NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Electronics Division Internal Report No. 96

A DOUBLE-SWITCHED WATER VAPOR RADIOMETER

James L. Dolan

OCTOBER 1970

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Introduction

This report should be associated with Electronics Division Internal Report No. 89, "General Description and Operating Instructions for the Water Vapor Receiver". The radiometer described in report No. 89 has been considerably modified, the most significant modification being the addition of a second synchronous detector (described later). The original water vapor unit was placed in operation approximately one year ago (fall of 1969). The data collected thus far has been analyzed by B. A. Manchester and J. W. Waters. (See the progress reports that have been issued.)

Local Oscillator Frequencies

The Gunn effect devices currently in use as local oscillators have given some trouble, particularly in switching (or pulsed) mode. It is difficult to find two frequencies at which both oscillators in both units turn on and off reliably. The oscillators are now operating as follows:

High position $\approx$ 22.8 GHz

Low position $\approx$ 20.4 GHz

The respective oscillators in each unit are set as nearly as possible to the same frequency to avoid cross-coupling by placing the local oscillator within the 40 MHz dead-band centered on the local oscillator frequency.

Thermal calibrations were run on September 4, 1970 for each unit and each frequency. Results were as follows:

Unit 1	Low frequency....cal	= 67.5°
	High frequency....cal	= 72°
Unit 2	Low frequency....cal	= 70.5°
	High frequency....cal	= 66.5°

Modifications

After considerable data reduction and attempts to correlate the interferometer phase changes with the measured water vapor, it became obvious that a method to separate water vapor line emission from condensed water continuum radiation was needed. A method of doing this was devised by Dr. S. Weinreb. Simply, it consists of a radiometer that is simultaneously load and frequency switched. The front-end (Dicke) switch is driven at F_1 (presently about 50 Hz) and switches from the antenna to a comparison termination (load switched). Synchronous detector number 1 is also driven at the same switch rate, F_1. Theoretically, synchronous detector number 1 will not respond to continuum radiation. The local oscillator is switched from F Low to F High at switch rate F_2 (presently $\simeq$ 2 Hz). The switched output from synchronous detector number 1 is routed to synchronous detector number 2, where it is synchronously detected at 2 Hz. We have defined 22.8 GHz (High LO) as signal, and 20.4 (Low LO) as comparison. The output of synchronous detector number 2 can be:

1) signal - comparison
2) signal + comparison
3) signal
4) comparison.

We are presently monitoring signal - comparison, and comparison, although this may change in the future. Aside from some minor instrumental problems, the systems are performing as planned.

Operating Procedure Changes

Reference frequency ..... Normally set to 50 Hz. Controls only Dicke switch and synchronous detector number 1. The local oscillators and synchronous detector number 2 are driven $\approx$ 2 Hz. No external adjustment is possible.

Operating Procedure Changes (continued):

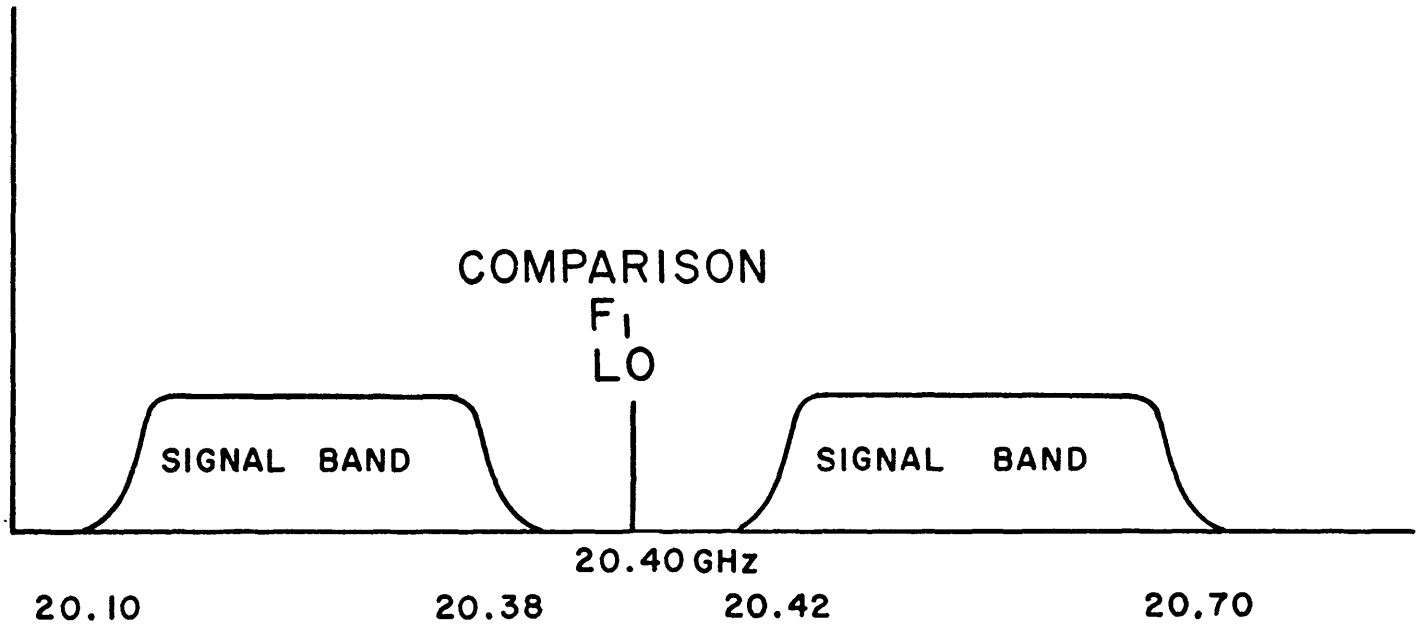
Dicke switch ..... Previously set to "Sig" — now should be set to "Mod".

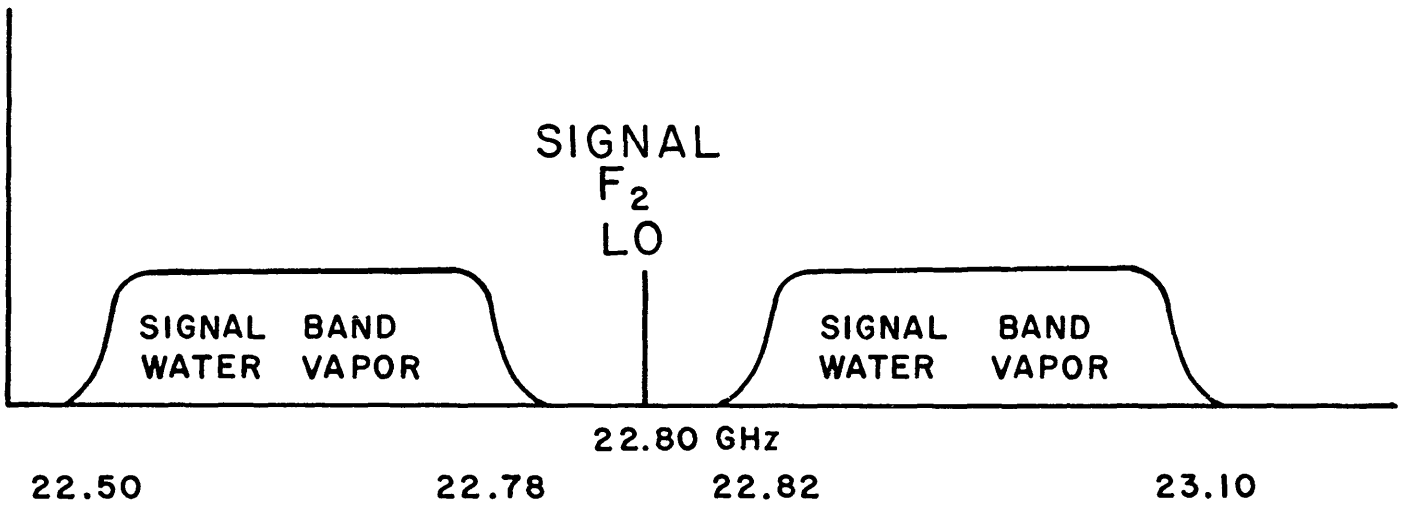
Circuit Additions

In addition to the second synchronous detector, a total power DC back-off-times-ten amplifier was added between the total power monitor front panel and rear panel. This allows total power at the rear panel only to be backed off to ϕ and ΔV to be amplified ten times. (See drawing number S2.502-12.)

