Oct. 25, 1949. W. A. MILLER 2,485,905

HIGH-FREQUENCY THERMOCOUPLE FOR WAVE GUIDES

Original Filed April 23, 1945

Fig. 1.

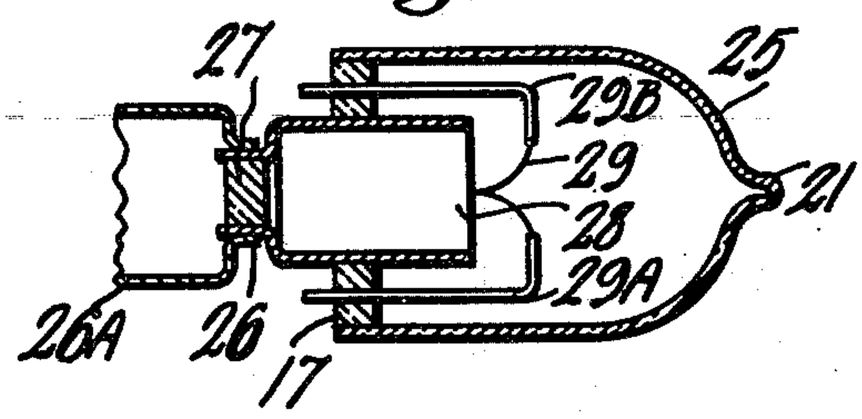


Fig. 2.

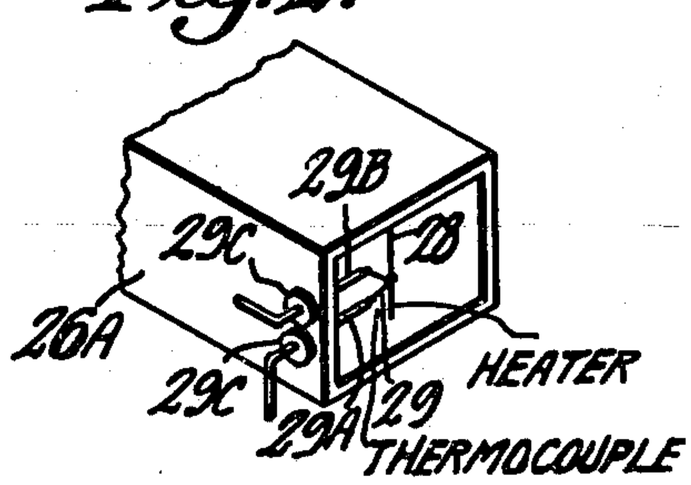


Fig. 3.

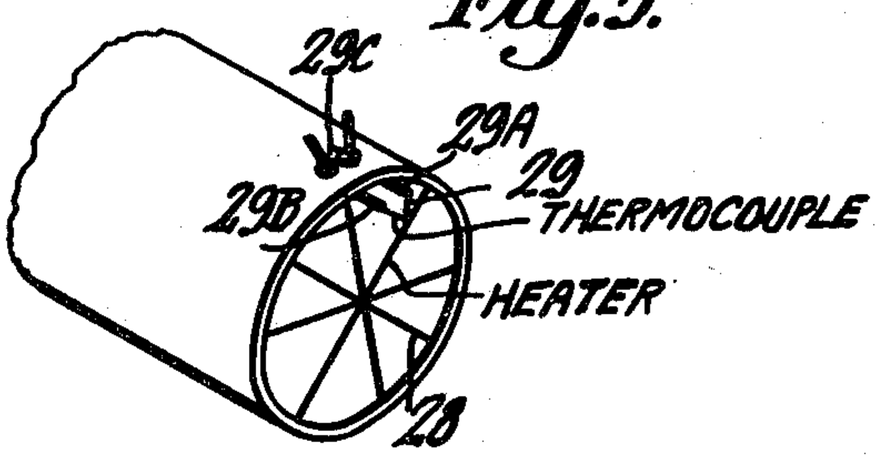


Fig. 4.

