NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION INTERNAL REPORT NO. 287

85-3 S AND X RECEIVER SYSTEM

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APRIL 1990

NUMBER OF COPIES: 150

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1.0 General

This receiver system was designed to be used with the 85-3 Antenna as a VLBI station for the Naval Observatory. It receives the 2210 to 2310 and 8200 to 8600 MHz frequency bands. All the oscillators used for frequency conversion are derived from a Hydrogen Maser Time Standard located at the 140 Foot Antenna. The Mark III VLBI station at the 140-foot is being used to process and record the receiver outputs. When a VLBA type converter is completed, it will be installed at the Interferometer Control Building to record the data.

The system consists of the receiver package at the prime focus of the 85-3 Antenna, a fiber optic system, and a control computer. The fiber optic system is used to transmit the IF signals to the 140 Foot Antenna control room, the local oscillator reference signals from there to 85-3, and to transmit the receiver control and monitor signals. The receiver control and monitor computer is located at the Interferometer Control Building.

2.0 S and X Receiver Package

The receiver is mounted in a standard NRAO Green Bank front end box 60" by 28" by 28" supported in the focus and polarization mount by a 45" diameter circular flange. The receiver box is kept at a temperature of 25 C + or - 3 C with thermoelectric heat pumps and a proportional controller. The block diagram, parts list and a photograph of the receiver are shown in Figures 1, 2 and 3. As shown on the block diagram both the right and left hand circularly polarized signals are received. The two polarizations at each frequency are designated X-R, X-L and S-R, S-L. The signal flow is from the feed through the low noise amplifier. After amplification in the low noise amplifier the signals are limited in frequency by the band pass filters. The RF amplifiers increase the signal level ahead of the mixer to minimize the mixer contribution to the overall noise temperature. The Intermediate Frequency signals from the mixer are amplified and detected to get the total power for monitoring receiver performance. The X-R and S-R IF signals along with the 500 MHz Local Oscillator reference signal are combined in the IF triplexer. The ALC amplifier provides a constant input level of 0 dBm to the optical transmitter which sends the signals through the fiber to the 140-foot antenna control room.

2.1 S and X Feed

A dual-frequency dual-polarized feed was designed for this receiver. It illuminates the reflector antenna with an f/d of .43 with minimum spillover. From feed patterns obtained on the test range the computed aperture efficiency was 58% at S-Band and the spillover and scattered noise was 6 Kelvin. At X-band feed patterns predicted 58% aperture efficiency and 3 Kelvin spillover. The antenna efficiency was measured as 52 % at S-band and 34% at

X-band on 85-3. An outline drawing of the feed is shown in Figure 4.[1]

2.2 Dewar Assembly

The receiver uses low noise HEMT amplifiers cooled to 15 Kelvin with a closed cycle helium refrigerator system. The S-band inputs to the dewar are through rectangular wave guide. The X-band input is a circular waveguide with the polarizer inside the dewar. Typical gain and noise temperatures for the S-band channels are 33 dB and 12 Kelvin. The X-band noise temperatures at the dewar flange are 14 Kelvin with a gain of 35 dB.[2]

2.3 Local Oscillator System

The local oscillator system generates the X-band and S-band signals at 7600 MHz and 2000 MHz. These signals are phase locked to reference derived from a step recovery diode comb generator driven by a 100 MHz crystal oscillator. Phase changes through the step diode are minimized by comparing the 500 MHz comb output with a 500 MHz reference signal from the Hydrogen Maser and controlling the phase of the 100 MHz crystal oscillator to keep the phase difference constant.

The local oscillators can be switched on and off from the control computer. This allows one to determine if offsets exist in the total power monitors used for system temperature measurements.

2.3.1 Phase Detector Module

A phase detector, loop amplifier and lock indicator module was developed for use in the three phase lock loops in the receiver front end and one in the interface at the 140 foot. The schematic and parts list are shown in Figure 5 and 6. Signal and reference input levels are 0 dBm. The mixers M1 and M2 perform as phase detectors. The signal input to the lock detector mixer M2 is shifted 90 degrees by the lumped constant quarter wave transmission line so it's output is maximum when the oscillator and reference are locked. If the lock indicator level drops below -.5 volt level set by pot K1, power is applied to the 555 timer to generate a square wave. This signal is injected into the loop amplifier to sweep the oscillator frequency to aid in attaining lock. The phase detector module is used for the S-Band LO, X-Band LO, and 100 MHz phase locked loops. The X-Band and S-Band LO phase lock loops have 200 MHz inputs to the phase detector and the 100 MHz phase lock loop has 500 MHz signal and reference inputs. The phase lock loop natural frequency and damping are set by R14, C15 and R13. As shown on the parts list these are different for each VCO to compensate for the different tuning sensitivities.[3]

2.4 Analog Optical Fiber Link

The analog optical fiber link transmits the S and X band Intermediate Frequencies to the VLBI equipment at the 140-foot antenna. The link consists of an optical transmitter, an optical receiver and the interconnecting fiber. The transmitter and receiver operate at optical wavelength of 1300 nanometer. The laser diode transmitter is amplitude modulated by the radio frequency signals. An rf band of 10 to 1000 MHz can be transmitted through this link. Single mode fibers are used to carry these broadband signals. To minimize the noise from the optical transmitters the reflections in the fiber must be low. Low reflection optical connectors were installed on the transmitters and receivers. Fusion splices were used to interconnect the buried fiber with the antenna and control building fibers. There are four single mode fibers from the 85-3 Front End Box down the antenna to the Interferometer Control Building. There, two fibers are spliced to buried cable that goes to 85-1 and then on to the 140-Foot Control Room. This run is 2.6 kilometers long and contains four splices with low reflection connectors on each end and has an optical loss of about 8 dB. The buried cable contains four single mode fibers for use with the analog links and four multimode fibers for digital links.

The rf transmission loss with the transmitter connected directly to the receiver is about 15 dB. The maximum input power level is +10 dBm, and with narrow band signals the S/N at the receiver is 70 dB. When broadband signals are transmitted through the link, the noise level increases due to intermodulation. With the 200 MHz wide S-Band IF and the 400 MHz X-Band IF signals transmitted on the same link, the S/N at the 140 control room is 26 dB or more.

