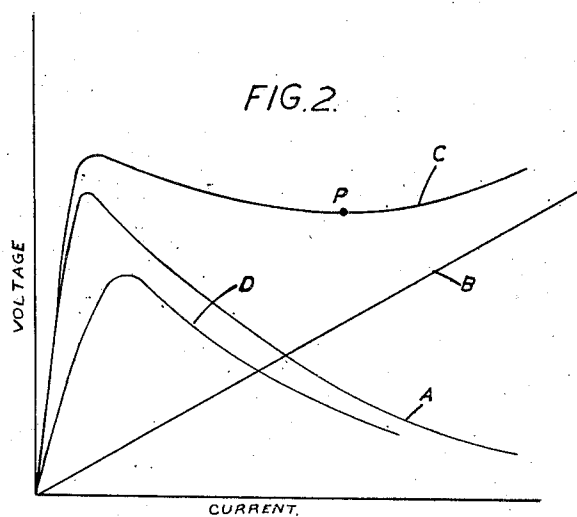
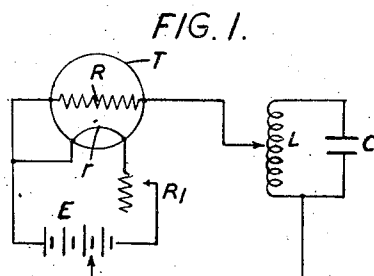


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NEGATIVE RESISTANCE DEVICE FOR GENERATING
OSCILLATIONS OR REDUCING DAMPING
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NEGATIVE RESISTANCE DEVICE FOR GENERATING OSCILLATIONS OR REDUCING DAMPING

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1 Claim. (Cl. 250—36)

1.

The present invention relates to electric resonant circuits particularly those used in oscillation generators and employs the special properties of the thermally sensitive resistance elements known as thermistors.

Thermistors are thermosensitive resistance elements having a temperature coefficient of resistance which may be either positive or negative and which is moreover many times the corresponding coefficient for a pure metal such as copper. This property renders thermistors particularly suitable for a variety of special applications in electric circuits.

Various different materials are available for the resistance element of a thermistor, these various materials having different properties in other respects; as one example, a resistance material having a high negative temperature coefficient of resistance comprises a mixture of manganese oxide, and nickel oxide with or without the addition of certain other metallic oxides, the mixture being suitably heat treated.

Thermistors have been employed in two different forms: (a) known as a directly heated thermistor and comprising a resistance element of the thermally sensitive resistance material provided with suitable lead-out conductors or terminals, and (b) known as an indirectly heated thermistor comprising the element (a) provided in addition with a heating coil electrically insulated from the element. A directly heated thermistor is primarily intended to be controlled by the current which flows through it and which varies the temperature and also the resistance accordingly. Such a thermistor will also be affected by the temperature of its surroundings and may therefore be used for thermostatic control and like purposes with or without direct heating by the current flowing through it. An indirectly heated thermistor is chiefly designed to be heated by a controlling current which flows through the heating coil and which will usually, but not necessarily, be different from the current which flows through the resistance element, but this type of thermistor may also be subjected to either or both of the types of control applicable to a directly heated thermistor.

More detailed information on the properties of thermistors will be found in an article by G. L. Pearson in the Bell Laboratories' Record Dec. 1940, page 106.

In the present invention, thermistors having a negative temperature coefficient of resistance are employed, since under appropriate conditions they may behave like negative resistances and

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therefore may be used to generate oscillations in a resonant circuit in a particularly simple way. By suitable adjustment of the constants of the circuit, oscillations may just be prevented from occurring, and in that case a resonant circuit, which may have a very low resonance frequency and a very high value of Q , may be easily obtained for use in filter and other like circuits.

According to one aspect of the invention, therefore, there is provided an electric resonant circuit comprising an inductance, a thermistor having a negative temperature coefficient of resistance, and a source of direct current, coupled together in such a manner that the ratio of reactance to resistance of the inductance is effectively raised to a predetermined value.

According to another aspect, the invention provides an electric resonant circuit comprising an inductance at least part of which is connected in series with the resistance element of a thermistor having a negative temperature coefficient of resistance, to a source of direct current, the thermistor circuit resistance being adjusted so that the voltage-current characteristic curve of the thermistor circuit has a portion whose slope is slightly positive, and so that the current through the resistance element is represented by a point on the said portion of slightly positive slope.

According to the invention, also, the thermistor circuit resistance in either of the above mentioned aspects may be alternatively adjusted so that oscillations take place in the resonant circuit.

The invention will be described with reference to the accompanying drawing in which:

Fig. 1 shows an example of one circuit according to the invention; and

Fig. 2 shows characteristic curves used to explain the operation of Fig. 1.

