E. THOMSON.

VARIABLE RESISTANCE.

APPLICATION FILED SEPT. 28, 1905.

910,743.

Patented Jan. 26, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

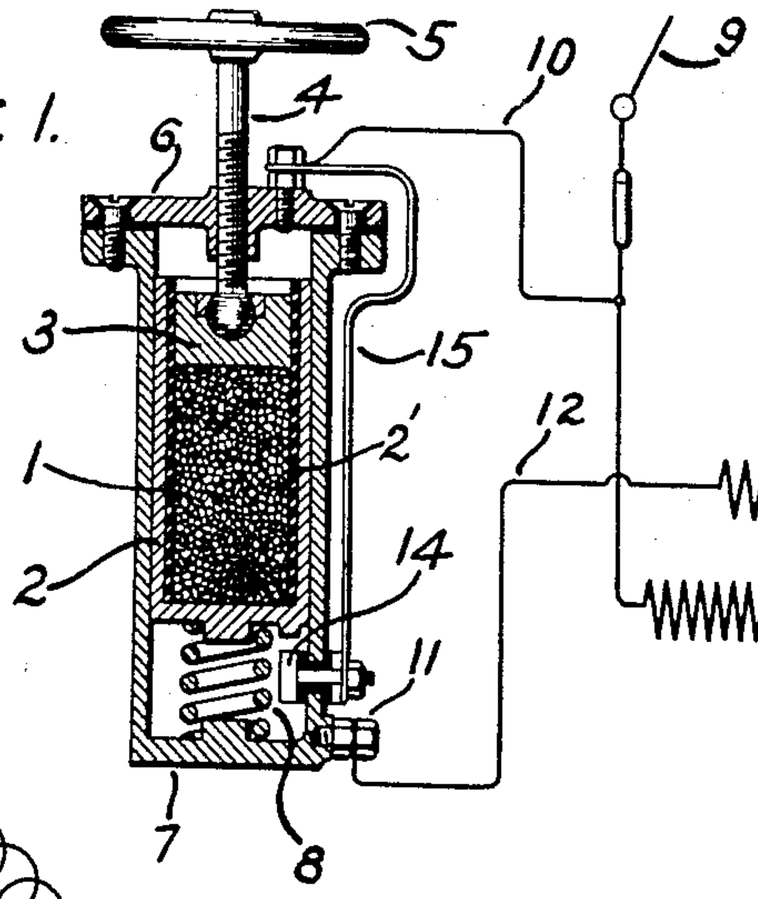


Fig. 3.

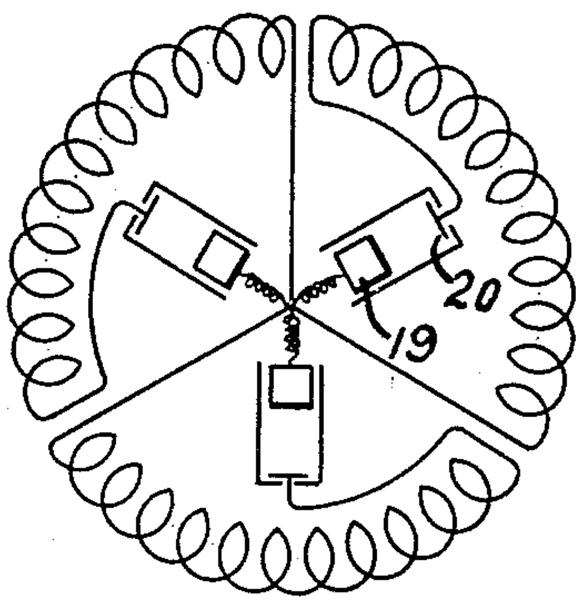


Fig. 4.

