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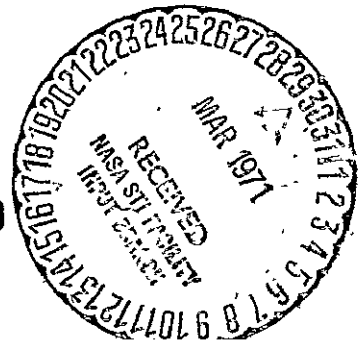
GODDARD SPACE FLIGHT CENTER MOBILE FM/FM TELEMETRY GROUND STATION H CAPABILITY REPORT

(REVISION 1)

B. F. KARMILOWICZ



OCTOBER 1970

GSFC

GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

X-743-70-374

GODDARD SPACE FLIGHT CENTER
MOBILE FM/FM TELEMETRY GROUND STATION H
CAPABILITY REPORT

(REVISION 1)

by
B. F. Karmilowicz
Instrumentation Branch
National Aeronautics and Space Administration

October 1970

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

SUMMARY

This report describes, primarily, the functions and characteristics of the telemetry equipment of Goddard Space Flight Center's Mobile FM/FM Trailer, designated Ground Station H. It also describes the physical appearance and functions of the trailer.

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GODDARD SPACE FLIGHT CENTER
MOBILE FM/FM TELEMETRY GROUND STATION H
CAPABILITY REPORT

INTRODUCTION

Mobile Telemetry Trailer, Ground Station H, was designed to provide emergency backup tracking facilities in the field. It carries all FM/FM telemetry equipment and instrumentation needed to provide accurate, reliable and uninterrupted data from the flight transmitters, and for recording and displaying these data, both for "quick look" and for later analytic evaluation. The station also contains the necessary instrumentation for testing, calibration and maintenance of the equipment, as well as living facilities for its operators. The trailer was designed and its facilities fabricated by the personnel of the Instrumentation Branch of Goddard Space Flight Center.

The housekeeping as well as the telemetry equipment are described in the following text. The illustrations are in Appendix A, and the equipment specifications are in the tables in Appendix B. Appendix C gives the IRIG Standard Channels.

TRAILER

The living facilities of the trailer will accommodate two men who can comfortably reside in otherwise uninhabited or inclement areas, whether in tropic jungle, desert, or arctic surroundings. Photographs of the outside of the trailer and of the inside, showing the housekeeping equipment, are in the Frontispiece and Appendix A, Figures A-1 through A-9. Trailer and housekeeping specifications are contained in Appendix B, Tables B-I and B-II.

FM/FM CAPABILITY

Mobile Telemetry Trailer, Ground Station H, is equipped to receive transmitted data from airborne telemetry systems. These data can be simultaneously recorded on paper and on magnetic tape, and while the rocket is in flight, visual changes in data can be observed through meter and galvanometer movements. The station telemetry equipment is also used to check out the rocket telemetry packages during prelaunch checks.

Ground Station H FM/FM Telemetry equipment includes:

Special purpose antennas and receivers for the acquisition of data

Impedance matching and signal display components

Subcarrier discriminators for separating individual subcarriers from a complex (multiplex) signal

Magnetic tape and oscillographic recorders for storing and displaying acquired data

Tape speed compensation equipment

Test, calibration, and accessory equipment necessary to maintain and facilitate station operation

TELEMETRY ANTENNAS AND ASSOCIATED EQUIPMENT

Two types of telemetry antennas are used at Station H: single helix manual tracking, and tri-helix remotely controlled tracking.

SINGLE HELIX ANTENNA. Two 8-turn, 12-decibel gain, manual tracking, single helix antennas (Frontispiece, and Figure A-10) are used at Station H. During operations, these antennas are located on top of the trailer, on portable antenna mounts, which permit the antennas to be manually positioned in azimuth and angular elevation. These antennas are connected to the radio-frequency patch panel, inside the trailer, by means of forward and aft feed-through panels. (See Figure A-11.) The feed-through panels also provide for connection of the local intercommunication system, to permit communication between personnel at the receiver and antenna locations. Antenna characteristics are listed in Table B-III (Page B-6).

TRI-HELIX ANTENNA, CONTROLS, AND PREAMPLIFIER. The tri-helix antenna (Frontispiece and Figure A-12) consists of three ten-turn helical antennas, each with individual ground plane, combining network, and mounting spider. The helical elements are attached to a rigid aluminum framework, which, in turn, is mounted on a radar type pedestal. The pedestal which is mounted on a wooden base at the rear of the trailer incorporates a remote control system, controlling movement in each of the two axes of rotation (the azimuth and elevation axes). The remote controls, consisting of a control panel (Figure A-13) and an indicator panel (Figure A-14) are mounted in the trailer, in equipment racks three and four, respectively. A preamplifier, Model HFW-2(AS)

supplied by Applied Research, Incorporated, is used with this antenna. It is physically located inside the pedestal, and is connected in series with the antenna lead-in cable. The gain that it provides compensates for the extra attenuation caused by the longer antenna lead, so that signal level at the receiver input will be sufficiently higher than the noise level of the receiver input stage that the receiver output will have a good signal-to-noise ratio.

The power On-Off switch for the preamplifier is mounted on a small front panel, in equipment rack number four, directly above the antenna direction indicator (Figure A-14).

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

The radio-frequency receiving equipment used in Mobile Telemetry Trailer, Ground Station H, consists of two double-conversion VHF telemetry receivers (Figure A-19). These cover a range of frequencies from 215 to 265 megahertz, and have a noise figure of less than 7 decibels over the entire range.

The receivers (Table B-IV) can be operated either in crystal-controlled or in continuously-tunable modes. In either mode, a vernier tuning adjustment of the second local oscillator is available, for fine tuning, to compensate for crystal frequency tolerances or for transmitter drift.

Receiver outputs include:

(1) AM and FM video (raw complex telemetry) data, for recording or discrimination.

(2) A suitable sample of 30-megahertz (first-intermediate frequency) signal to drive a frequency display unit.

(3) An AGC voltage for signal strength recording.

When both receivers are used with a single antenna, a GEL Type 47A1 multi-coupler (Table B-IV) provides a means for maintaining, throughout the frequency range, a constant antenna-to-receiver input-impedance match. To achieve impedance matching between the receiver video output and the tape recorder/discriminator inputs, two Electro-Mechanical Research (EMR) line amplifiers, Model 173-A, (Table B-IV) having an amplification factor of 1:1, are used.

A diversity combiner (Figure A-15, Table B-IV) is used with the two GEL receivers to provide space diversity reception. When the receivers are connected

to two antennas separated by several wave lengths, the available signal may vary quite widely from one antenna to the other and, consequently, at the receiver outputs. When these outputs are fed into the diversity combiner, the noisy output from the receiver with the weak signal is rejected, while the strong signal from the other receiver becomes the output. There is, however, some improvement when equal strength signals are received. The two signal outputs are in phase and add directly. The internally-generated noise from each of the two receivers has only random frequency and phase with respect to the noise from the other, and does not add directly.

A GEL frequency display unit, Type 14D2-55, (Table B-IV) is used in conjunction with the two receivers to provide a means for visually verifying receiver frequency, for determining relative signal amplitudes, and for analyzing the spectrum around the signal frequency to which the receiver is tuned.

SUBCARRIER DISCRIMINATION AND TAPE-SPEED COMPENSATION EQUIPMENT

Ground Station H is equipped with eighteen discriminator channels, and thus can simultaneously display as many as eighteen data signals on photographic-paper record. Three FM decoding modules are used to isolate the individual subcarriers from a composite signal. Each of these modules consists of an Electromechanical Research, Incorporated (EMR) Model 222A rack adapter, containing six Model 210A fixed-channel, phase-locked-loop subcarrier discriminators (Figure A-21, Table B-V), and a Model 223B power supply (Table B-V).

Each discriminator is equipped with an interchangeable plug-in channel selector for one of the standard IRIG channels (see Appendix C), and a plug-in output filter. This subcarrier discriminator thus separates its specified data-channel from the composite input, and converts the FM data to AM, for further processing and recording. Precision power-supply regulators are also provided in each discriminator, to compensate for the effect of line-voltage and temperature variations, and to eliminate inter-channel cross-talk, which might otherwise be caused by common power-supply impedance.

By use of the system shown in Figure A-22, the discriminators are compensated for variations in the speed of the magnetic tape recorder/reproducer. In this system, a 100-kilohertz reference frequency, provided by an EMR Model 101A-2 crystal reference oscillator mixing amplifier (Table B-VI), is recorded simultaneously with the composite FM video signal from the telemetry receivers. Capability of this mixing amplifier is such that either: (1) one or two subcarrier

complexes; or (2) a single subcarrier complex, plus voice, can be mixed with the single reference frequency, and applied to either one or two tracks of the magnetic tape.

During the reproducing mode, a discriminator, containing a 100-kilohertz reference-channel selector, is used to introduce into the data discriminators a correction voltage, proportional to tape-speed variations. This reduces the effects of wow and flutter. An EMR Model 230A signal-delay unit is included in the system to match the time delay of the reference discriminator.

TAPE RECORDING EQUIPMENT

A seven-channel, magnetic tape recorder, Model VR-2800 (Consolidated Electrodynamics Corp.) is used for storage of video complex telemetry data at Station H. In addition to video data, tape reference signals and signal strength values may also be recorded. Standard 14-inch diameter reels, which accommodate 7200 feet of 1-mil, or 5000 feet of 1.5-mil mylar-base tape, are provided for use with the recorder. The installation also includes a precision frequency power supply to ensure tape speed accuracy. Tape recorder characteristics are listed in Table B-VII.

REAL-TIME RECORDING EQUIPMENT

Real-time recording capability at Station H is provided by a CEC Type 5-119-P4 recording oscillograph. The oscillograph is equipped to record a maximum of 36 separate channels of data. Record magazines available for use with the oscillograph are: a DATARITE magazine, which utilizes flash-chemical processing to produce fully developed, "quick look" records; and a standard magazine to produce permanent records. An oscillogram processor is also available for processing the permanent records, thus precluding the necessity for special darkroom facilities. The characteristics of the real time recording equipment are listed in Table B-VIII.

CALIBRATION AND TEST EQUIPMENT

Listed below are those components of Station H used for frequency determination of the airborne transmitter, instrumentation calibration of the test equipment, and measurements of circuit parameters:

(1) Electronic Counter

(2) Signal Generator (FM/AM)

(3) Oscillator (wide range)

(4) Telemetry Calibrator

(5) Cathode-Ray Oscilloscopes (2)

(6) VTVM

(7) Tape Recorder Monitor and Checkout Patch Panel

Characteristics of the test and calibration equipment are listed in Table B-IX. Characteristics of the Tape Recorder Monitor and Checkout Patch Panel are listed in Table B-X, and the equipment is illustrated in Figure A-23.

ACCESSORY EQUIPMENT

Accessory equipment installed in Station H as listed here, is specified in Table B-XI and shown in Figure A-18.

(1) TIME CODE GENERATOR.
Provides both 28-bit and 36-bit NASA time codes.

(2) COMMUNICATIONS RECEIVER.
Used for timing synchronization with WWV and/or local time signals.

(3) WHIP ANTENNA (104-INCH).
Used in conjunction with the communications receiver (see Figure A-11).

(4) STATION MULTIPLEX (7-CHANNEL).
Used to record a plurality of channels of information on one tape-recorder channel. These channels may consist of voice channels, telemetry data channels, and/or reference frequencies.

(5) AUXILIARY POWER SUPPLY.

(6) DUAL CHANNEL POWER AMPLIFIER.

(7) TAPE DEGAUSSER.
Removes stray magnetic fields, and when required, all data from the magnetic tape.

(8) TAPE RECORDER AND OSCILLOGRAPH REMOTE CONTROL UNIT.

(9) INTERCOMMUNICATION SYSTEMS.
Range and local.

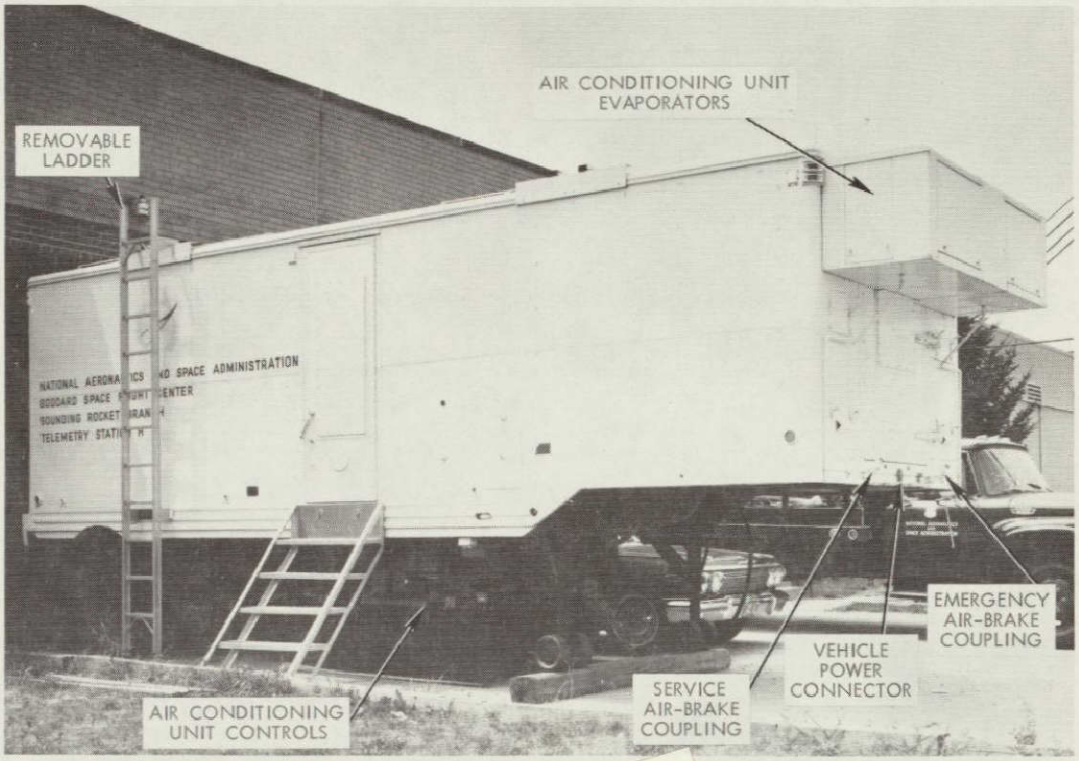
(10) LOUDSPEAKERS (2).

(11) RF AND MASTER PATCH PANELS.
Facilitate interconnections between equipments (See Figures A-16 and A-20).

(12) CRO-2 CHANNEL SELECTOR SWITCH PANEL.
Switches signals from different sources to Channel 1 and/or Channel 2 of Cathode-Ray Oscilloscope number 2 (CRO 2).

