NATIONAL RADIO ASTRONOMY OBSERVATORY

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ELECTRONICS DIVISION

INTERNAL REPORT NO. 2

THE ELECTRON BEAM PARAMETRIC AMPLIFIER

By

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The information contained herein covers the practical application of the Adler tube since it was returned from Zenith in March where the following modifications were made.

The input and output connectors have a "c" clamp to keep the inner conductor from moving the coupling loop. Micrometers were added to give an indication of mechanical alignment of the input and output couplers. End bell clamping assembly was modified to allow more precise positioning of the R. F. capsule in the magnet. Both tubes were checked; tube 333 was erratic and had to be reconditioned. The DC block and pump balun were modified to operate above ground, and a change was made in the power supply unit here and this was noted on the schematic.

Noise temperatures measured higher than those specified by Zenith. However, their measurements were made with an automatic noise figure indicator while the ones measured here by the Y-factor method, using an Argon tube and hot-cold source.

Stability tests with tube 334-R -- noise temperature of 140 °K and 40 db gain -- show approximately .3 °K peak-to-peak noise with 15 second integration time. Changes in room temperature are quite evident on the output record. By the process of elimination, the quadrapole voltage and magnet seem quite sensitive to such changes. Pump frequency and output seem to be constant with temperature change but both are quite critical to the proper alignment for obtaining best noise temperature of the EBPA. The magnet supply uses two Kepco power supplies in series. This modification was made by D. Durand and has good stability once warm-up has been obtained.

Variation of Adler Tube Noise Temperature With Operating Parameters

The results of measurements made on the noise temperatures of two Adler tubes between June 21 and September 15, 1962 are shown on the accompanying graphs.

In addition, to the plotted parameters, the interception current was also monitored. It was found that lowest noise temperatures and best stability occurred simultaneously with low interception current. The interception current is monitored at the cuccia couplers and is used as an indication of proper beam position. Any mismatch or improper voltages and currents change the beam position and therefore induces a current into the plates of the couplers. Therefore, in beginning measurements after installing the tube, the best procedure is to adjust the mechanical adjustments for minimum interception current and the electrical adjustments as per the manufacturer's specifications. This will bring the noise temperature within a range readable on the Automatic Noise Figure Indicator. Once this is achieved, the system can be adjusted for lowest noise temperature directly. It was found that it is possible to get very close to the proper mechanical adjustment, local oscillator frequency, and mixer current on the first try. Following this, lowest noise temperature is achieved by cyclic adjustment of the other electrical parameters with occasional modification of the above-mentioned three. Once a low noise temperature was achieved, it remained constant over long periods of time (days). In fact, the distrubing factors were usually external to the tube, such as equipment failures or changes in the measurement program.

As can be seen from the attached graphs, the noise temperature is extremely sensitive to changes in the tube voltages, currents, and frequencies, and the Quadrapole voltage being the most critical and Electrode B Voltage being the least critical. The critical parameters are usually adjusted very close to the brink of noise temperature degeneration. If they are set too close to the drop off point, slight instabilities, in power supply or room temperature for instance, will cause a degradation in noise temperature.

The gain vs. pump power and noise temperature vs. pump power measurements show that the Rhode and Swartz SLRD is not as stable as the FXR pump. However, one should consider the fact that during the two above-mentioned measurements the pump had to be turned off and on, and therefore the stability would not be as good.

The two tubes showed similar characteristics as far as sensitivity to parameter change, but tube 233-R gave a much lower noise temperature (100°) than did tube 234-R (140°).

Voltages and Currents for Adler Tube 234-R

These are the values which are held constant while one at a time is varied for the following curves. (Noise temperature is measured with Hot-Cold Noise Source.)

A = 25.1 V
B = 14.5 V
CC = 11.4 V
Q = 7.3 V
Mag = 1.25 A (on PS No. 1312)
Call = 29 μA
Cath = 0+ (inception current)
Mixer = 1 mA
L/O = 1451 Mc
Pump = 2832.5 Mc
Mag Volts = PS 1312: 38 V
PS : 31 V

NT with above settings = 160 °K - 165 °K

Voltages and Currents for Adler Tube 233-R

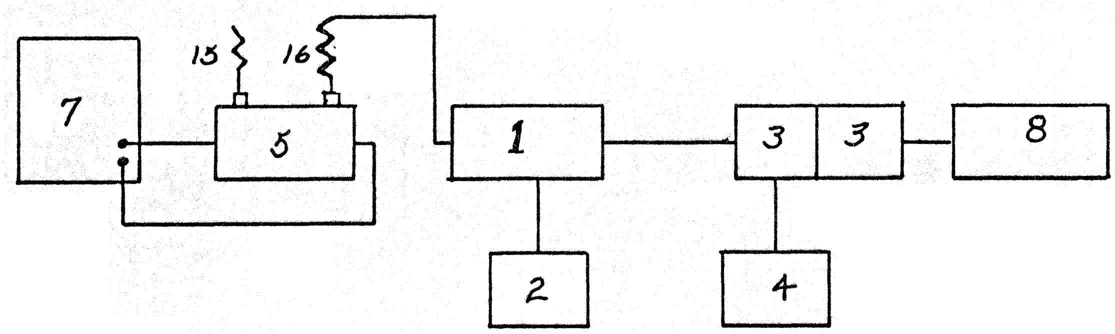
A = 26.2 V
B = 18.0 V
CC = 8.7 V
Q = 6.4 V
Mag = 1.255
Call = 18.5 μA
Cath = 12.6 mA
Inc = 0.5 μA
Mixer = 1 mA
L/O = 1435 Mc
Pump = 2809.5 Mc

NT with above settings = 110 °K - 130 °K

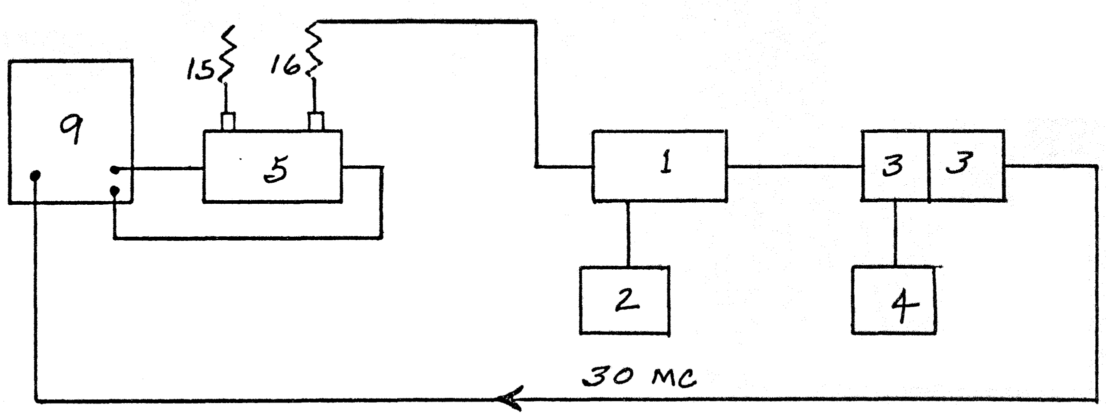
The following block diagrams describe the systems used in making the various measurements. A description of components is attached.

I. Noise Figure Measurements

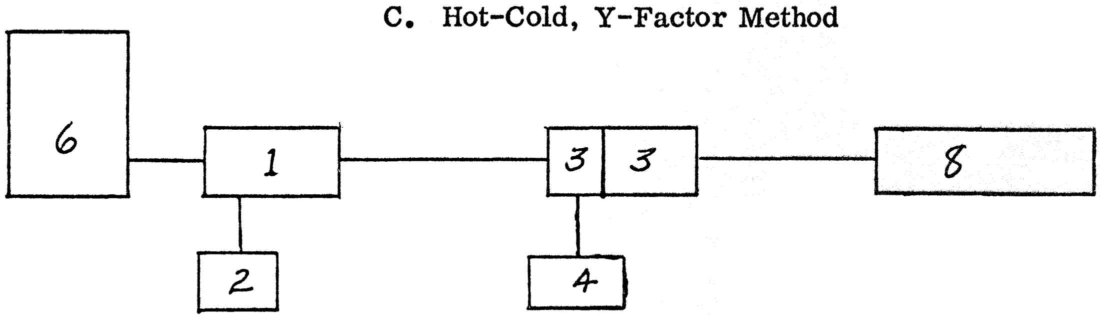
A. Y-Factor Method (Argon)



