**NATIONAL RADIO ASTRONOMY OBSERVATORY**
**GREEN BANK, WEST VIRGINIA**

# ELECTRONICS DIVISION TECHNICAL NOTE NO. 183

Title: Instruction Manual, NRAO Standard Receiver

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Date: August 1967

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# INSTRUCTION MANUAL
# NRAO STANDARD RECEIVER

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# INSTRUCTION MANUAL
# NRAO STANDARD RECEIVER

## I. General Description

The NRAO Standard Receiver contains the IF, gain modulator, detector, synchronous detector, reference generator, and switch driver portions of a radiometer. It is designed to operate with a wide variety of RF amplifiers and mixers which are mounted at the focal point of the antenna in use.

A block diagram of the receiver is shown in Figure 1 and a photograph is shown in Figure 2. The receiver can accept input signals of 3 types:

1) A detected signal of 1 volt DC level. This type of input comes from tunnel-diode TRF receivers which have detectors in the front-end box.

2) A low-level IF signal which arises when an RF amplifier and a mixer are in the front-end box. The IF signal must have a frequency spectrum between 1 Mc/s and 300 Mc/s and must be at a level >-70 dBm at the input of the receiver.

3) A high-level IF signal which arises when an RF amplifier, mixer, and IF amplifier are in the front-end box. The signal level must be between -25 and -35 dBm and the signal spectrum must also be within the 1 Mc/s to 300 Mc/s range.

A brief description of the components of the standard receiver is as follows:

IF Amplifier — The IF amplifier is made up of 2 wideband amplifier modules, an input step attenuator, and various filters. These components are contained in a slide-out drawer and are patched together to make up the desired gain and frequency response.

IF Gain Modulator — This unit multiplies the receiver gain by a factor, $\alpha$, when the front-end switch is in the reference position; the gain is unaffected when the front-end switch is in the antenna position. The gain modulation factor, $\alpha$, can be varied from .107 to 2.34 with high precision through the operation of a switched, coarse (1 dB steps) attenuator and a continuously variable, fine (± .7 dB) attenuator. Gain modulation is used to balance the radiometer and make its output independent of gain fluctuations; this is discussed in the next section. The gain modulator, square-law detector, and total power amplifier are all housed in one chassis. This unit also contains attenuators for adjusting the IF gain.

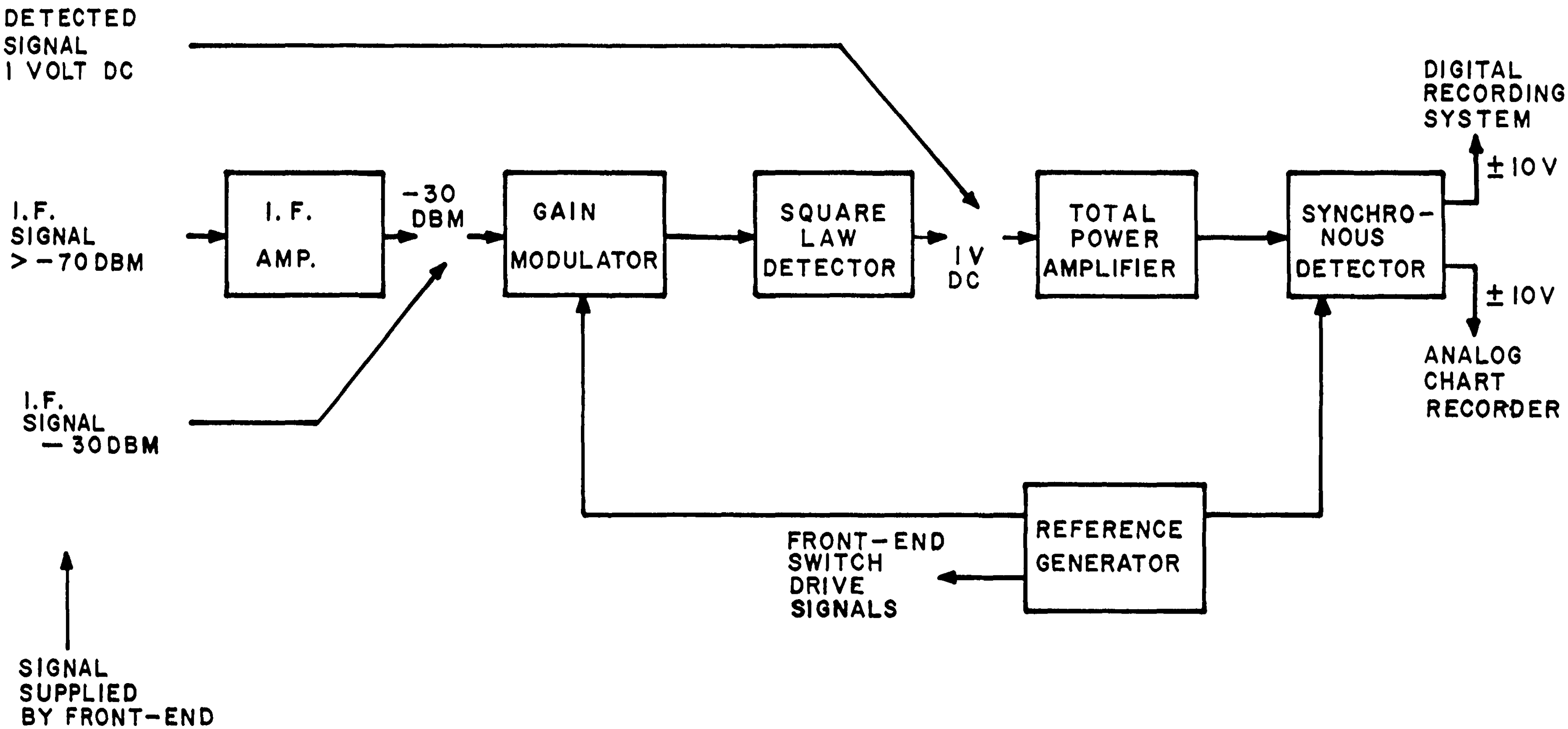



Figure 1 — Standard Receiver Block Diagram

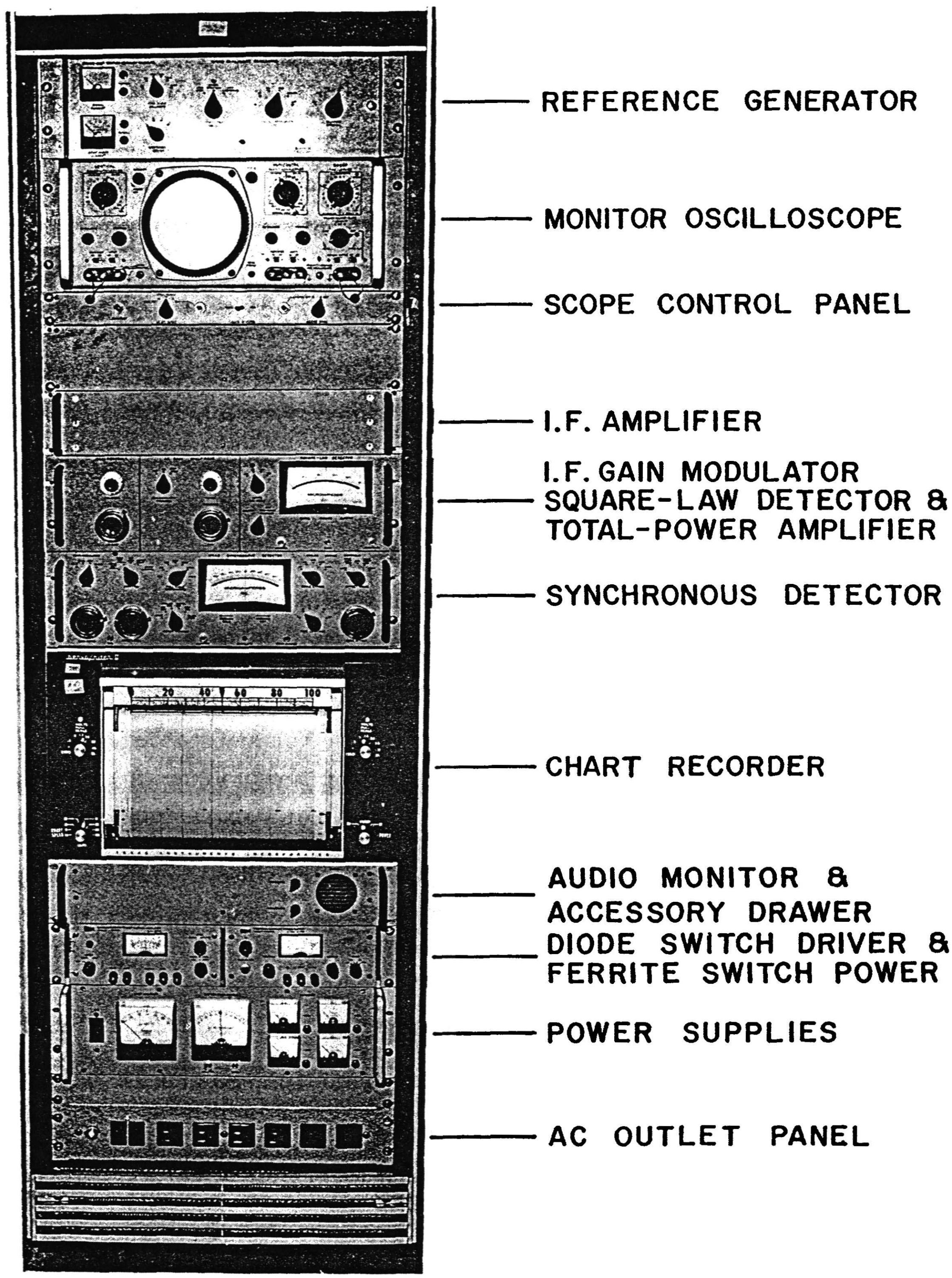



Figure 2 — NRAO Standard Receiver

Square-Law Detector — A detector which is carefully adjusted for square-law operation is incorporated in the receiver. The detector output will normally be within 2 percent of square-law for total power outputs between 0.3 volts and 3 volts (nominal total power output is +1 volt). A detector-law calibration curve is normally supplied with each radiometer.

Total Power Amplifier — This unit contains an optional 60∿ rejection filter and optional blanking circuits to remove the effects of front-end switch and gain-modulator transients. A meter which indicates the total power output is provided. The center scale of this meter can be expanded by x 10 to show small variations in the receiver total power.

Synchronous Detector — The synchronous detector extracts the switched component (antenna minus reference) of the total power output and provides the normal radiometer output. This unit contains a post-detection gain modulator that is used with TRF front-ends (which have no IF and therefore cannot use the IF gain modulator). The synchronous detector contains various gain, offset, and time constant controls. It provides outputs for a digital recording system and for an analog chart recorder.

Reference Generator — The reference generator provides square wave signals at frequencies of 1, 10, 50 and 400 cycles per sidereal second. These signals drive the synchronous detector, the IF gain modulators, and switch drivers for front-end switches. Two types of switch drivers are included. One provides a ± 20 volt, 0.5 amp maximum square-wave for driving diode switches; the second provides up to 90 volts at .75 amps for driving ferrite switches. The reference generator also provides blanking signals for use in the total power amplifier and synchronous detector.

## II. Theoretical Description

The NRAO Standard Receiver, when connected to a suitable front-end, forms a switched (Dicke) radiometer. The receiver is somewhat unconventional in that gain modulation and square-wave synchronous detection are utilized. These two aspects will be emphasized in this section.

The radiometer can be analyzed with reference to the block diagram shown in Figure 3. All of the switches in the figure are switched synchronously at a 1, 10, 50, or 400 cps rate. When all the switches are in the upper (antenna) position, the average total-power output signal is,

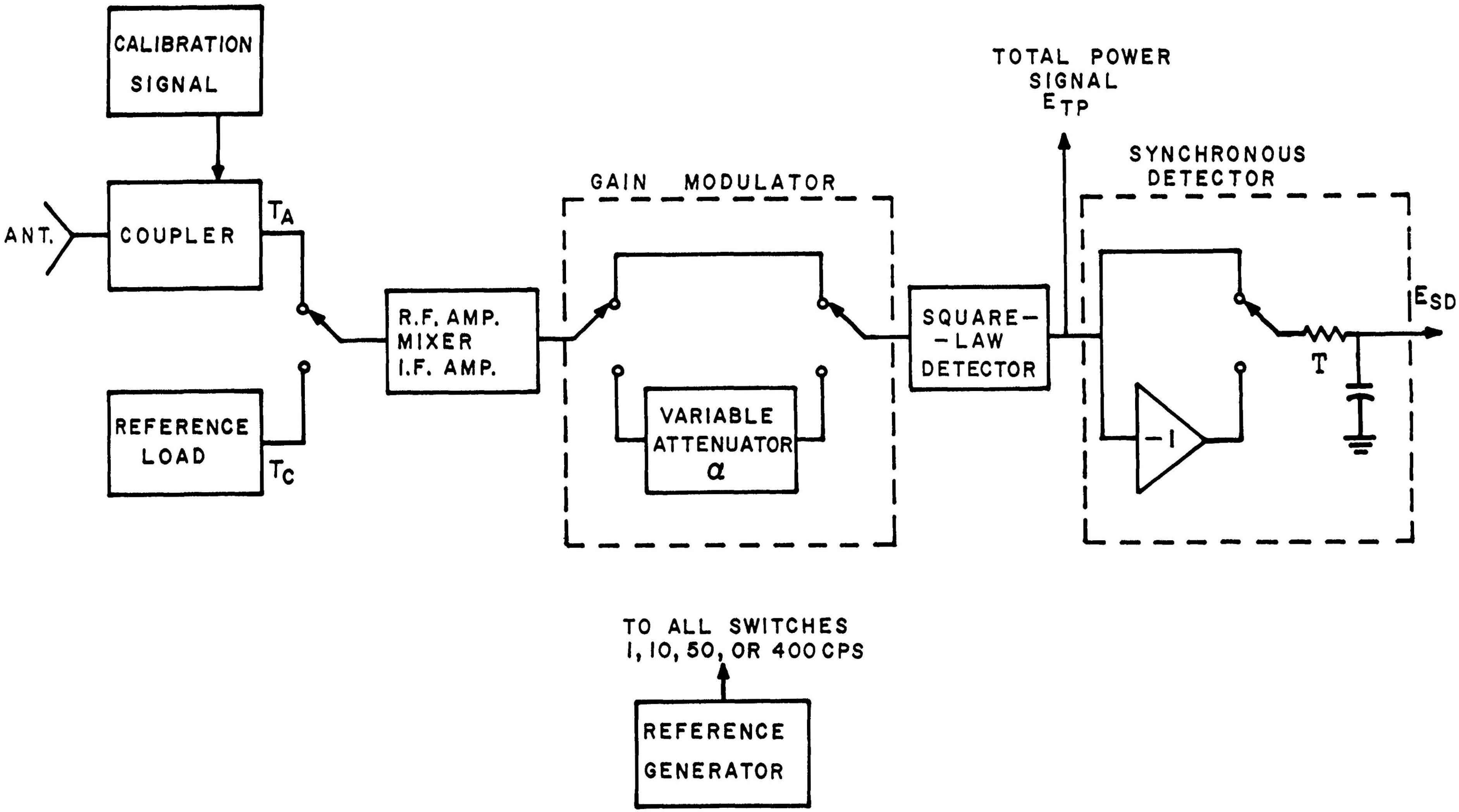



Figure 3 — Simple Model of Switched Radiometer with Gain Modulation

$$\overline{E_{TP}} = G(T_A + T_R)$$

where G is the receiver gain, $T_A$ is the antenna temperature, and $T_R$ is the receiver noise temperature.