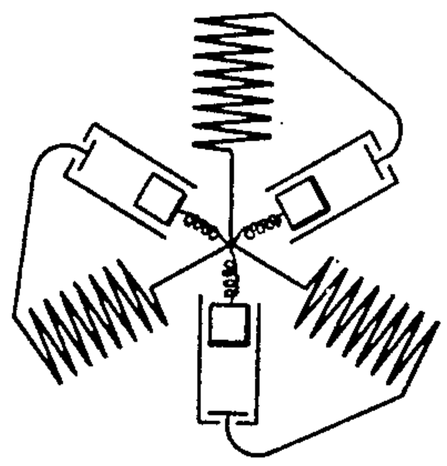
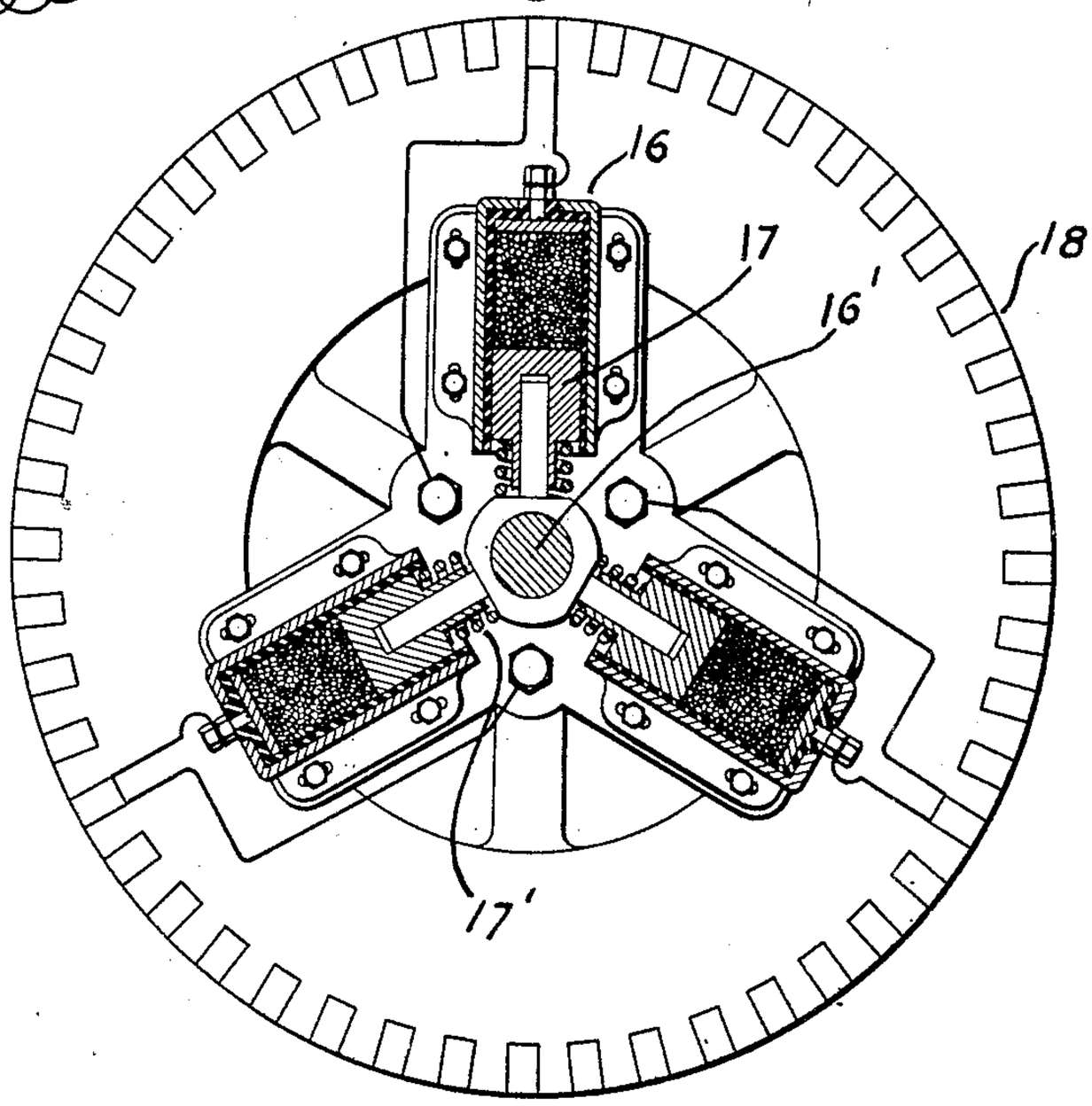


