NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Electronics Division Internal Report No. 108

11 CM, 3-FEED RECEIVER

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OCTOBER 1971

NUMBER OF COPIES: 150

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TABLE OF CONTENTS

LIST OF FIGURES

11 CM, 3-FEED RECEIVER

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1.0 Introduction

This report describes the 3-feed, 11 cm receiver that is used on the 300' telescope at Green Bank. Photographs, block diagrams and a brief description of each assembly are included along with general specifications on most components in the system.

2.0 Description of System

The receiver consists of three dual-polarized, S-band feed horns connected to four independent receivers. Two receivers (1 and 2) are connected to the center on-axis feed, one to each polarization, while the other two receivers (3 and 4) are connected to each of the other two feeds. Figure 1 shows the feed configuration and corresponding receivers. Figure 16 shows the feed E-vector position angles.

As seen in Figures 5 and 6, the receivers can be load switched (Dicke switched) or switched between the two polarizations available from each feed. Selection of the load or polarization switching mode on any feed is done from the control room along with noise injection available to offset the unbalance present due to unequal losses in the two switched paths when polarization switching. The noise injection can be modulated synchronously with the polarization switching rate and can be turned on or off from the control room.

The specifications of the receivers are given below:

Center Frequency:	2695 MHz
RF -3 dB Frequencies (DSB):	2575-2815 MHz
IF Bandwidth (-3 dB) (SSB):	5-55 MHz
Noise Temperature (T_R):	115 °K
Calibration Value:	4 °K
Three Feeds:	Dual linear or circular
IF Outputs:	4 independent
HPBW:	5' arc

3.0 Feed Specifications

The feed horns for the 3-feed, 11 cm system were manufactured by Radiation Systems, Inc., to the following specifications:

General: Three dual-polarized S-band feed horns, in line, with one on axis and at the focal point while the other two as close as possible in angular separation.

Polarization: Either dual-linear or dual-circular polarization, selected by mechanical change performed on feeds.

Frequency Range: 2650 to 2750 MHz.

VSWR: < 1.25:1.

Cross Polarization: The opposite sense polarization must be rejected by > 17 dB in the central 60° of the feed pattern. (Axial Ratio = 2.48 dB.)

Spillover: < 5%.

Aperture Efficiency: > 65% assuming a perfect reflector.

Resistive Losses: < 0.1 dB.

Pressurization: Capable of up to 3 p.s.i.

Physical Configuration: See Figure 1.

4.0 RF Assembly

The RF assembly consists of all components between the feeds and the output from the IF post-amplifier. There are four complete and virtually identical RF assemblies in this system and the components and their specifications are listed in the following sections of this report. The components are rigidly mounted to a solid plate. This is to eliminate any mechanical stresses being applied to the paramp which in turn would cause a gain change due to the physical nature of these particular paramps.

4.1 Parametric Amplifier Specifications

The system uses four AIL type 1784-00 degenerate parametric amplifiers, one for each channel.

Center Frequency:	2695 MHz
Instantaneous Bandwidth:	80 MHz (3 dB)
Double-Sideband Gain:	18 dB
Noise Temperature:	60 °K
Input/Output VSWR:	< 1.25:1
Pump Frequency/Power:	5390 MHz/10 mW

4.2 Mixer-Preamp Specifications

Model MMP2-4AA76 low-noise mixer-preamps manufactured by RHG, to the following specifications, are used in the system:

RF/LO Input Frequency:	2600 to 2800 MHz
IF Center Frequency:	27.5 MHz
IF Bandwidth:	55 MHz
Noise Figure:	< 5.0 dB (DSB)
RF to IF Gain:	31 dB
Power Required:	+15 V DC at 20 mA
Crystal Current:	2.5 mA (ext 100 ohm resistor)

4.3 IF Post-Amplifier

A special version of the NRAO WB-2 amplifier built to the following specifications follows each mixer-preamp:

Frequency Range:	4-65 MHz (0.5 dB)
Gain:	23 dB
Output Power:	+4 dBm (1 dB gain compression point)
Input/Output VSWR:	< 2.0:1
Power Required:	+15 V DC at 20 mA

4.4 Miscellaneous Components

The following components and their specifications are also included in the RF assembly:

1. Cross Guide Coupler: MDL WR 284 284XT139

   Frequency Range: 2645-2745 MHz

4.4 (Continued)

Coupling:	27 ± 1.0 dB
Directivity:	> 20 dB
MA VSWR:	< 1.05:1
SA VSWR:	< 1.20:1

2. Ferrite Switch: Amlabs AMF-2854 Three-Port Switched Circulator

Frequency:	2700 MHz
Bandwidth:	100 MHz
Isolation:	> 20 dB
Insertion Loss:	≤ 0.25 dB
VSWR:	≤ 1.15:1
Current Required:	± 200 mA

3. Waveguide to Coax (N) Adapter: MRC SP-84

Frequency Range:	2600-2900 GHz
VSWR:	< 1.03:1

4. Low Pass Filter: EMCO F-130N

F_c:	3000 MHz
Insertion Loss at 3000 MHz:	≤ 0.25 dB
Insertion Loss at 5390 MHz:	> 60 dB

5. DC Block: FXR HR-10N

Frequency Range:	100-4000 MHz
Max. VSWR:	1.2:1
Max. Insertion Loss:	0.2 dB

6. Isolator: Amlabs NL 1006

Frequency:	2695 MHz
VSWR:	1.1:1
Insertion Loss:	0.25 dB
Isolation:	27 dB

5.0 LO/Pump Frequency Assembly

Power at the local oscillator (2695 MHz) and pump frequency (5390 MHz) for the receiver is derived from a common crystal controlled power oscillator source and split into four paths, one for each channel. A phase shifter is included in each LO path so that the phase can be adjusted for maximum gain in each degenerate paramp. A portion of the 2695 MHz signal is also doubled and used to pump the paramp. A block diagram for this assembly is shown in Figure 3.

5.1 LO/Pump Frequency Source Specifications

This unit consists of a high-power S-band oscillator that is injection locked to a crystal controlled reference oscillator running at 134.7500 MHz. The unit was manufactured by Centilabs Corporation (now Wescom Corp.) to the following specifications (plus others):

Model No.:	271001X
Output Frequency:	2695.000 MHz ± .001% at 25 °C
Frequency Stability:	± 1 x 10^{-7}/°C/24 hrs. (± 0.1 ppm/°C/24 hrs.)
Power Output:	≥ 1.0 watt into 50 ohms
Output Protection:	Isolator
Spurious:	≥ 50 dB down
DC Power:	28 V DC at 500 mA

5.2 LO Frequency Path Components

3 dB Hybrid:	Aertech K-4000
Frequency Range:	2-4 GHz
Isolation:	≥ 25 dB
VSWR:	≤ 1.2:1
Directional Coupler:	Narda 4013B-10
Frequency Range:	2.0 to 4.0 GHz
Coupling:	10 dB
Directivity:	> 20 dB
Main VSWR:	< 1.15:1
Sec. VSWR:	< 1.20:1

5.2 (continued)

Phase Shifter:	ARRA AR-3012
Frequency Range:	2695 MHz ± 40 MHz
Phase Range:	180°
VSWR:	≤ 1.3:1
Variable Attenuator:	ARRA 4804-10X
Frequency Range:	2.5-4.0 GHz
Attenuation Range:	10 dB
Max. Insertion Loss:	0.5 dB
Max. VSWR:	1.5:1

5.3 Pump Frequency Path Components:

Frequency Doubler:	Applied Research VM 5390/125-2
Multiplication Factor:	X2
Power In/Power Out:	250 mW/> 50 mW
Output Frequency:	5390 MHz
Bandwidth:	5%
Spurious:	> 60 dB down
Bias:	+15 V DC
Current Controlled Attenuator:	HP 33008C
Frequency Range:	4.0-8.0 GHz
Attenuation Range:	3-45 dB
VSWR:	< 2.0:1
Control Current:	0 to -100 mA
Isolator:	Amlabs PL 1005
Frequency:	5390 MHz
VSWR:	1.06:1
Insertion Loss:	0.3 dB
Isolation:	27 dB

