Feb. 7, 1950 W. G. NEILD 2,496,742

TEMPERATURE COMPENSATED REGULATOR

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Fig. 1

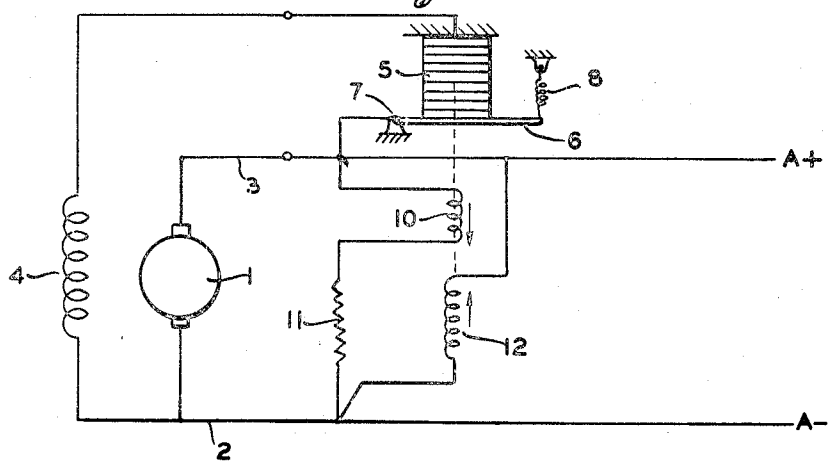
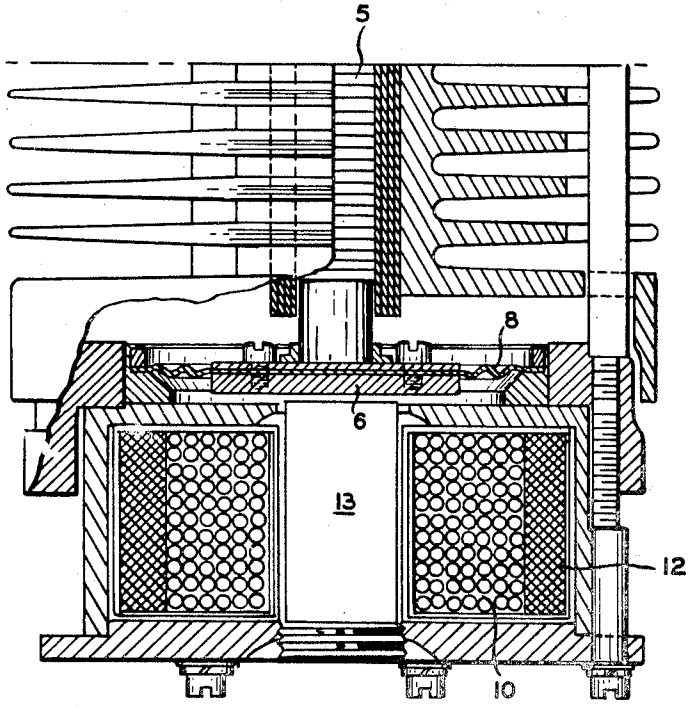


Fig. 2



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TEMPERATURE COMPENSATED REGULATOR

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5 Claims. (Cl. 323—95)

1

The present application relates to electrical regulators and more particularly to novel means for compensating electromagnetic windings for changes in resistance due to temperature.

An object of the present invention is to provide a novel circuit for compensating for variation in the resistance of a control winding of an electrical regulator due to change in temperature.

Another object of the invention is to provide an electrical regulator including a variable resistance element and an electromagnet for controlling the same, including a main electromagnetic winding of copper or other material having a resistance variable with temperature for controlling the element and a de-magnetizing winding of a material which changes its resistance with temperature and in which the main winding has connected in circuit therewith a resistor member with a substantially zero temperature coefficient of resistance. The said circuits being so arranged that upon a change in temperature varying the resistance of the magnetizing and demagnetizing windings, the resistance of the demagnetizing circuit will vary at such a greater rate with respect to the magnetic circuit due to the resistor member, that the magnetic force applied by the one electromagnetic winding will compensate for changes in the force applied through the other due to such changes in resistance.