CABLE NUMBER 18-19-20-21 TYPE 15 Twisted Pair No. 18

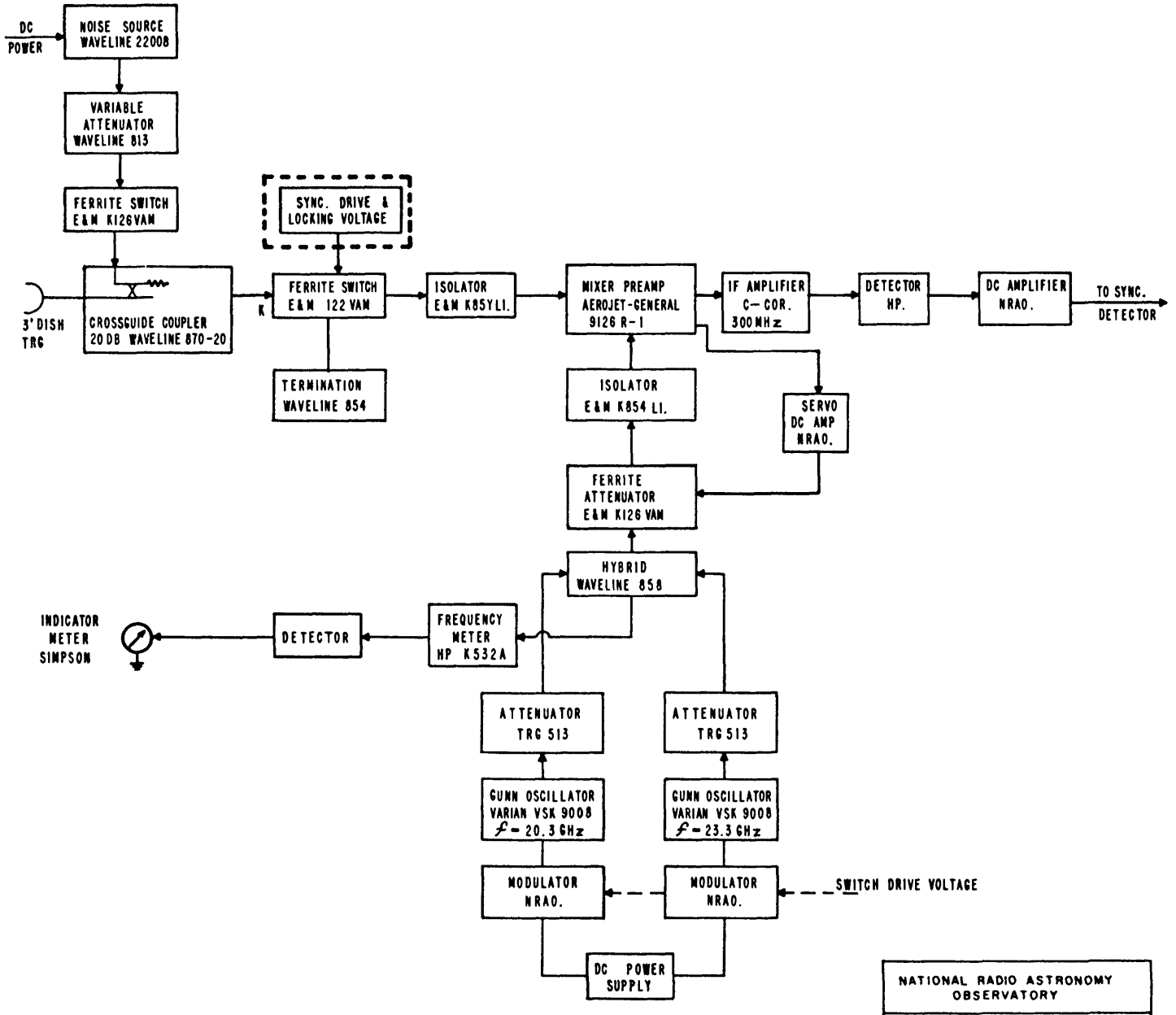
Color Code Per Pair	Color Code	Pin No.	Remarks
Blue Tracer	Red	A-1	+15
	Yellow	B-2	Common
	Shield	E	
Purple Tracer.....	Red	C-3	-15
	Yellow	D-4	Common
	Shield	J	
Gray Tracer	Red	O-5	+28
	Yellow	P-6	Common
	Shield	H	
Green Tracer	Red	F-7)	Thermistor (Blue)
	Yellow	G-8)	Control (White)
	Shield	M	
Yellow Tracer	Red	T-9)	Audio (Blue)
	Yellow	U-10)	(White)
	Shield	N	
Center Pair, No Tracer	Gray	K-11	Noise (K - Red, 11- White)
	Yellow	L-12	Tube (L - Black, 12-Red)
	Shield	R	
Center Pair, No Tracer	Blue	X-13	Ferrite Sw. (Gray)
	Yellow	Y-14	Drive (Red)
	Shield	Q	
Center Pair, No Tracer	Gray	Z-15)	Op Amp (Green) (N.T.
	Red	a-16)	Cal Sig - 7 (Yellow) Attn.)
	Shield	S	
Center Pair, No Tracer	Red	V-17	LO Sig (Card 3) (Blue)
	Yellow	W-18	(Switch) (White)
	Shield	d	
Black Tracer	Red	m-19	Det Sig (Card 2) (Orange)
	Yellow	n -20	(Black)
	Shield	e	
Orange Tracer	Red	b-21	Xtal Curr (Yellow)
	Yellow	c-22	No. 1 (Black)
	Shield	k	
Red Tracer	Red	r-23	Xtal Curr (Blue)
	Yellow	s-24	No. 2 (Black)
	Shield	x	
Brown Tracer	Red	t-25	Spare
	Yellow	u-26	
	Shield	y	
Center Pair, No Tracer	Blue	f-27	LO Atten (Green)
	Gray	g-28	Current (Black)
	Shield	p	
Center Pair, No Tracer	Red	h-29	Spare
	Blue	j-30	
	Shield	q	
Spare Pins (3)		v	
		w	
		z	





