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COAXIAL-LINE THERMISTOR MOUNT

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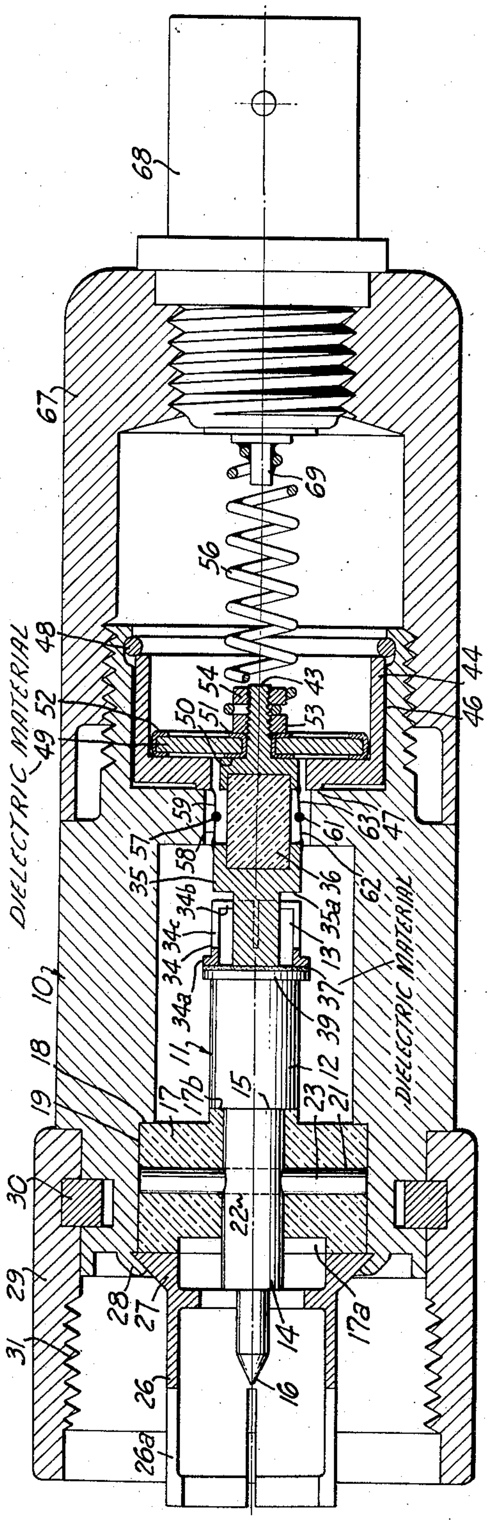

FIG_1

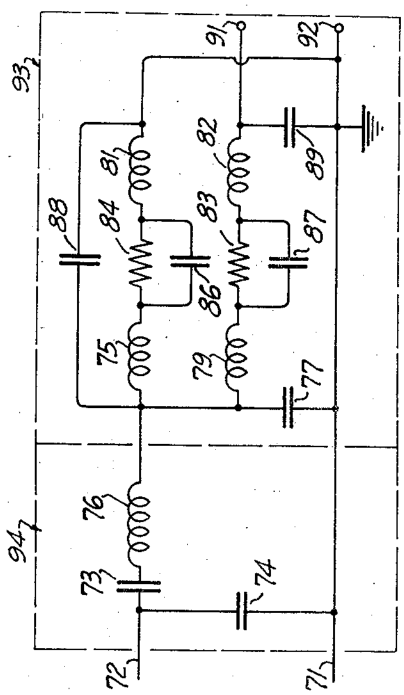

FIG_2

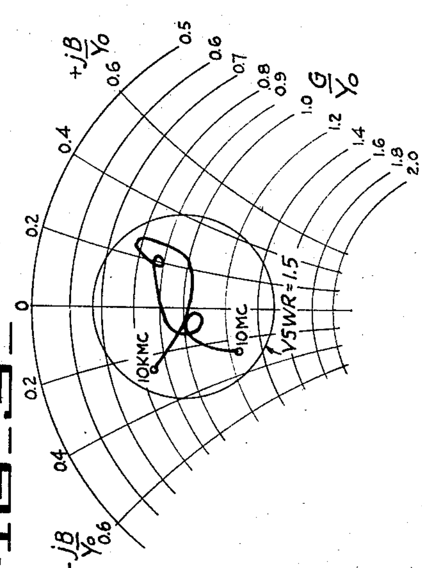

FIG_3

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COAXIAL-LINE THERMISTOR MOUNT

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5 Claims. (Cl. 333—22)

This invention relates generally to thermistor apparatus for detecting high frequency electrical energy, and more particularly to a coaxial-line thermistor mount of the untuned type.

It is an object of the present invention to provide an improved thermistor mount having matched mount impedance over a broad frequency band.