When the switches are in the lower (reference) position the output is,

$$\overline{E'_{TP}} = \alpha G(T_C + T_R)$$

where $\alpha$ is the gain modulation ratio and $T_C$ is the reference load temperature.

The synchronous detector extracts the average value of the difference of $E_{TP}$ and $E'_{TP}$; thus its output is

$$E_{SD} = G[T_A - \alpha T_C - (1 - \alpha)T_R]$$

The purpose of the switching system is to allow $T_A$ to be measured independent of small drifts in G and $T_R$. This performance is illustrated by examining the incremental change in $E_{SD}$ caused by incremental changes in $T_A$, G, and $T_R$. The resultant $\Delta E_{SD}$ is divided by G to put it in units of temperature; this quantity is designated as $(\Delta T_A)_{meas}$ and is given by

$$(\Delta T_A)_{meas} = \Delta T_A + \frac{\Delta G}{G} T_u - (1 - \alpha)\Delta T_R$$

where $T_u = T_A - \alpha T_C - (1 - \alpha)T_R$.

The gain modulation factor, $\alpha$, can always be adjusted to make the unbalance temperature, $T_u$, equal to zero. This makes the measured antenna temperature independent of the receiver gain. (Note that it does not matter if the gain change occurs before or after the gain modulator.) However, unless $T_A = T_C$ and $\alpha = 1$, the measured antenna temperature will be dependent on the receiver noise temperature. The ideal condition is, of course, $T_A = T_C$ and $\alpha = 1$; however, this often cannot be achieved because of the difficulty of obtaining a stable, adjustable, cold reference temperature, $T_C$.

The receiver noise temperature is usually quite stable and often $T_C$ is close to $T_A$ so that $\alpha$ is nearly 1. Under these conditions, gain modulation is quite useful.

In most Dicke radiometers a narrow-band audio amplifier tuned to the switch frequency is used between the square-law detector and the synchronous detector. In the past this was necessary because synchronous detectors could not be built with sufficient dynamic range to tolerate the wideband noise signal coming out of the detector. This is no longer true and the following five advantages result if the narrow-band amplifier is omitted:

1) The receiver sensitivity is increased by $\pi/2\sqrt{2} = 1.11$ because higher harmonics of the switch frequency are kept.

2) A post-detection gain modulator can be used. This type of gain modulator is useful in TRF receivers which cannot use an IF gain modulator. The post-detection gain modulator will not remove the effects of all gain changes if the detector is not perfectly square-law. The NRAO standard receiver has both types of gain modulators.

3) Switching transients can be "blanked" out after detection. The blanking operation can be performed by keeping the synchronous detector switch in a middle or "dead band" position for a short instant of time after each square-wave transition. The capacitor (in Figure 1) holds the previous voltage value and no "hole" is put in the output signal during the blanking interval.

4) The switch frequency can be changed without making any other changes in the receiver. The switch frequency is usually chosen as high as the front-end switch will allow. This varies with the type of front-end switch — diode, ferrite, or mechanical.

5) The output of the square-wave synchronous detector is a smooth DC signal even if the time constant is shorter than a switch period. This is useful in some applications which require very low switch frequencies or very short time constants.

A disadvantage of omitting the narrow-band amplifier is an increased sensitivity to spurious 60 cps modulation. At a 50 cps reference frequency a 10 cps beat note can appear in the synchronous detector output. This signal is attenuated by the output time constant but it can still be a source of difficulty. For this reason, the receiver has an optional 60 cps rejection filter. The filter is optional because it distorts the square-wave modulation waveform; this may be harmful in some cases.

The theoretical RMS fluctuation of the NRAO standard receiver is given by,

$$\Delta T = \frac{\sqrt{2}\,(T_R + T_A)}{\sqrt{B\tau}}$$

when B is the IF or RF noise bandwidth and $\tau$ is the RC time constant. If an ideal integration over a time period, $\tau$, is used, then the RMS fluctuation is $\sqrt{2}$ times larger.

## III. Detailed Description

### A. IF Amplifier

A block diagram of the components in the IF amplifier tray is shown in Figure 4. These components can be patched together in various combinations. Coaxial pads are sometimes required to isolate the amplifiers and filters.

The input attenuator in the IF amplifier tray is set to a nominally correct value when the receiver front-end is installed. The GAIN CONTROLS, located on the gain modulator chassis, are then used to make up small variations. The 1 DB STEPS control gives a ± 6 dB variation in IF attenuation proceeding the gain modulator. A 0-3 dB 5-turn control is used to give a fine variation in the gain after detection. The GAIN CONTROLS should be adjusted to give a 1 volt reading on the total power output meter. This output is not critical and outputs between 0.5 volt and 2 volts will cause no harm.

### B. Gain Modulator

A block diagram of the gain modulator and square-law detector is shown in Figure 5. The gain modulation is accomplished by switching with diode switches between a fixed attenuator (in the circuit when the front-end switch is in the antenna position) and a variable attenuator. The variable attenuator is the COARSE GAIN RATIO control on the front panel. This control varies the gain modulation factor, $\alpha$ (defined in Section I), from -9 dB (.126) to +3 dB (2.0) in 1 dB steps.

The FINE GAIN RATIO control is a 10-turn potentiometer which gives a ± 0.7 dB variation in the gain modulation factor; the resolution of this control is approximately ± .001 dB. The variation of attenuation is produced by adjusting the current through variable-resistance PIN diodes in gain modulator switches.

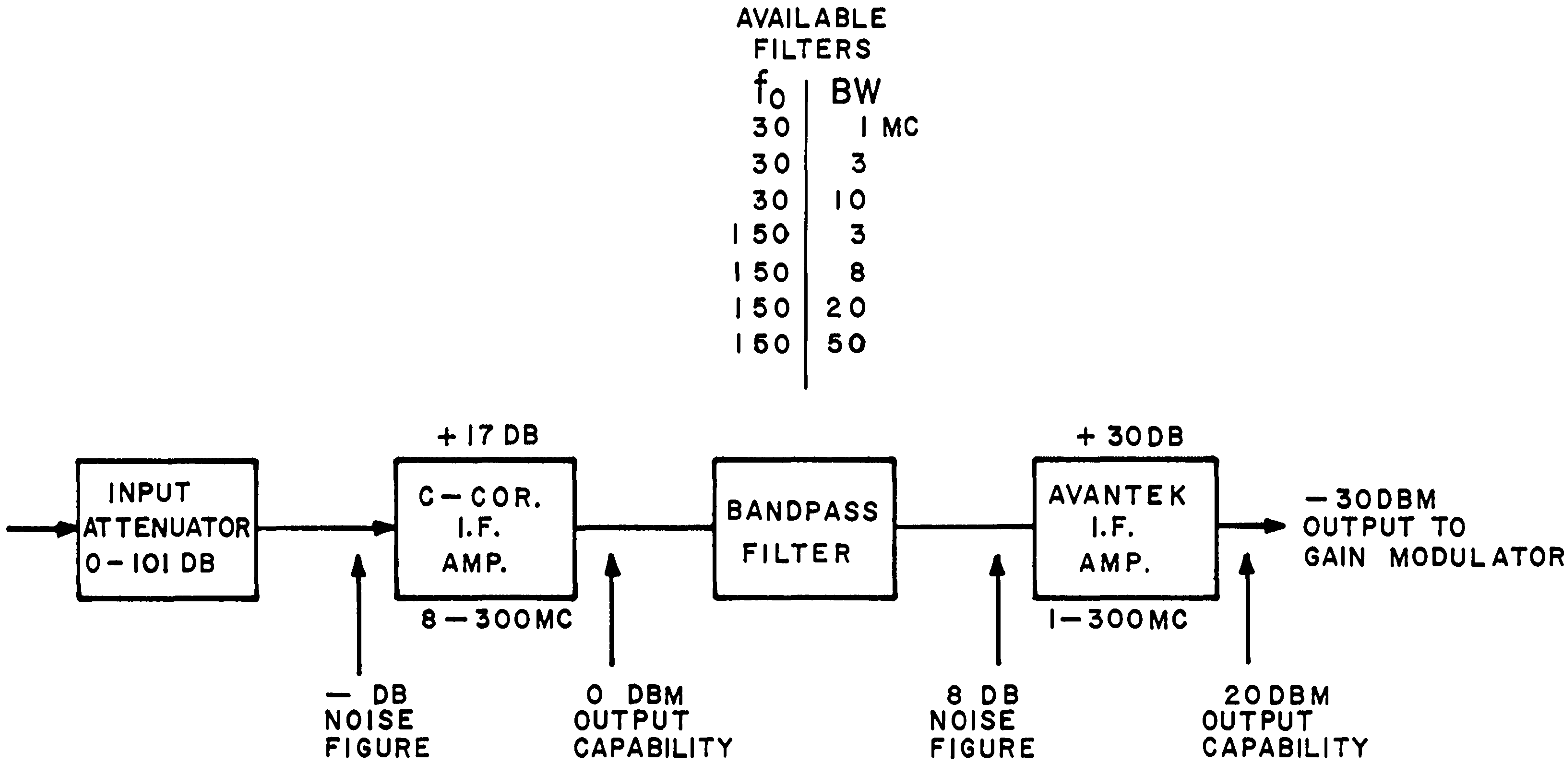



Figure 4 — IF Amplifier Tray

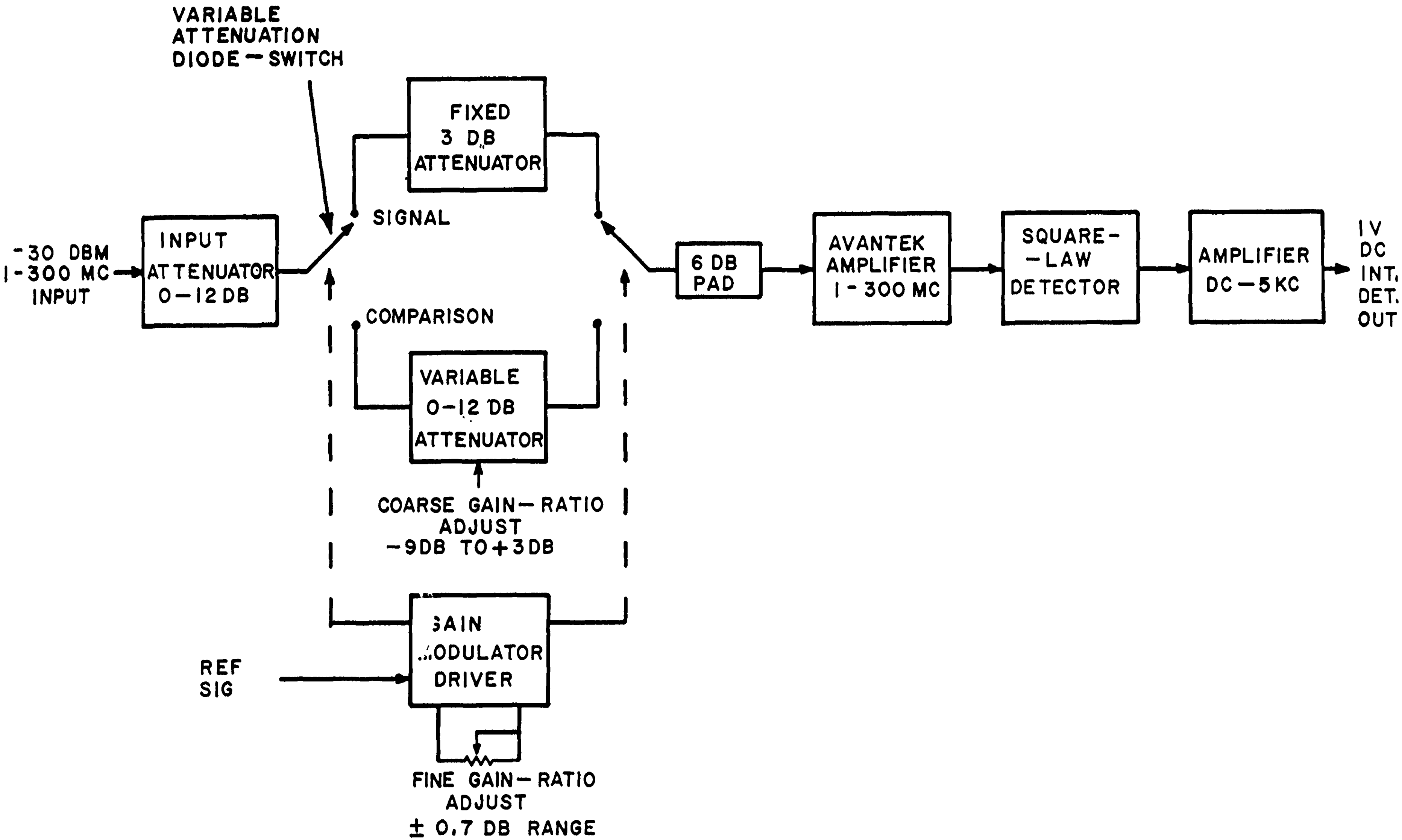



Figure 5 — Gain Modulator and Square-Law Detector

B. (continued):

The GAIN MODULATOR OPERATION switch allows the gain modulator to be turned OFF (locked in a fixed attenuation position), ON (modulated), or LOCK COMP (locked in the variable attenuator position).

C. Total Power Amplifier

The total power amplifier supplies a differential input, a 60 cps rejection filter, a blanking circuit, and metering circuits for the total power signal. The amplifier has unity gain and normally operates with 1 volt DC input and output. The input may arise from the internal square-law detector or from an external detector; this choice is made at the receiver top panel. A block diagram of the unit is shown in Figure 6.

The 60 CPS FILTER switch on the front-panel allows the 60 cps filter to be inserted (IN) or removed (OUT). The filter should only be used if there is a 60 cps spurious signal evident on an oscilloscope presentation of the total power signal. This 60 cps signal will cause a 10 cps beat note to occur on the synchronous detector output if a 50 cps reference frequency is used. A 60 cps spurious signal will have less effect at the other switch frequencies. The rejection filter will reduce the 60 cps signal by at least a factor of 10 but causes some distortion of the switched signal waveform; this distortion may increase the RMS fluctuation slightly.

