Oct. 25, 1949. W. A. MILLER 2,485,904

HIGH-FREQUENCY THERMOCOUPLE FOR CONCENTRIC LINES

Filed April 23, 1945

Fig. 1.

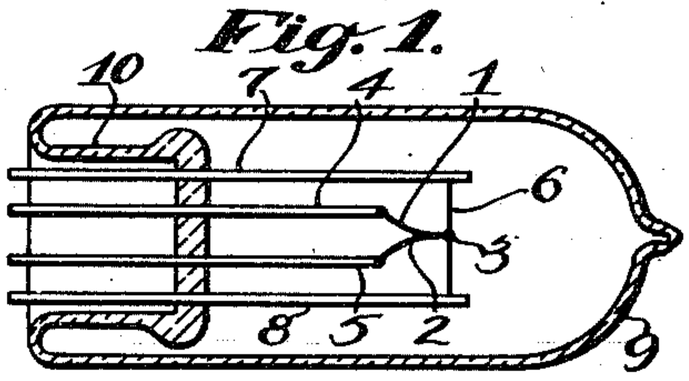


Fig. 5.

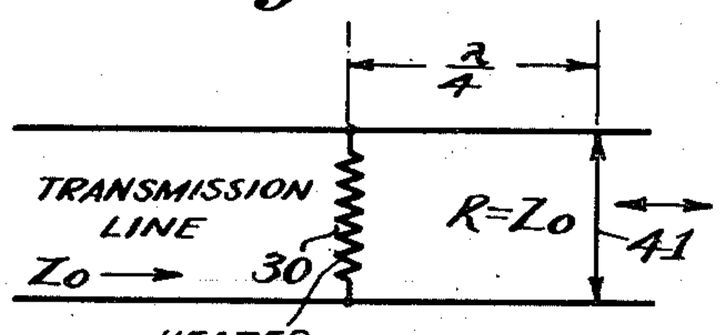


Fig. 2.

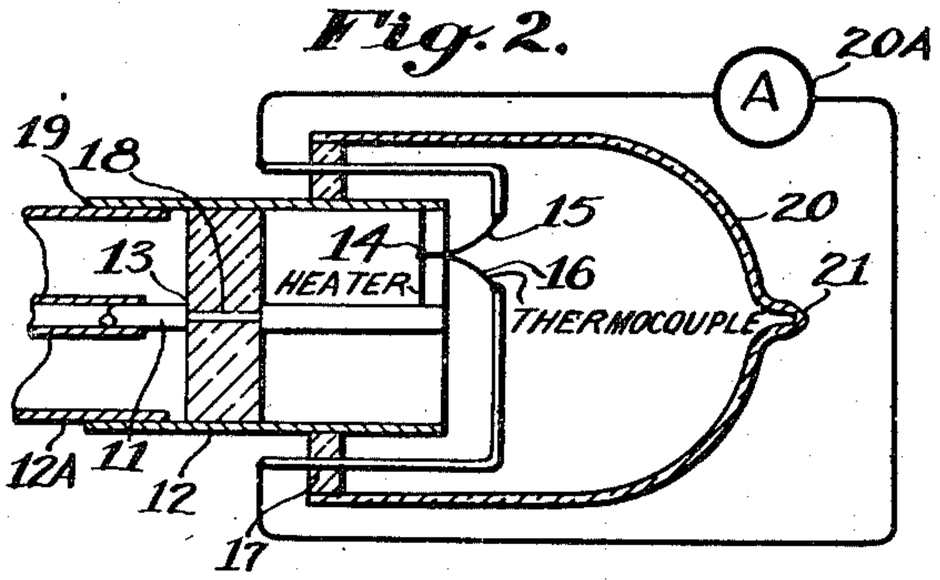


Fig. 3.

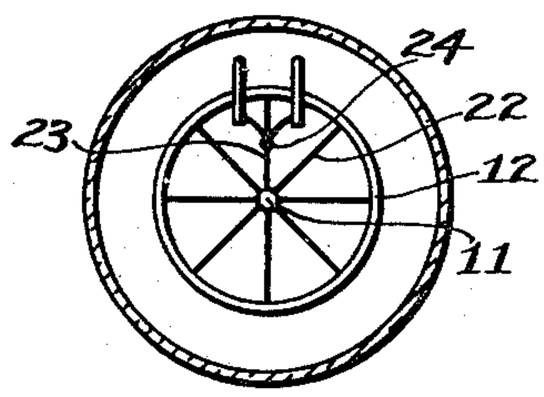


Fig. 6.