Additional objects of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

Figure 1 shows a cross sectional view of a coaxial thermistor mount;

Figure 2 shows an equivalent circuit for the apparatus of Figure 1; and

Figure 3 shows a plot of impedance at the plane of the first design reactive element as a function of frequency on a portion of the Smith chart.

My apparatus consists of a section of coaxial line adapted to be connected to an associated coaxial system. The apparatus incorporates thermistor means which are coupled to the coaxial line by impedance matching means, and which are connected with an external test or measuring circuit.

As illustrated in Figure 1, the section of coaxial line consists of the outer and inner conductors **10** and **11**. The inner conductor consists of two aligned portions **12** and **13**. Conductor **12** has a portion **14** reduced in diameter at **15** to compensate for the discontinuity introduced by the corresponding change in diameter of the outer conductor. The extremity **16** of portion **12** is formed to interfit the central conductor of an associated coaxial line conductor (not shown). The inner conductor is held in coaxial alignment by means of a low-loss dielectric spacer **17**. The spacer is formed with annular recess **17*a*** and shoulder **17*b*** to compensate for discontinuities in the end of the mount. The spacer is fitted and locked within the bore **19** of the outer conductor and is seated against the adjacent shoulder **18**. Aligned holes **21** and **22** are provided in the spacer and inner conductor and serve to accommodate the dielectric lock pin **23**. With this arrangement the inner conductor is held in fixed position by the spacer and with the shoulder formed by the change in diameter at **15**, abutting one side of the spacer.

The inner conductor extremity **16** is surrounded by the contactor sleeve **26**. This sleeve consists of a plurality of spring contact fingers **26*a*** which are adapted to make electrical contact with the outer sleeve conductor of the associated coaxial connector. The base **27** of the contactor sleeve can be in the form of a truncated cone. As illustrated, this base seats upon the adjacent end face of the spacer **17** and it is engaged by the turned flange **28** which is formed by the adjacent portion of the outer conductor.

A sleeve **29** is carried by one end of the outer conductor and is retained by the snap-in spring ring **30**. The internal threads **31** on the sleeve **28** are adapted to engage the externally threaded part of the associated connector.

The portion **13** of the inner conductor is formed by the interfitted conducting members **34** and **35**. Member **34** is in the form of a sleeve with its one end provided with an outwardly extending flange **34*a*** and its other end provided with an inwardly extending flange **34*b***. Circumferentially spaced slots **34*c*** permit a certain amount of spring or give whereby the inner periphery of the flange **34*b*** is adapted to press in good electrical contact with the adjacent periphery of the member **35**.

The low-loss dielectric wafer **37**, formed of suitable material, is interposed between member **34** and the adjacent end face of the inner conductor portion **12**. This end face of the inner conductor portion **12** is enlarged by an end flange **39** which has a diameter corresponding to the diameter of flange **34*a***.

The wafer **37** has thin films of conducting material on its side face, and these films are attached as by solder to the adjacent areas of the flanges **34*a*** and **39**.

The conducting member **35** has an end which is seated in member **34**. When the conducting member **35** is seated an annular notch **35*a*** is formed on the inner conductor portion **13**. As will be presently explained, the member **35** is removable with respect to the wafer and member **34**.

That end of the conducting member **35** remote from the wafer **37** is in the form of a reentrant cup which fits over the adjacent end of a cylindrical insulator **36**, which, for example, may be in the form of a glass bead. Terminal member **43** is provided with a similarly cupped end portion which fits upon the opposite end of insulator **36**.

Surrounding the terminal member **43** there is a sleeve-like terminal member **44** which is fitted within an enlarged bore **46** formed in the outer conductor. The outer terminal member **44** makes electrical contact with the outer conductor on the annular area indicated at **47** and is held in proper position by suitable means such as the spring wire snap-in ring **48**.

It is convenient to position a disk-shaped capacitor **49** between the terminal members **43** and **44** as illustrated. The peripheral terminals **51** and **52** of this capacitor make connection respectively to the terminals **43** and **44**.

Nuts **53** and **54** that are threaded upon terminal member **43** facilitate making electrical contact between the capacitor terminal **51** and the annular shoulder **50** of portion **43**. They also make contact between the spring **56** and the terminal member **43**. Although I prefer to use nuts **53** and **54** to make the connections indicated because of ease in assembly, it is readily seen that this could be done in other ways, for example, by soldering.

Two thermistors are mounted in the annular space surrounding the insulator **36**. Thus one thermistor **57** has its leads **58** and **59** connected respectively to the conductor member **35** and inner periphery of the terminal member **44**. The second thermistor **61** has its leads **62** and **63** connected respectively to the conductor **35** and the terminal member **43**.

