-COMPUTER INTERFACE ADAPTER SYSTEM (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-MH1074	APOLLO M&O CONSOLES
NASA-MH1048	INPUT/OUTPUT CONSOLE TYPE 1232A (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-MH1050	DIGITAL DISPLAY SYSTEM-VOLS I THRU IV (RAYTHEON COMPANY, MICROWAVE AND POWER TUBE DIVISION, ADMINISTRATION BUILDING)
NASA-MH1051	CONSOLE-COMPUTER INTERFACE ADAPTER SYSTEM (UNIVAC DIVISION OF SPERRY RAND CORPORATION)
NASA-MH1074	APOLLO M&O CONSOLES

H-1194. 6930

Figure C-5-1. Apollo Simulation, Checkout, and Training System Family of Manuals