2.5 Phase Calibration

The phase calibration system uses the Mark III VLBI Phase and Group delay calibrator to generate the 1 Mhz comb of frequencies. These signals are combined with the noise calibration signals as shown on Figure 1 and injected into the cal port on the dewar. The X-R channel has the phase cal but it has been removed from the X-L channel to increase the level in X-R. Both S-R and S-L channels have the phase cal signals. The input 5 MHz to the delay calibrator antenna unit is produced by dividing the 500 MHz local oscillator reference signal by 100.

2.6 Receiver Control and Monitor

The receiver has six power supply voltages as well as twenty other analog signals which are monitored and displayed at the Interferometer Control Building. There are also separate on/off controls for each of the local oscillators and the noise calibration signals. The control and monitor is implemented using a VLBA standard interface board mounted in an RFI tight enclosure in the receiver box. This board contains a microprocessor, an A-D Converter and multiplexer as well as digital I/O. Interrogation and control of the board functions is accomplished using a AT class AST personal computer located at the Interferometer Control Building. All functions are read once every two seconds. Interconnections between the two use a fiber optic driver and cable.[4]

The output from the computer is through the serial port which is operated at 56 kilobaud. The computer controls the antenna as well as the receiver. The computer program is quite complex as it determines which radio source is to be observed from an observing file and transforms the positions from the indicated epoch to 1950 positions. Then it precesses the positions to the current date, corrects for nutation, aberration, and antenna pointing errors and controls the drive motors to position the antenna on the source.

The computer program provides a real time display of the critical antenna and receiver functions as shown in Figure 7. The system temperatures for each of the four receiver channels are displayed. A good indication of the receiver stability is shown by the Rms Temps block. This is a 20 sample running average of the expanded total power rms. The Local oscillator levels and phase lock status are also displayed. The refrigerator second stage temperature and the receiver box temperature are shown along with the cryogenic compressor supply and return pressures. Antenna position and focus and polarization positions are presented.

For diagnosing receiver and cryogenic problems a number of zoom screens can be displayed. These screens show the last 15 minute records of selected functions at one minute intervals. In addition log files are written with all functions logged every 15 minutes as an aid to determining long term trends. The computer also provides manual control screens for testing the receiver and the antenna.[5]

2.7 System Noise Temperatures

The average system noise temperatures measured on the antenna were 37 Kelvin for the X-band and 36 degrees for the S-band channels. Using measurements in the test mount with the feed pointing up in the sky and the receiver measurements the various contributions to the system temperature were computed as shown in Table 1.

TABLE 1

85-3 System Noise Temperature Contributions

Channel	**X-R**	**X-L**	**S-R**	**S-L**
Receiver Temp at Dewar Flange	14	14	12	12
Feed and WG Losses	11	10	11	9
Feed spillover and scatter	7	7	9	9
Sky noise (est)	6	6	5	5

3.0 140-Foot 85-3 Interface

The function of this equipment is to receive the S-Band and X-Band Intermediate Frequencies transmitted from 85-3 over the optical fiber and convert the X-Band IF to the frequencies needed by the VLBI equipment.

A 500 MHz signal referenced to the Hydrogen Maser is generated and transmitted to the 85-3 front end as a local oscillator reference. It provides a round trip monitor through the fiber from the 140-Foot to 85 -3 of the 500 MHz phase shift. A block diagram and parts list are shown on Figure 8: 140-FOOT - 85-3 INTERFACE BLOCK DIAGRAM.

The X-Band IF is converted down to the range required by the MK III VLBI equipment by mixing with 500 MHz derived from the Hydrogen Maser. A listing of the S-Band and X-Band IF Converter Frequencies are tabulated below. The first oscillator is at 2000 MHz for the S-Band channels and 7600 MHz for the X-Band channels.

TABLE 2

VLBI IF Converter Local Oscillator Frequencies

S-Band Channels		**X-Band Channels**	
1	217.99 MHz	1	110.99 MHz
2	222.99 "	2	120.99 "
3	237.99 "	3	150.99 "
4	267.99 "	4	210.99 "
5	292.99 "	5	320.99 "
6	302.99 "	6	400.99 "
		7	450.99 "
		8	470.99 "

The diode switch is used to assure the 500 MHz reference is properly locked to the hydrogen maser before the signal is sent to the receiver. When the 100 MHz VCXO is locked to the maser the switch closes and transmits the 500 MHz reference to the 85-3. Operating this way, the 100 MHz lock/unlock message on the 85-3 Control and Monitor Computer screen indicates lock only when both of the 100 MHz oscillators in the front end box and in the 140 Foot Interface are locked. A Hewlett Packard Vector Voltmeter is used to measure the phase shift experienced by the 500 MHz signal transmitted through the optical fiber to 85-3 and back. Delay changes of 200 picoseconds in twelve hours through the 2.6 kilometer run of buried and exposed fiber are typical and are caused by outside temperature changes.

4.0 Acknowledgement

J. Oliver and W. Shank did layout, assembly, and wiring of most of the component boxes used in the receiver system. They also were involved with the installation, breakout and splicing of the optical fiber cable. R. Weimer designed the receiver control and monitor interface which was assembled by W. Vrable.

J. Cercone designed and wrote the computer program used for receiver and antenna control. R. Weimer and F. Ghigo have added additional features to the program.

G. Behrens designed the S and X Band Feed which was fabricated by the Green Bank Machine Shop. R. Norrod designed the dewar assembly which was assembled and tested by R. Simmons.

D. Williams and T. Henderson assembled the cryogenic compressors and associated lines and controls.

S. White designed the 500 to 5 MHz converter used to drive the antenna phase cal unit.

REFERENCES

1. S and X Band Feed Measurements, G. H. Behrens.

2. EDIR No. 283, "A S/X, Four Channel, Cryogenic Dewar Package," R. D. Norrod (April 1989).

3. VLA Electronics Memo No. 180, "Phase Lock Loop Parameters of F2 and F3 Modules," A.R. Thompson (March 1989).

4. Electronics Division Technical Note 152, "Optical Fiber at Green Bank,", R. B. Weimer (April 20, 1989).

5. "Controlling the 85-Foot Radio Telescope at Green Bank," J. A. Cercone, P.E., Assistant Professor, Department of Electrical Engineering, West Virginia Institute of Technology, Montgomery, West Virginia (1989).