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 5

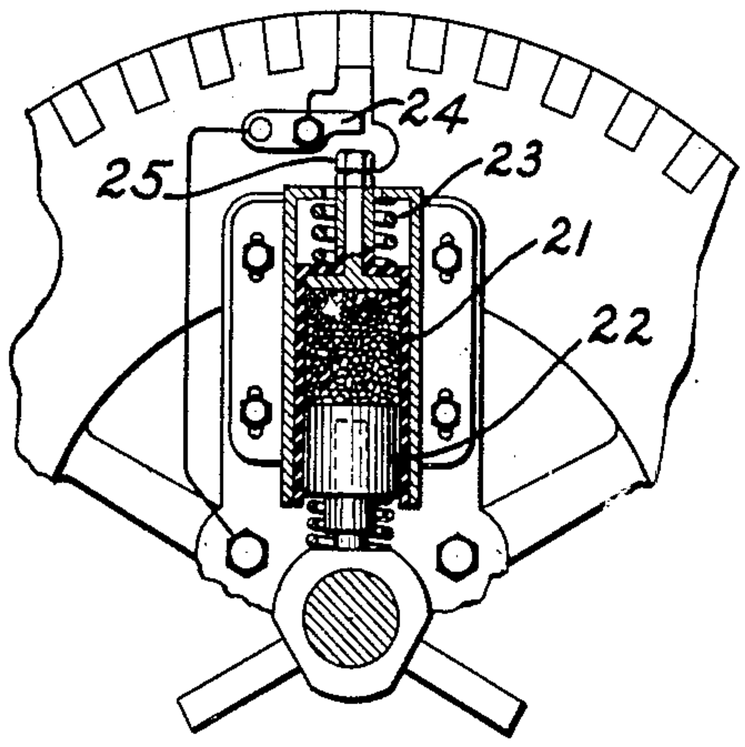


Fig. 6.

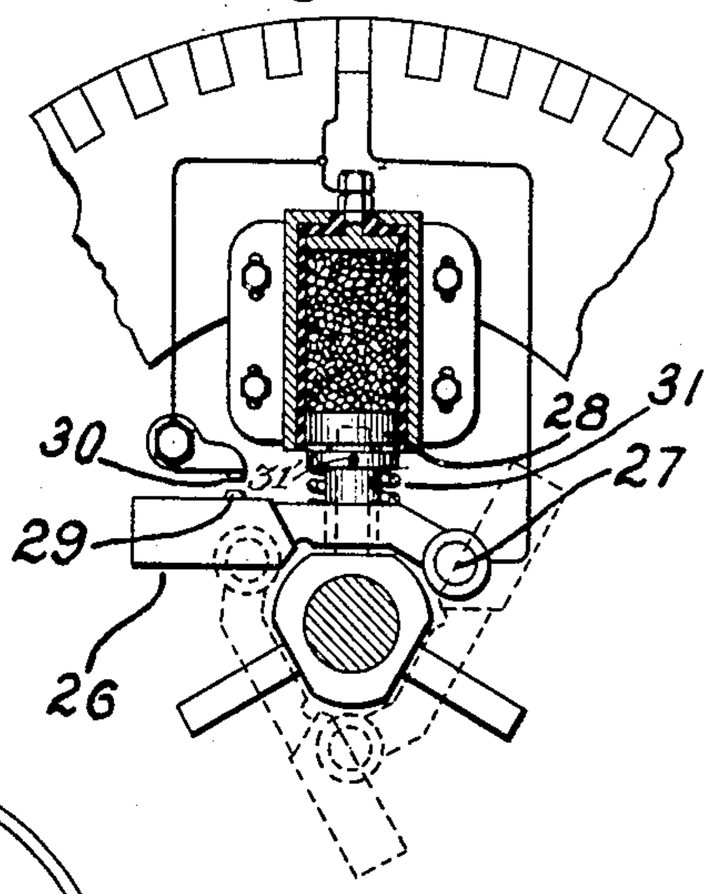


Fig. 7.