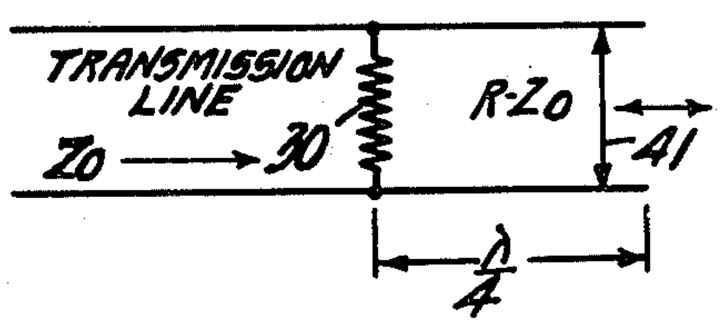
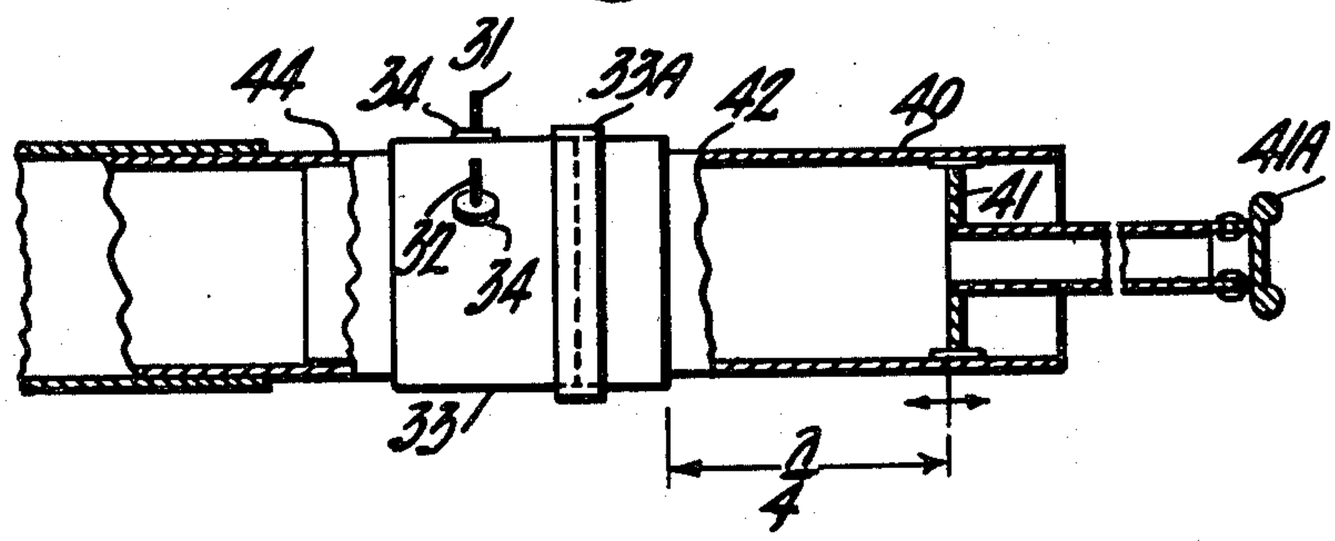


Fig. 5



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HIGH-FREQUENCY THERMOCOUPLE FOR WAVE GUIDES

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5 Claims. (Cl. 136—4)

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This invention relates to new and useful improvements in thermo-couples for the purpose of making electrical measurements at ultra high frequencies.

This application is a division of my copending application Serial No. 589,907, filed April 23, 1945. The parent application contains claims directed to the thermo-couple device as used with a concentric transmission line, whereas the present divisional application contains claims directed to a thermo-couple device particularly adapted for use with a wave guide.

An object of this invention is to provide improved high frequency thermo-couple apparatus.

Another object of this invention is to provide an improved thermo-couple which is particularly adapted for making measurements at ultra high radio frequencies.

