NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

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THERMAL CALIBRATION OF A RADIOMETER

By

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THERMAL CALIBRATION OF A RADIOMETER

Purpose

To determine the temperature of the calibration noise tube (gas discharge noise generator) which is used as a basis for the reduction of source temperature.

Material Required

One thermos bottle with ice water

One thermos bottle with 10 °C water

One 50 ohm load (must be water proofed)

One thermometer (0.1° graduation, 0 °C to 50 °C)

Cables -- type and length will depend on the situation; however, they must be long enough so that they can be attached to some permanent structure, thus assuring minimum movement of the cable while changing the thermos.

Procedure

Remove the input cable from the antenna and attach the 50 ohm load. If the cable normally used between the antenna and the front-end input does not meet the above-stated requirements, substitute a longer cable. Place the water proofed load in the thermos which contains the ice water. Since the thermal time constant of a Stoddard load, covered by a prophylactic, and a Microlab load soldered to a stainless steel rigid coax is several minutes, at least 10 minutes should be allowed for stabilization.

Balance the receiver in the normal manner using the same time constant that is normally used for most observations -- 2 or 5 seconds in most cases. Set the recorder speed to approximately 1 mm/minute.

After you have obtained approximately 1.5 cm of record, turn on the calibration noise tube and leave it on for approximately 1.5 cm of record. Turn off the noise tube, record another 1.5 cm of record, and then replace the ice water with the 10° water. Stir the water with caution. Do not move the load around. When the load has stabilized, that is, after the thermal calibration has leveled off, place the thermometer into the water and read the temperature. Write this temperature on the record. Leave the load in the 10° water until you have 1 cm of record. Read the temperature and write it on the record every half cm. Now replace the 10° water with the ice water and allow approximately 10 minutes for load stabilization. Record approximately 1.5 cm and then turn on the calibration noise tube. After another 1.5 cm of record, turn off the noise tube and record 1.5 cm again. This completes the thermal calibration.

Data Reduction

Find the mean value of the peak-to-peak fluctuations the entire length of the calibration base line and for the two noise tubes and the thermal calibration. Proceed as follows:

$$\Delta T_{cal} \times \frac{D_{nt}}{D_{cal}} = \Delta T_{nt}$$

Where

ΔT_{cal} = average temperature of thermal calibration.

D_{nt} = average deflection for noise tube.

D_{cal} = average deflection for thermal calibration.

ΔT_{nt} = temperature of noise tube calibration.

Such is the case only if the original cable was used. However, if another cable has been substituted, the difference of loss for the two cables must be considered and is done so in the following formula:

$$\Delta T_{cal} \times \frac{D_{nt}}{D_{cal}} \times \frac{L_1}{L_2} = \Delta T_{na}$$

Where

ΔT_{cal} = average temperature of thermal calibration.

D_{nt} = average deflection for noise tube.

D_{cal} = average deflection for thermal calibration.

L_1 = the loss of the original cable (expressed as power ratio).

L_2 = the loss of the substituted cable (expressed as power ratio).

T_{na} = the temperature of the noise tube calibration as seen from the antenna terminal.

If the substituted cable is longer than the original cable, the following can be applied also:

$$\Delta T_{cal} \times \frac{D_{nt}}{D_{cal}} \times \Delta L = \Delta T_{na}$$

Where

ΔT_{cal} = average temperature of thermal calibration.