RF SIGNAL BANDS FOR THE
WATER VAPOR RADIOMETERS

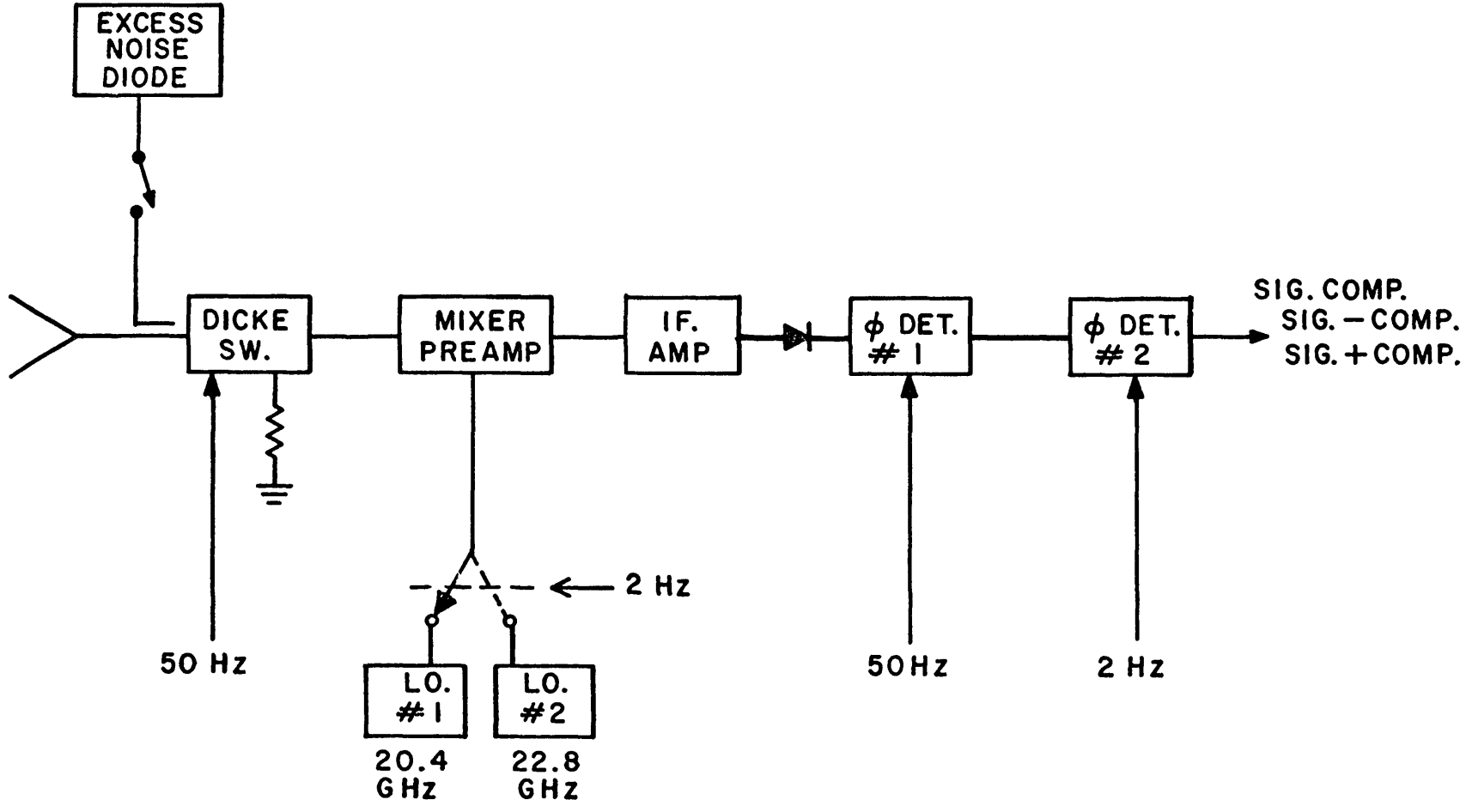
FIG. 1



NATIONAL RADIO ASTRONOMY OBSERVATORY

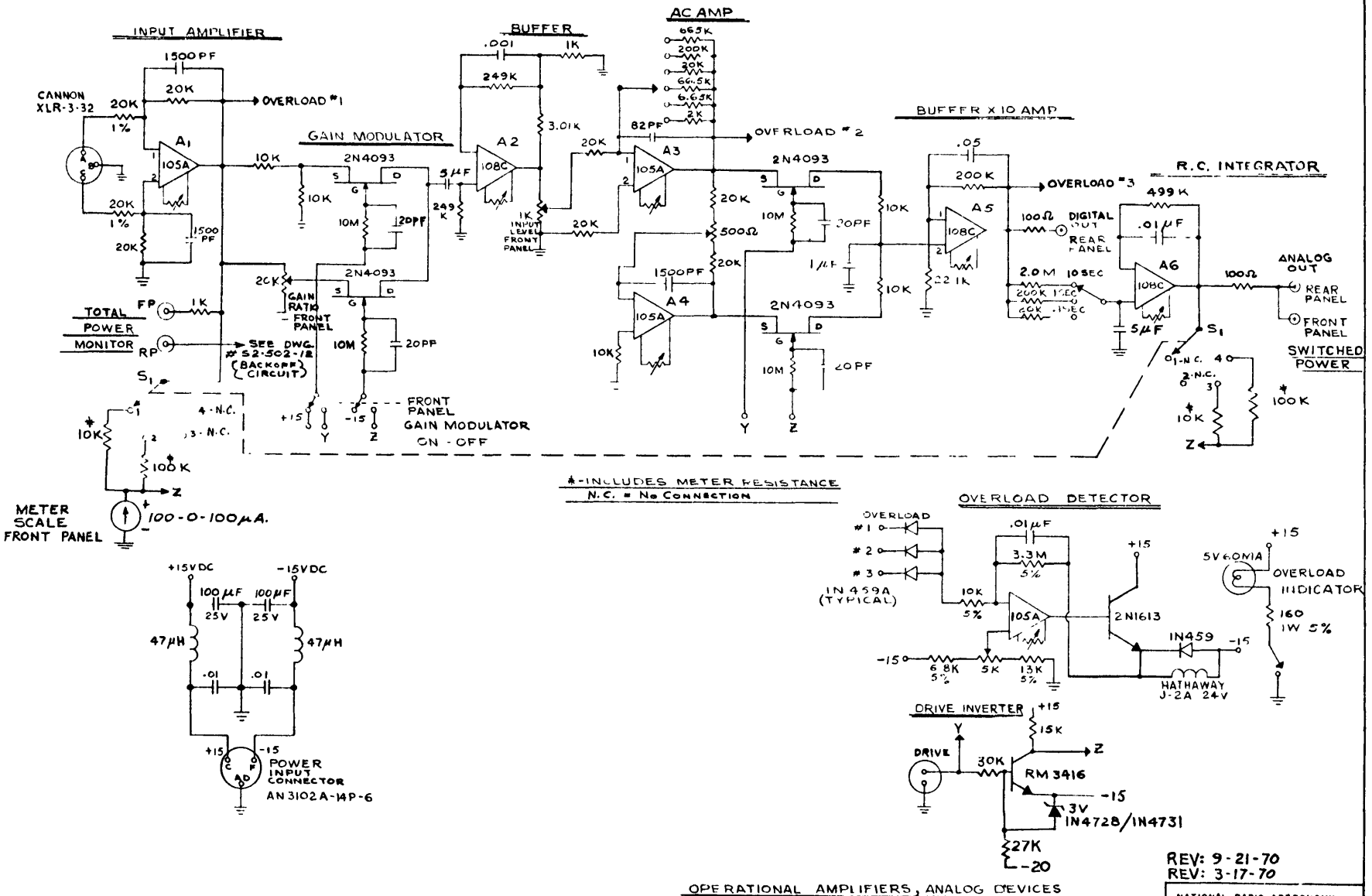
TITLE WATER VAPOR RECEIVER FRONT END BLOCK DIAGRAM

DSGN BY S.WEINREB	DATE 8-7-67
APPD BY	DR BY J.DOLAN/A.M.
DWG NO 82-502-1	



DOUBLE SWITCHED WATER VAPOR RADIOMETER
SIMPLIFIED BLOCK DIAGRAM

FIG. 2



*-INCLUDES METER RESISTANCE
N.C. = NO CONNECTION

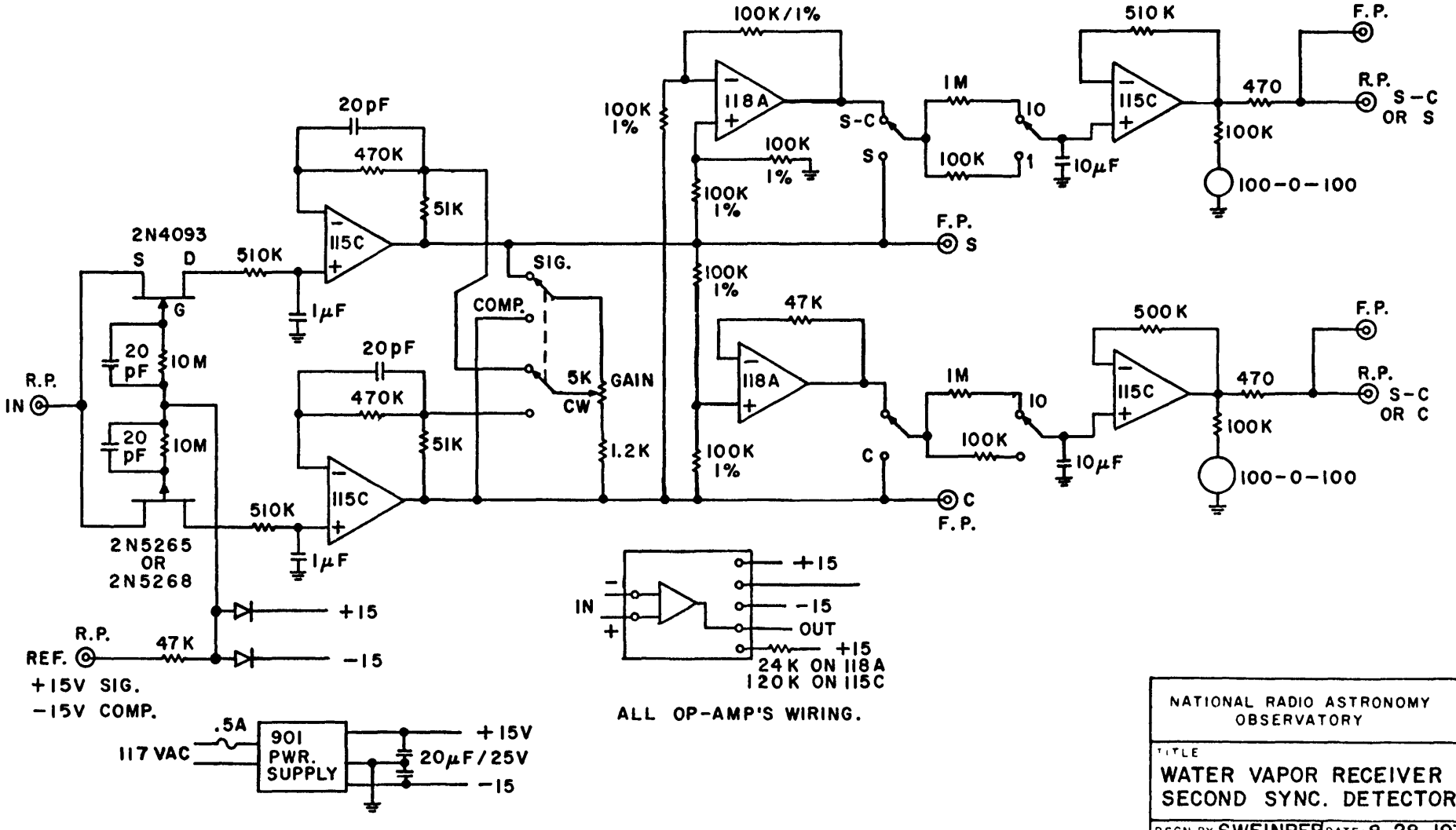
OPERATIONAL AMPLIFIERS, ANALOG DEVICES

REV: 9-21-70
REV: 3-17-70

NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE: WATER VAPOR SYNCHRONOUS-DETECTOR