Another object of this invention is to provide thermo-couples which are particularly adapted for use with wave guides as employed in ultra high frequency radio transmission and reception.

A feature of this invention is the novel arrangement which enables the heater leads for the thermo-couples to be short as compared with the operating wave length.

This invention deals with improvements in the construction of thermo-couples adapted for use with wave guides, for the specific purpose of making measurements of electrical current, voltage or power at ultra high radio frequencies.

This invention will best be understood by referring to the accompanying drawing, in which:

Fig. 1 shows a longitudinal section of a thermo-couple of this invention which is particularly adapted for use with a wave guide;

Fig. 2 is a perspective view of a thermo-couple device of this invention for use with a rectangular wave guide;

Fig. 3 is a perspective view of a thermo-couple device adapted for use with a circular or cylindrical type of wave guide;

Fig. 4 is a schematic circuit diagram used in the explanation of my invention; and

Fig. 5 is a detail, partly in section, of a shorted adjustable quarter wave section of a wave guide.

Prior art type of thermo-couple construction is satisfactory for ordinary frequencies, or as long as the heater leads are short as compared to a wavelength of radio frequency applied thereto. This condition is no longer fulfilled when a thermo-couple is used at ultra high frequencies as the inductance of the leads makes itself felt in a manner deleterious to the accuracy of the measurement. Furthermore, even though the

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wavelength of the leads may be large as compared with the operating wavelength, it is hard to effectively place the thermo-couple in such a position in a coaxial line that it will not upset the line characteristics sufficiently to cause grave errors in measurement in the ammeter circuit. The devices of the thermo-couples of this invention will overcome the above mentioned objections.

Fig. 1 shows a thermo-couple of this invention used with a wave guide. A difficulty experienced when using wave guides lies in the determination of the characteristic impedance of the guide. This impedance, it is to be noted, varies with the frequency for constant wave guide dimensions. It also varies with wave guide dimensions at a constant applied frequency. Thus, several thermo-couples must be used to prevent a mismatch, if a band of frequencies is to be covered at constant impedance or some type of Z matching circuit. The device of Fig. 1 comprises a glass envelope **25**, matched impedance portion of wave guide **26**, insulator **27**, heater wire **28**, thermo-couple **29**, and terminal support wires **29A** and **29B**. The wave guide and the thermo-couple associated therewith may be rectangular in form, as shown in Fig. 2, or circular, as shown in Fig. 3, depending on the mode to be used.

It will be noted, in referring to Fig. 1, that the terminal wires for the couple are shown as being 180° apart. This was done for clarity and only as a convenient way to illustrate the apparatus on the drawing. An actual and preferred construction is to have these wires brought through the seal **17** spaced side-by-side; thus both could be formed alike since they would have the same physical length. It will be seen, therefore, that a thermo-couple constructed as shown in Fig. 1 may be used at a much shorter wavelength; or in other words, at high radial frequencies than the prior art devices, since the thermo-couple of this invention is the equivalent of a properly terminated wave guide which can be arranged to fit in the end of a measuring line, or for other similar uses, without creating an electrical disturbance.

Fig. 2 shows the disposition of the wires in a rectangular guide **26A** for TE_{10} waves, and a circular form **26B** shown by Fig. 3 for TE_{01} waves, respectively. Other waves require different configurations.

The thermo-couple **29** is secured to a wire shunt or heater **28**. Terminal leads **29A** and **29B** are brought out through the metal wall **26A** and are insulated by glass bead insulators **29C**.

Fig. 3 shows an end view of a modification of

my invention which may be used when considerable power is to be dissipated. The construction of this modification is generally similar to that shown in Fig. 1 except that the outer conductor is connected by means of a plurality of radial wires 28 instead of one heater wire of which only one radial wire carries the thermal junction 29. The radial wires are so proportioned that the resistance of all the wires in parallel is equal to the surge or characteristic resistance of the wave guide. The device of Fig. 3 is roughly electrically equivalent in operation to that of a high sensitivity meter with a shunt associated therewith, each wire serving as a meter shunt. As eight wires are shown in Fig. 3, each wire takes one-eighth of the current.

