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MICROWAVE PHYSICS CORPORATION PARAMETRIC AMPLIFIER

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Description

The Microwave Physics Corporation L-band parametric amplifier, Part No. 10244, was designed to operate within the range of 1350-1450 Mc by adjustment of the klystron pump. Stable gains of 20 db should be realized within this range; however, the manufacturer's data sheet supplied with this amplifier specifies 15 db gain and all test results shown in this report were made using approximately this gain setting.

The parametric amplifier, as received from the manufacturer, consisted of two standard 19-inch panel rack-mounted assemblies. The beam and reflector power supplies are included in one assembly. The second assembly, which consisted of the parametric amplifier, associated pump circuitry, circulator and regulated filament supply, was later modified at NRAO. The data contained in this report was obtained from tests made on the equipment as received from the manufacturer, unless otherwise specified. All tests, including records obtained using the NRAO standard receiver, were conducted in the screened room.

Amplifier Alignment

Recommended procedures for alignment are given in the Operating Instructions Manual which was supplied by the manufacturer. Both the sweep generator method and the single frequency method are covered, including input level requirements. The importance of proper testing levels is discussed in this report under "Linearity".

Maintenance

Complete schematics of all electronic subassemblies are included in the Operating Instructions Manual. Troubleshooting information regarding klystron replacement, varactor testing and replacement, and power supply troubles are also covered.

Measurement of Gain-Bandpass Characteristic

A. Sweep-frequency method

The amplifier was aligned using the test-equipment arrangement shown in Figure 1. To avoid saturation of the amplifier, the input level should be kept below -38 dbM (see "Linearity" test).

By using square modulated CW the amplitude as well as the baseline was shown on the screen.

When the amplifier was tuned to 1400 Mc and adjusted for 15 db gain, the measured bandwidth was 38 Mc.

For accurate measurements of center frequency, gain and bandwidth, the single frequency method is preferred.

B. Single-frequency method

Test equipment arrangement for this measurement is shown in Figure 2. The VSWR meter was calibrated with a 3 db precision attenuator. With this method the measured bandwidth of the amplifier was 35 Mc.

Gain as a Function of Pump Power

The amplifier was adjusted for 15 db gain with center frequency of 1400 Mc. Bias voltage was set to 0.145 V.

The test equipment arrangement for this measurement is shown in Figure 4, and the test result is shown in Figure 3.

Gain and Center Frequency Change as a Function of Bias Voltage

For this measurement the pump power was set to approximately 0.1 mW and the bias potentiometer was varied over its full range. In Figure 4 both the gain and center frequency are plotted as a function of bias voltage.

Noise Figure Measurements

The noise figure measurements were made using the Y-factor method. Three different noise sources were used:

1. Argon noise generator.
2. AIL hot-cold generator.
3. 50 ohm precision load —

$$\frac{77}{290\ °K} .$$

A. Argon noise generator

The test set-up was used as shown in Figure 5. The paramp was adjusted for 15.0 db gain at center frequency 1400 Mc.

The first measurements were made using 10.1 db precision pad between noise source and the paramp.

The mixer-preamp was connected directly to the output of the paramp. No cables were used in front of the paramp.

With a 750 °K (double sideband) second stage amplifier, the noise contribution (T_{2C}) was calculated to 54 °K (at 1400 Mc).

f	Y_{db}	T_S	T_{2C}	T_R
1390	4.93	160°	----	----
1400	5.01	139	54	84°
1410	4.89	160	----	----

The Y-factor is an average of ten measurements. The gain of the paramp was not measured at 1390 and 1410 Mc. Therefore, the second stage noise contribution cannot be calculated for these frequencies.

The second measurement was made with a GOMBOS bandpass filter between the paramp and the mixer. The noise temperature of the second stage was in this case 1980° (SSB) giving a second stage contribution (T_{2C}) of 63 °K.

f	Y_{db}	T_S	T_{2C}	T_R
1390	4.80	190	----	----
1400	4.88	160	63	97
1410	4.74	195	----	----

The high system temperature at 1390 and 1410 is due to the bandpass characteristics of the filter.

The third measurement with the argon noise tube was made with a circulator inserted between the paramp and the GOMBOS bandpass filter. Second stage noise temperature = 2220 °K.

f	Y_{db}	T_S	T_{2C}	T_S
1390	4.72	----	----	----
1400	4.85	164	70	94
1410	4.61	----	----	----

T_S is in all these cases calculated with T_o = 300° (room temperature in the screen room was 27 °C), and with a 10.1 db precision attenuator between the amplifier and noise source. The temperature of the termination on the noise generator was estimated for 300 °K.

B. AIL hot-cold noise generator

The hot-cold noise source was used with a 35 cm long RG-9 U cable, with an insertion loss of 0.16 db. The gain of the paramp was 16.3 db at 1400 Mc.

The second stage noise temperature = 696 °K (DSB), Y_{db} = 1.41. The second stage noise contribution = 40°. Measured Y_{db} factor = 3.55.

With the cable after the hot-cold generator the effective temperatures of the generator are 85° and 371.5° instead of 77° and 373 °K. This gives a system noise temperature of 137 °K and an amplifier noise temperature of 97 °K.

C. Noise figure measurement using a 50 ohm load

In this case we used a Bendix load which had very good VSWR at room temperature and at 77 °K (VSWR < 1.1). First the load was cooled for 77 °K in liquid nitrogen and then heated to 17 °C by water. Second stage temperature = 800 °K (DSB) and gain = 16.3 db.

T_1	T_2	Y_{db}	T_S	T_{2C}	T_R
290°	77°	2.87	150°	44	106

This measurement was made with a 20 cm long rigid coaxial line between load and paramp, and the insertion loss of this cable could not be measured. Another measurement was made using a 35 cm long RG-9 cable (insertion loss 0.16 db) between the load and the paramp input.

	T_1	T_2	Y_{db}	T_S	T	T_{R_1}	T_{R_2}
a.	291.5	77	3.15	124°	44°	80°	71°
b.	290	77	2.91	146°	52°	94°	77°

Where T_{R_1} is the receiver temperature including cable

T_{R_2} is the receiver temperature excluding cable.

This method is not recommended. The Y-factor readings varied considerably, possibly due to this long thermal time constant of the load.

Summary of Result of Noise Measurement

Noise temperature measured with

Argon noise generator + 10.1 attenuator -------------- T_R = 84 °K

Argon noise generator + 10.1 db attn. + GOMBOS filter - T_R = 97 °K

Argon noise generator + 10.1 db attn. + filter + isolator - T_R = 94 °K

AIL hot-cold noise generator ------------------------ T_R = 97 °K

50 ohm load ------------------------------------ { T_R = 71°, T_R = 77° }

Linearity

The linearity of the amplifier was derived using the test set-up shown in Figure 6. The result is also shown in Figure 6. A 1 db deviation from linearity occurs with an input level of -32 dbM (≈ .6μW). However, for accurate measurements the input level should be < -38 dbM (≈ .016μW). In Figure 8 the solid line shows the gain-band-pass characteristic of a slightly over-loaded paramp. The bandwidth is 50 Mc instead of 38 Mc, which is the true bandwidth (dotted line).

Stability Test

The following list of records was made using the NRAO standard receiver:

Fig. 9	a. Switched receiver b. Total power record	}	Two 290 °K loads in constant temperature.
Fig. 10	a. Switched receiver b. Total power record	}	77 °K and 290 °K loads in constant temperature.
Fig. 11	a. Switched receiver b. Total power record	}	Two 290 °K loads, ambient temperature 0-40 °C
Fig. 12	a. Switched receiver b. Total power record	}	77 °K and 290 °K loads, ambient temperature 0 to 40 °C
Fig. 13	a. Switched receiver b. Total power record	}	Two 290 °K loads, line voltage varied from 90 V to 140 V.
Fig. 14	a. Switched receiver b. Total power record	}	77 °K and 290 °K loads, voltage varied from 90 V to 140 V.

Fig. 15 Noise temperature vs. ambient temperature.

Noise Temperature vs. Room Temperature

As a final test the system noise temperature was measured as a function of ambient temperature. The amplifier was contained in a temperature chamber and the temperature was varied from 10 °C to 40 °C. Result is given in Figure 15.

Modification

The parametric amplifier, as received from the manufacturer, was not suitable for use at NRAO. The rack-mounted chassis was too bulky and mechanically unstable for mounting in the pillbox, where space and mechanical stability are important considerations. Photographs of the amplifier chassis after modification are included in this report. This rearrangement of components allows us to use a shorter cable from the feed-horn to the amplifier input, thereby reducing the system noise temperature. Mechanical stability was improved considerably.

Noise figure measurements made on the parametric amplifier after modification showed no change in noise temperature.