The blanking circuit is to eliminate switch transients before they can overload further circuitry. The BLANKING INTERVAL switch on the reference generator adjusts the fraction of the switch cycle which is blanked. This fraction reduces the effective integration time and should be kept as small as possible. The BLANKING INTERVAL should be adjusted by observing the switch transients on the total power signal.

A 0-3 DB GAIN CONTROL allows a fine adjustment of gain. The helipot dial setting (500 to 1000) can be interpreted directly as a .500 to 1.000 gain multiplier.

The METER MID-SCALE switch allows the meter range to be changed. The usual setting is IV; the gain controls should then be adjusted so that the meter reads mid-scale. The NORMAL - X 10 SCALE EXPAND allows the middle 10 percent of the meter scale to be expanded by a factor of 10 to measure small changes in total power. A X10 scale expand output with a 1 second time constant is also provided to drive a chart recorder. This output is independent of the NORMAL - X10 SCALE EXPAND switch setting but is dependent upon the METER MID-SCALE switch setting. The synchronous detector output is independent of both switch settings.

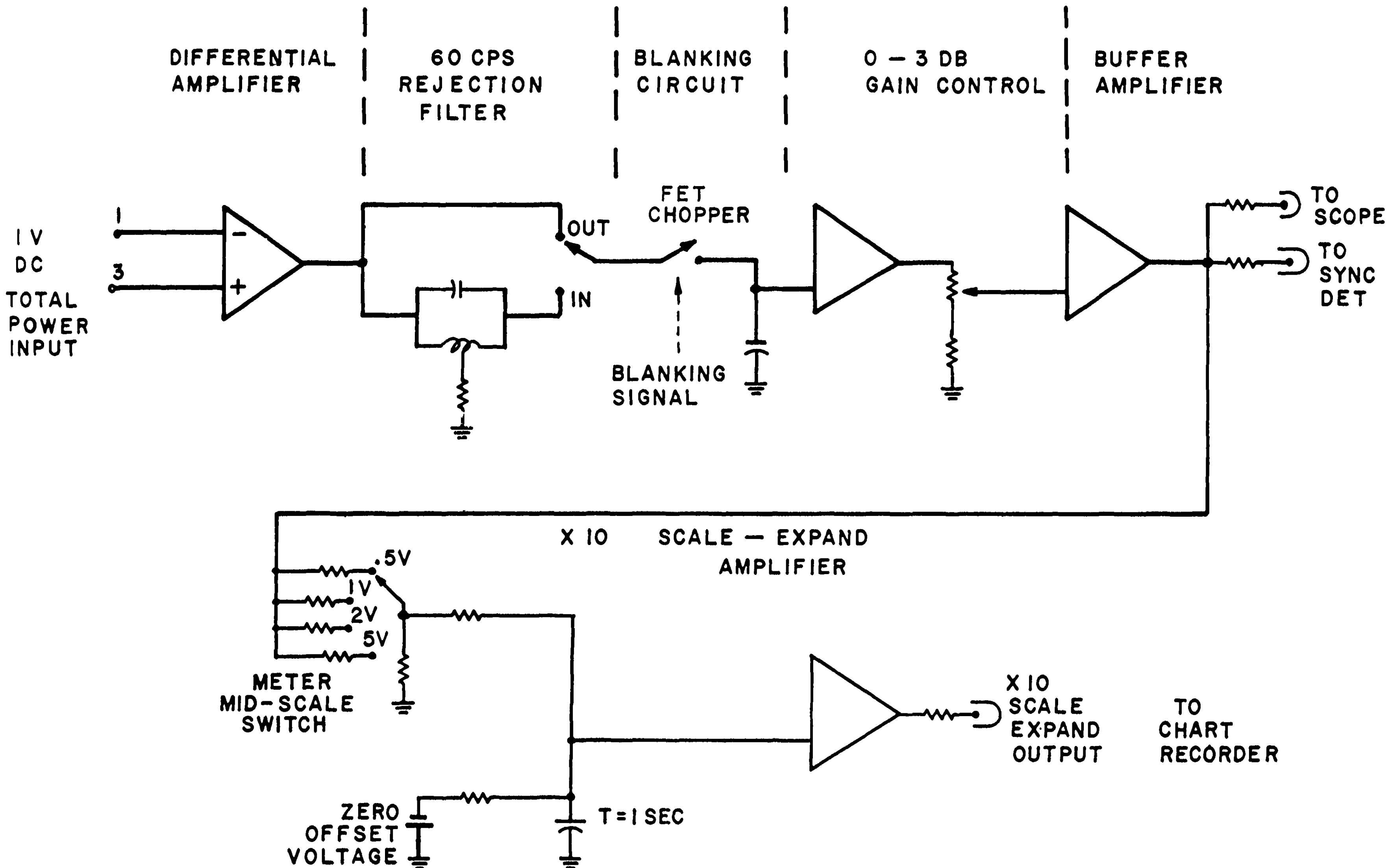



Figure 6 — Total Power Amplifier Block Diagram

C. (continued):

The ZERO TEST push button removes the RF signal from the detector and is useful for zero setting the total power output. This zero setting is important only for linearity measurements and for receiver noise temperature measurements.

D. Synchronous Detector

A block diagram of the synchronous detector is shown in Figure 7. The unit is quite complex because in addition to a basic synchronous detector it has a differential input (to eliminate ground problems), a post-detection gain modulator, scale controls, a variety of time constants, a high resolution zero offset, blanking circuits, and overload detection circuits.

The FUNCTION switch selects the mode of operation. In most cases this is the SYNC DET > 10 CPS position. If the reference frequency is < 10 cps, the SYNC DET < 10 CPS position should be used; the unit then operates correctly for reference frequencies down to 1 cps but has a long overload recovery time. In the other positions of the FUNCTION switch the unit does not function as a synchronous detector. In the TOT PWR position the receiver total power is measured. In the GATED SIG and GATED COMP positions the total power during antenna and comparison switch cycles is measured. The following table may be useful:

| FUNCTION SWITCH SETTING | OUTPUT PROPORTIONAL TO |
|---|---|
| SYNC DET $\gtrless$ 10 | $T_A - T_C$ |
| TOT PWR | $T_R + 1/2\ T_A + 1/2\ T_C$ |
| GATED SIG | $T_R + T_A$ |
| GATED COMP | $T_R + T_C$ |

where $T_R$ is the receiver noise temperature, $T_A$ is the antenna temperature, and $T_C$ is the reference load temperature.

The GAIN MODULATOR RANGE switch allows the post-detection gain modulator to be turned OFF or allows selection of various ranges for the gain modulation ratio, $\alpha$. The GAIN RATIO control then gives a linear (± 0.25 percent) variation in the selected range.

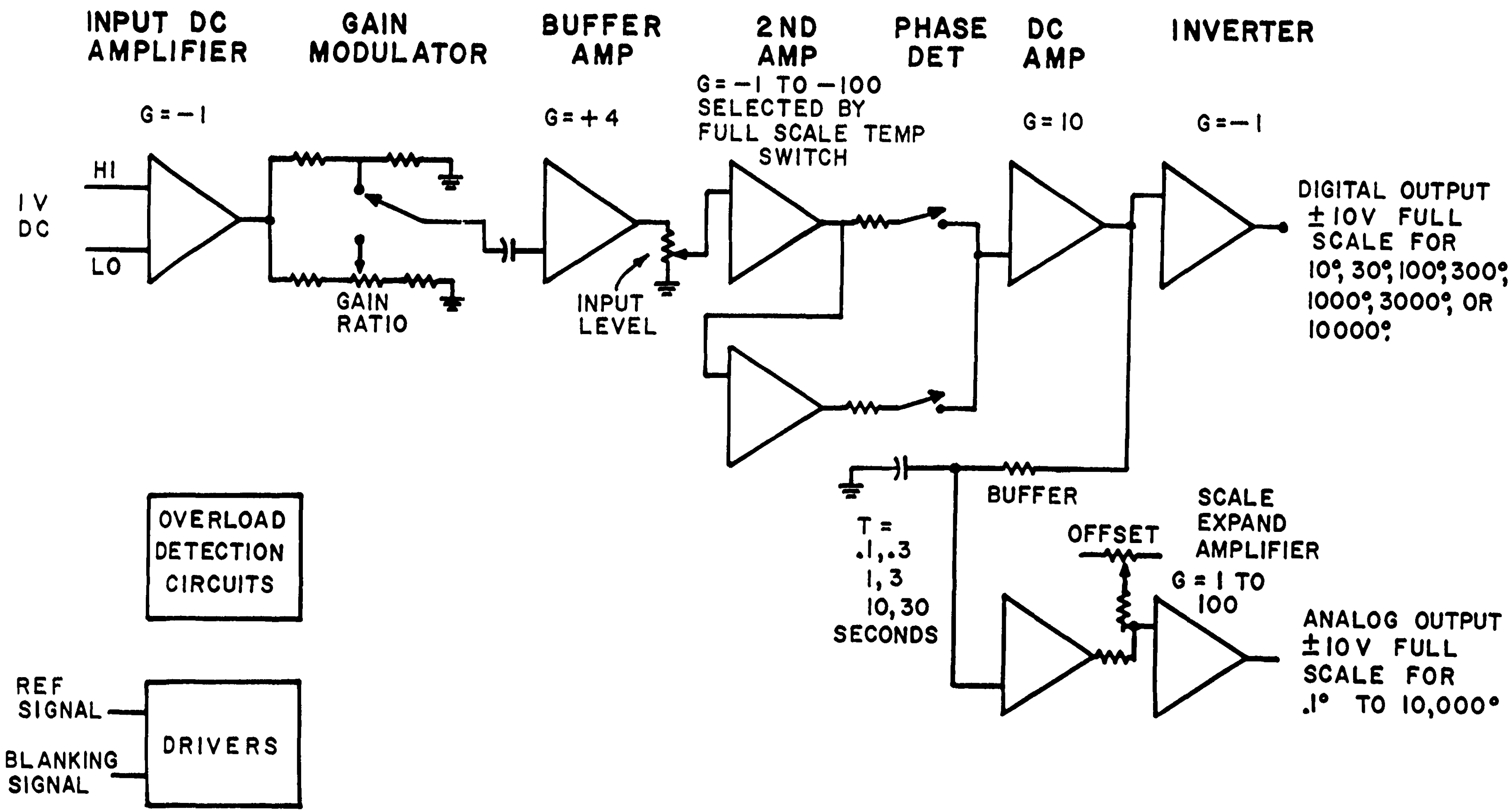



Figure 7 — Synchronous Detector Functional Diagram

The INPUT LEVEL control is simply a gain control; it should be adjusted so that the FULL SCALE TEMPERATURE ranges are correct as tested with a calibration signal. This will occur when the INPUT LEVEL helipot dial setting (0 to 1000) is set equal to the system noise temperature and the total power output voltage is 1 volt. If the system noise temperature is > 1000°, then the total power output should be increased to K volts and the INPUT LEVEL control will have a range of 0 to K x 1000 degrees.

The FULL SCALE TEMPERATURE range switch refers to the maximum temperature (before overload) which can be tolerated on the digital output or on the analog output with SCALE EXPAND at X1. This full scale temperature gives 10 volts output and will drive the meter to full scale.

The METER-MONITOR switch selects the variable displayed on the meter and presented on the front-panel and rear-panel monitor jacks. In the INPUT position, the total power voltage is monitored (the meter must read left of center). The most often used positions are ANALOG OUT and DIGITAL OUT which allow monitoring of the two synchronous detector outputs. The meter scale is always ± 10 volts full scale.

All of the controls to the right of the meter affect only the analog output signal. The SCALE EXPAND switch allows the full scale temperature (± 10 volts output) to be reduced by up to x 100 with an accuracy of ± 2%. The OFFSET RANGE switch and ZERO OFFSET controls allow the analog output zero to be shifted up to the full scale temperature (before expansion) value. The TIME CONSTANT switch allows selection of time constants between 0.1 second and 30 seconds of the analog output. (The digital output time constant is 20 ms.)

## IV. Input-Output Connections and Levels

**Power** 120 V, 60 Hz power is supplied to the rack through a 3-prong twist-lock connector located in the lower left corner of the back of the rack.

Power is available in the rack on two fused terminal strips, one of which is available from the front of the receiver.

**Top Panel** All necessary connections to the standard receiver can be made on the top panel. Please note which connections should be jumpered together for normal operation.

| Name | Level In or Out | Type of Connector | Drawing S 2.462- | Function |
|---|---|---|---|---|
| Ref x 128 Out | 0 to -6 V | BNC | 1 | To slave another reference generator jumper to Ext Ref in and set frequency selector switch to Ext/128. |
| Ref Out | 0 to -6 V | BNC | 1 | Additional reference output. |
| Sampling Sync | 0 to -6 V | BNC | 1 | Output for synchronizing a digital output system to reference frequency. (There is no connection to this jack on most receivers.) |
| Spare | --- | BNC feed through | | |
| Spare | --- | BNC feed through | | |
| Ref Sync Input | 0 to -6 V | BNC | 1 | Used to Sync Ref generator to a timing signal. A positive going pulse will reset all Ref Gen counters to a logical "0". |
| Spare | --- | BNC | | |
| Ext Ref In | 0 to -6 V | BNC | 1 | Input used to slave Ref Generators. (See Ref x 128 Out.) Note — When frequency selector switch is set to external, a 0 volt signal on the Ext Ref In produces a -6 V at the Ref Out. |
| Scope In-Out | --- | Floating BNC feed through | 11 | This is connected directly across the vertical input of the oscilloscope. |
| IF Out | -30 dBm nominal | BNC feed through | 4 | Output of IF amplifier tray. |
| Int Det Out | +1 V DC | BNC feed through | 8 | Output of HP 423A detector. |
| TP x 10 Out | 1 V/10% gain change | BNC feed through | 8 | Total power output for chart recorder. One volt represents 10% gain change |
| Sync Det Analog Out | 0 to ± 10 V | BNC feed through | 13 | Output for chart recorder |

VI. (continued):

| Name | Level In or Out | Type of Connector | Drawing S 2.462- | Function |
|---|---|---|---|---|
| Spare | --- | BNC feed through | | |
| Ferrite Switch | 0 to ± 100 V | 4 Pin MS/AN | 2 | Drive for ferrite switch 100 V, 0.9 amp maximum. |
| Marker Input | Depends on type of Chart Recorder | 4 Pin MS/AN | | Connects to marker pens on edges of chart recorder. |
| Input | -70 dBm 2-300 MHz | Type N | 4 | IF input to receiver. |
| G.M. In | -30 dBm nominal | BNC feed through | 5 | Gain modulator input. |
| Det Signal In | +1 V DC | 3 Pin Audio | 8 | Input for detected signal. |
| Chart Recorder A | 0 to ± 10 V | 3 Pin Audio | | Chart recorder inputs Pin No. 1 positive, Pin No. 2 negative, Pin No. 3 ground |
| Chart Recorder B | 0 to ± 1 V | 3 Pin Audio | | |
| Spare | ---- | 4 Pin MS/AN | | |
| Diode Switch | 0 to ± 20 V | 4 Pin MS/AN | 2 | Drive for diode switch ± 20 V, 0.5 amp. |
| Sync Det Dig Out | 0 ± 10 V | BNC feed through | 13 | A 0 to ± 10 V DC output from the synchronous detector for use by the digital recording system. |

In Normal Operation, these will be jumpered on the top panel:

| | | |
|---|---|---|
| IF OUT | to | G.M. IN |
| INT DET OUT | to | DET SIG IN |
| T.P. X 10 OUT | to | CHART RECORDER A |
| SYNC DET ANALOG OUT | to | CHART RECORDER B |

Switch Drive Connections

Improper switch connections can damage the switch.