For convenience in making connections to an external test or measuring circuit, a cap **67** is threaded upon the outer conductor and serves to mount a connector **68**. This connector can be of conventional construction, including the outer sleeve conductor which connects directly with the outer conductor **10** through the cap **67**, and a center conductor which has an inner extremity **69**. Means are then provided to provide an electrical connection between the said center conductor and the terminal member 43. Spring **56** provides the electrical connection in the embodiment shown.

The member **35** is removable with respect to the wafer and member **34** to permit mounting of the thermistors before the members are engaged. This also provides a means for replacing thermistor elements.

In Figure 2 I have shown a lumped equivalent circuit for the apparatus of Figure 1. Lines **71** and **72** represent the outer conductor and inner conductors of the coaxial section, respectively. Capacitor **73** represents the capacitance interposed in series with inner conductor by wafer **37**. Capacitor **74** represents the shunt capacity introduced by end flange **39** and the flange **34***a*. The inductance **76** represents the series inductance introduced by the notch **35***a*. Capacitor **77** represents the distributed shunt capacitance between the portion **35** and the adjacent outer conductor **10**. Inductors **75**, **79**, **81** and **82** represent the inductance of the thermistor leads. Resistors **83** and **84** represent the thermistor bead resistance. Capacitors **86** and **87** represent the capacity between the thermistor leads, and the capacitor **88** represents the capacitance across insulator **36**. The capacitor **89** represents the disk-shaped capacitor **49** which is placed between the terminal members **43** and **44**. The direct or audio frequency current connections are shown as **91** and **92**. The portion of the circuit represented by block **93** represents a network analysis of the thermistor mount and the circuit represented by block **94** represent the matching network which provides operation over a broad frequency band.

The wafer **37** is usually chosen so that it isolates portion **12** from the portion **13** of the inner conductor as far as direct and audio frequency currents are concerned. This wafer offers negligible impedance to a microwave energy flowing along the coaxial system. Similarly the disk capacitor **49**, represented by capacitor **89** in the equivalent circuit, is chosen so that it offers a short circuit to the high frequency current and an open circuit to the direct and/or audio frequency current.

Referring to Figure 2, capacitors **73** and **89** are short circuits at microwave frequencies. As a consequence, the thermistors present a parallel impedance to the coaxial system. If the thermistors have a resistance of 100 ohms each, a 50 ohm line is matched by the two thermistors. Capacitors **73** and **89** are open circuits to direct and audio frequency current. Referring to Figure 2, it is seen that the thermistors are in series to direct and audio frequency current. Assuming the above values, they would present an impedance of 200 ohms.

As is well known, the impedance of an element in a coaxial system is dependent upon the plane of reference. Therefore the location along the axis of the flanges **34***a* and **39** and notch **35***a*, which form the matching network is important. They must be located such that when the impedance of the matching network is combined with the impedance of the thermistors and mount, a match between the mount and coaxial system will result.

Referring more particularly to Figure 1, the direct current path is through the center conductor of the connector **68**, along the spring **56**, through the inner terminal member **43**, through thermistor **61**, through thermistor **57**, to the outer terminal member **44** and to the outer conductor of the connector **68**. The microwave current flows along the inner conductor portions **12**, **13** and **35** through the thermistors **57** and **61**, and back to the outer conductor **10**, in one case directly through the terminal member **44**, and in the other case through terminal member **43**, capacitor **49** and terminal member **44** to the outer conductor **10**. With the mount properly matched all the microwave energy is converted to heat in the thermistors. The microwave energy is measured by the method of substitution of energy which is well known. Briefly, it consists of supplying direct or audio frequency power to the thermistors from a balanced bridge circuit to maintain constant resistance, in this case 100 ohms each. As high frequency energy is supplied the direct or audio frequency power requirements are reduced. The reduction is a measure of the high frequency energy. The advantage of this method is apparent. The resistive component of the thermistors is constant and mount matching is simplified.

Apparatus was constructed as shown in Figure 1 and dimensioned as follows: Outer conductor had an inside diameter of 0.391 inch and an outside diameter of 0.781 inch, the bore adapted to receive the dielectric spacer **17** was 0.230 inch long and 0.455 inch in diameter, the portion adjacent the thermistor was 0.080 inch long and 0.203 inch in diameter, the main bore was 0.600 inch long. Portion **12** was 0.950 inch long, the flange was 0.205 inch in diameter and 0.010 inch thick, the portion adjacent the flange was 0.170 inch in diameter and 0.270 inch long, the portion which interfits the bead was 0.1205 inch in diameter and 0.475 inch long and the portion which interfits the inner conductor of the associated coaxial system was 0.065 inch in diameter; member **34** was 0.120 inch long and had a flange 0.205 inch in diameter and 0.010 inch thick, the inside diameter of the inwardly extending flange was 0.090 inch, the member was slotted with four slots 0.010 inch wide and 0.100 inch deep; member **35** was 0.235 inch long, the cup was 0.040 inch deep and 0.125 inch in diameter; the glass bead was 0.090 inch long and 0.125 inch in diameter; the terminal member had a cup which was 0.020 inch deep and 0.160 inch in diameter; the wafer had a capacity of 2000 $\mu\mu$f.; the disk-shaped capacitor **49** had a capacity of 550 $\mu\mu$f.; the thermistors were known by manufacturers' specifications as VECO 32A5.

