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RADIO AND ELECTRICAL ENGINEERING DIVISION

ASTRONOMY RECEIVER SYSTEMS FOR THE ALGONQUIN RADIO OBSERVATORY

- J. R. DAWSON -

OTTAWA

DECEMBER 1970

ABSTRACT

A manual for users of the receiving equipment on the 46-meter and 10-meter radio telescopes at the Algonquin Radio Observatory. The manual gives a general description of the equipment, including the data acquisition and control system, a table of receiver parameters, block diagrams, and a list of cable connections.

CONTENTS

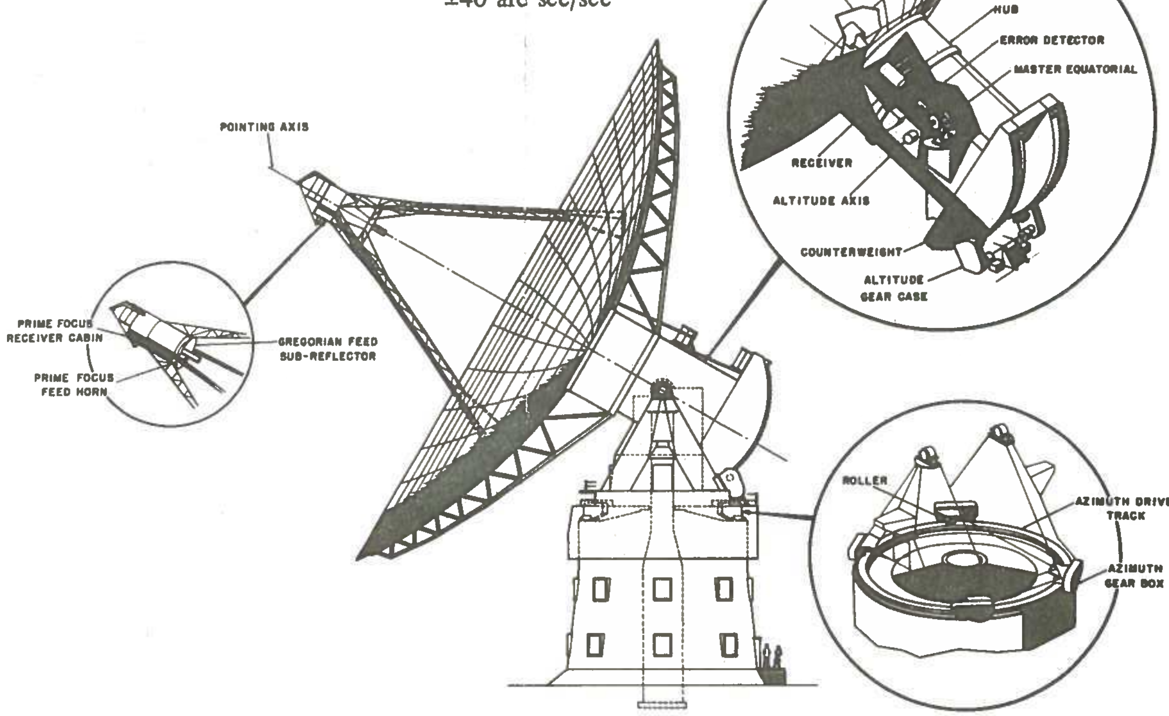
PLATES

THE 46-METER RADIO TELESCOPE

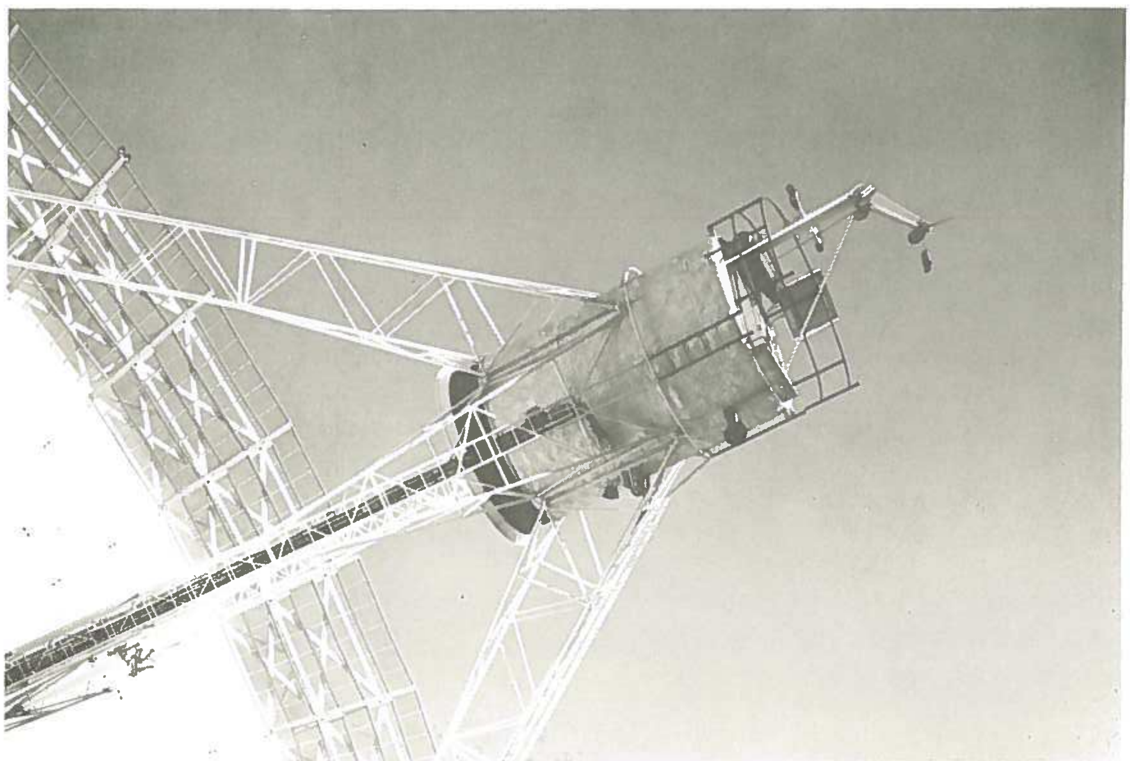
The 46-meter fully steerable parabolic telescope was designed for general use, but with primary emphasis on centimetric wavelengths. The reflecting surface has a solid central region, 36 meters in diameter, of specially shaped and stiffened steel plate, supported by 36 radial cantilevered ribs. This is surrounded by a 4.5 meter annulus consisting of stressed mesh panels of 1 mm steel wire on 6-mm centers. Ninety-eight percent of the incident energy at 10-cm wavelength is reflected by this mesh.

PERFORMANCE & SPECIFICATIONS

Focal length	18 meters
Diameter	36.5 meters solid, 45.7 meters to edge of mesh
Surface accuracy	rms departure from paraboloid of best fit 0.9 mm
Beamwidth	1.5 min arc at 1.35 cm 2.7 min arc at 2.85 cm
Aperture efficiency	0.42 at 2.85 cm
Range of motion	Azimuth ±205° Zenith angle −5° to 83°
Rates of motion	Azimuth – variable to 24°/min Zenith angle variable to 15°/min Equatorial (1) sidereal or solar rate (2) variable scan rates 0–2.5°/min (3) slewing rate – variable to 25°/min (4) incremental – variable 0 to ±40 arc sec/sec



Four lattice-type feed legs support a cylindrical cabin just beyond the focal point of the reflector. Receiving equipment is housed in this cabin on a platform whose axial position can be changed from the control room. This allows adjustment of the focus to be made to suit different receivers and to allow for a slight change in the focal length of the best-fit paraboloid with changes in temperature and elevation. The receiving apparatus can be withdrawn from the focal region in order to allow a Gregorian system of operation, in which the incoming energy is reflected from an ellipsoidal sub-reflector into a conical horn protruding from the central hub. The two methods of operation, Gregorian and prime focus, allow a change of receiving equipment and wavelength to be made in a couple of minutes.



Conversion from celestial co-ordinates to the alt-azimuth co-ordinates of the telescope is accomplished by a small equatorially controlled mirror independently mounted at the intersection of the azimuth and elevation axes, and by a light beam and error detector system mounted on the hub structure. The light beam is reflected from the mirror and error signals are applied to the azimuth and elevation motors, causing the telescope to follow the motions of the mirror. To avoid dynamic coupling with the telescope, the mounting of this master equatorial unit is isolated from the tower and turret structure. Alignment errors between the telescope and the master equatorial unit are not more than 3–5 seconds of arc.

It will be evident that with this type of guidance system, many of the errors in telescope pointing are contained within the servo loop. Refraction, the main source of pointing error not contained in the servo loop, varies with zenith angle in a predictable fashion, and is compensated for by a programmed bending of the error detector light beam.

THE 10-METER RADIO TELESCOPE

This instrument consists of a 10-meter diameter paraboloid carried on an equatorial mounting. The *f/D* of the reflector is 0.4, and the surface accuracy is approximately 0.063 cm rms, making it suitable for efficient use down to 1.3 cm wavelength. Prime focus feeds and receivers are mounted on a quadrapod structure which is attached to the reflector near its rim.

The equatorial mount, which was designed within the division, affords full-sky coverage. Provision is made for slewing about both the declination and polar axes. The polar axis can be rotated synchronously at the sidereal rate for tracking celestial objects, and higher speeds can be superimposed on this motion to permit more rapid scans. The scanning motion is imparted through a mechanical differential, and is derived from two separate motors, one covering the range 0.0005°/min to 0.050°/min and the other the range 0.050°/min to 1°/min. The motor for the slower speed is a stepping motor, driven from a pulse generator. The higher speed is obtained from a dc motor whose speed is controlled through the armature voltage in response to an error signal. This is derived by counting pulses generated by a wheel fitted to the motor shaft, and comparing these pulses with those from a reference generator.

Telescope position is displayed in both analog and digital fashion. The analog display is by means of printed film strip, servo driven from synchros fitted to the hour angle and declination axes. The digital system consists of reversible counters which register pulses derived from incremental encoders fitted to the shafts. The analog system, which is non-ambiguous, serves to provide a periodic check on the count of the digital system.

The mounting of receivers on the 10-meter telescope is the same as on the focus cabin of the larger telescope, with the main exception that it is not adjustable along the axis for focusing. The distance through the flat plate to prime focus is about 21 inches and provision should be made for shims (or leveling screws) under the rim of the receiver, so that small adjustments can be made in axial distance. Lateral motion is restricted only by the 12 inch diameter hole in the center of the mounting plate. Hoisting is done by 'cherry picker', with the telescope aimed at the horizon to avoid risk of dropping equipment onto the surface. Temperature control is available in standard receiver cases having thermoelectric heat exchangers. The driver amplifier is situated in the pedestal and the main control cabinet in the laboratory building.

Most of the observing time on the telescope has been spent on surveys of the galactic plane at a wavelength of 10 cm. Completed work includes surveys of the Cassiopeia and Cepheus regions of the galactic plane and of the Cygnus-X region. A considerable number of discrete sources imbedded in a general continuum of radiation were observed. Most of these sources are regions of ionized hydrogen surrounding very hot stars. A minority are believed to be remnants of supernovae explosions. The Cygnus-X region has also been surveyed at a wavelength of 4.5 cm. Observations at two frequencies permit separation of these two types of sources. The ionized hydrogen regions provide a view of stars at a very early stage in their evolution and, of course, the supernovae represent a very late stage in stellar evolution. Radio astronomical observations thus complement the optically derived picture of stellar evolution.

RECEIVERS FOR USE ON 46-METER TELESCOPE

There are two positions for mounting receivers – one at the prime focus, and the other at the vertex. At the prime focus the receiver is housed in a cabin suspended on three legs some 60 feet above the reflecting surface.

The receiver is lifted into the cabin through a four-foot opening by a hoist of 1000-lb capacity, and is centered on a plate whose center is directly in line with the center of the dish. A flange mounted on the receiver is firmly fastened to this plate by clamps, which are movable radially to accommodate various receiver configurations. Because of limitations in the hoisting apparatus, the receiver height should be not more than 60 inches.

At the vertex, the receiver is hoisted into the room through a 3-foot circular port, positioned below the center of the dish, and fastened in a manner similar to that in the focus cabin. Because of the size of the port, and because it is necessary to lift through the support structure of the dish when hoisting to the vertex room, a receiver should not be larger than 35 inches in diameter. If a receiver is to be used in both locations, its dimensions should not exceed 35 inches in diameter and 60 inches in height. The larger the receiver, the more difficult the mounting job becomes.

Since the telescope is some distance from the control building, multiconductor cables are used and are terminated at various locations (see page 22).

Receiver Characteristics

Temperature Regulation

The receivers are, for the most part, housed in temperature controlled cases, so that effects of external temperature variation are minimized. Except for some of the older radiometers, the receiving equipment is mounted in a standard frame (Dwg. No. DF-10-96E*) to which are fitted covers and a heat exchanger for temperature control within about ±1°C. (Assembly DF-10-58E*)

The temperature controller has a 200-watt heating or cooling capacity. This capacity is required during ambient temperature extremes to offset heat leakage through package walls. A dissipation limit of about 40 watts has been set for receiver components when operating at 100°F (ambient). Three complete systems are available, two for the vertex room and one for the focus of the 46-m telescope. A fourth (spare) system can be connected for experiments with the 10-mm telescope. The usual operating temperature inside focus packages is around 30°C.

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*Copies of these drawings are available from the Editorial Office, Radio & Electrical Engineering Division, National Research Council of Canada, Montreal Road, Ottawa 7, Ontario.

Aside from over-all focus-package temperature control, three channels of control are available for regulation of temperature of small components inside the receiver. These provide regulation of about 0.01°C, and have a maximum heating capacity of only 2 watts. They have been used in the past mainly for controlling 'room temperature' loads.

Receiver Parameters

The table on page 8 lists the important parameters of receivers at ARO. We have used B_{LF} as the low-pass bandwidth of the final output filter and ΔT in the formula

$$\frac{\pi^2 T_{syst}}{4} \cdot \sqrt{\frac{2B_{LF}}{B_{RF}}}$$

for a switched system with narrow band filter. The $\sqrt{2}$ factor for degenerate paramps and folded IF receivers has been included in the theoretical ΔT.

Frequency Stabilization

Several of the receivers have built-in local oscillators which may be synchronized using multiplier chains and/or 'lock boxes' referenced to a primary source.