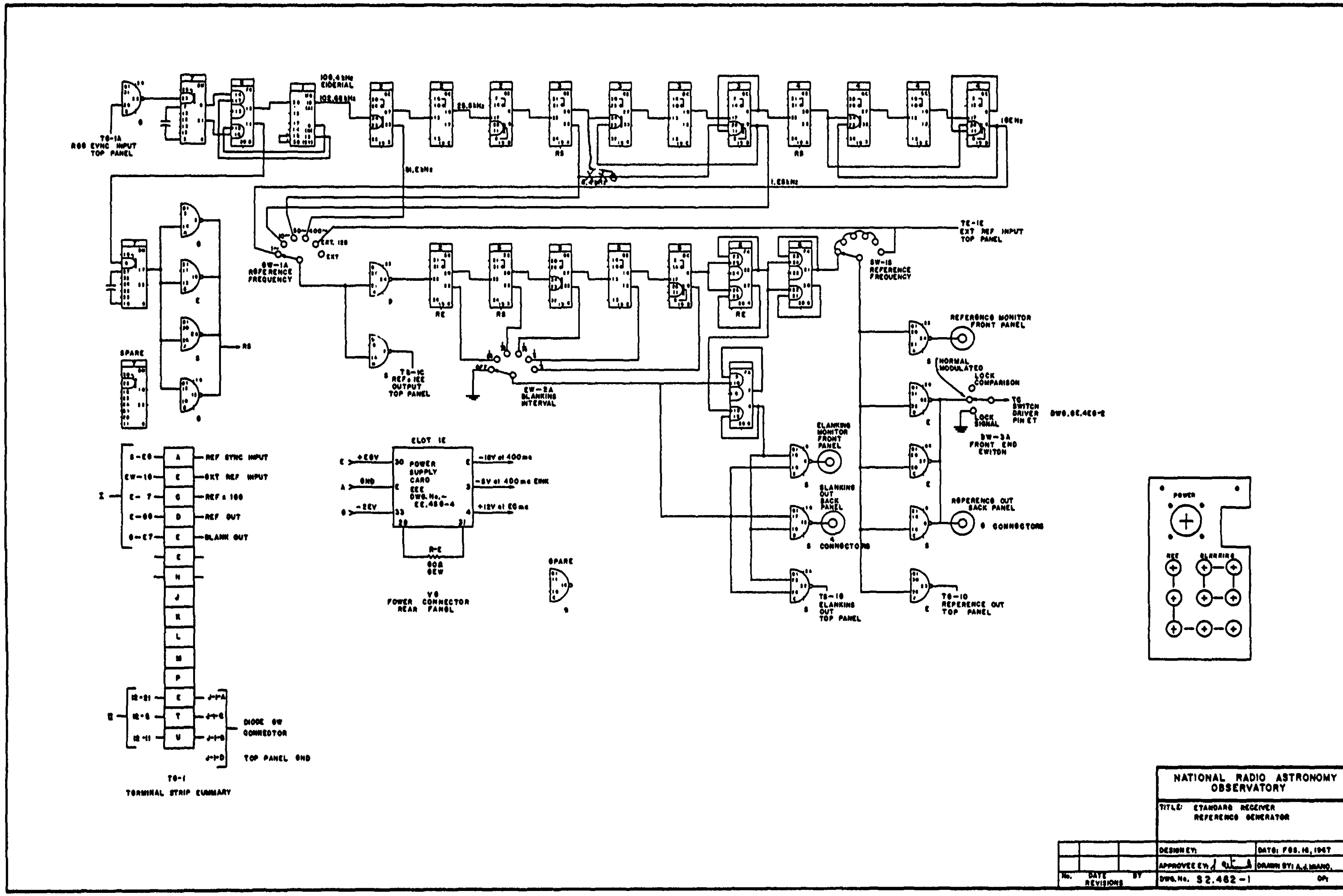
Diode Switches — There is no current limiting built into the standard receiver. Level and zero controls are on the Harrison 6823A power amplifier. See Standard Receiver Switch Driver Wiring — Dwg. No. S2.462-2.

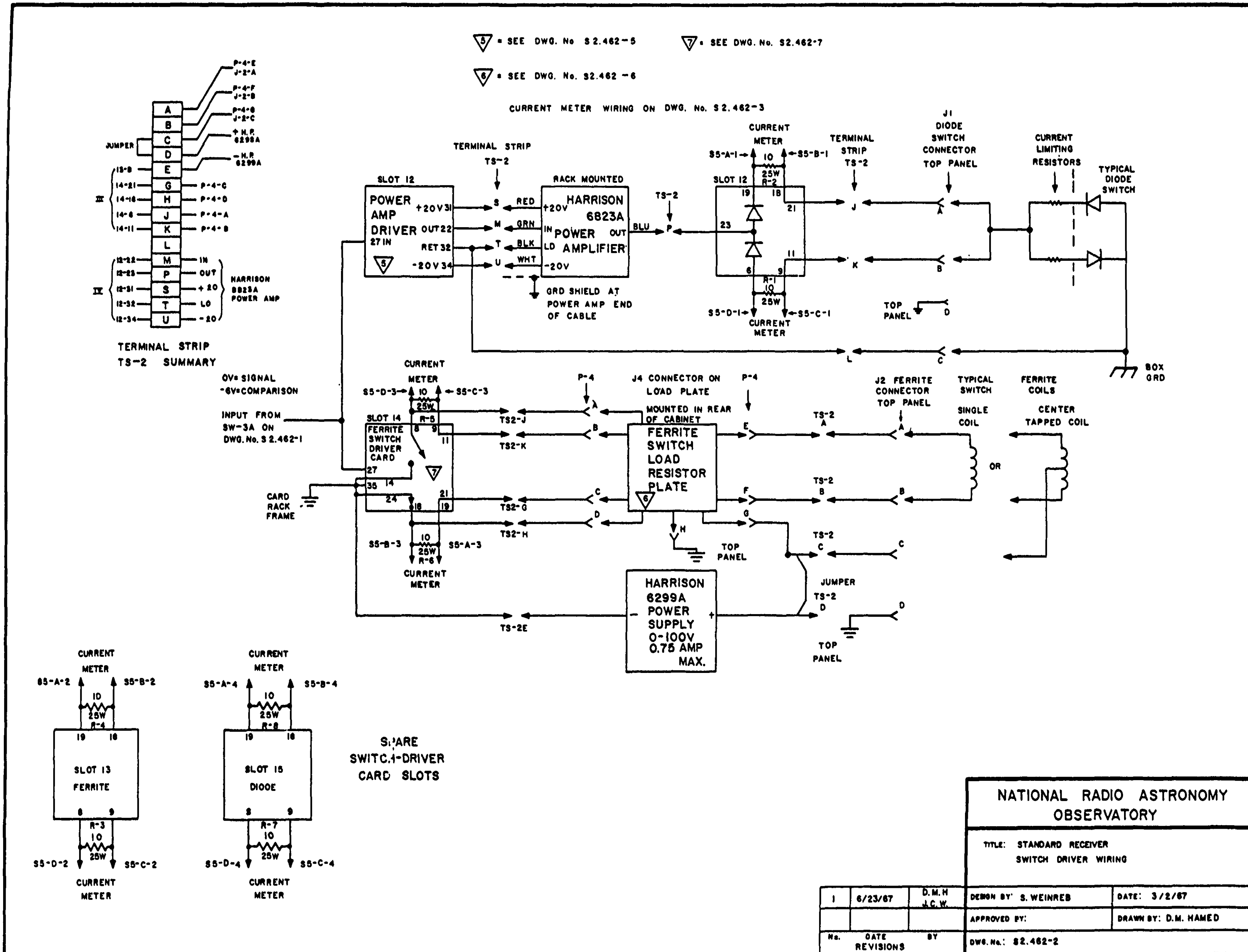
Ferrite Switches — See: Standard Receiver Ferrite Switch Load Resistor Plate — Dwg. No. S2.462-6, and Standard Receiver Switch Driver Wiring — Dwg. No. S2.462-2.

For single tap, coil current flows from A to B during signal. For center tap, current flows out B during signal.

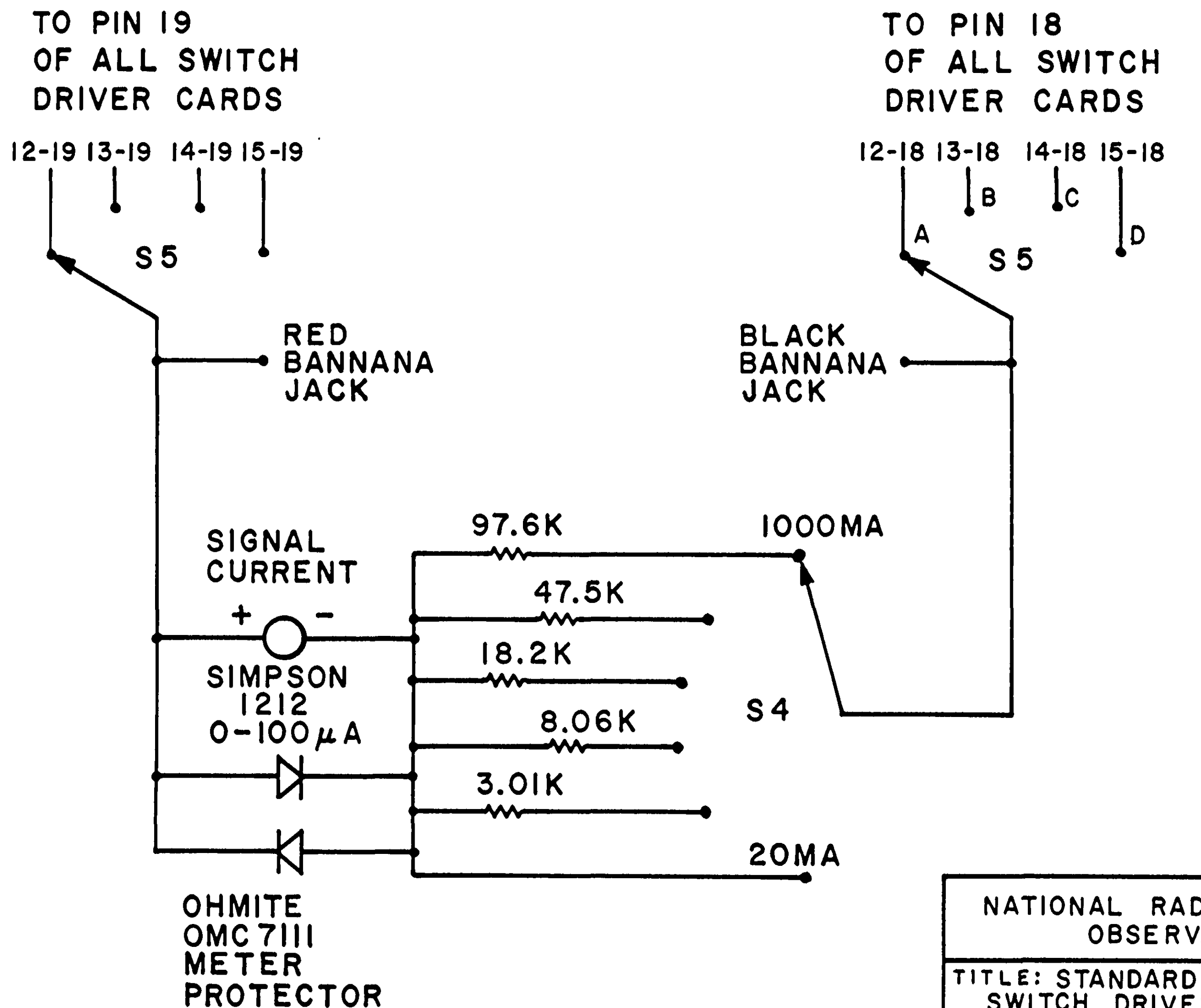
Switch connections should always be checked with dummy loads before connecting switch.

## V. Schematic Diagrams


TS-1A
REF SYNC INPUT
TOP PANEL
100.4 kHz
SIDERIAL
1 GHz
TS-1E
EXT REF INPUT
TOP PANEL
SW-1A
REFERENCE
FREQUENCY
EXT
SW-1B
REFERENCE
FREQUENCY
SPARE
TS-1C
REF x 100
OUTPUT
TOP PANEL
SW-2A
BLANKING
INTERVAL
REFERENCE MONITOR
FRONT PANEL
NORMAL
MODULATED
LOCK
COMPARISON
LOCK
SIGNAL
TO
SWITCH
DRIVER
PIN ET
SW-3A
FRONT END
SWITCH
BLANKING
MONITOR
FRONT
PANEL
BLANKING
OUT
BACK
PANEL
CONNECTORS
REFERENCE OUT
BACK PANEL
CONNECTORS
TS-1D
BLANKING
OUT
TOP PANEL
TS-1D
REFERENCE OUT
TOP PANEL
REF SYNC INPUT
EXT REF INPUT
REF x 100
REF OUT
BLANK OUT
DIODE SW
CONNECTOR
TOP PANEL GND
TS-1
TERMINAL STRIP SUMMARY
SLOT 12
POWER
SUPPLY
CARD
GND
-12V at 400 ma
-5V at 400 ma
+12V at 25 ma
V5
POWER CONNECTOR
REAR PANEL
SPARE
POWER
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: STANDARD RECEIVER
REFERENCE GENERATOR
DESIGN BY:
DATE: FEB. 16, 1967
APPROVED BY:
DRAWN BY: A. J. MANO.
DWG. No. 32.462-1
No.
DATE
BY
REVISIONS