DSGN BY J DOLAN | DATE 10-27-62
APPD BY J. DOLAN | DWN BY A.J.M.
DWG NO 52-502-2

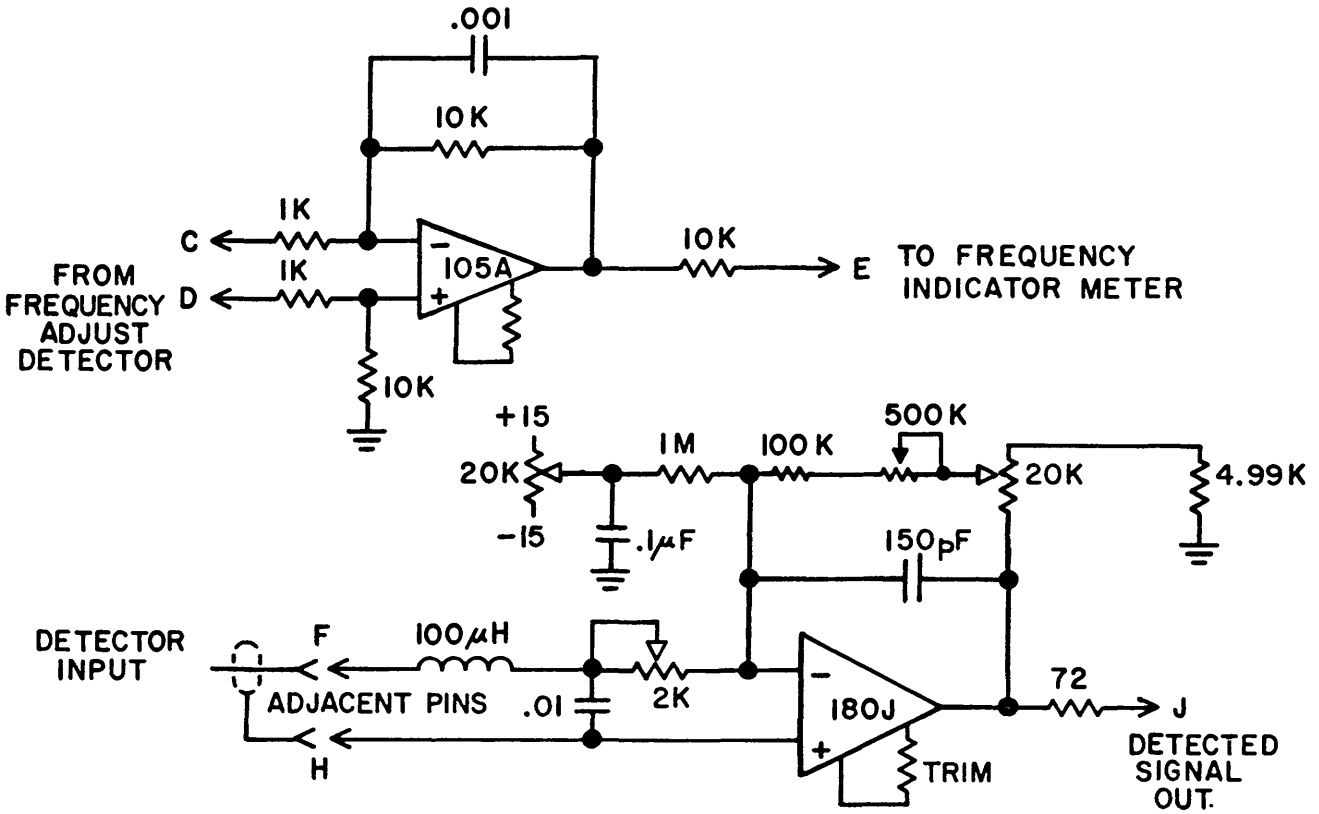


NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE

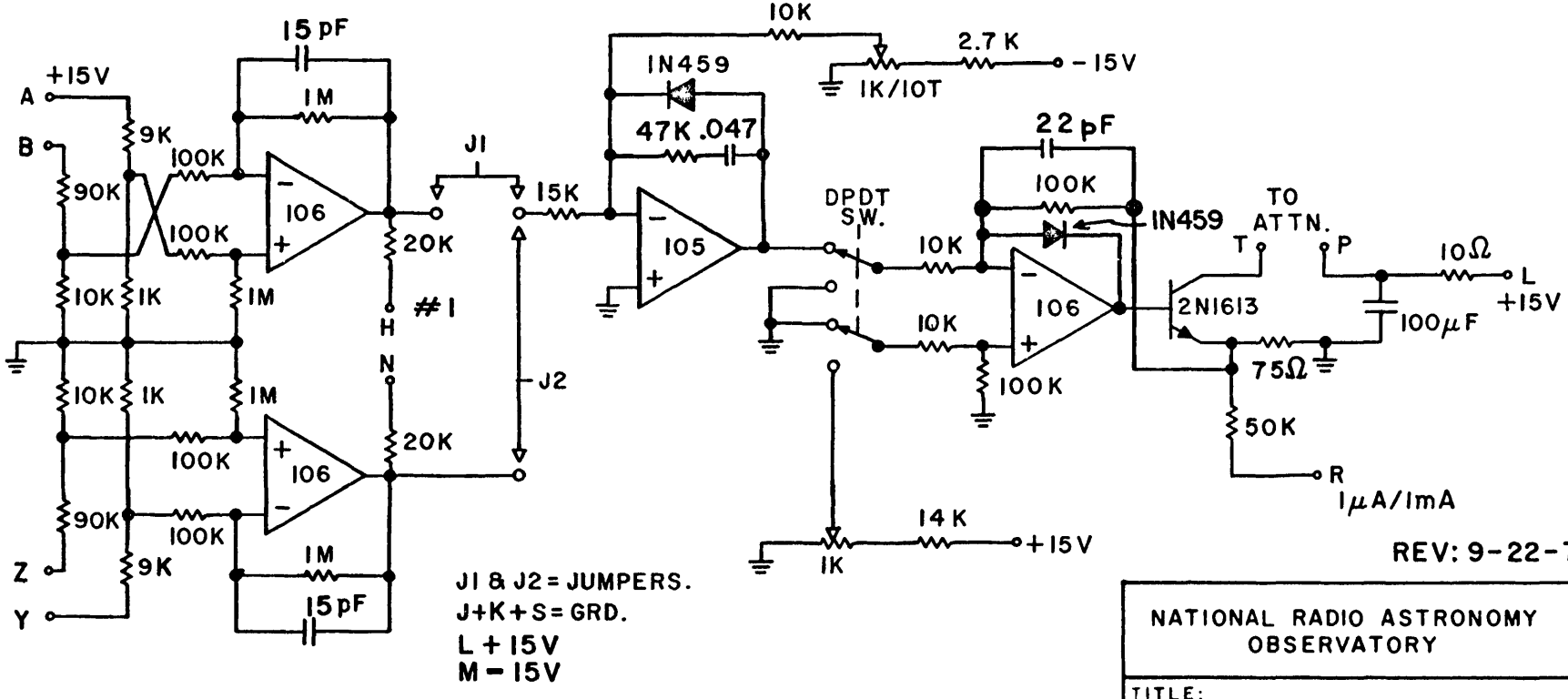
WATER VAPOR RECEIVER
SECOND SYNC. DETECTOR

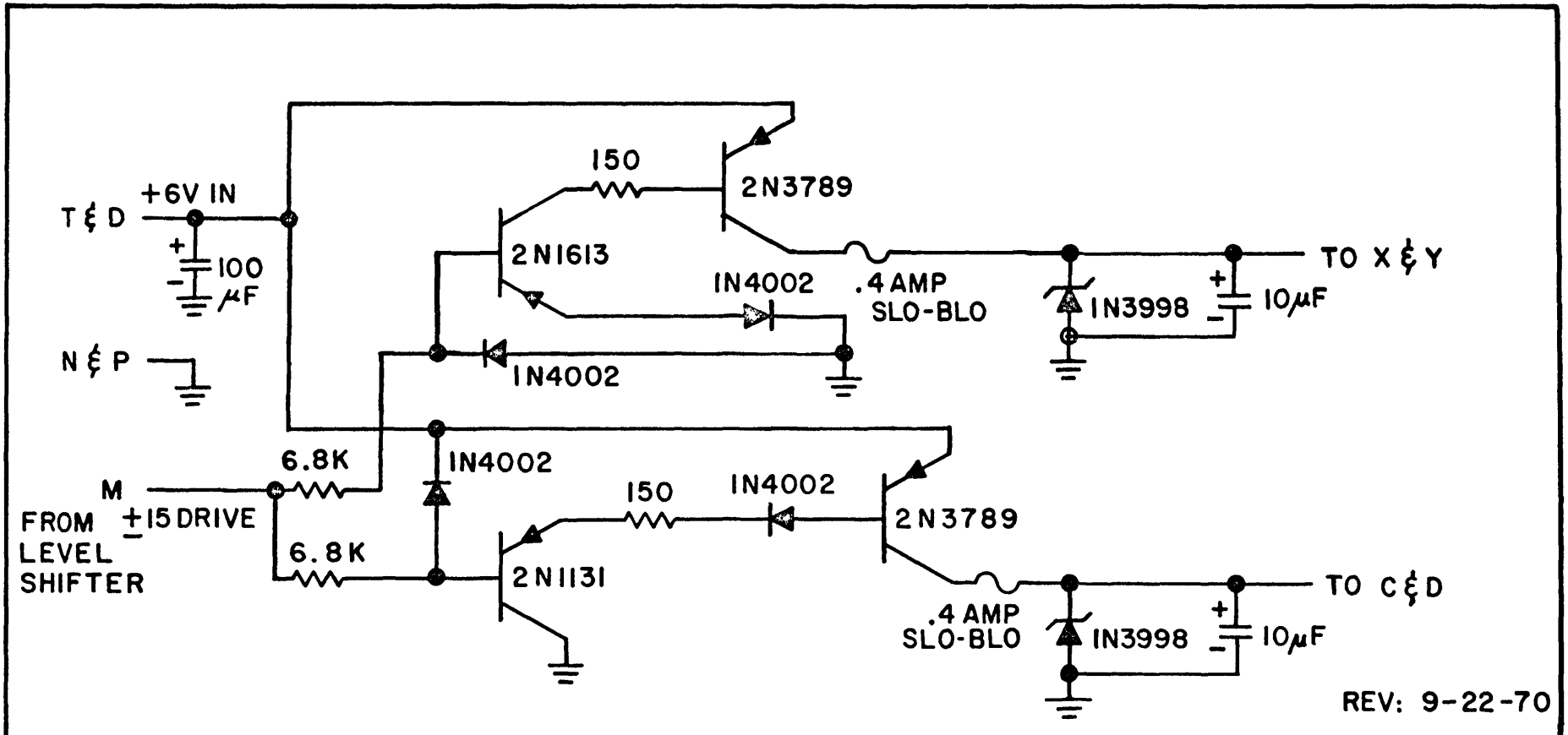
DSGN BY S.WEINREB	DATE: 8-28-1970
APPD. BY	DR. BY
DWG. NO S 2·502 – 11	

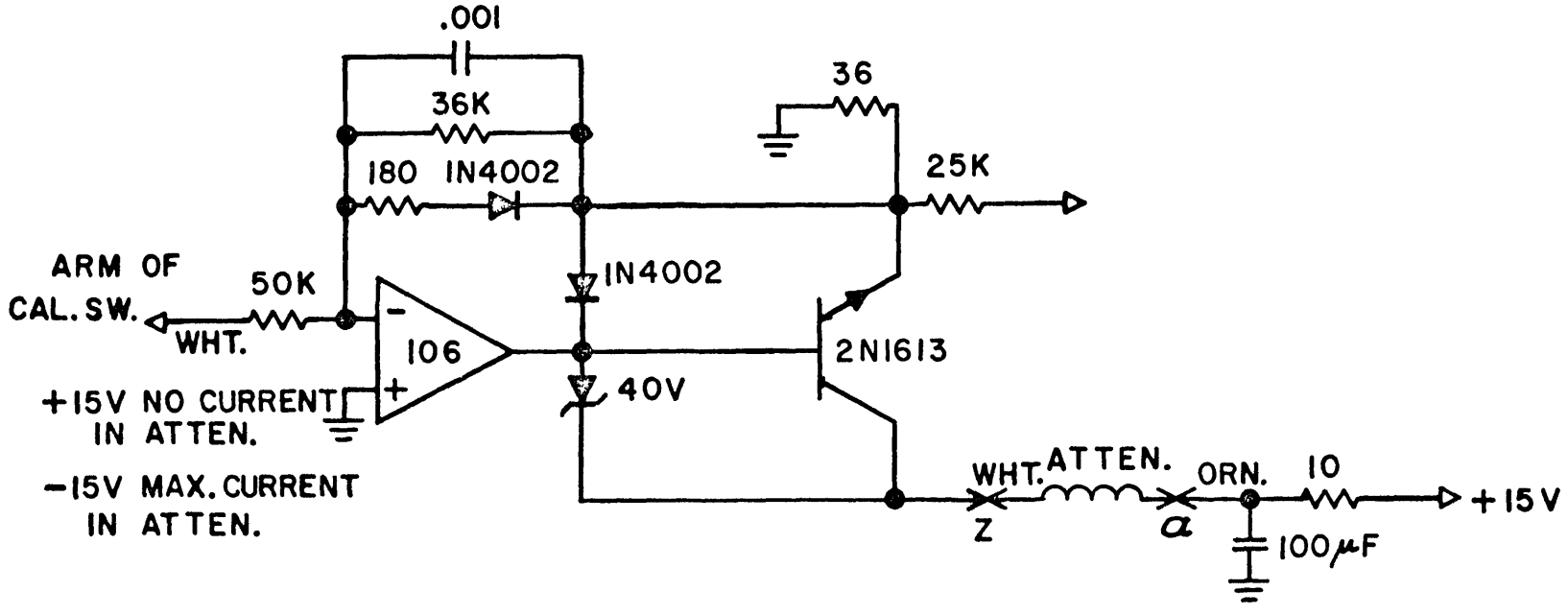


FRONT END
PRINTED CKT.
BOARD
PC2·502-3

NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: SQUARE LAW DETECTOR & FREQUENCY MONITOR	
DSGN.BY: THACKER	DATE: 10-28-69
APPD.BY: DOLAN	DR.BY: A.M.
DWG. NO. S 2·502-3	