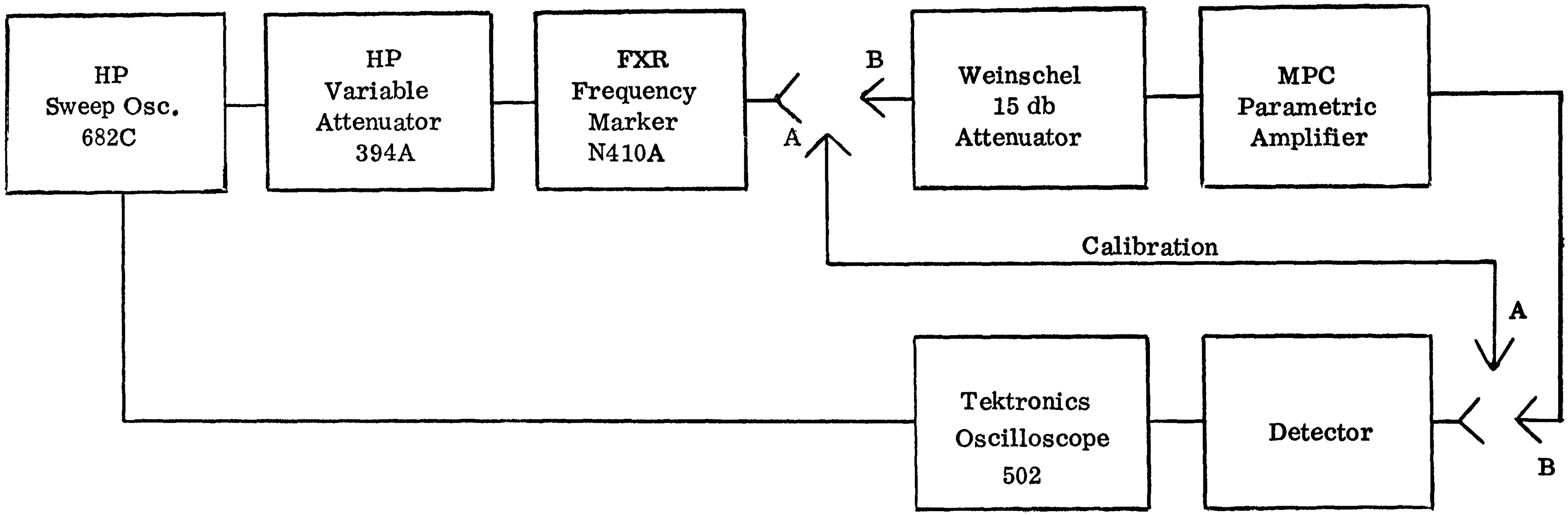


Figure 1. Test equipment arrangement used to observe gain-bandpass characteristics and for making adjustments on the parametric amplifier. The variable attenuator was set at 50 db. Scope sensitivity 200 μV/cm with 3 cm vertical deflection.

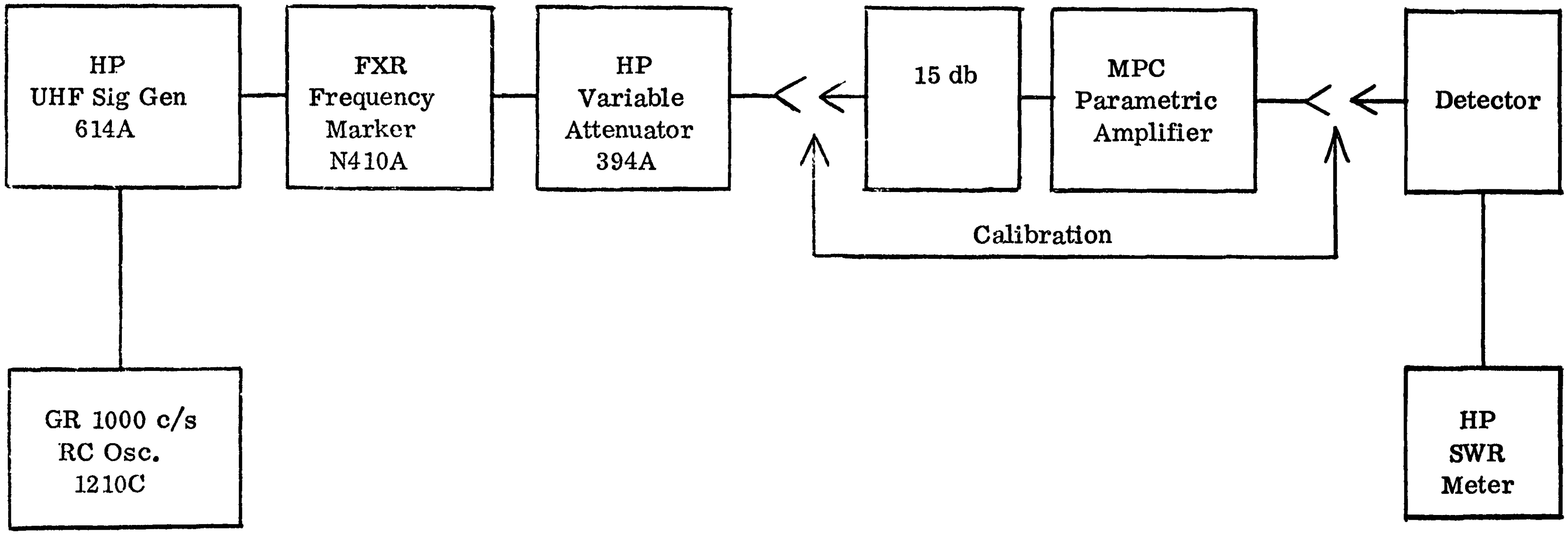
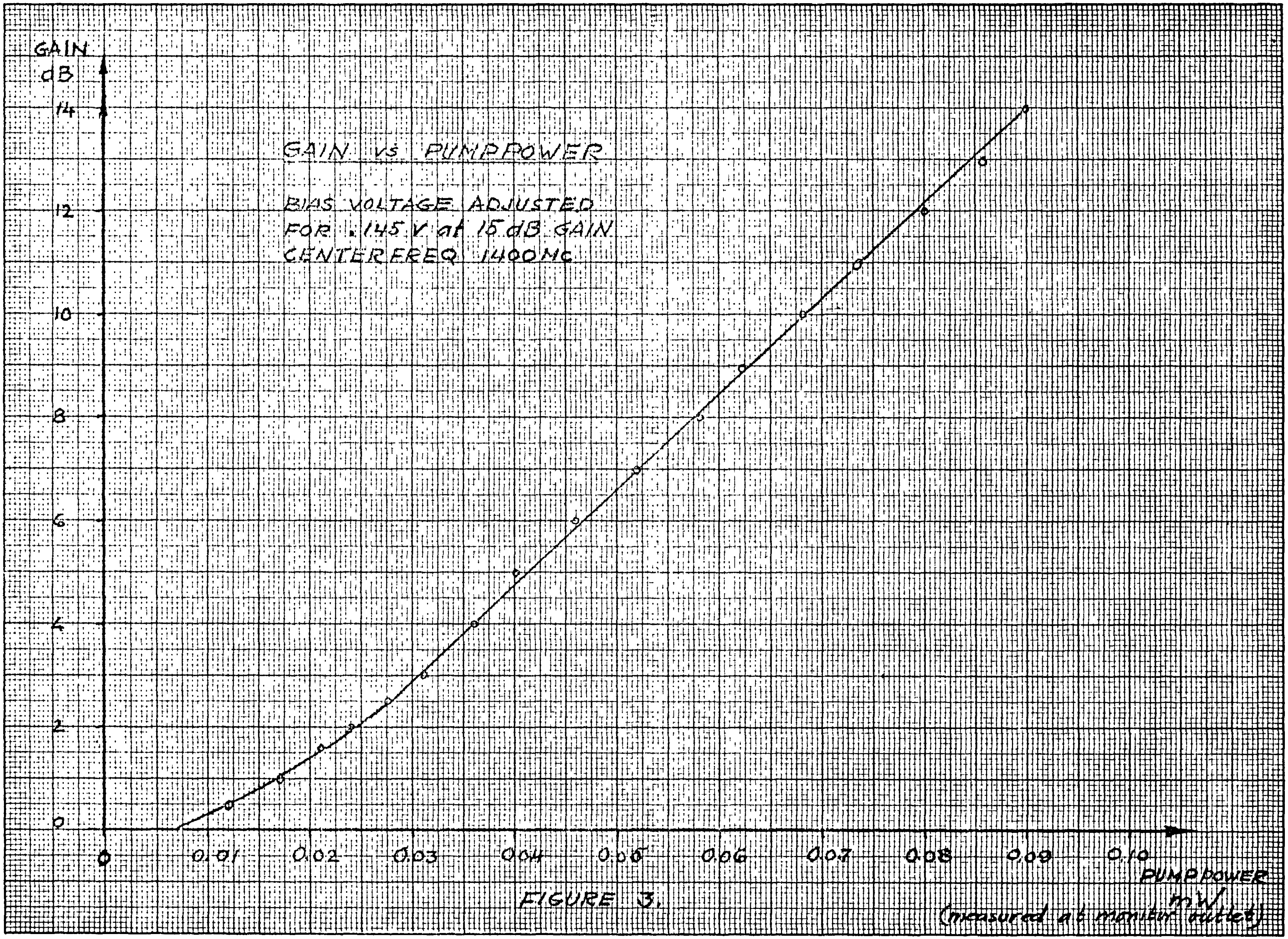
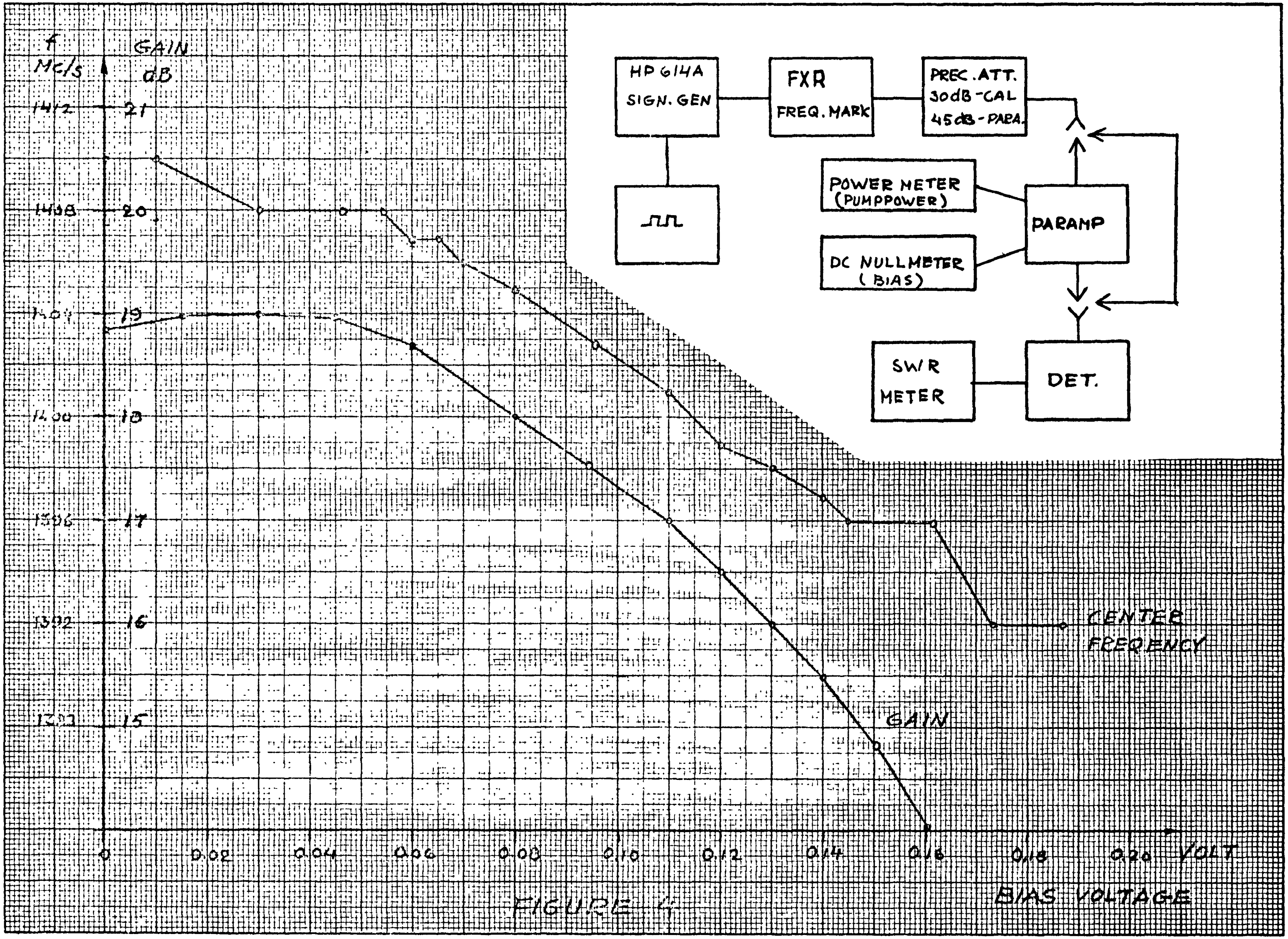