APPENDIX A

ILLUSTRATIONS



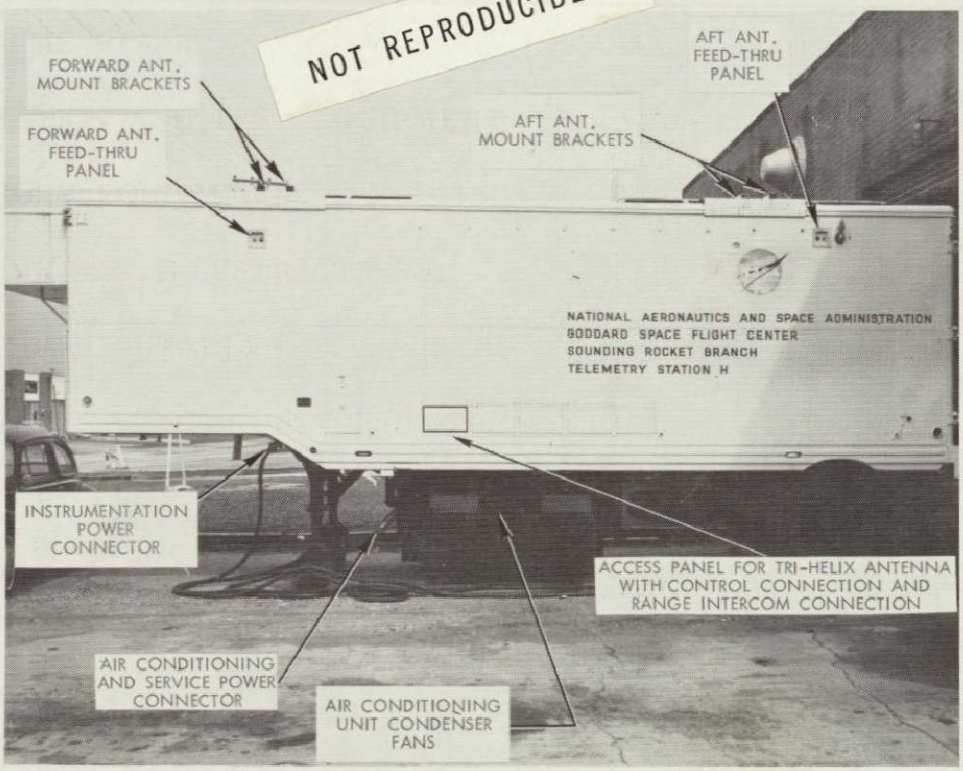


Figure A-1. GSFC Mobile FM/FM Telemetry Ground Station H, Exterior Configuration

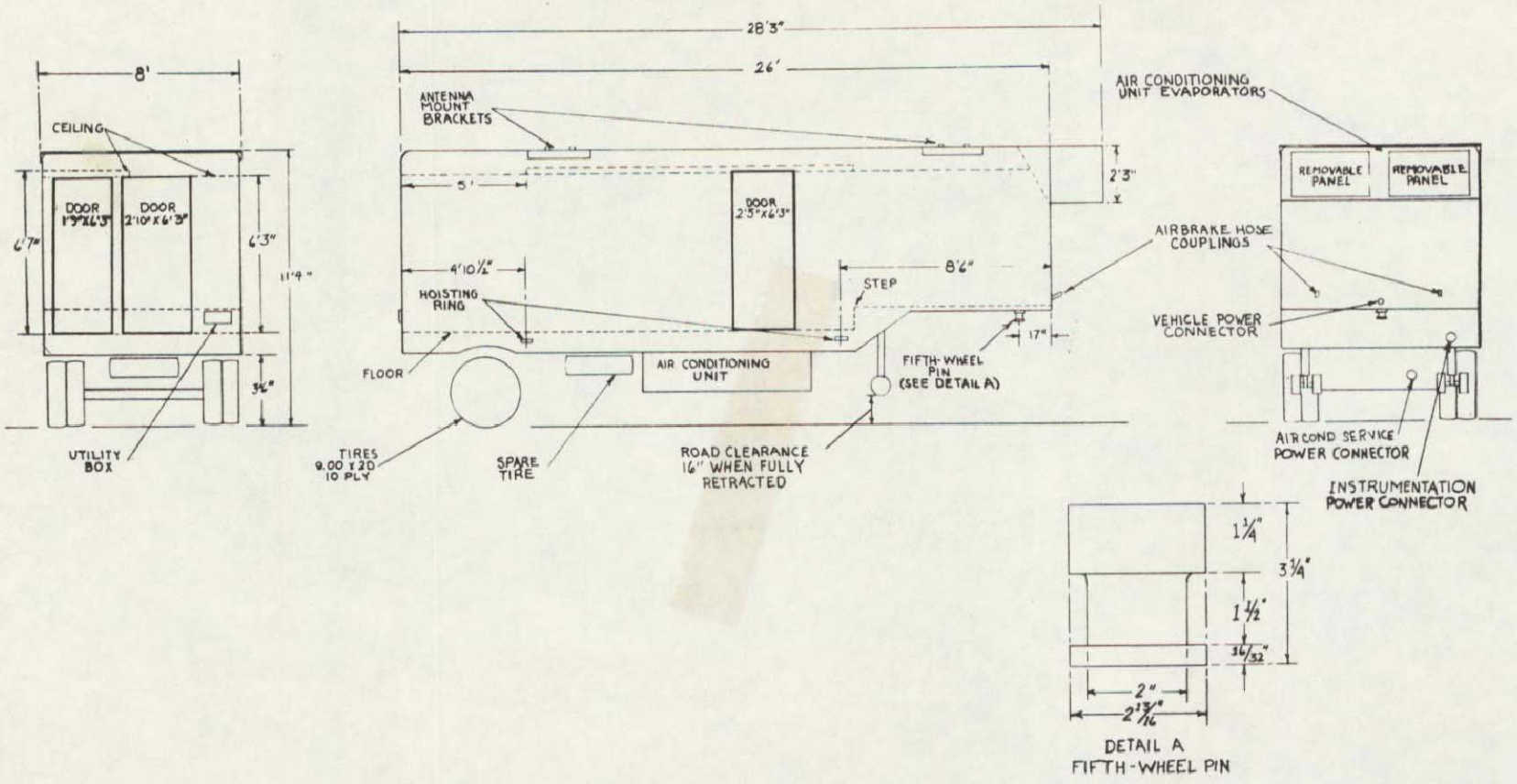


Figure A-2. GSFC Mobile FM/FM Telemetry Ground Station H, Diagram Showing Physical Dimensions in 1967