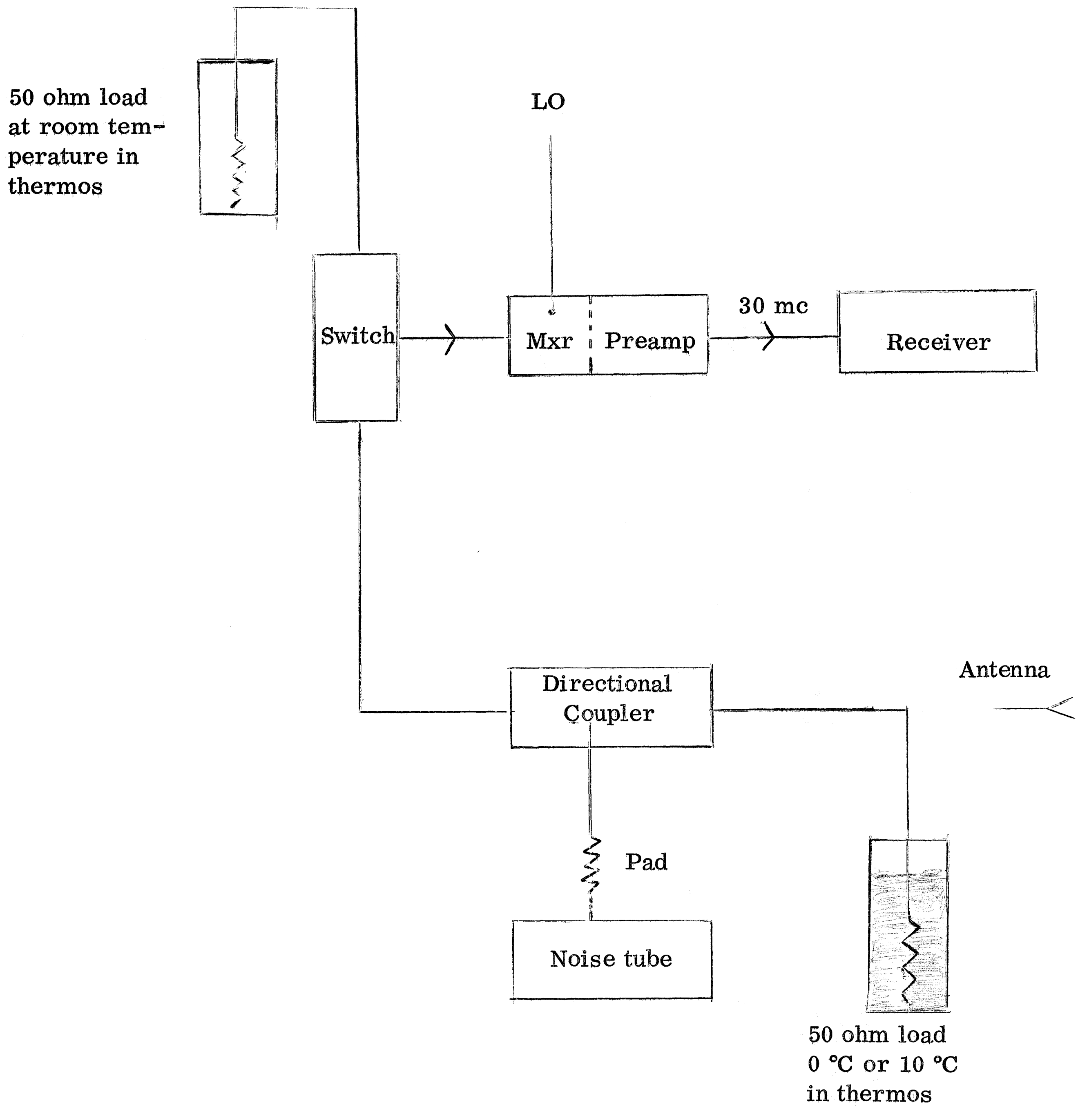
D_{nt} = average deflection for noise tube.

D_{cal} = average deflection for thermal calibration.