6.0 Noise Calibration and Injection Assembly

Figure 4 shows a block diagram of the noise calibration and noise injection components. The components and their specifications are shown below:

Constant Current Source:	MPD CCM 25-R
Input/Output Voltage:	28/15
Output Current Max.:	25 mA
Regulation:	1.0%
3 dB Hybrid:	Aertech K-4000
Frequency Range:	2-4 GHz
Isolation:	$\geq$ 25 dB
VSWR:	$\leq$ 1.2:1
Noise Diode:	MSC MC 7027
Frequency:	2700 MHz $\pm$ 100 MHz BW
Output:	35.2 dB TEX
Power Required:	+15 V DC
Variable Attenuator:	Merrimac AUM 15A
Frequency Range:	2-8 GHz
Attenuation Range:	0-15 dB
VSWR:	$\leq$ 1.5:1
Adjustment:	Mechanical screw
Attenuators:	FXR AG-03F, 06F, 10F
Frequency:	DC - 7 GHz
Attenuation Value:	3, 6, 10 dB
VSWR:	DC - 5 GHz, < 1.25:1
Directional Coupler:	Narda 4013-10
Frequency Range:	2.0-4.0 GHz
Coupling:	10 dB
Directivity:	> 20 dB
MA VSWR:	< 1.15:1
SA VSWR:	< 1.20:1