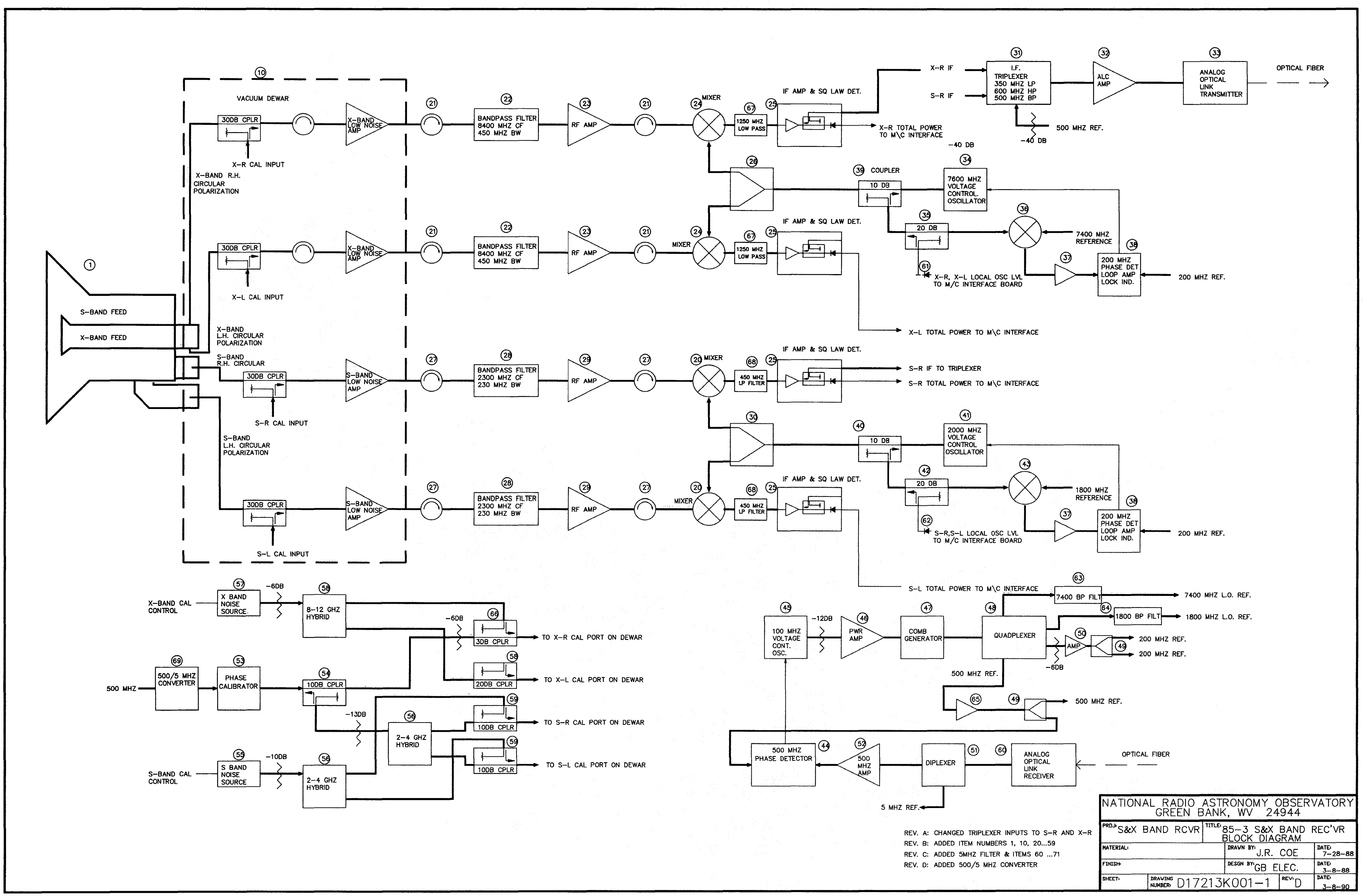

FIGURE 1

85-3 S and X Receiver Block Diagram

ITEM	QTY.	NAME	MANUFACTURER/PART NO.	SPECIFICATIONS
1	1	S/X FEED ASSEMBLY	NRAO GREEN BANK	DUAL FREQUENCY 2215 TO 2305 AND 8200 TO 8400 MHZ FEED
10	1	S/X DEWAR PACKAGE	NRAO GREEN BANK	ELECTRONICS DIVISION INTERNAL REPORT NO. 283
20	2	S-BAND MIXER	RHG DM2-4A	LO AND RF 2 TO 4 GHZ, 7 DB CONVERSION LOSS
21	4	ISOLATOR	APPLIED ENG CON. 9-8012-11	
22	2	BANDPASS FILTER	REACTEL 3C2-8400-450S11	1DB BANDWIDTH 8180 TO 8620 MHZ, 0.4DB INSERTION LOSS AT 8400 MHZ
23	2	R.F. AMPLIFIER	MITEQ AMF-2A-8286-45	18 DB GAIN 8.2 TO 8.6 GHZ, NF 2.9 DB, +15DBM 1 DB PT, 15VDC 72 MA.
24	2	X-BAND MIXER	TRIANGLE MICRO. FP50 MC2	9DB CONVERSION LOSS, 30 DB ISOL L-R RF AND LO 5 TO 15 GHZ
25	1	IF AMP & SQ LAW DET.	NRAO GREEN BANK	IF GAIN 24 DB, DET. OUT 1V AT -27 DBM, 4 CKTS IN PKG
26	1	POWER DIVIDER	ANAREN 40267	4 TO 8 GHZ IN PHASE POWER DIVIDER
27	4	ISOLATOR	APPLIED ENG CON. 9-2040-11	2 TO 4 GHZ
28	2	BANDPASS FILTER	REACTEL 5B2-2300-230S11	1DB BANDWIDTH 2164 TO 2435 MHZ, INSERTION LOSS 0.6 DB AT 2300 MHZ
29	2	RF AMPLIFIER	MITEQ AMF-2B-2224-35	19 DB GAIN FROM 2.2 TO 2.4 GHZ, 3DB NOISE FIGURE
30	1	POWER DIVIDER	ANAREN 40266	2 TO 4 GHZ IN PHASE POWER DIVIDER
31	1	IF TRIPLEXER	NRAO GB B17213Q003	350 MHZ LOW PASS FILTER, 600 MHZ HIGH PASS, 500 MHZ BANDPASS
32	1	ALC AMPLIFIER	AVANTEK ALC 1000M	5 TO 1000 MHZ MAX GAIN 52 DB, OUTPUT 0DBM,S/H CIRCUIT ADDED +5V LEVELING
33	1	ANALOG OPT. LINK TX	GEN OPTONICS AST1300	0DBM INPUT NOMINAL, 1 TO 1.5 GHZ BANDPASS
34	2	VOLT CONT. OSC.	COMM. TECH. C7306	+15 DBM 7400 TO 7600 MHZ, 20VDC SUPPLY 300 MA.
35	2	COUPLER, 20 DB	TRIANGLE MICRO. CO-432	4 TO 8 GHZ, 20 +- .5DB COUPLING
36	2	MIXER	AERTECH MX7500	
37	2	IF AMP	APLIED ENG CONS. 8285	36 DB GAIN 5 TO 200 MHZ
38	2	PHASE DETECT.200MHZ	NRAO GB B17213A002	0DBM SIGNAL AND REFERENCE INPUTS
39	1	COUPLER	TRIANGLE MICRO.CO-431	4-8 GHZ 10+-0.5DB COUPLING
40	1	COUPLER, 10 DB	NARDA MOD.40138-10	
41	1	VOLT.CONT.OSC.	MITEQ OTC1C01902120PAFC	+28DBM OUTPUT 1.9 TO 2.1 GHZ, 20VDC SUPPLY 130 MA.