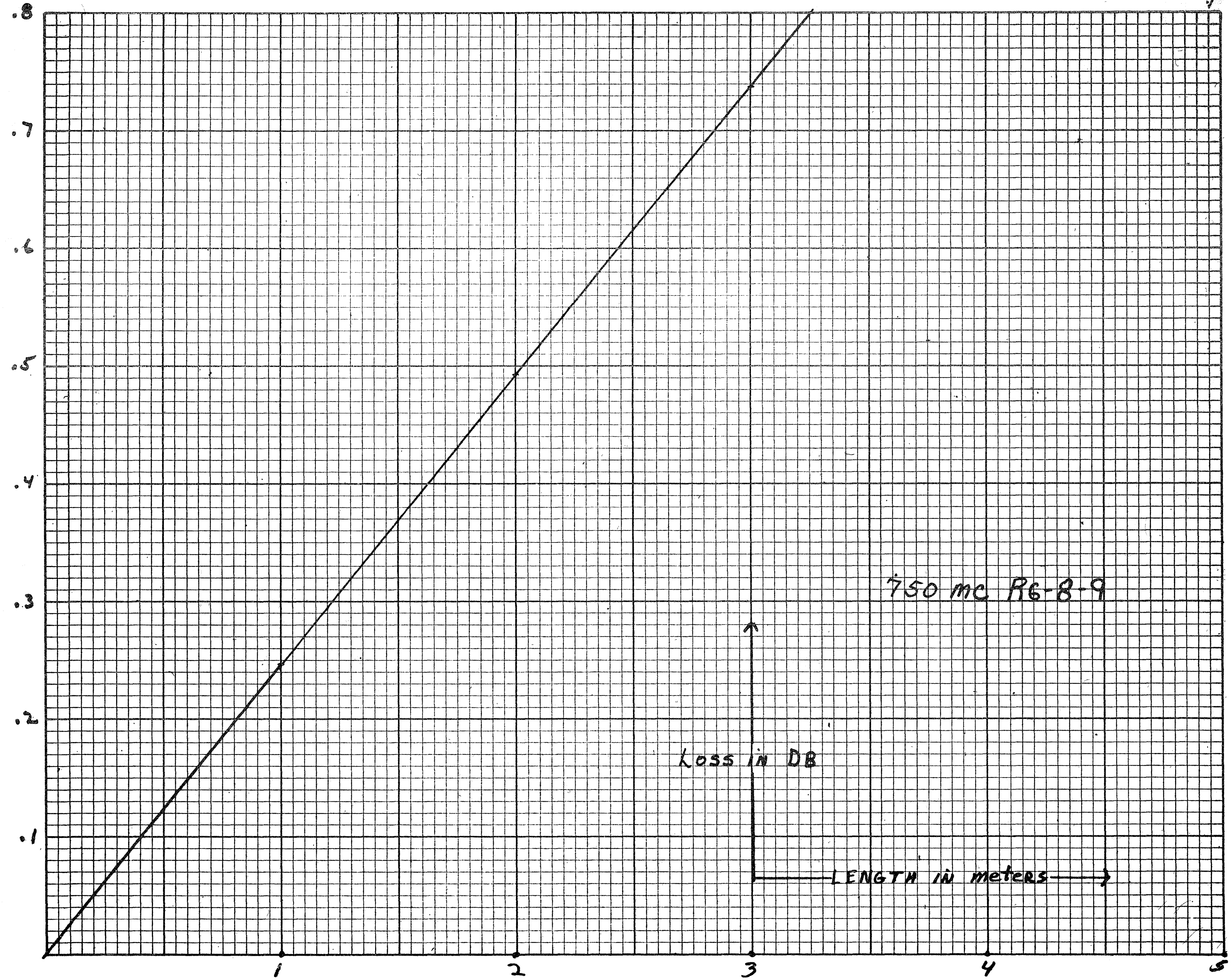
ΔL = the difference of length of the substituted and original cable expressed as power ratio loss.

T_{na} = the temperature of the noise tube calibration as seen from the antenna terminal.