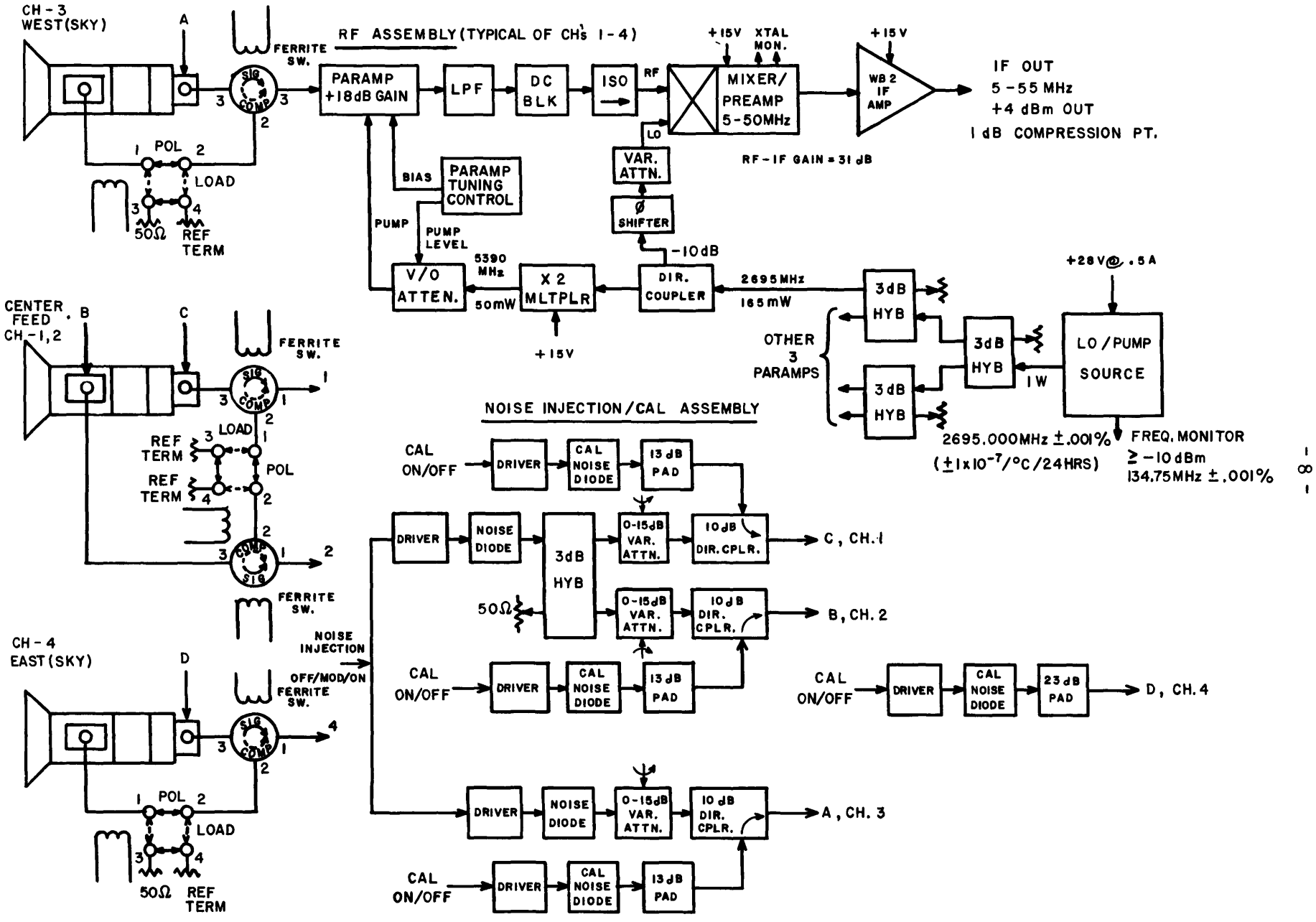

FIG. 1
BLOCK DIAGRAM
11 cm 3 FEED SYSTEM

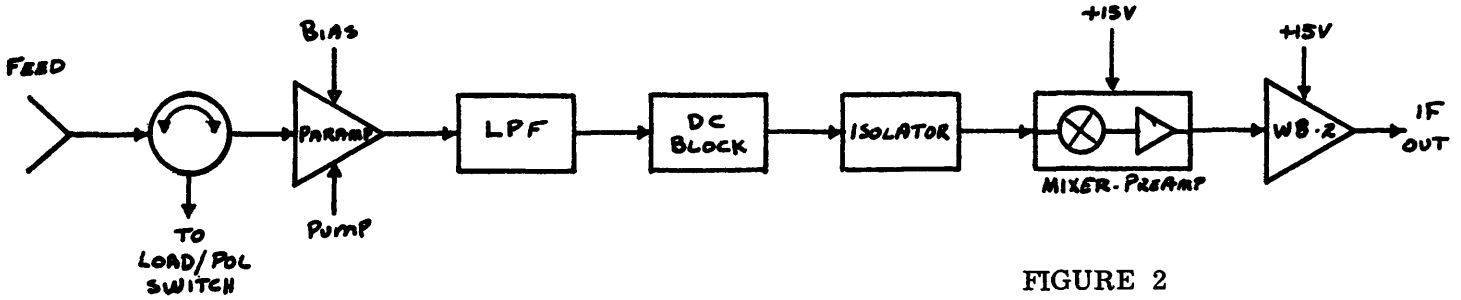

FIGURE 2
RF ASSEMBLY

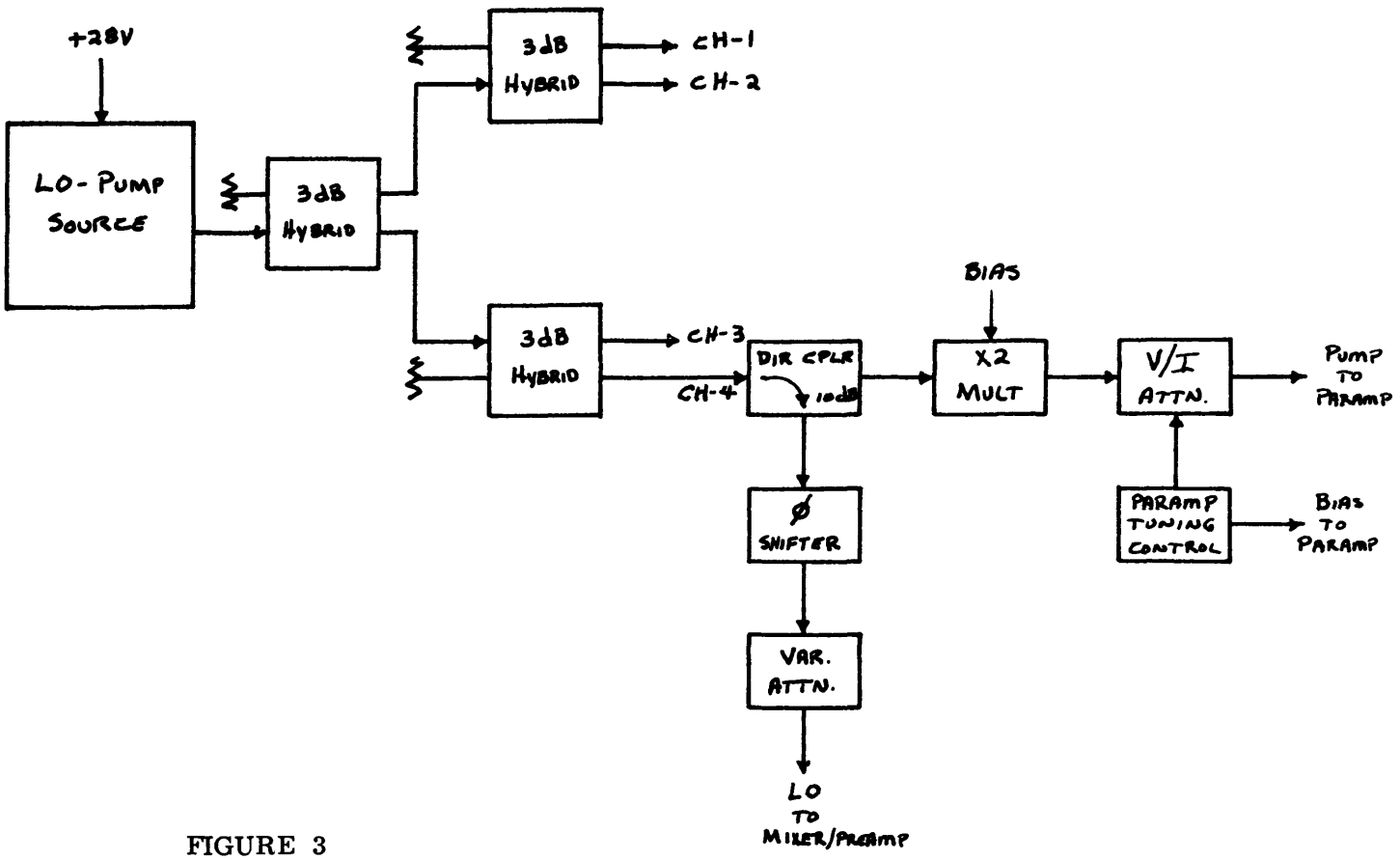

FIGURE 3

LO/PUMP FREQUENCY ASSEMBLY