Primary Sources

	Output and level into 50 ohms	
Hydrogen maser	5 MHz	1.0 V rms
	1 MHz	1.0 V rms
	0.1 MHz	1.0 V rms
	100 MHz	1.0 V rms
Rubidium standard	5 MHz	1.0 V rms
	1 MHz	1.0 V rms
	0.1 MHz	1.0 V rms

Secondary Sources (locked to primary or using internal standard crystal)

HP 5100 synthesizer	0–50 MHz	1.0 V rms
HP 5110 driver	3.0–3.9 in 0.1 steps	50 mV rms
	31–39 MHz in 1.0 steps	100 mV rms
Monsanto synthesizer	0–1.0 MHz	2.23 V rms (max. +20 db)
	Variable attenuation	70 μV rms in 10-db steps
	Fixed attenuation	22.3 mV rms (20 db)

Phase-locked Systems

1. Hewlett-Packard Model 608F signal generator, which may be phase-locked to Hewlett-Packard Model 8708A synchronizer, synchronizes with a tunable internal crystal clock, giving a frequency stability of 5 parts in 10^8 for 1 minute between 10 MHz and 455 MHz. In addition, by using a 5–20 MHz frequency multiplier, the 608F may be phase-locked, at any integral and half-integral number of megahertz over the same frequency range, to a standard 5-MHz frequency source. The maximum power output is 10 mW into 50 ohms.

2. There is also a general-purpose synchronizer ('lock-box'): Microwave System Model MOS-4F. This will enable any suitable voltage-tunable oscillator to be phase-locked in the range 1–40 GHz. Internal crystals provide continuous frequency coverage with good crystal stability (i.e., 1 part in 10^9 for 1 second, 1 part in 10^8 for 1 hour). In addition, the unit may be used to phase-lock voltage tunable oscillators to a 5-MHz standard frequency source. The following formulae enable the lock points at which phase-lock is obtained to be computed.

1 to 12.4 GHz : $15N \pm 26$ MHz

12.4 to 40 GHz : $180N \pm 26$ MHz

where N is any integer.

Frequency Multipliers

Non-commercial (NRC and University of Toronto designs)

1 MHz to 32 MHz	The output is about 10 mW into 50 ohms in every case
1 MHz to 31 MHz	
5 MHz to 10 MHz	
5 MHz to 20 MHz	
5 MHz to 30 MHz	
5 MHz to 55 MHz	
5 MHz to 80 MHz	
55 MHz to 440 MHz	

Commercial model

Micro-Now Model multiplier unit, 5 MHz to 480 MHz.

100-Channel Filter Spectrometer

This is an IF system to which a number of RF focus packages could be adapted by suitable conversion, provided satisfactory Dicke switching, either in frequency or against a flat load, and adequate calibration switching are available. Program control and data acquisition are by the computer. An Operating Manual is available to prospective users.

Characteristics

Input IF: 46.5 MHz ± 5 MHz

Nominal noise level in 10 MHz band: 10 mV rms

Resolutions:
1) 3 db channel bandwidth 100 kHz, 3 cascaded tuned circuits.
2) 3 db channel bandwidth 10 kHz, single (crystal) tuned circuit.

Switching:
1) Frequency of local oscillator on conversion from wide band 120 MHz IF to 46.5 MHz IF
2) 20°K load through ferrite switch inserted ahead of paramp

1st L.O. control: available from synthesizer through lock-box.

Calibration: computer controlled either by pulse to latching ferrite switch or by logic level on shielded cable; switching time must be less than 5 msec.

TABLE OF RECEIVER PARAMETERS

T = TRF; H = Heterodyne

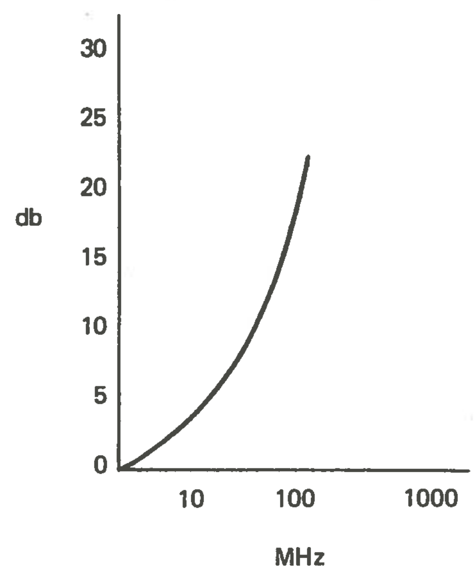
Focus Package / Parameter	9.4 cm (T) TDA	4.6 cm (T) degenerate paramp	2.8 cm (T) TDA	2.8 cm (H) paramp	2.2 cm (T) degenerate paramp	1.4 cm (H) mixer	74 cm (H) transistor (folded IF)	21 cm (H) paramp
System temperature single beam, °K	900	450	1400	120	350	3000	200	
System temperature dual beam, °K	N.A.*	400	1100	100	300	N.A.	N.A.	
3-db input band-width, MHz	475	210	1250	100	300	5	8.0	
Center frequency, GHz	3.24	6.63	10.63	10.52	13.50	22 ± 1	0.408	1.420
Wavelength, cm	9.26	4.52	2.82	2.84	2.22	1.36 ±	73.5	
Theoretical ΔT single-beam switching, °K	$.14\sqrt{B_{LF}}$	$.15\sqrt{B_{LF}}$	$.14\sqrt{B_{LF}}$	$.044\sqrt{B_{LF}}$	$.075\sqrt{B_{LF}}$	$4.9\sqrt{B_{LF}}$	$.37\sqrt{B_{LF}}$	
Theoretical ΔT dual-beam switching, °K	N.A.	$.14\sqrt{B_{LF}}$	$.11\sqrt{B_{LF}}$	$.044\sqrt{B_{LF}}$	$.06\sqrt{B_{LF}}$	N.A.	N.A.	
Gain stability db/hr					±0.1 random .22 drift			
Switching available	load	load	load	load or frequency	load	frequency	load	frequency
Load temperature, °K	300	80	300	40	80	– –	300 or 80	.– –

**N.A. – Not Applicable*

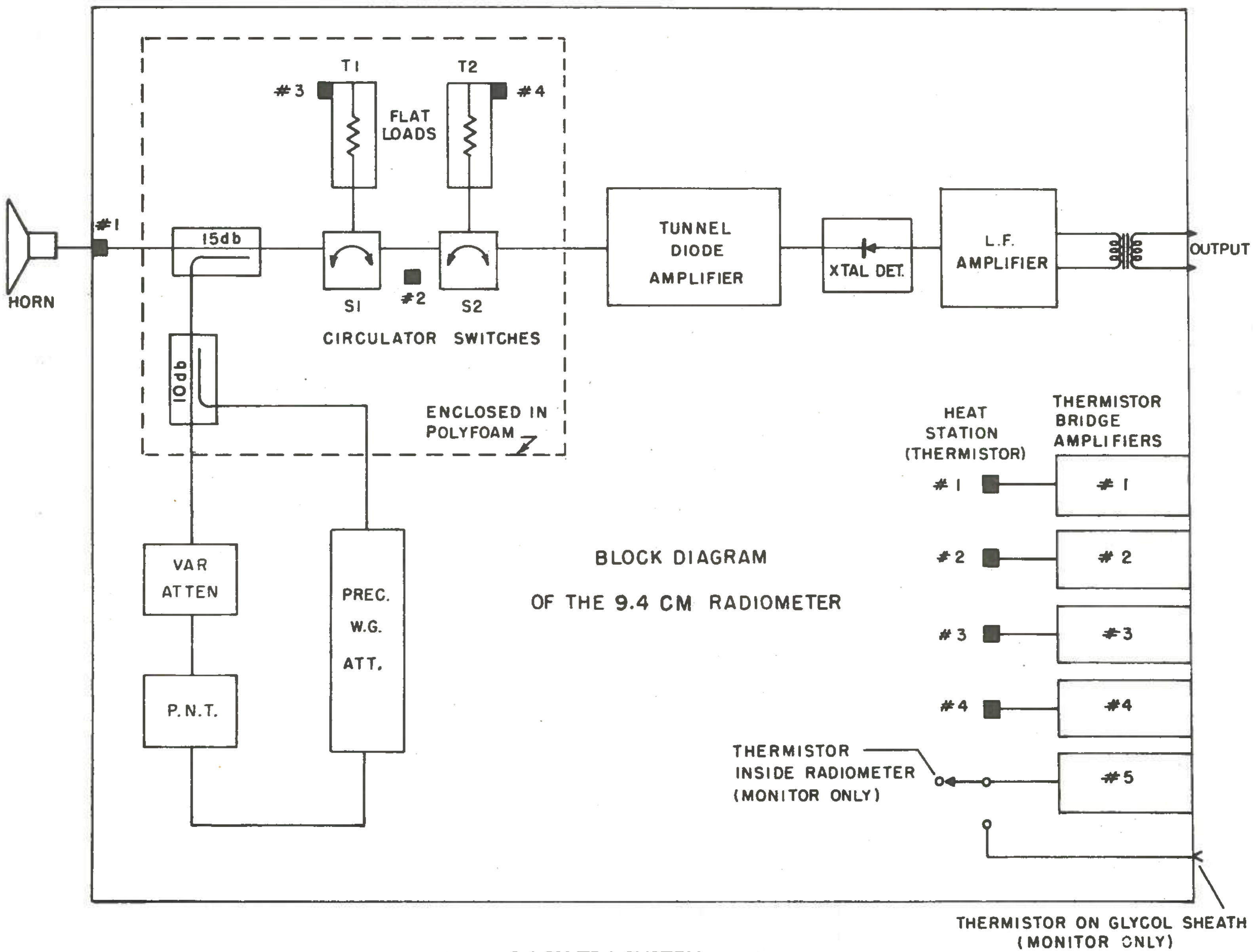
RECEIVER SYSTEM BLOCK DIAGRAMS

The following block diagrams show the switching and calibration schemes available on each receiver. On the TRF receivers, the focus package output is a video (ac) signal in the 20 Hz to 30000 Hz band with a peak-to-peak amplitude of about 10 mV. The heterodyne receivers, with 46.5-MHz focus package output, have a noise bandwidth depending on the pre-filter up to about 50 MHz, and the level is between 5 and 10 mV rms into the remote cables.

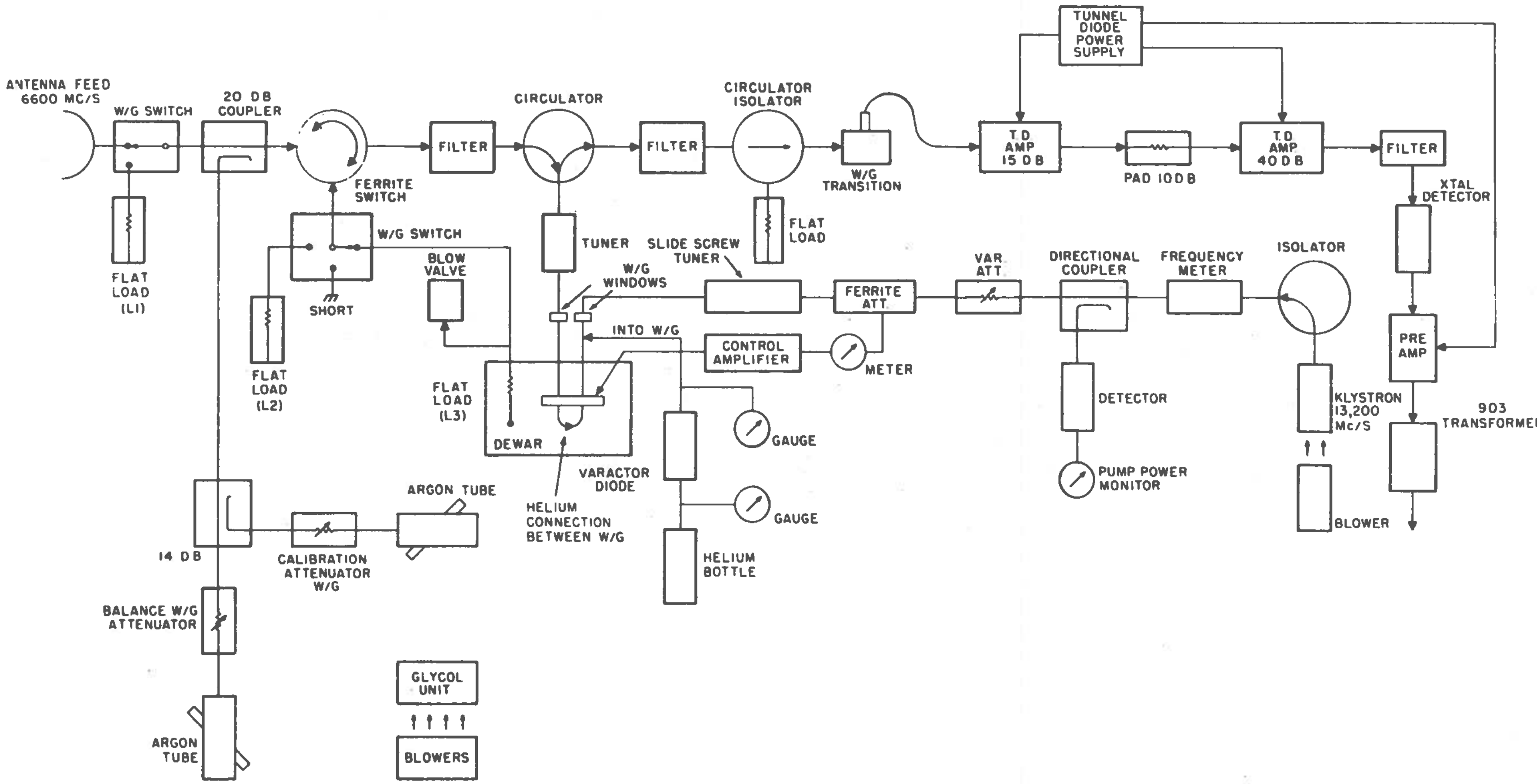
Cable losses in the RG 8/U cables are given approximately below.



