

1,400,410.

Patented Dec. 13, 1921.

Fig. 1.

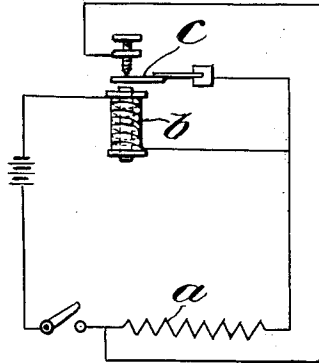


Fig. 2.

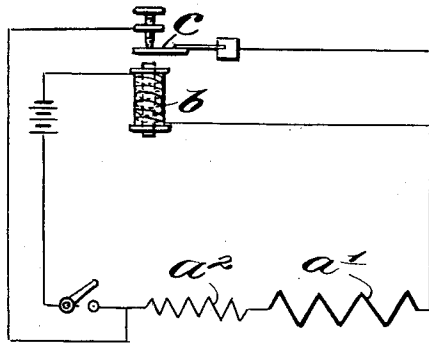
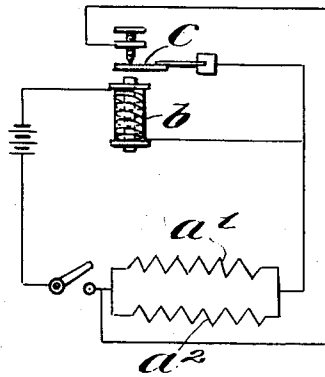


Fig. 3.



Witness

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ELECTRIC RESISTANCE.

1,400,410.

Specification of Letters Patent.

Patented Dec. 13, 1921.

Application filed August 25, 1917. Serial No. 188,223.

To all whom it may concern:

Be it known that I, PIERRE BOSSU, engineer, citizen of the French Republic, residing at Paris, France, have invented certain new and useful Improvements in Electric Resistances, (for which I have made application in France July 20, 1916, and Great Britain July 26, 1916,) of which the following is a specification.

10 This invention relates to electro-magnetic apparatus, such for example as electro-magnetic devices for switching or regulating purposes and it pertains more particularly to an electro-magnet which is so constructed
15 that when its armature is attracted, a resistance is cut into the circuit of its magnetizing coil. The purpose of so cutting in a resistance is to diminish the current flowing through the magnetizing coil as soon as
20 the air-gap is diminished by the movement of the armature toward attracted position and to thus compensate for the effect due to the variation of the reluctance produced by said movement. The armature is usually
25 subject to the restoring action of a spring, the force of which does not vary greatly when the armature is in its released and attracted position respectively. The resistance thus cut into the magnetizing circuit,
30 in the attracted position of the armature, is hereinafter termed "compensating resistance," the utility and effects of which may be briefly explained as follows:—

If no compensating resistance were provided for an electro-magnet having a greatly
35 varying airgap between its core and armature, the release of the attracted armature would take place only when the voltage has dropped considerably below the voltage of
40 the current which attracted the armature, because a current of comparatively very small voltage will maintain sufficient magnetic flux through the reduced airgap, to overcome the restoring action of the armature-releasing spring. However, if a
45 compensating resistance is provided and it is automatically cut into the magnetizing circuit as soon as the armature leaves its attracted position, the amount of reduction in
50 voltage required to cause releasing of the armature can be determined, as desired, by giving the compensating resistance different values in comparison with the ohmic value of the magnetizing coil.

55 It has been found, however, that in using

electro-magnets provided in the usual way with compensating resistance, disadvantages arise from the fact that the compensation obtained varies with changes in temperature of the apparatus.