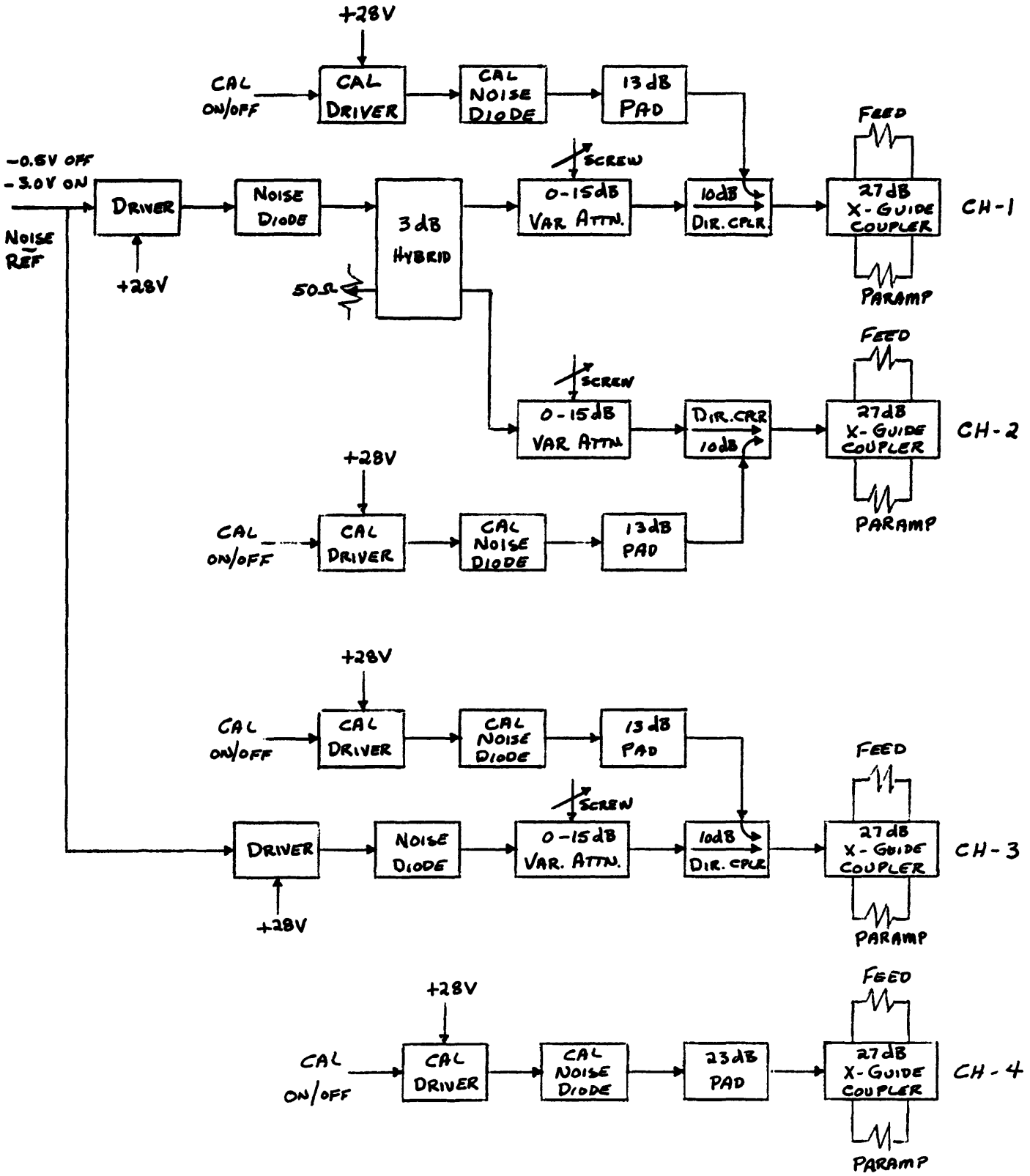

FIGURE 4

NOISE CALIBRATION AND INJECTION ASSEMBLY

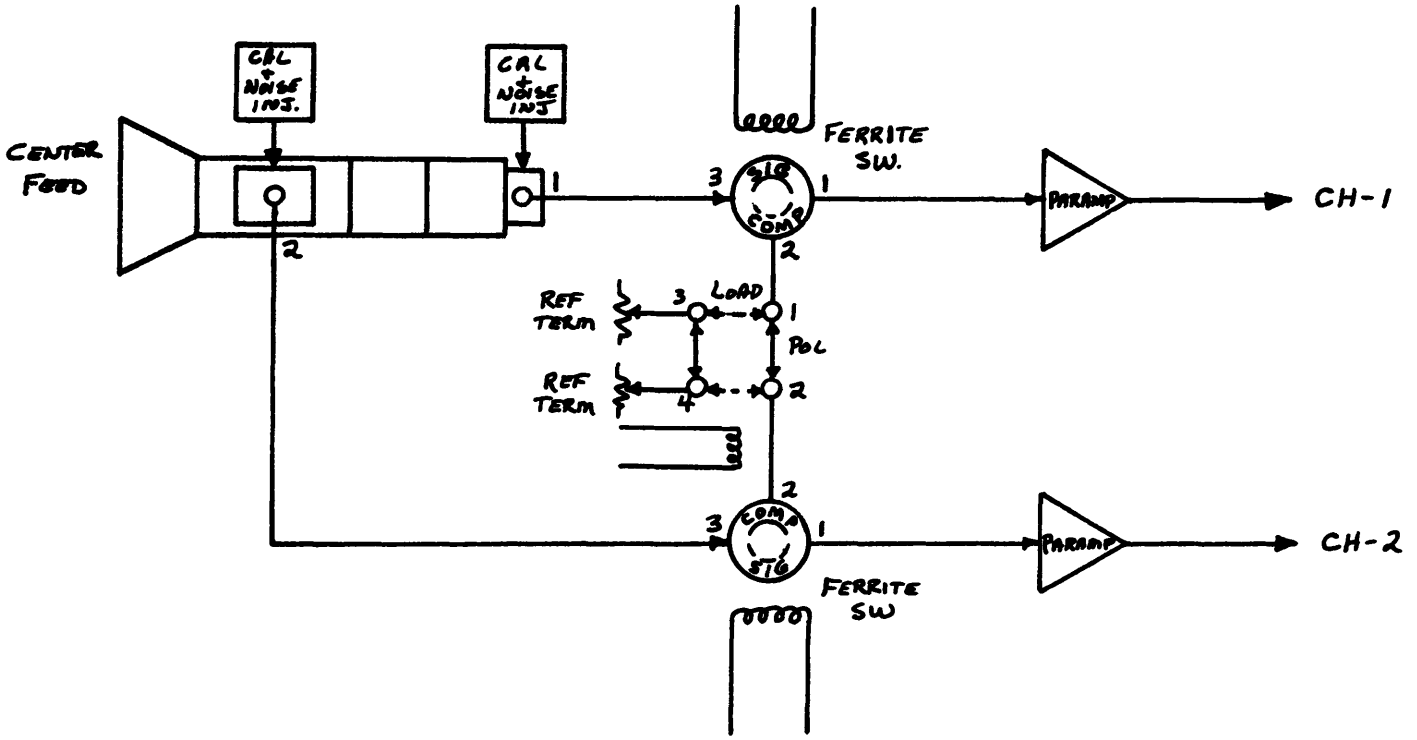

FIGURE 5 — CENTER FEED CONFIGURATION

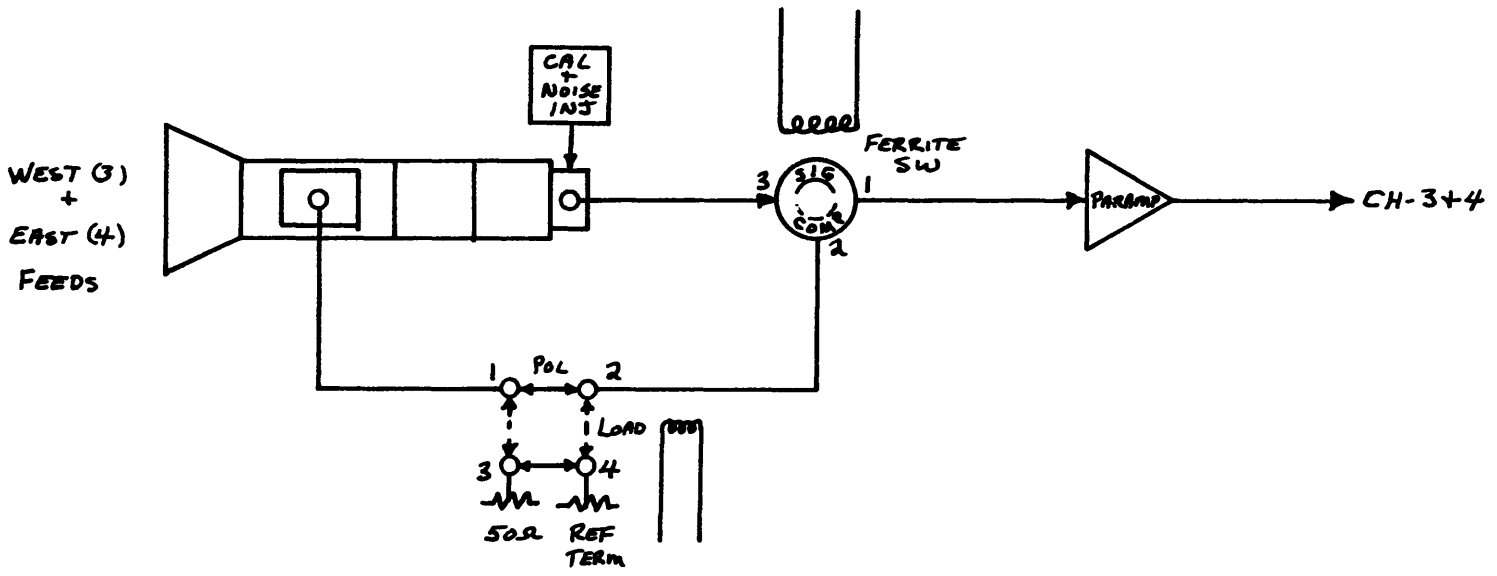