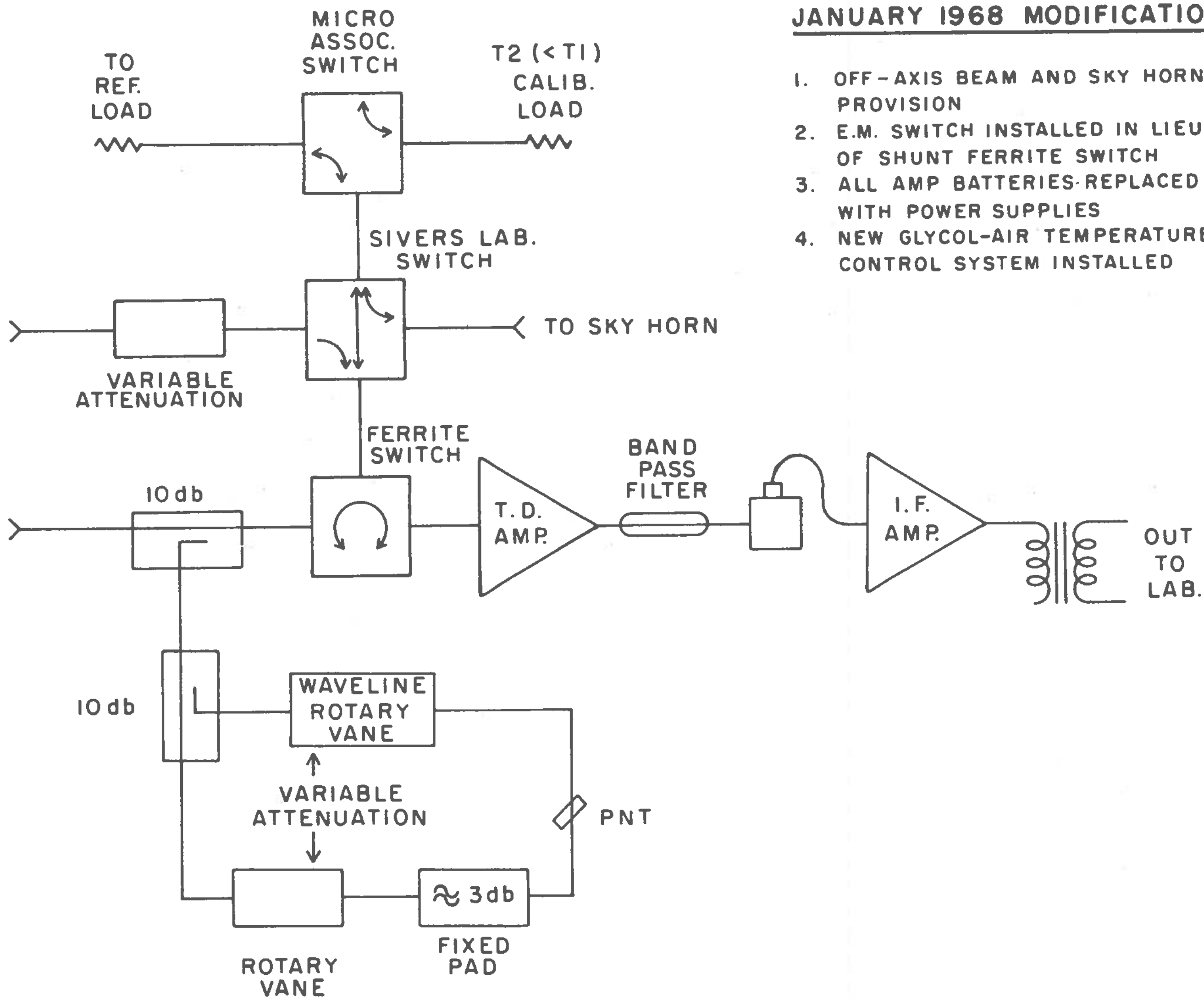
SIGNAL LOSS VS FREQUENCY IN CABLE



9.4-CM TDA SYSTEM



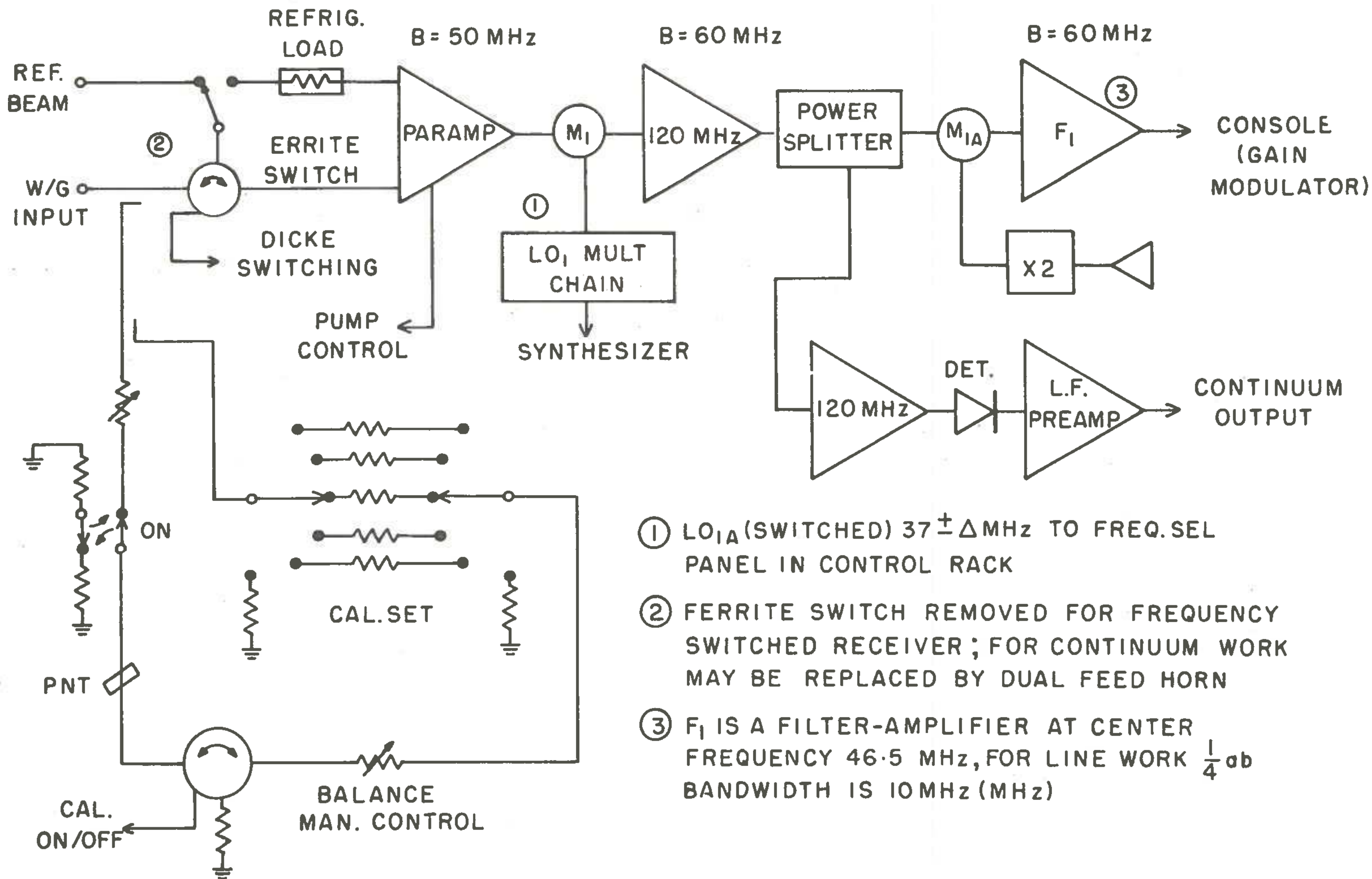
4.6-CM PARAMP SYSTEM



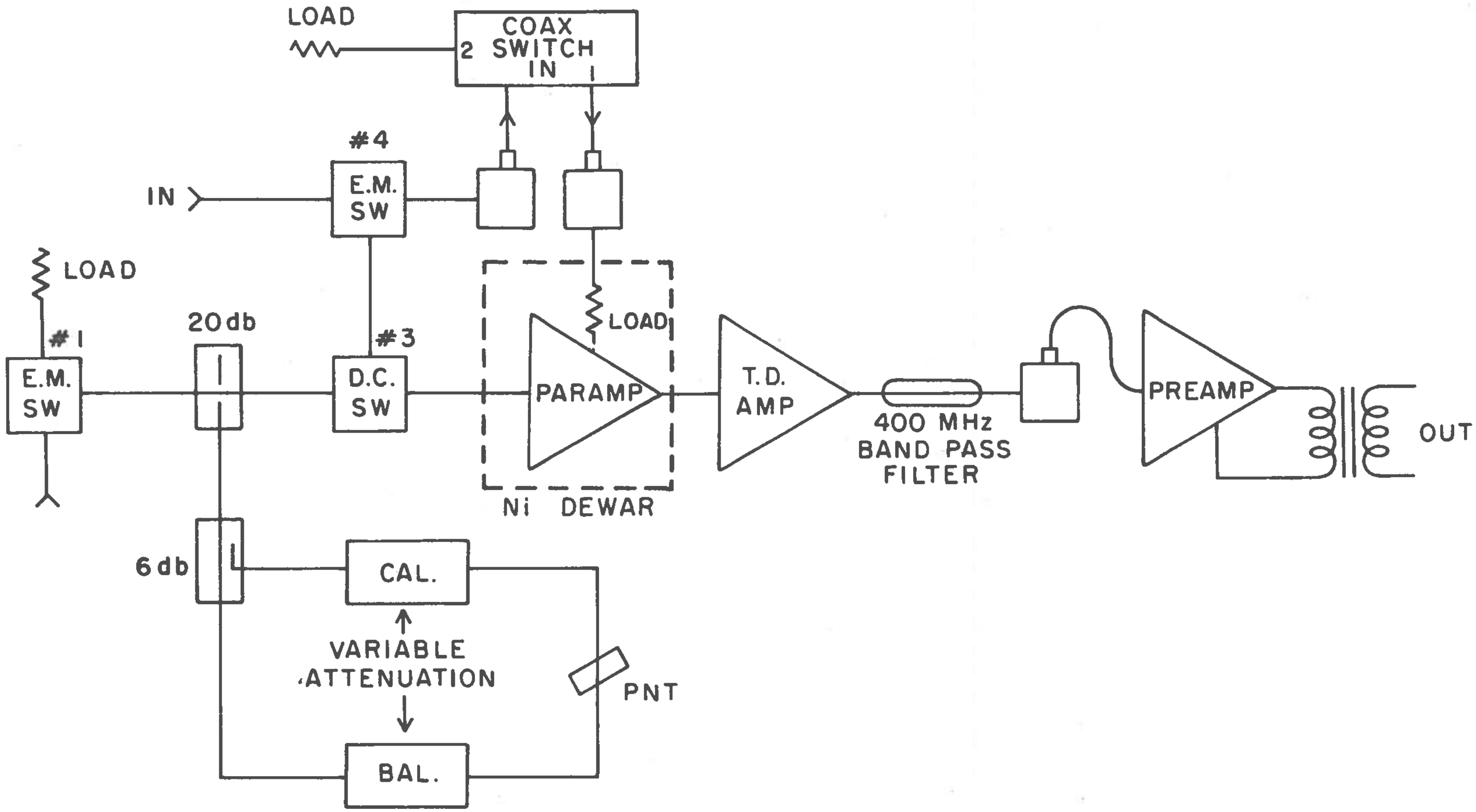
JANUARY 1968 MODIFICATION

1. OFF-AXIS BEAM AND SKY HORN PROVISION
2. E.M. SWITCH INSTALLED IN LIEU OF SHUNT FERRITE SWITCH
3. ALL AMP BATTERIES REPLACED WITH POWER SUPPLIES
4. NEW GLYCOL-AIR TEMPERATURE CONTROL SYSTEM INSTALLED