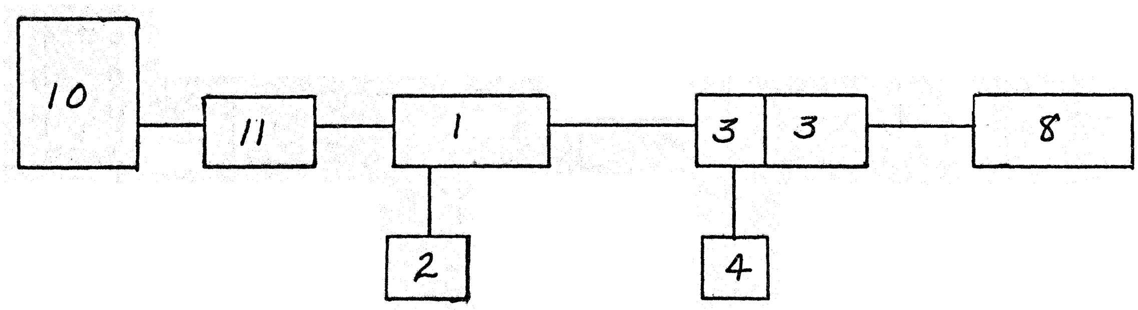
B. Automatic Method



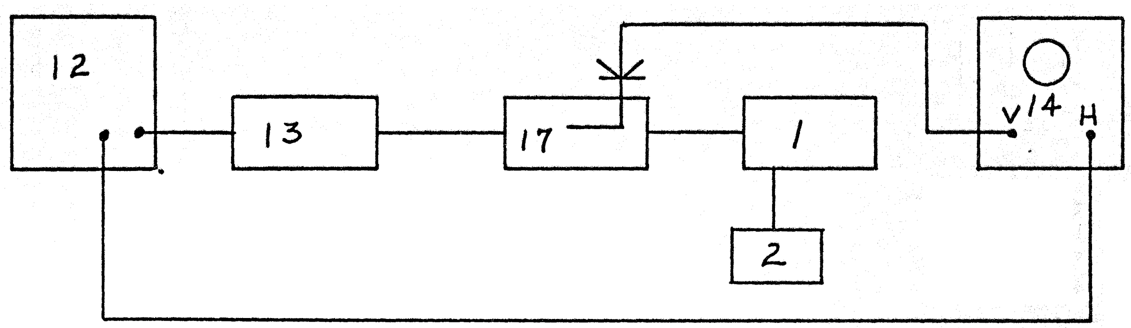
C. Hot-Cold, Y-Factor Method



II. Gain Measurements

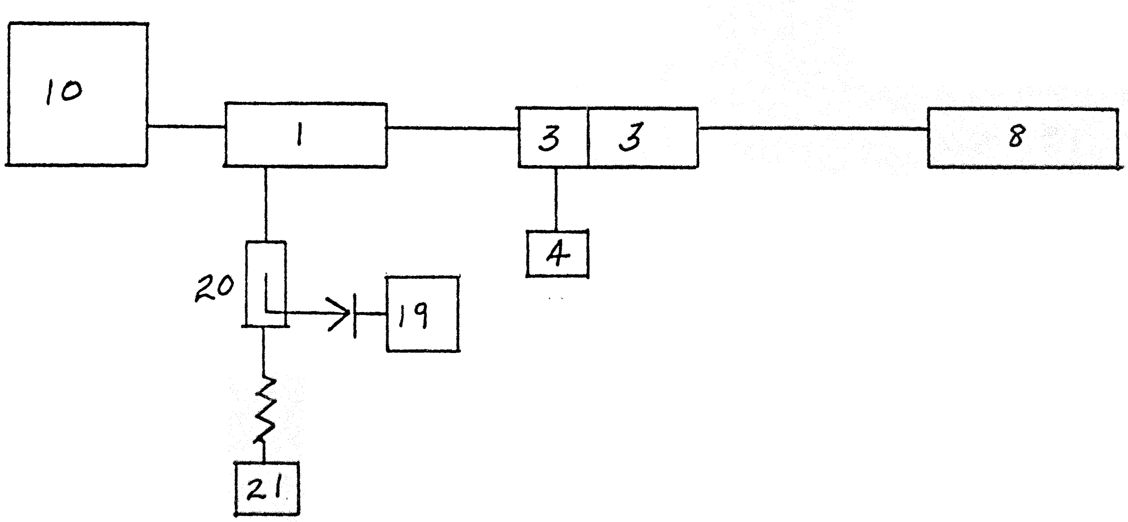


III. Coupler Alignment

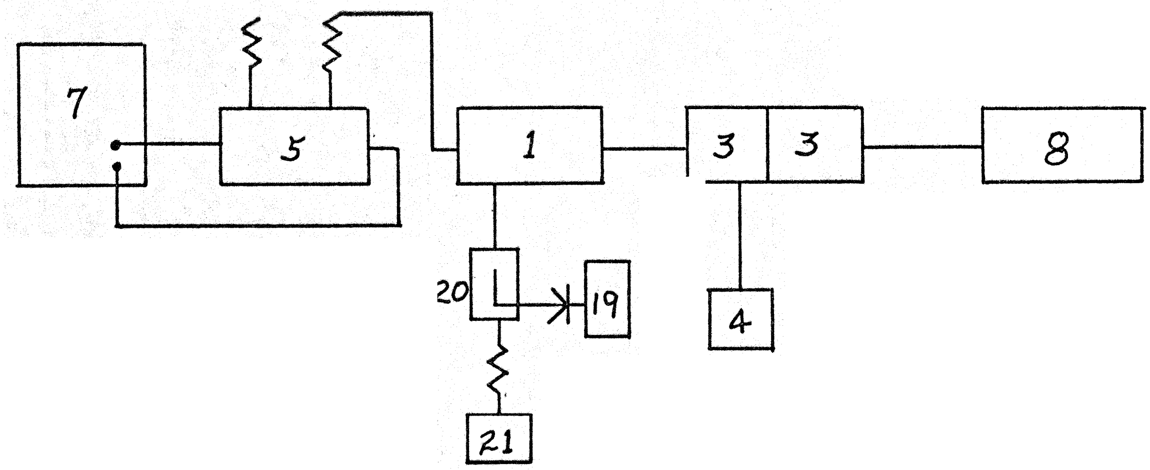


A. Input coupler adjusted with voltages applied.
B. Output coupler adjusted without voltages applied.

IV. Gain Measurement as a Function of Pump Power

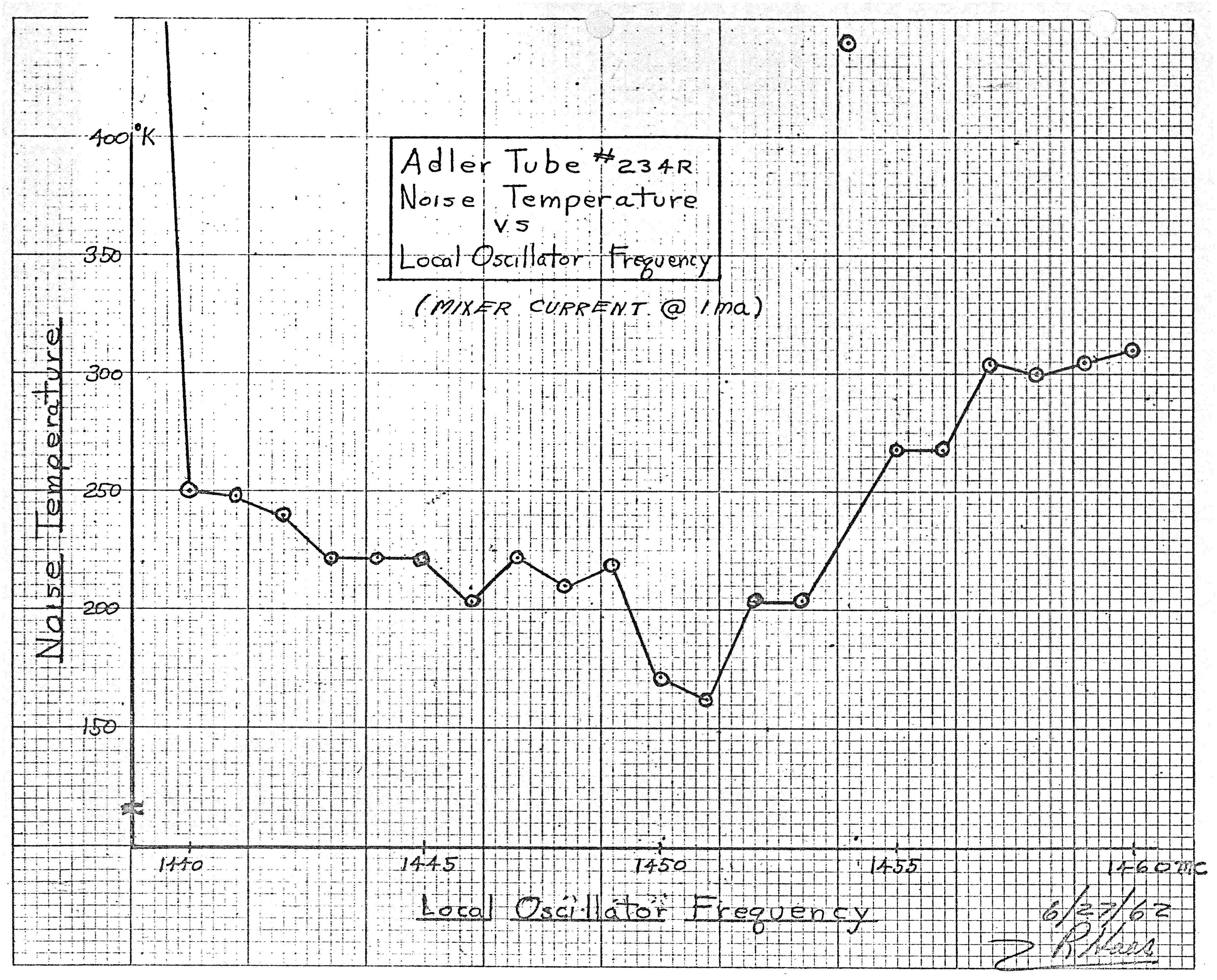


V. Noise Measurements as a Function of Pump Power

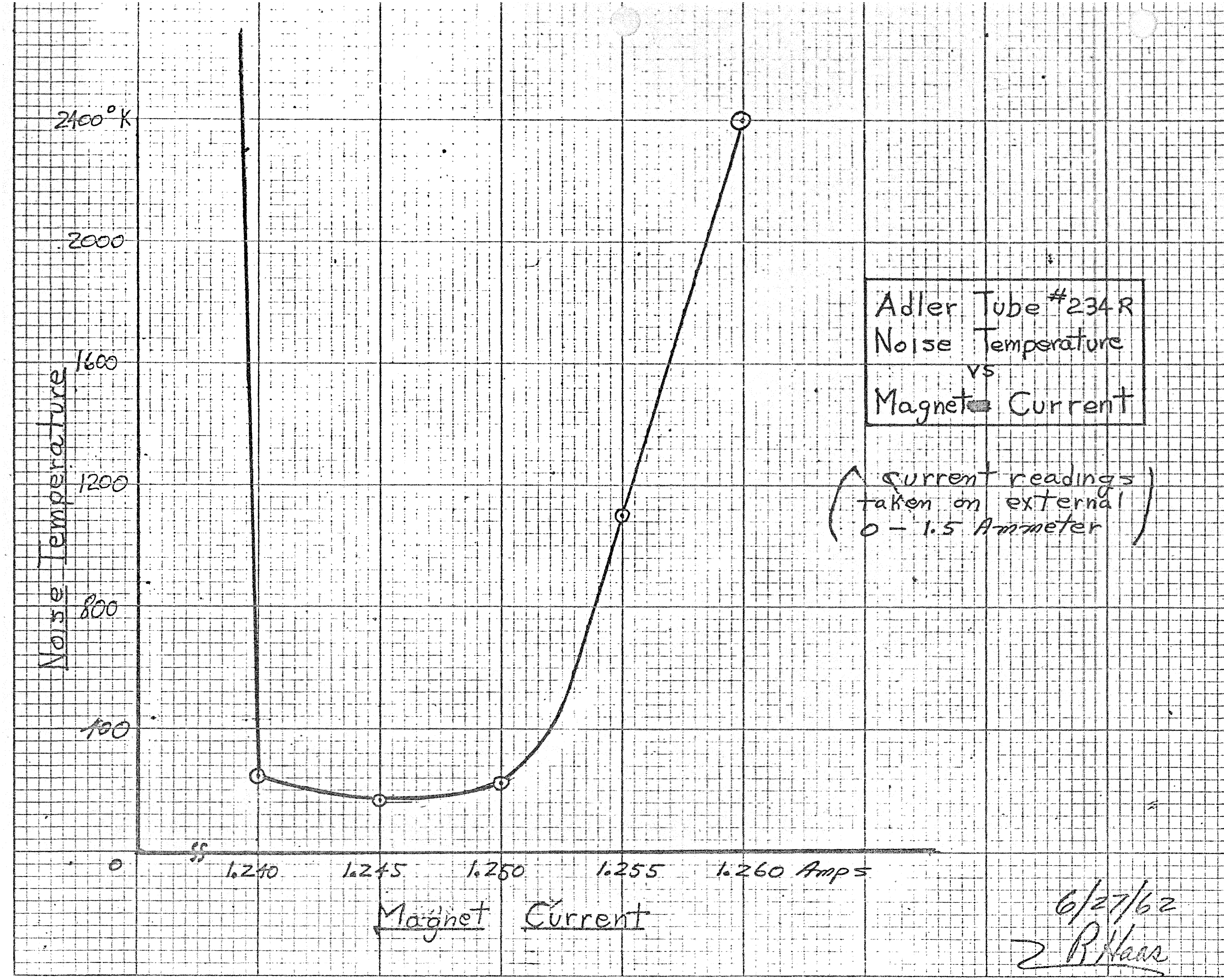


Components Used in Measurement

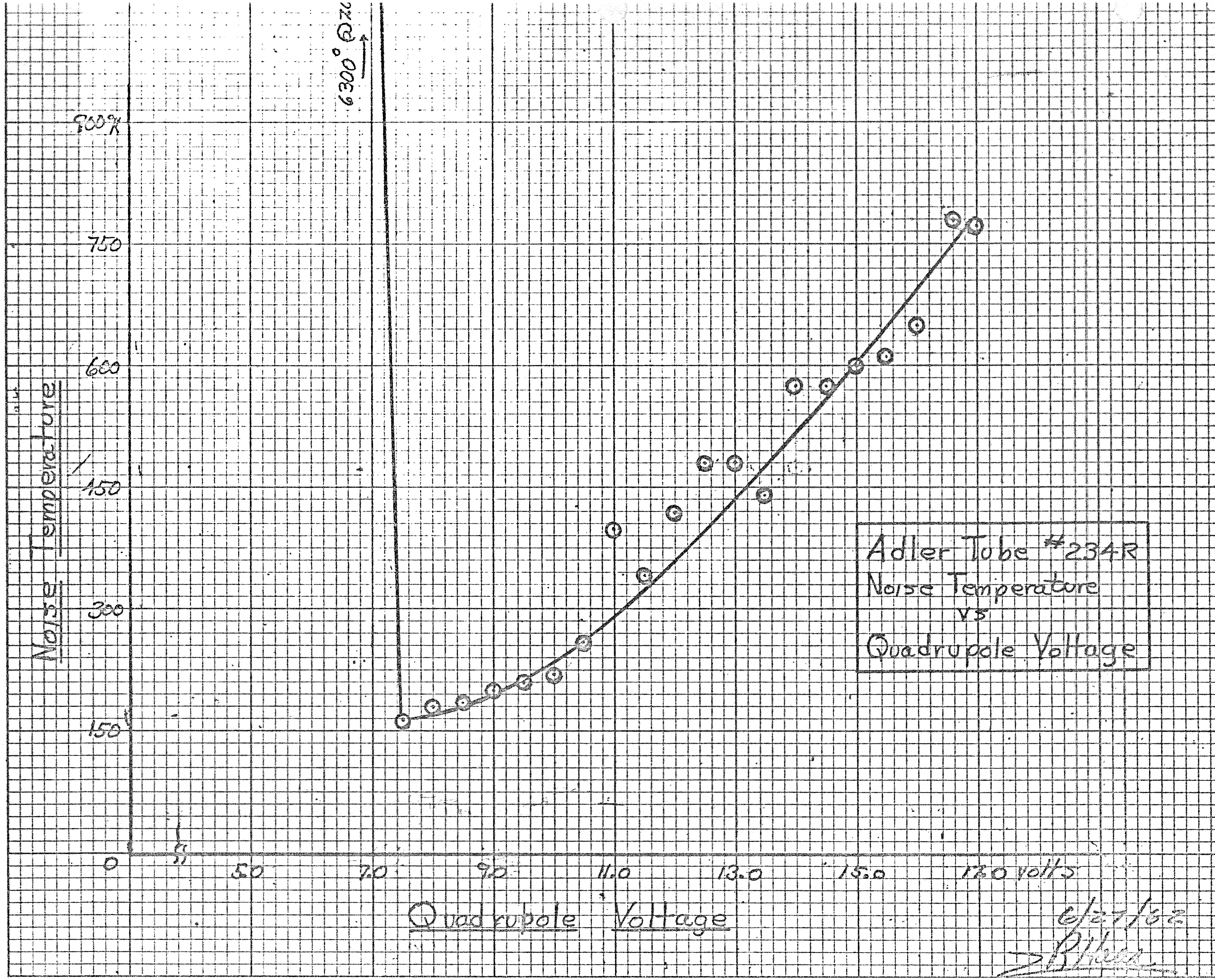
1.	EBPA	
2.	Pump	FXR Model S772A
3.	Mixer-Preamplifier	LEL Model LAC-3
4.	L.O.	GR Model 1218-A
5.	Noise Source (Argon)	AIL Model 7010