FIGURE 6 — OUTBOARD FEEDS CONFIGURATION

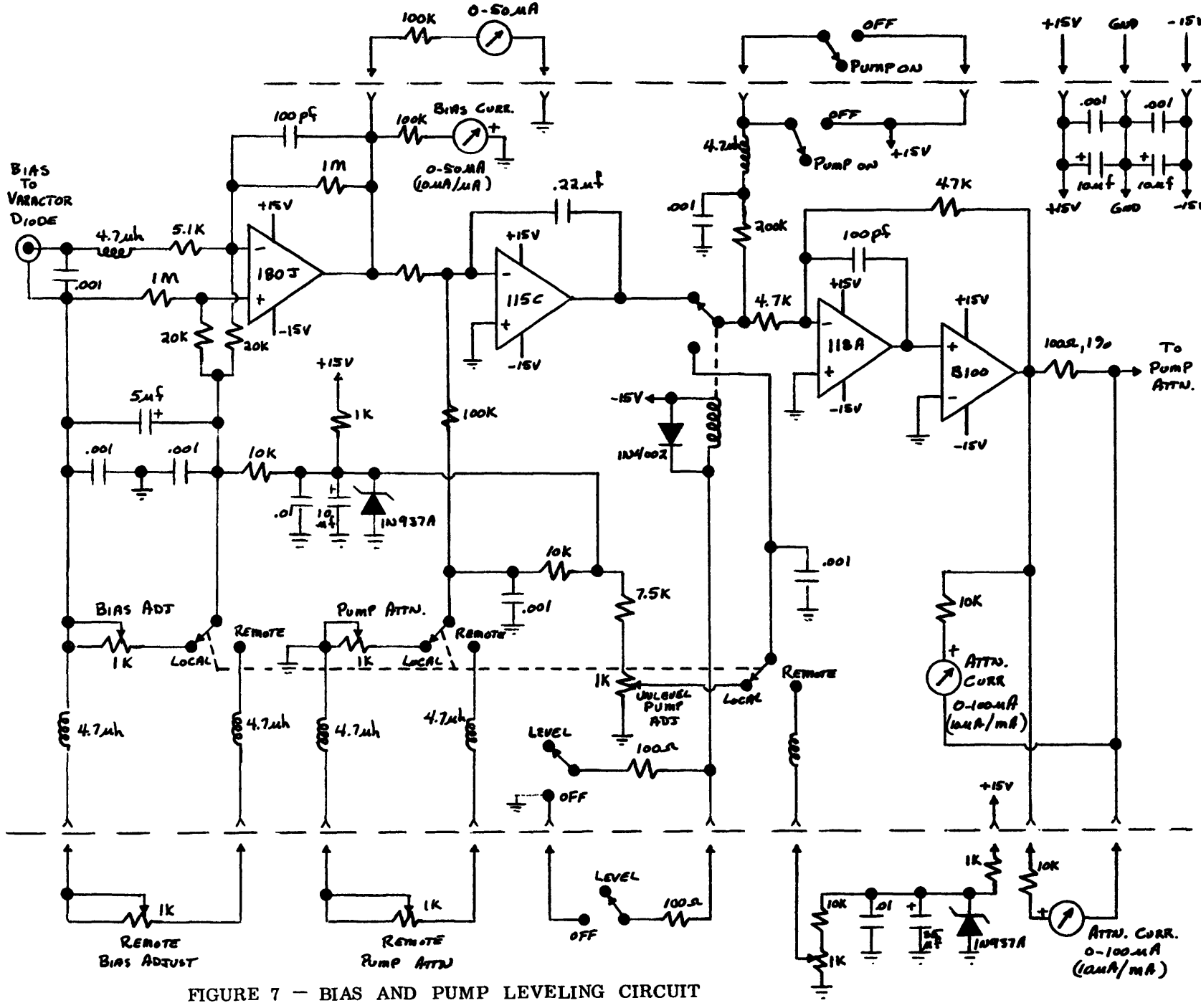

FIGURE 7 — BIAS AND PUMP LEVELING CIRCUIT

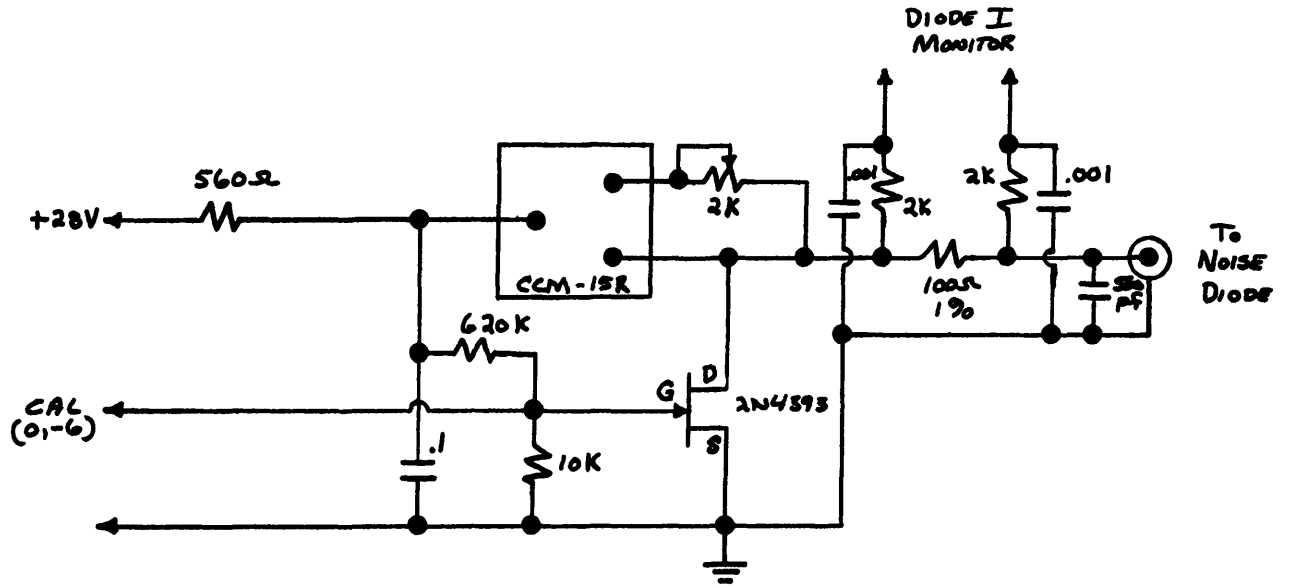

FIGURE 8

NOISE DIODE DRIVER

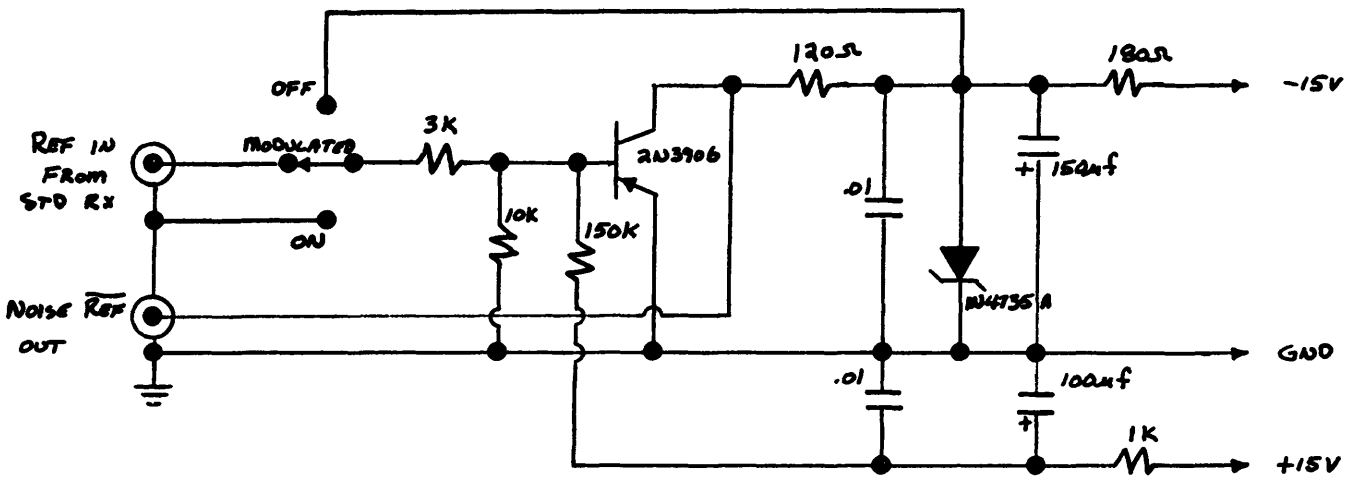