42	1	COUPLER, 20DB	ANAREN 10616-20	
43	1	MIXER	MINI-CIRCUITS ZLW-11	LO AND RF 5 TO 2000 MHZ, IF 10 TO 600 MHZ, 9 DB MAX CONV. LOSS
44	1	PHASE DET.500 MHZ	NRAO GB B17213A002	SIGNAL AND REFERENCE INPUTS 500 MHZ AT 0DBM
45	1	VOLT. CONT. OSC.	VECTRON CO233-9516	OUTPUT +7DBM MIN, +15 VDC SUPPLY
46	1	POWER AMPLIFER	MINI-CIRCUITS ZHL-3A	24 DB GAIN .4 TO 150 MHZ, 1 DB PT + 29.5 DBM, 24VDC .6A
47	1	COMB GENERATOR	HEWLETT PACKARD 33002A	
48	1	QUADPLEXER-1	NRAO GB D17213P005	7400, 1800, 500, AND 200 MHZ OUTPUTS
49	1	POWER DIVIDER	MINICIRCUITS ZFSC 2-1	TWO-WAY IN PHASE 5 TO 500 MHZ
50	1	AMPLIFIER	NRAO GB	19 DB GAIN
51	1	DIPLEXER-1	NRAO GB B17213A003	15 MHZ LOW PASS, 300 MHZ HIGH PASS, GAIN 23 DB AT 5 AND 500 MHZ
52	1	AMPLIFIER	NRAO GREEN BANK	GAIN 30 DB AT 500 MHZ
53	1	PHASE CALIBRATOR	NRAO/HAYSTACK	
54	1	COUPLER	OMNI-SPECTRA 20055-10	
55	1	S-BAND NOISE SOURCE	INTER. MIC/WV. NOR2628-30	
56	1	2-4GHZ HYBRID	OMNI-SPECTA 20154-3	
57	1	X-BAND NOISE SOURCE	INTER. MIC/WV. NOR8082-30	
58	1	8-12GHZ HYBRID	ANAREN 10018-3	
59	2	10DB COUPLER	NARDA 4013B-10	
60	1	ANALOG OPT LINK RX	GENERAL OPTRONICS ASR1300	
61	2	DETECTOR		
62	2	DETECTOR		
63	1	7400MHZ BP FILTER	REACTEL 4C7-7400-100S11	3DB BW 7350 TO 7450, STOP BAND ATTEN > 30DB AT 7200 AND 7600
64	1	1800MHZ BP FILTER	REACTEL 4B2-1800-50S11	3DB BW 1775 TO 1825, STOP BAND ATTEN. > 30 DB AT 1700 AND 1900 MHZ
65	1	AMPLIFIER	AVANTEK UTO 1003	
66	1	3DB COUPLER	OMNI-SPECTRA 20156-3	
67	2	1250 MHZ LP FILTER	K&L 4L120-1250/T7400-0/0	3DB PT AT 1250 MHZ, > 60DB DOWN AT 7400 MHZ
68	2	450 MHZ LP FILTER	REACTEL 4L2-450-S11	3DB DOWN AT 450 MHZ
69	1	500/5 MHZ CONVERTER	NRAO GREEN BANK	

NOTE: TO ADD TO PARTS LIST INSERT BLOCK PL. ATTRIBUTE TAGS ARE SPECS, MANUF, NAME, Q, NO. WHICH WERE DEFINED IN THAT ORDER.

NATIONAL RADIO ASTRONOMY OBSERVATORY GREEN BANK, WV 24944			
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MATERIAL:	DRAWN BY: J.R. COE	DATE:	
FINISH:	DESIGN BY:	DATE:	
SHEET:	DRAWING NUMBER: B172213K001-2	REV:	DATE:

FIGURE 2

85-3 S and X Receiver Parts List

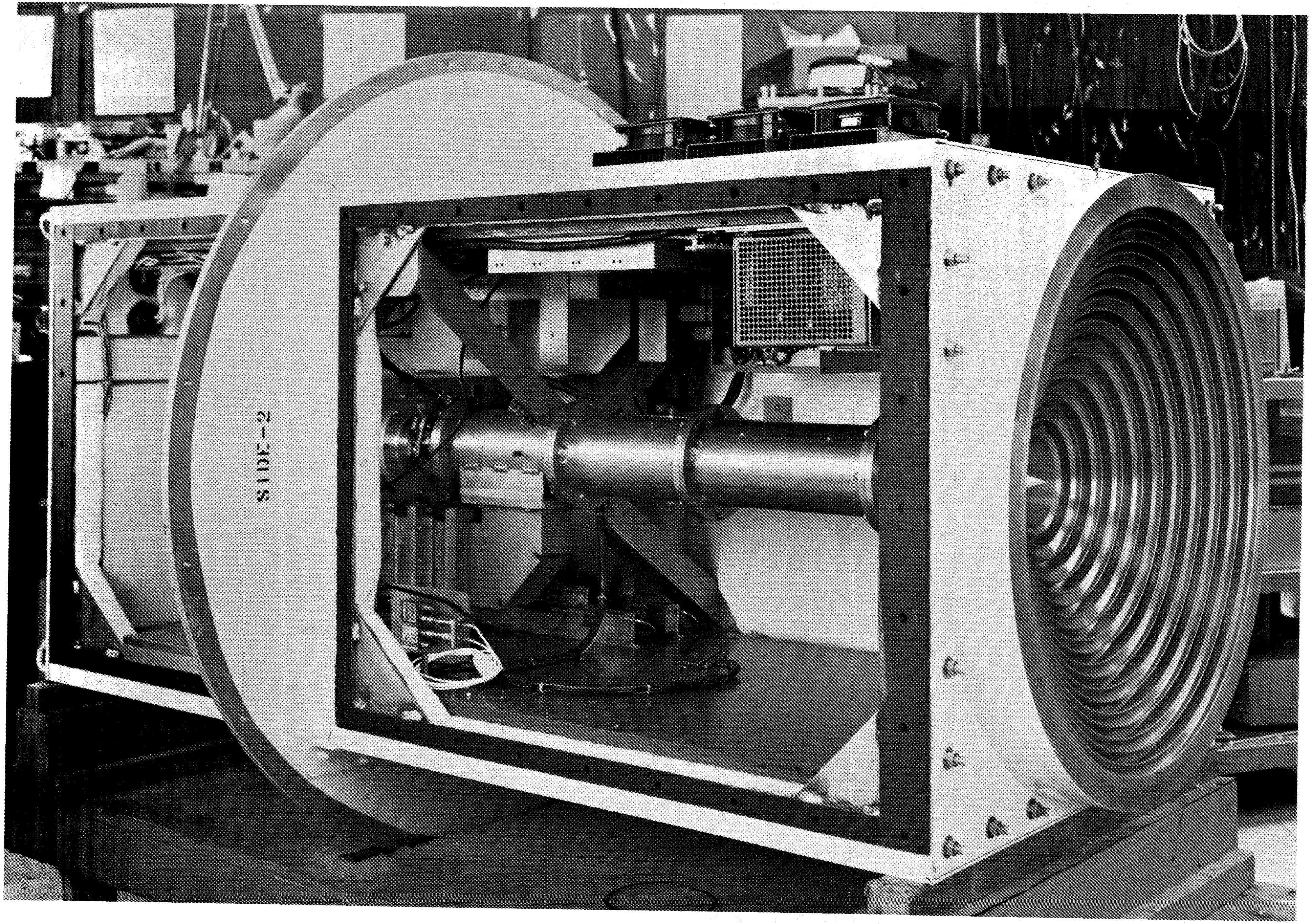


FIGURE 3

S and X Receiver Front-End Box

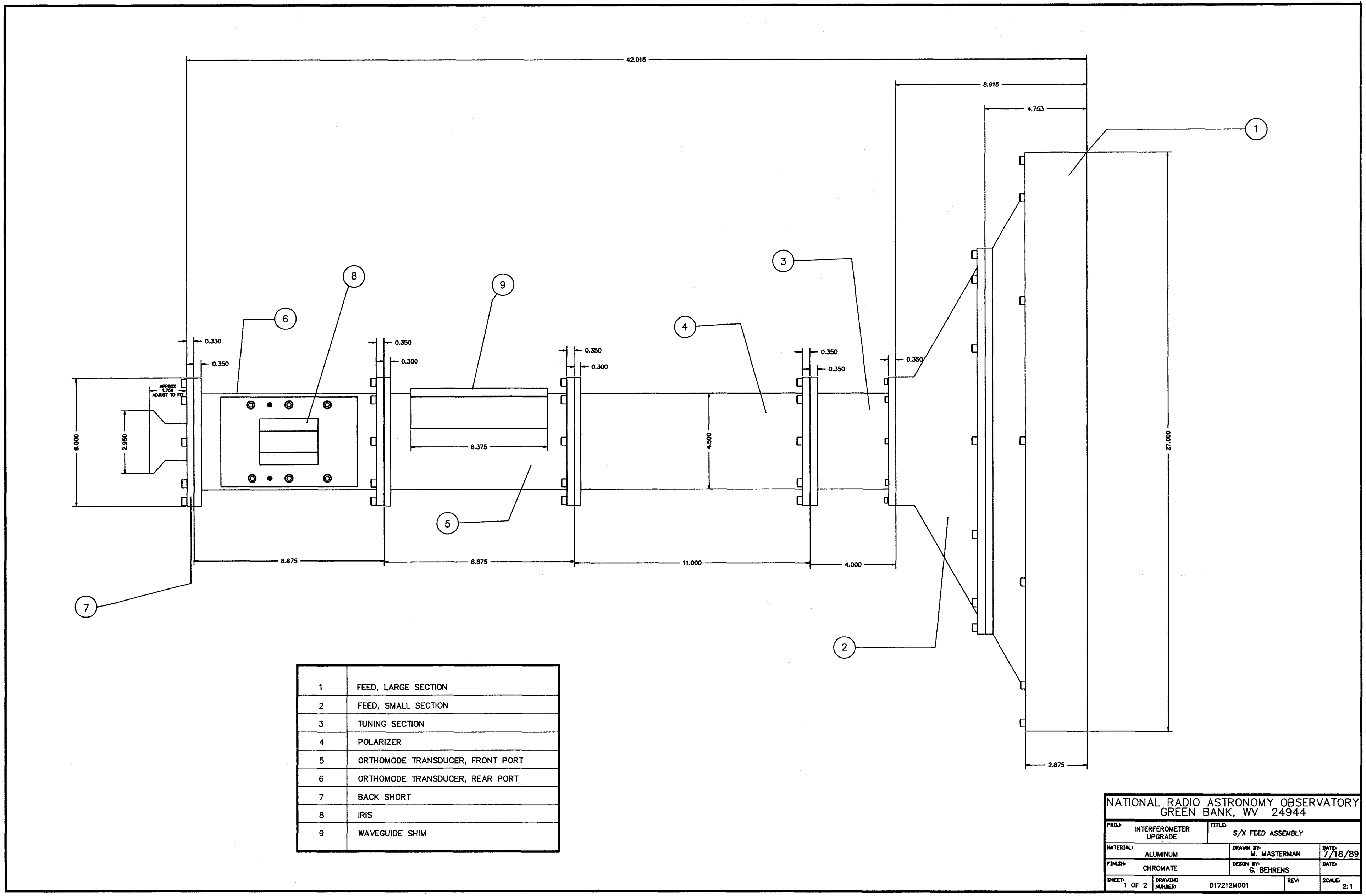


FIGURE 4

S and X Feed Assembly

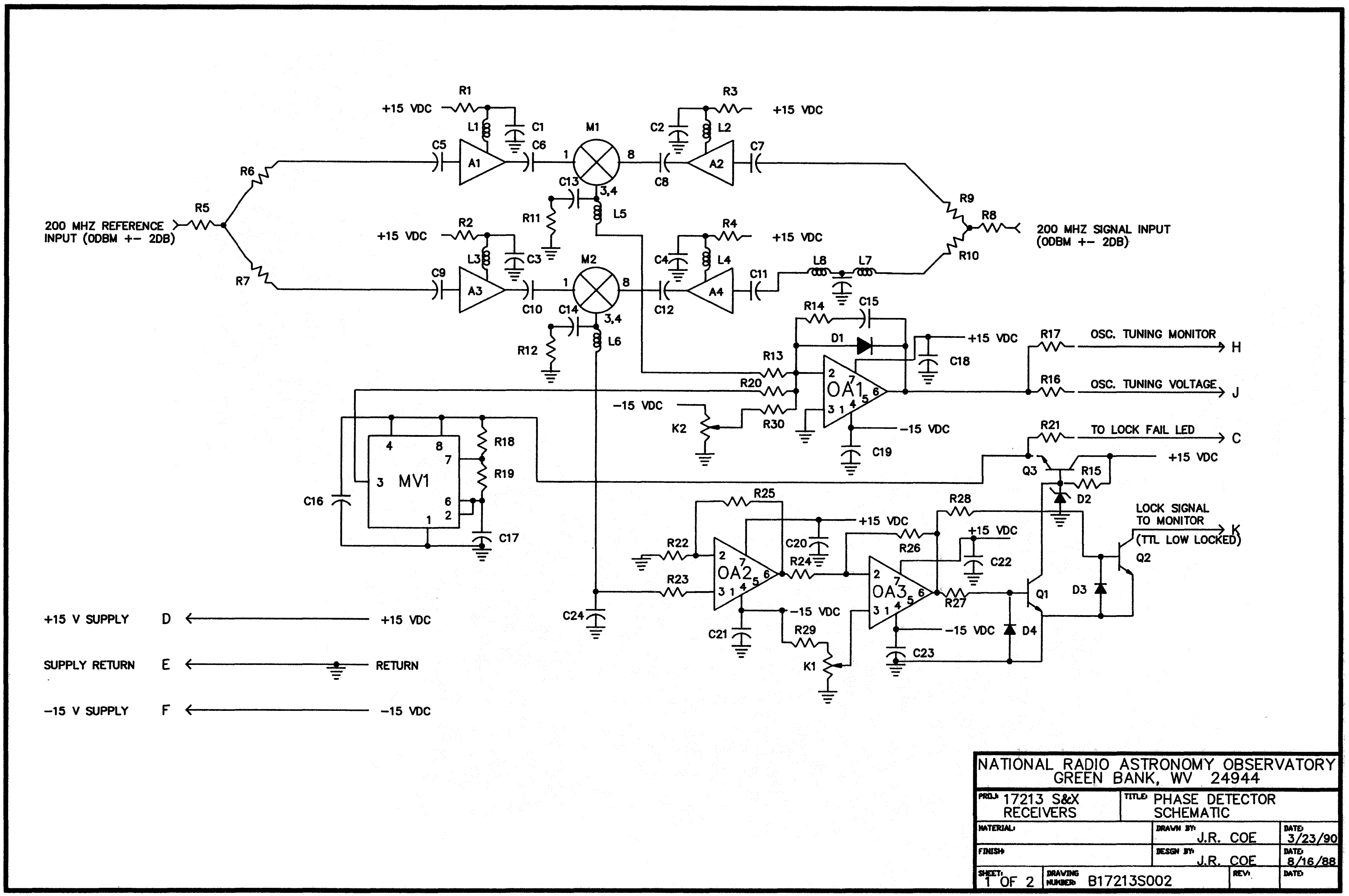


FIGURE 5

Phase Detector Loop Amplifier and Lock Indicator Schematic

PARTS LIST

ITEM	QTY		DESCRIPTION	MANUFACTURER PART NUMBER
1	4	A1,A2,A3,A4	AMPLIFIER ,RF	AVANTEK MSA-0304
2	3	OA1,OA2,OA3	OP- AMP	ANALOG DEVICES AD OP-07
3	1	MV1	TIMER	SIGNETICS 555
4	2	M1, M2	MIXER PHASE DETECTOR	MINI-CIRCUITS MPD-2
5	4	R1,R2,R3,R4	RESISTOR 5% 1/2W 300 OHM	
6	6	R5,R6,R7,R8,R9,R10	RESISTOR, CHIP 5% 20 OHM	DALE CRCW1206
7	2	R11,R12	RESISTOR, CHIP 5% 51 OHM	DALE CRCW1206
8	1	R13	RESISTOR, 1% 1/4W (.1GHZ LOOP AMP USE 1K OHM) (2GHZ - 2.75K OHM) (7.6 GHZ - 5K OHM)	
9	1	R14	RESISTOR, 1% 1/4W (.1 GHZ LOOP AMP USE 9.76 K OHM) (2 GHZ - 100 OHM) (7.6 GHZ - 475 OHM)	
10	1	R15	RESISTOR, 1K, 5% 1/2 W	
11	1	R16	RESISTOR, 1% 1/4W 511 OHM	
12	1	R17	RESISTOR, 1% 1/4W 10K OHM	
13	1	R18	RESISTOR, 1%, 1/4W 10K OHM	