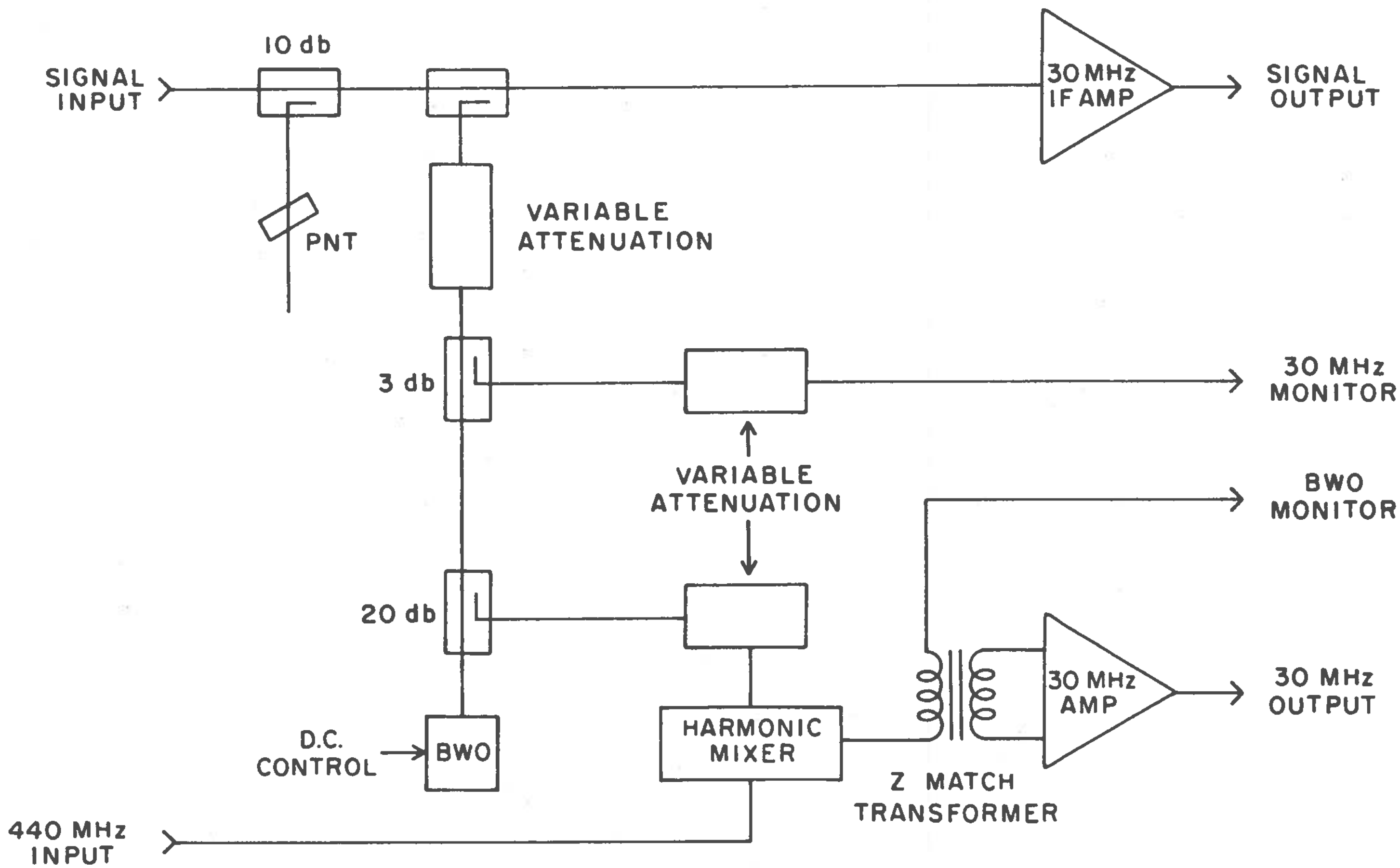
2.8-CM TDA SYSTEM



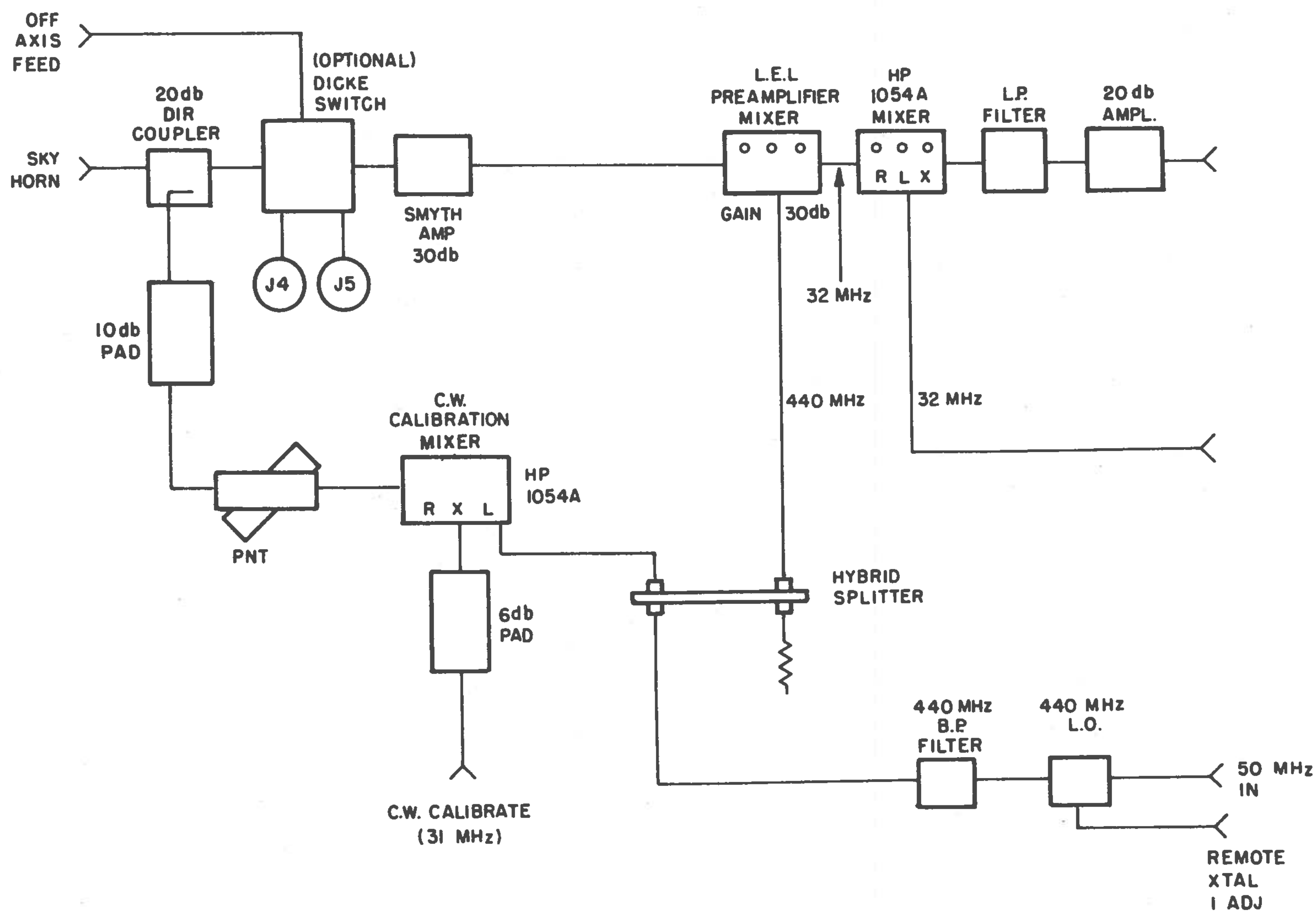
2·8 CM PARAMP SYSTEM



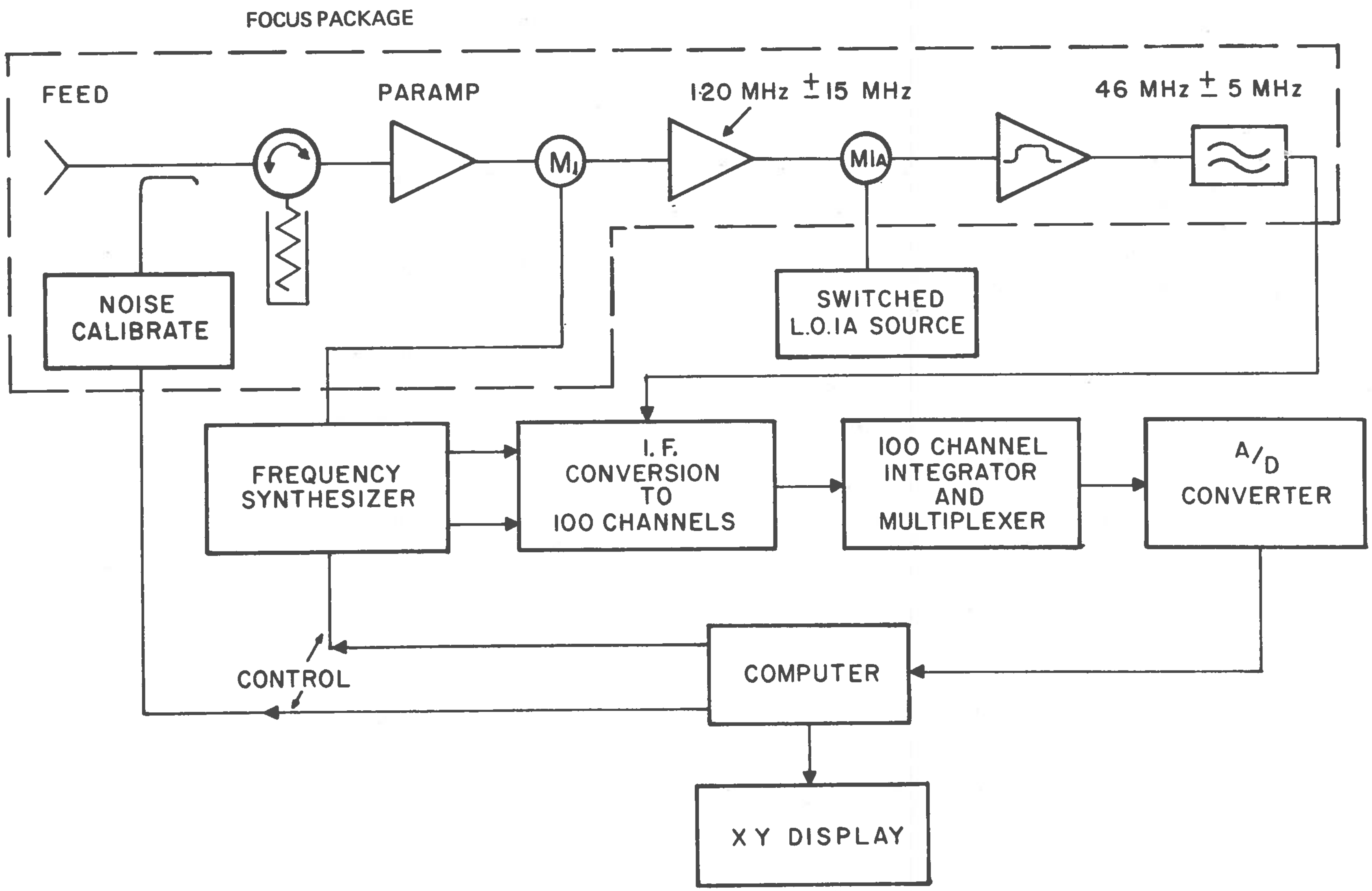
2.2 CM PARAMP SYSTEM



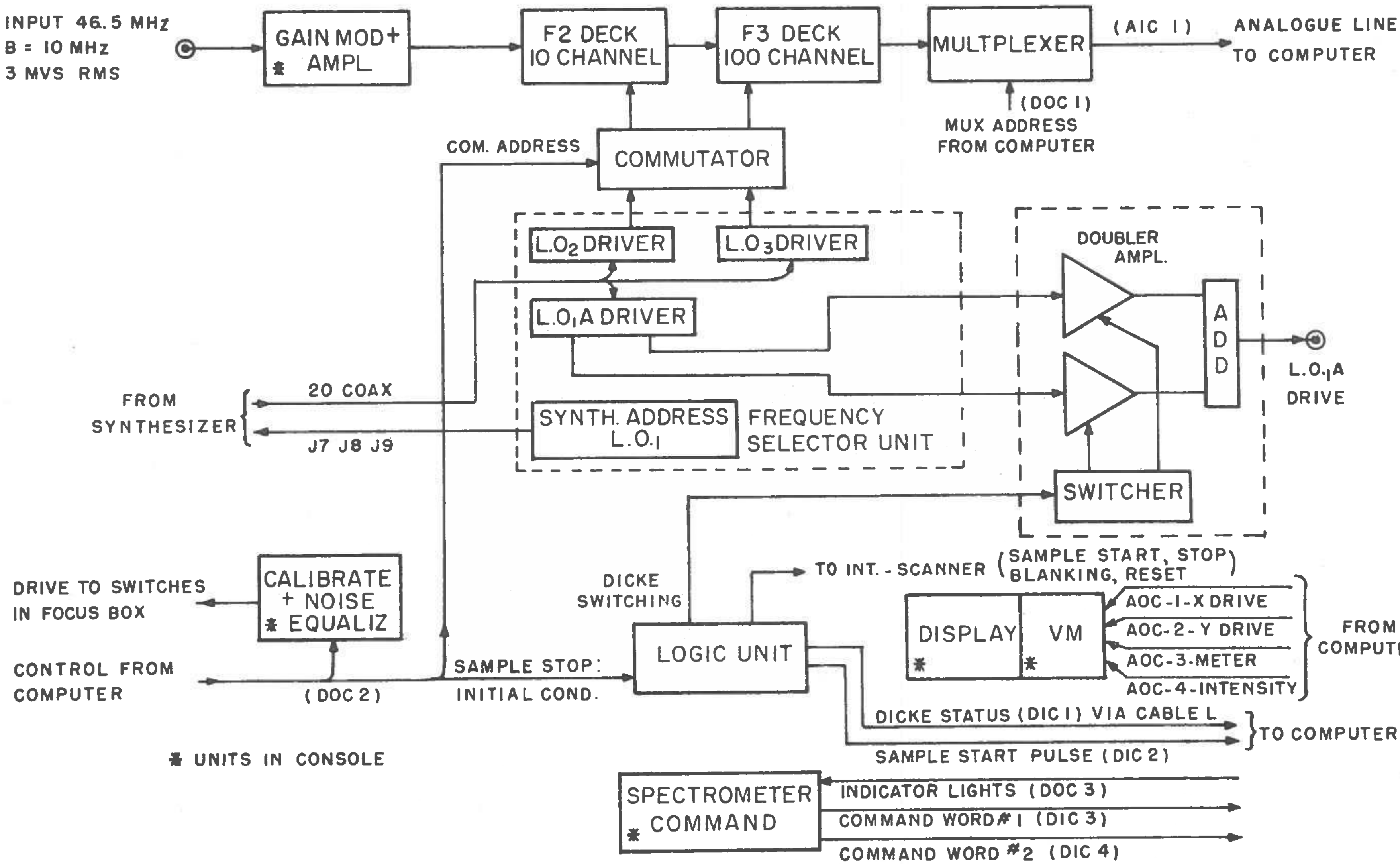
1.35 CM MIXER SYSTEM


OFF
AXIS
FEED
(OPTIONAL)
DICKE
SWITCH
20db
DIR
COUPLER
SKY
HORN
J4
J5
SMYTH
AMP
30db
L.E.L
PREAMPLIFIER
MIXER
GAIN
30db
HP
1054A
MIXER
R L X
L.P.
FILTER
20db
AMPL.
32 MHz
440 MHz
32 MHz
10db
PAD
C.W.
CALIBRATION
MIXER
HP
1054A
R X L
PNT
HYBRID
SPLITTER
6db
PAD
C.W. CALIBRATE
(31 MHz)
440 MHz
B.P.
FILTER
440 MHz
L.O.
50 MHz
IN
REMOTE
XTAL
I ADJ

74-CM SYSTEM



100-CHANNEL FILTER SPECTROMETER



SPECTROMETER FUNCTIONAL DIAGRAM

DATA ACQUISITION AND CONTROL

General

The computer system at the Algonquin Radio Observatory was designed as a data acquisition and control system for the 46-meter radio telescope. The system was supplied by Systems Engineering Laboratories of Fort Lauderdale, Florida. The computer is a small machine with a 24-bit word length, 12K word core memory and a cycle time of 1.75 μsec. The system configuration is illustrated on page 21. The primary peripherals consist of an ASR-33 console teletype, two ASR-35 remote teletypes, a high-speed paper tape reader, a high-speed paper tape punch, and two magnetic tape units. A special custom buffer interface was designed and built by the vendor to satisfy the unique computer–telescope interfacing problem at ARO. This custom section of the computer system performs signal conversion and handles the analog and discrete signal input/output (I/O) transfers.