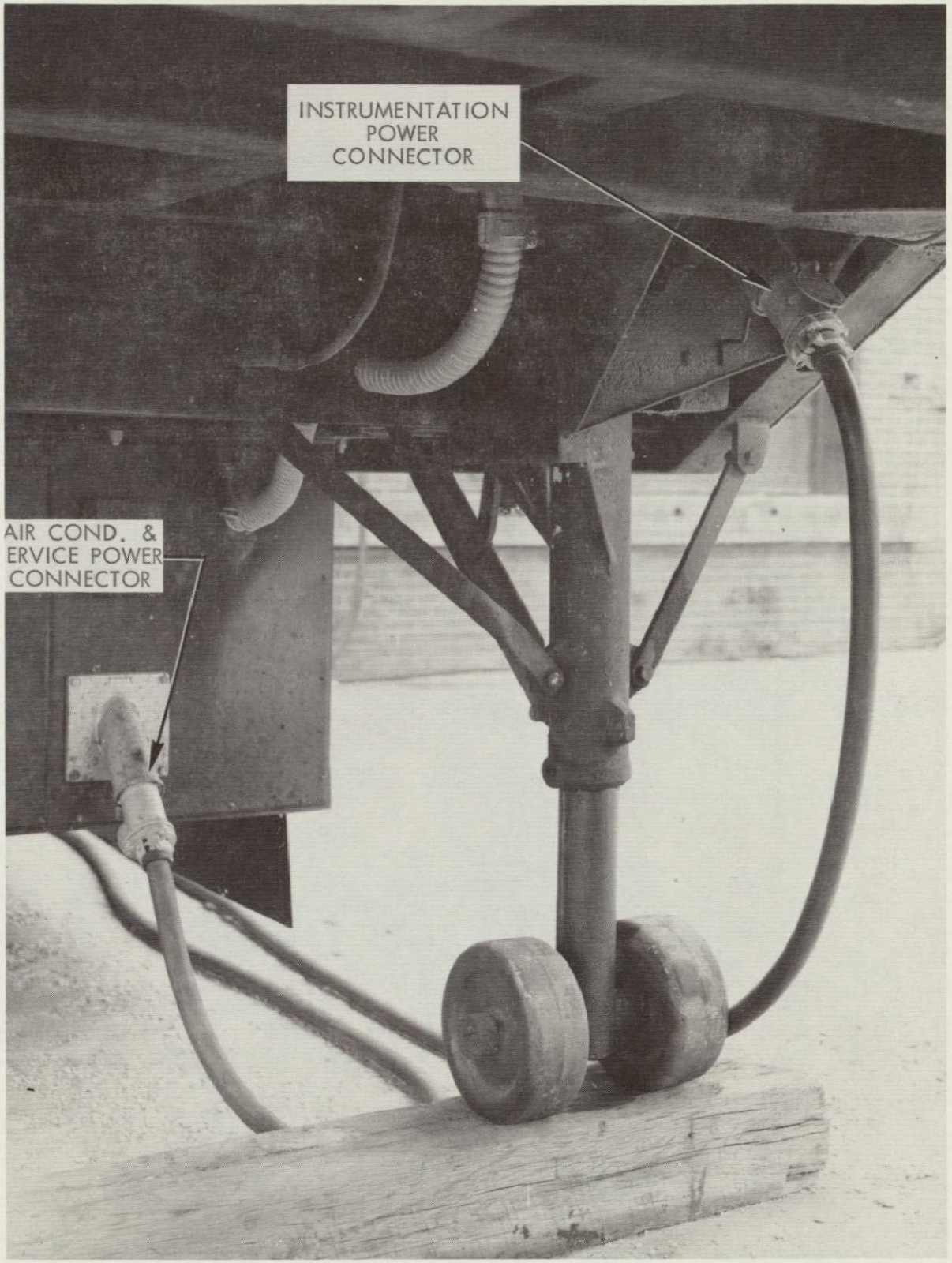


Figure A-3. Service and Instrumentation Power Connectors

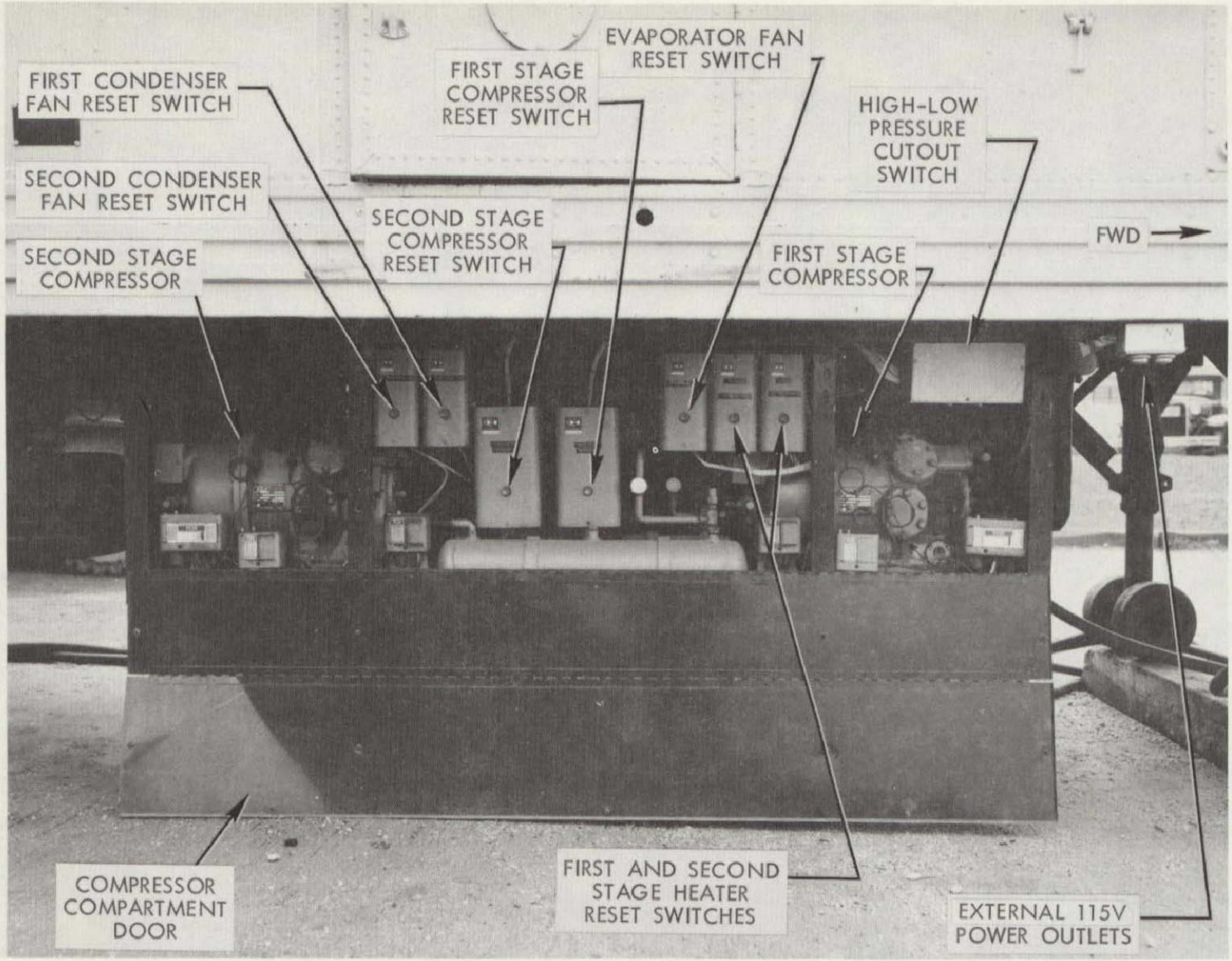


Figure A-4. Air Conditioning Unit and Controls

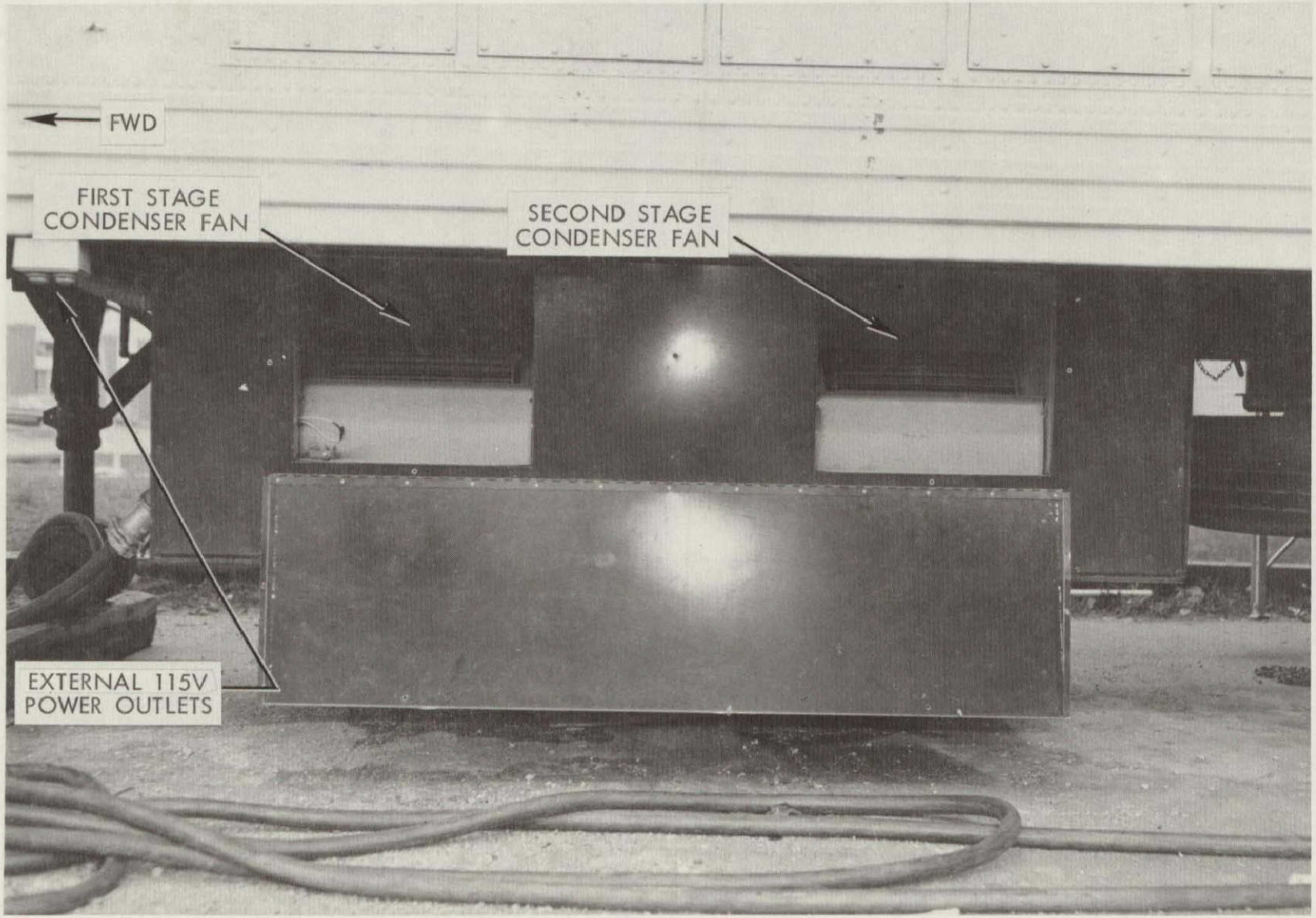


Figure A-5. Air Conditioning Unit Condenser Fans

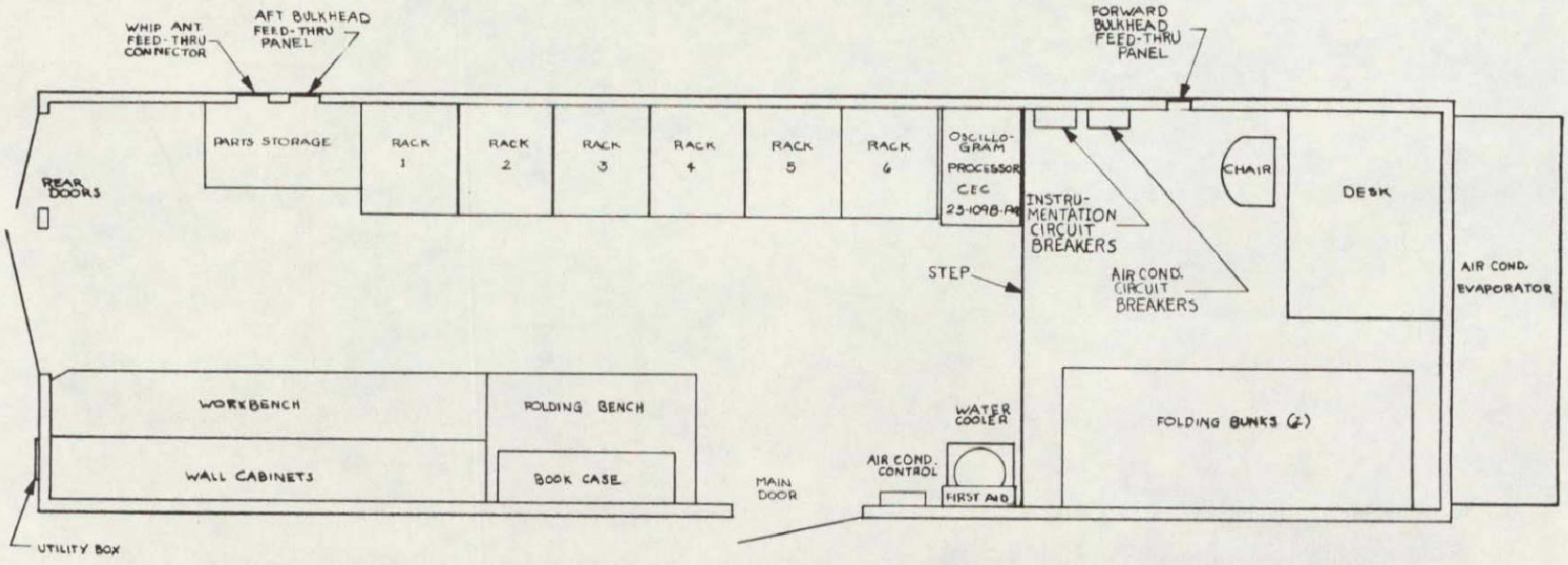


Figure A-6. GSFC Mobile FM/FM Telemetry Ground Station H, Internal Layout

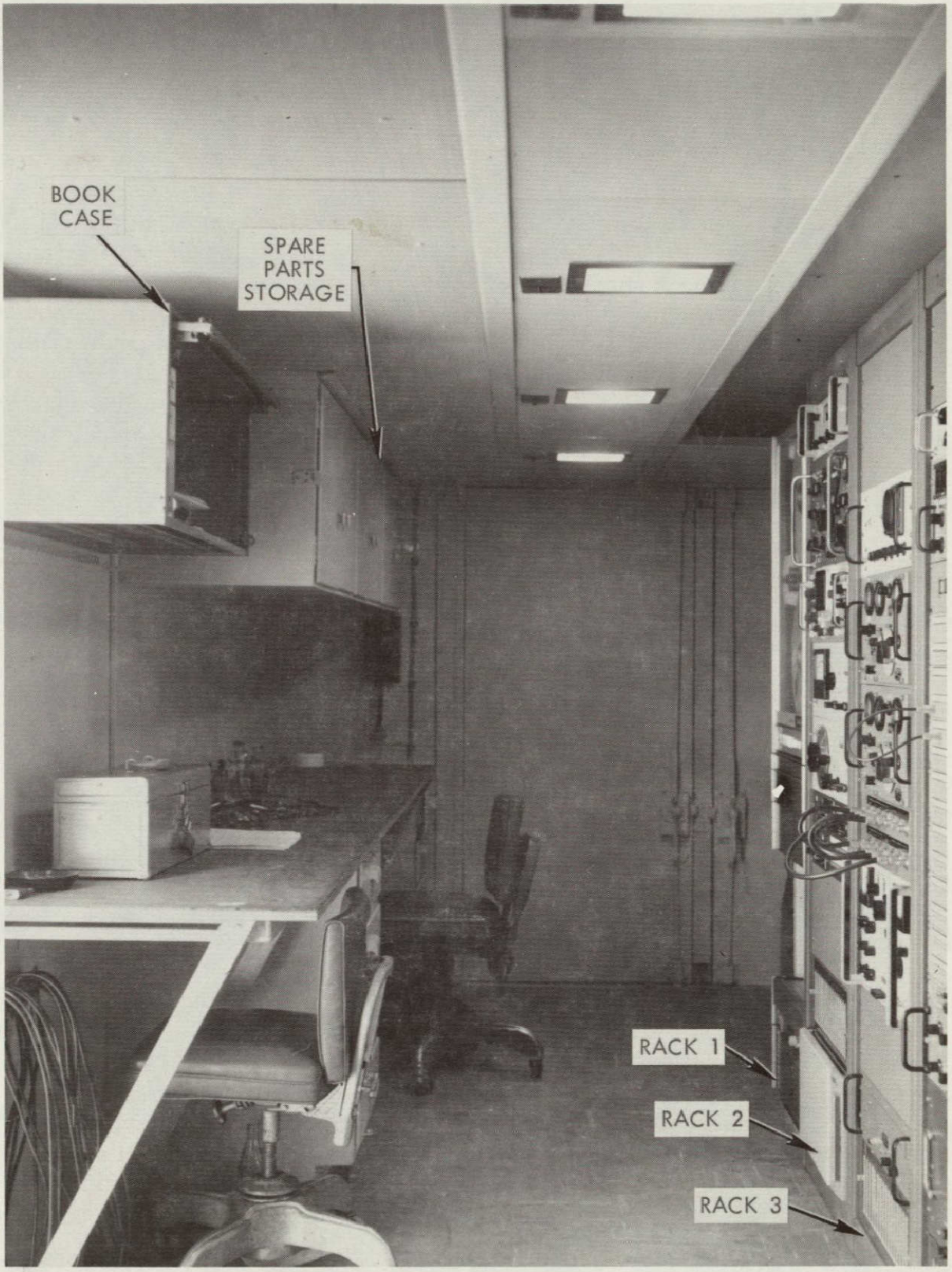


Figure A-7. Trailer Work Area

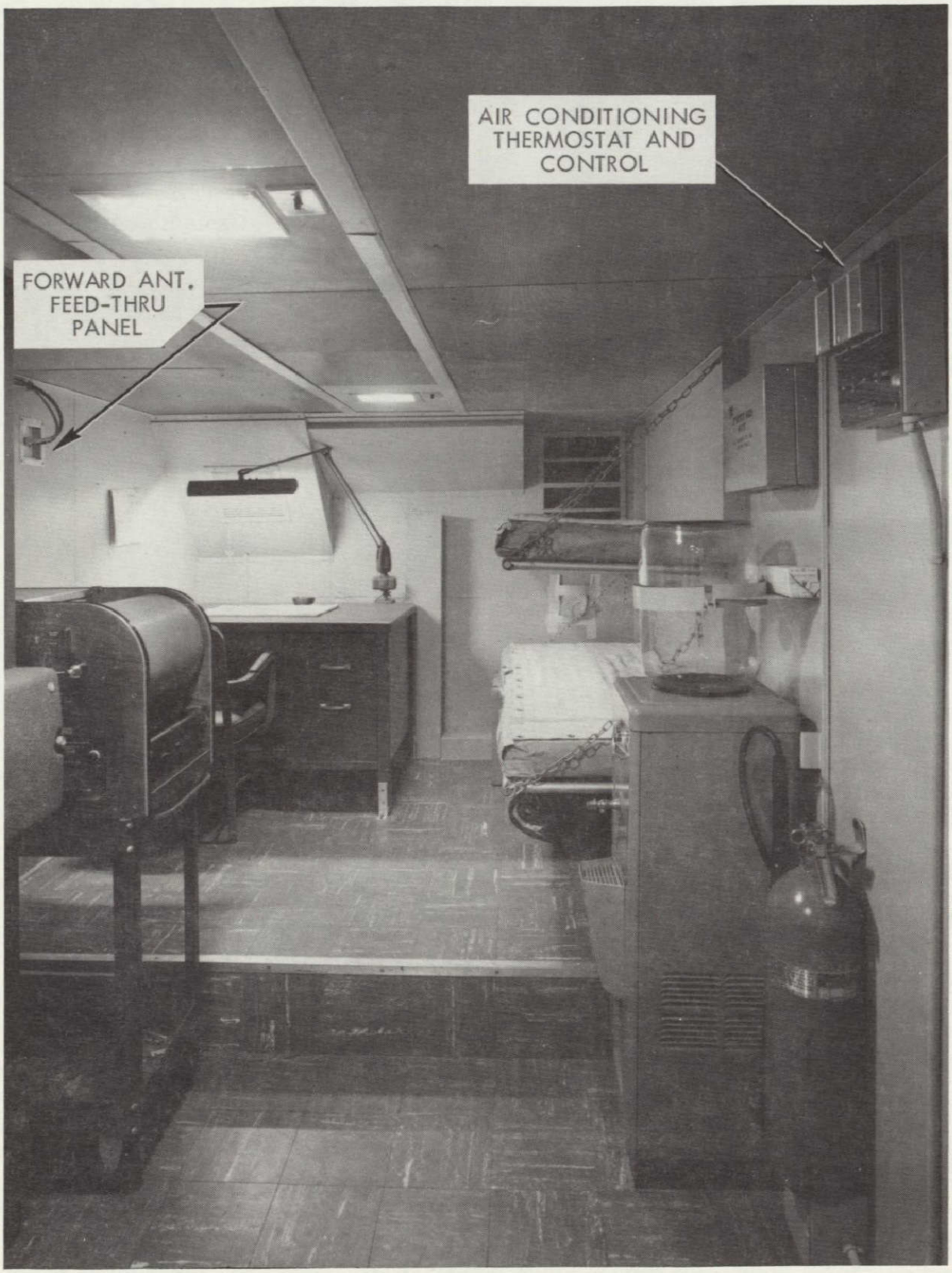


Figure A-8. Forward End of Trailer

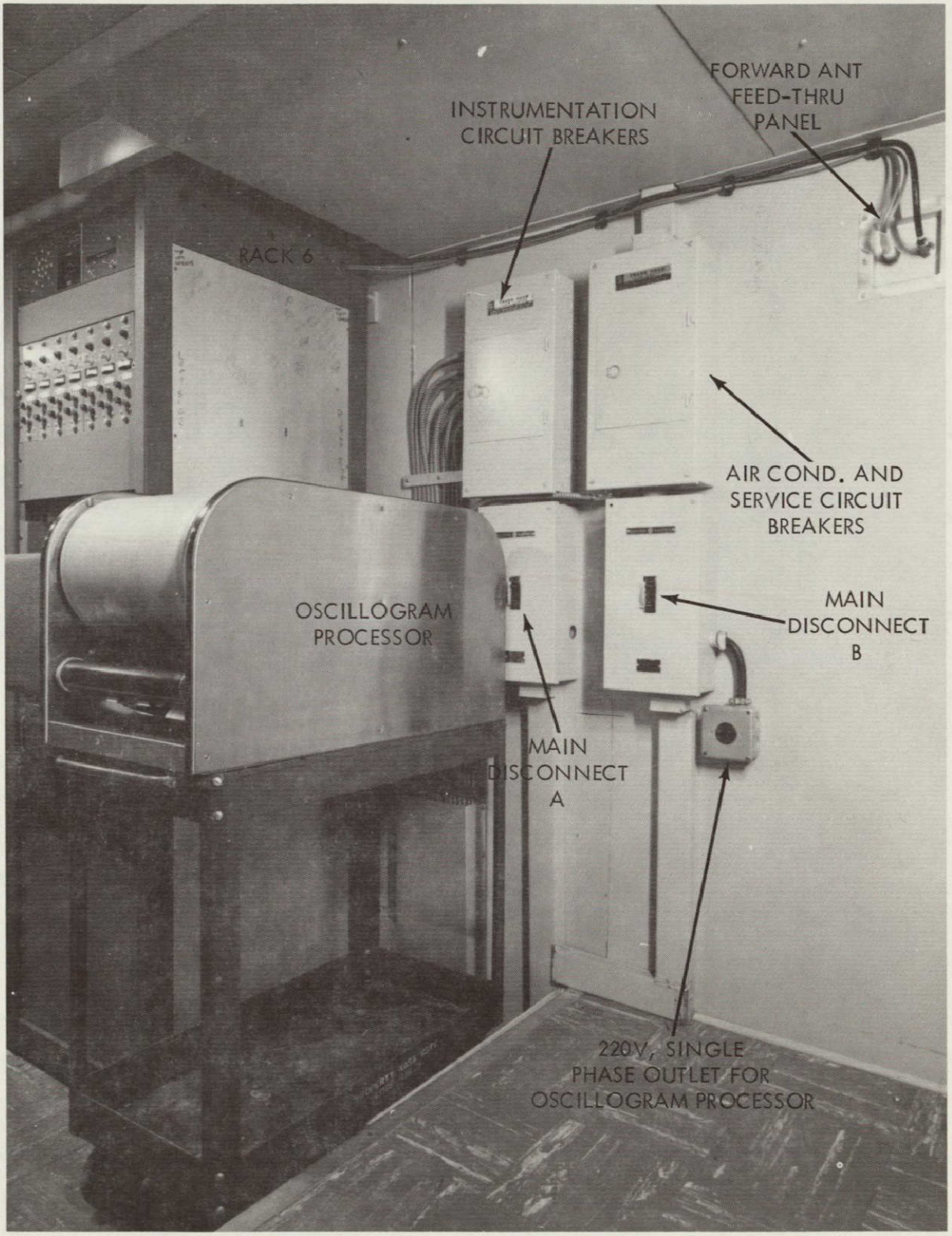


Figure A-9. Main Circuit Breaker Panels

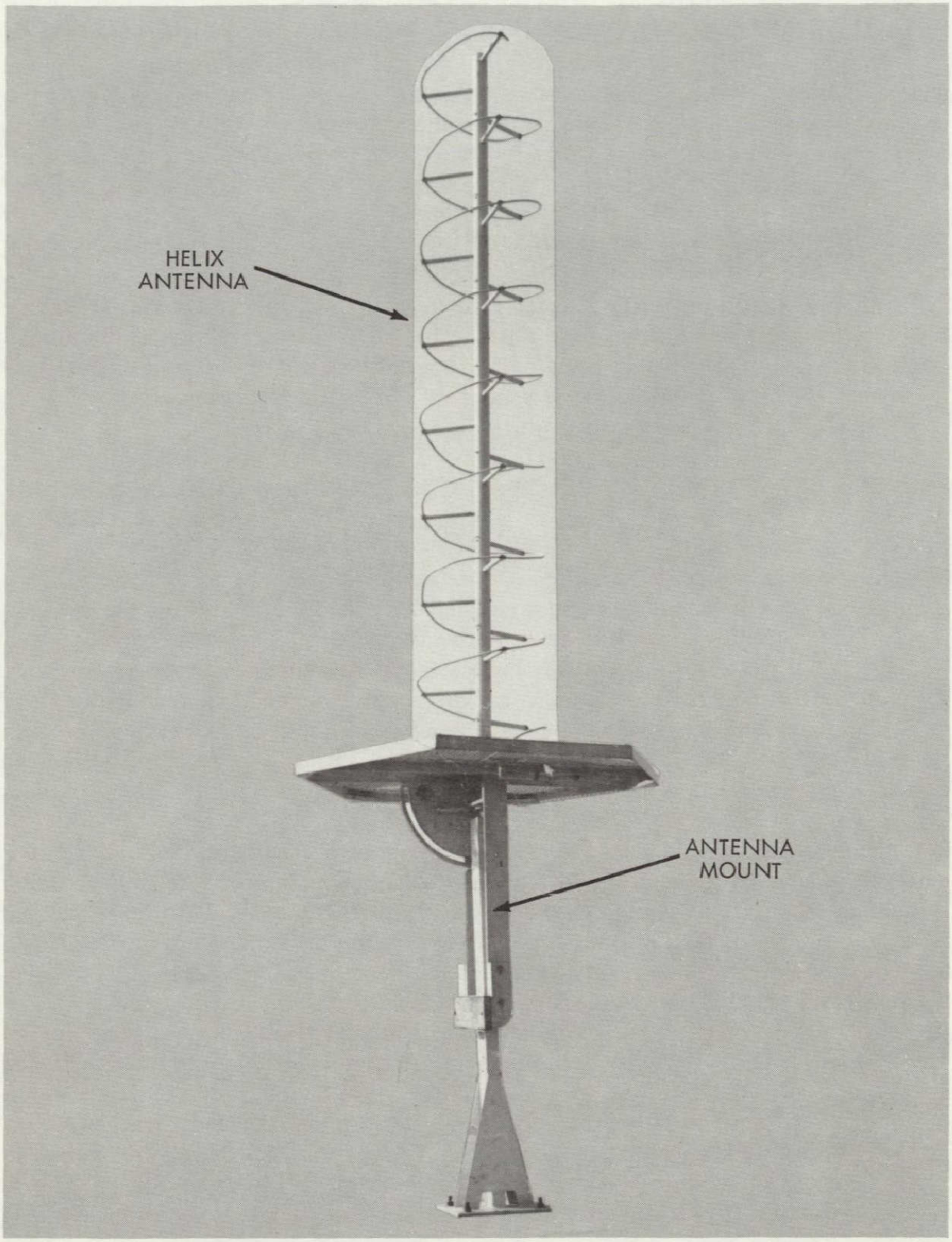