Figure 2. Single frequency method. Test equipment arrangement for measuring gain and locating 3 db points. The variable attenuator was set at 35 db and the generator adjusted for maximum output (1 mw).



GAIN
dB
GAIN vs PUMPPOWER
BIAS VOLTAGE ADJUSTED
FOR .145 V at 15 dB GAIN
CENTERFREQ 1400Mc
0
2
4
6
8
10
12
14
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
PUMPPOWER
mW
(measured at monitor outlet)

FIGURE 3.



f
Mc/s
GAIN
dB
1412
21
1408
20
19
18
17
16
15
0
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
VOLT
BIAS VOLTAGE
CENTER FREQENCY
GAIN
HP 614A SIGN. GEN
FXR FREQ. MARK
PREC. ATT. 30dB-CAL 45dB-PARA.
POWER METER (PUMPPOWER)
DC NULLMETER (BIAS)
PARAMP
SWR METER
DET.

FIGURE 4

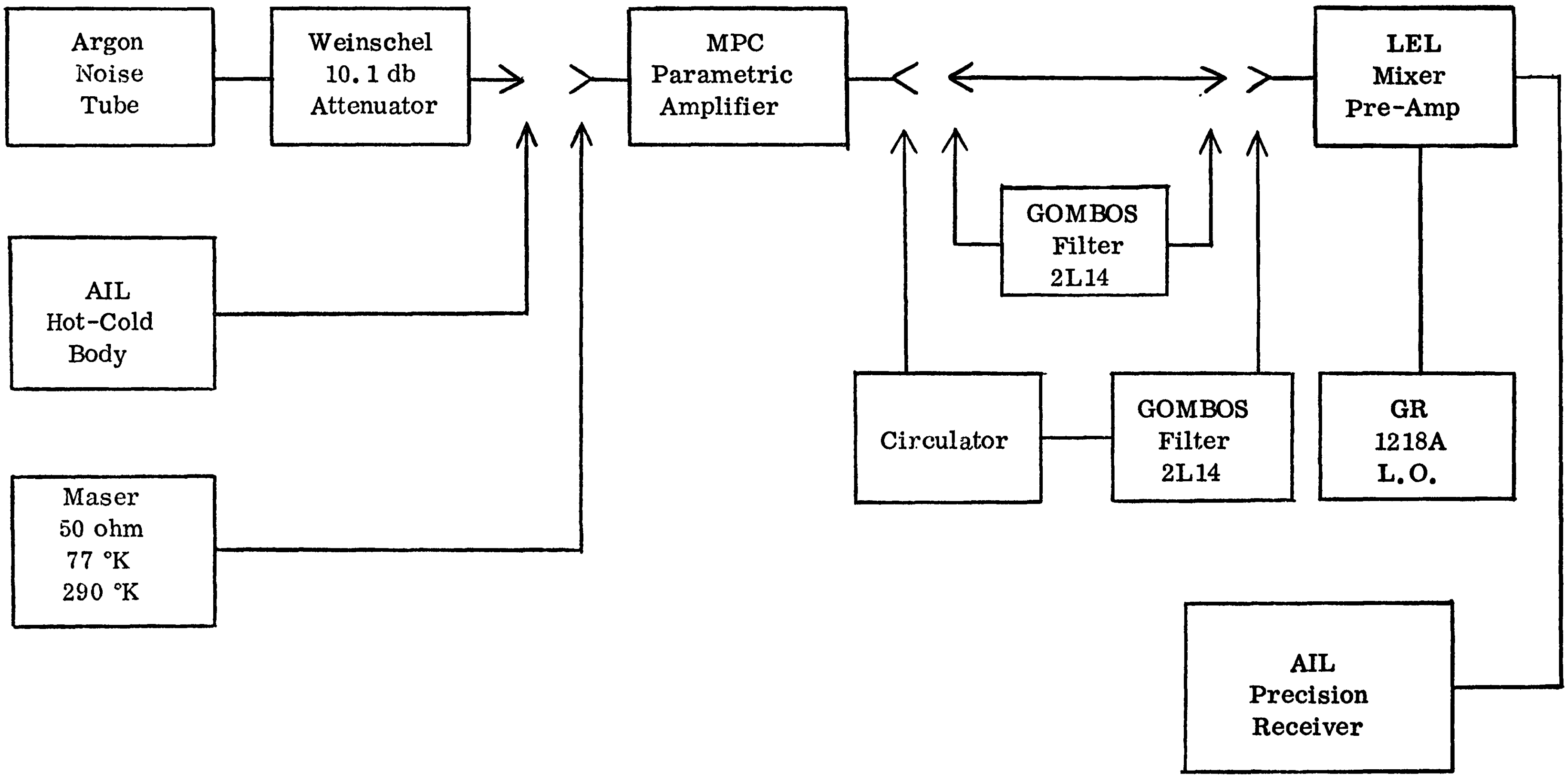


Figure 5. Methods used for making noise-figure measurements.