Up to 16 analog signals can be input to the computer via the 16-channel multiplexer and 12-bit analog-to-digital converter. The analog-to-digital converter is under program control and can convert analog signals in the range ±4.096 volts at a rate of 20K samples/sec. A digital-to-analog converter provides 13 channels of analog output. Ten of these analog channels have an analog output range of 0 to − 11 volts and the remaining three have an output range of ±4.096 volts. The digital-to-analog converter converts a 12-bit binary number into an analog voltage in one of the two above ranges. Digital or discrete data can be input to the computer via a digital multiplexer and input register. There are 12 digital input channels, each 24 bits in length. Each input is buffered by a cable terminator. Eight 16-bit registers are available to output digital information from the computer. Digital buffers are used to provide a cable driving facility for the digital output registers.

One of the most important pieces of hardware essential to real-time computer operation is the priority interrupt system. The ARO system has 30 levels of priority interrupt, all of which are under program control.

At the present time there are three distinct computer system operating configurations which a potential user might want to use. These are the data acquisition and control system, the line-receiver system, and special purpose programs. The following sections describe these three configurations.

Data Acquisition and Control System

This is the primary and most versatile software system available at the observatory. At the time of writing the data acquisition system is complete and fully operational, with the computer control phase in the initial stages and unavailable. The data acquisition system in its normal mode of operation samples the radiometer data and coordinate quantities specified by the user at specific predetermined intervals and records these on magnetic tape, as well as doing on-line calculations on the data. The flexibility of the system enables the user to generate a system tailored to his own observing program quickly and easily. The user in generating his system can specify a number of parameters, such as, the quantities to be sampled, the sampling interval, events to be executed such as calibrations, and the type of processing he wishes to be carried out on his data giving him a wide degree of control over his observing. There are many on-line processing routines available which are at the disposal of a potential user but, if he so desires, he can write his own programs to do his on-line processing, subject to the constraints of the system. Anyone seriously contemplating using the data acquisition system should read *The User's Manual for the ARO Data Acquisition System** as it is a comprehensive guide to using the system and is replete with helpful examples.

Although computer control of the telescope is not complete, a limited control facility exists for automatically doing a number of forward and reverse scans and for controlling the nodder.

Line Receiver System

The second available configuration is the line receiver system. In this system the computer's primary function is the sampling and integration of the 100 filter outputs of the receiver, the calculation of the output spectrum, and its display on a CRT. The computer controls the Dicke switching and automatically inserts calibrations at pre-determined intervals. This is basically a fixed system and requires very little user interaction. The user communicates with the system by a control panel and a teletype. Hard copies of the output spectrum are produced upon user activation of a control panel push button. A potential user should read *The User's Manual for the ARO Line Receiver System* (ERB-853 – in preparation).

Special Purpose Programs

If a user has an application for the computer not covered by the above two systems, a special purpose program is necessary. In some cases, depending upon the work load, the computer group in the Radio Astronomy Section of the Radio and Electrical Engineering Division of NRC may be able to produce special purpose programs if notified well in advance of the date required.

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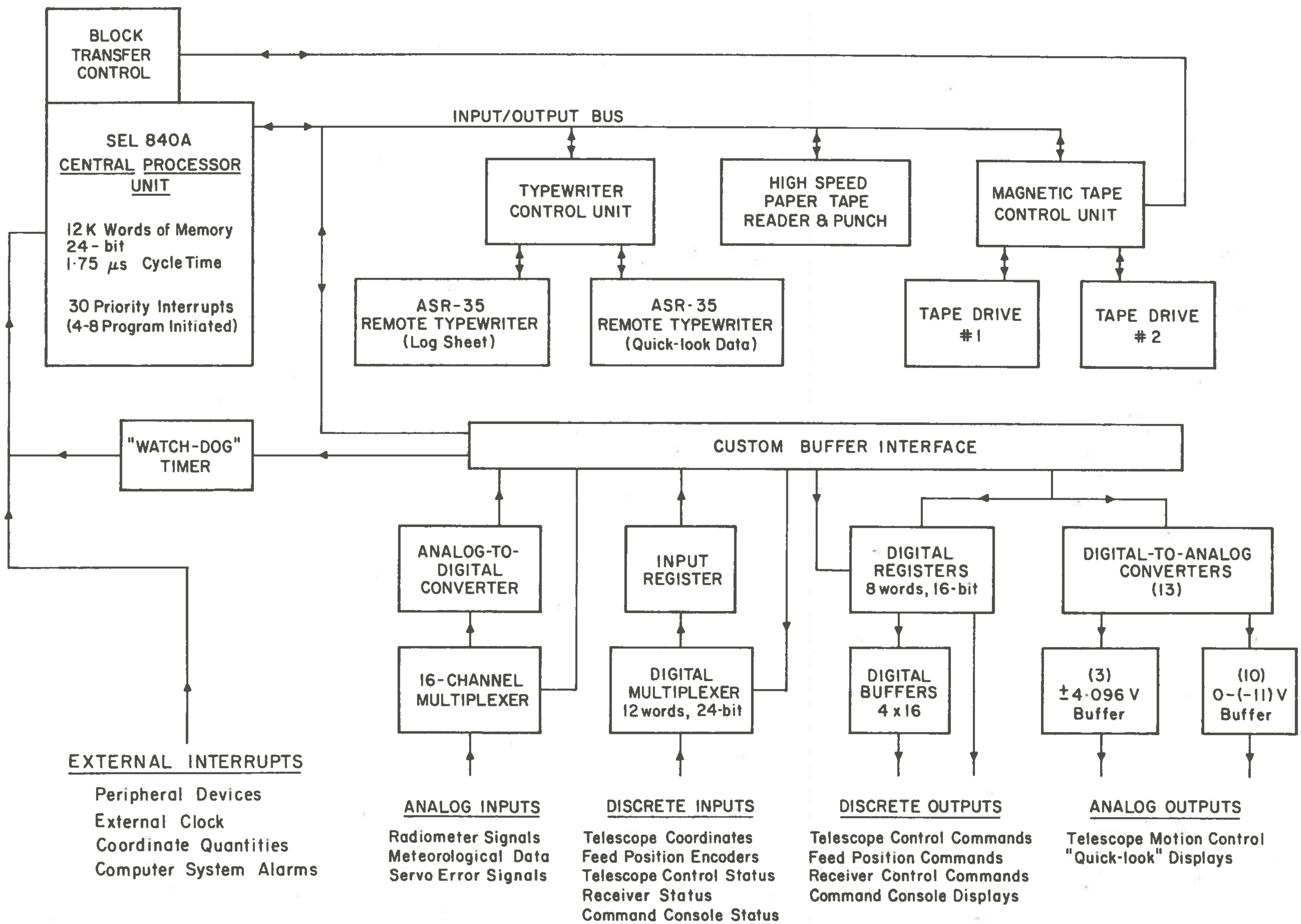
*NRC Report ERB-815



BLOCK TRANSFER CONTROL
INPUT/OUTPUT BUS
SEL 840A
CENTRAL PROCESSOR UNIT
12 K Words of Memory
24 - bit
1·75 μs Cycle Time
30 Priority Interrupts
(4-8 Program Initiated)
TYPEWRITER CONTROL UNIT
HIGH SPEED PAPER TAPE READER & PUNCH
MAGNETIC TAPE CONTROL UNIT
ASR-35 REMOTE TYPEWRITER (Log Sheet)
ASR-35 REMOTE TYPEWRITER (Quick-look Data)
TAPE DRIVE #1
TAPE DRIVE #2
"WATCH-DOG" TIMER
CUSTOM BUFFER INTERFACE
ANALOG-TO-DIGITAL CONVERTER
INPUT REGISTER
DIGITAL REGISTERS 8 words, 16-bit
DIGITAL-TO-ANALOG CONVERTERS (13)
16-CHANNEL MULTIPLEXER
DIGITAL MULTIPLEXER 12 words, 24-bit
DIGITAL BUFFERS 4 x 16
(3) ±4·096 V Buffer
(10) 0-(-11) V Buffer
EXTERNAL INTERRUPTS
Peripheral Devices
External Clock
Coordinate Quantities
Computer System Alarms
ANALOG INPUTS
Radiometer Signals
Meteorological Data
Servo Error Signals
DISCRETE INPUTS
Telescope Coordinates
Feed Position Encoders
Telescope Control Status
Receiver Status
Command Console Status
DISCRETE OUTPUTS
Telescope Control Commands
Feed Position Commands
Receiver Control Commands
Command Console Displays
ANALOG OUTPUTS
Telescope Motion Control
"Quick-look" Displays

CABLES AVAILABLE FOR RECEIVERS ON THE 46-METER TELESCOPE

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1. The Basement (Control Building) to Vertex and Radio Room (Telescope) cables are approximately 420 ft. in length, 360 feet of #17 gauge stranded wire between junction boxes and 70 feet of #22 gauge stranded wire from junction boxes to the termination panels concerned, with exception of (f) (g) (h)

   Following is a list of cables available:

   (a) 9 runs of 16 conductor shielded cable terminating in a 17 pin male chassis connector Cannon or Amphenol #MS3102A-20-29P in the basement panel and a female chassis connector #MS3102A-20-29S in the Radio and Vertex Room. The shield is terminated on the last pin of the connector.

   (b) 2 runs of 14 conductor Hi Voltage cable terminating in a 15 pin male chassis connector Amphenol #973102A-36-405P on the basement panel and a female chassis connector #973102A-36-405S in the Radio and Vertex Room. The shield is terminated on the last pin of the connector.

   (c) 4 runs of 9 conductor shielded cable terminating in a 10 pin male chassis connector Cannon or Amphenol #MS3102A-18-1P on the basement panel and a female chassis connector #MS3102A-18-1S in the Radio and Vertex Room. The shield is terminated on the last pin of the connector.

(d) 3 runs of 7 conductor shielded cable terminating in an 8 pin male chassis connector Cannon or Amphenol MS3102A-18-8P on the basement panel and a female chassis connector #MS3102A-18-8S in the Radio and Vertex Room. The shield is terminated on the last pin of the connector.

(e) 11 runs of 3 conductor shielded cable terminating in a 4 pin male chassis connector Cannon or Amphenol MS3102A-18-4P on the basement panel and a female chassis connector #MS3102A-18-4S in the Radio and Vertex Room. The shield is terminated on the last pin of the connector.

(f) 5 runs of 3 conductor #14 gauge cab tire terminating in a 6 pin male chassis connector Cannon or Amphenol MS3102A-22-5P on the basement panel and a female chassis connector #MS3102A-22-5S in the Vertex and Radio Room. Only 3 pins are used and they are as follows:

Pin A Green (Ground)
Pin B White (Neutral)
Pin E Black (Hot)

This #14 gauge cab tire is only in the 70 ft. length to the junction boxes and the rest of the 360 feet is a #17 gauge shielded cable which is not grounded.

(g) 8 runs of RG214/U COAX terminating in a female feed thru Type "N" connector mounted on insulated material on the panels in the Basement and Radio Room. In the Vertex it comes out at the jumper junction box, on insulated material.

(h) 20 runs of shielded cores terminating in a female BNC feed thru mounted on insulated material on the panels in the basement and Radio and Vertex Rooms. These can be used for signal lines. They are connected to the junction boxes from the panels with RG58/U cable and the runs between junction boxes are shielded #17 gauge wire.

2. The Vertex to Focus cabin cables are approximately 165 feet in length, 135 feet of #17 gauge stranded wire between junction boxes and 30 feet of #22 gauge stranded wire from junction boxes to the termination panels concerned, with exception of (f) (g) (h)

Following is a list of cables available:

(a) 4 runs of 16 conductor shielded cable terminating in a 17 pin male chassis connector Cannon or Amphenol

#MS3102A-20-29P on the Vertex panel and a female chassis connector #MS3102A-20-29S in the Focus Cabin. The shield is terminated on the last pin of the connector.

(b) 1 run of 14 conductor Hi Voltage cable terminating in a 15 pin male chassis connector Amphenol #97 3102A-36-405P on the Vertex panel and a female chassis connector #973102A-36-405S in the Focus Cabin. The shield is terminated on the last pin of the connector.

(c) 3 runs of 9 conductor shielded cable terminating in a 10 pin male chassis connector Cannon or Amphenol MS3102A-18-1P on the Vertex panel and a female chassis connector #MS3102A-18-1S in the Focus Cabin. The shield is terminated on the last pin of the connector.

(d) 1 run of 7 conductor shielded cable terminating in an 8 pin male chassis connector Cannon or Amphenol #MS3102A-18-8P on the Vertex panel and a female chassis connector #MS3102A-18-8S in the Focus Cabin. The shield is terminated on the last pin of the connector.

(e) 5 runs of 3 conductor shielded cable terminating in a 4 pin male chassis connector Cannon or Amphenol MS3102A-18-4P on the Vertex panel and a female chassis connector #MS3102A-18-4S in the Focus Cabin. The shield is terminated on the last pin of the connector.

(f) 2 runs of 3 conductor #14 gauge cab tire terminating in a 6 pin male chassis connector Cannon or Amphenol MS3102A-22-5P on the Vertex panel and a female chassis connector MS3102A-22-5S in the Focus Cabin. Only 3 pins are used and they are as follows:

Pin A Green (Ground)
Pin B White (Neutral)
Pin E Black (Hot)

This 14 gauge cab tire is only in the 30 foot lengths to the junction boxes and the rest of the 135 feet is a #17 gauge shielded cable which is not grounded.

(g) 8 runs of RG214/U COAX terminating in a female feed thru Type "N" connector mounted on insulated material in the jumper junction box in the Vertex and the junction box in the Focus Cabin.

(h) 10 runs of shielded cores terminating in a female BNC feed thru mounted on insulated material on the Vertex panel and the Focus panel. The runs are RG58/U from the panels to the junction boxes and then are attached to #17 gauge shielded cores between boxes.

3. Jumpers are provided in the system so that connection can be made directly to the Focus Cabin from the basement by jumpering appropriate plugs on the Vertex panel and COAX jumper box.