14	1	R19	RESISTOR, 1% 1/4W 511K OHM	
15	1	R20	RESISTOR, 1% 1/4W (.1GHZ LOOPAMP USE 49.9K OHM) (2GHZ - 665K OHM) (7.6 GHZ - 665K OHM)	
16	1	R21	RESISTOR, 1% 1/4W 470 OHM	
17	4	R22,R23,R24,R25	RESISTOR, 1% 1/4W 10 K OHM	
18	1	R26	RESISTOR 1% 1/4W 100K OHM	
19	1	R27	RESISTOR, 1% 1/4W 10K OHM	
20	1	R28	RESISTOR, 1% 1/4W 20K OHM	
21	1	R29	RESISTOR, 1% 1/4W 10K OHM	
22	1	R30	RESISTOR, 1% 1/4W 2.5M OHM	
23	13	C1, C12, C14	CAPACITOR, CHIP .1 UF	
24		C13	CAPACITOR, CHIP 1000PF	
25	1	C15	CAPACITOR, 0.047 UF	
26	1	C16	CAPACITOR, .47 UF	
27	1	C17	CAPACITOR, 1UF	
28	5	C18,C19,C21,C22,C23,C24	CAPACITOR, CHIP .1 UF	
29	1	C25	CAPACITOR, CHIP ,(15PF FOR 200 MHZ PD)(6.2 PF FOR 500 MHZ PD)	
30	1	C20	CAPACITOR, .1 UF	
31	1	K1	POTENTIOMETER, 1K 1 TURN	BOURNE CERMET TRIMMER TYPE 3329H
32	1	K2	POTENTIOMETER 20K 1TURN	
33	4	L1,L2,L3,L4	INDUCTOR, 4.7uH	
34	2	L5,L6	INDUCTOR, 1.5 uH	
35	2	L7,L8	INDUCTOR, (40 nH for 200 MHz PD) (16 nH for 500 MHz PD) (NOTE 1)	
36	2	Q1,Q2	TRANSISTOR, 2N3904	
37	1	Q3	TRANSISTOR, 2N2219	
38	3	D1,D3,D4	DIODE, 1N456	
39	1	D2	DIODE, ZENER 5V	