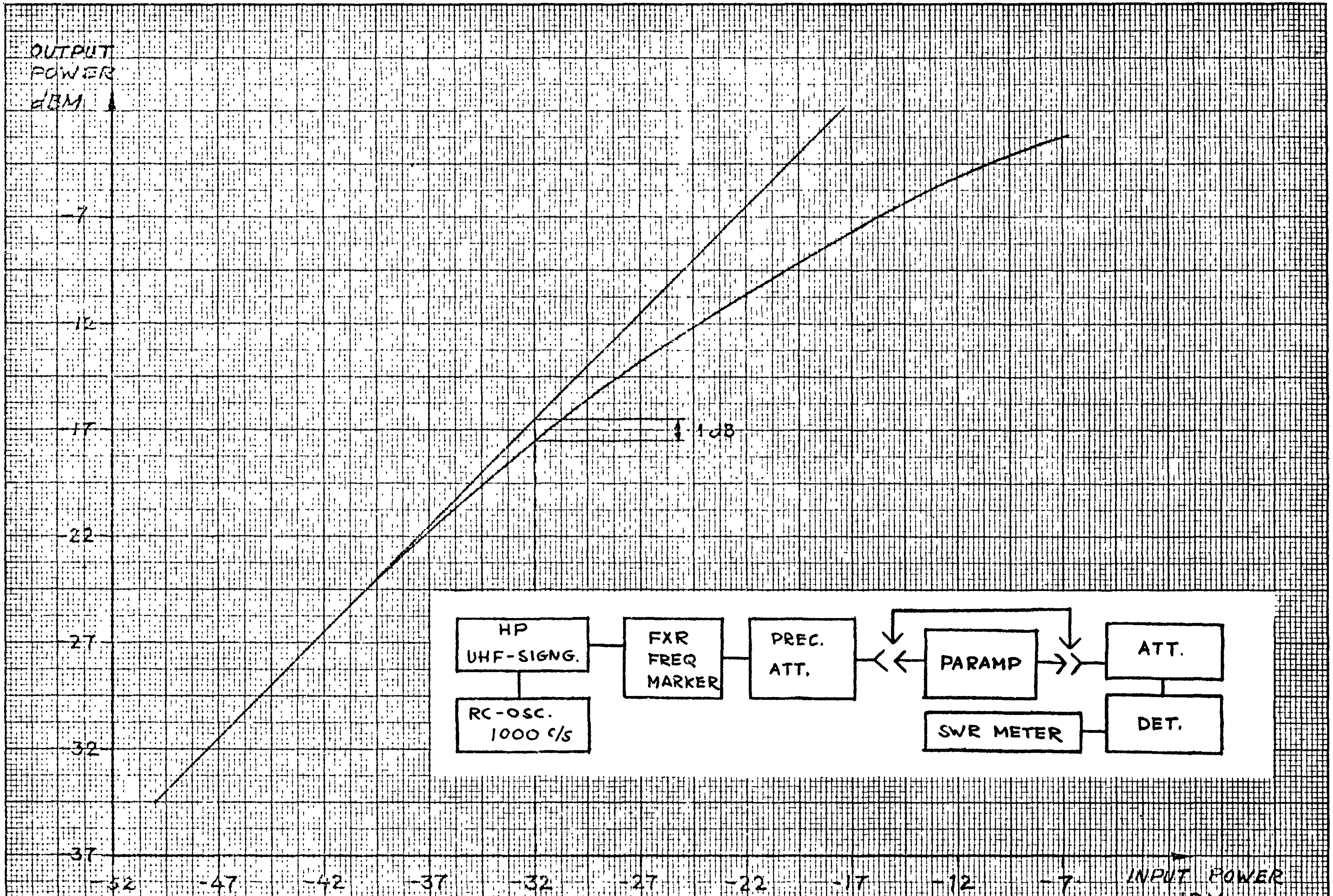

OUTPUT POWER dBM
-7
-12
-17
-22
-27
-32
-37
1 dB
-52
-47
-42
-37
-32
-27
-22
-17
-12
-7
INPUT POWER dBM
HP UHF-SIGNG.
RC-OSC. 1000 c/s
FXR FREQ MARKER
PREC. ATT.
PARAMP
ATT.
DET.
SWR METER

FIGURE 6

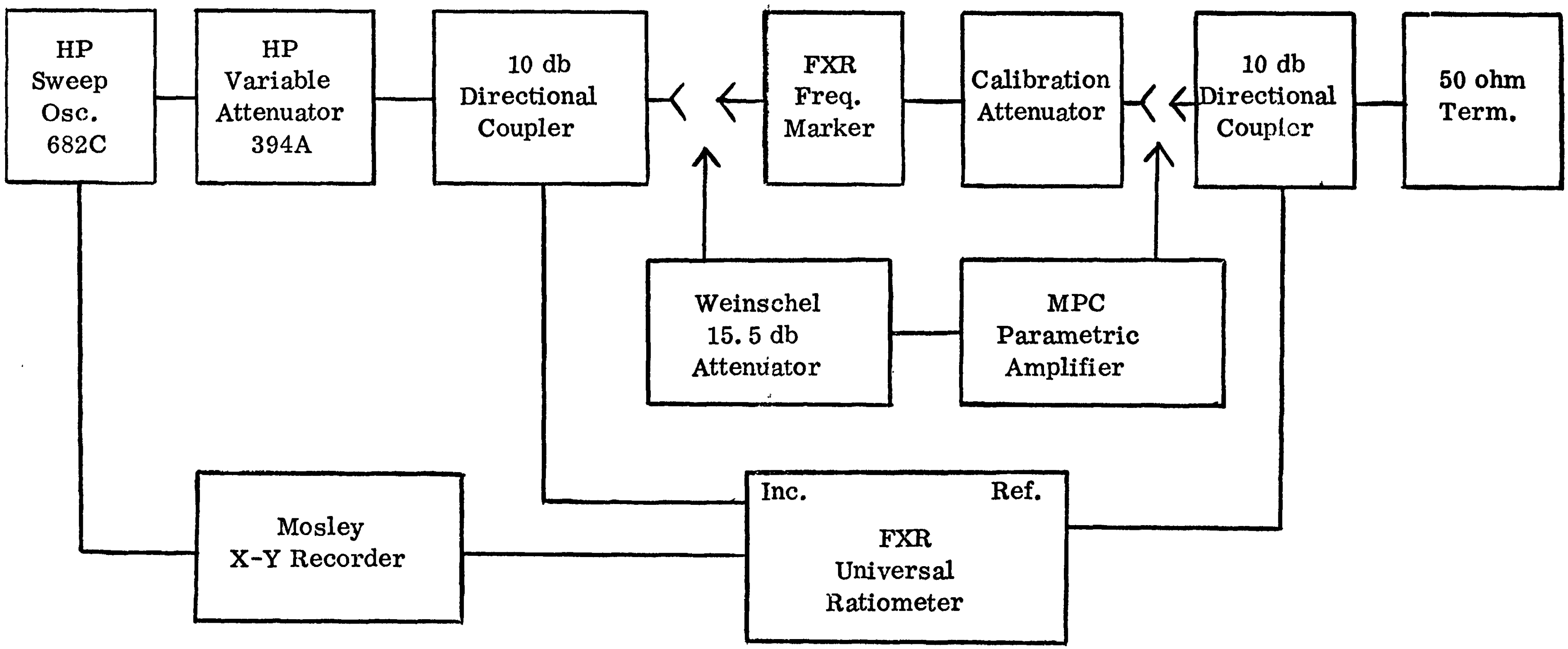


Figure 7. Test equipment arrangement to plot the gain-bandpass characteristics of the parametric amplifier. The variable attenuator was set at 26 db. This was the maximum allowable attenuation for proper operation of the ratiometer. Results of this test were unsatisfactory due to saturation of the parametric amplifier. Refer to Figure 8 for overload characteristics and results of this test.