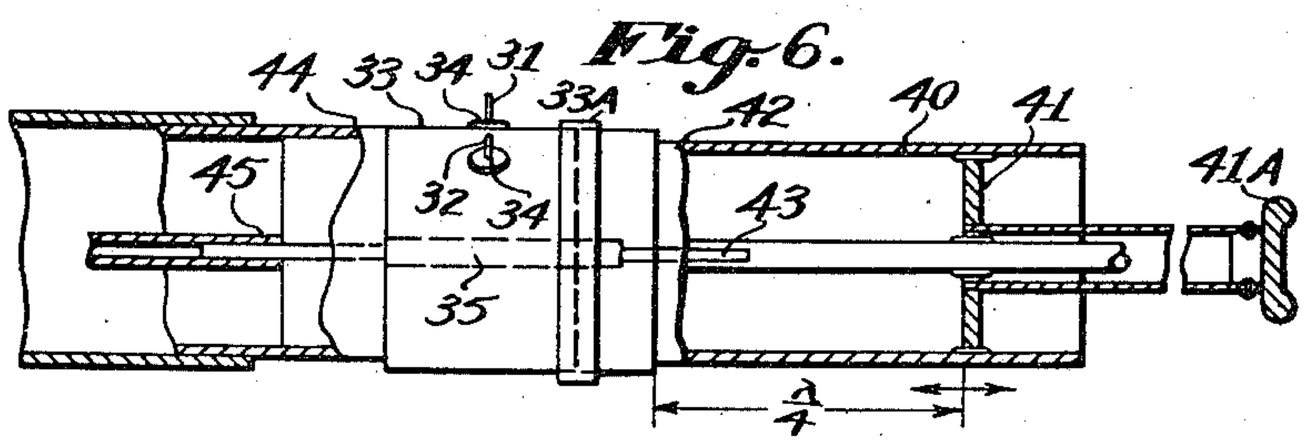
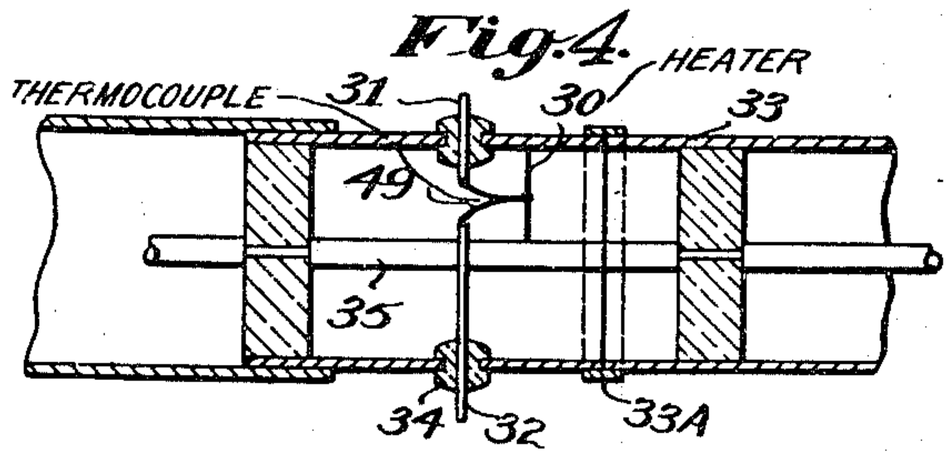


Fig. 4.



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HIGH-FREQUENCY THERMOCOUPLE FOR CONCENTRIC LINES

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Application April 23, 1945, Serial No. 589,907

6 Claims. (Cl. 136—4)

1

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

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 concentric lines and 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 application contains claims directed to a thermo-couple device as used with a concentric transmission line. Applicant also has a copending divisional application Serial No. 702,711, filed October 11, 1946, which contains claims directed to a thermo-couple device particularly adapted for use with a wave guide.

This invention deals with improvements in the construction of thermo-couples 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 view, in section, of a thermo-couple of common form.