4. In the Focus Cabin we have a set of 10 ft. jumper cables that terminate in a female cable plug to fit on to a receiver. This set includes:

4	-	16 conductor cables shielded
1	-	14 conductor Hi Volt Cable
3	-	9 conductor cables shielded
1	-	7 conductor cable shielded
5	-	3 conductor cable shielded
2	-	3 conductor cab tire cables
10	-	BNC Shielded cables (male)
8	-	RG214/U cables (Male) Type N

5. In the Vertex we have a set of 15 ft. jumper cables that terminate in a female cable plug and in the Radio Room a set 30 ft. long.

These sets include:

9	-	16 conductor cables shielded
2	-	14 conductor Hi Volt cables
4	-	9 conductor cables shielded
3	-	7 conductor cables shielded
11	-	3 conductor cables shielded
5	-	3 conductor cab tire cables
20	-	BNC shielded cables (Male)
8	-	RG214/U cables (Male) Type N

6. There is also available regulated 110/220V 60 ∿ power in the Focus Cabin Vertex and Radio Room.

CABLES AVAILABLE FOR RECEIVERS ON THE 10-METER TELESCOPE

1. The cables are approximately 200 feet in length and terminate at a panel in the basement of the control building and at a panel at the base of the focus platform.

At the control building panel Cannon or Amphenol connectors, Type "MS" are used, at the focus panel Cannon MR 02 weather proof connectors are used.

Following is a list of cables available:

(a) 4 runs of 16 conductor shielded cable terminating in a 17 pin male chassis connector Cannon or Amphenol #MS-3102A-20-29P on the basement panel and a female chassis connector MR-02-20-29S at the panel. The shield is terminated on the last pin of the connector.

(b) 1 run of 14 conductor Hi Voltage cable terminating in a 15 pin male chassis connector Amphenol #97 3102A-36-405P on the basement panel and a female chassis connector #973102A-36-405S in the Focus panel. The shield is terminated on the last pin of the connector.

(c) 4 runs of 9 conductor shielded cable terminating in a 10 pin male chassis connector Cannon or Amphenol MS3102A-18-1P on the basement panel and a female chassis connector MR-02-18-1S in the Focus panel. The shield is terminated on the last pin of the connector.

(d) 1 run of 7 conductor shielded cable terminating in an 8 pin male chassis connector Cannon or Amphenol #MS3102A-18-8P on the basement panel and a female chassis connector MR 02A-18-8S in the Focus panel. The shield is terminated on the last pin of the connector.

(e) 5 runs of 3 conductor shielded cable terminating in a 4 pin male chassis connector Cannon or Amphenol MS 3102A-18-4P on the basement panel and a female chassis connector MR02A-18-4S in the Focus panel. The shield is terminated on the last pin of the connector.

(f) 2 runs of 3 conductors #14 gauge cab tire terminating in a 6 pin male chassis connector Cannon or Amphenol MS3102A-22-5P on the basement panel and a female chassis connector MR 02A-22-5S in the Focus panel. Only 3 pins are used and they are as follows:

Pin A	Green (Ground)
Pin B	White (Neutral)
Pin E	Black (Hot)

This 14 gauge cab tire is only in the 30 foot lengths to the junction boxes and the rest of the 135 feet is a #17 gauge shielded cable which is not grounded.

(g) 4 runs of RG214/U COAX terminating in a female connector mounted on insulated material in the focus panel and the panel in the basement.

(h) 10 runs of RG 58 COAX terminating in a female BNC connector mounted on insulated material on the focus panel and the basement panel.

2. At the focus panel we have a set of 10 ft. jumper cables that terminate in a Cannon or Amphenol female cable plug MR 02 weather proof type to fit on to a receiver. This set includes:

   4 - 16 conductor cables shielded
   1 - 14 conductor Hi Volt Cable
   4 - 9 conductor cables shielded
   1 - 7 conductor cables shielded
   5 - 3 conductor cables shielded
   2 - 3 conductor cab tire cables
   10 - BNC shielded cables (male)
   4 - RG214/U cables (male) type N

3. In the control building we have a set of 30 ft jumper cables that terminate in a Cannon or Amphenol female cable plug type MS 3106 to fit on to a receiver used on main floor. These sets include:

   4 - 16 conductor cables shielded
   1 - 14 conductor Hi Volt cables
   4 - 9 conductor cables shielded
   1 - 7 conductor cables shielded
   5 - 3 conductor cables shielded
   2 - 3 conductor cables shielded
   2 - 3 conductor cab tire cables
   10 - BNC shielded cables (male)
   4 - RG214/U cables (male) type N

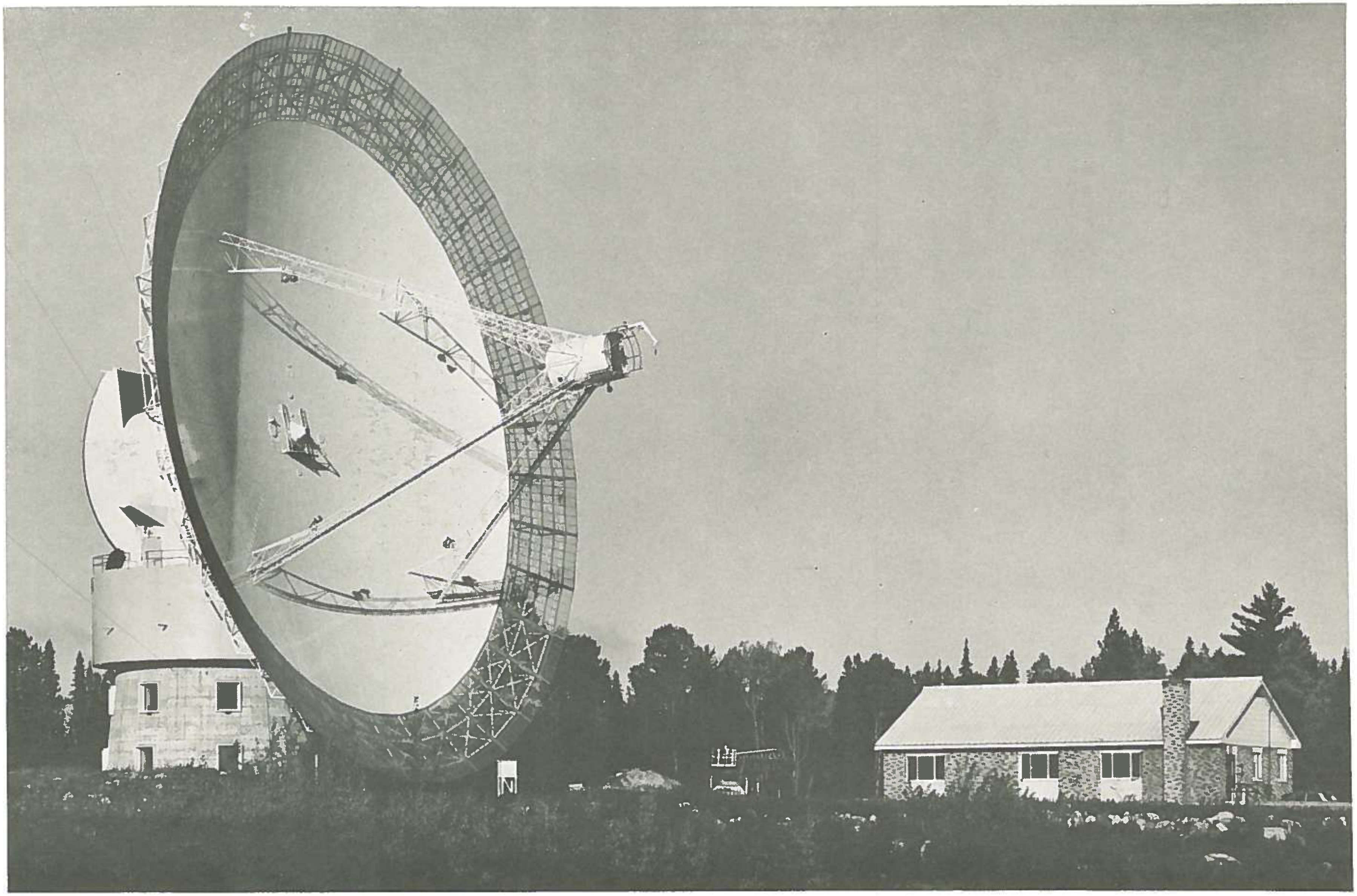


PLATE I 46-METER TELESCOPE SHOWING THE VERTEX AND FOCUS LOCATION FOR THE RADIOMETER. AT LOWER RIGHT IS THE TELESCOPE CONTROL AND LABORATORY BUILDING (SITE 3)

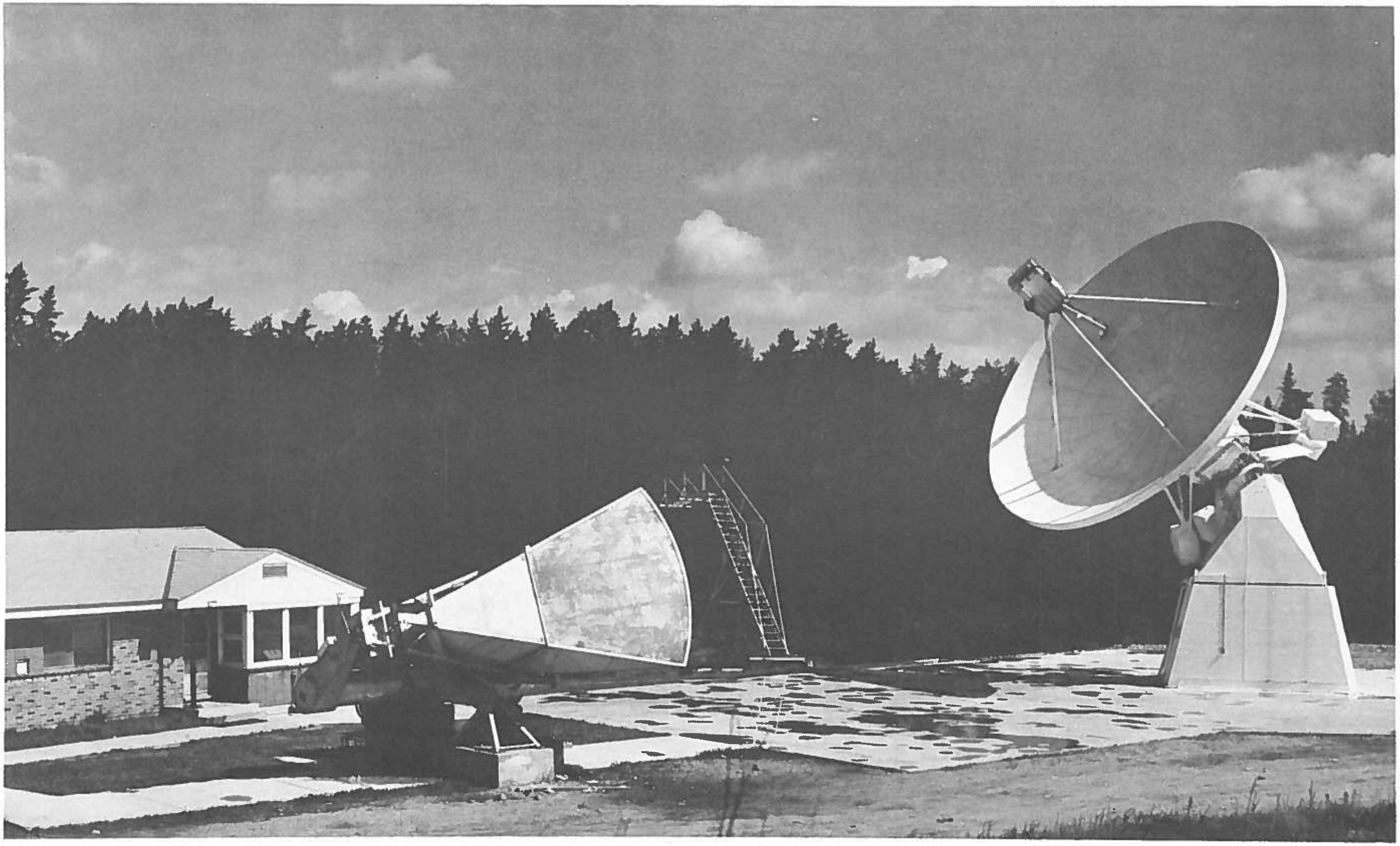
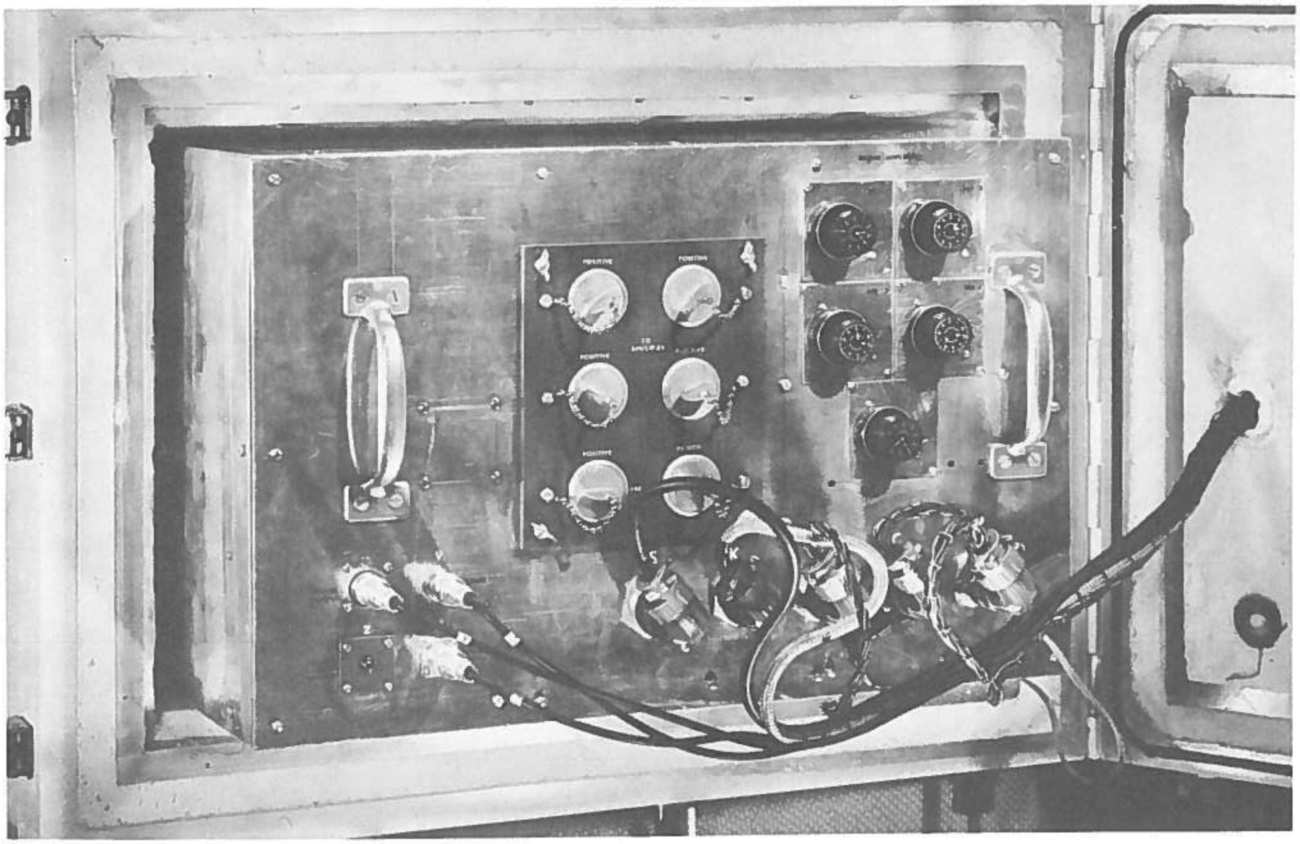