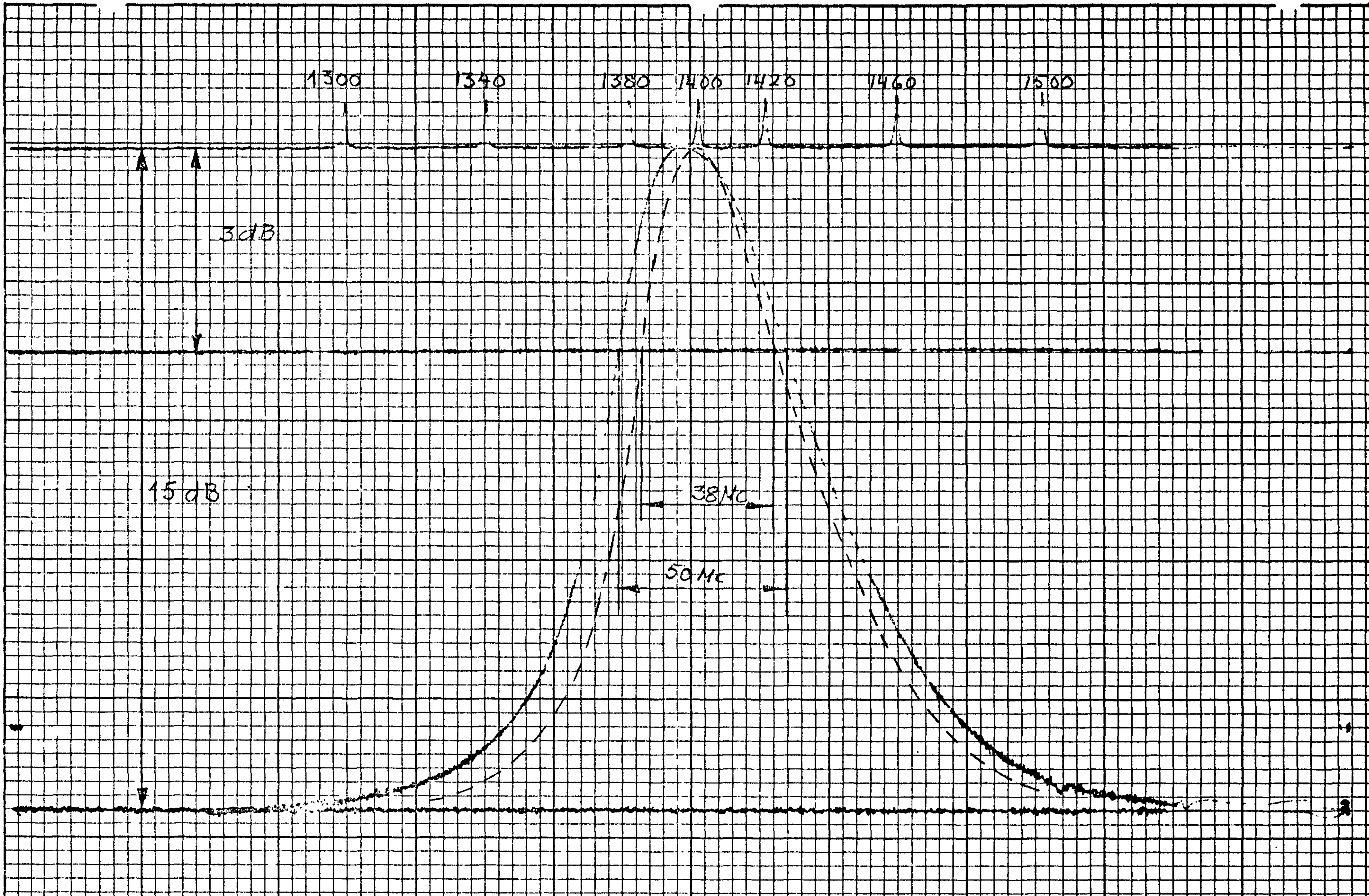


FIGURE 8

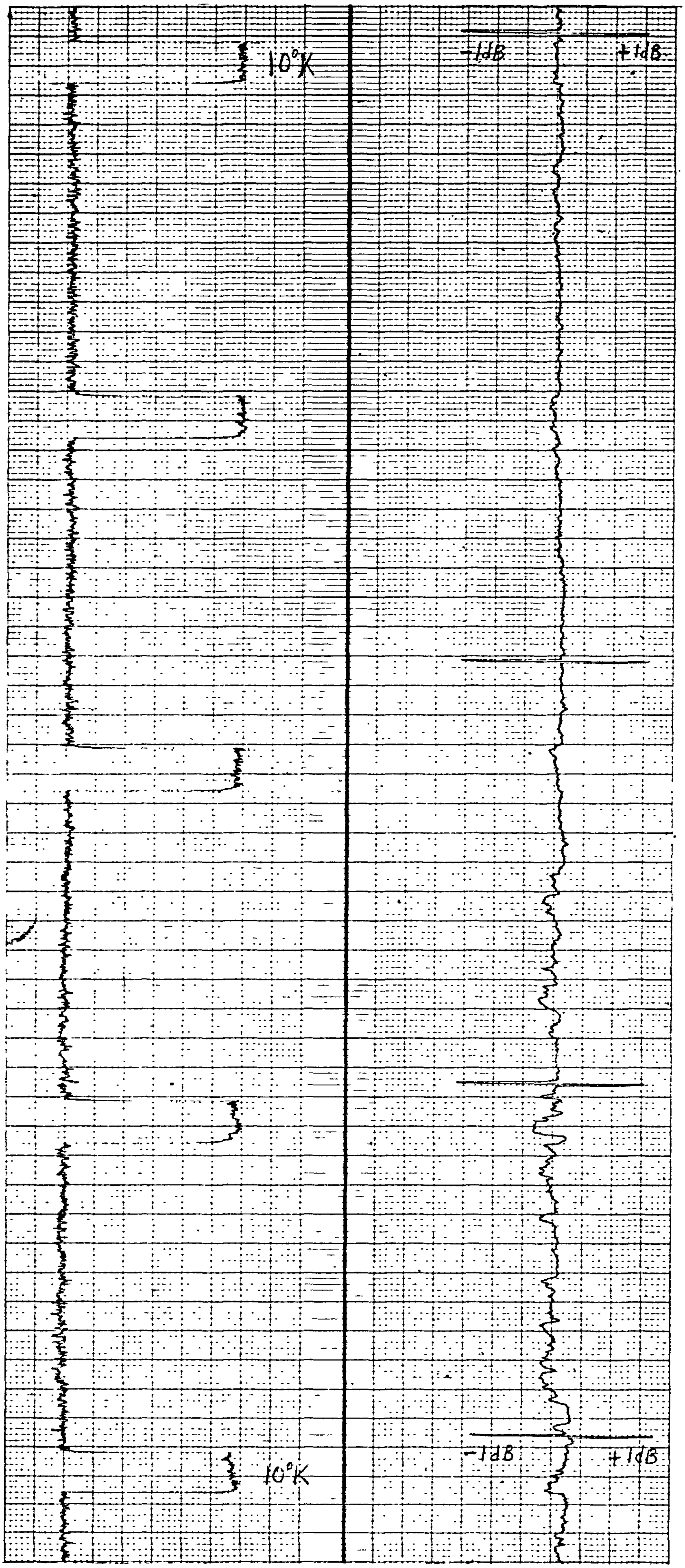


Figure 9. Portion of overnight record.
Receiver switched between two 290 °K loads.
Chart speed 2 mm/m.
Time constant 2 sec.
Temperature approx. 28 °C.

