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Title U. H. F. Power Measurement

By

Electronic Tube Engineering Div.

Information prepared for

Tests made by

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Date May 16, 1944

7219.3

U.H.F. POWER MEASUREMENT

OBJECT:

The object of this data folder is to describe a method of measuring power output in the ultra high frequency range that is readily adaptable to factory test sets.

SUMMARY:

Two methods of measuring power output utilizing the advantages of a lossy line load are discussed. The first is a calorimetric method which is good for any frequency above the minimum for which the load is designed. An improvement applicable to spot-frequency testing is described which is more rapid and convenient. This change involves the addition of a thermocouple which is heated by the R.F. current flowing in the line. As a result the power is indicated instantaneously on a meter and the load coupling is the only adjustment required.

Type of Load

A "lossy" coaxial cable of sufficient length forms an excellent load for test oscillators for a number of reasons:

1. No stubs or "line stretchers" required.
2. Coupling adjustment only tuning operation necessary.
3. Essentially a resistive load.
4. Negligible radiation from load.
5. Good for any frequency above the lowest for which it is designed.

Method of Measuring Power

The power dissipated in such a load may be measured by enclosing it in a water jacket, measuring temperature rise in the water and its rate of flow. The power may then be computed from the relation:

$$\text{Watts} = 4.18 \times (\text{c.c./sec.}) \times (\text{degrees C rise})$$

An accurately calibrated differential thermocouple and galvanometer combination or thermometers having scales which may be read to one tenth of a degree or better will be satisfactory for measuring the temperature difference between the water entering and leaving the water jacket.

The water flow may be checked with a graduate and stop watch but a good flow meter is advisable so that any change may be quickly noticed. It is important that the water flow be maintained constant. To accomplish this a reservoir is used having water fed into it at such a rate that some is always going out through an overflow pipe.

Before any measurement, sufficient time must be allowed for the system to come to a steady state and temperature readings for zero power noted. With this equipment approximately five minutes is required for the temperature to rise to its full value after the power is turned on. For this reason tuning for maximum power output is difficult to accomplish unless some sort of instantaneous indicator is used, such as a crystal detector loosely coupled near the input end of the line.

An Improved Method

If only spot-frequency testing is required, some advantages may be obtained by incorporating a thermocouple junction in the center conductor of the load line at the input end and measuring the voltage generated when it is heated by the R.F. current flowing through it. The voltmeter is connected at the far end of the lossy line where there is no appreciable R.F. voltage. If a probe is used for coupling, a quarter-wave stub must be used between the thermocouple and the oscillator to provide a complete D.C. path for measuring the thermocouple voltage.

The magnitude of the power to be measured and the frequency must be considered in choosing the size and material of the thermocouple. The R.F. resistance should be such as to cause a conveniently measurable voltage to be generated when the R.F. current flows through the thermocouple, without overheating it.

Calibration

Because of the skin effect, the effective resistance of the thermocouple will change with frequency so the calibration of this system must be made at each frequency to be used. Each thermocouple must be individually calibrated.

Calibration may be made against the water cooled line described above. Beckman thermometers are particularly useful for obtaining good accuracy. Since in many cases the temperature rise is in the order of only a few degrees, care must be taken to eliminate stray thermal effects.

Example

This system is being used to measure power output from a tube giving a maximum of 60 watts at 600 Mc approximately. The load line is 30 ft. of Western Electric D-163296 50-ohm "lossy" cable. For calibrating purposes it is threaded through copper tubing which is coiled up and enclosed in a wooden box. The cable is brought out through water-tight seals at both ends. A .009" diameter copper-copnic couple is used. The meter is a 300 microampere meter of 8 ohms resistance with 12 ohms added in series.

CONCLUSIONS:

Once this system has been carefully calibrated the necessity for measuring water flow and the inaccuracy introduced thereby are eliminated. Power output is indicated immediately by a single meter, enabling the operator to adjust the load coupling for maximum power quickly without extra indicators.

Technical Memorandum 411-TM-39

Radio Research Laboratory

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ENGINEERING
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5-16-44