PLATE II   10-METER TELESCOPE SHOWING THE FOCUS POSITION FOR THE RADIOMETER. AT CENTER IS A HORN REFLECTOR USED FOR ABSOLUTE FLUX MEASUREMENTS. ON THE LEFT IS THE TELESCOPE CONTROL AND LABORATORY BUILDING (SITE 2)



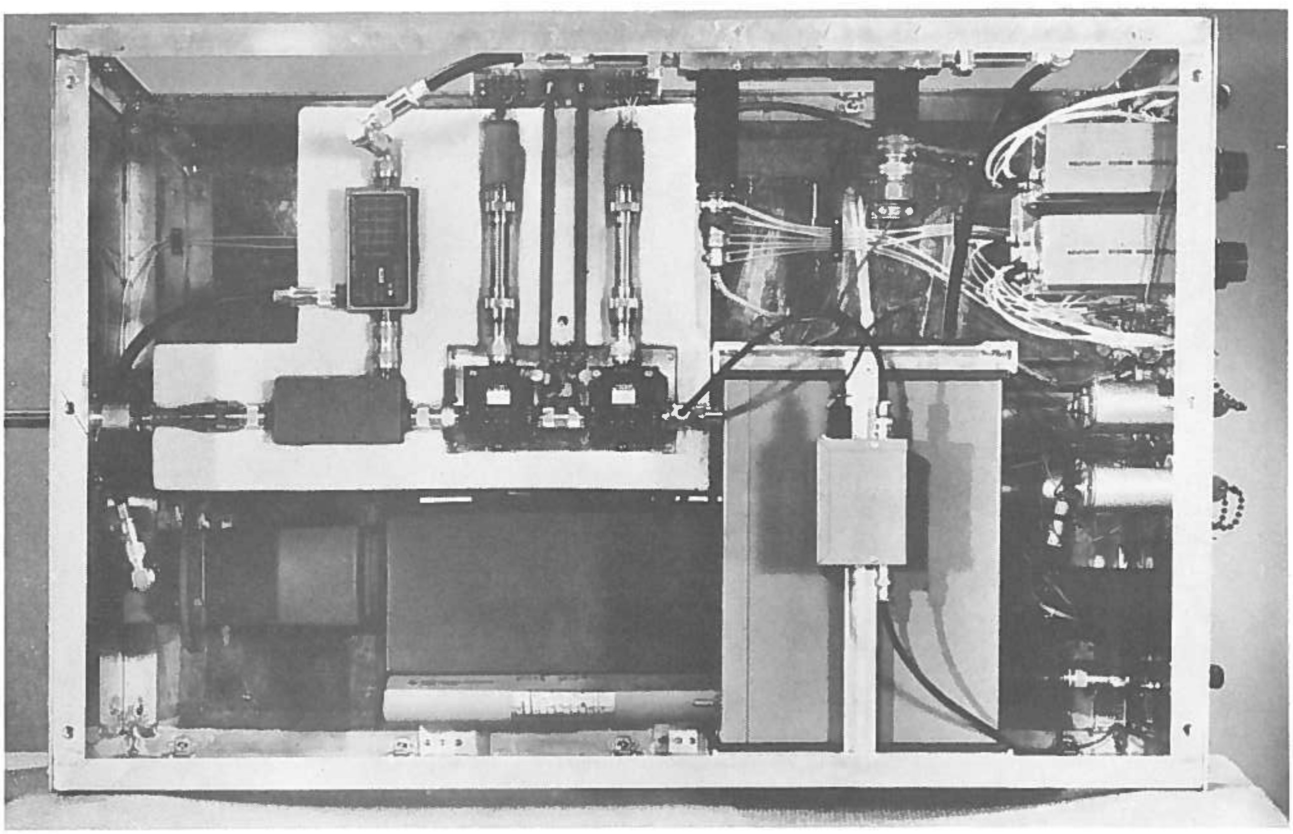


PLATE III 9.4-CM TDA SYSTEM

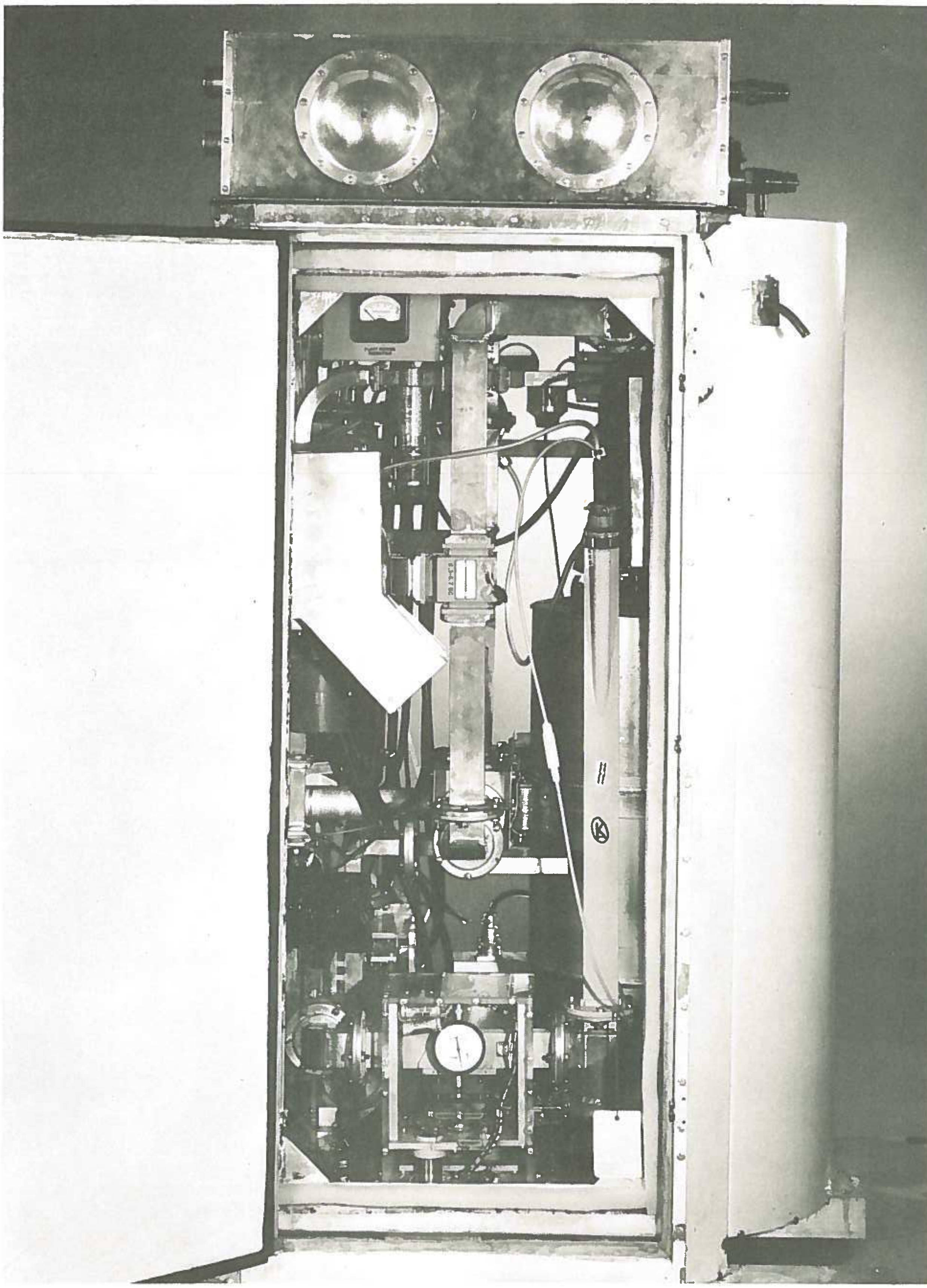


PLATE IV 4.6-CM PARAMP SYSTEM