Figure A-10. 8-Turn, Right-Circular, Single-Helix Antenna

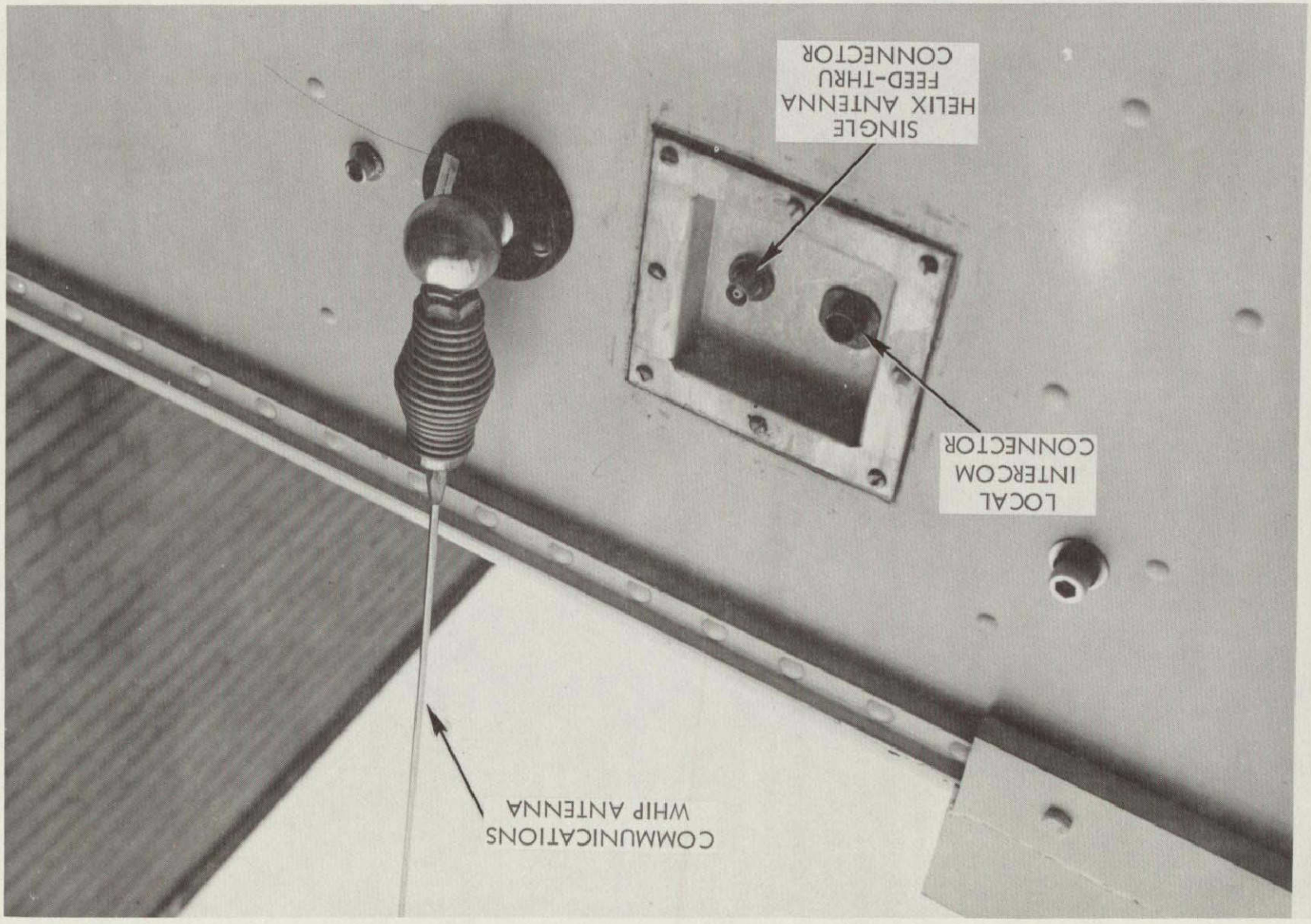


Figure A-11. Aft Bulkhead Feed-Through Panel and Whip Antenna

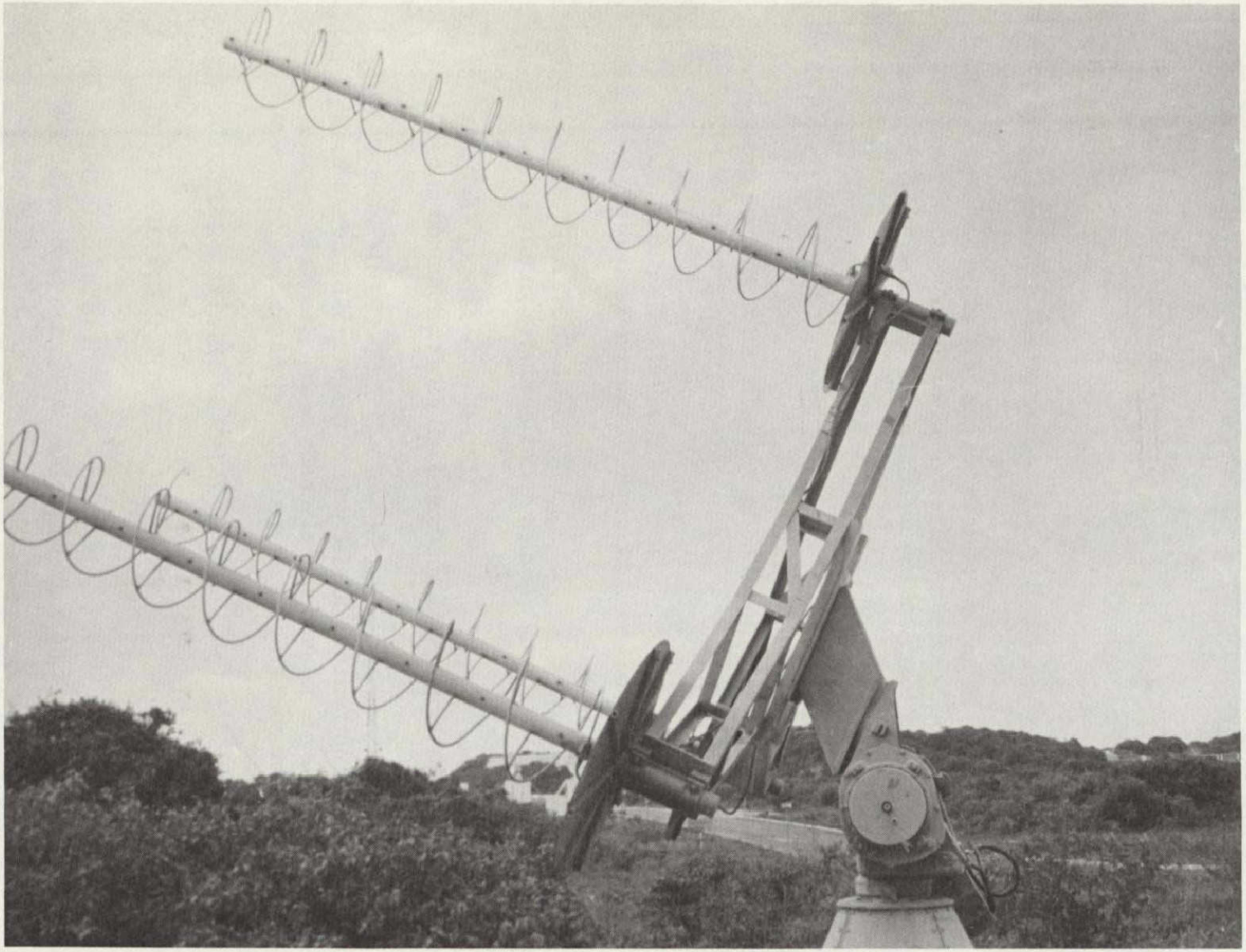


Figure A-12. New, 10-Turn, Right-Circular Tri-Helix Antenna

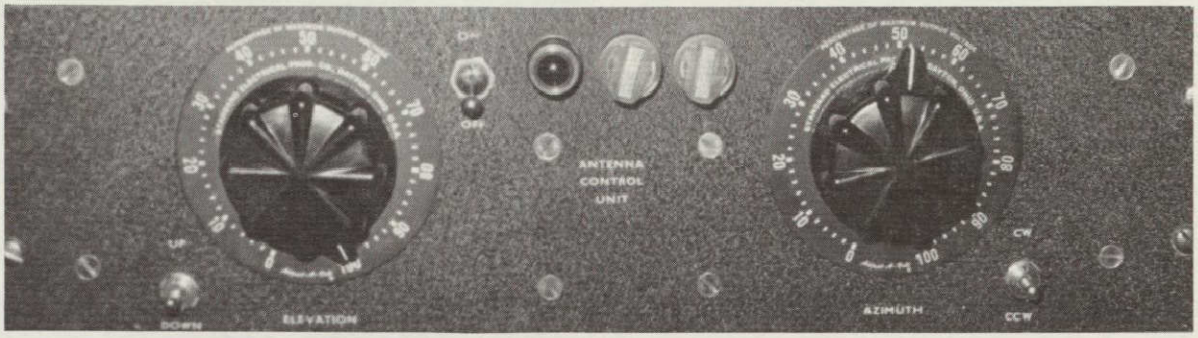


Figure A-13. Tri-Helix Antenna Control Unit

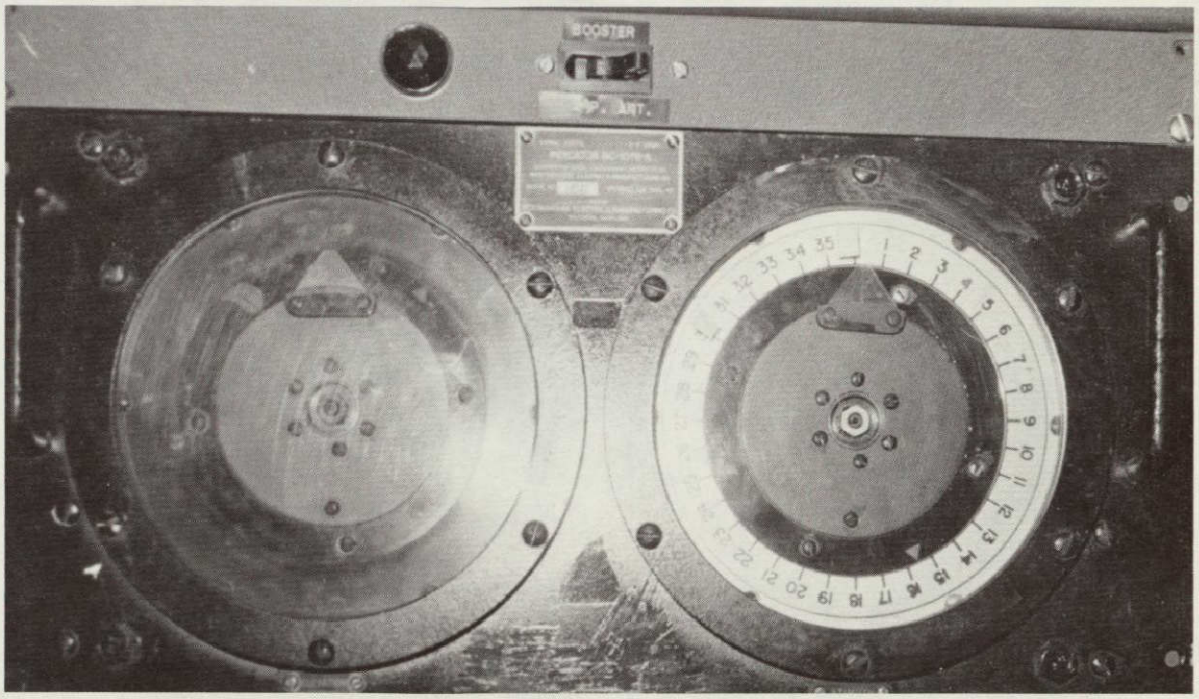


Figure A-14. Tri-Helix Antenna Direction Indicator and Preamplifier Power Switch

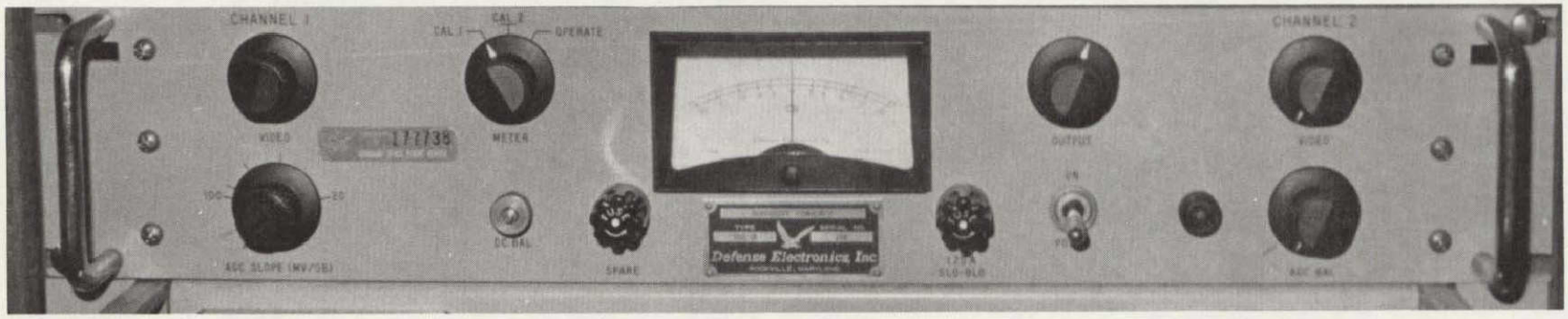


Figure A-15. Diversity Combiner

Figure A-16. RF Patch Panel

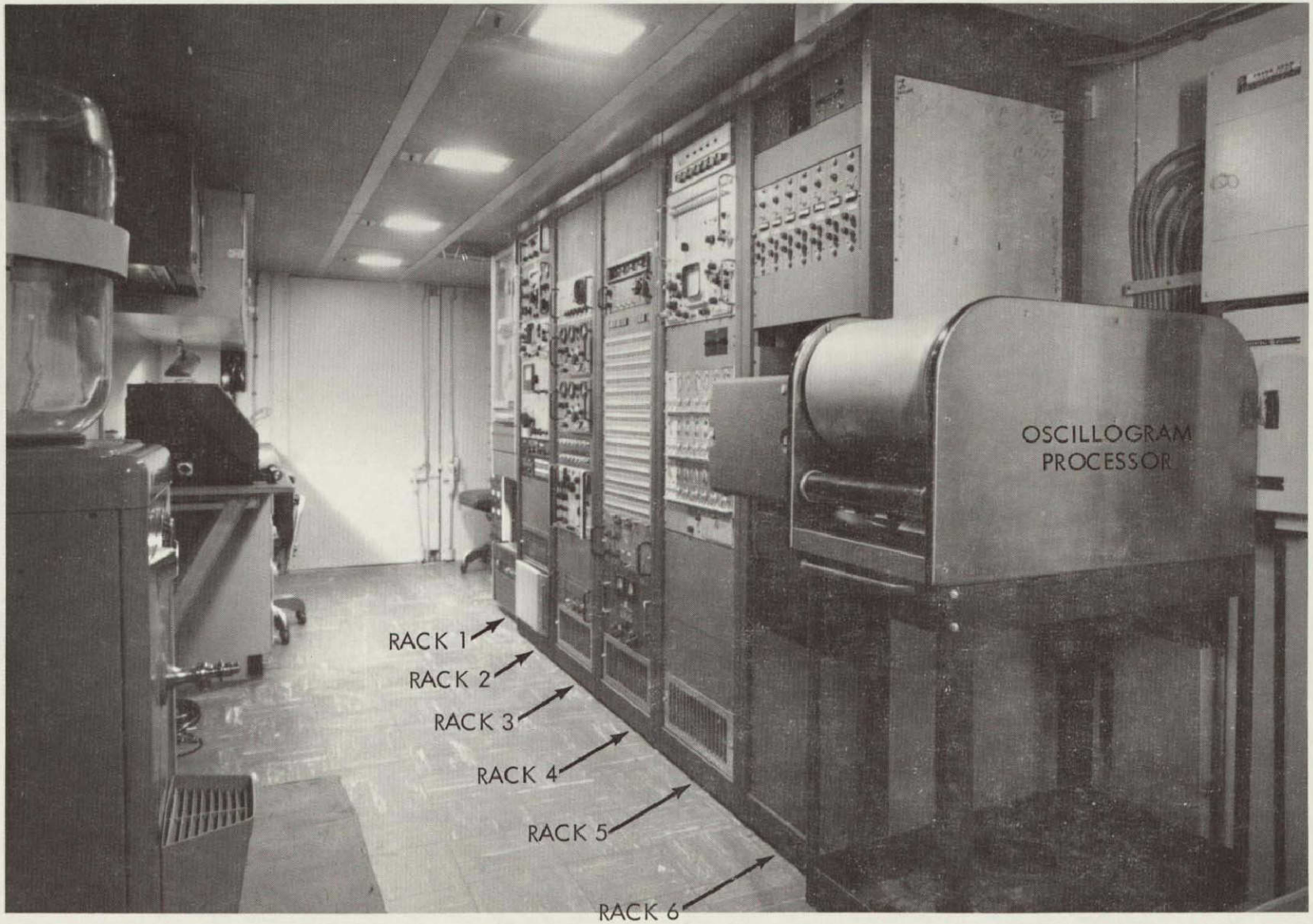


Figure A-17. Telemetry Equipment in 1967 (Inside View)

