June 19, 1945. E. O. THOMPSON 2,378,873

VOLTAGE REGULATOR

Filed Oct. 28, 1943

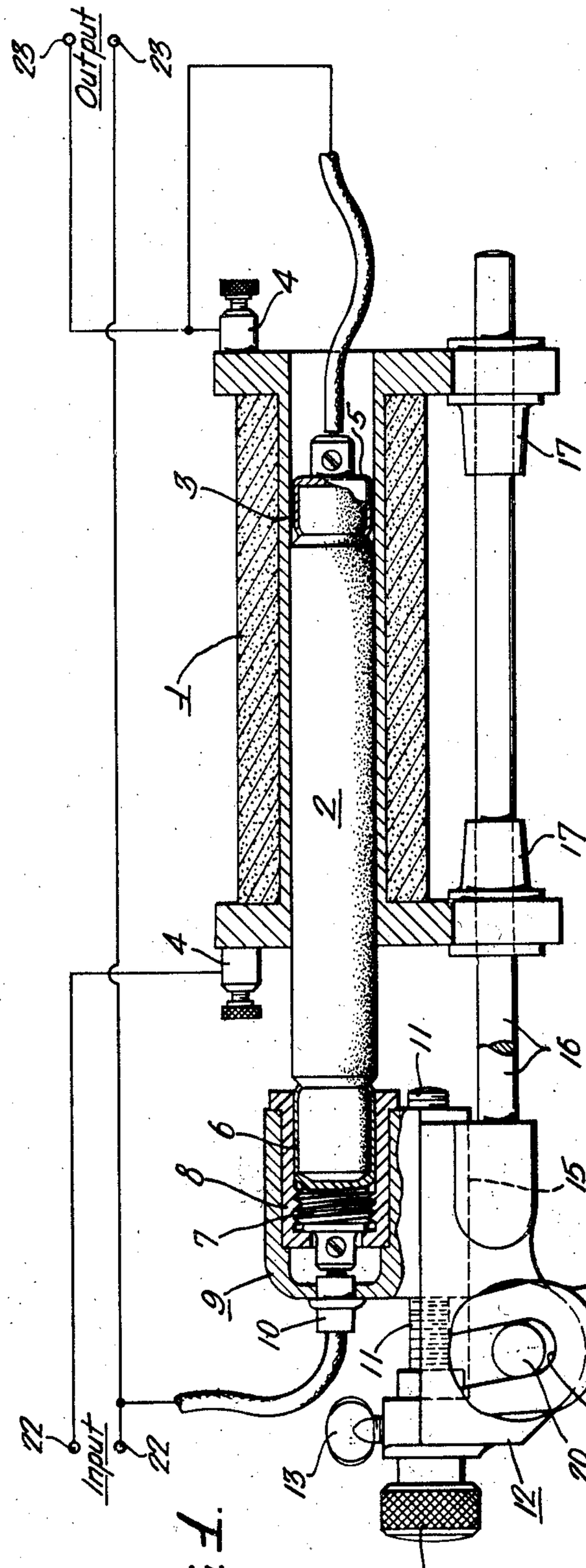

FIG. 1.