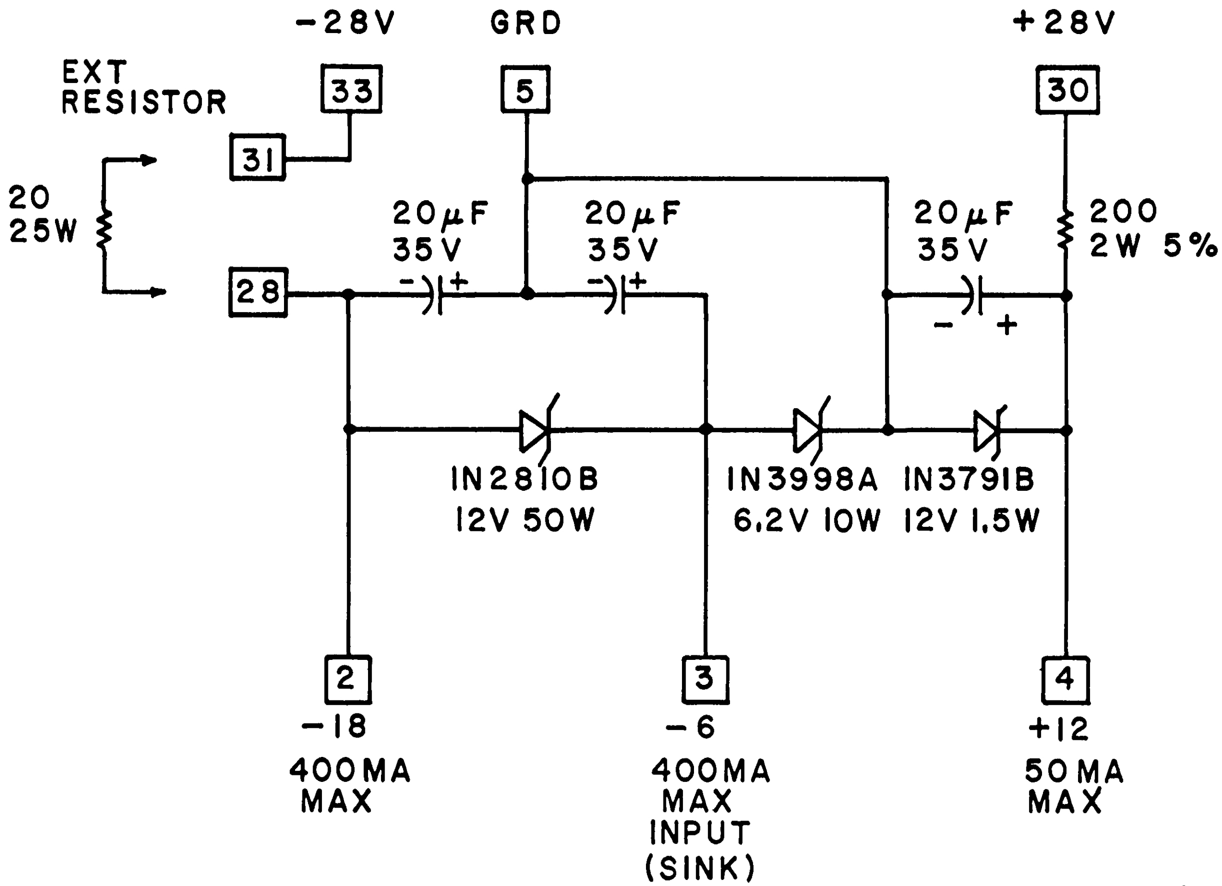
5 = SEE DWG. No S2.462-5
6 = SEE DWG. No. S2.462-6
7 = SEE DWG. No. S2.462-7
CURRENT METER WIRING ON DWG. No. S2.462-3
JUMPER
TERMINAL STRIP
TS-2 SUMMARY
HARRISON 6823A POWER AMP
SLOT 12
POWER AMP DRIVER
TERMINAL STRIP TS-2
RACK MOUNTED
HARRISON 6823A POWER AMPLIFIER
RED
GRN
BLK
WHT
BLU
GRD SHIELD AT POWER AMP END OF CABLE
CURRENT METER
TERMINAL STRIP TS-2
J1 DIODE SWITCH CONNECTOR TOP PANEL
CURRENT LIMITING RESISTORS
TYPICAL DIODE SWITCH
TOP PANEL
BOX GRD
0V= SIGNAL
-6V=COMPARISON
INPUT FROM SW-3A ON DWG. No. S2.462-1
SLOT 14
FERRITE SWITCH DRIVER CARD
CARD RACK FRAME
J4 CONNECTOR ON LOAD PLATE
MOUNTED IN REAR OF CABINET
FERRITE SWITCH LOAD RESISTOR PLATE
J2 FERRITE CONNECTOR TOP PANEL
TYPICAL SWITCH
FERRITE COILS
SINGLE COIL
CENTER TAPPED COIL
OR
HARRISON 6299A POWER SUPPLY 0-100V 0.75 AMP MAX.
JUMPER
TOP PANEL
SLOT 13 FERRITE
SLOT 15 DIODE
SPARE SWITCH-DRIVER CARD SLOTS
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: STANDARD RECEIVER SWITCH DRIVER WIRING
1 6/23/67 D.M.H J.C.W.
No. DATE REVISIONS BY
DESIGN BY: S. WEINREB
DATE: 3/2/67
APPROVED BY:
DRAWN BY: D.M. HAMED
DWG. No.: S2.462-2




WIRING OF COMPARISON CURRENT
METER IS IDENTICAL EXCEPT
PINS 9 & 8 ARE USED.

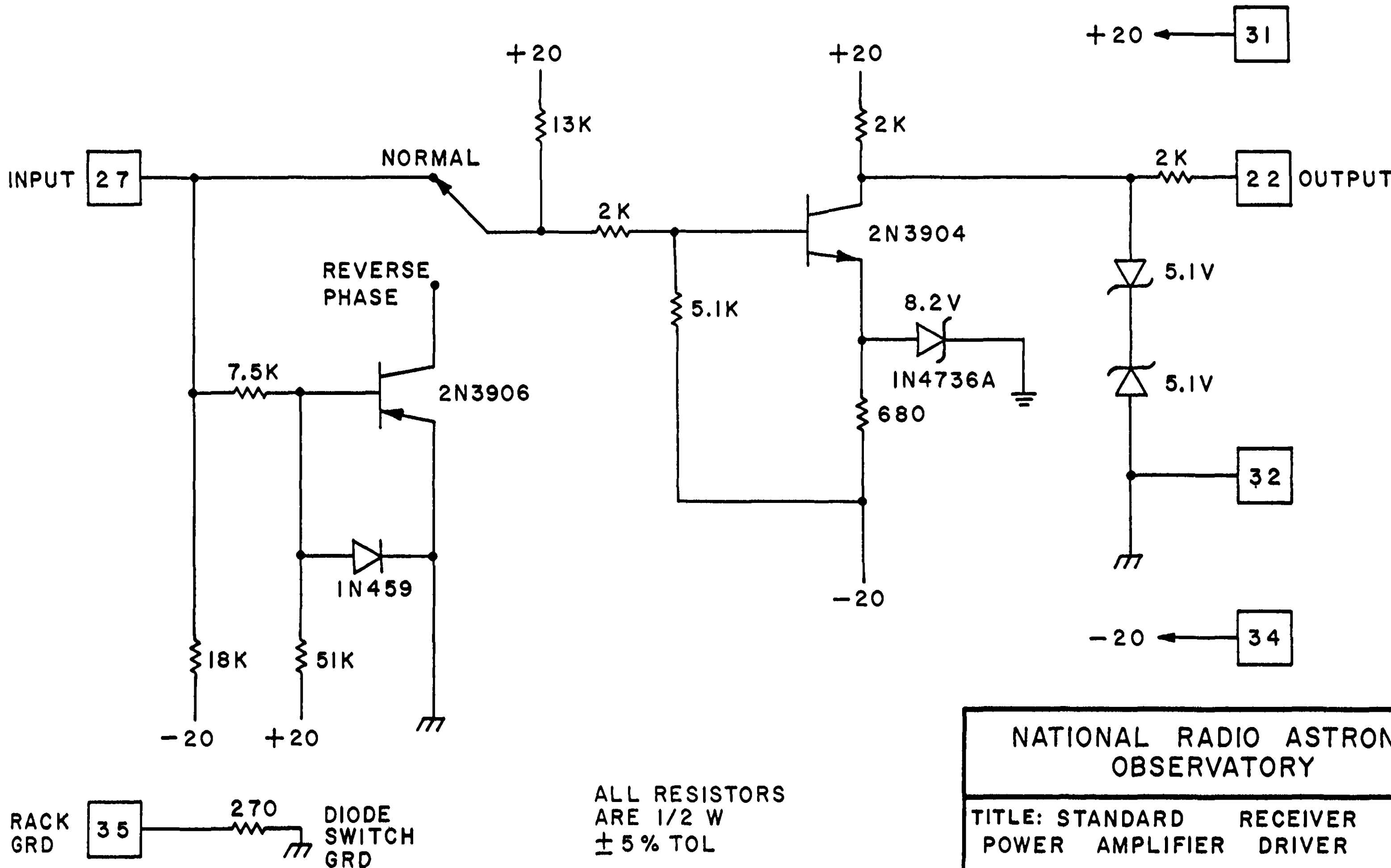
ALL RESISTORS
1%, 1/8W

| | |
|---|---|
| NATIONAL RADIO ASTRONOMY OBSERVATORY | |
| TITLE: STANDARD RECEIVER SWITCH DRIVER CURRENT MONITOR | |
| DSGN.BY: S.WEINREB | DATE: 2-12-66 |
| APP'D. BY: | DR.BY: A.J.MIANO |
| DWG.NO. S2·462-3 | |




MOUNT IN2810B & IN3998A
ON WAKEFIELD NC621 HEAT SINKS

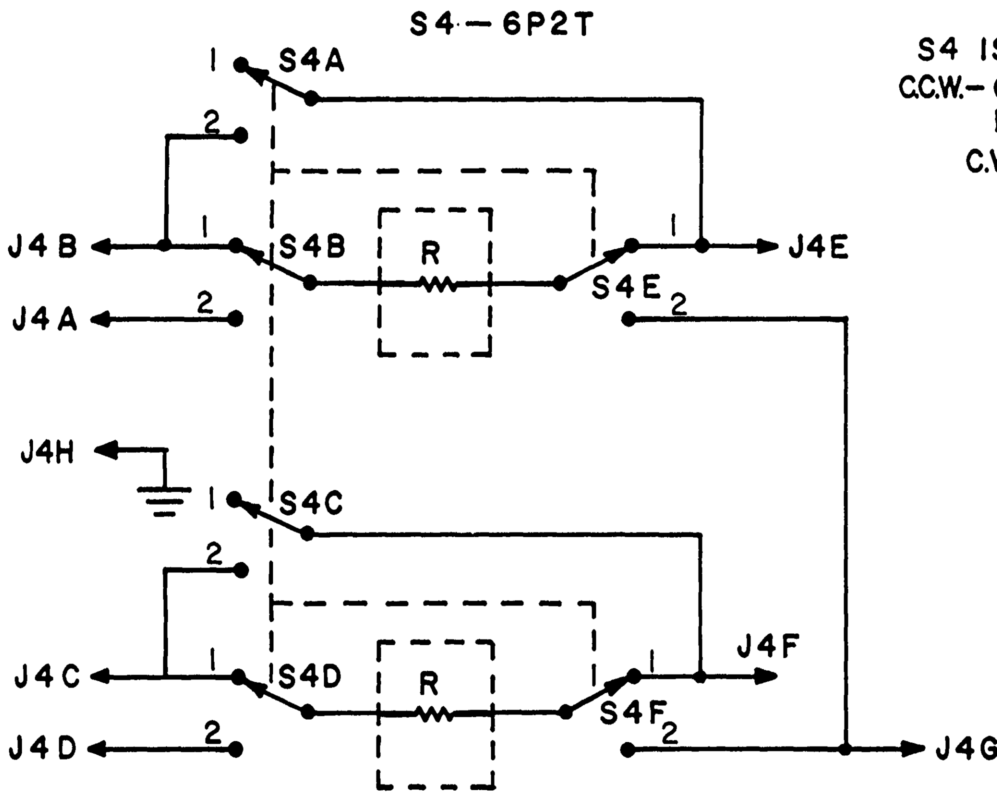
| | |
|---|---|
| NATIONAL RADIO ASTRONOMY OBSERVATORY | |
| TITLE: STANDARD RECEIVER POWER SUPPLY MODULE | |
| DSGN. BY: S. WEINREB. | DATE: 2-12-66 |
| APPD. BY: | DR. BY: A.J. MIANO. |
| DWG NO S2-462-4 | |




NATIONAL RADIO ASTRONOMY OBSERVATORY

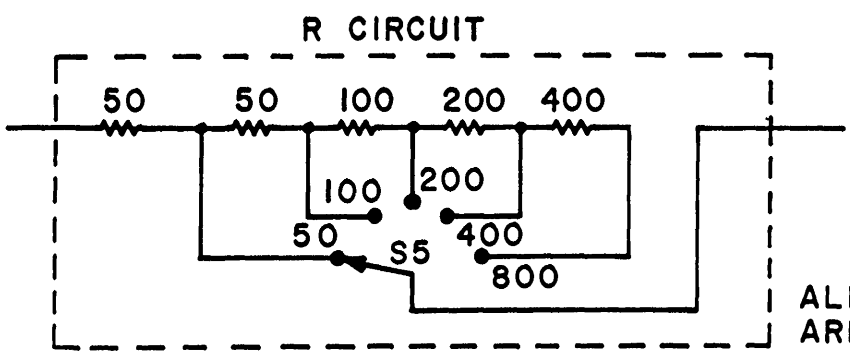
TITLE: STANDARD RECEIVER POWER AMPLIFIER DRIVER

| NO. | DATE | BY | DESIGN BY: R.MAUZY | DATE: 2-9-67 |
|---|---|---|---|---|
| | | | APPROVED BY: | DRAWN BY: A.J.MIANO. |
| REVISIONS | | | DWG. NO. S 2.462-5 | |




S4 IS FERRITE SWITCH TYPE SELECTOR
C.C.W.– CENTER TAPPED SWITCH OR MAGNETICALLY BIASED SWITCH
C.W.– SINGLE COIL REVERSE CURRENT SWITCH