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THIRD ANGLE PROJECTION

K-

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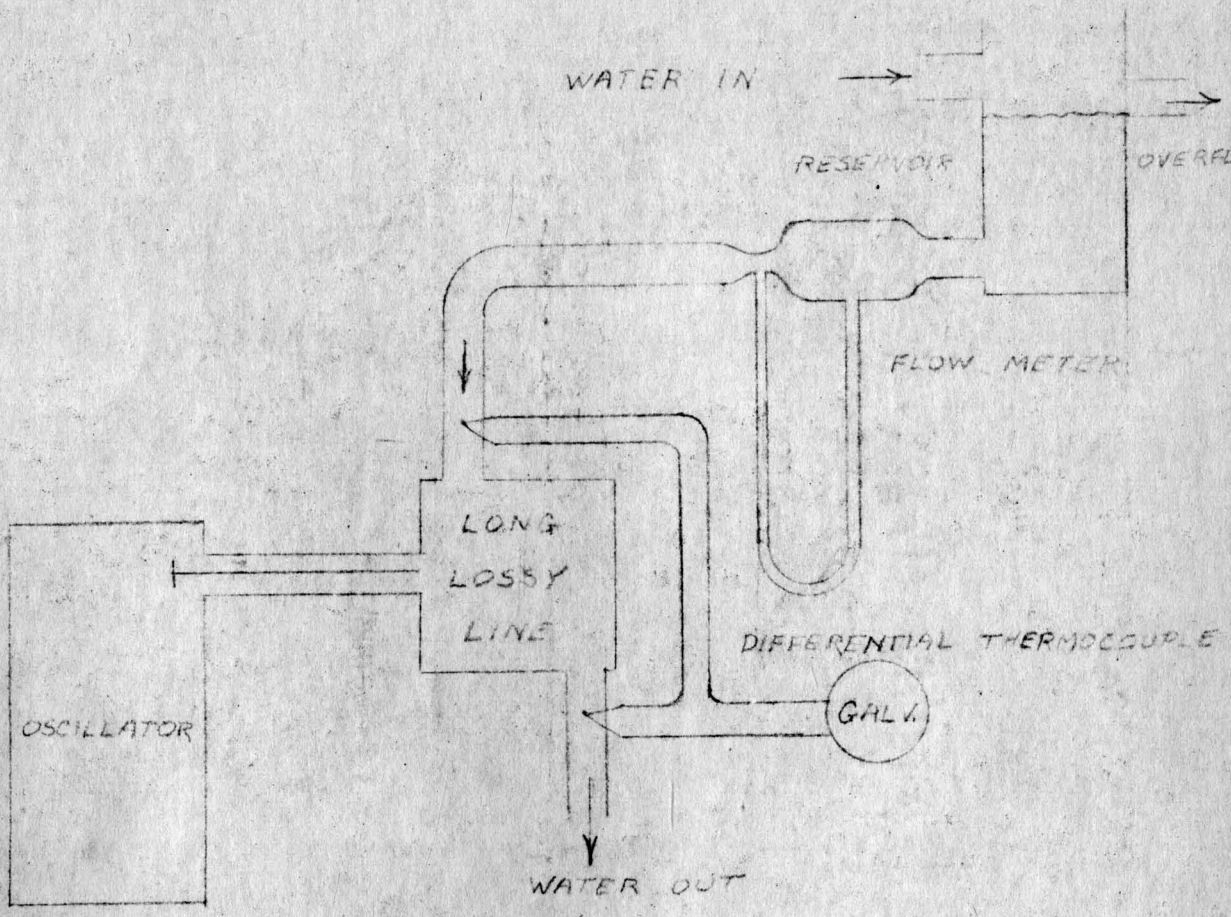
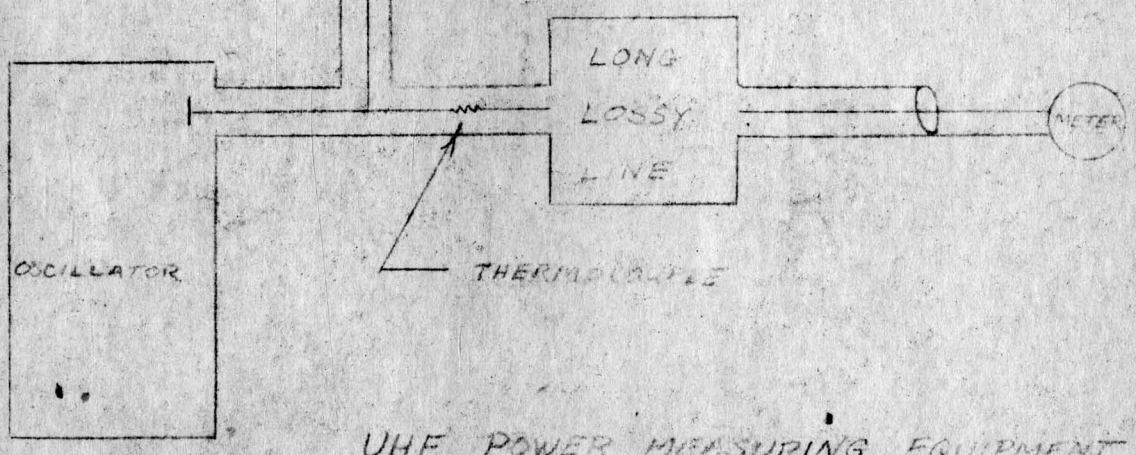


$\frac{\lambda}{4}$ STUB (NECESSARY ONLY WHEN R.F. RETURN PATH FOR METER DOES NOT EXIST)



UHF POWER MEASURING EQUIPMENT

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