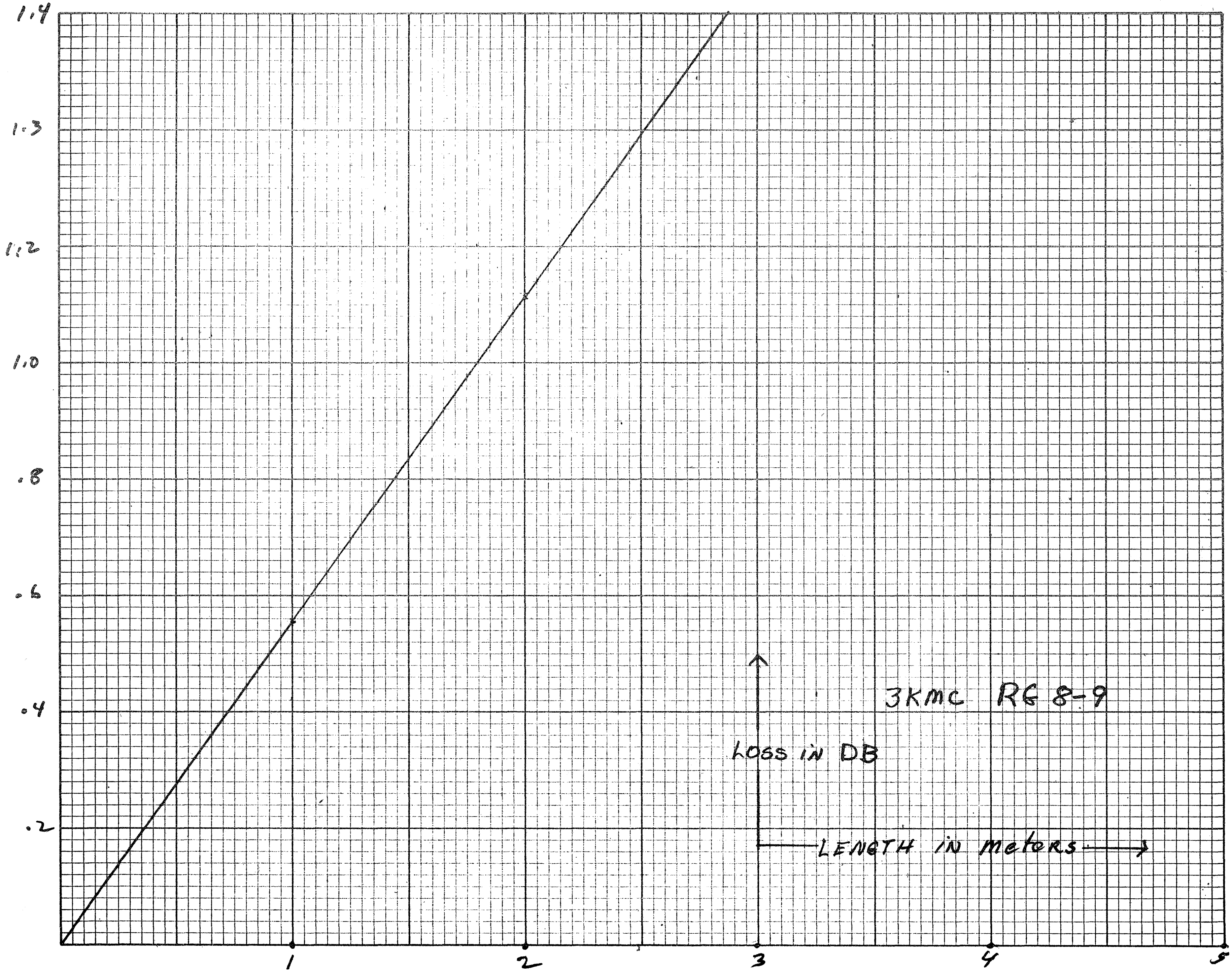
A block diagram and a thermal calibration taken at the 85-foot telescope on 750 mc and 10 cm receivers are shown on the following pages.