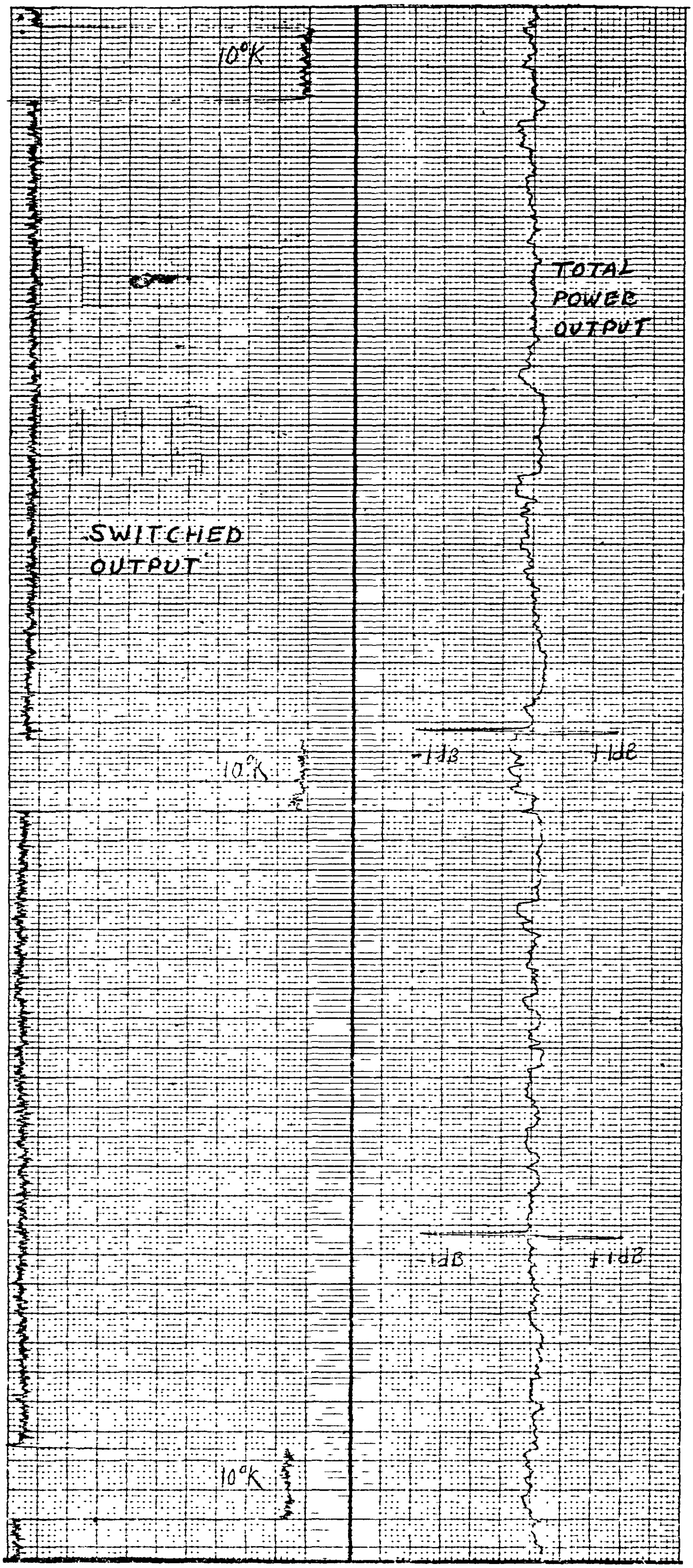


Figure 10. Receiver switched between 77 °K and 290 °K loads.

Chart speed 2 mm/m.
Time constant 2 sec.
Room temperature 28 °C.

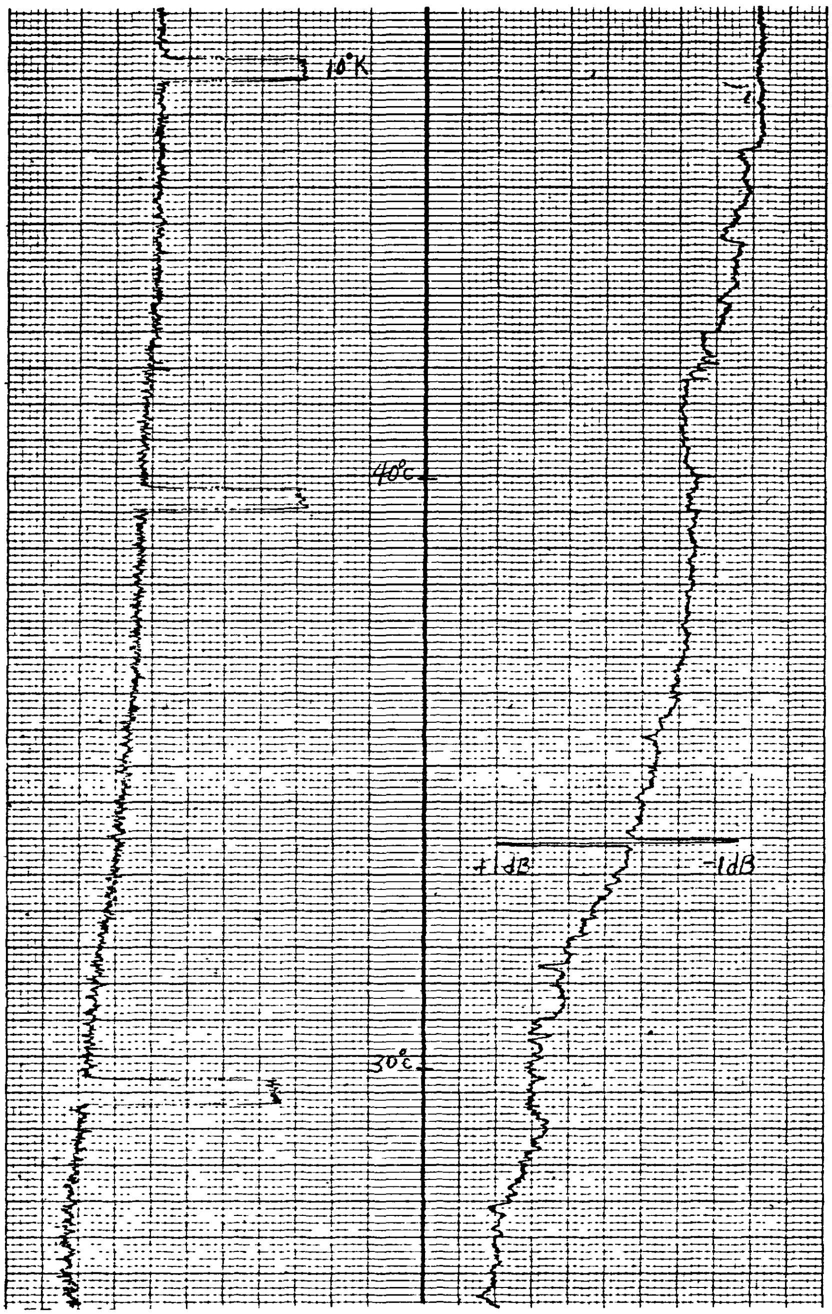


Figure 11. Ambient temperature vs. output.

Receiver switched between two 290 °K loads.

Chart speed 2 mm/m.
Time constant 2 sec.
Receiver balanced at approx. 28 °C.