FIGURE 9

NOISE INJECTION DRIVER

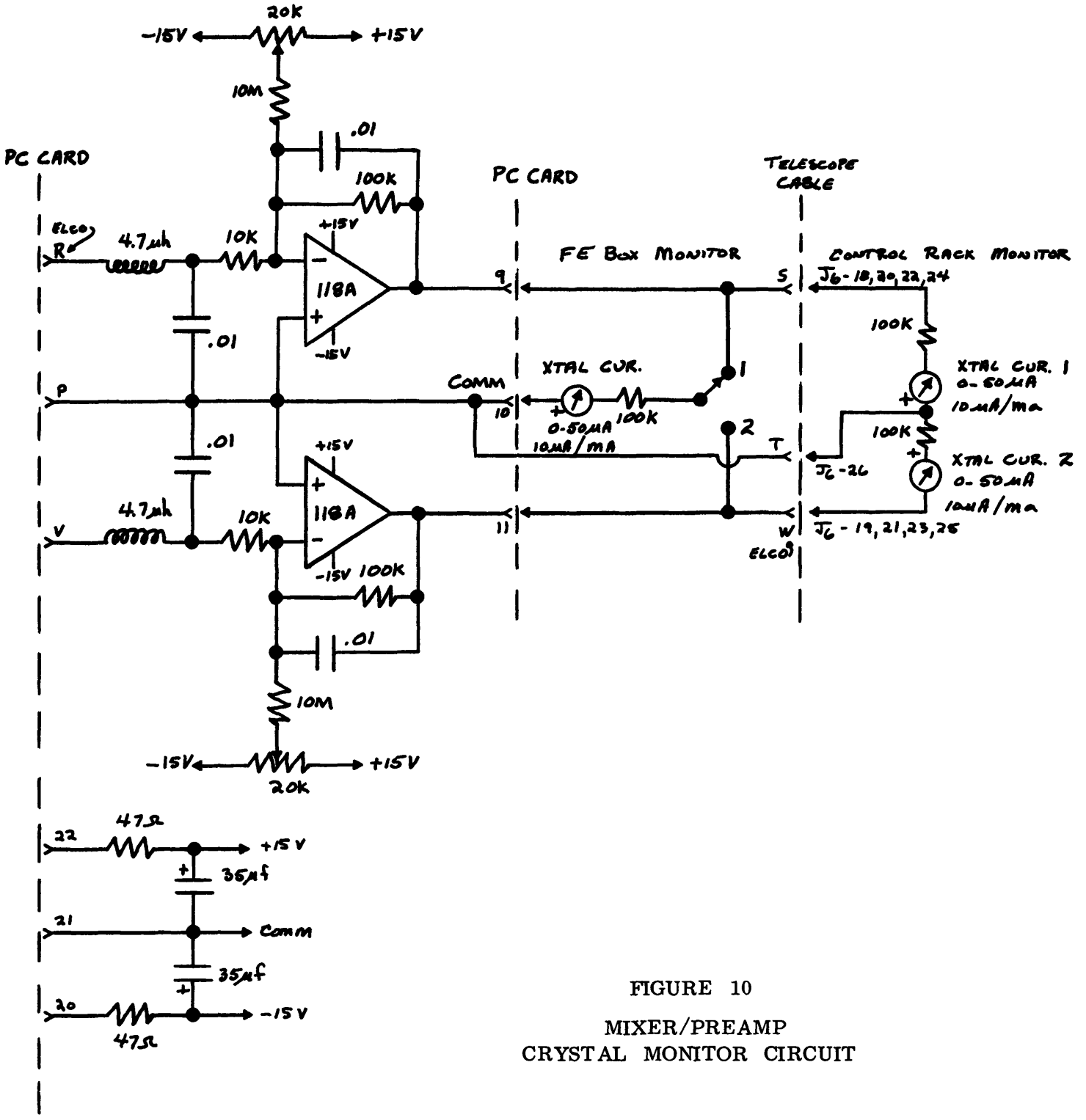

FIGURE 10

MIXER/PREAMP
CRYSTAL MONITOR CIRCUIT

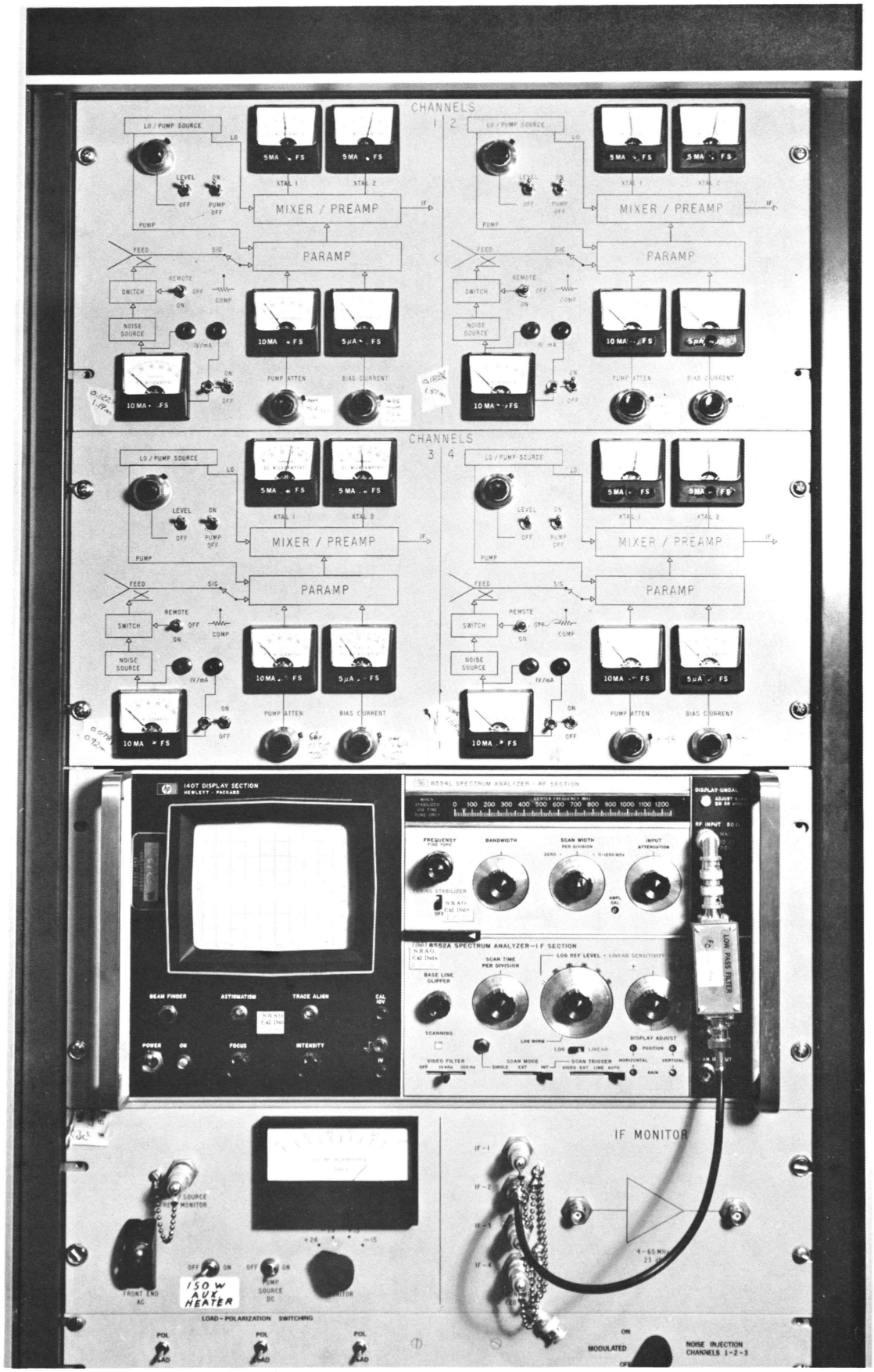

FIGURE 11

FRONT-END CONTROL RACK

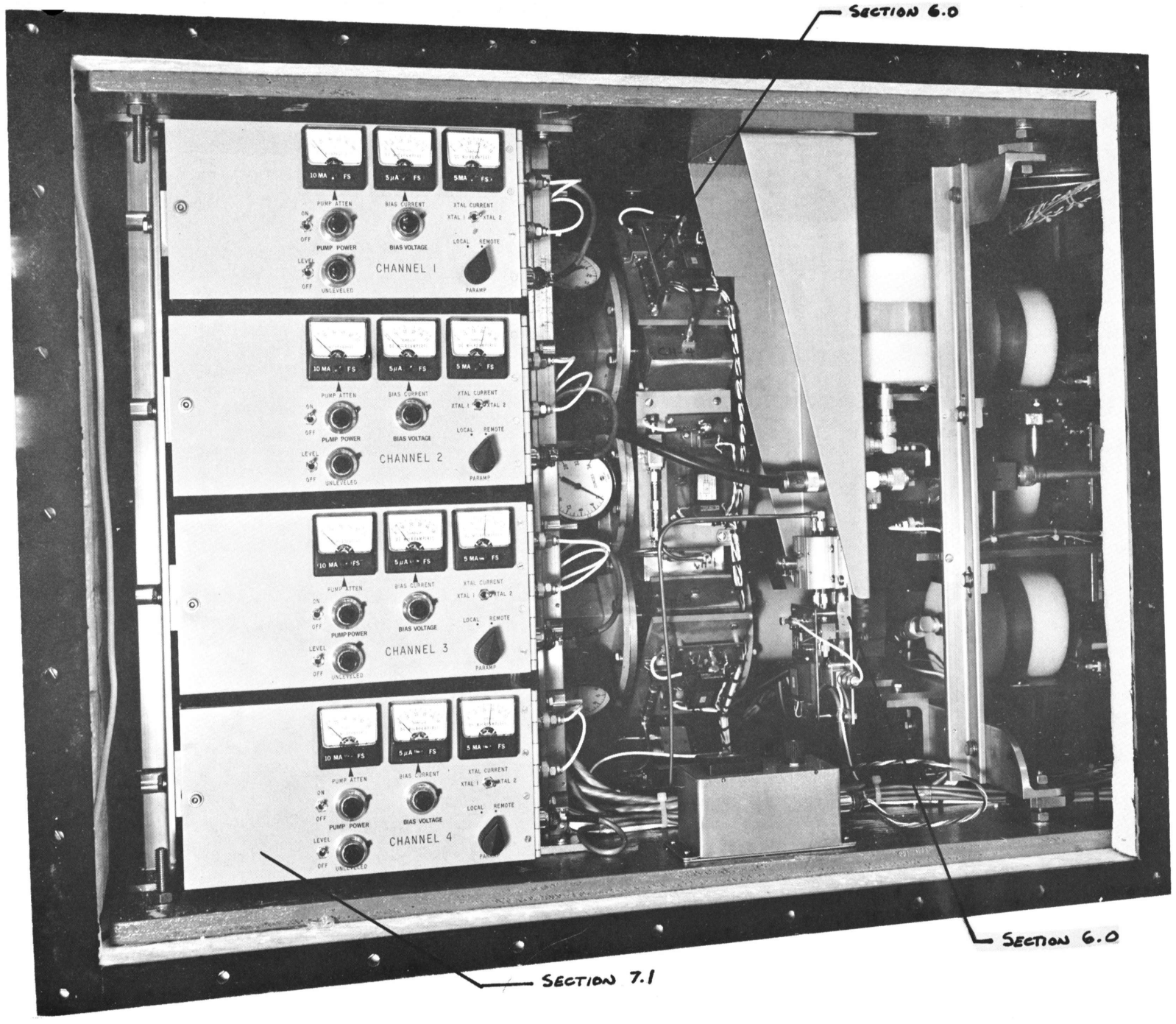