6.	Noise Source, Hot-Cold	AIL Model 70
7.	Noise Source, Power Supply	AIL Model 71
8.	Test Receiver	AIL Model 132
9.	Automatic Noise Figure Indicator	HP Model 340B
10.	Signal Generator	HP Model 614A
11.	Isolator	Melabs Model RL-1
12.	Sweep Generator	HP Model 682C
13.	Frequency Meter, Cavity	FXR Model N410A
14.	Scope	
15.	50	
16.	10 db Attenuator	
17.	Directional Coupler	
18.	Crystal Detector	
19.	Power Meter and Bolometer	HP Model 431A
20.	Directional Coupler	
21.	Pump	Rhode & Swartz SLRD



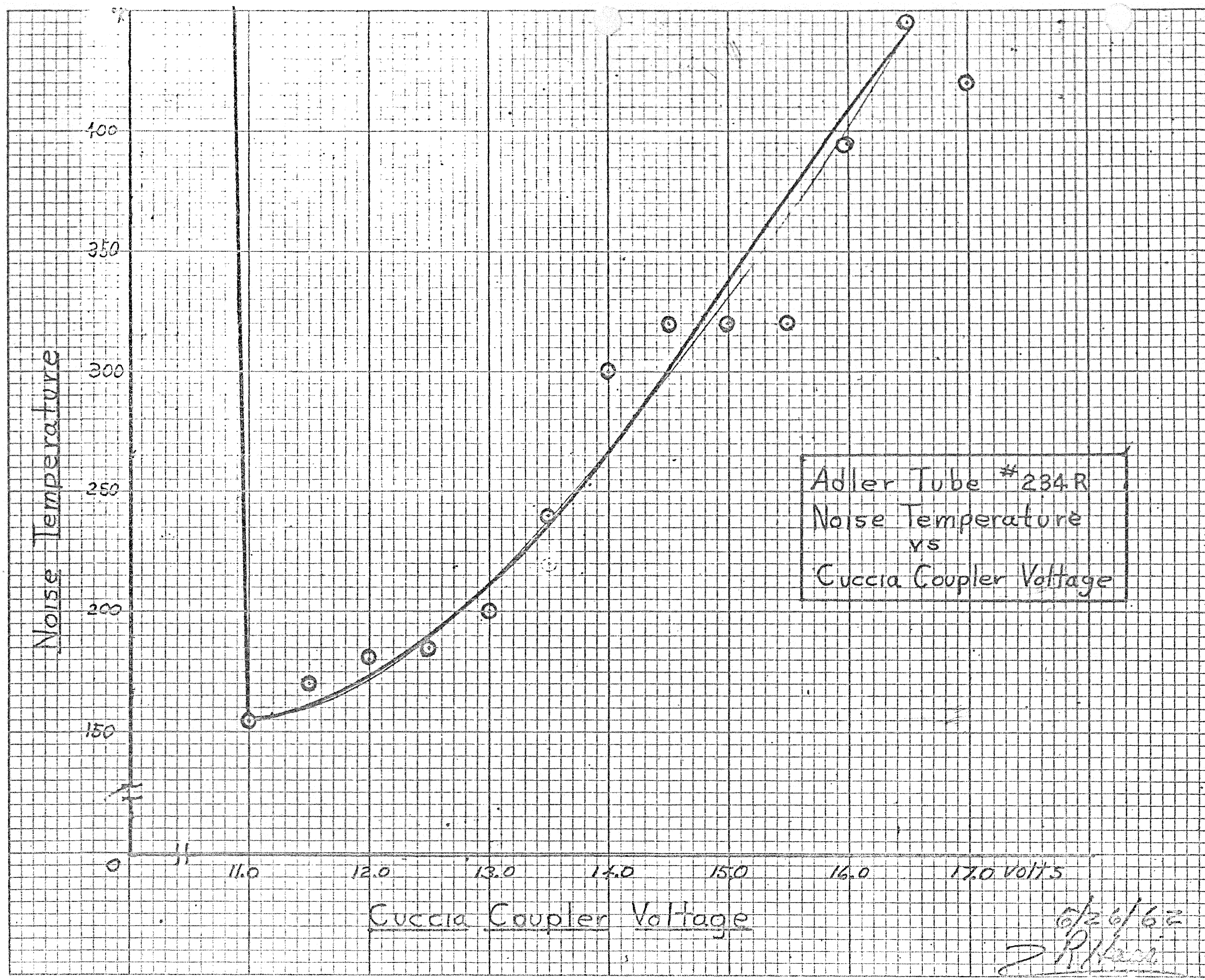
Adler Tube #234R
Noise Temperature
vs
Local Oscillator Frequency
(MIXER CURRENT @ 1ma)
400°K
350
300
250
200
150
Noise Temperature
1440
1445
1450
1455
1460 mc
Local Oscillator Frequency
6/27/62