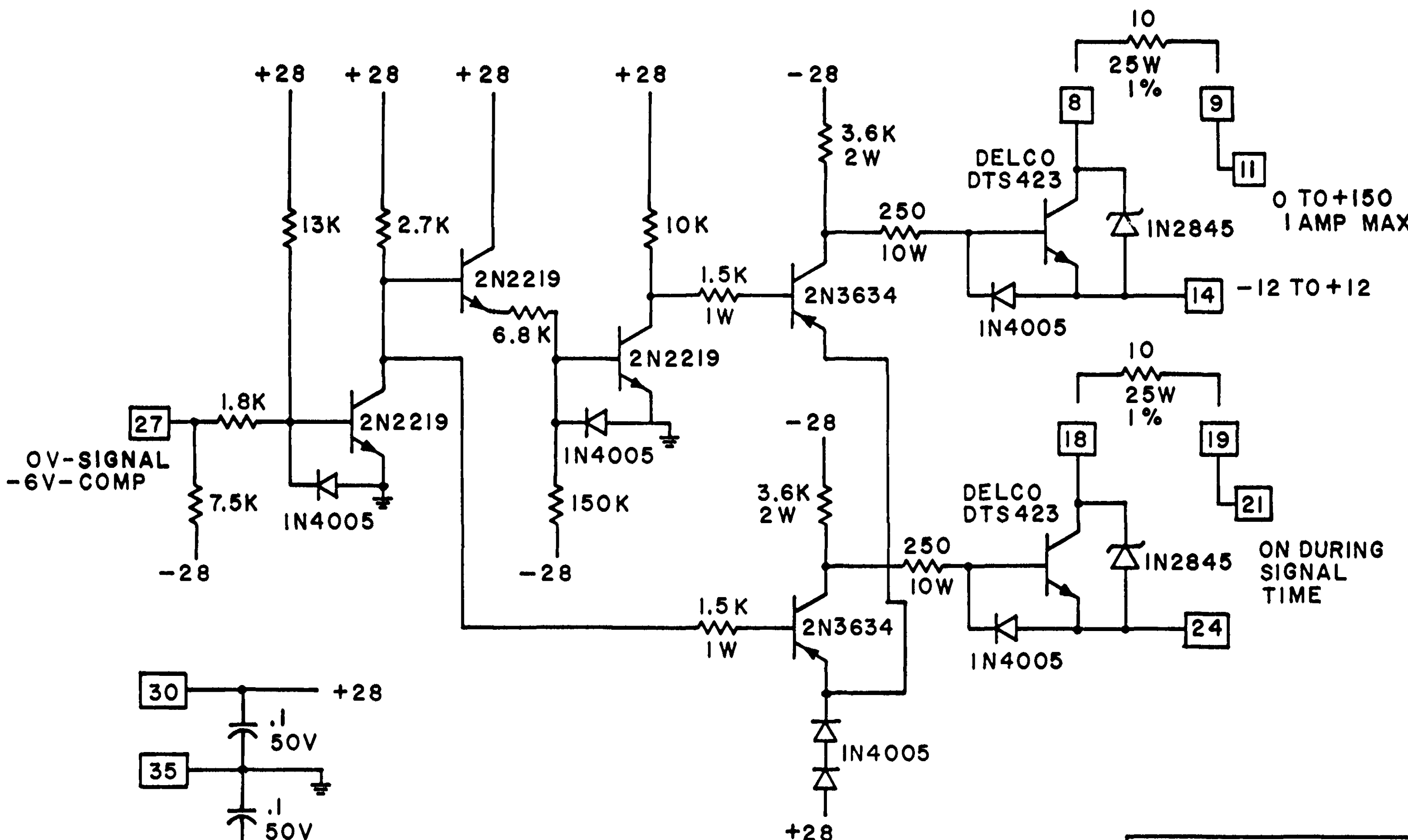
NOTE: S-4 CTS-T-9
S-5 CTS-T-2
INDEX CTS-T-79
J-4 AMP 3102A-18-1P




ALL RESISTORS ARE DALE 50W-1%

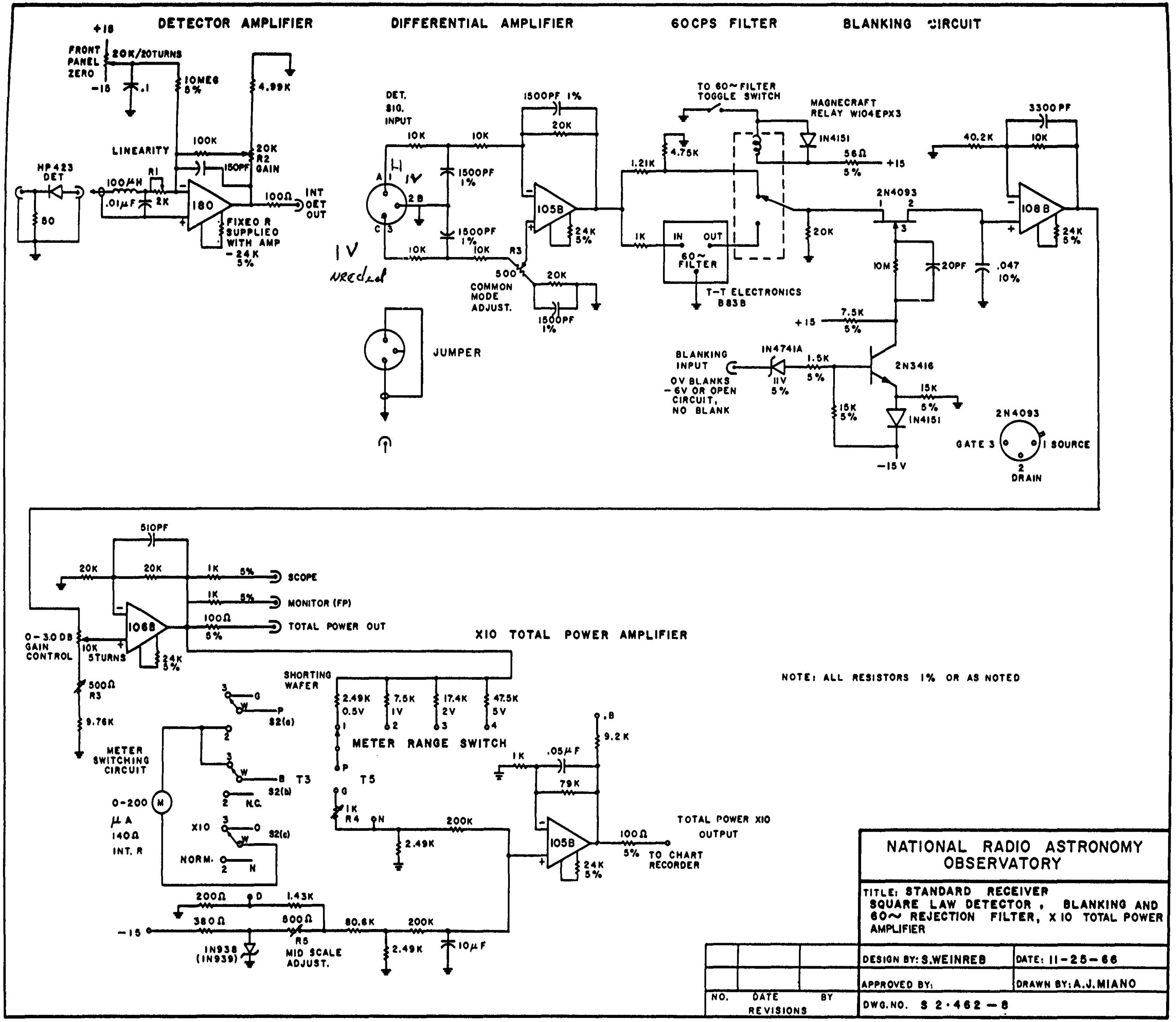
FERRITE SWITCH LOAD RESISTOR SELECTOR SWITCH S5 –2P5T

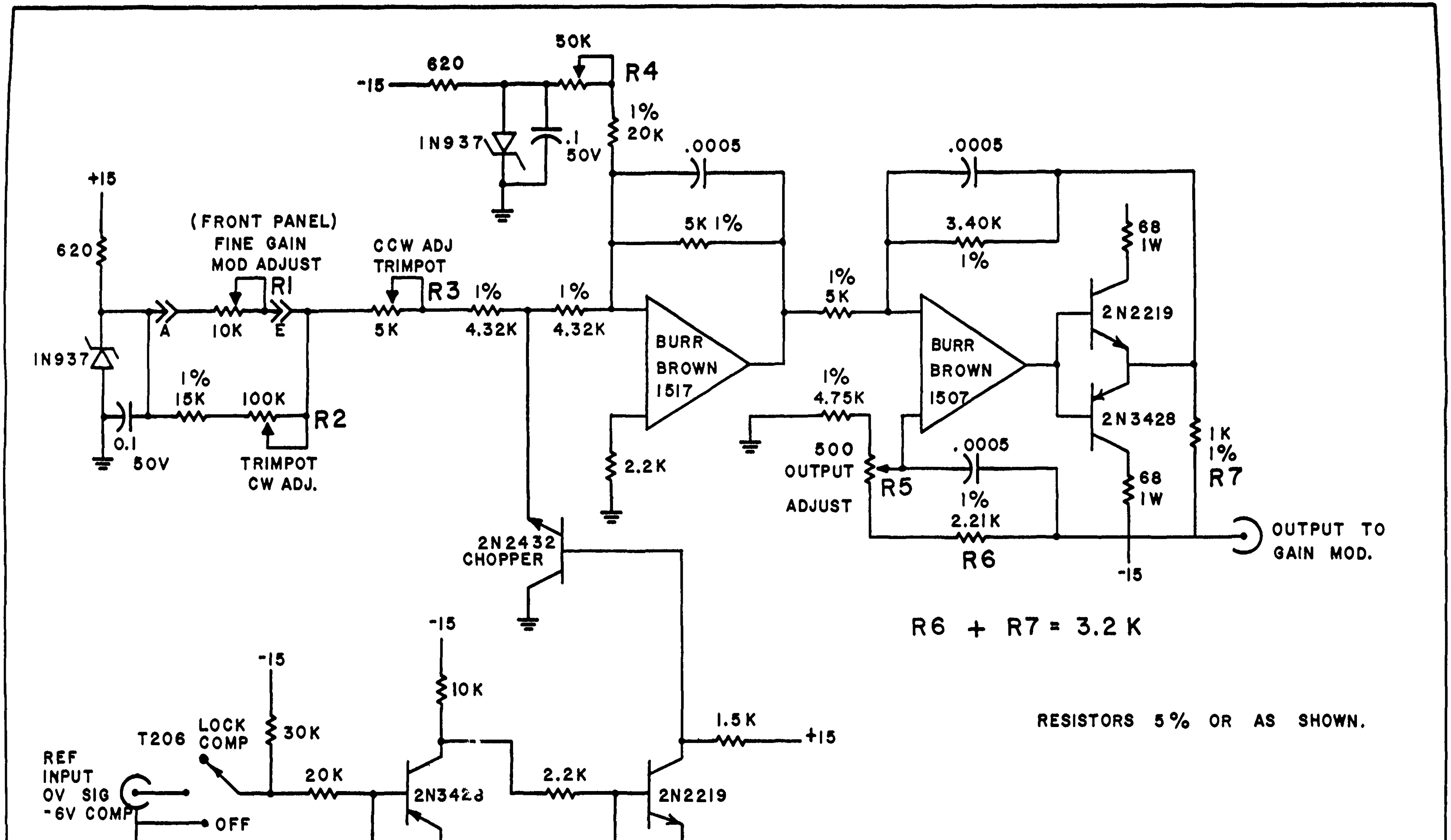
| NATIONAL RADIO ASTRONOMY OBSERVATORY | |
|---|---|
| TITLE: STANDARD RECEIVER FERRITE SWITCH LOAD RESISTOR PLATE | |
| DSGN.BY: S.WEINREB | DATE: 2-9-67 |
| APPD.BY: | DR.BY: A.J.MIANO |
| DWG.NO. S 2·462–6 | |




ALL RESISTORS 1/2W, 5%
UNLESS OTHERWISE INDICATED

| | |
|---|---|
| NATIONAL RADIO ASTRONOMY OBSERVATORY | |
| TITLE: STANDARD RECEIVER SWITCH DRIVER MODULE (FERRITE) | |
| DSGN. BY: S. WEINREB | DATE: 2-12-66 |
| APPD. BY: | DR. BY: A.J. MIANO. |
| DWG. NO. S 2·462—7 | |


DETECTOR AMPLIFIER
DIFFERENTIAL AMPLIFIER
60CPS FILTER
BLANKING CIRCUIT
+15
FRONT PANEL ZERO
20K/20TURNS
-15
10MEG 5%
4.99K
LINEARITY
100K
20K R2 GAIN
150PF
HP423 DET
100μH
R1
2K
.01μF
50
180
FIXED R SUPPLIED WITH AMP
-24K 5%
100Ω
INT DET OUT
DET. SIG. INPUT
10K
1500PF 1%
1500PF 1%
20K
105B
24K 5%
R3
500
COMMON MODE ADJUST.
1500PF 1%
1V
1V needed
JUMPER
TO 60~ FILTER TOGGLE SWITCH
MAGNECRAFT RELAY W104EPX3
1N4151
4.75K
1.21K
56Ω 5%
1K
IN OUT
60~ FILTER
T-T ELECTRONICS B83B
2N4093
20K
10M
20PF
.047 10%
3300PF
40.2K
108B
7.5K 5%
BLANKING INPUT
0V BLANKS -6V OR OPEN CIRCUIT, NO BLANK
1N4741A
11V 5%
1.5K 5%
2N3416
15K 5%
1N4151
-15V
GATE 3
1 SOURCE
2 DRAIN
510PF
SCOPE
MONITOR (FP)
TOTAL POWER OUT
0-3.0DB GAIN CONTROL
10K 5TURNS
106B
X10 TOTAL POWER AMPLIFIER
SHORTING WAFER
2.49K 0.5V
7.5K 1V
17.4K 2V
47.5K 5V
METER RANGE SWITCH
500Ω R3
9.76K
METER SWITCHING CIRCUIT
0-200 μA 140Ω INT. R
X10
NORM.
S2(a)
S2(b)
S2(c)
T3
T5
N.C.
1K R4
2.49K
200K
.05μF
9.2K
79K
TOTAL POWER X10 OUTPUT
TO CHART RECORDER
NOTE: ALL RESISTORS 1% OR AS NOTED
200Ω
1.43K
380Ω
500Ω R5 MID SCALE ADJUST.
80.6K
10μF
1N938 (1N939)
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: STANDARD RECEIVER SQUARE LAW DETECTOR, BLANKING AND 60~ REJECTION FILTER, X10 TOTAL POWER AMPLIFIER
DESIGN BY: S.WEINREB
DATE: 11-25-66
APPROVED BY:
DRAWN BY: A.J.MIANO
NO. DATE BY REVISIONS
DWG.NO. S 2-462-8