NOTE 1: 40 nH Ind. 4T on .1 dia.
16 nH Ind 3T on .064 dia. form

NATIONAL RADIO ASTRONOMY OBSERVATORY GREEN BANK, WV 24944			
PROJ: 17213 S&X RECEIVERS	TITLE: PHASE DETECTOR SCHEMATIC		
MATERIAL:	DRAWN BY: J.R. COE		DATE: 5/5/88
FINISH:	DESIGN BY: J.R. COE		DATE: 5/5/88
SHEET: 2 OF 2	DRAWING NUMBER: B17213S002	REV:	DATE: 3/23/90

FIGURE 6

Phase Detector Assembly Parts

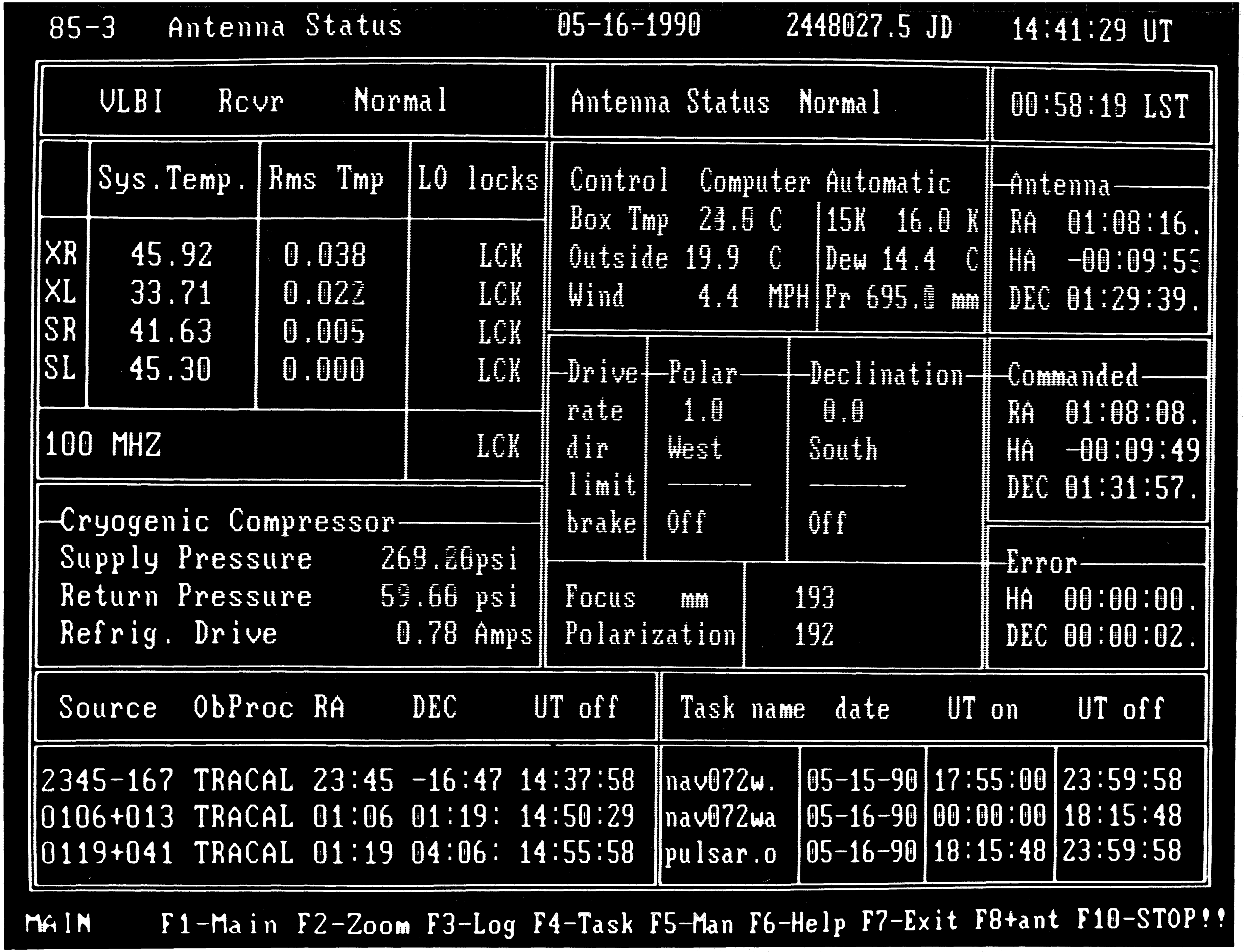
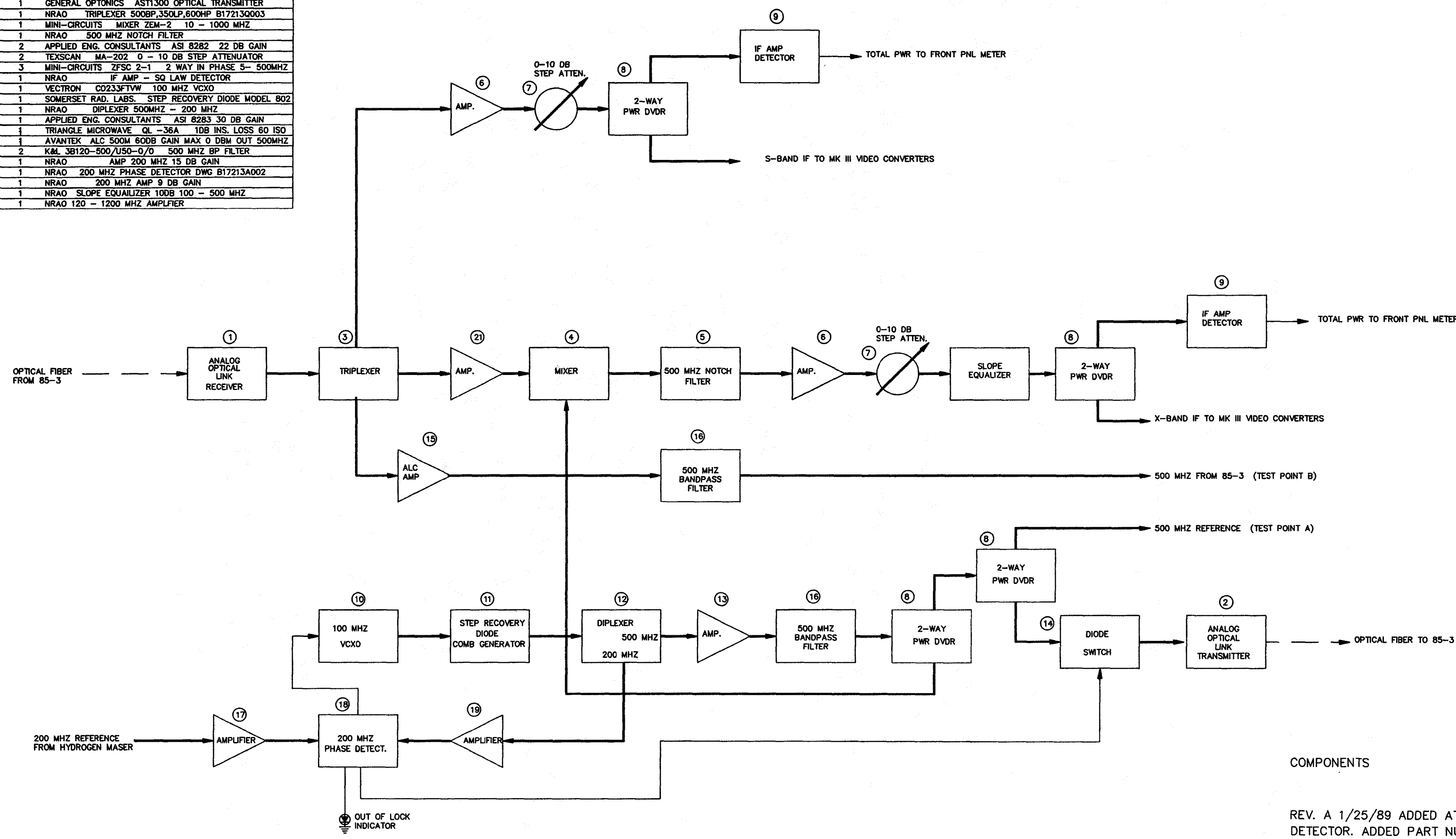