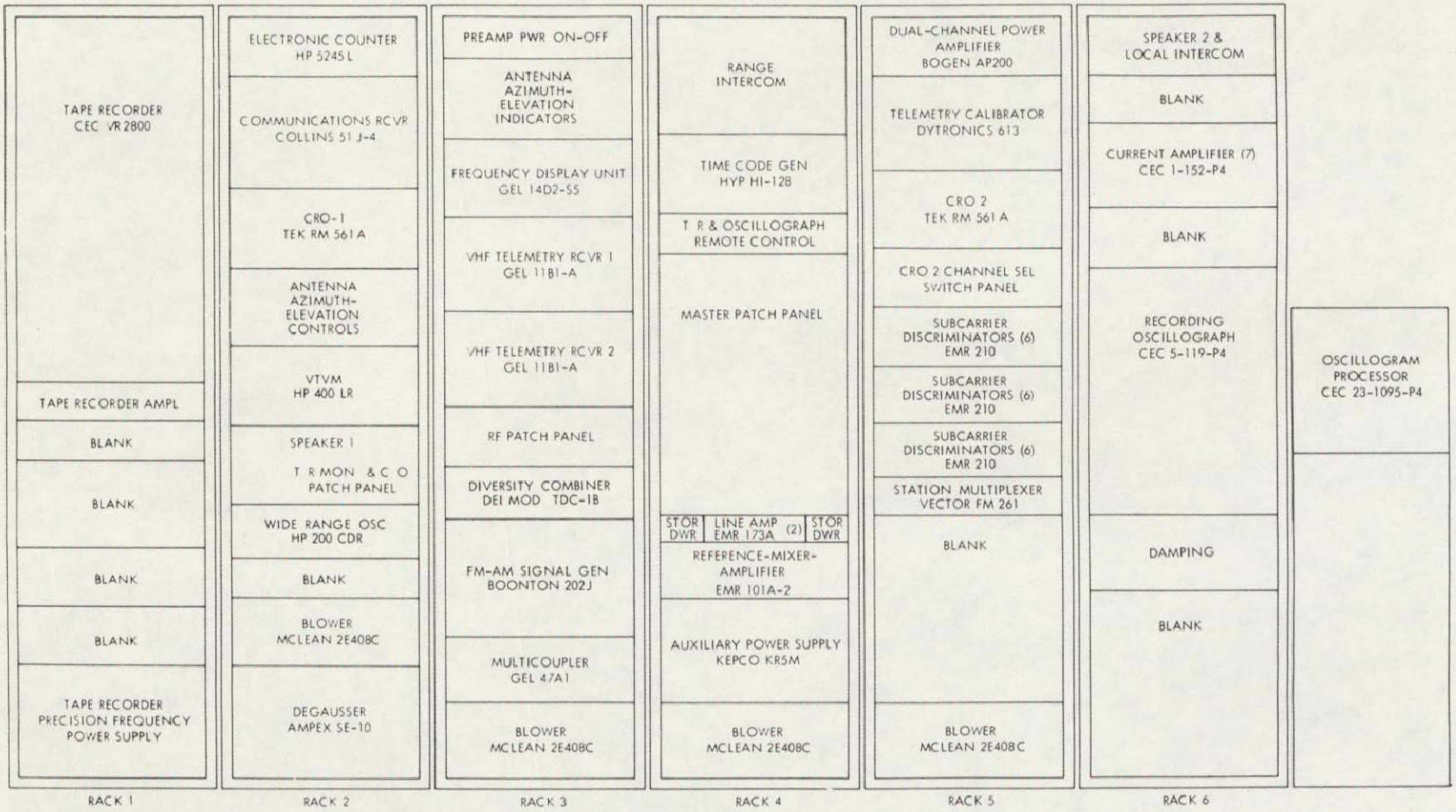


Figure A-18. Telemetry Equipment Relay Rack Layout

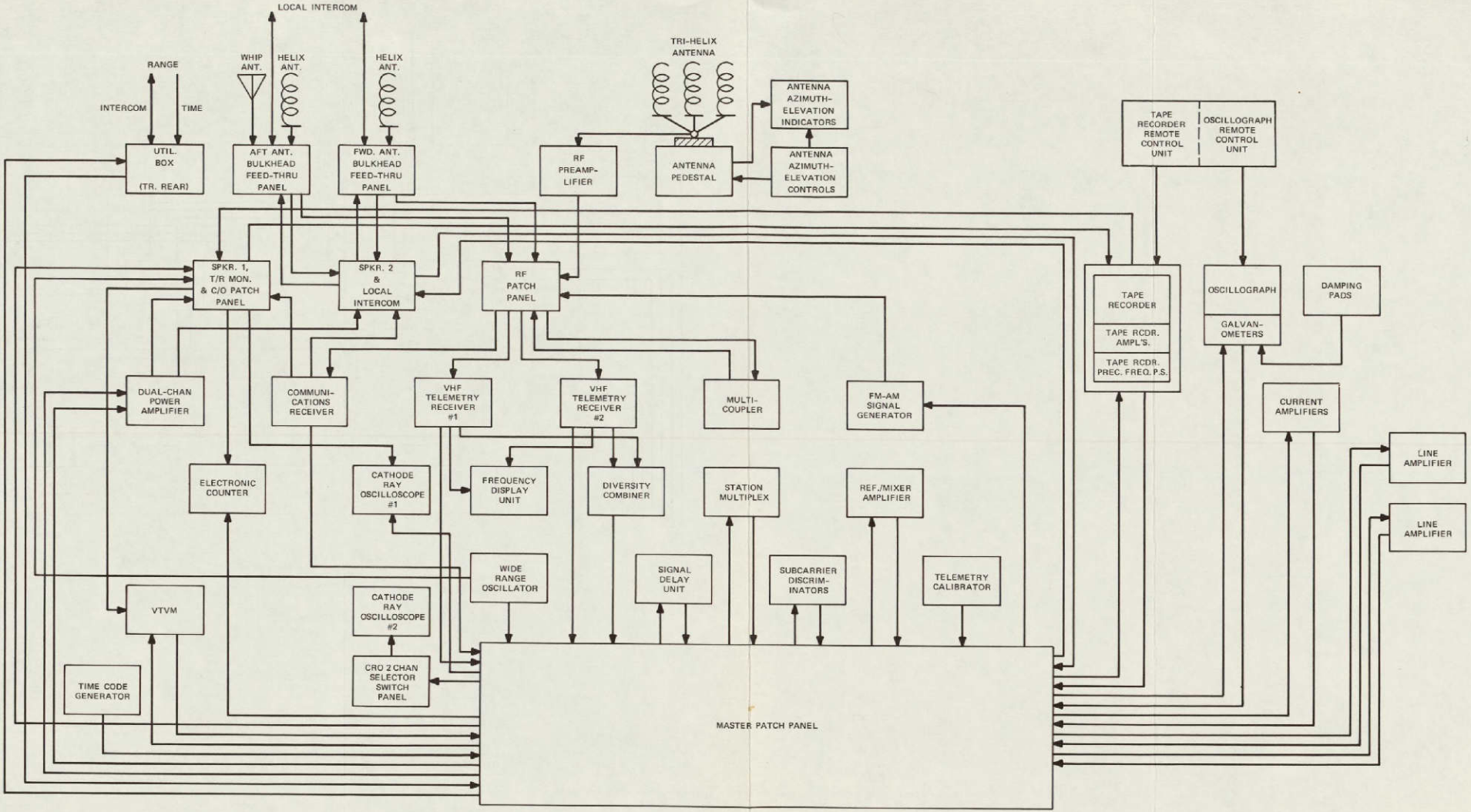


Figure A-19. Telemetry Equipment Block Diagram

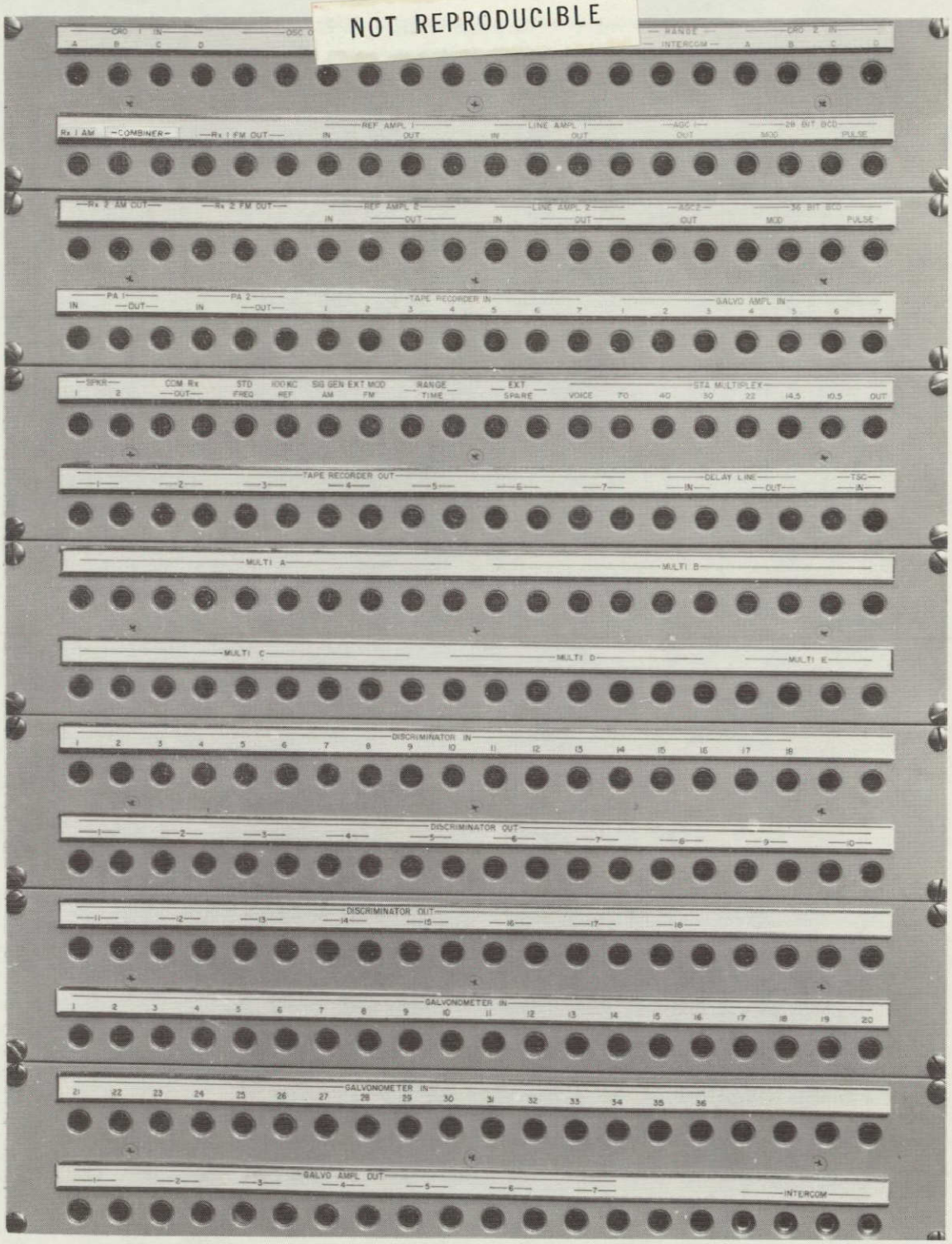
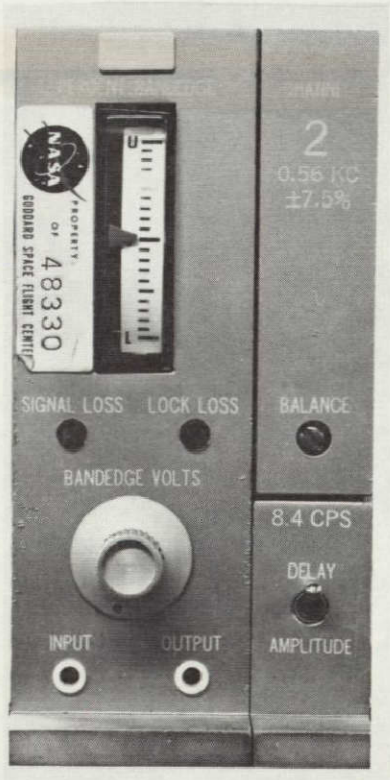