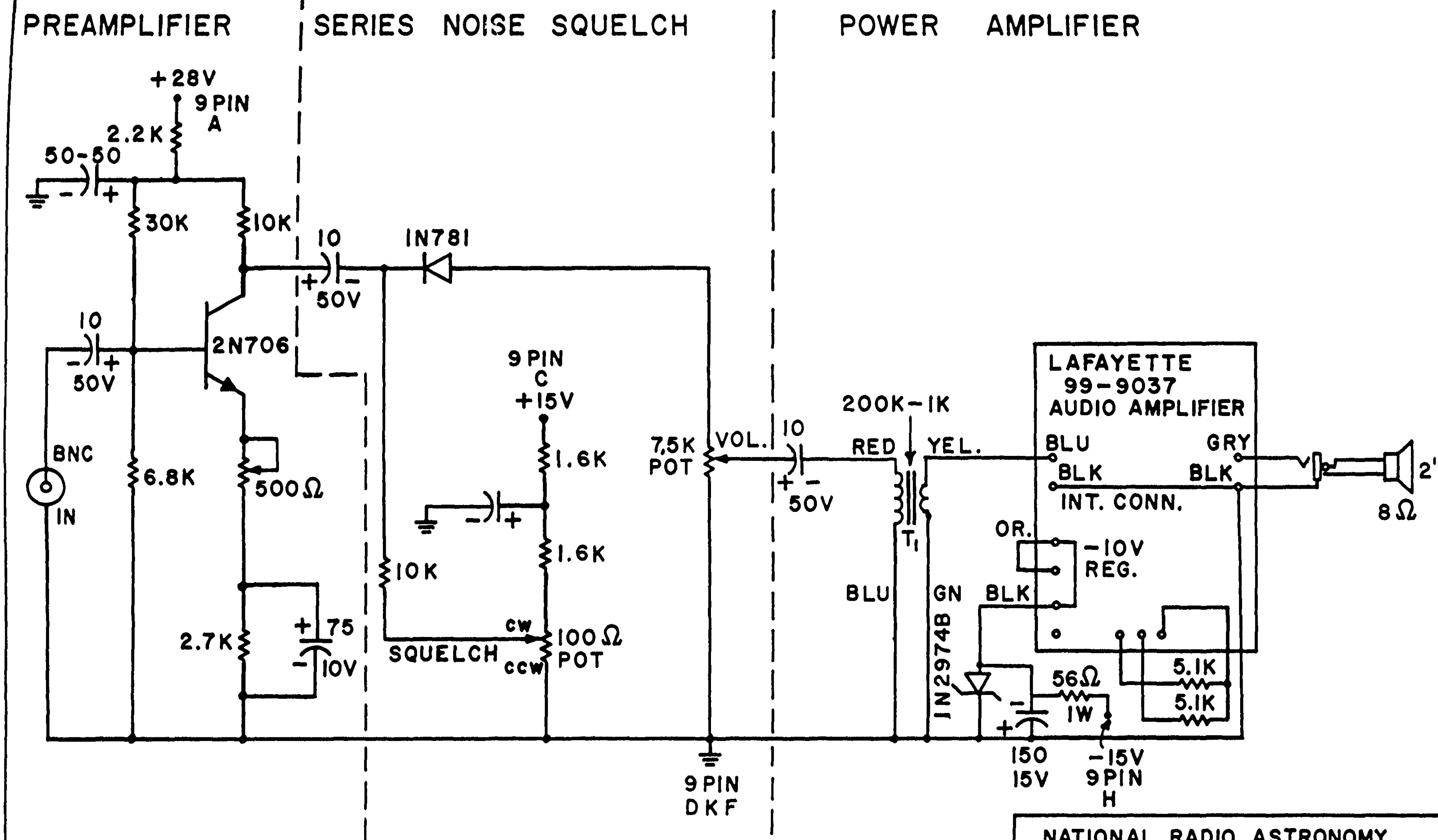

NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE: GAIN MODULATOR DRIVER

DSGN. BY: S. WEINREB DATE: 4-9-66

APPD. BY: DR. BY: J. HILL

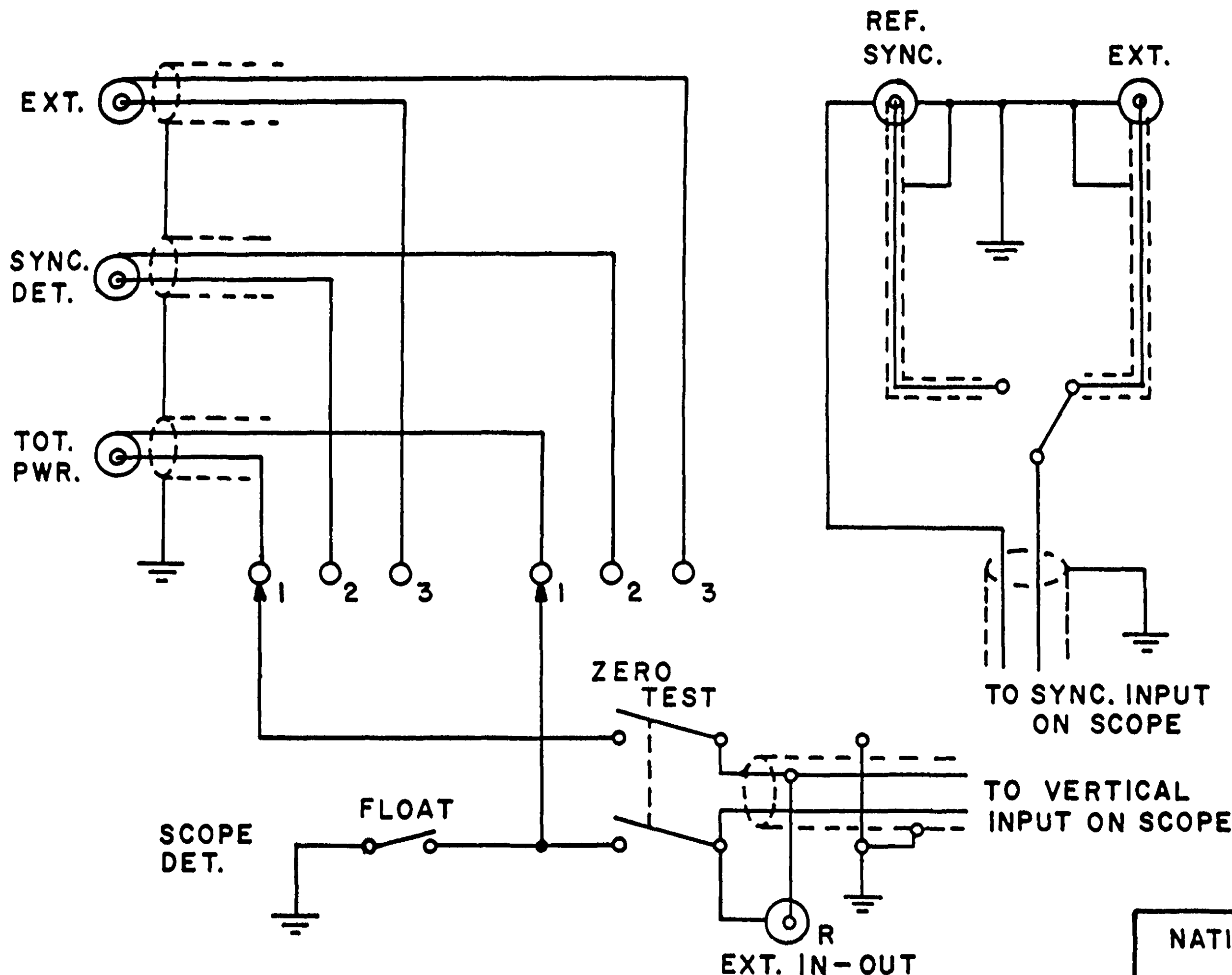
DWG. NO. S 2.462-9




ALL RESISTORS = $\frac{1}{4}$ WATT

CAPACITOR VALUES IN $\mu$FD

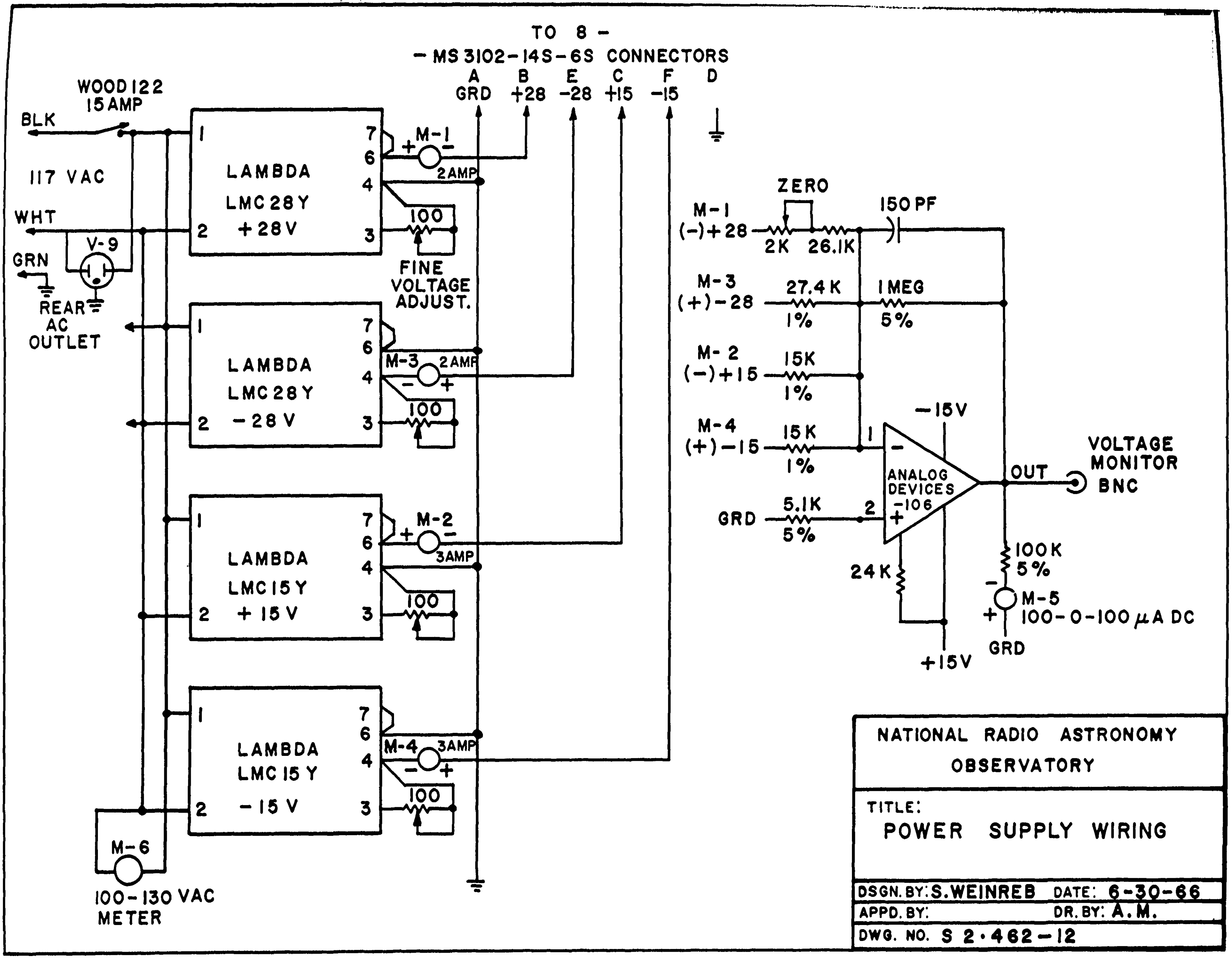
| | |
|---|---|
| NATIONAL RADIO ASTRONOMY OBSERVATORY | |
| TITLE: AUDIO MONITOR | |
| DSGN: S. WEINREB | DATE: 6-23-67 |
| APPD: | DR: A.M. |
| DWG. NO. S 2·462-10 | |

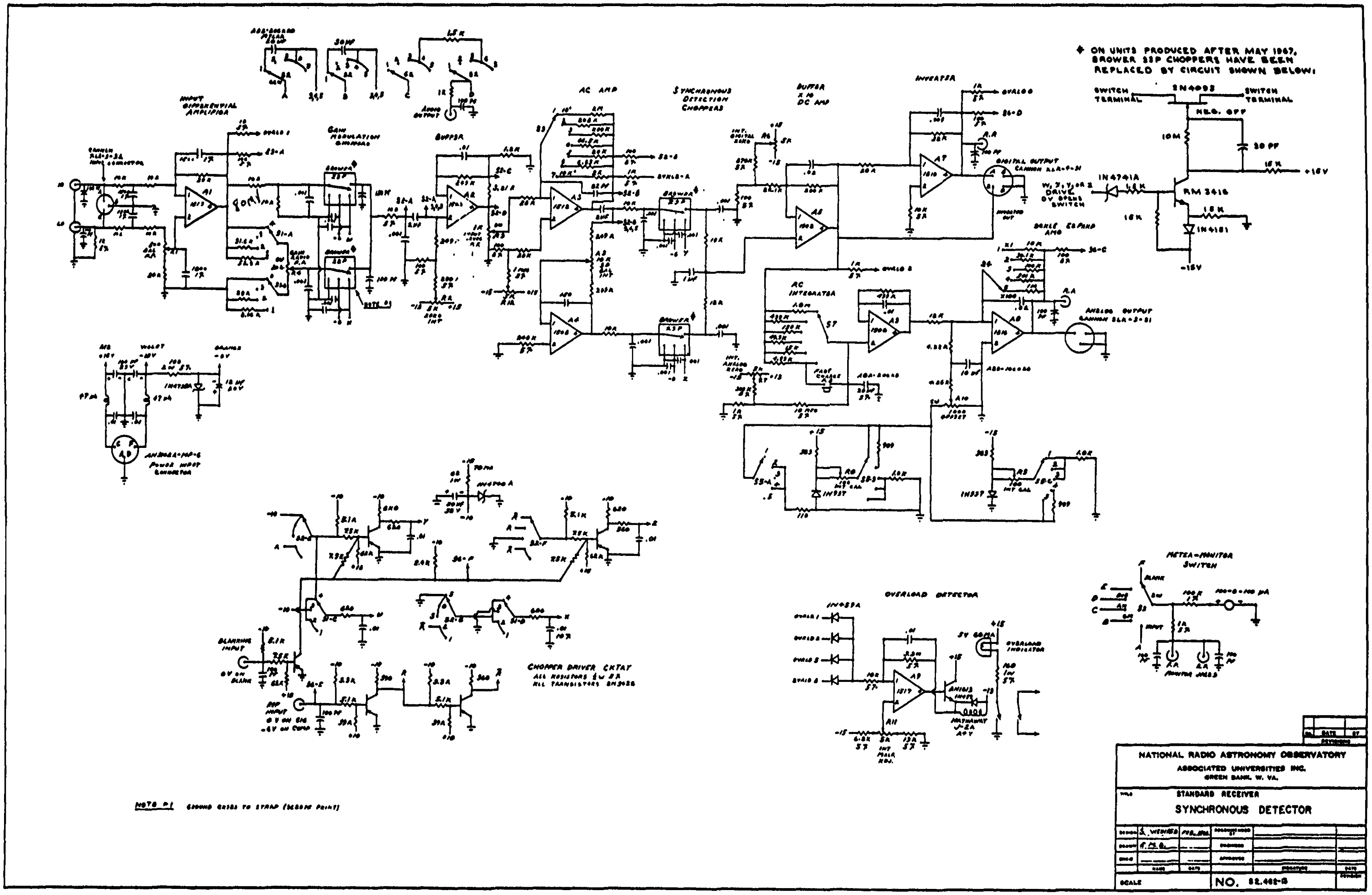



NATIONAL RADIO ASTRONOMY OBSERVATORY

TITLE: STANDARD RECEIVER SCOPE CONTROL PANEL WIRING

| | |
|---|---|
| DSGN. BY: S. WEINREB | DATE: 6-23-67 |
| APPD. BY: | DR. BY: A.M. |
| DWG. NO. S2·462-11 | |


TO 8 -
- MS 3102-14S-6S CONNECTORS
A GRD
B +28
E -28
C +15
F -15
D
WOOD 122
15 AMP
BLK
117 VAC
WHT
GRN
V-9
REAR AC OUTLET
LAMBDA
LMC 28 Y
+28 V
M-1
2 AMP
100
FINE VOLTAGE ADJUST.
LAMBDA
LMC 28 Y
-28 V
M-3
2 AMP
LAMBDA
LMC 15 Y
+15 V
M-2
3 AMP
LAMBDA
LMC 15 Y
-15 V
M-4
3 AMP
M-6
100-130 VAC METER
ZERO
M-1 (-)+28
2K
26.1K
150 PF
M-3 (+)-28
27.4 K 1%
1 MEG 5%
M-2 (-)+15
15K 1%
M-4 (+)-15
15 K 1%
GRD
5.1K 5%
-15V
ANALOG DEVICES -106
24 K
+15V
OUT
VOLTAGE MONITOR BNC
100K 5%
M-5
100-0-100 μA DC
GRD
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: POWER SUPPLY WIRING
DSGN. BY: S. WEINREB
DATE: 6-30-66
APPD. BY:
DR. BY: A. M.
DWG. NO. S 2·462-12



ON UNITS PRODUCED AFTER MAY 1967, BROWER 22P CHOPPERS HAVE BEEN REPLACED BY CIRCUIT SHOWN BELOW:
SWITCH TERMINAL
2N4093
SWITCH TERMINAL
NEG. OFF
10M
IN4741A
RM 3416
IN4151
+15V
-15V
AC AMP
SYNCHRONOUS DETECTION CHOPPERS
INVERTER
IN4733
OVERLOAD DETECTOR
CHOPPER DRIVER CKT
METER-MONITOR SWITCH
NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.
STANDARD RECEIVER
SYNCHRONOUS DETECTOR
SCALE
NO. 82.462-B

## VI. Alignment Procedures

### A. Square Law Detector Adjustment Procedure (See Figure 8.)

1) Set the AIL precision attenuator at 15.00 dB.