It will be understood that any resistances other than thermistors employed in this invention are of the ordinary kind in which the resistance value is substantially independent of the current.

Fig. 1 shows an example of a circuit according to the invention. An indirectly heated thermistor T having a negative temperature coefficient of resistance has its resistance element R connected in series with part of an inductance L and a tapped battery or other direct current source E . The heating coil r of the thermistor is connected to the battery in series with an adjustable resistance R_1 . A parallel resonant circuit is produced by connecting a condenser C across the inductance L .

In Fig. 2 are shown characteristic curves for the

circuit of Fig. 1. The abscissae represent the currents and the ordinates the corresponding voltages.

Curve A shows the curve for the thermistor T alone, with no current in the heating coil. As the current through the resistance element R is increased, the voltage across R first increases to a maximum and then decreases continuously. The part of the curve beyond the maximum has a negative slope, and this means that the effective resistance to current changes is negative.

The straight line B represents the characteristic for the resistance of that part of the inductance L which is in series with the thermistor (together with any other resistance there may be in the circuit) and this resistance is assumed to be substantially constant. Curve C has been obtained by adding the ordinates of curves A and B, and represents the resistance characteristic of the whole of the circuit. It will be seen that curve C is horizontal in the neighbourhood of the point P signifying that the effective resistance to changing currents is zero. According to known principles, the circuit will oscillate in the neighbourhood of the point P at a frequency determined substantially by L and C.

The effect of passing a current through the heating coil r will be generally to lower the curves A and C and to render the voltage maximum less sharp. Curve D shows the manner in which the curve A would thus be changed. This provides a convenient means of adjusting the characteristic of the thermistor to produce the desired oscillation condition. The operation of the circuit may also be controlled by including a suitable resistance (not shown) in series with the thermistor element R. This will change the slope of the line B in Fig. 2.

The oscillation output may be taken from the tuned circuit L, C in any suitable way (not shown). Although adjustable connections to the battery and to the inductance L are indicated for convenience, these could of course be fixed; and if adjustment of the characteristics of the thermistor are not required, one of the directly heated type could be used, the resistance R_1 and its connections being omitted.

The tuned circuit could furthermore be coupled to the thermistor circuit by means of a separate winding (not shown) coupled to the inductance L, and connected in series with the thermistor and source E, and various other modifications will occur to those skilled in the art.

It should be added that owing to the fact that the response of the thermistor to changes in the current is not instantaneous, the frequencies to which the circuit is applicable will generally be low. Thermistors having very rapid response are however known, and frequencies of several hundred periods per second may be possible.

The circuit of Fig. 1 is particularly simple since

it does not contain any valves which would require a high tension or cathode heating source. It would be useful, for example, as a low frequency generator; as a vibrator for power packs, or to generate ringing frequencies for telephone circuits.

Referring again to Fig. 2, if the resistance connected in series with the resistance element R be increased, the slope of the curve B will be also increased and the horizontal part of the curve C will move to the left until it reaches the voltage maximum of the curve. At, or a little after, this stage, the curve C will be found to have no horizontal portion, and no portion of negative slope, but there will be a very short region in the neighbourhood of the maximum of the curve where the slope is only very slightly positive. Under these conditions oscillations will not occur, but the ratio Q of reactance to resistance of the inductance L may effectively be very high, and can be given any desired value by suitably adjusting the circuit. In this way a resonant circuit L, C tuned to a very low frequency, and having a very high value of Q, is obtained in a very simple way; this is well known to be difficult at low frequencies, requiring very bulky coils or complicated amplifying arrangements by known methods.

It may be added that another method of obtaining the desired slightly positive slope is to adjust the resistance R_1 in Fig. 1 instead of adjusting the resistance in series with R. By increasing the current through the heating coil r the horizontal portion of the curve C will also move to the left until it disappears in the neighbourhood of the maximum of the curve. It is further to be noted that in Fig. 1, the current for the heating coil r could, if desired, be obtained from a direct or alternating current source (not shown) entirely separate from the direct current source E.

What is claimed is:

Electrical circuit including, connected in series, an indirectly heated, negative characteristic thermistor, a source of direct current, and at least part of an inductance, also including a capacity shunting said inductance and forming therewith a resonant circuit, said series connected circuit also including a variable resistance connected in series with the heater of said thermistor, whereby the characteristic voltage-current curve of said thermistor may be altered in shape and position, so that a given current flow therethrough may be made to lie at a predetermined point of said curve, said point being located at a portion of said curve having sufficient negative slope to cause said resonant circuit to oscillate.

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