FIGURE 7

85-3 Antenna Status

ITEM	QTY.	MANUFACTURER	DESCRIPTION
1	1	GENERAL OPTONICS	ASR1300 OPTICAL RECEIVER
2	1	GENERAL OPTONICS	AST1300 OPTICAL TRANSMITTER
3	1	NRAO	TRIPLEXER 500BP,350LP,600HP B17213Q003
4	1	MINI-CIRCUITS	MIXER ZEM-2 10 - 1000 MHZ
5	1	NRAO	500 MHZ NOTCH FILTER
6	2	APPLIED ENG. CONSULTANTS	ASI 8282 22 DB GAIN
7	2	TEXSCAN	MA-202 0 - 10 DB STEP ATTENUATOR
8	3	MINI-CIRCUITS	ZFSC 2-1 2 WAY IN PHASE 5- 500MHZ
9	1	NRAO	IF AMP - SQ LAW DETECTOR
10	1	VECTRON	CO233FTVW 100 MHZ VCXO
11	1	SOMERSET RAD. LABS.	STEP RECOVERY DIODE MODEL 802
12	1	NRAO	DIPLEXER 500MHZ - 200 MHZ
13	1	APPLIED ENG. CONSULTANTS	ASI 8283 30 DB GAIN
14	1	TRIANGLE MICROWAVE	QL -36A 1DB INS. LOSS 60 ISO
15	1	AVANTEK	ALC 500M 60DB GAIN MAX 0 DBM OUT 500MHZ
16	2	K&L	3B120-500/U50-0/0 500 MHZ BP FILTER
17	1	NRAO	AMP 200 MHZ 15 DB GAIN
18	1	NRAO	200 MHZ PHASE DETECTOR DWG B17213A002
19	1	NRAO	200 MHZ AMP 9 DB GAIN
20	1	NRAO	SLOPE EQUAILIZER 10DB 100 - 500 MHZ
21	1	NRAO	120 - 1200 MHZ AMPLFIER



COMPONENTS

REV. A 1/25/89 ADDED ATTEN. AND IF AMP-DETECTOR. ADDED PART NUMBERS.

REV. B 3/27/89 ADDED CABLE DELAY CAL.

REV. C 3/27/90 REMOVED CABLE DELAY CAL.

NATIONAL RADIO ASTRONOMY OBSERVATORY GREEN BANK, WV 24944			
PROJ: S & X BAND RECEIVER	TITLE: 140 FOOT - 85-3 INTERFACE BLOCK DIAGRAM		
MATERIAL:	DRAWN BY: J.R. COE	DATE: 10-14-88	
FINISH:	DESIGN BY: J.R. COE	DATE: 10-14-88	
SHEET:	DRAWING NUMBER: D17213K002	REV: C	SCALE:

FIGURE 8

140-Foot/85-3 Interface Diagram