Fig. 2 is a longitudinal view, in section, of a novel thermo-couple of this invention.

Fig. 3 is a cross-sectional view of a modified form of a device of Fig. 2.

Fig. 4 is a longitudinal view of the thermo-couple adapted for use with a junction portion of a transmission line.

Fig. 5 is a schematic circuit diagram used in the explanation of my invention; and,

Fig. 6 is a detail, partly in section, of a short adjustable quarter wave section of a concentric line.

Referring now in detail to Fig. 1 of the drawing, there is shown a thermo-couple device of common form. The couple herein mentioned, and referred to in this specification and in the drawing, consists of two dissimilar metals 1 and 2, joined at a point 3 to form a hot junction, the members 2 and 3 being normally maintained in the V form. The open ends of the couple are

2

soldered, brazed or spot welded to lead in and supporting wires 4 and 5, as shown, forming a cold junction. The closed end of the couple is then spot welded, brazed or soldered to a third wire 6 (which is to be called, throughout the specification, the heater) which is supported in the manner shown by support and connection wires 7 and 8, the entire arrangement being located within a glass container or any other suitable evacuated envelope 9 provided with a stem or press 10, which stem forms the base of the tube and is made in a manner similar to that used in vacuum tube construction.

Connecting the two thermo-couple wires to each other and to the heater is generally performed in one operation; the result of such an operation is the production of what is known as a thermo-junction, or, more simply, a junction or couply.

When radio frequency current is allowed to flow in the heater wire 6, a direct current is generated by the thermo-couple. This current is then permitted to flow in a suitable ammeter which should be connected to the leads 4 and 5. This current is proportional to the square of the radio frequency current, since the heat generated in the heater is proportional to the square of the current flowing through it.

Although Fig. 1 is not drawn to any particular scale, it is smaller than some thermo-couples in use, and larger than others. Such a construction as shown in Fig. 1 is satisfactory for ordinary frequencies, or as long as the heater leads 7 and 8 are short as compared to a wave length of radio frequency applied thereto. This condition is no longer fulfilled when a thermo-couple is used at ultra high frequency as the inductance of the leads makes itself felt in a manner deleterious to the accuracy of the measurement. Furthermore, even though the 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 Figs. 2 to 7, inclusive, show constructional details of thermo-couples of this invention which will overcome the above mentioned objections.

Fig. 2 shows the thermo-couple which is devised to perform two functions; namely, it will not only measure the ultra high radio frequency flowing in the heater but it may also be made to terminate the transmission line by a proper choice of heater resistance. The device shown

in Fig. 2 comprises an inner conductor 11 which is concentrically arranged within a portion of an outer conductor 12, and insulatingly supported therefrom by means of an insulating disc 13 of glass or other suitable material having a low dielectric loss. A metal-to-glass seal is provided at the junction of disc 13, inner conductor 11 and outer conductor 12. The inner and outer conductors 11 and 12, respectively, are joined by the heater wire 14 which is proportioned to have the proper value of resistance to terminate the transmission line with a resistance which is equal to its characteristic impedance. This arrangement insures negligible reflection from the open end and also assures maximum power transfer to the heater, making the junction which includes thermo-couple wires 15 and 16 respectively less disturbing to the circuit and more sensitive.

The thermo-junction shown in Fig. 2 also includes an insulating base member 17 which is positioned where the inner and outer conductors 11 and 12 are sealed to the glass disc 13. The inner conductor is necked down at 18. The amount of this reduction in the inner conductor diameter is governed by the fact that the dielectric constant of the glass insulator 13 is greater than that of air and, therefore, the spacing must be increased by reducing the diameter at point 18 in order that the characteristic impedance remains constant. Since it is desirable to telescope the outer conductor at this point to provide for fitting the thermo-couples into a regular transmission line, the diameter of the outer conductor may be slotted and decreased in diameter slightly at 19, as shown. The entire device is sealed within an envelope 20 of glass, and properly evacuated, and then sealed off at the tip 21. The current flow in the circuit between wires 15 and 16 is measured by ammeter 20A.

It will be noted, in referring to Fig. 2, 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. 2 may be used at a much shorter wavelength; or in other words, at higher radio frequencies than the one shown in Fig. 1, since the thermo-couple of this invention is the equivalent of a properly terminated transmission line which can be arranged to fit in the end of a measuring line, or for other similar uses, without creating an electrical disturbance.