2) Set the Gain-Modulator and Square-Law Detector controls as follows:

| | |
|---|---|
| 1 DB STEPS ...................... | 6 dB |
| 0-3 DB .......................... | 750 |
| GAIN MODULATOR OPERATION ..... | Off |
| METER-MID SCALE ................ | 5 V |
| NORMAL - X10 ................... | Normal |

3) Adjust the signal generator output level so that $P_{IN}$ is -17 dBm (.02 mW) as read on a power meter.

4) Push the ZERO TEST push button and adjust the ZERO to within 1 mV of zero volts.

5) Set the linearity control, F1, at minimum resistance.

6) Adjust the interval detector gain (R2, a 20 K pot) so that the digital voltmeter reads 1.000 volts.

7) Note the output voltage when the attenuator is set to 12.00 dB. The correct value should be 1.995. If the meter reading is above this amount, increase R1 and repeat steps 6 and 7 until a reading between 1.985 and 2.005 is achieved. If the meter reading is below 1.985 with R1 at minimum resistance then the detector can probably not be used.

8) Measure the output voltage for the following attenuator settings; the correct values are also noted below. The ZERO should be checked during this procedure.

(continued on page 34) --

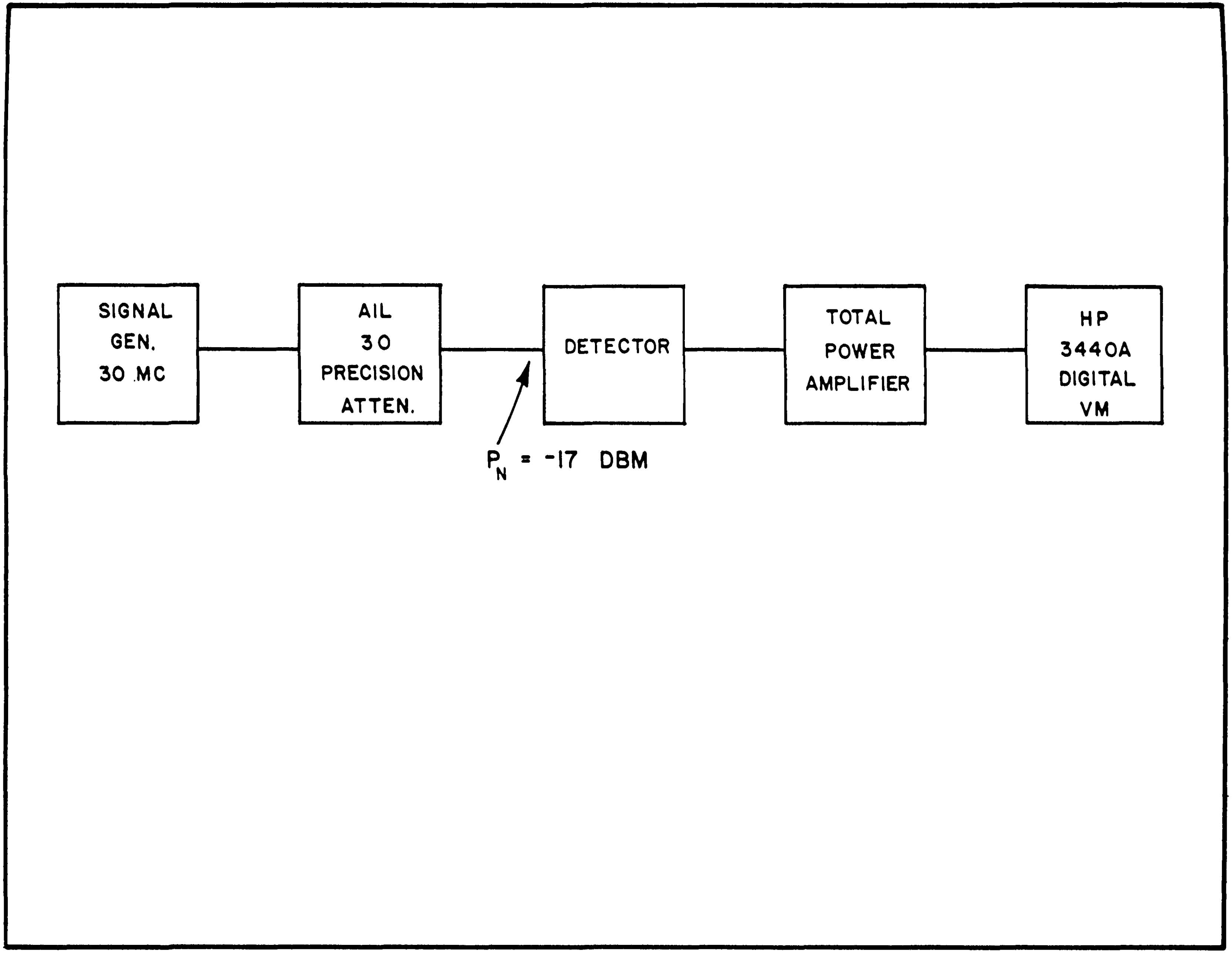



Figure 8 — Square Law Detector Adjustment Procedure

| AIL Attenuator Setting | Correct Output Voltage |
|---|---|
| 21 | 0.251 |
| 18 | 0.501 |
| 17 | 0.631 |
| 16 | 0.794 |
| 15 | 1.000 |
| 14 | 1.259 |
| 13 | 1.585 |
| 12 | 1.995 |
| 10 | 3.162 |
| 9 | 3.981 |
| 8 | 5.012 |
| 7 | 6.310 |
| 6 | 7.943 |
| 5 | 10.000 |

9) The error is defined as:

$$100\% \cdot \frac{\text{READING - CORRECT VALUE}}{\text{CORRECT VALUE}}$$

This should be plotted for the values in the preceding table. An acceptable detector must have less than ± 2% error for output voltages of 0.50 volts to 4.0 volts. A typical error curve is attached.

10) Switch the oscilloscope to TOTAL POWER and set the VERTICAL SENSITIVITY to 2 mV/cm (AC coupled), HORIZONTAL at X1, and SWEEP at 5 ms/cm. The peak-to-peak noise should be less than 3 mV; the actual value should be recorded. If the noise is above 4 mV, repeat the entire procedure with -15 dBm in step 3. This will reduce the noise by 0.6. If the noise is low but the detector error is too high at large output voltages, repeat the procedure with -20 dBm in step 3.

11) With the meter reading exactly mid-scale, the mid-scale adjustment, R5, should be set so no change takes place in the meter reading when switching from NORMAL to X10.

12) The meter substitution pot, R4, should be adjusted so there is no change in the voltage out of the X10 SCALE EXPAND output jack when switching from NORMAL to X10.

## B. Gain Modulator Driver Adjustment Procedure

### R5 Output Impedance Adjustment

1) Connect output of gain modulator driver to input on test box.

2) Connect output of test box to digital voltmeter.

3) Adjust R5 so voltage reading on DVM does not change when pot on test box is turned full range.

### R1, R2, R3, R4 Adjustment

4) Reconnect gain modulator driver to gain modulator.

5) Connect signal generator to SIGNAL INPUT on back of gain modulator-square law detector chassis. Frequency should be between 2 and 300 MHz (30 MHz is a good point).

6) Connect reference generator to REF INPUT and power plug to back of box.

7) Adjust input level from signal generator with gain controls set at mid-range so that total power output meter reads approximately 1 volt.

8) Connect oscilloscope with 423A detector to output of wideband amplifier.

9) If negative type detector (such as 423A) is used, connect it to DC <u>inverted</u> input on scope; in order that the following directions apply, check to see that removal of input signal causes scope beam to <u>drop</u>.

10) Set scope vertical sensitivity to 1 mV per cm, time base to .5 m sec per cm and reference generator to 400 cps.

11) Set IF gain modulator coarse gain ratio knob on 3 dB.

12) Set fine gain ratio dial (R1) to reäd 500.

13) If step 9 is observed, it will be noted that increasing attenuation with coarse gain ratio knob will shift comparison channel downward. Set coarse gain ratio knob back to 3 dB and adjust R4 so that signal and comparison channels are balanced, i.e., they form a straight line on the scope.

14) Now move R1 (fine gain ratio dial) to 0, then to 1000. This shifts comparison above and below signal channel. When R2 and R3 are properly adjusted, R1 should shift comparison channel approximately .7 dB above and below signal channel. (This .7 dB can be estimated by using a 1 dB step by means of the coarse gain ratio knob for comparison.)

15) The following chart should facilitate adjustment of R2 and R3:

a) Set R1 at 500 each time before readjusting.

b)

| R2 | | R3 | |
|---|---|---|---|
| CW | CCW | CW | CCW |
| Reduces attenuation on lower side of signal channel more than on upper side. | Increases attenuation of lower side more than upper. | Reduces attenuation of lower side only. | Increases attenuation of lower side only. |

c) After adjusting R2 and/or R3, balance comparison and signal with R4.

d) Repeat step 14.

e) If driver is not properly adjusted, repeat steps 15 a-d.

16) If, due to a difference in characteristics of the PIN diodes in the gain modulator, the attenuation range of the comparison channel is too great or too small and cannot be compensated for by adjusting R2 and R3, then it may be necessary to change R7.

16) continued --

a) If the attenuation range is too small (< .6 dB either side), then increase the value of R7; if attenuation range is too large (> .8 dB either side), then decrease R7. (Resistance must be changed by 20-30% to be significant.)

b) After the proper value of R7 has been determined, R6 must be changed in order that R5 has enough range to properly adjust the output impedance. The value of R6 is determined by the relation:

$$R6 = 3.2\,K - R7$$

c) After R6 and R7 have been changed, readjust output impedance according to steps 1-3.

## C. Synchronous Detector Adjustment Procedure

Equipment Required: Tektronix 502 Scope
HP 412 VTVM
HP Digital VM or Fluke Differential VM
Input Test Box
Reference Generator

Initial Control Settings: Gain Modulator — Off
Gain Ratio — 600
Mode — Synchronous Detector > 10 Hz
Input Level — 000
Monitor — Input
Full Scale — 10 degrees
Scale Expand — X1
Offset Switch — Off
Offset Control — 250
Time Constant — 0.1 sec.

1) Mechanically zero meter pointer.

2) Adjust +15 and -15 volt power supplies to within .05% of 15.00 volts.

3) Connect input test box and return on AC common mode signal and DC radiometer simulation signal. Connect the scope (1 mV/cm - AC, 5 ms/cm, line sync) to the monitor jack. Adjust the balance pot, R1, for a minimum of 60 Hz deflection. The 60 Hz component should be under 1 mV peak to peak. Turn off 60 Hz source.

4) Connect the HP digital VM or HP 412 VTVM to the monitor jack and turn the monitor switch to GM out. Adjust R 12 for a zero reading (within ± 2 mV from zero). Turn up the input level control to 1000 and adjust R2 for a zero reading.

5) Turn the monitor switch to dig out and the full scale switch to 10 K. Adjust R6 for a zero reading on the VM (still connected to the monitor jack).

6) Turn the monitor switch to analog out and adjust R7 for a zero reading.

7) Turn the offset switch to move left — high. Adjust R8 so that VM reads -2.500 volts. Turn the offset switch to move right — high. Adjust R9 so that the VM reads +2.500 volts. Turn the offset switch to off.

8) Turn the monitor switch to dig out, the full scale switch to 100°, and the gain modulator switch to .7-1.2 range. Adjust the front panel gain ratio control so that the VM reads +10.0 volts. Now turn R11 so that the overload light just turns on.

9) Turn the gain modulator switch back to off and connect a 3.0 meg 5% resistor from +15 volts to point, S2-B pos 3, 4, 5. Adjust R5 so that the VM reads zero. Disconnect the resistor.

## D. Synchronous Detector Noise Test

| | |
|---|---|
| Equipment Required: | Chart Recorder having ± 10 V full scale |
| | Input Test Box |
| | Reference Generator |
| Initial Control Settings: | Gain Modulator — Off |
| | Gain Ratio — 1000 |
| | Mode — Synchronous Detector 10 Hz. |
| | Input Level — 1000 |
| | Monitor — Analog Output |
| | Full Scale — 10 degrees |
| | Scale Expand — X100 |
| | Offset Switch — Off |
| | Offset Control — 1000 |
| | Time Constant — 1 second |

1) The noise fluctuations on the front panel meter should be observed for reference frequencies of 1, 10, 50, and 400 cps and for input level settings of 100 and 1000. The fluctuations should be within the following limits:

Maximum Synchronous Detector Noise Fluctuations

| Reference Frequency | Input Level = 1000 | Input Level = 100 |
|---|---|---|
| 1 cps ............ | ± 40 | ± 5 |
| 10 cps ............ | ± 2 | ± 1 |
| 50 cps ............ | ± 1 | ± 1 |
| 400 cps ............ | ± 1 | ± 1 |

(Units are meter microamps, 1 meter microamp = .001 °K = 100 mV.)

It may be necessary to zero the meter with the offset controls at higher reference frequencies.

D. (continued) --

2) Turn the gain modulator switch to the .7 to 1.2 range and the offset switch to move left high. Adjust the gain ratio control so that the meter is near mid-scale (very sensitive adjustment). The fluctuations should be less than those indicated in the above table. A re-adjustment of the gain ratio pot will be necessary when the input level is changed from 100 to 1000.