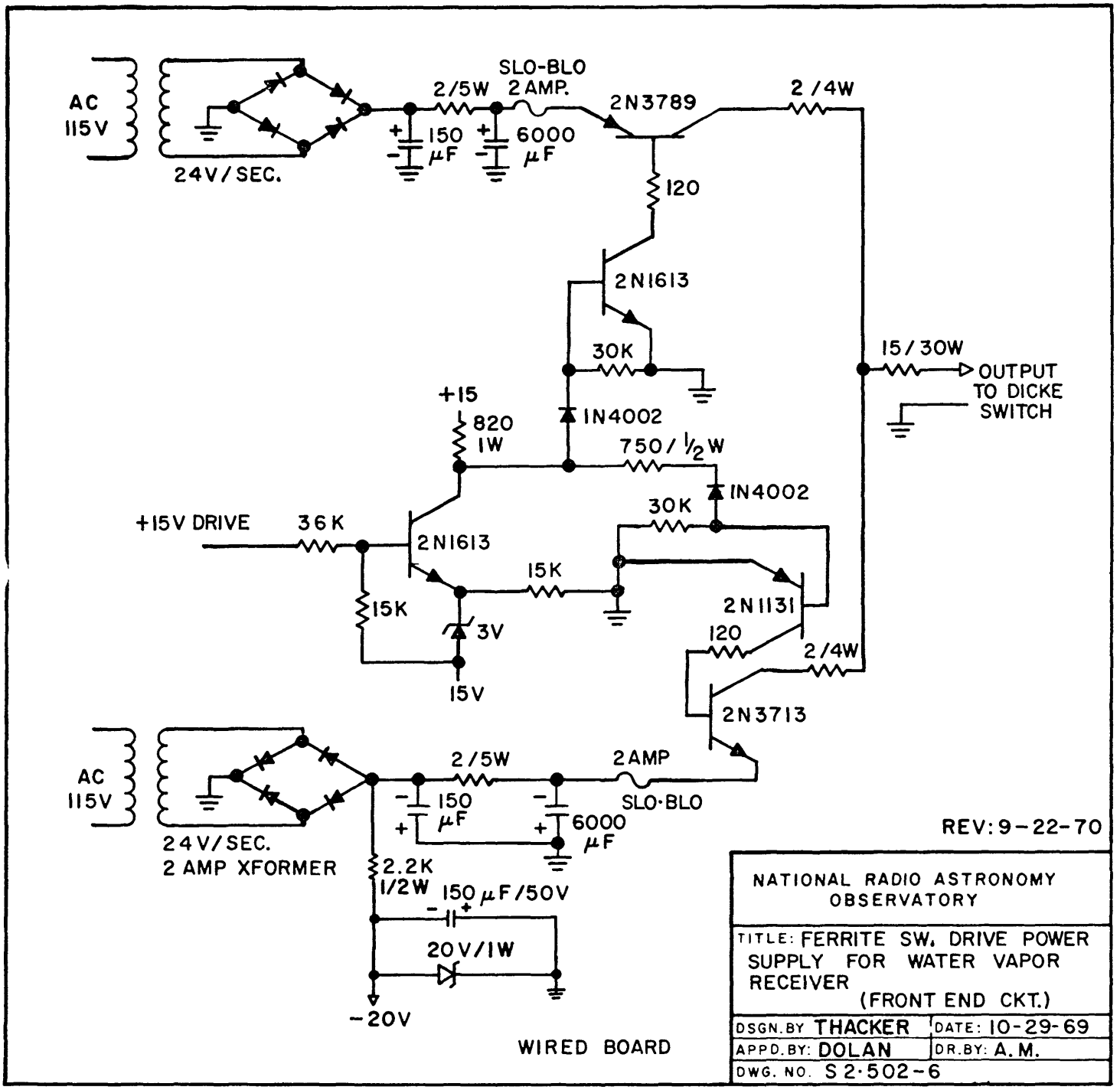

+15V
A
B
Z
Y
9K
90K
10K
1K
1M
100K
15 pF
106
20K
#1
H
N
J1
J2
15K
10K
IN459
47K .047
105
2.7 K
-15V
1K/10T
22 pF
DPDT SW.
TO ATTN.
T
P
10Ω
L
+15V
2N1613
100μF
75Ω
50K
R
1μA/1mA
14 K
J1 & J2 = JUMPERS.
J+K+S = GRD.
L +15V
M -15V
FRONT END PRINTED CKT. BOARD PC 2·502-1
REV: 9-22-70
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE:
LO. LEVELER FOR WATER VAPOR RADIOMETER
DSGN. BY: S.THACKER
DATE: 10-10-68
APPD. BY: J. DOLAN
DR. BY: A.M.
DWG. NO. S 2·502-1

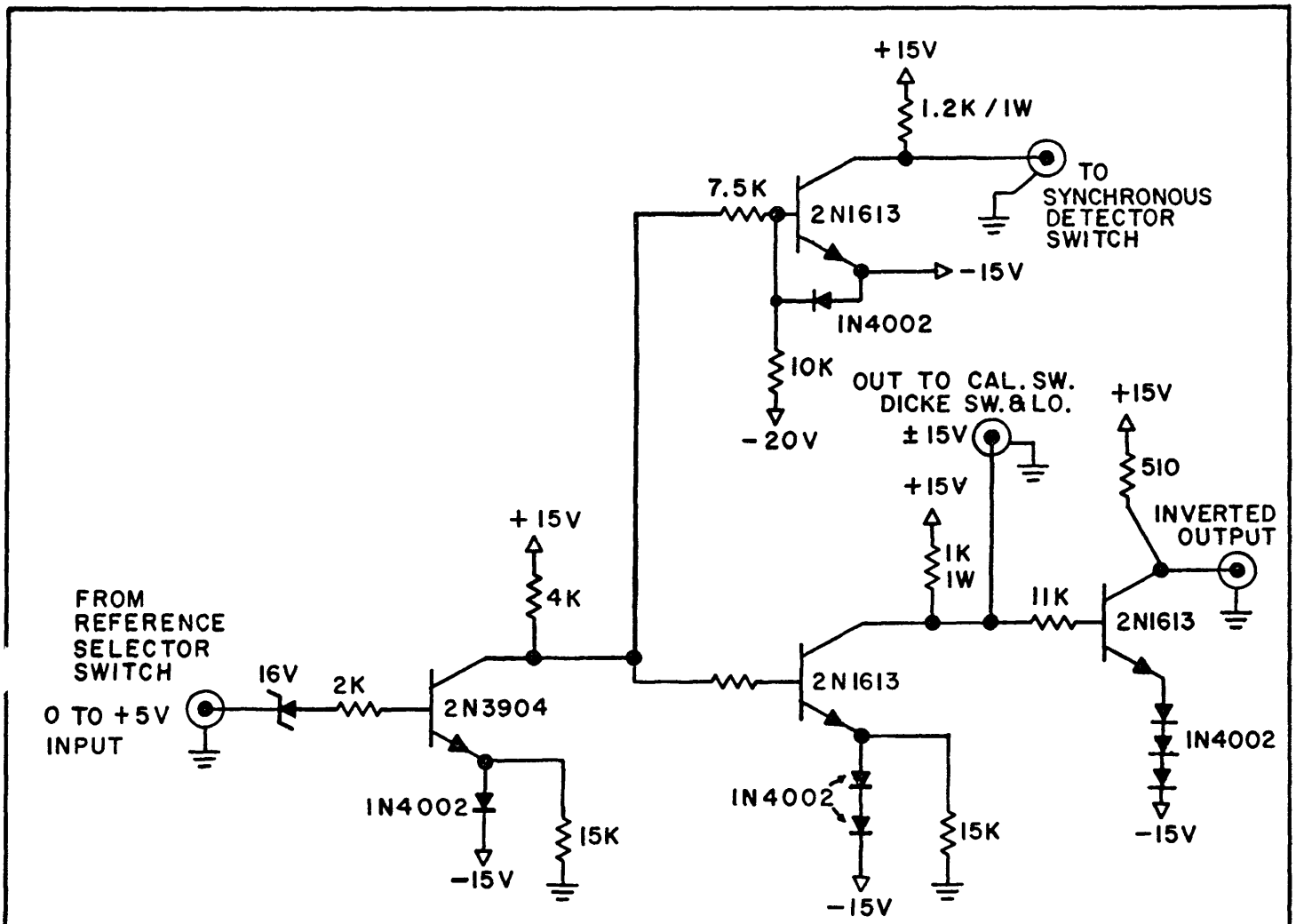

+6V IN
T & D
100 μF
N & P
150
2N3789
2N1613
IN4002
.4 AMP SLO-BLO
IN3998
10μF
TO X & Y
IN4002
M
FROM ±15 DRIVE LEVEL SHIFTER
6.8K
6.8K
IN4002
150
IN4002
2N3789
2N1131
.4 AMP SLO-BLO
IN3998
10μF
TO C & D
REV: 9-22-70
FRONT END WIRED BOARD
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: MODULATOR FOR SOLID-STATE FREQUENCY SOURCES IN WATER VAPOR RECEIVERS
DSGN. BY: THACKER
DATE: 10-28-69
APPD. BY: DOLAN
DR. BY: A.M.
DWG. NO. S 2·502-4