Figure 3 is a plot of admittance as a function of frequency for the frequency range 10 mc. to 10 kmc. on a portion of a Smith chart. The circle represents a constant standing wave ratio of 1.5. It is apparent that this thermistor mount has an acceptable voltage standing wave ratio over a broad band of frequencies.

I claim:

1. In a coaxial line thermistor mount, outer and inner concentric conductors forming a section of coaxial line and adapted to be connected to an associated coaxial system, the inner conductor comprising first and second aligned portions, dielectric means providing a continuous path for high frequency energy through said first and second aligned portions, two thermistors, a pair of terminals adapted to be connected to an external measuring circuit, means forming a high frequency by-pass capacitor connected between the terminals, the leads of the first thermistor being connected to the second portion of the inner conductor and one of said terminals, the leads of the second thermistor being connected to the second portion of the inner conductor and the other one of said terminals, and impedance matching means formed on said first and second portions serving to match the impedance of said thermistors and mount to that of the associated coaxial system.

2. In a coaxial line thermistor mount, outer and inner concentric conductors forming a section of coaxial line and adapted to be connected to an associated coaxial system, the inner conductor comprising first and second aligned portions, dielectric means providing a continuous path for high frequency energy through said first and second aligned portions, two thermistors, a pair of terminals adapted to be connected to an external circuit, means forming a high frequency by-pass capacitor connected between the terminals, the leads of the first thermistor being connected to the second portion of the inner conductor and one of said terminals, the leads of the second thermistor being connected to the second portion of the inner conductor and the other one of said terminals, means formed on said first and second inner conductor portions introducing a capacitive element between the inner and outer conductor, and means formed on said second portion introducing an inductive element in series with the inner conductor, said capacitive and inductive elements forming an impedance matching network whereby an impedance match is obtained between the thermistor mount and the associated coaxial system.

3. Apparatus as in claim 2 wherein said second portion of the inner conductor comprises inner and outer interfitting members, the outer members being slotted and having one end thereof adapted for electrical contact with the peripheral portion of the inner member.

4. Apparatus as in claim 2 wherein said means forming a capacitive element between the inner and outer conductor comprises flanges formed on said inner conductor, wherein the means forming an inductive element comprises a notch interrupting the periphery of said second portion of the inner conductor.

5. In a coaxial line thermistor mount, outer and inner conductors forming a section of coaxial line and having one end thereof adapted to be connected to an associated coaxial system to receive high frequency energy, the inner conductor consisting of first and second aligned portions, the first portion being adapted for connection with the associated coaxial system and the second portion being adapted for connection with the thermistor means, the second portion comprising inner and outer interfitting members, the outer member being slotted and having one end thereof adapted for electrical contact with the peripheral portion of the inner member, a wafer of dielectric material interposed between the opposing end faces of said portions, said wafer serving to insulate said portions one from the other to direct an audio frequency current and providing a low impedance path one to the other to the high frequency current, a pair of terminals adapted to be connected to an external circuit, a high frequency by-pass capacitor connected between said terminals, one of said terminals being coaxial with said inner conductor and spaced axially with respect to the inner member of the second portion, an insulator interposed between said inner member and said one terminal, a first thermistor disposed adjacent said insulator and having its one terminal lead connected to the said inner member and its other lead connected to one of said terminals, a second thermistor spaced circumferentially from said first thermistor and likewise disposed adjacent said insulator, one terminal lead of the second thermistor lead being connected to said inner member and the other being connected to the other one of said terminals whereby the two thermistors are connected in series with the terminals, said section of coaxial line serving to supply high frequency energy to said two thermistors in shunt, the adjacent parts of the first portion and the outer member of the second portion formed with an enlarged diameter to thereby form a capacitive element between the same and the adjacent surrounding portion of the outer conductor, and the inner member of the second portion having a shoulder formed thereon which is spaced axially from the adjacent end portion of the outer member to thereby form an annular notch providing an inductive element in series with the inner conductor, said capacitive and inductive elements providing an impedance matching network which matches the impedance of the mount to that of the associated coaxial system.

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