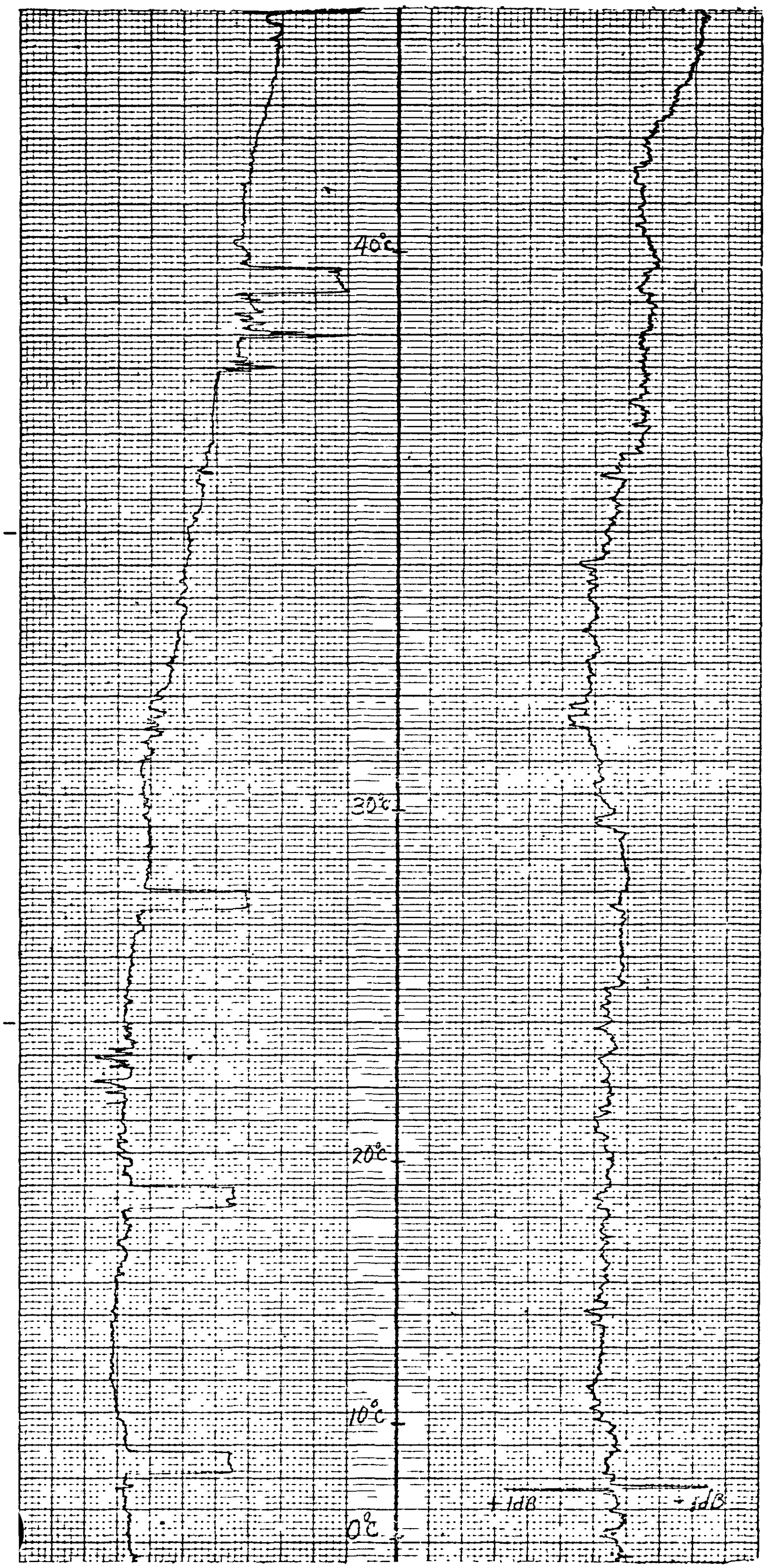


Figure 12. Ambient temperature vs. output.

Receiver switched between 77 °K and 290 °K loads.

Chart speed 2 mm/m.
Time constant 2 sec.
Receiver balanced at approx. 28 °C.

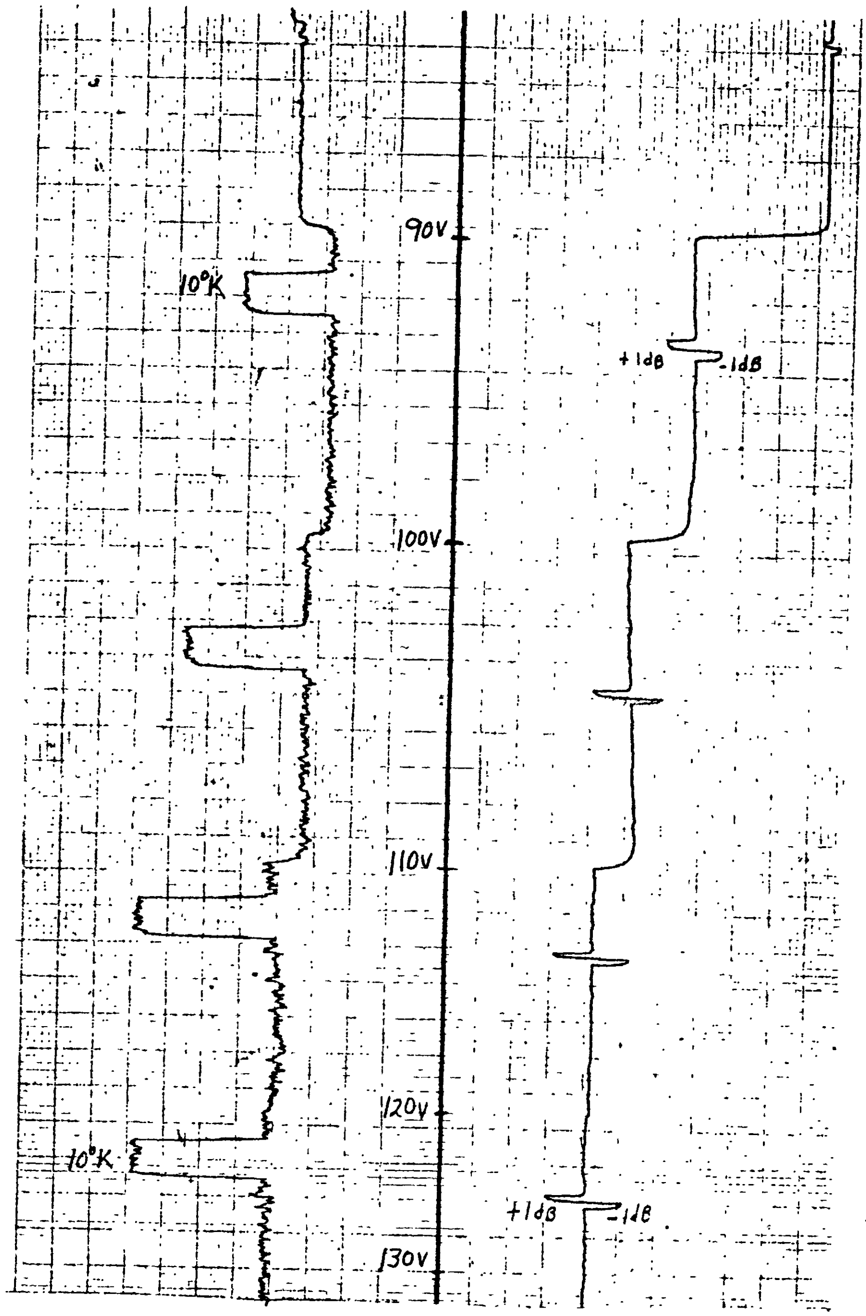


Figure 13. AC Line Voltage vs. Output

Receiver switching between two 290 °K loads.

Chart speed 5 mm/m.
Time constant 2 sec.
Receiver balanced at 115 VAC and temperature approx. 28 °C.

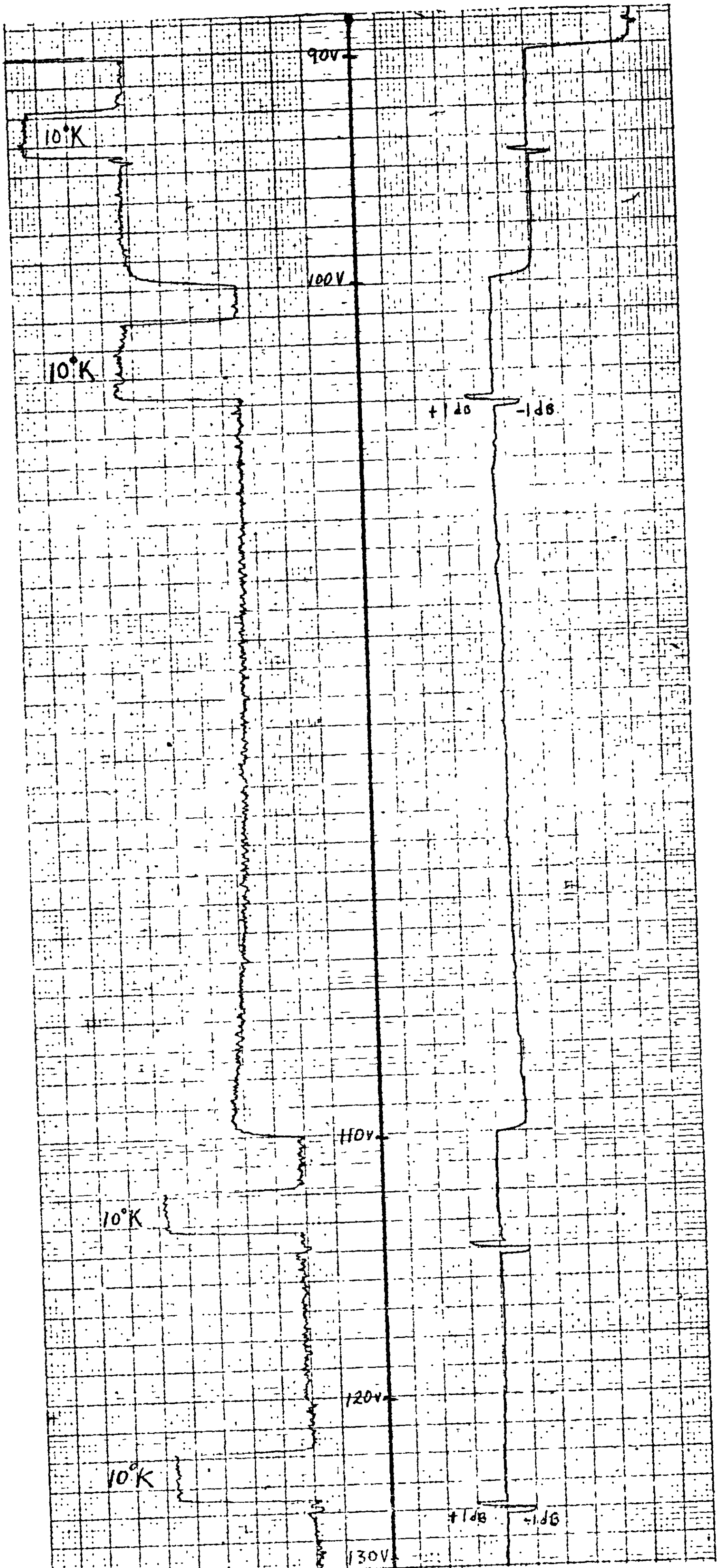


Figure 14. AC line voltage vs. output

Receiver switched between 77 °K and 290 °K loads.