Fig. 5 shows a thermo-couple of this invention which is particularly adapted to operate in a circuit as shown in Fig. 4. The resistance Z_o of Fig. 4 corresponds to the heater wire 30. The shorted quarter wave section 40 (Fig. 5) is adjustable by means of the sliding metallic disc 41. A handle 41A is provided to actuate the movement of disc 41. Section 40 may be plugged in at 42 and 43 to one end of the thermo-couple, while the other end 44 and 45 is plugger into the end of a wave guide. Adjustment of the quarter wave section 40 by operation of handle 41A is used to correct accidential mismatch of impedance due to improper heater resistance 30 and the disturbing effect of the terminal support wires 31 and 32. It is desirable that the support wires 31 and 32 should lie on the same plane as the heater and slightly toward the end intended for use in the matching section. According to this invention, it is preferable that support wires 31 and 32 should be led through the walls and insulated from the outer conductor 33 by a glass bead insulator 34. Wires 31 and 32 should be led through the walls close to each other and should only protrude slightly into the space between outer conductor 33 and inner conductor 35, the remainder of the distance being covered by the thin wires 49 of the couple itself. An assembly metal ring seal 33A is provided to permit assembly of heater wire 30. The ring 33A is soldered to the split sections of the outer conductor 33.

A wave guide shorted quarter wave section thermo-couple may be made in the same general manner as that described above. The construction would have the advantage over the form shown by Figs. 2 and 3, in that any mismatch between the guide impedance and the heater wire could be at least partially corrected by tuning the stub 40 by means of disc 41.

The thermo-couple envelopes for the devices of this invention should be made vacuum tight and thoroughly evacuated since this makes the couple more sensitive and less affected by fluctuations in the temperature of the surrounding objects. The vacuum chamber in which the thermal junction is located gives improved thermal insulation. The metallic material of the wave guide should not be too good a heat conductor. The thermo-couples of this invention should be found more useful than the normal prior art variety. The glass insulating material is selected for its low dielectric losses at the ultra high frequencies. If desired, the thermo-couple devices of this invention may be provided with any suitable mounting or socket connection means (not shown).

In making electrical measurements with devices of this invention, it is desirable to have the resistance of the meter the same as the resistance of the thermo-couple.

What is claimed is:

1. A thermo-couple device comprising a metallic member having means for joining a wave guide, an evacuated envelope enclosing the end of said metallic member, a heater wire located between and connected to opposite inner walls of said wave guide, and a thermo-couple element having its junction point connected to said heater wire.

2. A thermo-couple device comprising a metallic member having means for joining a wave guide, an evacuated envelope enclosing the end of said metallic member, an insulating base member surrounding said metallic member, a heater wire located between and connected to opposite inner walls of said wave guide, and a thermo-couple element having its junction point connected to said heater wire, and connection leads from said thermo-couple element extending out through said base member.

3. A thermo-couple device comprising a metallic member having means for joining a wave guide, an evacuated envelope enclosing the end of said metallic member, an insulating base member surrounding said metallic member, a heater wire located between and connected to opposite inner walls of said wave guide, a thermo-couple element having its junction point connected to said heater wire, and connection leads from said thermo-couple element extending out through said base member, said connection leads being short compared to the operating wavelength of said wave guide.

4. A thermo-couple device comprising a metallic member having means for joining a wave guide, an evacuated envelope enclosing the end of said metallic member, an insulating base member secured to the end of said metallic member, a heater wire located between and connected to opposite inner walls of said wave guide, a thermo-couple element having its junction point connected to said heater wire, and connection leads from said thermo-couple element extending out through said base member.

5. A thermo-couple device as claimed in claim 2, wherein the inner walls of the metallic wave guide have a plurality of heater wires connected between them, one of said heater wires being joined to said thermo-couple element at the junction point thereof.

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