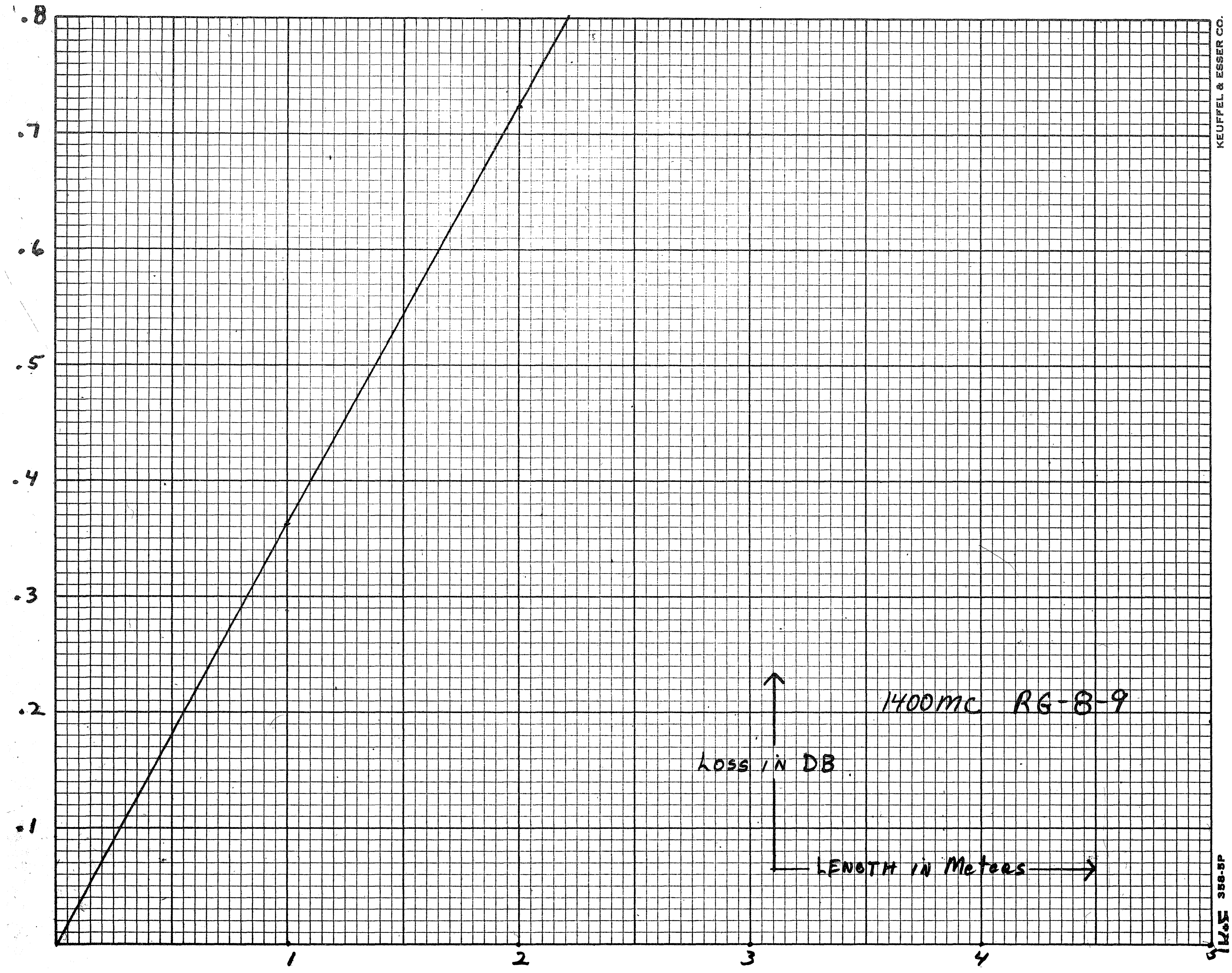


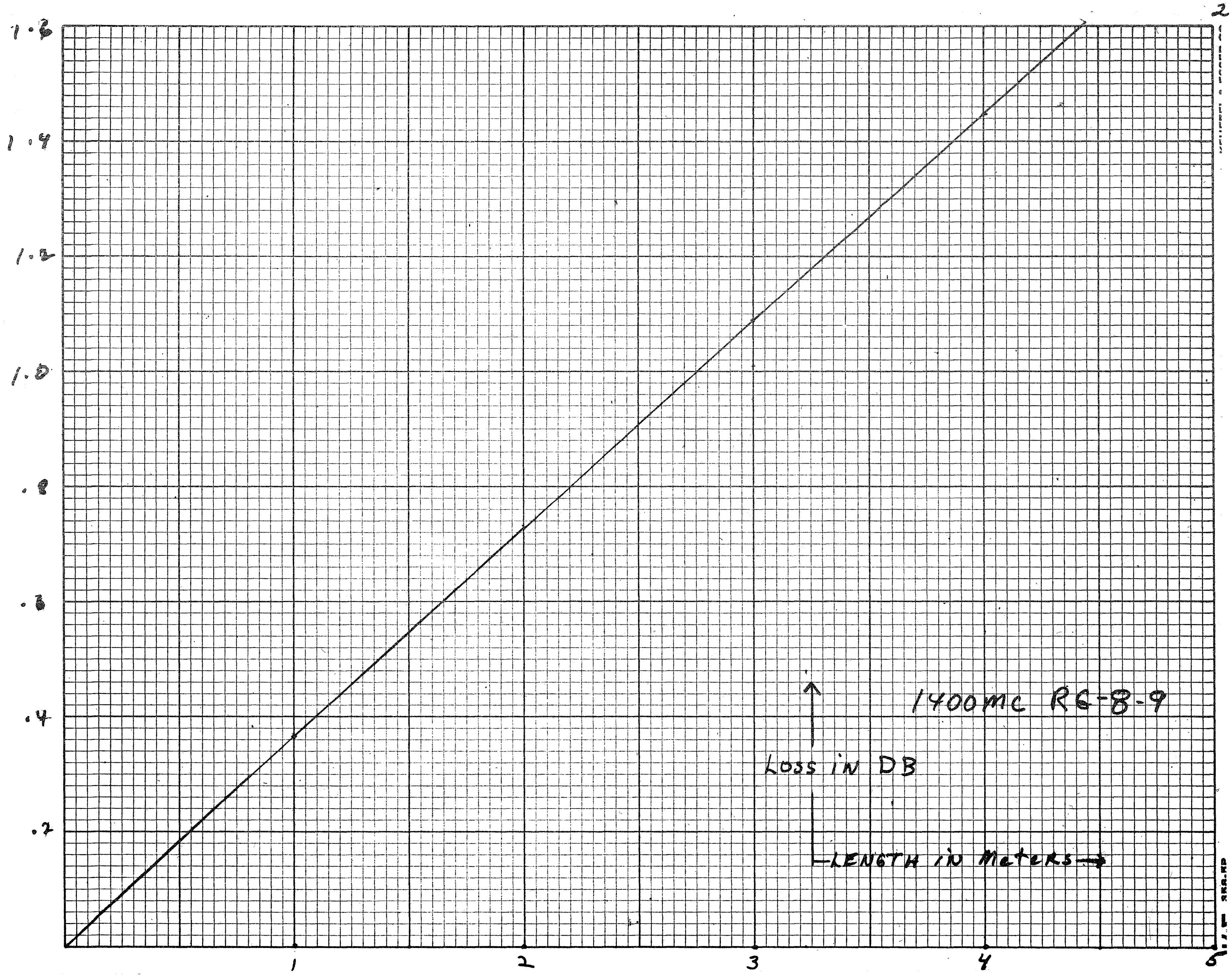
50 ohm load
at room tem-
perature in
thermos
LO
Switch
Mxr
Preamp
30 mc
Receiver
Directional
Coupler
Antenna
Pad
Noise tube
50 ohm load
0 °C or 10 °C
in thermos