**Chart speed 5 mm/m.
Time constant 2 sec.
Receiver balanced at 115 VAC and temperature approx. 28 °C.**

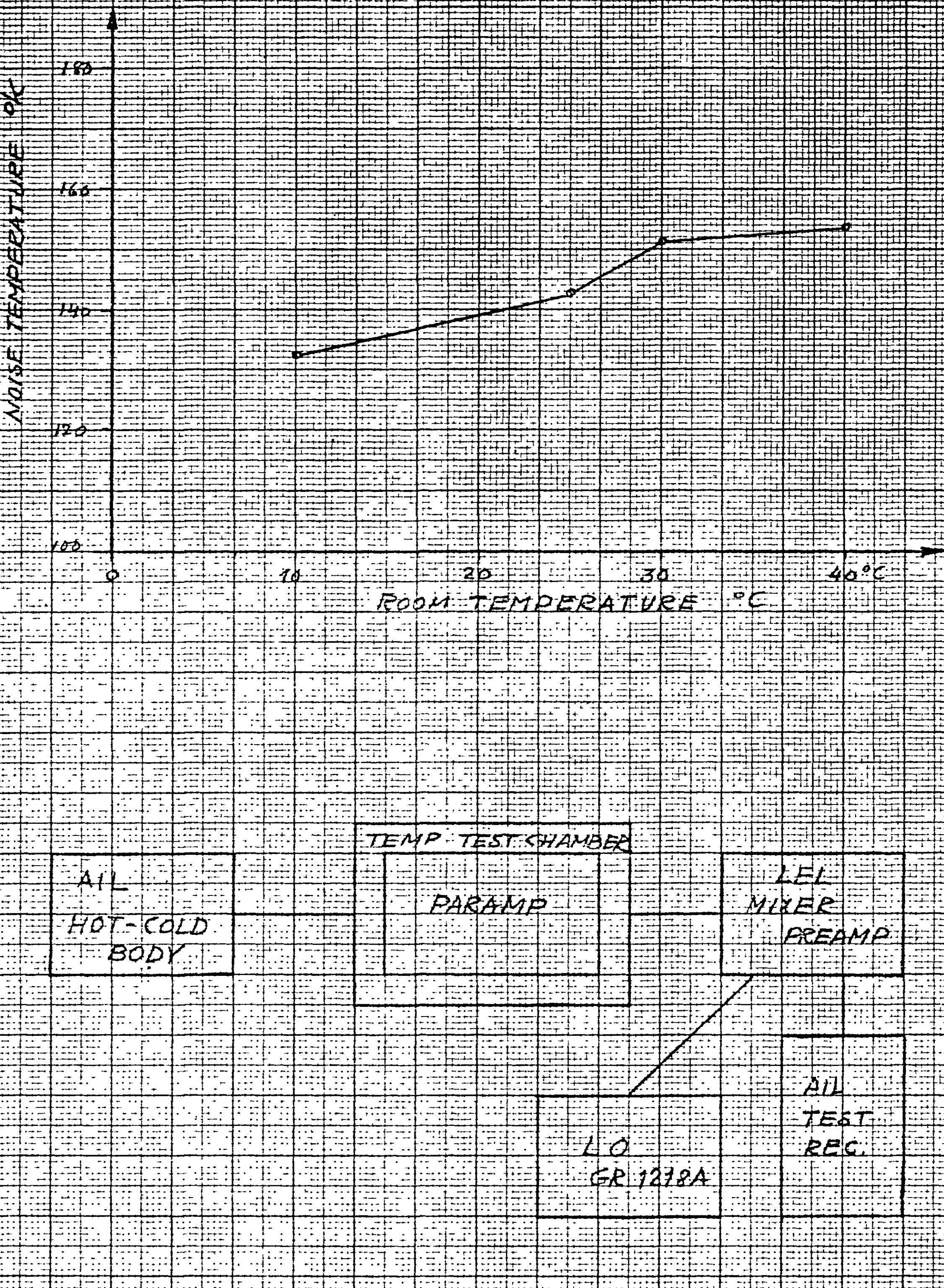
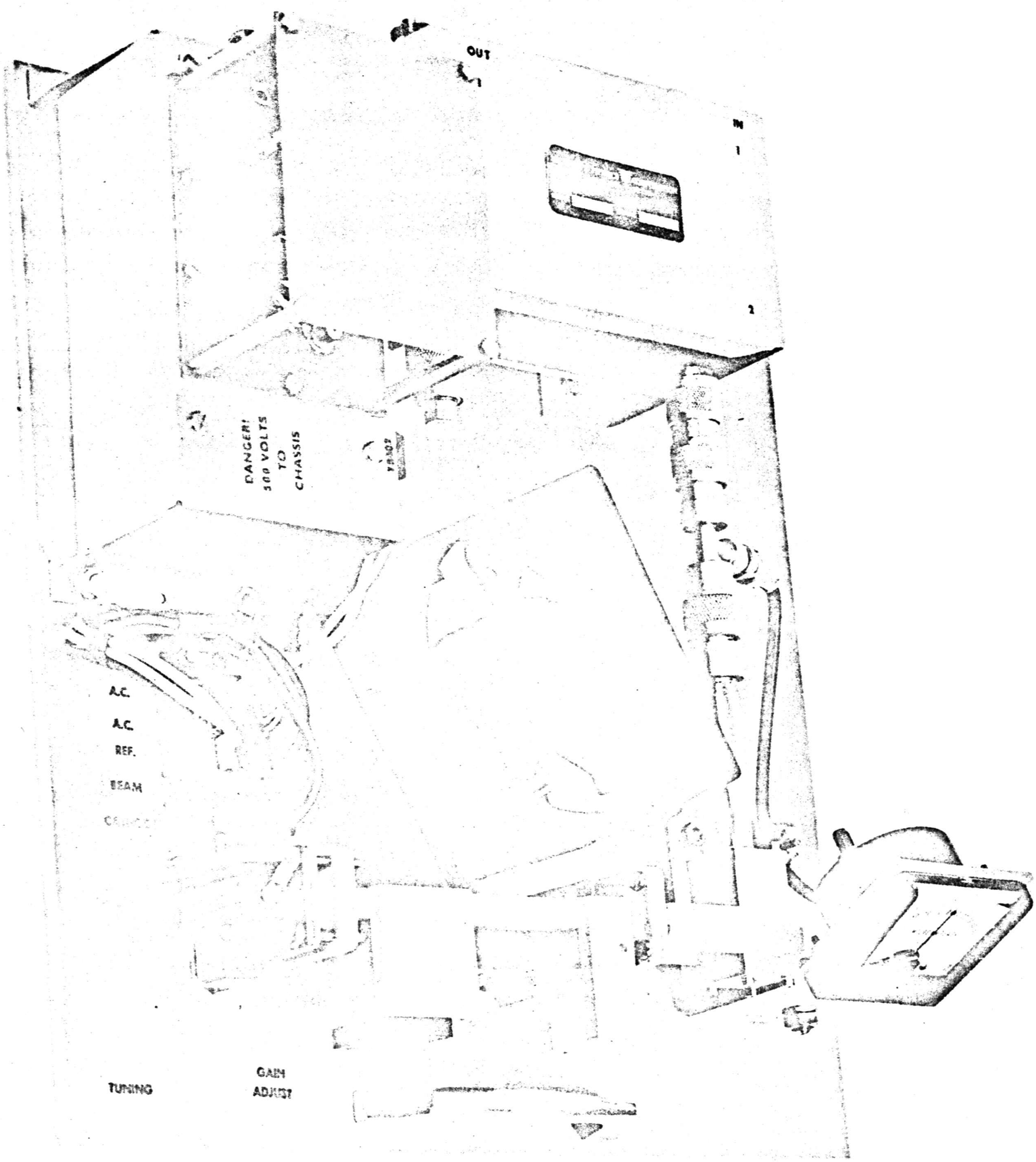

NOISE TEMPERATURE °K
180
160
140
120
100
0
10
20
30
40°C
ROOM TEMPERATURE °C
AIL
HOT-COLD
BODY
TEMP TEST CHAMBER
PARAMP
LEL
MIXER
PREAMP
LO
GR 1218A
AIL
TEST
REC.

FIGURE 15


OUT
1
IN
1
2
DANGER!
300 VOLTS
TO
CHASSIS
A.C.
A.C.
REF.
BEAM
TUNING
GAIN
ADJUST