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. 2 except that the inner and outer conductors are connected by means of a plurality of radial wires 22 instead of one heater wire of which only one radial wire 23 carries the thermal junction 24. 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 transmission line. 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.

Figs. 4 and 6 show a thermo-couple of this invention which is particularly adapted to operate in a circuit as shown in Fig. 5. The resistance Z_0 of Fig. 5 corresponds to the heater wire 30. The shorted quarter wave section 40 (Fig. 6) 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 plugged into the end of a transmission line. Adjustment of the quarter wave section 40 by operation of handle 41A, is used to correct accidental 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. As shown by Fig. 7, 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.

The thermo-couple enclosure 20 or 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 transmission line should not be too good a heat conductor. Such a material is that of copper-plated "Kovar" metal alloy of low thermal expansion containing cobalt of about 12 per cent, nickel about 15 per cent, the balance of the alloy being substantially that of iron which alloy has been found to be satisfactory for good ordinary ultra high frequency practice. The thermo-couples of this invention, constructed as described in Figs. 2 to 6, inclusive, should be found more useful than the normal variety shown in Fig. 1. The glass insulating material is selected for its low dielectric losses at the ultra high frequencies, such as, for example, Corning glass seal 705 AG and 706 AG, which material combines well with the copper plated "Kovar." 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 relatively short portion of a concentric line including an outer conductor and an inner conductor, an insulating member concentrically spacing said conductors apart, the inner conductor being reduced in its diameter at the position of said insulator, a heater wire connected between said inner and outer conductors at one end thereof, a thermo-couple element having its junction point connected to said heater wire intermediate the outer and inner conductor, an insulating base member surrounding said outer conductor, and connection leads for said thermo-couple extend-

ing through said base member surrounding said outer conductor.

2. A thermo-couple device comprising a relatively short portion of a concentric line including an outer conductor and an inner conductor, an insulating member concentrically spacing said conductors apart, the inner conductor being reduced in its diameter at the position of said insulator, a heater wire connected between said inner and outer conductors at one end thereof, a thermo-couple element having its junction point connected to said heater wire intermediate the inner and outer conductors, an insulating base member surrounding said outer conductor, connection leads for said thermo-couple extending through said base member, and an envelope secured at one end to said base member for enclosing said heater, said thermo-couple and the ends of the inner and outer conductors.

3. A thermo-couple device for ultra high frequency measurement purposes, comprising a relatively short section of an inner conductor and an outer conductor, said inner conductor being of reduced diameter, a block of insulation material located at the portion of reduced diameter of said inner conductor, a thermo-couple element located within a portion of the outer conductor, a heater wire extending between and connected to the outer and inner conductors, a thermo-couple device having its junction point connected to a point on said heater wire, an insulating base member surrounding a portion of said outer conductor, and a pair of leads insulatingly passing through the walls of said insulating base member surrounding said outer conductor for establishing electrical connection to said thermo-couple.

4. A thermo-couple device comprising a relatively short portion of a concentric line including an outer conductor and an inner conductor, a heater wire connected between said inner and outer conductors at one end thereof, a thermo-couple element having its junction point connected to a point on said heater wire intermediate the outer and inner conductors, a pair of insulating beads spaced apart from each other and passing through the walls of said outer conductor, and connection leads from said thermo-couple extending out through said insulating beads.

5. A thermo-couple device comprising a relatively short portion of a concentric line including an outer conductor and an inner conductor, a plurality of radial heater wires connected between said inner and outer conductors at one end thereof, a thermo-couple element having its junction point connected to at least one of said radial heater wires at intermediate the outer and inner conductors, an insulating base member surrounding said outer conductor, and connection leads from said thermo-couple extending out through said base member surrounding said outer conductor.

6. A thermo-couple device comprising a means to join a terminating portion of an outer conductor and an inner conductor of a concentric line, an insulating base member surrounding said outer conductor, an envelope enclosing said means, a plurality of radial heater wires connected between said inner and outer conductors, a thermo-couple element having its junction point connected to at least one of said heater wires at a junction point thereof, and connection terminal leads for said thermo-couple passing through the walls of said base member.

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