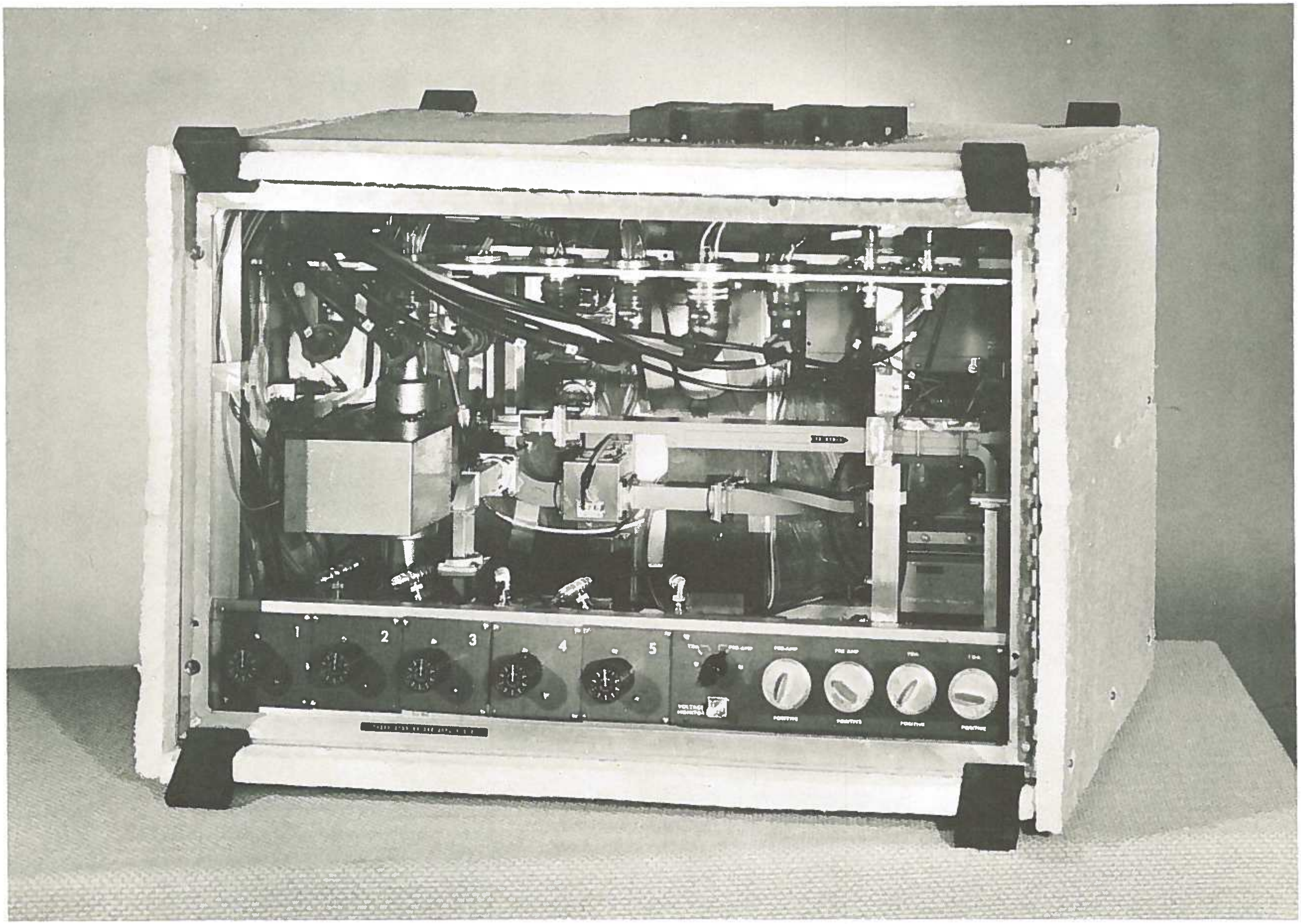


PLATE V 2.8-CM TDA SYSTEM

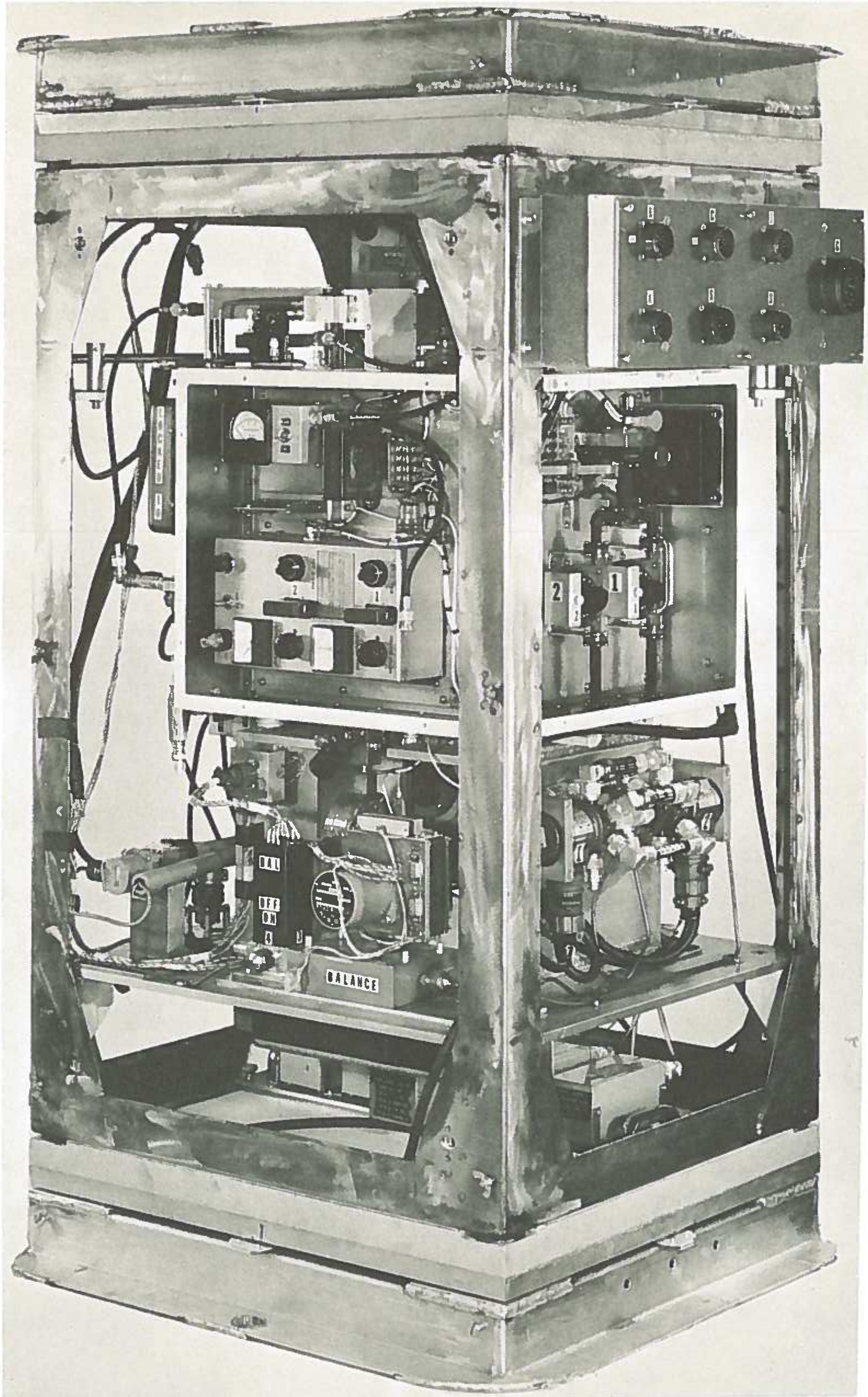


PLATE VI 2.8-CM PARAMP SYSTEM

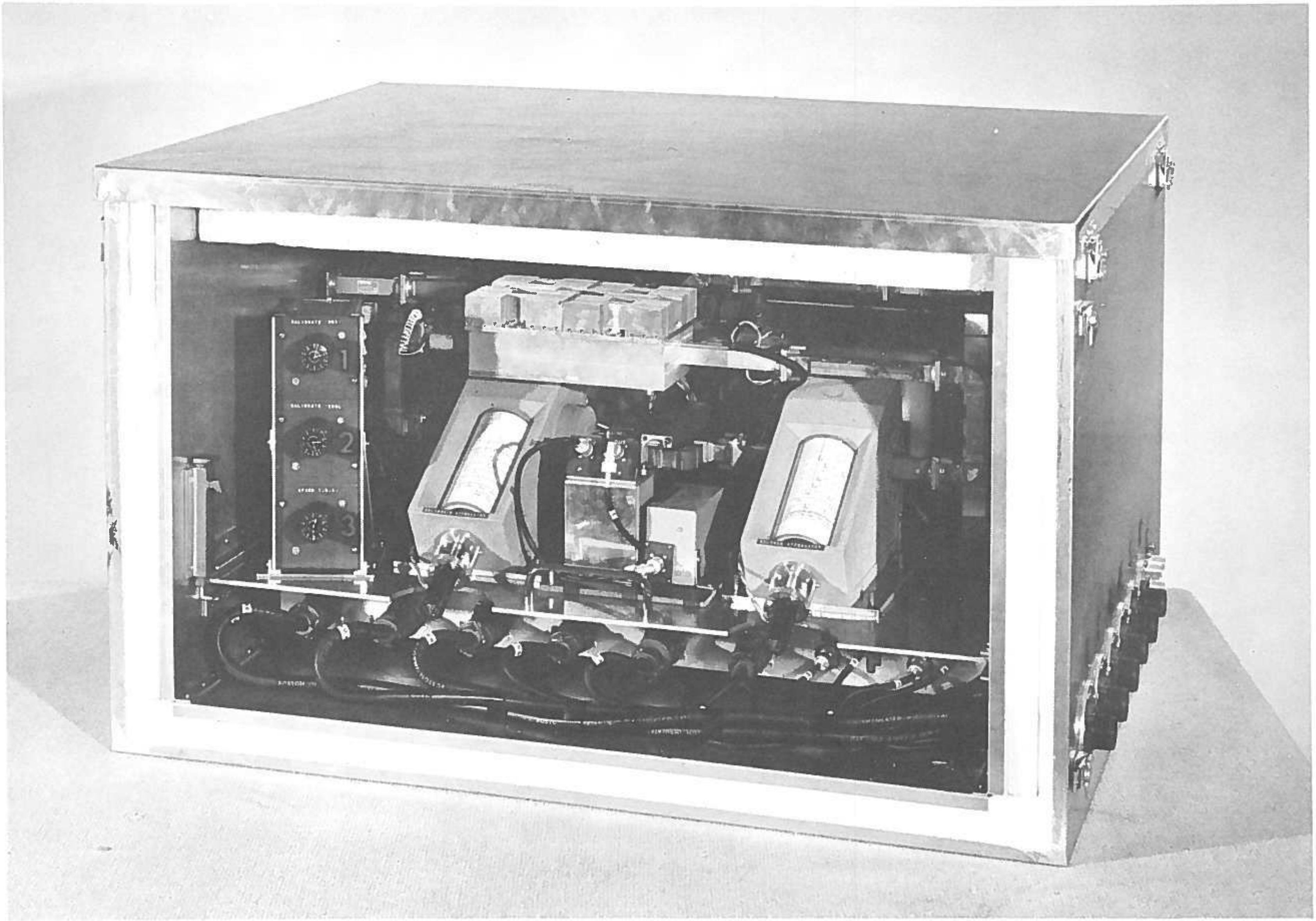


PLATE VII 2.2-CM PARAMP SYSTEM

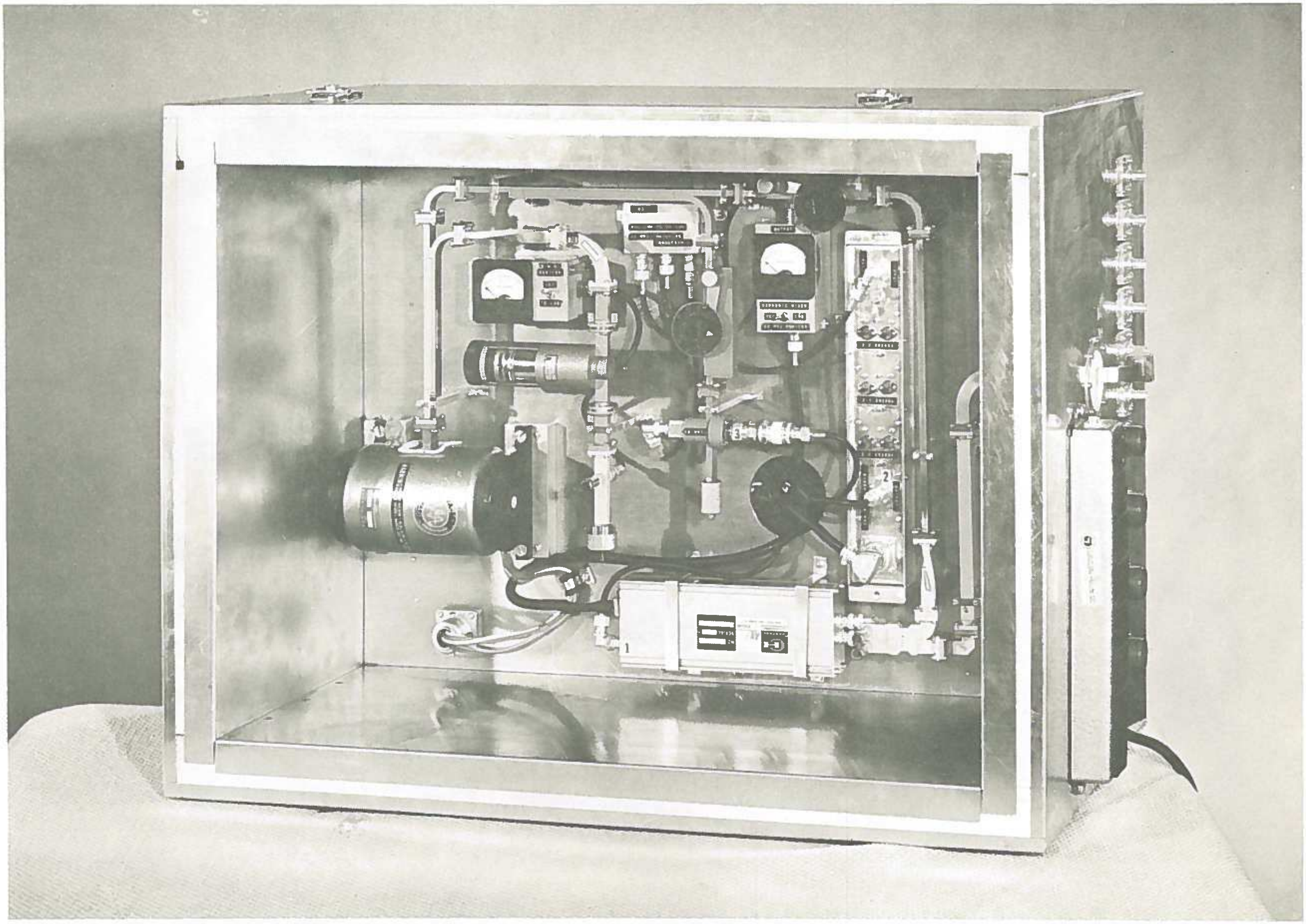


PLATE VIII   1.35-CM MIXER SYSTEM

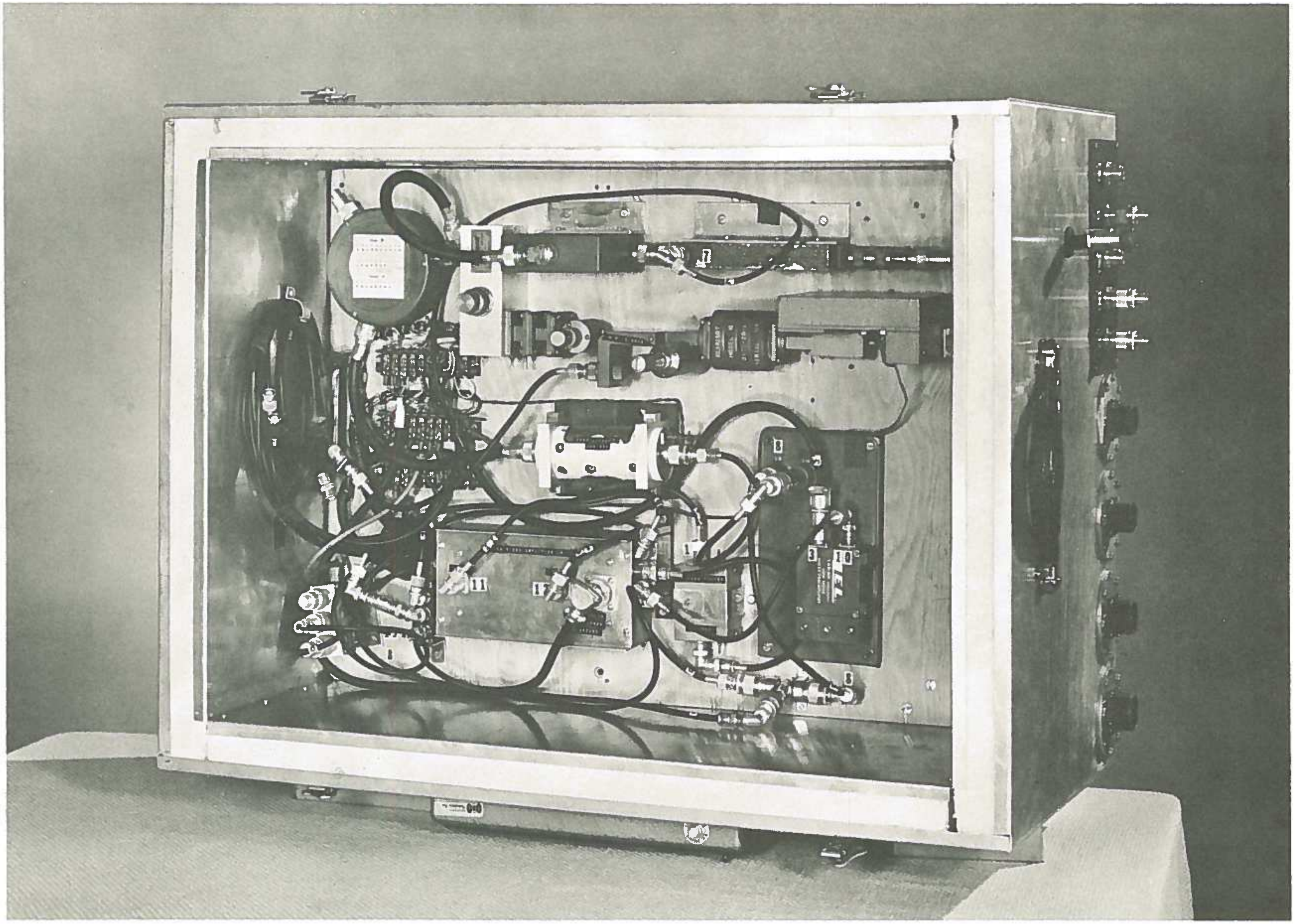


PLATE IX   74-CM LBI SYSTEM