Figure A-20. Master Patch Panel



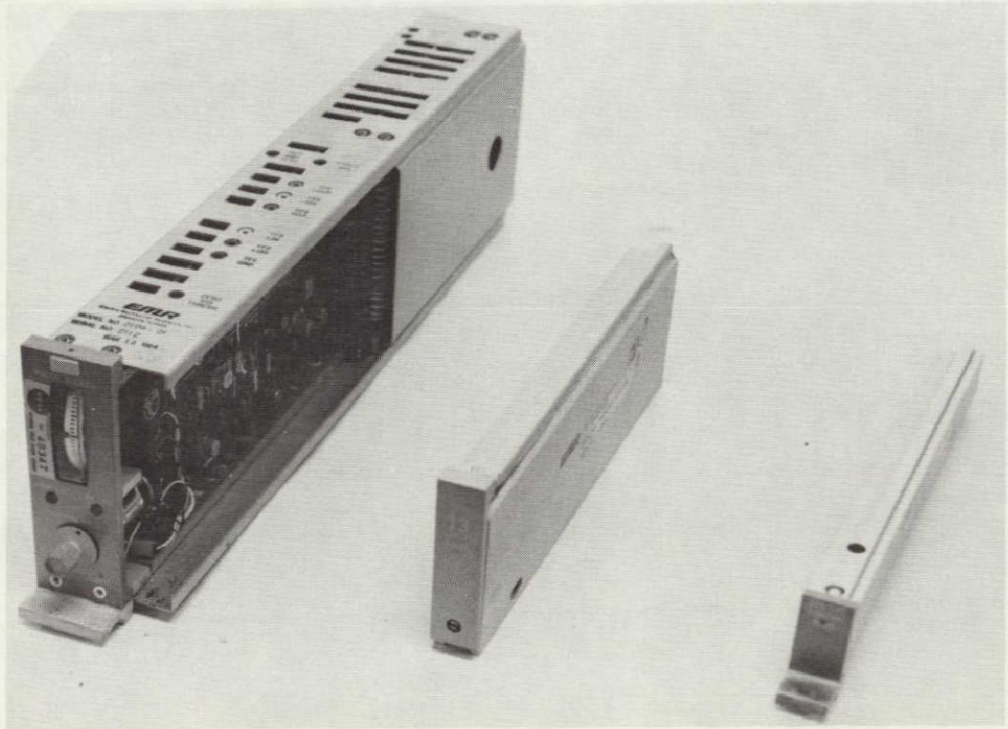


Figure A-21. Model 210A Phase-Locked-Loop Subcarrier Discriminator

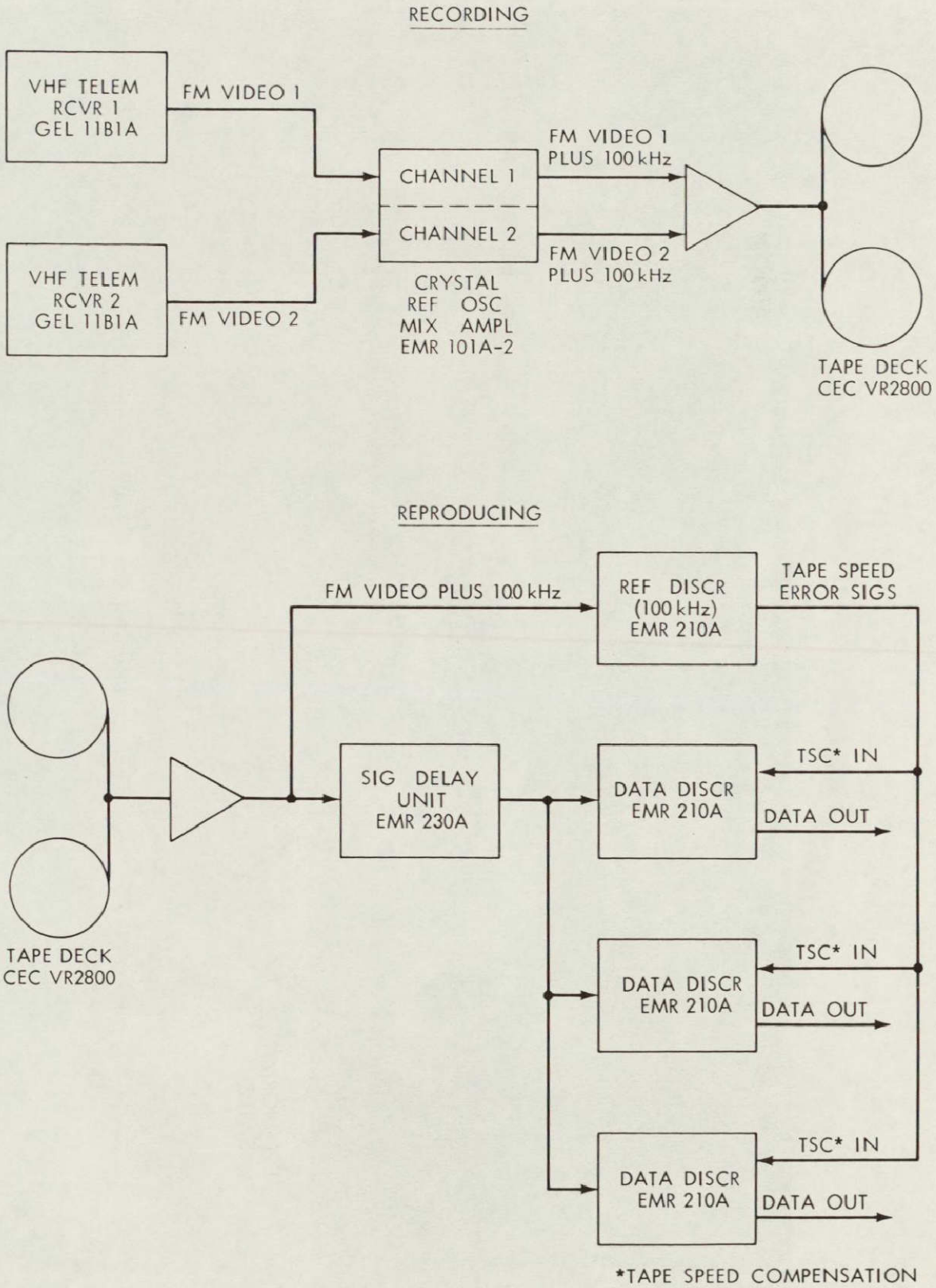


Figure A-22. Tape Speed Compensation System

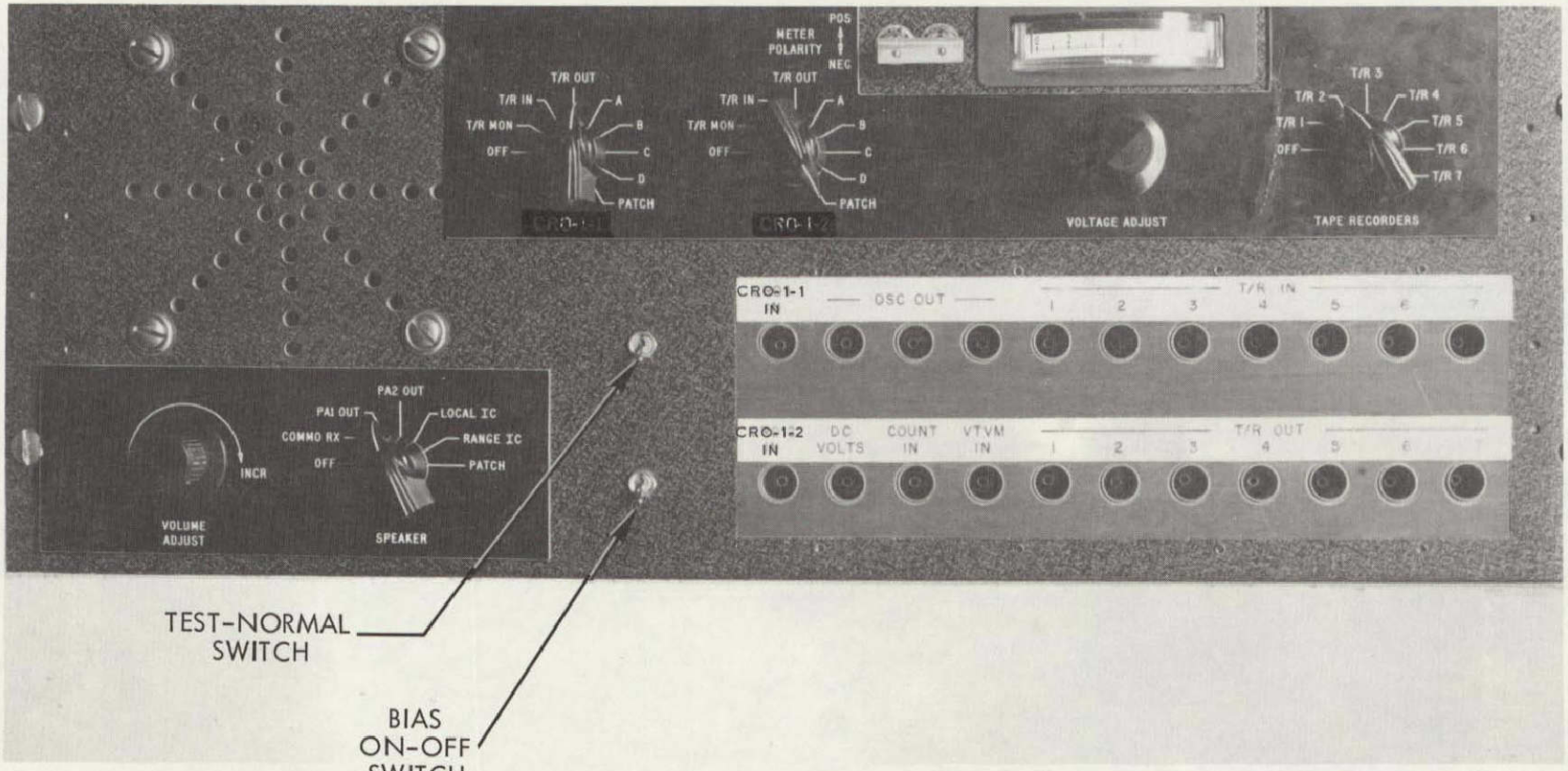


Figure A-23. Tape Recorder Monitor and Checkout Patch Panel

APPENDIX B

TABLES

Table B-I

STATION H TELEMETRY TRAILER

Trailer	Specifications
DIMENSIONS	(See Figure A-2)
Length	28 feet, 3 inches (external) 25 feet, 6 inches (internal)
Width	8 feet (external) 7 feet, 6 inches (internal)
Height	11 feet, 4 inches (external) 6 feet, 7 inches (relay rack area) 6 feet, 3 inches (headroom)
Overall Volume	2,560 cubic feet
Weight	23,600 pounds (loaded)
TIRES	
Size	9.00 x 20, 10 ply
Air pressure	70 pounds
VEHICLE POWER CONNECTORS	Berg Type 752 Deluxe (female) on trailer; Type 753 Deluxe (male) on cable
BRAKES	
Emergency and Service Airbrake Couplings	Midland Air Brake Type N1202-C on trailer; Midland Ross Type N1202-S on air line

Table B-II

TRAILER FACILITIES AND EQUIPMENT

Facilities and Equipment	Specifications
POWER	
Power Rating	208Y/120 volts, 3 phase, 50 to 60 Hz, 100 amperes, 4 wire
Air Condition and Service Power Connectors	Russell & Stoll Type 3134W on trailer; Type 3138W on cable
Instrumentation Power Connectors	Russell & Stoll Type 3134W on trailer; Type 3138W on cable
Vehicle Power Connectors	Berg Type 752 Deluxe (female) on trailer; Type 753 Deluxe (male) on cable
AIR CONDITIONING	
Air Conditioning Unit	Harvey W. Hottel Model HAC-72-A-60 (modified)
Rating	Nominal 6 tons, 72,000 Btu per hour
Controls (located in trailer):	
Function Switch	Controls function of Air Condition unit: In OFF position, entire control system deenergized. In FAN position, starts evaporator blower operation. In CONDITIONING position, starts operation of all system components
SUMMER-WINTER Switch	Permits thermostat to control either the two stages of cooling (SUMMER position) or two stages of heating (WINTER position)
HEATING	
Heaters (two stages)	Four, resistance type, rated at 2.2 kW each
Dehumidifying Capacity	Nominal 21,600 Btu per hour

Table B-II (Continued)

TRAILER FACILITIES AND EQUIPMENT

Facilities and Equipment	Specifications
COMPRESSORS (2)	Worthington Model 23JF5
Pressure	Adjustable between 210 and 375 psi
Bore	2 3/64 inches
Stroke	1 7/16 inches
Number of Cylinders	5
Revolutions per Minute	1750 r/min
Displacement	23.96 cfm
Refrigerant	Freon 12 or 22
Oil Charge	4 1/2 pints
Motors (2)	10 hp, 60 Hz, 3 phase, 208-220 V, 38A (nameplate, full load), 140-148A (locked rotor) CAUTION: To prevent stalling or overheating at high loads or low voltage, maximum trip current of protector must not exceed 51.5 amperes
Condenser Fan Motors (2)	1 1/2 hp, 1140 r/min
Evaporator Fan Motors (2)	1 1/2 hp, 1750 r/min
OTHER EQUIPMENT	
Bunks (2)	
Desk	
Work Bench	
Storage Equipment	
Tools	
Water Cooler	Westinghouse; 5-gallon capacity
First Aid Kit	Johnson & Johnson

Table B-III

TELEMETRY ANTENNA CHARACTERISTICS

Equipment	Specifications
8-TURN SINGLE HELIX (2)	New Mexico State University Model 21.004
Frequency Range	230 to 260 MHz
Gain	12 dB
Beamwidth	20 degrees
Polarization	Right-hand circular
Impedance	50 ohms nominal
VSWR	Better than 1.5 to 1
Tracking	Manual
10-TURN TRI-HELIX	Taco D-1387-(10)
Frequency Range	215-265 MHz
Impedance	50 ohms nominal, Type "N" input
VSWR	1.50 to 1 or less
Beamwidth	15 to 25 degrees between the half-power points of the main lobe in the horizontal and vertical planes.
Polarization	Right circular
Circularity	Plus or minus 1.5 dB (over band) Plus or minus 1.0 dB (average)
Gain	(Nominal over a circularly polarized isotropic) 18.5 dB at 215 MHz 21.2 dB at 265 MHz

Table B-III (Continued)

TELEMETRY ANTENNA CHARACTERISTICS

Equipment	Specifications
RF PREAMPLIFIER	Applied Research, Inc., Model HFW-2 (AS)
Frequency Range	225 to 256 MHz
Bandwidth	31 MHz
Gain	20 dB
Noise Figure	2.5 dB
Input Impedance	50 ohms
Output Impedance	50 ohms
Connectors	
Input	Type N
Output	Type N
Power	MS3102E-10SL-3P
Power Requirements	115 Volts, AC, 60 hertz, at 25 watts
Mounting Requirements	5 7/16 inches by 11 1/16 inches, with four 1/4-inch holes

Table B-IV

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

Equipment	Specifications
VHF TELEMETRY RECEIVERS (2)	General Electronic Laboratories, Inc. Type 11B1-A
Type	Double-conversion superheterodyne; 30 MHz first i-f; 10 MHz, second i-f
Frequency Range	215 to 265 MHz
First Local Oscillator	Continuously tunable or crystal controlled, temperature compensated
Second Local Oscillator	Tunable over ±150 kHz front panel control
Deviation Range	25, 75, 150, and 250 kHz; selected by use of front panel switch
I-F Bandwidth	300 and 500 kHz using plug-in second i-f amplifiers
I-F Rejection	Greater than 80 dB
Image Rejection	Greater than 60 dB
Noise Figure	Less than 7 dB
Selectivity	Response has 60 to 6 dB ratio of approximately 2.5
Discriminator Linearity	1% over 250 kHz
Input Impedance	50 ohms
Metering:	
TUNING	Center reading, front panel meter indicates zero when signal is centered in i-f passband
SIGNAL LEVEL	Front panel meter indicates level of received signal in microvolts
DEVIATION	Front panel meter indicates peak deviation of single FM/FM subcarrier

Table B-IV (Continued)

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

Equipment	Specifications
VHF TELEMETRY RECEIVERS (2) (Continued)	
Outputs Provided:	
FM Video	
Frequency Response	10 Hz to 300 kHz (within 3 dB)
Sensitivity	0.08 volts (peak) per kHz deviation
Source Impedance	Less than 500 ohms
Output Load	10 kilohms shunted by 1000 picofarads
AM Video	
Frequency Response	150 Hz to 150 kHz (within 3 dB)
Output Load	10 kilohms shunted by 500 picofarads
Frequency Display Unit	Taken from 30-MHz first i-f
AGC Voltage	Varies from between 7 and 2 volts on noise to between 8 and 15 volts on maximum signal
Source Impedance	250,000 ohms (approximately)
Power Requirements	115 volts, 60 Hz, 165 watts
MULTICOUPLER	General Electronics Laboratories, Inc.
Type	Type 47A1
Frequency Range	215-260 MHz
Gain	Approximately Unity (input to any output)
Gain Variation over Passband	Less than 1 dB
Input and Output Impedance Levels	50 ohms, nominal

Table B-IV (Continued)

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

Equipment	Specifications
MULTICOUPLER (Continued)	
Outputs	
Number	8
Isolation Between	35 dB minimum
Power Input	115 v, 50 to 400 Hz, 20 watts
Connectors	Power, Hubbell 7486G; RF, Type "C" (other to special order)
Weight	22 pounds
Size	Standard relay rack 5 1/4" x 19" x 13"
LINE AMPLIFIERS (2)	Electro-Mechanical Research Model 173A
Frequency Range	200 Hz to 150 kHz
Frequency Response	+0.5 dB to -3 dB throughout frequency range (reference: 10 kHz)
Time Delay	Sufficiently uniform throughout passband to prevent degradation of tape-speed compensation effectiveness
Harmonic Distortion	Less than 0.3% for frequencies below 50 kHz at 25 degrees C (77 degrees F); less than 0.6% at 0 degrees C (32 degrees F)
Voltage Gain	Adjustable in steps of 0.5, 1, 2, 5, and 10
Input Level	12 volts peak-to-peak (max) with de-emphasis at infinite corner frequency; 8 volts peak-to-peak (max) with de-emphasis at finite corner frequency
Noise and 60-Hertz Hum	8 millivolts peak-to-peak (max)

Table B-IV (Continued)

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

Equipment	Specifications
LINE AMPLIFIERS (2) (Continued)	
Input Impedance	Greater than 50,000 ohms, shunted by less than 30 picofarads
Output Impedance	Less than 10 ohms
Load Characteristics	90 ohms (min) shunted by 0.01 microfarads (max)
Power Requirements	120 volts, 50 to 60 Hz, 12 watts
FREQUENCY DISPLAY UNIT	General Electronic Laboratories, Inc., Type 14D2-S5
Display	3-inch cathode-ray tube, Type 3RP1A or 3RP2A
Input Center Frequency	30 MHz
Sweep Width	Continuously adjustable from zero to 3 MHz
Amplitude Constancy over Display Range	Within 3 dB of response at center frequency
Resolution	20 kHz (approximately)
Sensitivity	80 dB or greater
Image Rejection	80 dB or greater
Second I-F Frequency	4.3 MHz
Oscillator Mean Frequency	25.7 MHz
Power Requirements	117 volts, 50 to 400 Hz, 95 watts
DIVERSITY COMBINER	Defense Electronics, Inc., Model TDC-1-B
Mode of Operation	Dual-diversity, optimum-ratio combining

Table B-IV (Continued)

RECEIVING AND SPECTRUM DISPLAY EQUIPMENT

Equipment	Specifications
DIVERSITY COMBINER (Continued)	
Signal-to-Noise Ratio Improvement	Greater than 2.5 dB for inputs of equal signal-to-noise ratio
Combining Rate	10 kHz maximum (0.1 millisecond)
Video Input Level	1.4 volts rms minimum
Video Input Impedance	10 K ohms
Video Output Level	Adjustable to provide 4 volts peak-to-peak
Video Output Load	1000 ohms shunted by 500 picofarads
Video Response	2 Hz to 500 kHz at 1 dB points
Pulse Rise and Decay Times	0.5 microseconds, maximum
Required Control Function	Approximately logarithmic AGC, 1 volt minimum gradient for 20 dB changes in receiver input
Control Input Impedance	500 K ohms
Common Mode Rejection	Control voltage variations cause less than 0.5 dB change in output amplitude
Metering	Video balance, control balance, and channel contribution
Power Requirements	115 volts ±10%, 60 Hz, approximately 110 watts

Table B-V

SUBCARRIER DISCRIMINATOR CHARACTERISTICS

Equipment	Specifications
SUBCARRIER DISCRIMINATORS (18)	Electro-Mechanical Research Model 210A, with the correct channel selector and output filter for the selected subcarrier frequency (See Figure A-21)
Type	Modular phase-locked-loop
Subcarrier Frequencies	Standard IRIG Channels (see Appendix C) selected from: 1 through 18 (narrow band); and A, C, and E (wide band)
Subcarrier Frequency Deviations	±7.5% and ±15% (see Appendix C)
Deviation Ratio	Sufficiently wide to prevent loss-of-lock with bandedge-to-bandedge step of subcarrier frequency
AM Rejection	With deviation ratio of 5, a 20-dB step of input amplitude, anywhere in the 60-dB dynamic range, causes peak transient of less than 1.0% of bandwidth
Linearity	Best straight line linearity at least ±0.5% of bandwidth
Tape Speed Compensation	Improvement ratios in excess of 20 to 1 for tape speed errors of ±4%, and 30 to 1 for tape speed errors of ±3%
Metering	(See Figure A-21)
PERCENT BANDEDGE	Front panel PERCENT BANDEDGE meter indicates percentage of bandedge frequency deviation