WIRED BOARD

NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: H_2O RADIOMETER CAL. SW. (ATTEN.) DRIVER (BACK END CIRCUIT)	
DSGN. BY: THACKER	DATE: 10-28-69
APPD. BY: DOLAN	DR. BY: A.M.
DWG. NO. S 2·502-5	

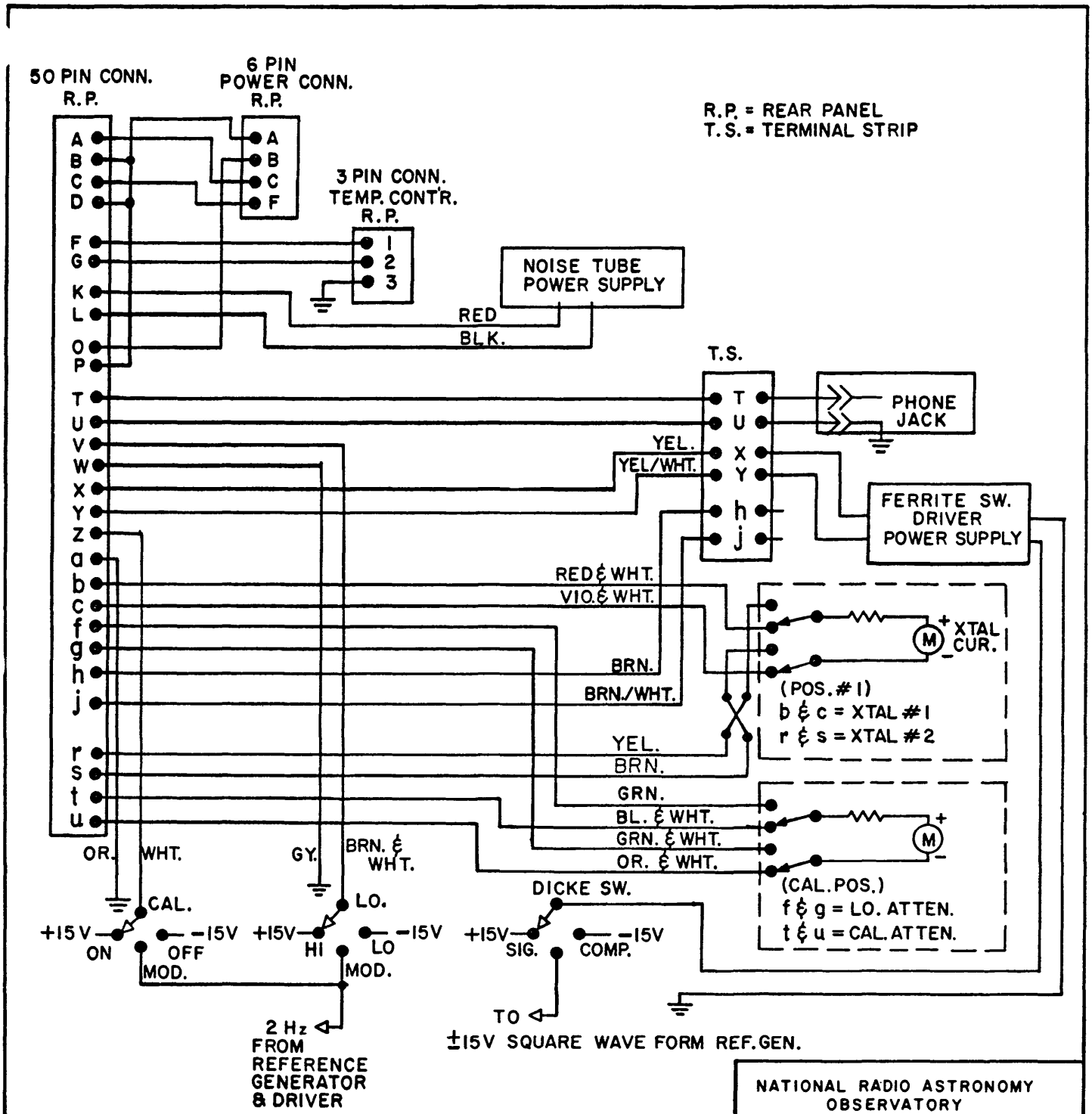

AC
115V
24V/SEC.
SLO-BLO
2/5W
2 AMP.
150 μF
6000 μF
2N3789
2/4W
120
2N1613
30K
15/30W
OUTPUT TO DICKE SWITCH
+15
820
1W
1N4002
750/½W
1N4002
30K
+15V DRIVE
36K
2N1613
15K
15K
2N1131
3V
120
2/4W
15V
2N3713
AC
115V
2/5W
2AMP
150 μF
SLO-BLO
6000 μF
24V/SEC.
2 AMP XFORMER
2.2K
1/2W
150 μF/50V
20V/1W
-20V
WIRED BOARD
REV: 9-22-70
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: FERRITE SW. DRIVE POWER SUPPLY FOR WATER VAPOR RECEIVER
(FRONT END CKT.)
DSGN. BY THACKER
DATE: 10-29-69
APPD. BY: DOLAN
DR. BY: A. M.
DWG. NO. S 2·502-6



REV: 9-21-70

BACK END WIRED BOARD

NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: +15V & −15V DRIVER FOR WATER VAPOR RECEIVER (LEVEL SHIFTER #1)	
DSGN. BY: THACKER	DATE: 10-29-69
APPD. BY: DOLAN	DR. BY: A.M.
DWG. NO S 2·502−7	