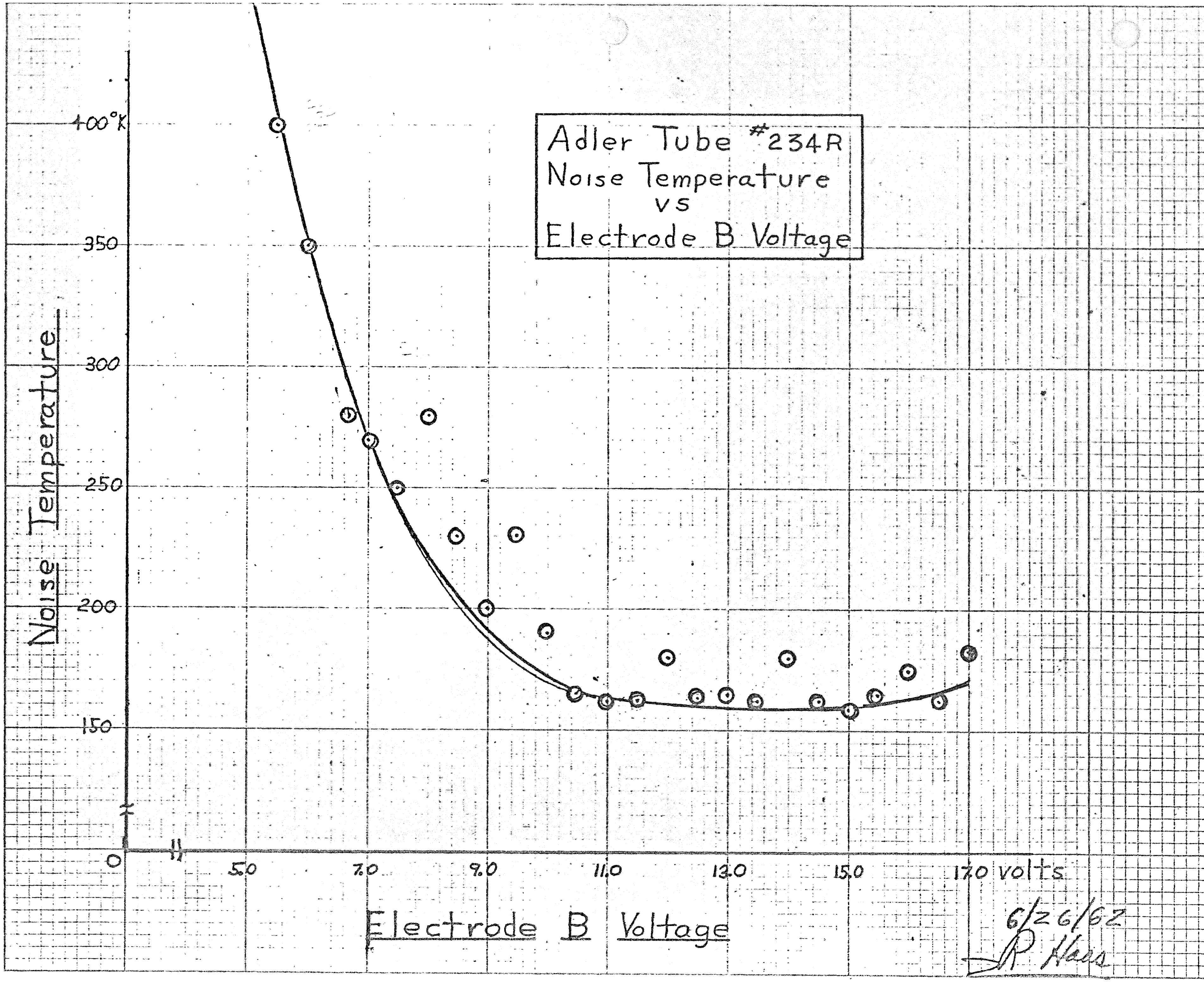
Adler Tube #234R
Noise Temperature
vs
Magnet Current
(current readings taken on external 0 - 1.5 Ammeter)
2400 °K
2000
1600
1200
800
400
0
1.240
1.245
1.250
1.255
1.260 Amps
Noise Temperature
Magnet Current
6/27/62
R Haas

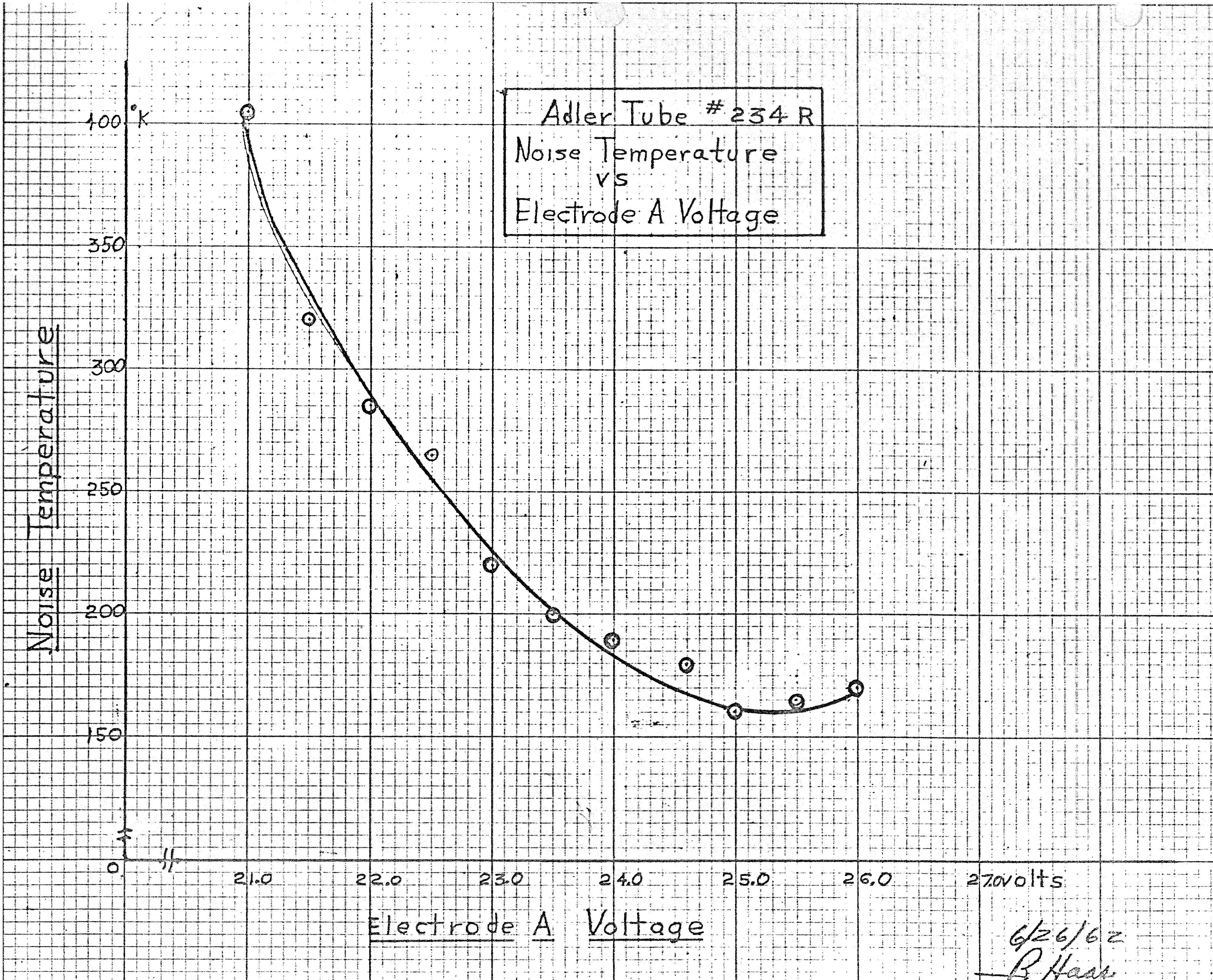


Adler Tube #234R
Noise Temperature
vs
Quadrupole Voltage
Noise Temperature
900°K
750
600
450
300
150
0
5.0
7.0
9.0
11.0
13.0
15.0
17.0 volts
Quadrupole Voltage
6300° @ 7.0
6/27/62