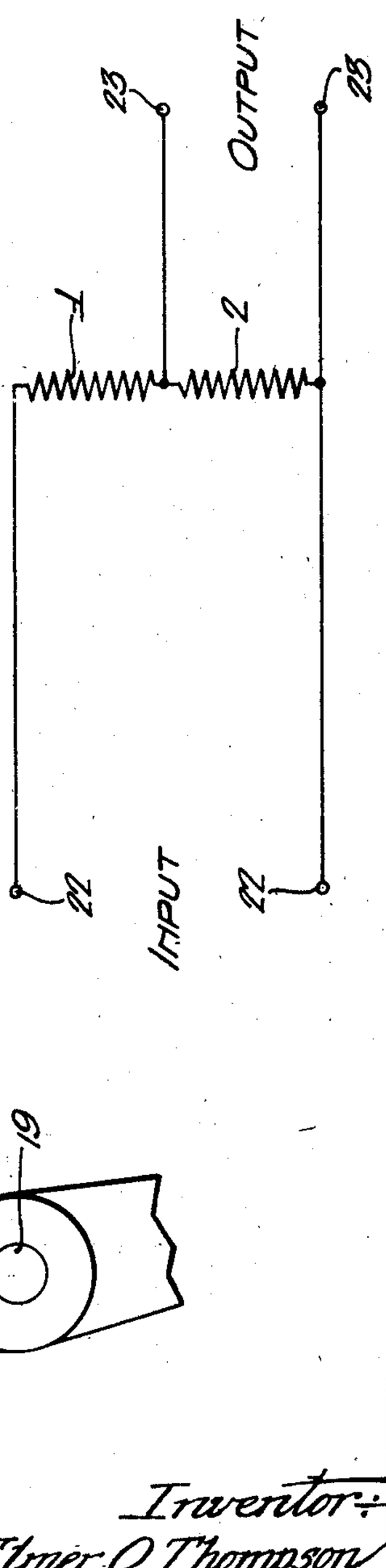

FIG. 2.

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Patented June 19, 1945

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UNITED STATES PATENT OFFICE

2,378,873

VOLTAGE REGULATOR

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Application October 28, 1943, Serial No. 508,030

7 Claims. (Cl. 171—229)

This invention relates to voltage regulators and has for its principal object the provision of a simple, inexpensive, and efficient voltage regulator of the novel character hereinafter described.

Another object of the invention is to provide a voltage regulator comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being arranged in thermal transfer relation to one another, and one of them having a negative temperature coefficient to reduce or minimize voltage variations thereacross, the output voltage being derived from across the said last-mentioned resistor.

A further object of the invention is to provide a device of this character in which one of the said resistors has a negative temperature coefficient while the other resistor has a positive temperature coefficient.

Still another object of the invention is to provide a device of this character in which the resistors are arranged for relative adjustment to effect variations in the thermal transfer therebetween and thus vary the regulation of the device.

A still further object of the invention is to provide a device of this character in which the two resistors are telescopically arranged, the inner resistor having a negative temperature coefficient and the outer resistor having a positive temperature coefficient, and the inner resistor being adjustable so as to vary the thermal transfer between the two resistors.

Other objects and features of the invention will be apparent from the following detailed description.

In the accompanying drawing:

Fig. 1 is a view, partly in elevation and partly in section, of a voltage regulating device constructed in accordance with the present invention; and

Fig. 2 is a diagrammatic illustration of the electrical connections of the said device.

Referring particularly to Fig. 1 of the drawing, there is shown an outer resistor 1 of hollow or tubular form and an inner resistor 2 disposed within the outer resistor and adapted to be moved longitudinally with relation thereto. It will be seen that two resistors are in intimate thermal transfer relation with respect to one another, and adjustment of the inner resistor 2 varies the thermal transfer between them. In the arrangement shown, the outer resistor 1 is mounted upon a tubular support 3 within which the inner resistor 2 is disposed. It is essential that the two resistors be electrically insulated from one another and, therefore, the support 3 is composed of insulating material. It will be obvious, however, that the support could be formed of conductive material if the resistors and their connections are electrically isolated therefrom. In either case, it will be understood that the support material should be thermally conductive.

Electrical connection may be made to the outer resistor 1 by means of suitable terminals 4 carried by the support 3. The outer resistor preferably has a positive temperature coefficient, i. e. its resistance increases with increase of temperature. This resistor may take any desired form, but it is preferred to employ a resistor of the type known by the trade-name "Globar," which is manufactured by The Carborundum Company. If desired, however, the outer resistor may be of the wound wire type, or it may take any other suitable form.