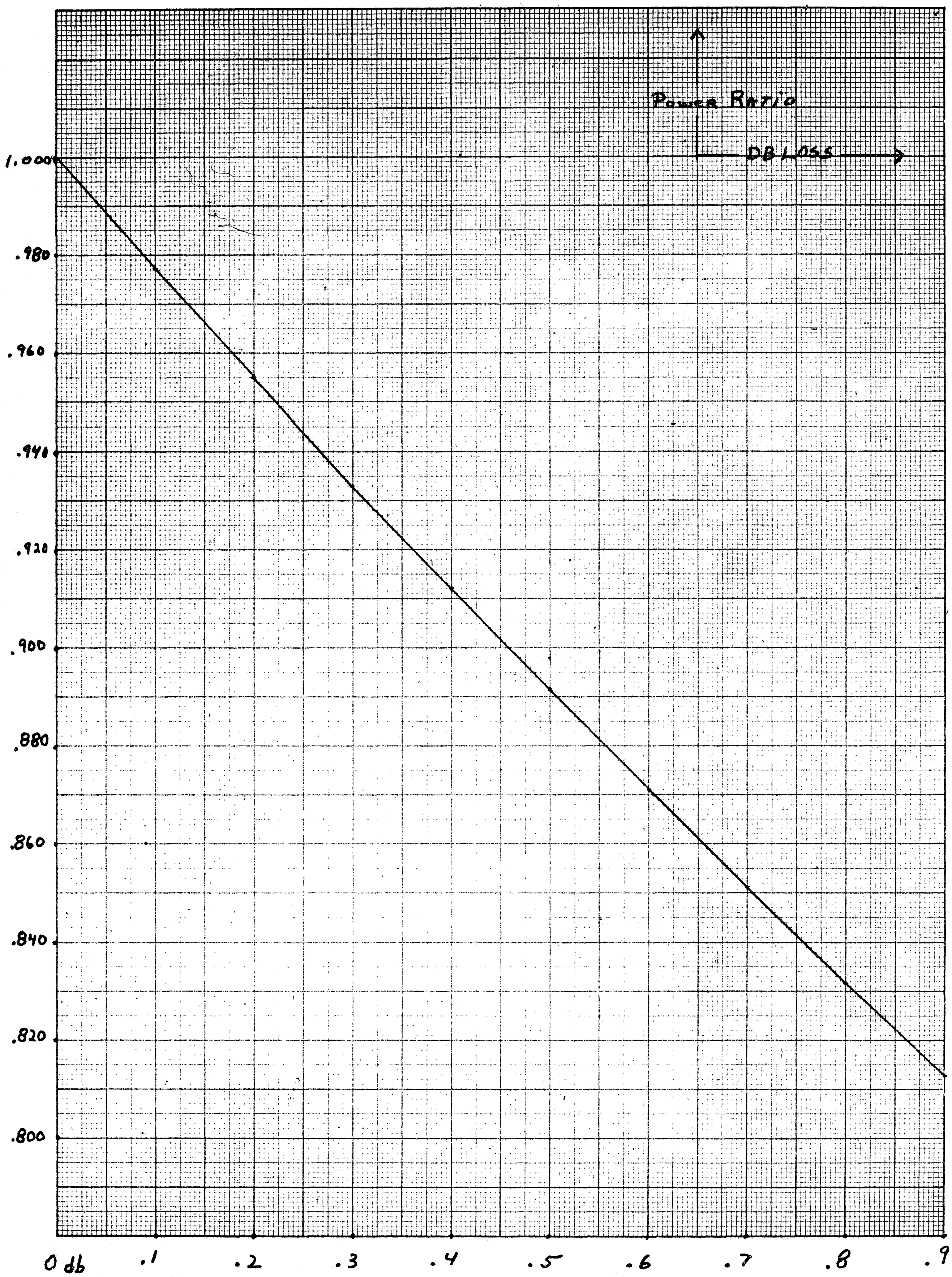
.8
.7
.6
.5
.4
.3
.2
.1
1
2
3
4
5
750 mc RG-8-9
LOSS IN DB
LENGTH IN meters