FIGURE 12

LOWER SOUTH SIDE OF BOX

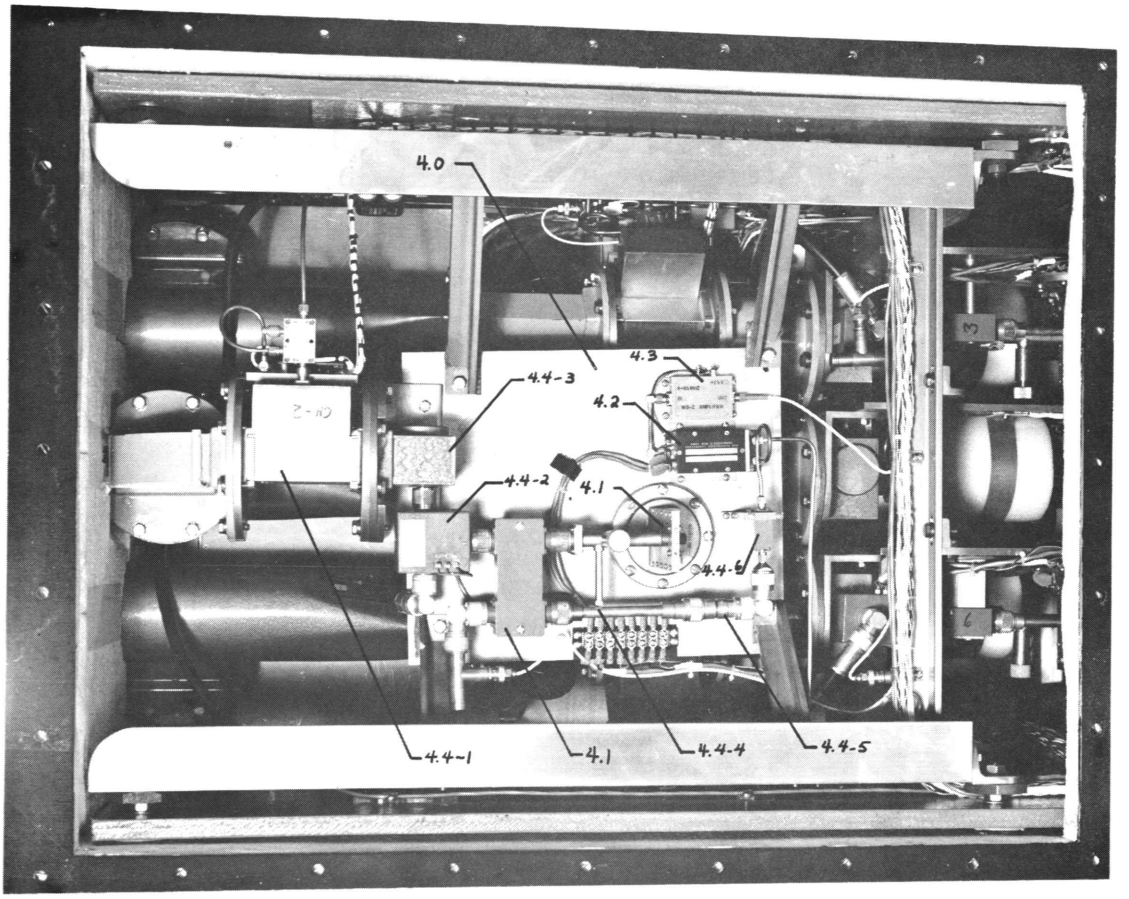

FIGURE 13

LOWER NORTH SIDE OF BOX

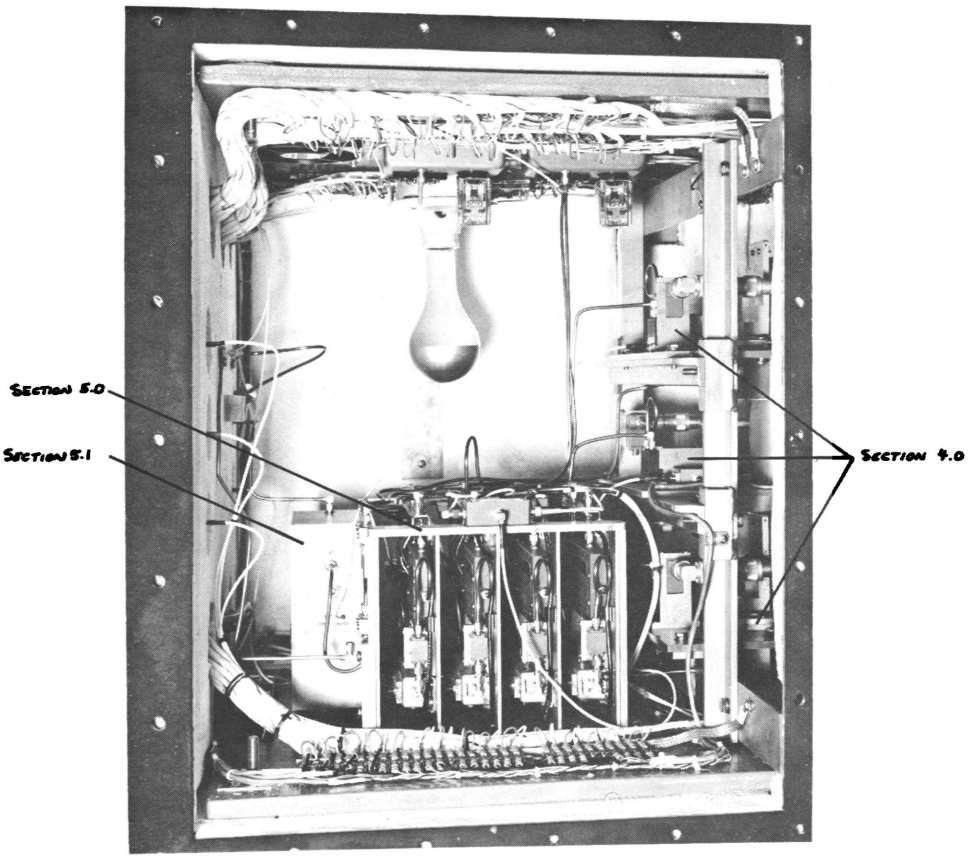

FIGURE 14

TOP NORTH SIDE OF BOX