The inner resistor 2 has a negative temperature coefficient, i. e. its resistance decreases with increase of temperature and vice versa. It is preferably of the type manufactured by the Keystone Carbon Company and designated by the said company as the NTC resistance unit, meaning "negative temperature coefficient." However, the inner resistor may also take any suitable form, provided it has the desired negative temperature coefficient. While telescopically arranged resistors have been illustrated, it will be evident that the invention is not limited thereto.

Electrical connection may be made to the inner resistor by means of terminal caps 5 and 6 embracing reduced ends of the resistor as shown. The terminal cap 5 at one end of the resistor is of simple form and requires no detailed description. The terminal cap 6, however, is of special form as it serves to attach the resistor to the adjusting means presently to be described. To this end, the terminal cap 6 is provided with screw threads 7 which engage complementary threads on an insulating sleeve or bushing 8 within which the terminal cap 6 is disposed. The bushing 8 is in turn disposed within and held by a movable member or block 9. Electrical connection is made to the terminal cap 6 through an insulating bushing 10 seated in an opening in a wall portion of member 9.

The lower portion of block 9 has an internally threaded bore to accommodate an adjusting screw 11 which is rotatably mounted on a carriage member 12. A thumb screw 13 serves to lock the screw 11 against rotation after each adjustment of the resistor 2 utilizing the said adjusting screw. By loosening the thumb screw 13 and by

rotating the adjusting screw through the medium of its knurled head 14, a vernier adjustment of the resistor 2 may be effected. The movable block 9 is supported within a recess or track in carriage 12, indicated by the broken line 15 in Fig. 1. Thus during the vernier adjustment by rotation of screw 11, the block 9 rides in the said recess.

The carriage 12 is supported by means of rods 16 which are slidably supported by bushings or retainers 17 carried by the support member 3. A manually operable lever 18 pivoted at 19 has one end connected to carriage 12 by means of the pin and slot connection 20—21. By rotating lever 18 about its pivot, a coarse adjustment of the inner resistor 2 may be effected.

Thus there is provided an arrangement by means of which the resistor 2 may be quickly and coarsely adjusted through the medium of the lever 18, and the position of the said resistor may be finely or accurately adjusted whenever desired through the medium of the adjusting screw 11. It will be understood of course that the specific adjusting mechanism is exemplary of a preferred form and that other suitable adjusting mechanisms may be employed.

As shown more clearly in Fig. 2, the resistors 1 and 2 are series-connected and are adapted to be connected across a voltage source represented by the input terminals 22. The output or regulated voltage is taken from across the resistor 2 having a negative temperature coefficient as above mentioned, the output terminals being shown at 23. By means of this arrangement, the device operates as an automatic potentiometer to maintain the output voltage substantially constant despite fluctuations of the applied or input voltage.

Assuming a given positional adjustment of the inner resistor 2 in relation to the outer resistor 1, the resistance of the inner resistor will be varied in inverse relation to fluctuations of the input voltage primarily by reason of the thermal transfer from the outer resistor to the inner resistor, and secondarily as a result of the quantity of heat generated in said inner resistor. It will be noted that the entire current supplied to the device flows through the outer resistor 1 and, since the temperature of such resistor varies as the square of the current flow therein, any fluctuation of the input voltage will cause a substantial variation in temperature of the said resistor. Due to the thermal transfer relation between the two resistors, the temperature of the inner resistor will likewise vary substantially, and, since the inner resistor has a predetermined negative temperature coefficient, it will act to prevent any variation in the output voltage. Thus, if the input voltage rises above its normal value, the current flow will be increased and the temperature of resistor 2 will be increased, thereby causing its resistance to decrease and thus prevent any substantial increase in the output voltage. Similarly, a decrease in the input voltage below its normal value will cause an increase in the resistance of the resistor 2 to prevent any substantial decrease in the output voltage.

As mentioned above, the outer resistor 1 preferably has a positive temperature coefficient, and if the two resistors are so chosen as to have complementary temperature coefficients, their resistances will vary differentially and their total series resistance will remain substantially constant. Accordingly, there will be produced an automatic regulating effect corresponding to the manual adjustment of a potentiometer.