Table B-V (Continued)

SUBCARRIER DISCRIMINATOR CHARACTERISTICS

Equipment	Specifications
SUBCARRIER DISCRIMINATORS (18) (Continued)	
Loss-of-Lock Indication	Front panel LOCK LOSS lamp indicates loss-of-lock of the phase-locked-loop
Signal Loss Indication	Front panel SIGNAL LOSS lamp indicates signal less than predetermined level
Dynamic Input Signal Range	60 dB, 10 millivolts to 10 volts rms
Input Impedance	Greater than 3,000 ohms for 18 discriminators connected in parallel: greater than 100 kilohms for each discriminator for center frequencies, to and including 10.5 kHz
Outputs Provided	Front panel INPUT test jack provides for monitoring band-pass input filter output signal
	Front panel OUTPUT test jack provides for monitoring discriminator output signal
	Data output: single ended, referenced to ground
Output Voltage	Continuously variable from 1 to 10 volts dc
Output Current Capability	100 milliamps from dc to 5 kHz; decreases linearly to 20 milliamperes at 45 kHz
Output Noise	Rms value less than 0.05% of bandwidth in a 15-hour period after a 15-minute warmup

Table B-V (Continued)

SUBCARRIER DISCRIMINATOR CHARACTERISTICS

Equipment	Specifications
SUBCARRIER DISCRIMINATORS (18) (Continued)	
Deviation Sensitivity	±0.2% in a 15-hour period after a 15-minute warmup
Output Impedance	2 ohms or less at 10 volts bandedge output, decreasing linearly to 0.2 ohms or less
DISCRIMINATOR POWER SUPPLY UNITS (3; 1 for each 6 discr's.)	Electro-Mechanical Research, Inc. Model 223B
Input Voltage	120 volts ±10%, 47 to 420 Hz
Unregulated Output Voltages	-26 volts dc ±10% at 0.45 amperes and 105 volts dc ±10% at 0.02 amperes
Percent Ripple	Less than 6% of dc supply voltage at full load for -26 volt supply; less than 15% of dc supply voltage for -105 volt supply
Regulated Output Voltages	+17.5 and -17.5 volts dc ±5% at 1.5 amperes; regulated output will not change more than ±2% for any combination of line voltage and load current
Output Impedance	Less than 1 ohm from dc to 300 kHz
Output Ripple	Ripple appearing on dc output is less than 0.15 volts rms at maximum rated load
Current Limiting	Limited internally to 2 amperes

Table B-V (Continued)

SUBCARRIER DISCRIMINATOR CHARACTERISTICS

Equipment	Specifications
Metering	
SUBCARRIER AMPLITUDE	Front panel meter indicates amplitude of subcarrier signal, at output of discriminator bandpass input filter, but referenced to subcarrier signal amplitude at input to discriminator (at center frequency)
Meter Ranges	0.1, 0.3, 1.0, 3.0, and 10 volts as selected by METER RANGE switch

Table B-VI

CRYSTAL REFERENCE OSCILLATOR,
MIXING AMPLIFIER CHARACTERISTICS

Equipment	Specifications
CRYSTAL REFERENCE OSCILLATOR MIXING AMPLIFIER	Electro-Mechanical Research, Inc. Model 101A-2
Oscillator Section	
Reference Frequency	100 kHz
Calibration Accuracy	±0.0001% ±1 Hz
Stability	±5 parts per million of frequency
Output	1.5 volts rms minimum to mixing amplifiers
Mixing Amplifier Section	
Gain	Variable from zero to unity for both reference frequency subcarrier complexes
Harmonic Distortion	Less than 0.1%
Intermodulation Distortion	When two sine waves of equal amplitude, but different frequency, are amplified. Amplitudes of sum and difference frequencies are less than 0.5% of the input amplitude.
Bandwidth	Reference-frequency channel: 1.5 to 150 kHz Subcarrier channel: 200 Hz to 150 kHz
Input Impedance	20,000 ohms
Output Voltage	20 volts peak-to-peak maximum
Output Current	5 milliamperes peak-to-peak maximum
Output Impedance	Less than 50 ohms above 150 Hz
Power Requirements	105 to 125 volts, 50 to 60 Hz, 100 watts

Table B-VII

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications	
MAGNETIC TAPE* RECORDER-REPRODUCER	Consolidated Electrodynamics Corp. Model VR-2800	
Magnetic Heads		
Number of Tracks	7	
Track Width	0.050 ±0.002 inches	
Track Spacing	0.140 ±0.002 inches	
Gap Azimuth Alignment	90 degrees ±1 minute of arc to the base	
Gap Scatter	±50 microinches	
Tape Transport	TAPE DIMENSIONS*	
Reels Provided	14 by 0.5 inches	
Reel Capacity	7200 feet by 1-mil	
	5000 feet by 1.5-mil	
Tape Speed	RUNNING TIME	
	TIME	TAPE DIMENSIONS
60 Inches per Second	24 minutes	1.0 mil
	18 minutes	1.5 mil
30 Inches per Second	48 minutes	1.0 mil
	36 minutes	1.5 mil
15 Inches per Second	1 hour, 36 minutes	1.0 mil
	1 hour, 12 minutes	1.0 mil
7 1/2 Inches per Second	3 hours, 12 minutes	1.0 mil
	2 hours, 24 minutes	1.5 mil
3 3/4 Inches per Second	6 hours, 24 minutes	1.0 mil
	4 hours, 48 minutes	1.5 mil

*All Mylar-base Tape

Table B-VII (Continued)

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications	
MAGNETIC TAPE* RECORDER-REPRODUCER (Continued)		
Tape Speed (Continued)	RUNNING TIME (Continued)	
	TIME	TAPE DIMENSIONS
1 7/8 Inches per Second	12 hours, 48 minutes	1.0 mil
	9 hours, 36 minutes	1.5 mil
Tape Speed Accuracy	±0.2% (for periods longer than 1 second)	
Maximum Cumulative Peak-to-Peak Flutter	PER CENT FLUTTER	PASS-BAND
60 Inches per Second	0.25	0.2 Hz to 10 kHz
30 Inches per Second	0.30	0.2 Hz to 5 kHz
15 Inches per Second	0.40	0.2 Hz to 2.5 kHz
7 1/2 Inches per Second	0.60	0.2 Hz to 1.25 kHz
3 3/4 Inches per Second	0.60	0.2 Hz to 625 Hz
1 7/8 Inches per Second	0.70	0.2 Hz to 312 Hz
Direct Record/Reproduce System Characteristics		
Frequency Response Bandwidth, (at ±3 dB Points) per Tape Speed		
60 Inches per Second	100 Hz to 200 kHz	
30 Inches per Second	100 Hz to 100 kHz	
15 Inches per Second	100 Hz to 50 kHz	
7 1/2 Inches per Second	100 Hz to 25 kHz	

*All Mylar-base Tape

Table B-VII (Continued)

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications
MAGNETIC TAPE* RECORDER-REPRODUCER (Continued)	
Frequency Response Bandwidth, (at ±3 dB Points) per Tape Speed (Continued)	
3 3/4 Inches per Second	100 Hz to 12 kHz
1 7/8 Inches per Second	100 Hz to 6 kHz
Signal-to-Noise Ratio (RMS Signal to RMS Noise) over Frequency Bandwidth Specified	
60 Inches per Second	29 dB
30 Inches per Second	29 dB
15 Inches per Second	29 dB
7 1/2 Inches per Second	28 dB
3 3/4 Inches per Second	27 dB
1 7/8 Inches per Second	25 dB
Input Level for Normal Record Level	1 volt rms, nominal (0 dB)
Input Sensitivity	0.25 to 10 volts rms; adjustable with input potentiometer for normal record level
Input Impedance	20 kilohms (min), unbalanced to ground
Output Impedance	Less than 100 ohms in series with 25 microfarads, unbalanced to ground

*All Mylar-base Tape

Table B-VII (Continued)

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications	
MAGNETIC TAPE* RECORDER-REPRODUCER (Continued)		
Output Level and Load	1 volt rms into 600 ohms (min) and 3000 micromicrofarads (max load) at normal record level, unbalanced to ground	
Distortion	1% ±0.01% third harmonic distortion of a 1-kHz signal, and less than 0.6% intermodulation distortion when recording and reproducing at normal record level (0 dB) at 60 inches per second	
FM Record/Reproduce System, Frequency Response per Tape Speed	CENTER Freq. (kHz)	INFORMATION Freq. (kHz)
60 Inches per Second	108.0	0 to 20 ±0.5 dB
30 Inches per Second	54.0	0 to 10 ±0.5 dB
15 Inches per Second	27.0	0 to 5 ±0.5 dB
7 1/2 Inches per Second	13.5	0 to 2.5 ±0.5 dB
3 3/4 Inches per Second	6.75	0 to 1.25 ±0.5 dB
1 7/8 Inches per Second	3.375	0 to 0.625 ±0.5 dB
Signal-to-Noise Ratio (RMS Signal to RMS Noise)		
60 Inches per Second		45 dB
30 Inches per Second		45 dB
15 Inches per Second		41 dB
7 1/2 Inches per Second		41 dB
3 3/4 Inches per Second		38 dB
1 7/8 Inches per Second		38 dB

*All Mylar-base Tape

Table B-VII (Continued)

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications
MAGNETIC TAPE* RECORDER-REPRODUCER (Continued)	
Total Harmonic Distortion	1.5%
Input level to produce full scale modulation ±40% of carrier	1.0 volt rms nominal (0 dB)
Input Sensitivity	0.5 to 1 volt rms; adjustable with input potentiometer for full scale modulation
Input Impedance	10 kilohms, unbalanced to ground
Output Level	1 volt rms, across 10 kilohms load impedance, unbalanced to ground, for full scale modulation
Transient Response	Adjustable on low-pass filters for flat frequency response or optimum transient response:
	Flat frequency response rise and fall time (±20%); 20% overshoot (max)
60 Inches per Second	17.5 microseconds
30 Inches per Second	35.0 microseconds
15 Inches per Second	70.0 microseconds
7 1/2 Inches per Second	140.0 microseconds
3 3/4 Inches per Second	280.0 microseconds
1 7/8 Inches per Second	560.0 microseconds
	Optimum transient response rise and fall time (±20%); 5% overshoot (max)
60 Inches per Second	22.0 microseconds
30 Inches per Second	44.0 microseconds

*All Mylar-base Tape

Table B-VII (Continued)

TAPE RECORDER CHARACTERISTICS

Equipment	Specifications
MAGNETIC TAPE* RECORDER-REPRODUCER (Continued)	
Transient Response (Continued)	Optimum transient response rise and fall time (±20%); 5% overshoot (max) (Continued)
15 Inches per Second	88.0 microseconds
7 1/2 Inches per Second	175.0 microseconds
3 3/4 Inches per Second	350.0 microseconds
1 7/8 Inches per Second	700.0 microseconds
PRECISION FREQUENCY POWER SUPPLY	
Frequency	60 Hz -0.01%
Outputs	Precision 60 Hz, 205 to 280 volts peak-to-peak square wave, to capstan motor
	Precision 60 Hz, 10 volts peak-to-peak -20%, to drive record electronics
Power Requirements	105 to 125 volts, 48 to 65 Hz, single phase

*All Mylar-base Tape

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Table B-VIII

REAL TIME RECORDING EQUIPMENT CHARACTERISTICS

Equipment	Specifications	
RECORDING OSCILLOGRAPH	Consolidated Electrodynamics Corp. Type 5-119-P4	
Trace Capacity	36 active data channels	
Reference Traces	4 static reference traces	
Trace Identification	Sequential trace interruption	
Record Identification	5-digit record number automatically photographed at end of each record.	
Event Identification	5-digit event-number counter may be activated by external-contact closure twice per second, and photographed on record; counter may be reset to zero, at any time.	
Timing	Electronic flash timing: 0.2-second or 0.01-second lines, with every tenth line emphasized, full width of record or 3/4-inch wide at each margin.	
Record Speed Selection (in/s) by Two-Position LOW-HIGH Switch with Speed Ratios set at 1 to 10	LOW	HIGH
	0.16 inches per second	1.60 inches per second
	0.25 inches per second	2.50 inches per second
	0.40 inches per second	4.00 inches per second
	0.63 inches per second	6.30 inches per second
	1.00 inches per second	10.00 inches per second

Table B-VIII (Continued)

REAL TIME RECORDING EQUIPMENT CHARACTERISTICS

Equipment	Specifications	
RECORDING OSCILLOGRAPH (Continued)		
Record Speed Selection (Continued)	LOW	HIGH
	1.60 inches per second	16.00 inches per second
	2.56 inches per second	25.60 inches per second
	4.00 inches per second	40.00 inches per second
	6.40 inches per second	64.00 inches per second
	10.00 inches per second	100.00 inches per second
	16.00 inches per second	160.00 inches per second
Optical Arm	11.5 inches	
Frequency Response	0 to 5000 Hz	
GALVANOMETERS (25 total, 7 spares)	Consolidated Electrodynamics Corp. Type 7-362	
Damping	Fluid damped	
Frequency Response	Flat 0 to 2500 (±5%) Hz	
Undamped dc Sensitivity	12.0 milliamperes per inch; 0.0833 inch per milliampere	
CURRENT AMPLIFIERS (7)	Consolidated Electrodynamics Corp. Type 1-152-P4-1	
Input Impedance	1000,000 ohms shunted by 32 micromicrofarads	

Table B-VIII (Continued)

REAL TIME RECORDING EQUIPMENT CHARACTERISTICS

Equipment	Specifications
CURRENT AMPLIFIERS (7) (Continued)	
Input Sensitivity	1.414 volts dc, or 1-volt rms, at input produce full scale at output
Frequency Response	0 to 10,000 kHz (±0.5 dB)
Transient Response	With square-wave input, not more than 5% overshoot in output into resistive load; will be damped within 2 cycles or less
Distortion	0.5% total, up to 5000 Hz
Noise	0.3% rms maximum (inputs shorted)
Phase Shift	Less than 5 degrees up to 2000 Hz
Drift	Less than 10 millivolts peak-to-peak, in a 0 to 0.5 Hz bandwidth, over 8-hour period
Full Scale Output	5 volts peak; output current sufficient to drive recording galvanometers to 2-inch peak-to-peak deflection
Maximum Capacitive Load	Less than 0.1 microfarad on amplifier output
Output Impedance	Less than 2 ohms, zero to 10,000 Hz
Linearity	±0.5% (terminal)
Metering	Front panel, zero-center meter indicates percent full scale output
Power Requirements	115-volts rms (±10%), 60 Hz (±5 Hz), single phase, at 20 voltamperes

Table B-VIII (Continued)

REAL TIME RECORDING EQUIPMENT CHARACTERISTICS

Equipment	Specifications
DAMPING PADS (18)	
DATARITE MAGAZINE	Consolidated Electrodynamics Corp. Type 5-036
Length of Record Paper between Applicator and Magazine Record Exit	17 inches
Paper Capacity	475 feet thin-base record paper
Record Paper	Consolidated Electrodynamics Corp. Type 33 or Dupont Type 203 (Spec. 28)
Length	475 feet
Width	12 inches
Processing Method	Internal flash-chemical developing
Processing Chemicals	Consolidated Electrodynamics Corp. Part No. 49943-3 or Dupont Rapid Access Photo Recording Developer
Applicator Tank Capacity	14 fluid ounces
Preheat Time	15 minutes
Power Requirements	115 volts, 60 Hz, 1500 watts for combination of magazine and oscillograph
STANDARD MAGAZINE	Consolidated Electrodynamics Corp. Type 5-006
Record Paper	Eastman Ektaline 16 (Spec. 28)
Length	475 feet
Width	12 inches

Table B-VIII (Continued)

REAL TIME RECORDING EQUIPMENT CHARACTERISTICS

Equipment	Specifications
OSCILLOGRAM PROCESSOR	Consolidated Electrodynamics Corp. Type 23-109B-P4
Magazine Capacity	475 feet thin-base paper; 250 feet standard-base paper
Tank Capacity	500 square feet or more of sensitized paper can be processed with one charge of chemicals
Processing Chemicals	Eastman Ektaline Processing Kit
Preheat Time	30 minutes (starting with solutions at 18 degrees C, 65 degrees F)
Bath Operating Temperature	37.8 degrees C (100 degrees F); thermostatically controlled (manually adjustable)
Drum Operating Temperature	Automatically maintained at manually selected points from ambient to 149 degrees C (300 degrees F)
Transport Speed	Manually adjustable from 3.5 to 10 feet/minute (±10%)
Drying Speed	5 to 10 feet/minute
Environmental Requirements:	
Optimum Ambient Temperature	21.1 to 37.8 degrees C (70 to 100 degrees F)
Optimum Ambient Humidity	Up to 80% relative humidity
Light	Normal room light
Power Requirements	115 volts, 60 Hz, single phase, 15 amperes (max); bath heaters draw 1600 watts on PREHEAT, 170 watts (approx.) on OPERATE; drum heater draws 1000 watts