These and other objects and features of the invention are pointed out in the following description in terms of the embodiment thereof which is shown in the accompanying drawing. It is to be understood, however, that the drawing is for the purpose of illustration only, and is not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

Figure 1 is a diagrammatic view of a circuit embodying the invention.

Figure 2 is a fragmentary sectional view of a regulator showing the compensating windings of the invention.

In the drawing of Figure 1 there is illustrated diagrammatically a typical circuit embodying the present invention in which there is indicated by the numeral 1 a direct current generator of a type well known in the art and including output lines 2 and 3. The generator 1 has a field winding 4 connected across the output lines 2 and 3 through a variable resistance element 5.

The variable resistance element 5 may be of the carbon pile type, indicated diagrammatically in

2

Figure 1 as having an armature 6 pivoted at 7 and biased under force of a spring 8 in a direction for compressing the carbon pile 5. The carbon pile regulator may have diaphragm type spring and armature of a type as disclosed and claimed in my co-pending application Serial No. 612,691, filed August 25, 1945, now Patent No. 2,481,771, and illustrated herein by Figure 2.

A main control winding 10 is connected in series with a resistor member 11 across the output lines 2 and 3 and serves to draw the armature 6 in a direction increasing the resistance of the carbon pile 5 and in opposition to the biasing force of the spring or diaphragm in a manner such as described in the latter application. Thus as the output voltage tends to increase, the resistance of the carbon pile 5 increases so as to maintain the output voltage substantially constant.

The main control winding 10 may be of a copper material or other material having an electric resistance which increases with a rise in temperature while the external resistor element 11 is preferably formed of a material such as Nichrome having a substantially zero temperature coefficient of resistance.

A second counteracting de-magnetizing winding 12 formed of a material also having a resistance which increases with a rise in temperature such as copper or iron is connected across the output lines 2 and 3 and so wound as to counteract in part the magnetic force applied by the winding 10 on the armature 6.

The windings 10 and 12 are arranged so as to be effected by the same temperature variations, but change in temperature will cause the resistance of the magnetizing circuit to vary only in part, whereas a proportionately greater change in the resistance of the de-magnetizing circuit will be effected.

Thus upon a rise in temperature increasing the resistance of the windings 10 and 12, the increase in the resistance of the winding 12 will be so much greater than that of winding 10, while the resistance of member 11 remains constant, that the proportionate decrease in the de-magnetizing effect of the winding 12 for a given output voltage will counteract the decrease in the magnetizing effect of winding 10 due to such change in temperature.

An opposite counteracting effect will result upon a decrease in the resistance of the windings 10 and 12 due to decrease in temperature. Thus it will be seen that there has been provided a novel circuit arrangement for compensating for

changes in the resistance of an electromagnetic winding due to temperature change.

The main magnetizing winding 10 as shown in Figure 2, is preferably formed as an inner winding about a core 13 formed of a ferro-magnetic material. The core 13 cooperates with the armature 6 and diaphragm type spring 8 as explained in my aforenoted copending application. The winding 10 has a short mean length of turn and is formed of relatively large size wire, while the de-magnetizing winding 12 is wound about the inner winding 10 with a relatively long mean length of turn and comprises a large number of turns of small size wire in order that substantially the total resistance of the de-magnetizing circuit will be in the winding 12.

The number of turns in both windings 10 and 12, wire sizes and material can be varied to give the desired temperature compensation as well as the resistance value of the external resistor 11.

Operation

In the aforedescribed temperature compensating means, the winding 10 is described as the main control winding and the winding 12 is described as a demagnetizing or compensating winding. It will be clear then that the main control winding 10 predominates in its ampere turn effects and that the demagnetizing winding 12 functions to vary with temperature its demagnetizing effect so that the differential magnetic force applied by the winding 10 under varying temperature conditions may be maintained substantially constant for a given voltage condition.