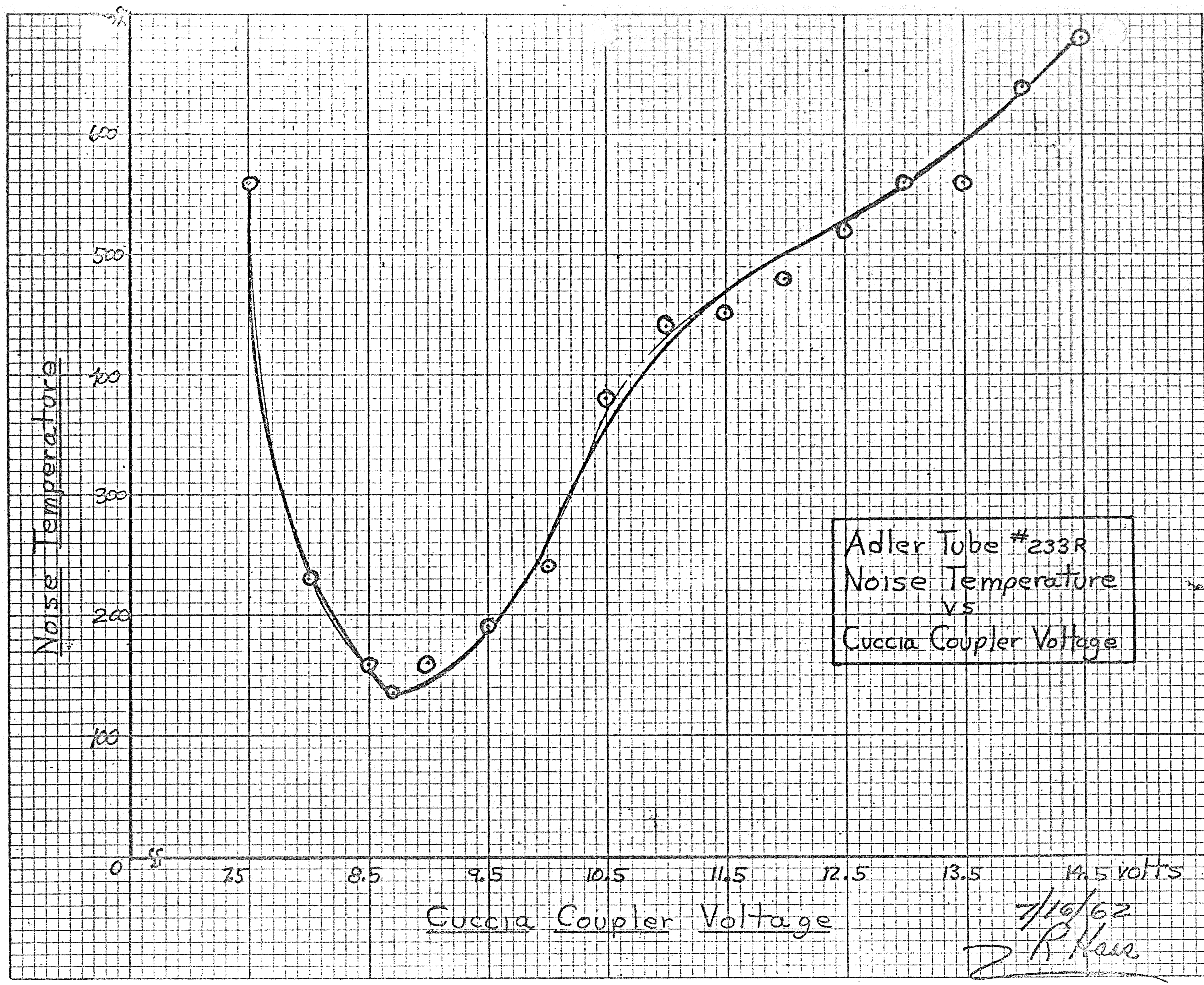


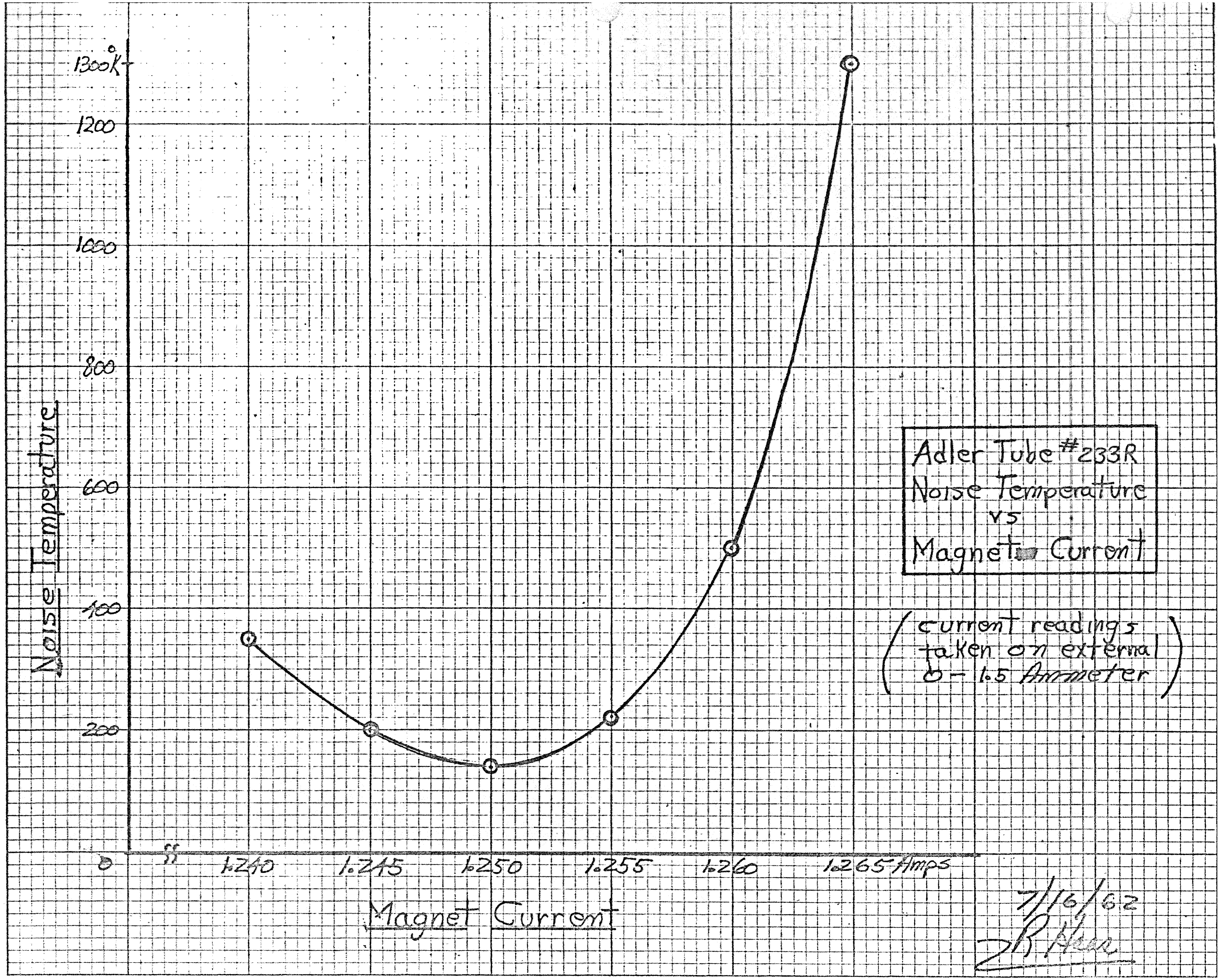
Adler Tube #234 R
Noise Temperature
vs
Cuccia Coupler Voltage
Noise Temperature
°K
400
350
300
250
200
150
0
11.0
12.0
13.0
14.0
15.0
16.0
17.0 Volts
Cuccia Coupler Voltage
6/26/62


Adler Tube #234R
Noise Temperature
vs
Electrode B Voltage
400°K
350
300
250
200
150
0
5.0
7.0
9.0
11.0
13.0
15.0
17.0 volts
Noise Temperature
Electrode B Voltage
6/26/62
R Haas

