Feb. 20, 1945. L. W. HOUGHTON 2,369,675

CONSTANT CURRENT ELECTRICAL CIRCUIT

Filed Jan. 6, 1943

Fig. 1.

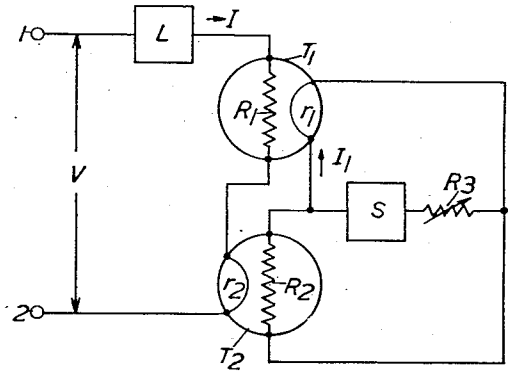
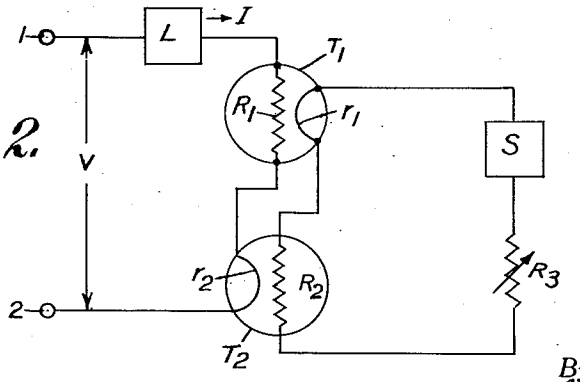


Fig. 2.



Inventor.
L. W. Houghton.
By James N. Curtin
Attorney

Patented Feb. 20, 1945

2,369,675

UNITED STATES PATENT OFFICE

2,369,675

CONSTANT CURRENT ELECTRICAL CIRCUITS

Leslie Wilfred Houghton, London, England

Application January 6, 1943, Serial No. 471,395
In Great Britain May 29, 1942

6 Claims. (Cl. 171—229)

The present invention relates to arrangements for stabilising the current in electrical circuits, and in particular employs thermally sensitive devices known as thermistors.

Thermistors have been in use for some years and are characterized by 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, December 1940, page 106.

The present invention employs two indirectly heated thermistors for the purpose of supplying a constant current to a load which may be variable from a source of voltage which may also be variable.

According to the invention, there is provided a circuit arrangement for supplying a constant current to a load from a source of voltage, either or both of which may be variable, comprising a first indirectly heated thermistor and a second indirectly heated thermistor, the resistance element of the first thermistor being connected to the variable source in series with the heating coil of the second thermistor, the heating coil of the first thermistor and the resistance element of the second thermistor being supplied with current from a local source of electromotive force.

The invention will be more clearly understood by reference to the detailed description which follows, and to the accompanying drawing which shows schematic circuit diagrams of arrangements according to the invention.

In the drawing:

Fig. 1 is a schematic circuit diagram illustrating the invention in a preferred form.

Fig. 2 is a modification thereof.

The diagram of Fig. 1 shows two indirectly heated thermistors T_1 and T_2, which have a negative temperature coefficient of resistance. The resistance element R_1 of T_1 is connected in series with the heating coil r_2 of T_2 and with a load L to two terminals 1 and 2, across which there exists a difference of potential V which may be continuous or alternating. The heating coil r_1 of T_1 and the resistance element R_2 of T_2 are connected in parallel to a local direct current or alternating current source S having an adjustable constant resistance R_3 connected in series therewith. The source S should preferably supply a substantially constant voltage.

It is assumed that the resistances r_1 and r_2 of the heating coils are approximately constant. Suppose that it is required to produce a constant current I in the load L irrespective of the variations of V or of the load L. The resistance R_1 will depend partly on the current I and partly on the current I_1 flowing through r_1. The latter depends on R_3 and R_2 (assuming the source S has a constant voltage). Now suppose that the voltage V increases, or the load resistance decreases, or both. The current I will momentarily increase, and this will raise the temperature of T_2 which reduces R_2. This will in turn reduce the current I_1 through r_1 and the temperature of T_1 raising the value of the resistance R_1. The increase in I will also tend to raise the temperature of T_1 thus lowering R_1. By adjusting R_3 it is possible to arrange so that the net effect is to lower the temperature of T_1 thus raising its resistance by the amount required to compensate for the

change in V and/or L, so that the current I is brought back to the original value.

Similarly, when the voltage V decreases, or the load resistance increases, or both, the reverse process takes place, and the momentary decrease of I is very quickly corrected. To obtain the best results, R_2 should be smaller than r_1 and R_3 should be large compared with R_2.

If thermistors having positive temperature coefficients are employed, the circuit shown in the figure will be seen to operate also in the desired manner. For when the current I tends to increase, the temperature of T_2 is raised as before, but R_2 now increases thereby increasing the current I_1. This raises the temperature of T_1 which increases R_1 as desired, to restore I to its original value.

If one thermistor has a positive temperature coefficient and one has a negative temperature coefficient the desired operation is obtained by a simple modification of the circuit as shown in Fig. 2. In this modification, r_1 and R_2 are connected in series with R_3 and S instead of in parallel. If T_1, for example, has a negative temperature coefficient, it is clear that if I should increase, the rise in temperature of T_2 will cause T_1 to cool so that the resistance R_1 increases as desired. If T_2 has the negative coefficient the reverse process occurs, again increasing R_1. Adjustment of R_3 enables the necessary amount of compensation to be obtained in either case.

By suitable design of the thermistors it can be arranged so that the heating effect of the current which passes through the resistance element is negligible, in which case only the effect produced by the heating coils need be taken into account. It is to be noted however that when T_1 has a positive temperature coefficient, the heating by the current I will aid the desired compensating effect, while when it has a negative temperature coefficient, as already explained, it will oppose the desired effect.

The source S may be any power source which may conveniently be available, and if necessary any suitable means for obtaining a convenient voltage therefrom may be supplied.

What is claimed is:

1. A circuit arrangement for supplying a constant current to a load from a source of voltage, either or both of which may be variable, comprising a first indirectly heated thermistor and a second indirectly heated thermistor, the resistance element of the first thermistor being connected to the variable source in series with the heating coil of the second thermistor, the heating coil of the first thermistor and the resistance element of the second thermistor being supplied with current from a local source of electromotive force.

2. A circuit arrangement according to claim 1 in which both thermistors have a temperature coefficient of resistance of the same sign, the heating coil of the first thermistor and the resistance element of the second thermistor being connected in parallel.

3. A circuit arrangement according to claim 1 in which the thermistors have temperature coefficients of resistance of opposite sign, the heating coil of the first thermistor and the resistance element of the second thermistor being connected in series.

4. A circuit arrangement according to claim 1 in which the thermistors both have negative temperature coefficients of resistance.

5. A circuit arrangement according to claim 1 in which the first thermistor has a positive temperature cofficient of resistance.

6. A circuit arrangement according to claim 1 in which an adjustable constant resistance is connected in series with the local source of electromotive force.

LESLIE WILFRED HOUGHTON.