If the main control winding 10 alone were provided, it will be readily seen, if the same be formed of copper having a positive temperature coefficient of resistance as suggested herein, that as the temperature increased the resistance of the winding 10 would likewise increase so that the ampere turn effect of the main control winding 10 for a given output voltage would decrease and thereby introduce into the control of the carbon pile 5 an error due to the effect of temperature change on the main control winding 10.

In the present invention the error due to the temperature effects on the main control winding 10 are corrected by the demagnetizing winding 12, which is connected in a parallel circuit to the winding 10. The winding 12 is arranged in relation to the winding 10 so as to have a demagnetizing or compensating effect on the winding 10 which varies with temperature and counteracts in parts the magnetic force applied by the winding 10 on the armature 6. The winding 12 as suggested herein may be formed of copper or iron having a positive temperature coefficient of resistance as in the case of the main control winding 10.

It will be seen then that an increase in temperature tending to increase the resistance of the main control winding 10 so as to decrease the ampere turn effect thereof, will also tend to increase the resistance of the demagnetizing or compensating winding 12 so as to lessen the demagnetizing effect thereof on the main control winding 10, and thereby tend to correct for changes in the magnetic force of the main control winding 10 on the armature 6 due to changes in temperature.

However, inasmuch as the electromagnetic force applied by the main control winding 10 predominates and is the controlling force on the armature 6, it is necessary in order to effect substantially complete compensation that the rate of change in resistance of the compensating circuit be sufficiently greater than that of the control circuit for unit of temperature change to match the changes in the force thereof.

This desired compensating effect is thus furthered by provision of the resistor 11 in circuit with the main control winding 10 so as to decrease the rate of change in the total resistance of the main control circuit for unit of change in temperature. As previously described, the resistor 11 may be formed of a material such as Nichrome having a substantially zero temperature coefficient of resistance. Thus change in temperature will cause the resistance of the main control circuit, including the resistor 11 and main control winding 10 to vary only in part and at a relatively low rate for unit of temperature change, while a proportionately greater change in a like sense in the resistance of the parallel connected compensating circuit, including the winding 12, will be effected by such temperature change. The windings 10 and 12 and resistor 11 are so proportioned that the greater change in the resistance of the parallel connected winding 12 proportionately varies the demagnetizing effect of the winding 12 and so controls the diversion of current from the main control circuit, that the change in the demagnetizing effect of the winding 12 for a given output voltage will substantially counteract the change in the predominating magnetizing effect of the main control winding 10, due to such change in temperature.

It is desired to have a relatively low resistance in the main control winding 10 and a relatively high resistance in the demagnetizing or compensating winding 12. As all of the resistance of the coil 12 is in the winding, advantage is taken of the long mean length of turn gained by winding many turns of relatively fine wire on the outside of the main control winding 10 to form the coil 12. The smaller the resistance of the main control winding 10 with respect to its complete circuit (10+11) the less the effect of coil 12 will be necessary to compensate for changes in the resistance of coil 10 due to changes in temperature.

The specific values of the windings 10 and 12 and the resistor 11 is dependent of course upon the regulated voltage, the magnetic circuit of the regulator involved and the N. I. requirements of the particular regulator system under consideration.

However, by proper apportionment of the windings 10 and 12 and the resistor 11 for the operating conditions involved and so as to cooperate in the manner indicated, substantial temperature compensation may be effected.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangements of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. An electromagnet comprising a main winding formed of a material having a relatively high positive temperature coefficient of resistance, a resistor connected in series with said main winding and having a relatively low temperature coef-

ficient of resistance, an auxiliary winding shunted across said main winding and resistor and formed of a material having a relatively high positive temperature coefficient of resistance, a ferromagnetic core, and said main and auxiliary windings wound about said core, and armature cooperating with said core, and said main and auxiliary windings so arranged in relation to said core that said auxiliary winding tends to counteract in part only the magnetic force applied by said main winding, the counteracting magnetic force applied by said auxiliary winding decreasing with increase in temperature and of a value sufficient to substantially compensate for changes in the electromagnetic force applied by said main winding due to temperature change.