In any instance the selection of the resistors with regard to their normal resistance values and their particular resistance-temperature characteristics will depend upon the use to which the device is to be applied.

By reason of the adjustability of the inner resistor 2, the thermal transfer between the resistors may be varied at will to vary the regulation and to compensate for different load conditions. Thus, when the inner resistor is only partially within the outer resistor, the heat transfer is reduced and, therefore, the temperature of the inner resistor is reduced and the output voltage is increased. For any given load, the thermal coupling between the resistors may be adjusted to give the desired load voltage. Adjustment of the inner resistor effectively shifts the operating range along the resistance-temperature characteristic of said resistor. Thus the resistor may be caused to operate over portions of its said characteristic of different slope, thereby varying the regulation of the device.

The device is capable of general application in connection with either an A. C. or D. C. voltage source. The device eliminates the need for expensive elements, such as the gas discharge tube frequently employed in voltage regulator systems. While capable of general application, the device is particularly adapted for use in radio circuits and the like.

It will be understood of course that the invention is not limited to the specific structure shown but is capable of various modifications within the scope of the appended claims.

I claim:

1. A voltage regulating device, comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being arranged in thermal transfer relation to one another and being relatively adjustable to vary the thermal transfer therebetween, one of said resistors having a negative temperature coefficient to reduce voltage variations thereacross, and means for deriving an output voltage from across said last-mentioned resistor.

2. A voltage regulating device, comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being telescopically arranged in thermal transfer relation to one another and being relatively adjustable to vary the thermal transfer therebetween, the inner one of said resistors having a negative temperature coefficient to reduce voltage variations thereacross, and means for deriving an output voltage from across said last-mentioned resistor.

3. A voltage regulating device, comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being arranged in thermal transfer relation to one another, one of said resistors having a negative temperature coefficient, the other of said resistors having a positive temperature coefficient, and means for deriving an output voltage from across said first-mentioned resistor.

4. A voltage regulating device, comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being arranged in thermal transfer relation to one another and being relatively adjustable to vary the thermal transfer therebetween, one of said resistors having a negative temperature coefficient, the other of said resistors having a pos-

itive temperature coefficient, and means for deriving an output voltage from across said first-mentioned resistor.

5. A voltage regulating device, comprising a pair of series-connected resistors adapted to be connected across a voltage source, said resistors being telescopically arranged in thermal transfer relation to one another and being relatively adjustable to vary the thermal transfer therebetween, the inner one of said resistors having a negative temperature coefficient, the other of said resistors having a positive temperature coefficient, and means for deriving an output voltage from across said first-mentioned resistor.

6. A voltage regulating device, comprising an outer resistor of hollow form, an inner resistor slidably disposed within said outer resistor so as to be thermally affected thereby, said inner resistor having a negative temperature coefficient, said resistors being connected in series relation and being adapted to be connected across a voltage source, means for deriving an output voltage from across said inner resistor, the negative temperature coefficient of said inner resistor and its thermal association with said outer resistor serving to reduce voltage variations across said inner resistor, and manually-operable means for varying the position of said inner resistor, thereby to vary the thermal transfer from said outer resistor to said inner resistor and thus vary the regulation of the device.

7. A voltage regulating device, comprising an outer resistor of hollow form, an inner resistor slidably disposed within said outer resistor, whereby the two resistors are arranged in thermal transfer relation to one another, said inner resistor having a negative temperature coefficient, said outer resistor having a positive temperature coefficient, said resistors being connected in series relation and being adapted to be connected across a voltage source, means for deriving an output voltage from across said inner resistor, the inversely-related temperature coefficients of said resistors and their thermal relation serving to oppose changes in the total resistance of both resistors, and also serving to reduce voltage variations across said inner resistor, and manually-operable means for varying the position of said inner resistor, thereby to vary the thermal transfer between said resistors and thus vary the regulation of the device.

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