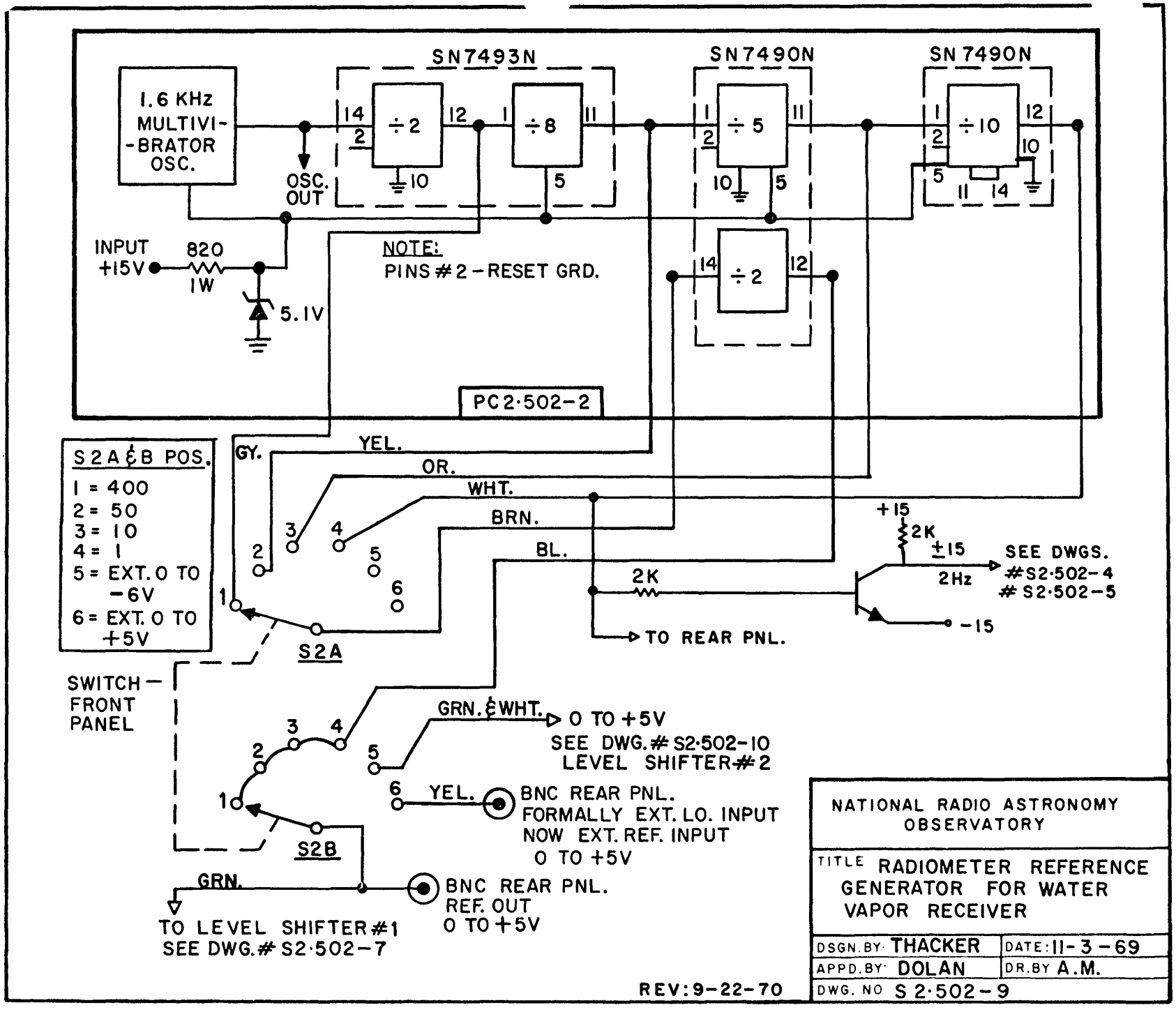


NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE: BACKEND CABLE & SWITCH CONNECTIONS FOR WATER VAPOR RECEIVER

DSGN. BY: THACKER	DATE: 10-30-69
APPD. BY: DOLAN	DR. BY: A.M.
DWG. NO S2-502-8	

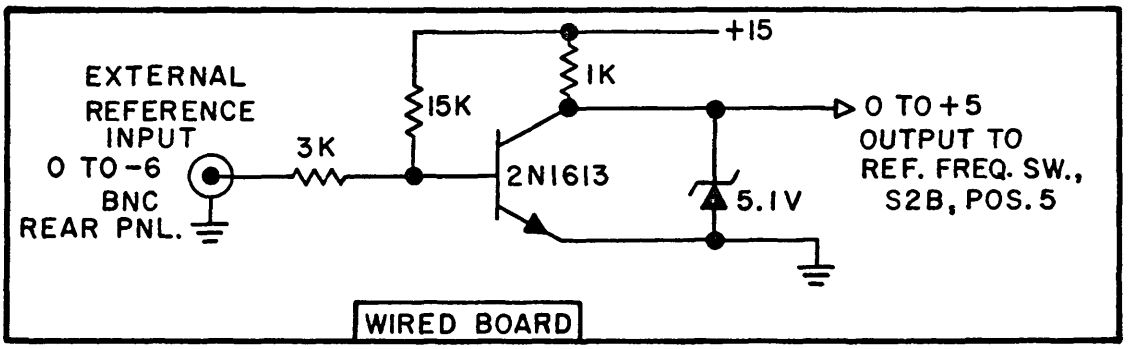
REV: 9-21-70



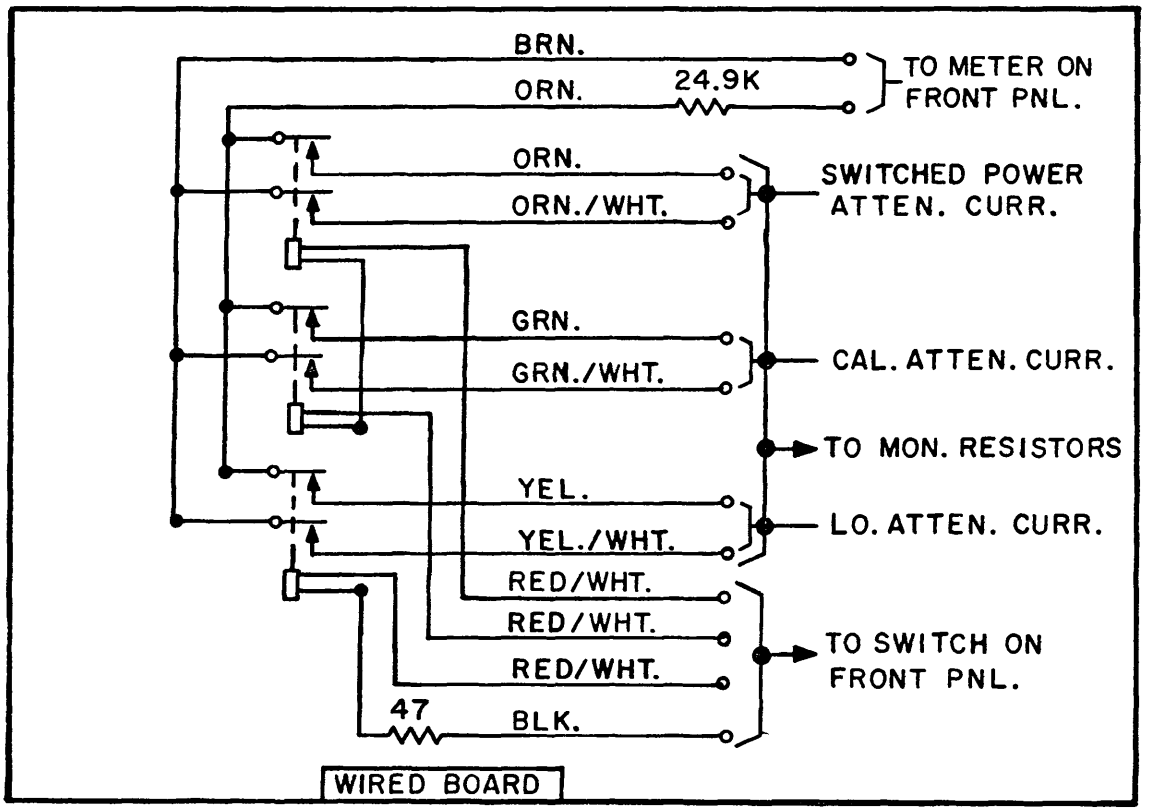
NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE RADIOMETER REFERENCE GENERATOR FOR WATER VAPOR RECEIVER

DSGN. BY THACKER	DATE: 11-3-69
APPD. BY DOLAN	DR. BY A.M.
DWG. NO S 2·502-9	

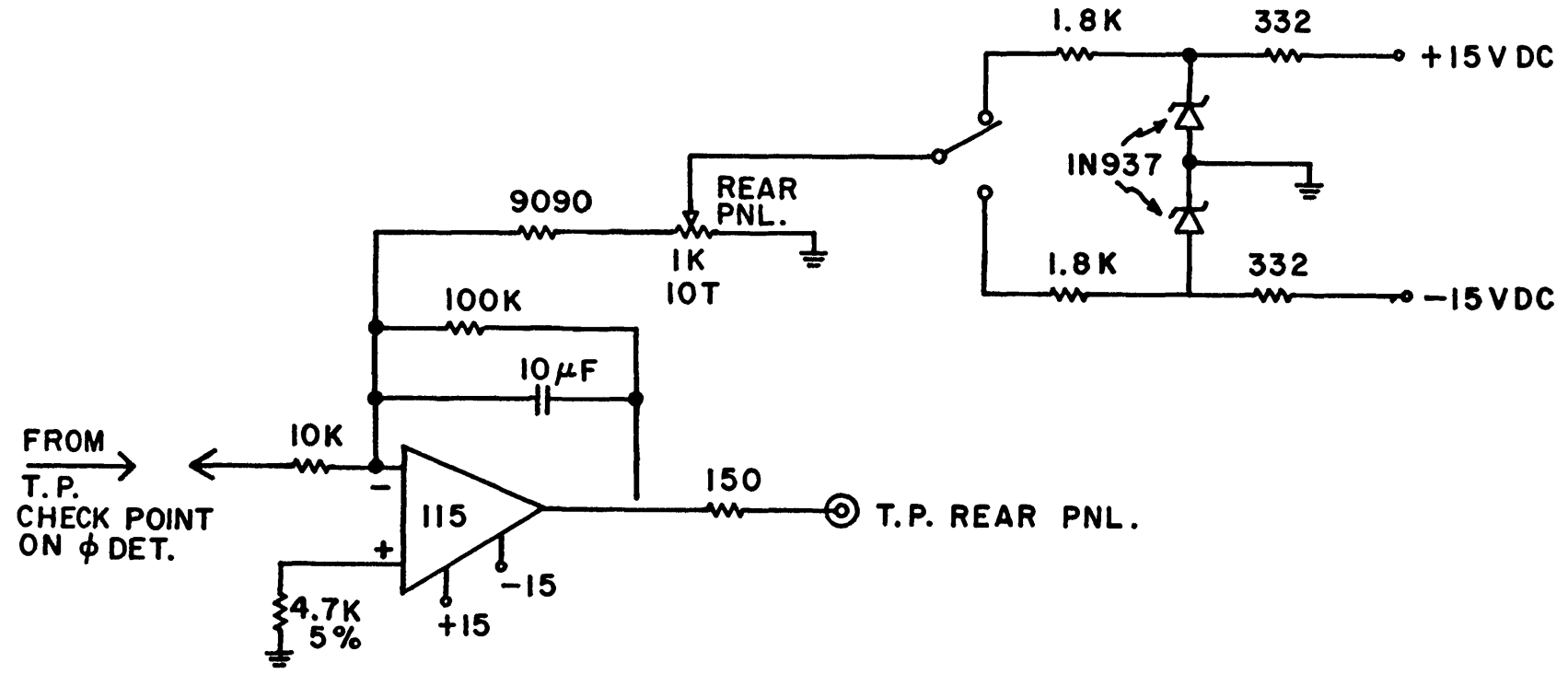


LEVEL SHIFTER #2



ATTEN. CURR. MON. CKT.

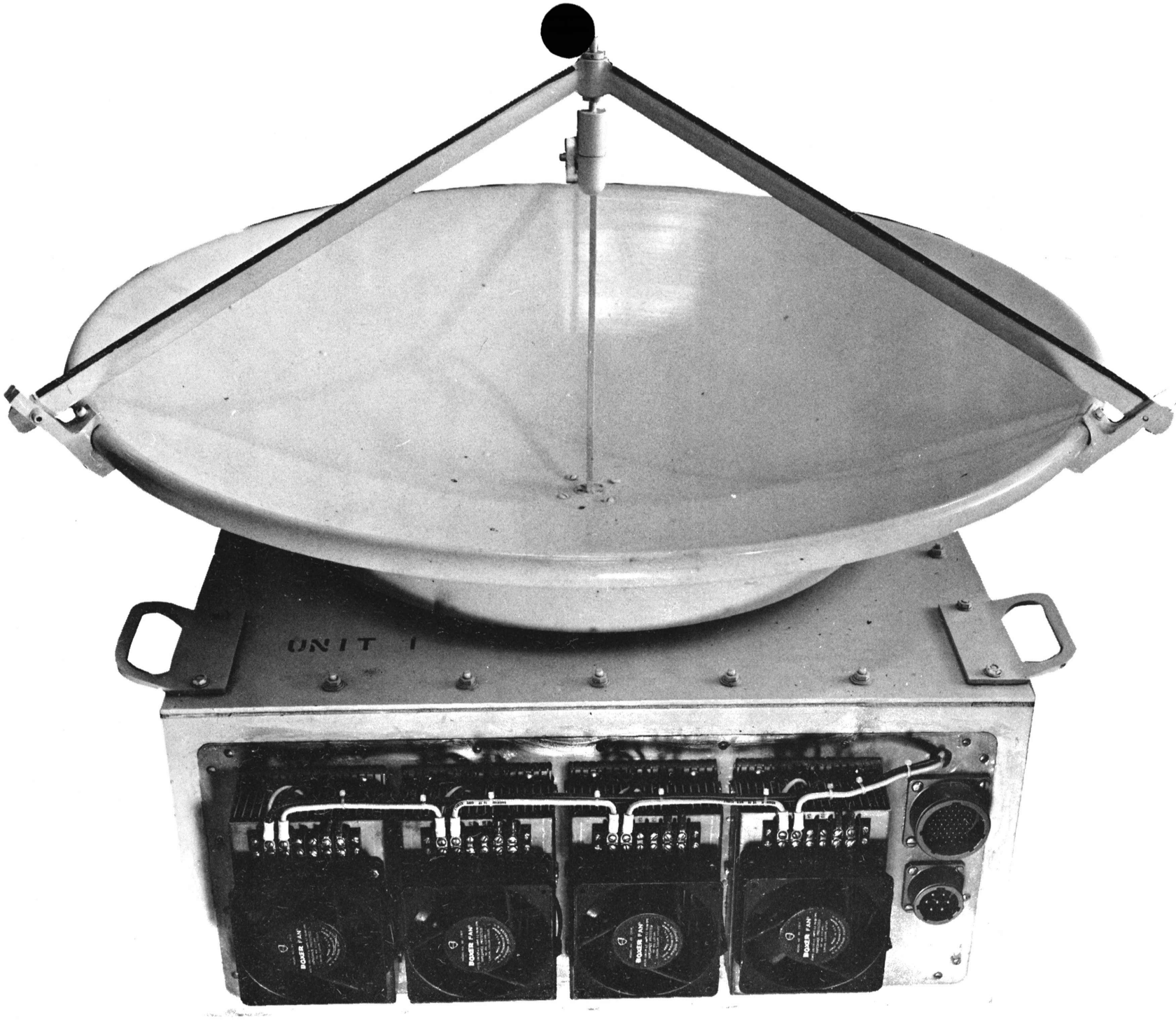
NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: LEVEL SHIFTER #2 & ATTEN. CURR. MON. CKT. FOR WATER VAPOR RECEIVER	
DSGN. BY: THACKER	DATE: 11-6-69
APPD. BY: DOLAN	DR. BY: A. M.
DWG. NO S 2·502-10	