2. In an electric regulator of the type including a variable resistance element, an electromagnet, an armature operated by said electromagnet and operably connected to said variable resistance element, and spring means opposing the electromagnet and biasing said armature in a resistance decreasing direction; the improvement comprising said electromagnet including a first and a second winding, the resistances of said windings varying with temperature in a like sense, the first winding supplying a controlling electromagnetic force, and the first and second windings electrically connected in parallel and supplying opposing electromagnetic forces, the electromagnetic force of said second winding counteracting in part only the force of said first winding, the rate of change of the resistance of said second winding being greater than the rate of change of the resistance of said first winding so that the first winding may be compensated by the second winding for change in electromagnetic force due to change in temperature.

3. In an electric regulator of the type including a variable resistance element, an electromagnet, an armature operated by said electromagnet and operably connected to said variable resistance element, and spring means opposing the electromagnet and biasing said armature in a resistance decreasing direction; the improvement comprising said electromagnet including a first winding and a second winding, the first winding supplying a controlling electromagnetic force, the second winding connected in parallel to the first winding and acting in opposition thereto, the resistances of the first and second windings varying with temperature at different rates, the first winding having a relatively short mean length of turn and being formed of a relatively large size of wire, the second winding having a relatively long mean length of turn and being formed of a relatively large number of turns of small wire, and the resistance of the first winding increasing with temperature at such a low rate and the resistance of the second winding increasing with temperature at such a great rate that decrease in the electromagnetic force supplied by said first winding due to increase in temperature is substantially counteracted by decrease in the electromagnetic force supplied by the second winding due to such increase in temperature, whereby the second winding may compensate the first winding for such increase in temperature.

4. In an electric regulator of the type including a variable resistance element, an electromagnet, an armature operated by said electromagnet and operably connected to said variable resistance element, and spring means opposing the electromagnet and biasing said armature in a resistance decreasing direction; the improvement comprising said electromagnet including a first winding and a second winding, the first winding supplying a controlling electromagnetic force and the first and second windings supplying opposing electromagnetic forces changeable with temperature, the first winding having a relatively short mean length of turn and being formed of a relatively large size of wire, the second winding having a relatively long mean length of turn and being formed of a relatively large number of turns of small wire wound about said first winding and adjacent thereto, the first winding being formed of a material having a relatively high positive temperature coefficient of resistance, and the second winding being formed of a material having a relatively high positive temperature coefficient of resistance, a resistor formed of a material having a relatively low temperature coefficient of resistance and connected in series with the first winding, said second winding shunted across said first winding and series connected resistor so that the rate of change in the resistance of said series connected resistor and first winding due to variations in the temperature of the first winding is substantially less than the rate of change of the resistance of the second winding due to such temperature variations, such rates of change in resistance being of such values that the second winding substantially compensates the first winding for change in electromagnetic force due to change in temperature.

5. An electromagnet comprising a main winding formed of a material having a relatively high temperature coefficient of resistance, a resistor connected in series with said main winding and having a relatively low temperature coefficient of resistance, an auxiliary winding shunted across said main winding and resistor and formed of a material having a relatively high temperature coefficient of resistance, said main and auxiliary windings formed of a material in which the resistance varies with temperature in a like sense, said main and auxiliary windings being in the same magnetic circuit and the auxiliary winding so wound in relation to said main winding as to apply an electromagnetic force variable with temperature and tending to counteract in part only the electromagnetic force applied by said main winding, each of said windings responsive to a temperature change affecting the other winding so that upon a change in such temperature a corresponding change in the resistances of said main and auxiliary windings and in the magnetic force applied by said auxiliary winding tends to compensate for changes in the magnetic force applied by said main winding due to variance in the resistance of said main winding upon said temperature change.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,146,927	Conrad	July 20, 1915
1,987,992	Creveling	Jan. 15, 1935
2,082,121	Rypinski	June 1, 1937
2,093,368	Rypinski	Sept. 14, 1937

FOREIGN PATENTS

Number	Country	Date
443,793	Germany	May 11, 1927
382,565	Great Britain	Oct. 27, 1932