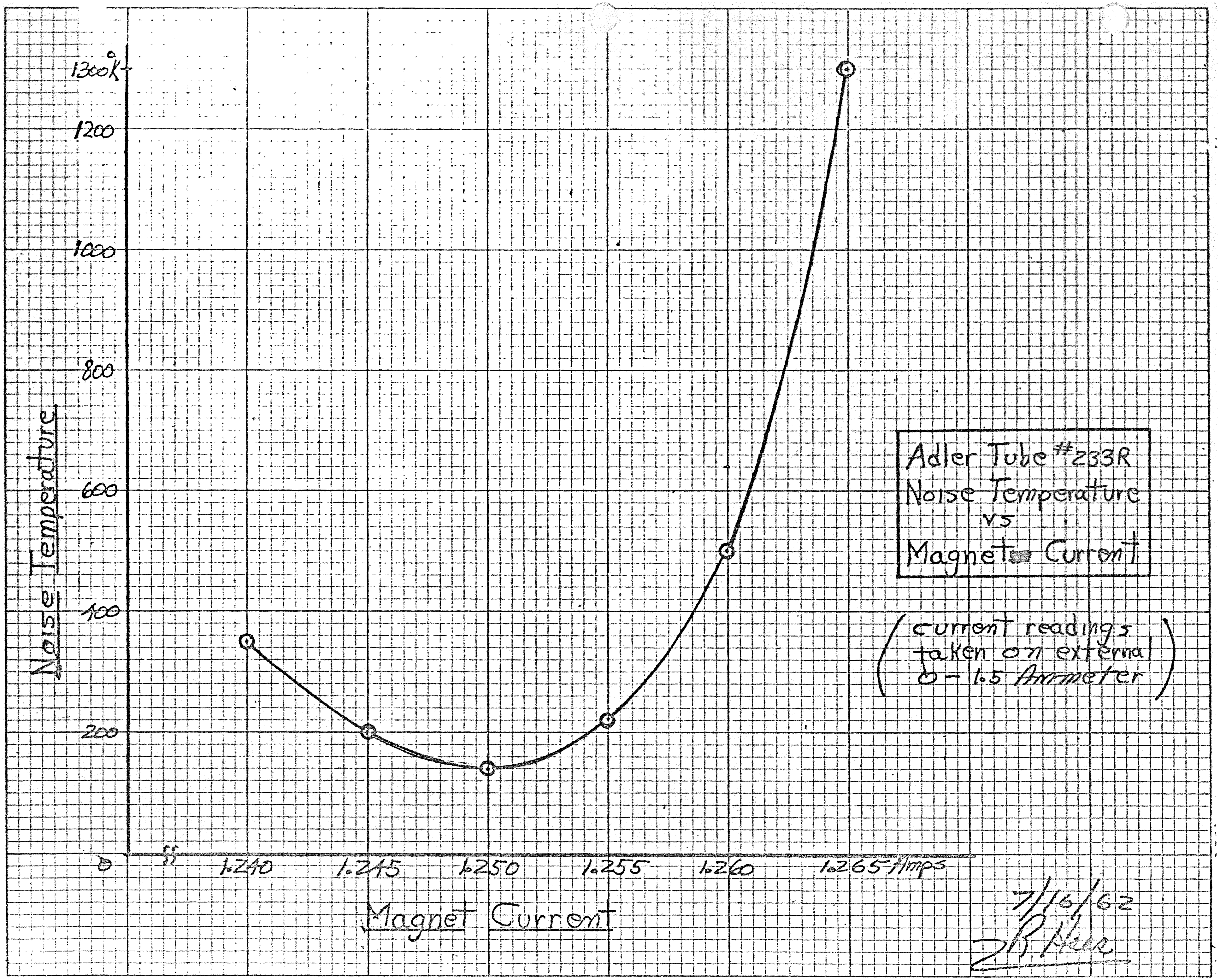


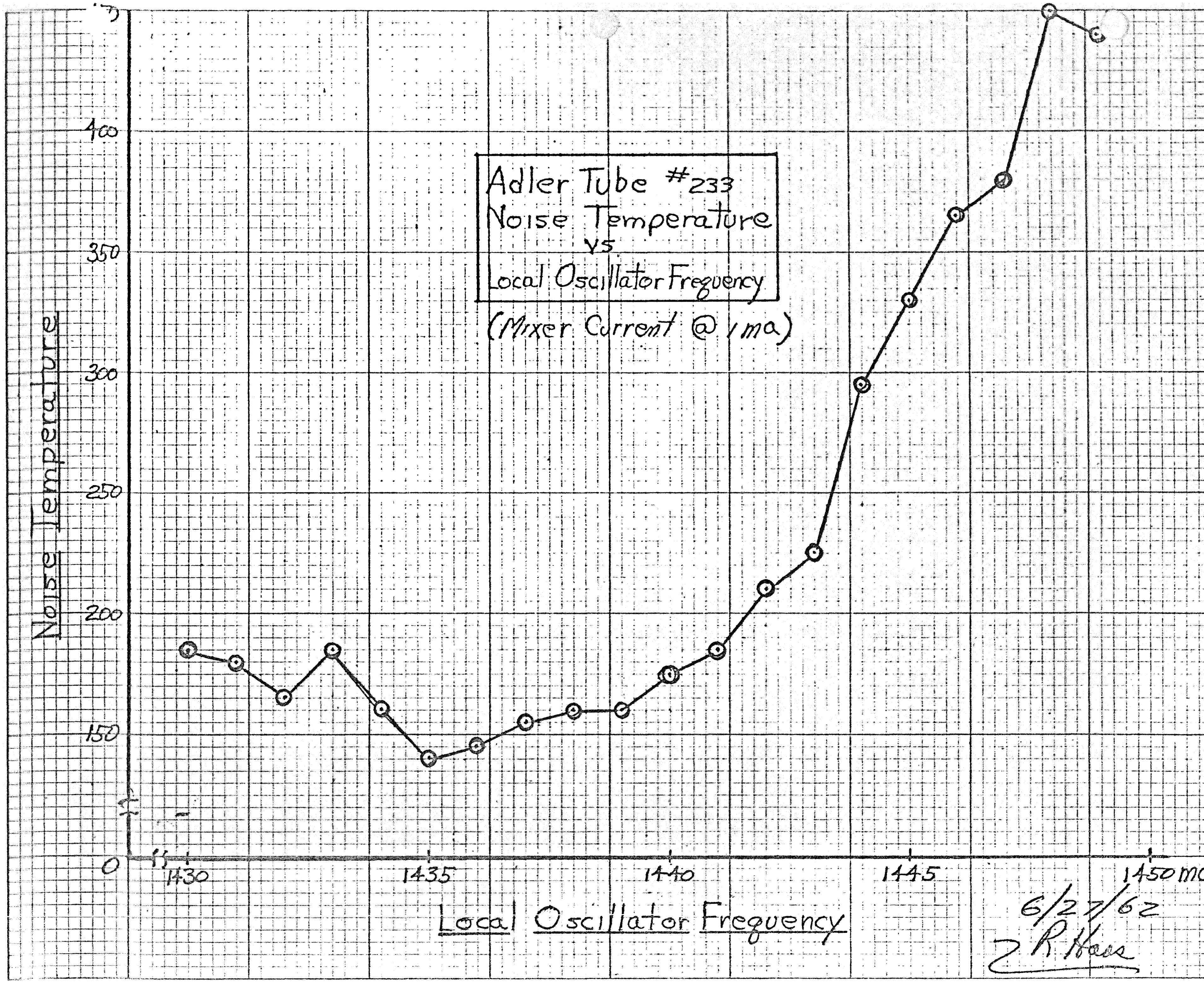
Adler Tube # 234 R
Noise Temperature
vs
Electrode A Voltage
400 °K
350
300
250
200
150
0
21.0
22.0
23.0
24.0
25.0
26.0
27.0 volts
Noise Temperature
Electrode A Voltage
6/26/62


Adler Tube #233R
Noise Temperature
vs
Cuccia Coupler Voltage
Noise Temperature
600
500
400
300
200
100
0
7.5
8.5
9.5
10.5
11.5
12.5
13.5
14.5 volts
Cuccia Coupler Voltage
7/16/62
R Kaue

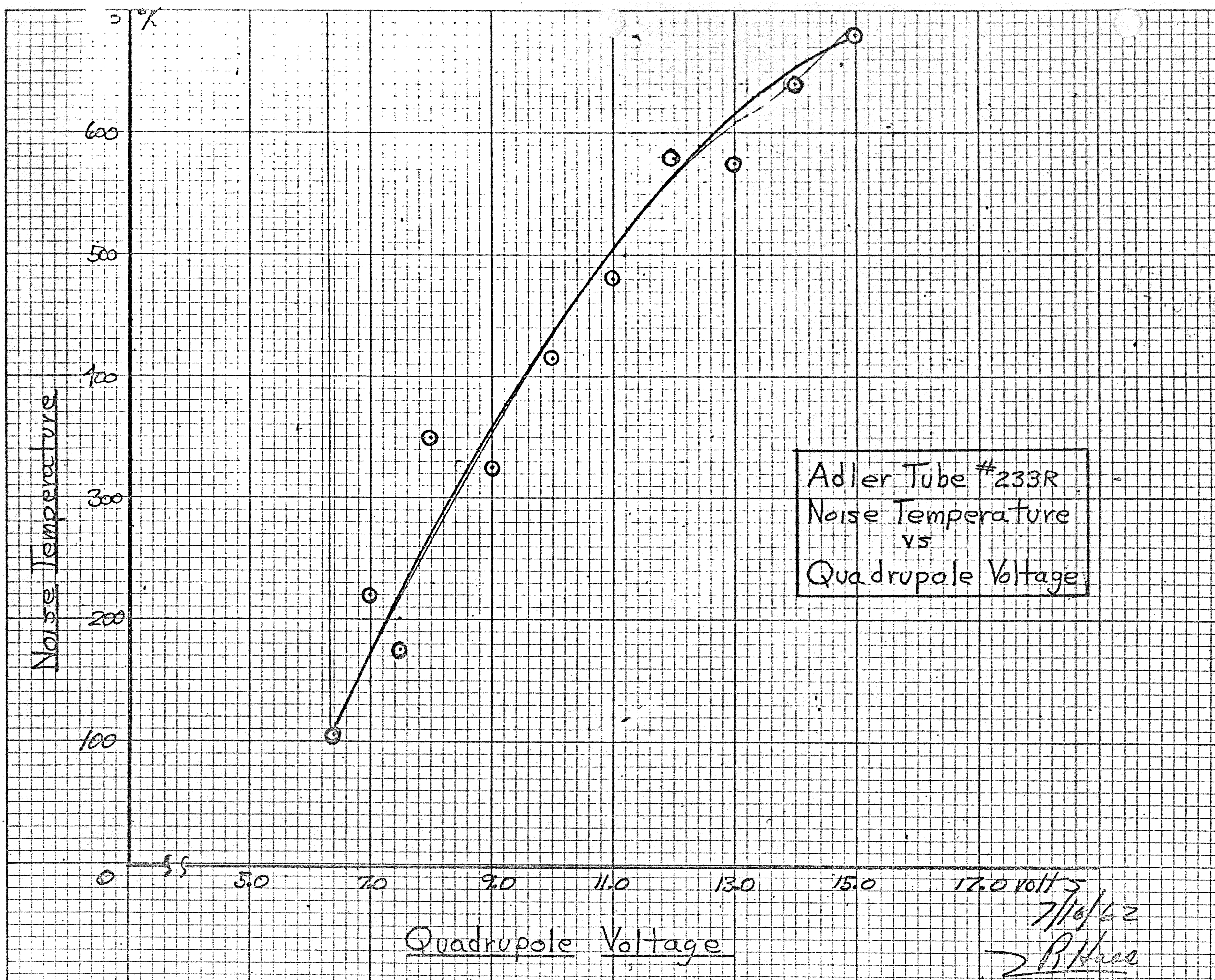


Adler Tube #233R
Noise Temperature
vs
Magnet Current
(current readings taken on external 0 - 1.5 Ammeter)
1300°K
1200
1000
800
600
400
200
0
1.240
1.245
1.250
1.255
1.260
1.265 Amps
Noise Temperature
Magnet Current
7/16/62