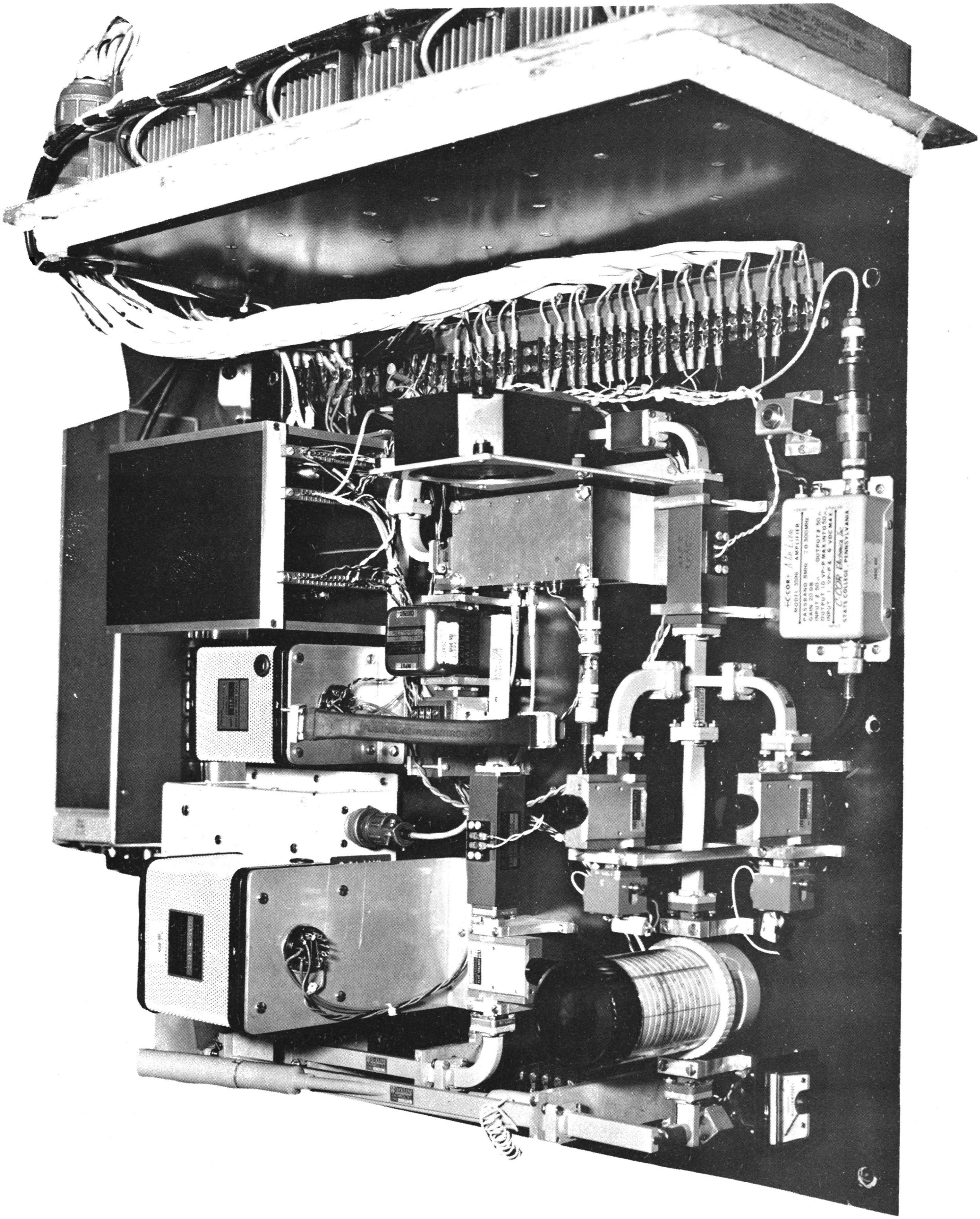


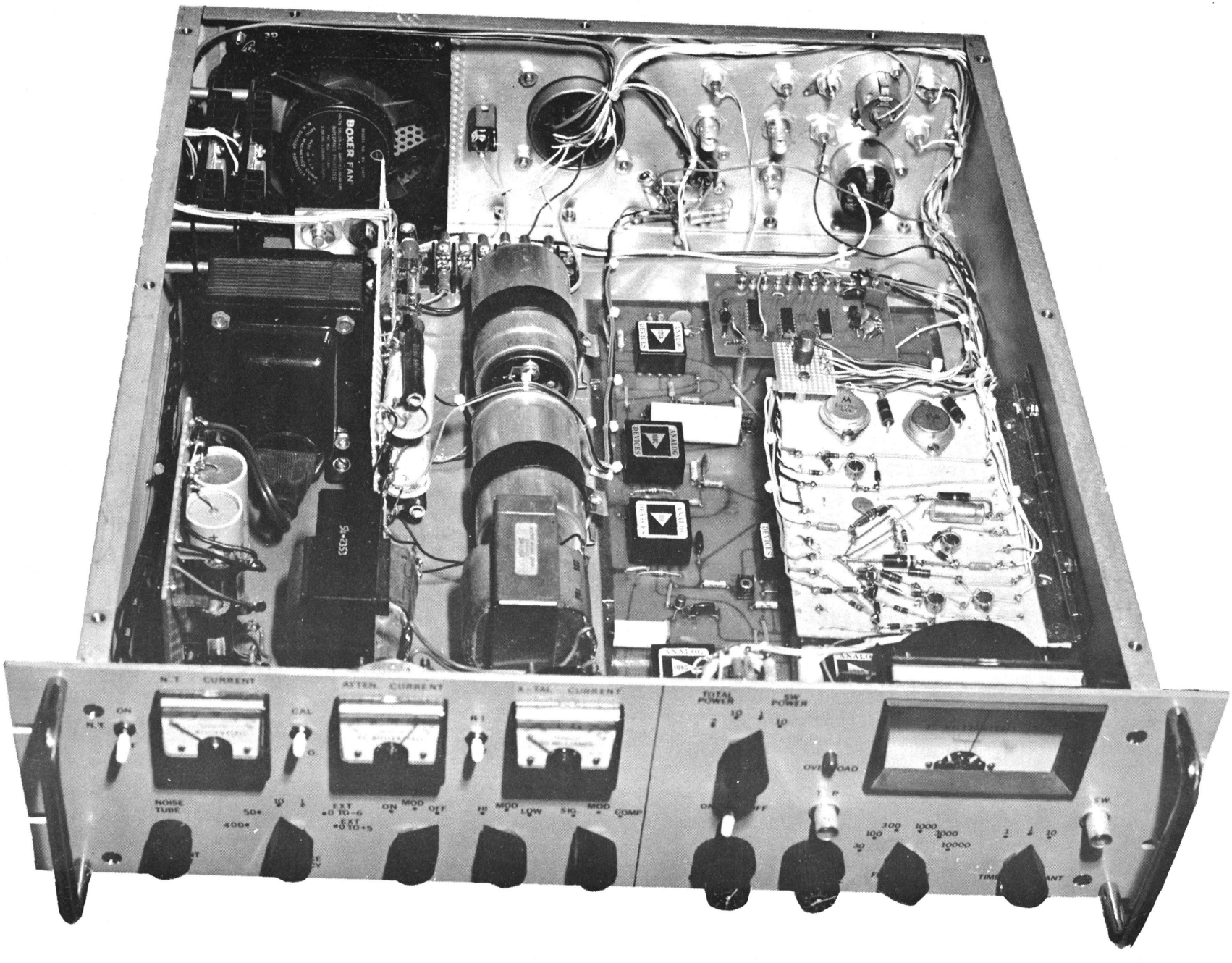
RESISTORS = 1% OR AS INDICATED

TOTAL POWER BACK-OFF AND X·10 CKT.

NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: WATER VAPOR RADIOMETER	
DSGN. BY: J. DOLAN	DATE: 9-22-70
APP'D. BY:	DR. BY:
DWG. NO. S 2·502 - 12	


UNIT 1
BOXER FAN
BOXER FAN
BOXER FAN
BOXER FAN




BOXER FAN
N.T CURRENT
ATTEN. CURRENT
X-TAL CURRENT
TOTAL POWER
SW POWER
N.T
ON
CAL
NOISE TUBE
50*
400*
EXT 0 TO -6
EXT 0 TO +5
ON
MOD
OFF
HI
MOD
LOW
SIG
MOD
COMP
OVERLOAD
ON
OFF
SW
TIME CONSTANT