The object of the present invention is to provide a compensating resistance of such properties or characteristics that correct compensation may be obtained with precision, or in an equal degree for all temperature conditions, thus overcoming the disadvantages of the ordinarily-used compensating resistances wherein the compensating effect diminishes when the temperature of the apparatus increases. This undesirable variation in the compensating effect is due to the fact that the ordinary compensating resistances are generally composed of metallic wires of high resistivity which have a very small temperature coefficient. For
60 example, the temperature coefficient of the metals and alloys used for ordinary compensating resistances may be either positive, zero, or even negative, while the magnetizing coils of the electro-magnet with which
65 they are used generally are composed of metallic wires having a very high positive temperature coefficient. The result of this difference in temperature coefficients in the ordinary devices is, that the relative value of
70 the compensating resistance and the resistance of the magnetizing coils varies greatly with temperature changes, owing to the fact that the ohmic resistance of the magnetizing coil greatly increases and decreases with the
75 increases and the decreases of its temperature, while the ohmic resistance of the compensating resistance is substantially invariable under the same conditions. The resulting variations in the ratio of the ohmic
80 values of the compensating resistance and the magnetizing windings causes an incorrect operation of the compensating arrangement. The lack of uniformity in the operation of such apparatus under the influence
85 of different temperatures will be clearly understood if it is supposed that the compensating resistance of such an apparatus has been given such a value as to effect release of the armature at the ordinary temperature,
90 when the voltage which caused the armature to be attracted has been reduced by a predetermined amount of, say " x " volts. Now, if the temperature rises above the ordinary temperature, the result will be
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that the resistance of the magnetizing coils will greatly increase while that of the compensating resistance will remain substantially constant. In consequence, the proportionate value of the compensating resistance to that of the coil has become diminished, so that the former reduction of "x" volts will not suffice to cause release of the armature, but, on the contrary, a greater amount of reduction in voltage will be necessary, due to the diminution in the compensating effect caused by the temperature increase. If a substantial increase in temperature takes place, the compensating effect may grow so weak that even a hunting effect may take place, to the detriment of the working of the apparatus.

With the object of insuring a constant or equal compensating effect, notwithstanding variations of the temperature, (such object requiring a constant ratio between the ohmic resistance of the magnetizing coil and that of the compensating resistance) the invention chiefly consists in making up the compensating resistance in such a manner that it has a positive coefficient of temperature which is relatively high and so chosen that its variations of resistance due to the fluctuations of the temperature of the apparatus correspond substantially to the variation of the magnetizing coil resistance, due to the fluctuations of temperature.

Assuming, for example, the invention to be applied to a voltage regulator provided with a compensated electro-magnet, that is to say, a regulator comprising one or several electro-magnets each so arranged that its armature is attracted at a given tension of E volts and interposes, when attracted, in the circuit of the winding of its electro-magnet a compensating resistance of such a value that the armature is released when the tension is reduced by the amount of "x" voltage, which, as already said and as known by those conversant with this art, may be, owing to said compensating resistance, as small as desired, the aim being to obtain the independence of the compensation effect from the temperature changes, the following or an analogous course is adopted:

The ordinary compensating resistance of the regulator, which, as usual, is made of a metal of conveniently high resistivity, and having in such case a comparatively unimportant temperature coefficient, is substituted by a resistance constituted by: either a wire-metal identical with that of the magnetizing coils, which course, however, has the drawback, in consequence of the small resistivity of such metal and accordingly, of the large quantity of wire that would have to be used, of taking up a considerable space whereby the use of such an arrangement could, in apparatus of small dimensions, be rendered very difficult if not impossible; or

by a certain number of elementary resistances consisting of wires of different nature and having different coefficients of temperature of which at least one has a positive coefficient of temperature superior to that of the wires of the magnetizing coils of the electro-magnet, while the others have a greater resistivity and may have coefficients of temperature weaker than that of the wires of the magnetizing coil, or a coefficient *nil* or even negative, provided that always the total resistance which results from the combination of the wires of different nature, rises with the temperature substantially in the same proportion, or even more rapidly than that of the magnetizing coils.

The accompanying drawing embodies examples of practical disclosures of the invention, in which the compensating resistances are composed of the combination of wires made of nickel and constantan.

In the drawing:—

Figures 1, 2 and 3 represent diagrammatic views of various forms of the features of the invention.