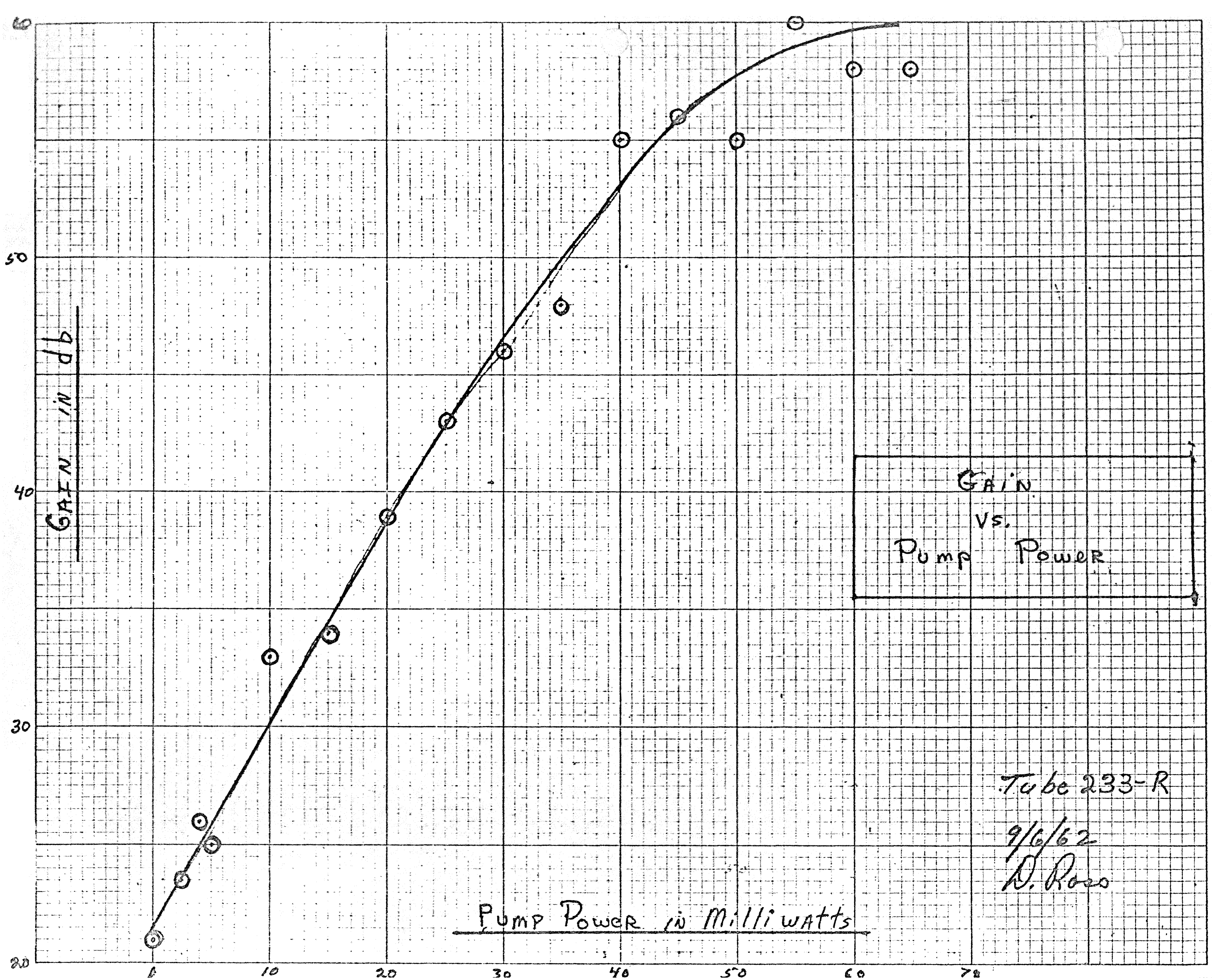

Adler Tube #233R
Noise Temperature
vs
Magnet Current
(current readings taken on external 0 – 1.5 Ammeter)
1300°K
1200
1000
800
600
400
200
0
1.240
1.245
1.250
1.255
1.260
1.265 Amps
Noise Temperature
Magnet Current
7/16/62

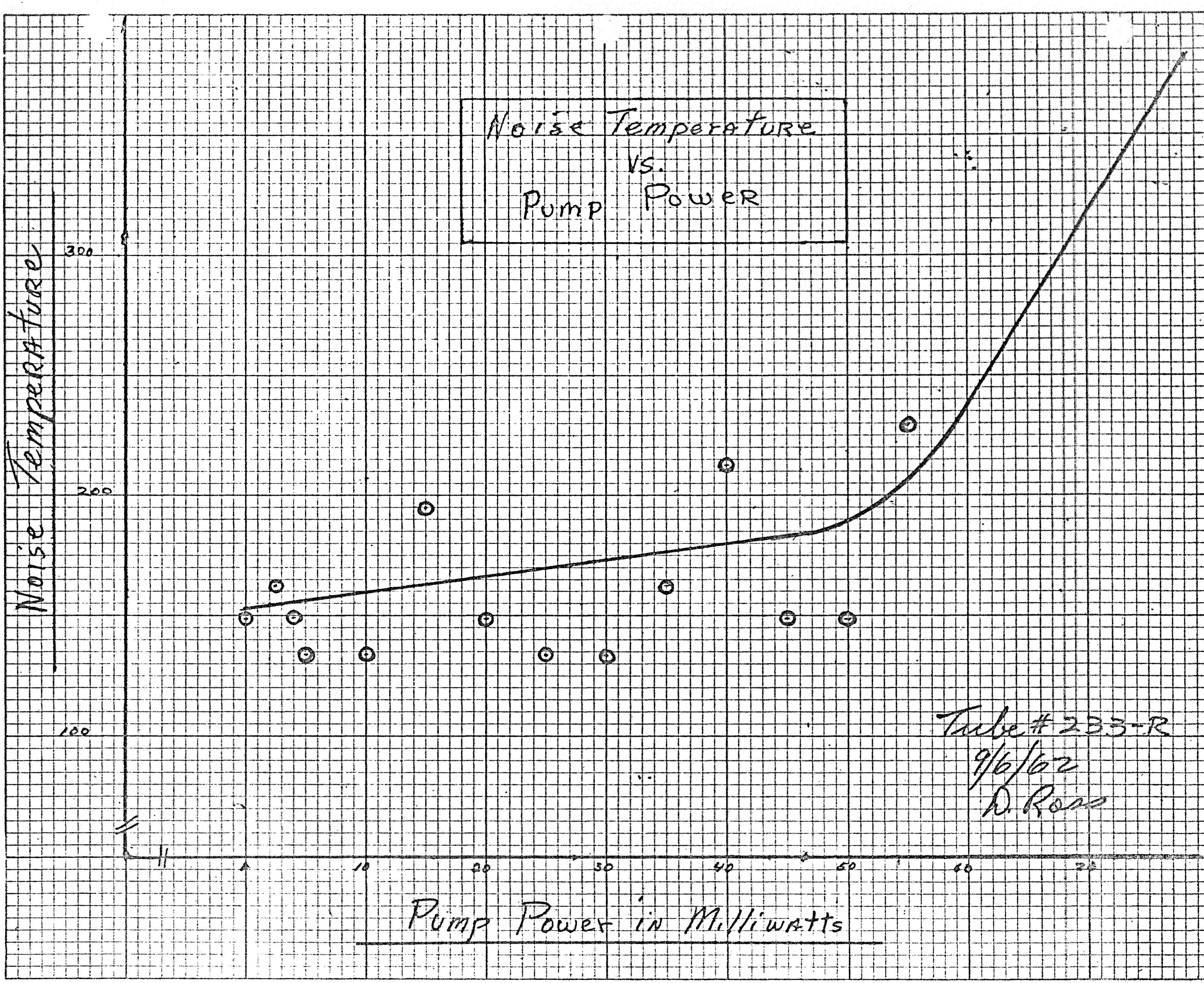


Adler Tube #233
Noise Temperature
vs
Local Oscillator Frequency
(Mixer Current @ 1 ma)
Noise Temperature
400
350
300
250
200
150
0
1430
1435
1440
1445
1450 mc
Local Oscillator Frequency
6/27/62
R. Haas