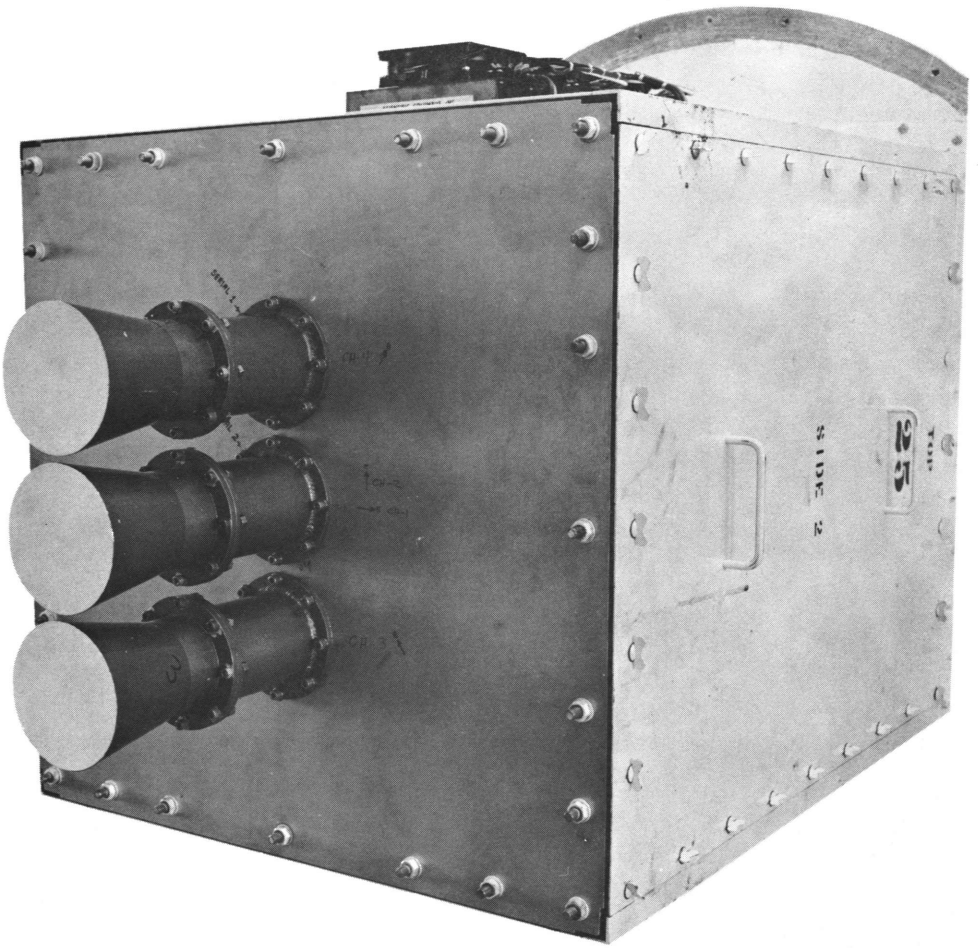

FIGURE 15

FEED END OF BOX

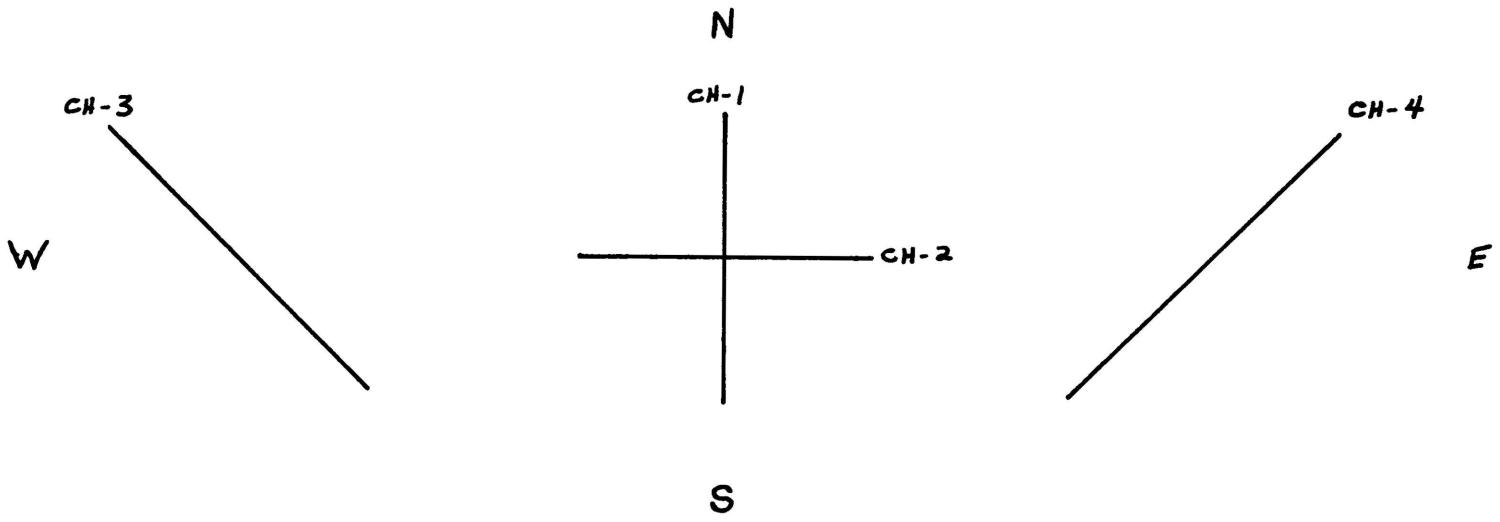

FIGURE 16

FEED E-VECTOR POSITION ANGLES ON SKY

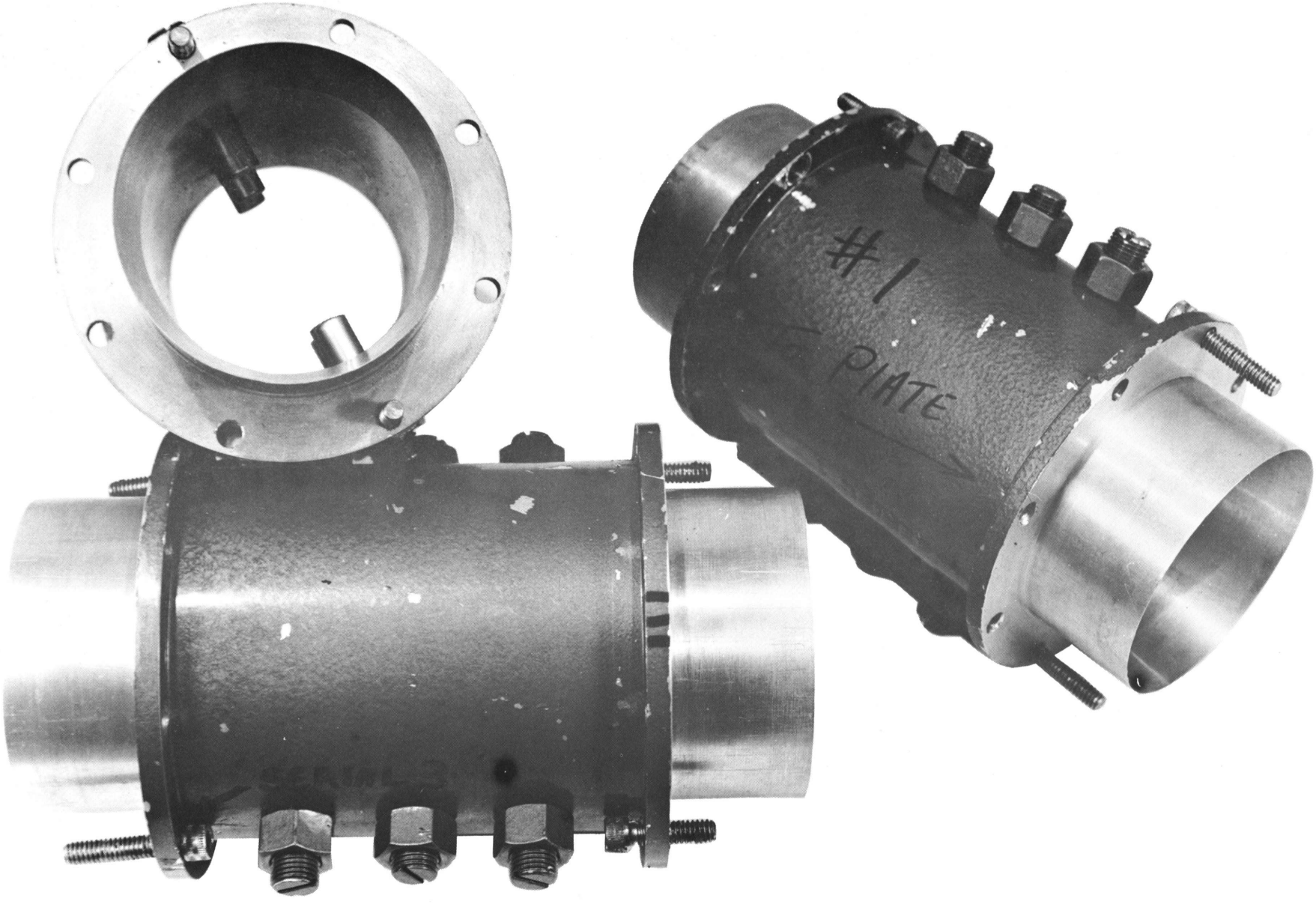

FIGURE 17

FEED CIRCULAR POLARIZER SECTIONS