Fig. 1 illustrates a compensating resistance *a* which is cut into the circuit of the magnetizing coil *b* of an electro-magnet, as soon as its armature *c* is attracted. Said armature *c* is so arranged that, when attracted, it does not come into electrical contact either with the core of said electro-magnet, or with the upper end of its magnetizing coil *b*, said armature, when attracted, simply disengaging from a contact screw which previously had completed a circuit around the compensating resistance *a*. Therefore, in the attracted position of the armature, this compensating resistance is cut into the circuit of the magnetizing coil *b* while in the released position of the armature, it is cut out of said circuit. To this end, the right-hand extremity of the compensating resistance is electrically connected to a fixed part of the armature, while the left-hand extremity is connected to the fixed contact screw against which the armature rests in its released position, so that for this position the current passes around the resistance. These connections are usual and are not a part of the invention. According to one embodiment of this invention, the compensating resistance *a* is made of wire-metal identical with the wire-metal composing the magnetizing coil. In consequence of the small resistivity of the wire, and accordingly, of the large quantity of wire that would have to be used in such compensating resistance *a*, this arrangement might be objectionable in some instances, because of the considerable space which it would require and its use, therefore, in apparatus of small dimensions, would be difficult and often impracticable.

In Fig. 2 the compensating resistance comprises a part or element composed of

nickel-wire a' connected in series with a second part or element of constantan wire a^2 .

Finally in Fig. 3, the compensating resistance is composed of a part or section a' of nickel wire connected in parallel to a part or section a^2 of constantan wire.

Such compensating resistances, moreover, are preferably arranged so as to be subjected substantially to the same temperature as the magnetizing coil b itself. To this end, they are in practice located either on or below the magnetizing coil, or else partly above and partly below the said coil. It follows that the temperature of the magnetizing coil and the compensating resistance will be practically the same. The temperature coefficients being the same, or substantially the same, it follows also that the ratio or proportion of the magnetizing coil resistance and the compensating resistance remains the same, notwithstanding decreases and increases of temperature such as results from changes, on the one hand, between summer and winter, and on the other hand, between a short or a prolonged period during which the apparatus may be in action.

Of course, if only the ratio or proportion of the resistances remains invariable, without the absolute value of these resistances being invariable, it follows that though the compensation effect itself remains perfect, the absolute value of the voltage, to which the apparatus is sensible, varies with the variation of the temperature. But it is easy to provide known devices in order to obtain an apparatus which attracts its armature at the same voltage in spite of variations of temperature. Such known devices consist, for instance, in providing an armature which suitably bends under the influence of various temperatures so as to maintain at each temperature an amount of airgap which permits attraction of the armature at substantially the same voltage. Such an apparatus will thus attract its armature at always the same voltage, owing to the above-mentioned bending of the armature and it will release the armature at always the same voltage, when compensated in accordance with the present invention.

Compensating resistances of a metal or alloy which does not seem to exist nowadays, but which may eventually be discovered in the future and which would have a coefficient of temperature approximately equal to that of copper but would possess a considerably higher resistivity than copper, would like-

wise be of particular advantage for use in connection with this invention.

The object of the invention is chiefly to render the working of the compensating device independent of the changes of the surrounding temperature which may vary greatly in different climates, with sudden changes of altitude, and with the effect of the internal heat developed in the wires through Joule-effect, which, however, may in practice be so limited by the proper proportioning of the conductors, that its action may, in some cases, be practically negligible.

As will be obvious, the invention is not limited to the specific modes of carrying it into effect as hereinbefore indicated, but is capable of numerous modifications, within the scope of the appended claims.

What I claim is:—

1. An electro-magnetic device comprising an electro-magnet provided with a magnetizing coil, a vibratory armature, a core for attracting the armature, and a compensating resistance adapted to be cut into the circuit of the magnetizing coil when the armature is in its attracted position and to be cut out of said circuit when the armature is in its released position, the magnetizing coil being composed of the usual conducting wire-metal having a high conductivity and a great variability of resistance consequent upon decreases and increases of temperature, and the compensating resistance being composed of a wire-metal which is variable in consequence of decreases and increases of temperature to maintain, throughout a given temperature range, a substantially constant ratio between the amount of the ohmic resistance of the magnetizing coil and the amount of the ohmic resistance of the compensating resistance.

2. An electro-magnetic device as described in claim 1, wherein the compensating resistance is composed of a plurality of elementary wire resistances.

3. An electro-magnetic device as described in claim 2, wherein the compensating resistance is composed of nickel wire and constantan wire arranged in series.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

PIERRE BOSSU.

Witnesses:

CHAS. P. PRESSLY,
EUGÈNE JULLIEN.