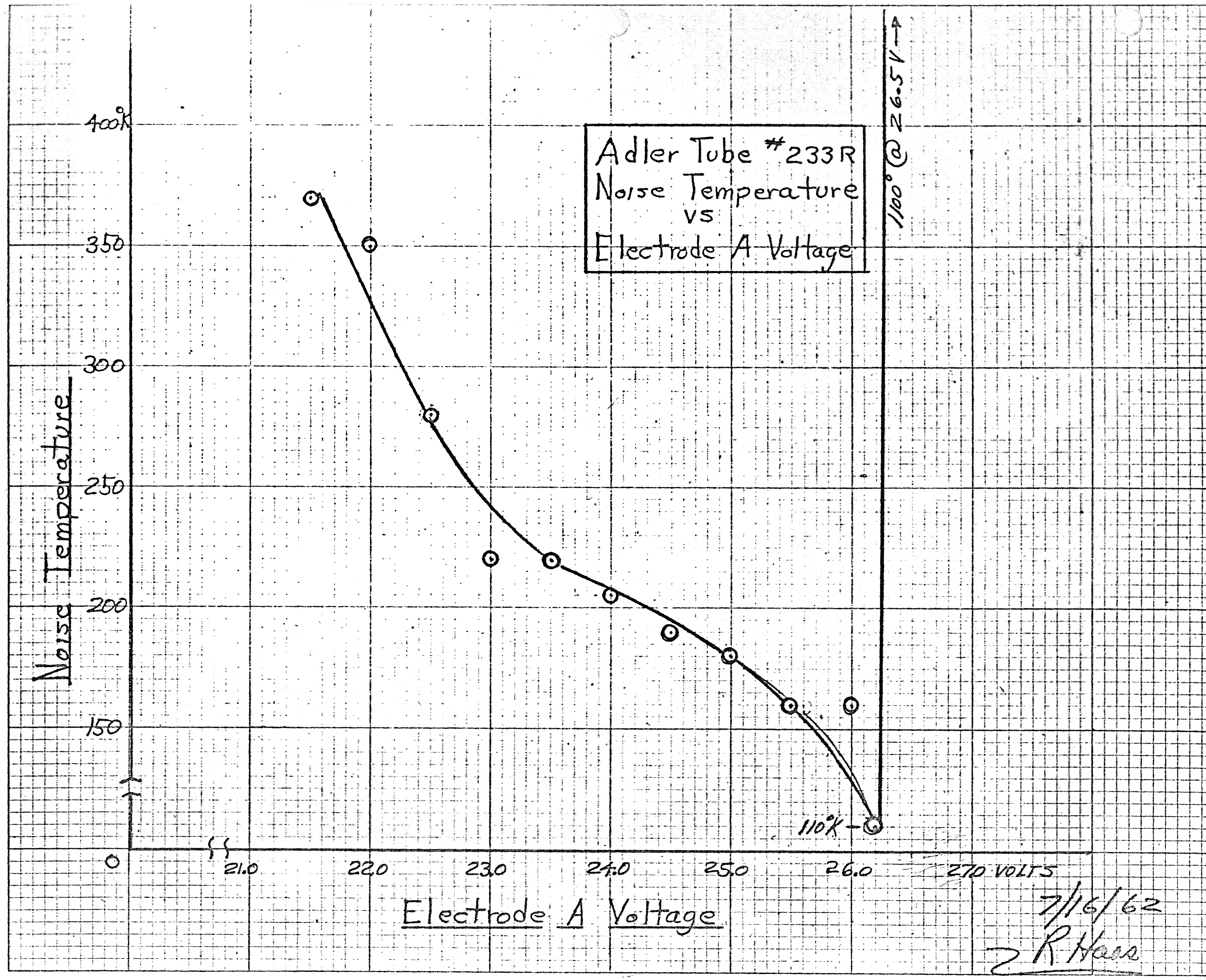


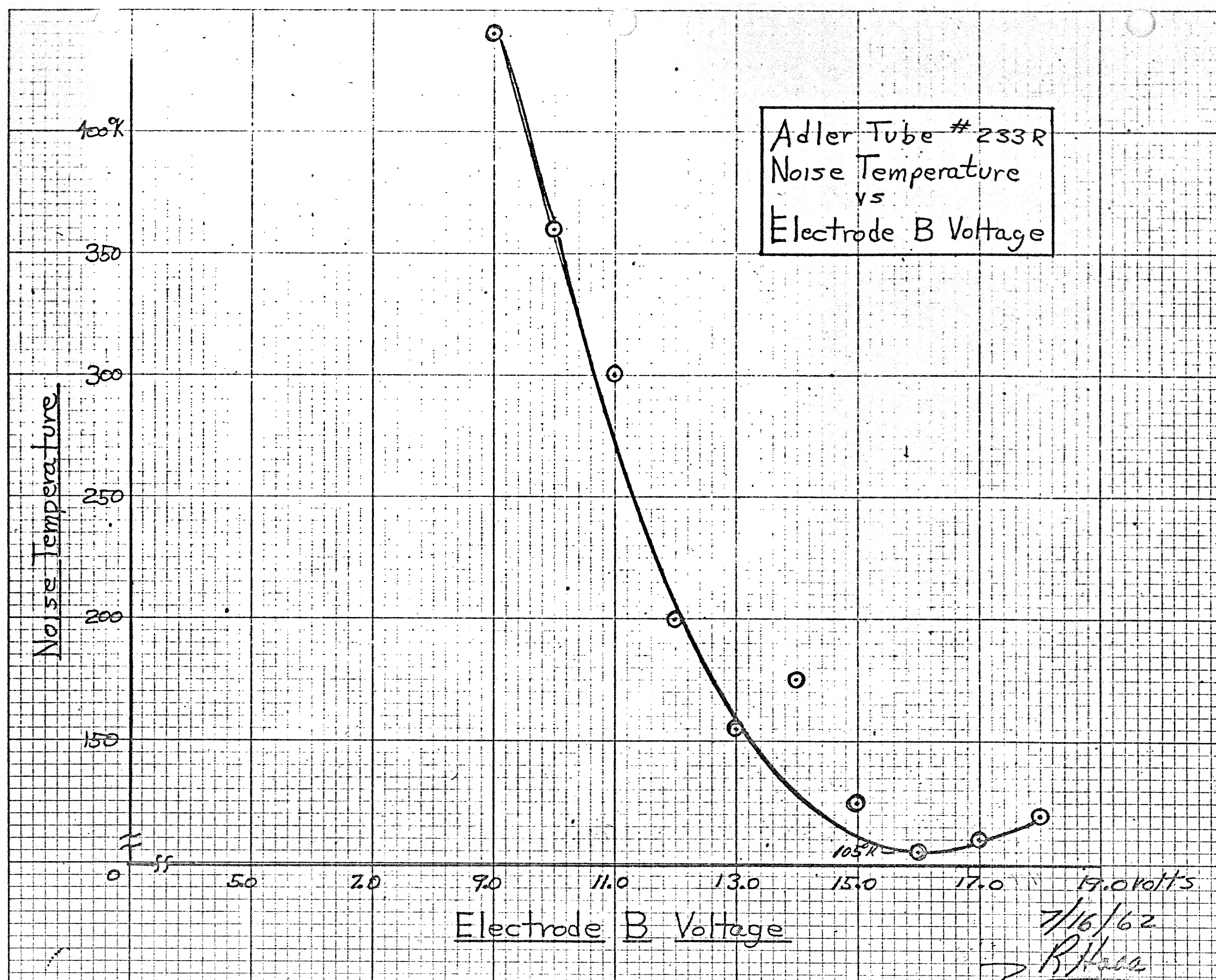
Adler Tube #233R
Noise Temperature
vs
Quadrupole Voltage
°K
600
500
400
300
200
100
0
Noise Temperature
5.0
7.0
9.0
11.0
13.0
15.0
17.0 volts
Quadrupole Voltage
7/16/62


GAIN vs. PUMP POWER
Tube 233-R
9/6/62
D. Rosso
PUMP POWER IN MILLIWATTS
GAIN IN db
60
50
40
30
20
0
10
20
30
40
50
60
70

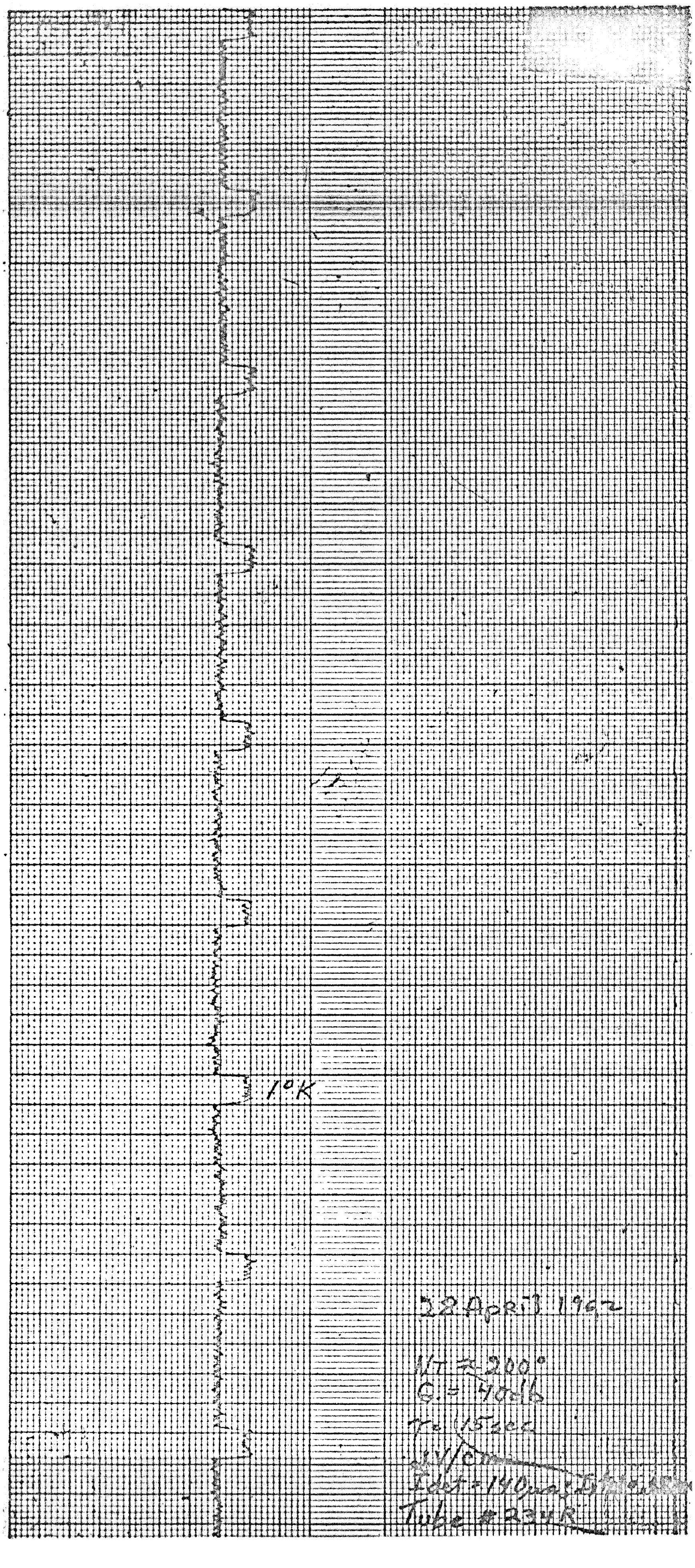


Noise Temperature
Vs.
Pump Power
300
200
100
10
20
30
40
50
60
Noise Temperature
Pump Power in Milliwatts
Tube #233-R
9/6/62
D. Ross


Adler Tube #233R
Noise Temperature
vs
Electrode A Voltage
1100° @ 26.5V →
400°K
350
300
250
200
150
0
21.0
22.0
23.0
24.0
25.0
26.0
27.0 VOLTS
110°K
Noise Temperature
Electrode A Voltage
7/16/62
R. Hass



Adler Tube #233R
Noise Temperature
vs
Electrode B Voltage
Noise Temperature
400°K
350
300
250
200
150
0
105°K
5.0
7.0
9.0
11.0
13.0
15.0
17.0
19.0 volts
Electrode B Voltage
7/16/62


1°K
22 April 1962
NT ≈ 200°
G = 40db
τ = 15sec
Tube #234R