3KMC RG 8-9
LOSS IN DB
LENGTH IN meters
1.4
1.3
1.2
1.0
.8
.6
.4
.2
1
2
3
4
5

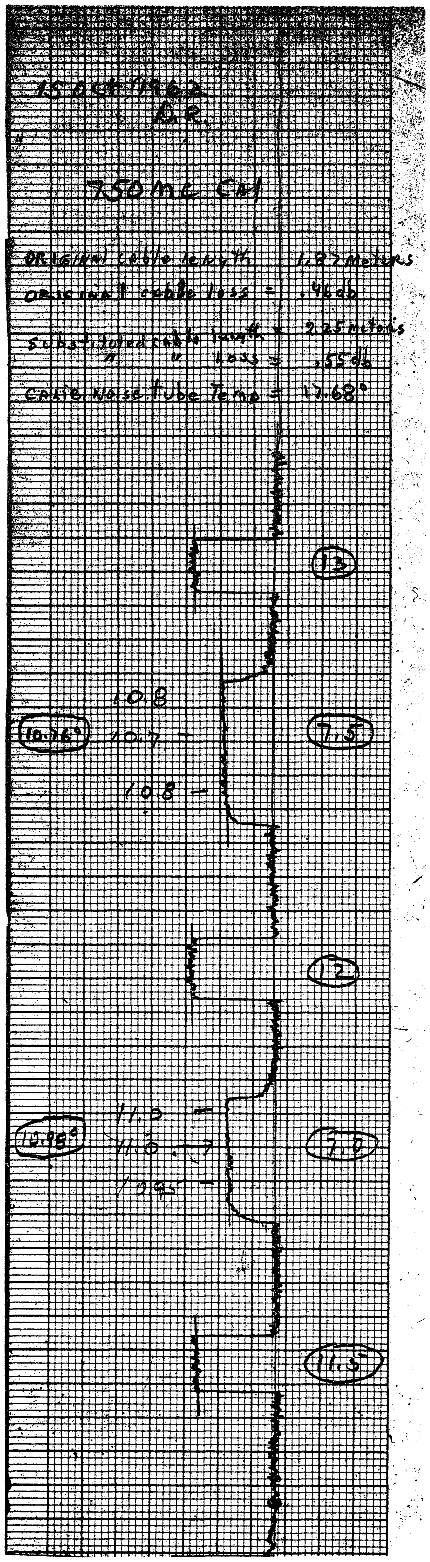

1400mc RG-8-9
LOSS IN DB
LENGTH IN Meters
.8
.7
.6
.5
.4
.3
.2
.1
1
2
3
4
5
KEUFFEL & ESSER CO.
358-5P

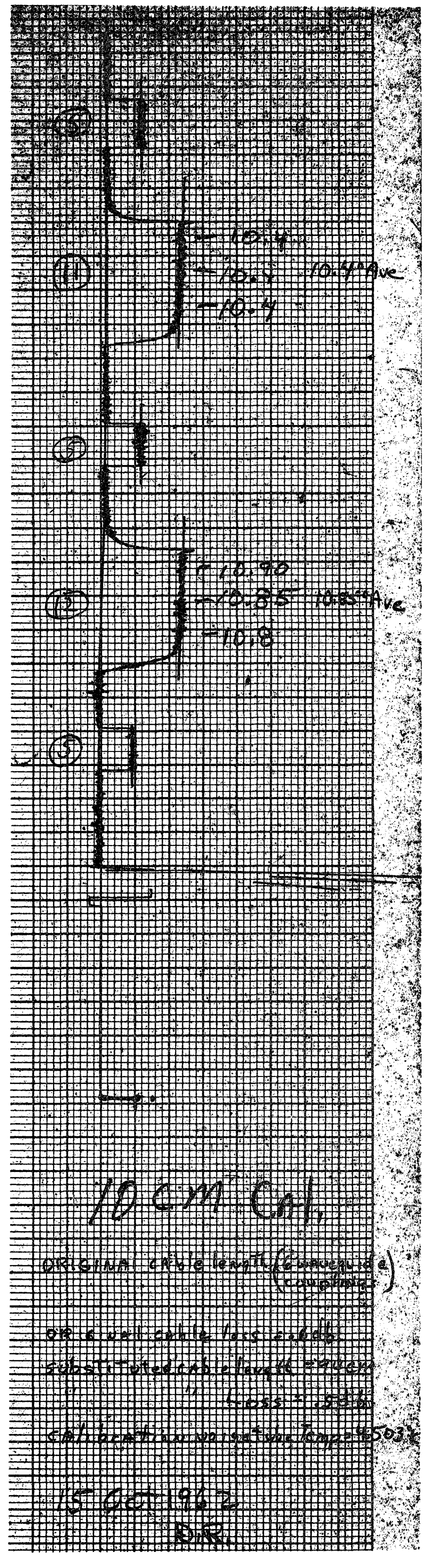


1400MC RG-8-9
LOSS IN DB
LENGTH IN METERS
2
1.6
1.4
1.2
1.0
.8
.6
.4
.2
1
2
3
4
5



POWER RATIO
DB LOSS
1.000
.980
.960
.940
.920
.900
.880
.860
.840
.820
.800
0 db
.1
.2
.3
.4
.5
.6
.7
.8
.9


15 Oct 1962
D.R.
750 mc Cal
ORIGINAL cable length 1.87 meters
ORIGINAL cable loss = .46 db
substituted cable length = 2.25 meters
" " loss = .55 db
CALIB Noise tube Temp = 17.68°
13
10.8
10.76°
10.7
7.5
10.8
12
11.0
10.95°
11.0
10.95
7.5
11.5


11
10.4
10.4
10.4° Ave
10.4
5
12
10.90
10.85
10.85° Ave
10.8
5
10 CM Cal.
ORIGINAL cable length (& waveguide coupling)
ORIGINAL cable loss = .6 db
substituted cable length = 94 cm
" " Loss = .53 db
calibration noise tube Temp = 4503°K
15 Oct 1962
D.R.