Table B-IX

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
ELECTRONIC COUNTER	Hewlett-Packard Model 5245L
Frequency Range	0 to 50 MHz
Gate Time	1 microsecond to 10 seconds in decade steps
Accuracy	±1 count ± time base
Time Base	1 MHz (internal)
Display	Eight-digit in-line display; decimal point position and measurement units displayed automatically.
FM-AM SIGNAL GENERATOR	Boonton Model 202J
Radio-Frequency Characteristics	
RF Range	195 to 270 MHz
RF Accuracy	Main dial: ±0.5% after one-hour warmup
	Electronic vernier: ±(10% +1 kHz) after one-hour warmup
RF Calibration	Main dial: increments of 0.5 MHz
	Mechanical vernier: 2200 divisions through range
	Electronic vernier: increments of 1 kHz over 30-kHz
RF Stability	Greater than 0.02% per hour after two-hour warmup
RF Output	Range: 0.1 microvolt to 0.2 volts across external 50-ohm load at panel jack

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
FM-AM SIGNAL GENERATOR (Continued)	
RF Output (Continued)	Accuracy: ±10%, 0.1 microvolt to 50 k microvolts: ±20%, 50 k microvolts to 0.2 volts Automatic level set: holds rf monitor meter to "red line" over band Impedance: 50 ohms VSWR: <1.2 Spurious output: all spurious output (rf) voltages are at least 25 dB below desired fundamental Leakage: sufficiently low to permit measurements at 0.1 microvolts
FM Deviation Range	Internal: 0 to 300 kHz in four ranges External: 0 to 300 kHz in four ranges
FM Deviation Accuracy	±5% of full scale (indication proportional to peak-to-peak modulating waveform)
FM Calibration	0 to 15 kHz (increments of 0.5 kHz) 0 to 30 kHz (increments of 1 kHz) 0 to 150 kHz (increments of 5 kHz) 0 to 300 kHz (increments of 10 kHz)
FM Non-Linearity	<1.5% at 150 kHz <5% at 300 kHz

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
FM-AM SIGNAL GENERATOR (Continued)	
FM Bandwidth	±3 dB, 3 Hz to 1 MHz
FM Fidelity (modulation rate)	±1 dB, 5 Hz to 500 kHz
Spurious FM	Total rms spurious FM from 60 Hz power source is at least 60 dB below 150 kHz
External FM Requirements	<1-volt rms into 100 kilohms for 150 kHz deviation
AM Characteristics	
AM Range	Internal: 0 to 50% External: 0 to 100%
AM Accuracy	±10% at 30% and 50% AM
AM Calibration	30, 50, and 100%
AM Distortion	<5% at 30%; 8% at 50%; 20% at 100%
AM Fidelity	±1 dB, 30 Hz to 200 kHz
External AM Requirements	Approximately 50-volts rms into 6000 ohms for 100% AM
Pulse Modulation Characteristics	
Source	External
Rise Time	<0.25 microsecond
Fall Time	<0.8 microsecond

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications	
FM-AM SIGNAL GENERATOR (Continued)		
Modulation Oscillator Characteristics		
OSC Frequency	50 Hz	10.5 kHz
	400 Hz	30 kHz
	1700 Hz	70 kHz
	3900 Hz	100 kHz
OSC Accuracy	±5%	
OSC Distortion	<0.5%	
OSC External Output	20 volts (approx.) at external FM posts 30 volts (approx.) at external AM posts)	
Power Requirements	105 to 125 or 210 to 250 volts, at 100 watts, at 50 to 60 Hz	
WIDE RANGE OSCILLATOR	Hewlett-Packard Model 200 CDR	
Range	5 Hz to 600 kHz covered in five ranges:	
	X 1	5 Hz to 60 Hz
	X 10	50 Hz to 600 Hz
	X 100	500 Hz to 6 kHz
	X 1K	5 kHz to 60 kHz
	X 10K	50 kHz to 600 kHz

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
WIDE RANGE OSCILLATOR (Continued)	
Accuracy	±2% including calibration errors, warmup, changes due to aging of components, tubes, etc.
Frequency Response	±1 dB entire frequency range (reference 1 kHz)
Output	160 milliwatts (10 volts) into 600 ohm rated load, 20 volts open circuit
Output Balance	Better than 0.1% at lower frequencies and approximately 1% at higher frequencies
Internal Impedance	600 ohms, balanced to ground for zero attenuation (may be operated with one side grounded if desired)
Distortion	Less than 0.5% below 500 kHz; less than 1% at 500 kHz and above (independent of load impedance)
Power Requirements	115 or 230 volts ±10%, at 50 to 1000 Hz, 75 watts
TELEMETRY CALIBRATOR	Dytronics Model 613
Output Frequencies	Standard subcarrier frequencies (see Appendix A)
Frequency Stability	Better than 0.1% for an 8-hour period at 25 degrees C (77 degrees F) after warmup
Output Voltage	Adjustable from about 0.08 to 1.5 volts rms
Output Impedance	400 ohms

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
OSCILLOSCOPES (2)	Tektronix Model RM 561
Indicator Unit	
Cathode-Ray Tube	Type T503RP2
Accelerating Potential	3500 volts
Usable Vertical Viewing Area	8 divisions (3-1/8 inch)
Usable Horizontal Viewing Area	10 divisions (3-15/15 inches)
Deflection Plate Sensitivity (at 3500 volts)	Vertical: 23.2 volts per centimeter Horizontal: 18.7 volts per centimeter
Calibrator Voltages	
Amplitude	1 millivolt to 100 volts (peak-to-peak) in six fixed steps
Accuracy	3%
Waveshape	Square wave at line frequency
Rise Time	Typically 4 microseconds
Dual-Trace Amplifier	Plug-in Type 3A72, Two channel, 0 to 650 kHz bandpass (each channel)
Sensitivity	
Calibrated	Variable in eleven calibrated (within 3%) steps from 10 millivolts per livision to 20 volts per division
Uncalibrated	Continuous control from 10 millivolts to 50 volts per division
Input Resistance	1 megohm paralleled by 47 picofarads at all sensitivity settings

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
OSCILLOSCOPES (Continued)	
Operating Modes	Channel 1 only: normal or inverted Channel 2 only Alternate: Channel 1 and Channel 2 electronically switched on alternate sweeps Chopped: successive 16-microsecond segments of each channel are displayed at an approximate rate of 30 kHz per channel; chopped transient blanking is provided Added: outputs of Channel 1 and Channel 2 algebraically added
Time-Base Unit	Plug-in Type 2B67
Sweep Rates	1 microsecond to 5 seconds per division (within 3%) in 21 calibrated steps. Uncalibrated control provides continuously variable sweep rates to about 3 times the step-switch setting
Magnifier	5 times expansion of center two divisions of display. Extends fastest sweep rate to 0.2 microsecond/division with 1% linearity after first four divisions
Triggering Modes	Internal, external, and line; trigger coupling may be selected from ac-slow, ac-fast, and dc (triggering level and polarity continuously adjustable)

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
OSCILLOSCOPES (Continued)	
Triggering Signal Requirements	Internal: signal producing two minor divisions of deflection
	External: signal from 0.5 volts at dc to 20 volts at 2 MHz. Sweep will trigger on larger signals, but LEVEL control limit is ±10 volts
Single Sweep	Sweep operates only after manual reset for either triggered or free-running operations when single sweep is used
External Signal Input	Band-pass: 0 to about 750 kHz, ±3 dB Sensitivity: about 1 volt/division
Power Requirements	105 to 125 volts, at 185 watts, at 50 to 60 Hz
VTVM	Hewlett-Packard Model 400LR
Frequency Range	10 Hz to 4 MHz
Accuracy	10 Hz to 20 Hz: ±5% of rdg.
	20 Hz to 50 Hz: ±3% of rdg. or ±2% of t.s.*
	50 Hz to 500 kHz: ±2% of rdg. or ±1% of f.s.*
	500 kHz to 1 MHz: ±3% of rdg. or ±2% of f.s.*
	1 MHz to 2 MHz: ±4% of rdg. or ±3% of f.s.*
	2 MHz to 4 MHz: ±5% of rdg.

*% of full scale (f.s.) or % of reading (rdg.) whichever is more accurate.

Table B-IX (Continued)

CALIBRATION AND TEST EQUIPMENT CHARACTERISTICS

Equipment	Specifications
VTVM (Continued)	
Long-Term Stability	Reduction in G_m of amplifier tubes to 75% of nominal value results in error of less than 0.5%, at 50 Hz to 1 MHz
Calibration	Reads rms value of sine wave. Logarithmic voltage scales 0.3 to 1, and 0.8 to 3. Linear dB scale, -10 dB to +2 dB (based on 0 dB equal to 1 milliwatt in 600 ohms); 10 dB intervals between ranges
Input Impedance	10 megohms shunted by 15 picofarads on ranges 1 to 300 volts, and 25 picofarads on ranges 0.001 to 0.3 volts
Amplifier	Output approximately 0.15 volt maximum. Internal impedance 50 ohms. Maximum gain approximately 150 on 0.001 range
Power Requirements	115 or 230 volts ±10% at 100 watts at 50 to 1000 Hz

Table B-X

TAPE RECORDER MONITOR AND CHECKOUT PATCH PANEL, CONTROLS AND INDICATORS

Control/Indicator	Function
CRO-1 Switch	Permits selection of data for display on Channel 1 of CRO-1, as follows: In T/R MON position, head current of tape recorder track selected by TAPE RECORDERS switch is displayed In T/R IN position, input data to tape recorder track selected by TAPE RECORDERS switch are displayed In T/R OUT position, output from reproducing amplifier of track selected by TAPE RECORDERS switch is displayed In A, B, C, or D position, Channel 1 input of CRO-1 is connected to corresponding jack on master patch panel (see Figures A-20 and A-23) In PATCH position, Channel 1 input of CRO-1 is connected to CRO-1 jack on tape recorder monitor and checkout patch panel (Figure A-23)
CRO-2 Switch	Permits selection of data for display on Channel 2 of CRO-1. (Switch positions and functions same as for CRO-1 switch)
TAPE RECORDERS Track Switch	Permits selection of tape recorder tracks 1 through 7
VOLTAGE ADJUST Control	Provides for adjusting magnitude (-12 volts to +12 volts) of accessory dc voltage generated by tape recorder power supply

Table B-X (Continued)

TAPE RECORDER MONITOR AND CHECKOUT PATCH PANEL, CONTROLS AND INDICATORS

Control/Indicator	Function
VOLTAGE ADJUST Control (Continued)	
Meter	Indicates magnitude of accessory dc voltage
METER POLARITY Switch	Selects either positive (POS) or negative (NEG) polarity of dc accessory voltage
SPEAKER Switch	Permits selection of audio input to Speaker 1, as follows: In COMMO position, speaker is connected to communications receiver In PA 1 OUT or PA 2 OUT position, speaker is connected to Channel 1 or 2 of Bogen AP 200 power amplifier In LOCAL I. C. position, speaker is connected to local intercom amplifier In RANGE I. C. position, speaker is connected to range intercom terminal at utility box (rear of trailer) In PATCH position, speaker is connected to SPKR 1 jack at master patch panel
VOLUME ADJUST Control	Provides for controlling Speaker 1 volume
Test-Normal Switch	In test (up) position, locks tape recorder tape transport and applies voltage to record amplifiers to permit adjustment of record amplifiers level during tests

Table B-X (Continued)

TAPE RECORDER MONITOR AND CHECKOUT PATCH PANEL, CONTROLS AND INDICATORS

Control/Indicator	Function
VOLUME ADJUST Control (Continued)	
Test-Normal Switch (Continued)	In normal (down) position, unlocks tape recorder tape transport and removes test voltage from record amplifiers
Bias On-Off Switch	In bias on (up) position, applies bias frequency to all record amplifiers
	In bias off (down) position, removes bias frequency from record amplifiers

Table B-XI

ACCESSORY EQUIPMENT

Equipment	Specifications
TIME CODE GENERATOR	Hyperion Model HI-128
Time Code Format	36-bit, 100 p/s NASA code (mark-space ratio adjustable between 10:1 and 2:1)
	28-bit, 2 p/s NASA code (mark-space ratio adjustable between 0 and 4 volts)
Visual Display	Time of year (days, hours, minutes, and seconds)
Synchronization and Test Signals:	
WWV IN	Provision for introduction of audio from WWV receiver
TICK & PEDESTAL	Pedestal imposed on WWV tick voltage to give indication of coincidence when viewed on oscilloscope
1 P/S	1 p/s pre-count and 1 p/s count signals
PEDESTAL	-10 volts dc, going to 0 volts for 5 milliseconds during pedestal
COMMUNICATIONS RECEIVER	Collins Model 51J-4
Frequency Range	540 kHz to 30.5 MHz
Modes of Operation	AM, CW, or MCW
Dial Calibration	Direct reading in MHz and kHz
Tuning	Linear tuning with uniform bandspread
Frequency Stability	Dial calibration at room temperature is within 300 Hz if nearest 100 kHz calibration point is used for adjustment reference
Temperature Range	-20 degrees C (-4 degrees F) to +60 degrees C (+140 degrees F)

Table B-XI (Continued)

ACCESSORY EQUIPMENT

Equipment	Specifications
COMMUNICATIONS RECEIVER (Continued)	
Sensitivity	Band 1, less than 15-microvolt signal gives 10 dB s/n; bands 2 to 30, less than 5-microvolt signal gives 10 dB s/n
Spurious Frequency Response	Down at least 40 dB
S Meter	Meter calibrated in 20, 40, 60 dB above AVC threshold, and -10 to +6 dB audio level with 6 milliwatts as reference
Noise Limiter	Series type, ahead of first audio stage
Audio Power Output	Band 1, at least 0.5 watt for 15 microvolt signal. Bands 2 to 30, at least 0.5 watt for 5 microvolt signal
Audio Frequency Response (overall)	±3 dB from 200 to 2500 Hz when 6-kHz filter is used
Audio Distortion	Less than 10% at 0.5 watt output
Audio Output Impedance	4 and 600 ohms
I-F Output Impedance	50 ohms
RF Input Impedance	Operates into high impedance whip or single-ended antenna
Power Requirements	85 watts at 115 volts, 45 to 70 Hz. Same when reconnected for 230-volt 45 to 70 Hz operation
WHIP ANTENNA	104-inch high impedance whip antenna (Figure A-11)
STATION MULTIPLEXER	Vector Model FM 261

Table B-XI (Continued)

ACCESSORY EQUIPMENT

Equipment	Specifications
STATION MULTIPLEXER (Continued)	
Channels (7)	One voice, 100 to 3000 Hz with low-pass filter; six Vector Type TS-56A VCO's for IRIG channels 12 through 16 and E (see Appendix C); mixer and power supply
POWER SUPPLY (Auxiliary)	KEPCO Model KR5M
Power Output	100 to 200 volts dc at 600 milliamperes
DUAL-CHANNEL POWER AMPLIFIER	Bogen Model AP 200
Power Output	20 watts per channel, 40 watts combined
Frequency Response	20 to 20,000 Hz, ±1 dB
Distortion	0.6% at rated output
Output Impedance	4, 8, and 17 ohms
Power Requirements	117 volts, 60 Hz
TAPE DEGAUSSER	AMPEX Model SE-10
TAPE RECORDER AND OSCILLOGRAPH REMOTE CONTROL UNIT	See Figure A-18
RANGE AND LOCAL INTERCOM	See Figure A-18
LOUDSPEAKERS	Two
RF PATCH PANEL	See Figure A-16
MASTER PATCH PANEL	See Figure A-20
CRO-2 CHANNEL SELECTOR SWITCH PANEL	See Figure A-18

APPENDIX C

INTER-RANGE INSTRUMENTATION GROUP (IRIG) STANDARD CHANNELS

APPENDIX C

INTER-RANGE INSTRUMENTATION GROUP (IRIG) STANDARD CHANNELS

(Based on a Modulation Index of 5)

IRIG Channel Number	Channel Center Freq. (kHz)	Deviation	Intelligence Cutoff Freq. (Hz)
1	0.40	±7.5%	00006.0
2	0.56	±7.5%	00008.4
3	0.73	±7.5%	00011.0
4	0.96	±7.5%	00014.0
5	1.30	±7.5%	00020.0
6	1.70	±7.5%	00025.0
7	2.30	±7.5%	00035.0
8	3.00	±7.5%	00045.0
9	3.90	±7.5%	00059.0
10	5.40	±7.5%	00081.0
11	7.35	±7.5%	00110.0
12	10.50	±7.5%	00160.0
13	14.50	±7.5%	00220.0
14	22.00	±7.5%	00330.0
15	30.00	±7.5%	00450.0
16	40.00	±7.5%	00600.0
17	52.50	±7.5%	00790.0
18	70.00	±7.5%	01050.0
19	93.00	±7.5%	01390.0
20	124.00	±7.5%	01860.0
21	165.00	±7.5%	02475.0
A	22.00	±15.0%	00660.0
B	30.00	±15.0%	00900.0
C	40.00	±15.0%	01200.0
D	52.50	±15.0%	01575.0
E	70.00	±15.0%	02100.0
F	93.00	±15.0%	02790.0
G	124.00	±15.0%	03720.0
H	165.00	±15.0%	04950.0