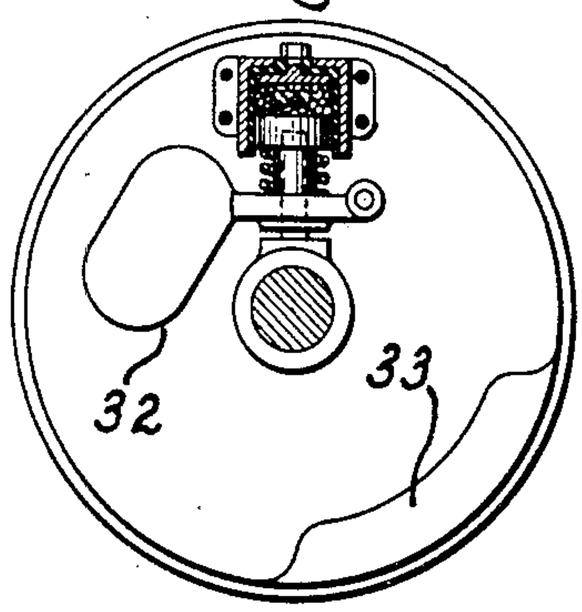
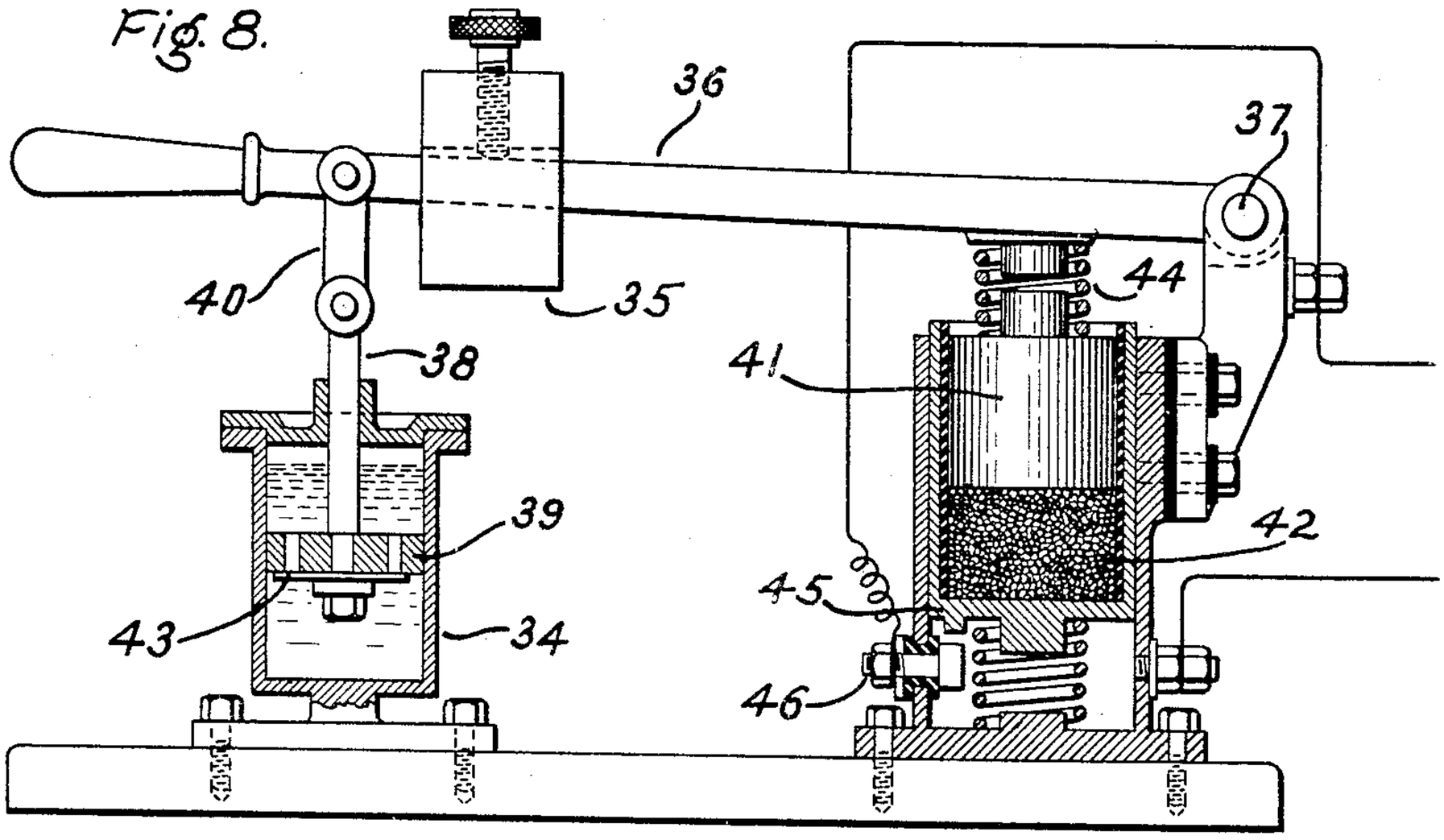


Fig. 8.



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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

VARIABLE RESISTANCE.

No. 910,743. Specification of Letters Patent. Patented Jan. 26, 1909.

Application filed September 28, 1905. Serial No. 280,525.

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing at Swampscott, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Variable Resistances, of which the following is a specification.

This invention relates to means for controlling electric circuits and has for its object the provision of means of this character adapted to a wide range of application and which at the same time is cheap, safe, efficient, and practically indestructible.

One of the objects of my invention is to provide a simple and reliable means for varying the resistance in circuit with a motor or dynamo-electric machine so as to regulate the supply of current in the system. Many devices for bringing about this result have been produced, many of which are very successful under suitable conditions. As is well known, it is a common practice to vary the resistance in an electric circuit by means of resistance conductors which are gradually cut out of circuit so as to reduce the resistance. Stick resistance, both in the cast and molded form, has likewise been used with more or less success. The use of granular or flake resistance has also been suggested, it having been proposed to vary the resistance of the granular material by varying the pressure thereon. It is this latter form of resisting means which it is my intention to improve, it having been found that for various reasons the devices heretofore proposed have not worked successfully.

The materials heretofore commonly used as a granular or flake resistance have been graphite or carbon. These materials have been open to the objection that they do not completely recover after being submitted to pressure but upon being relieved of pressure they remain packed. This is due, in part, to the fact that the materials are fusible or oxidizable at temperatures frequently attained in ordinary operation and there is, therefore, a tendency for the materials to become plastic. The absence of elasticity in these materials also contributes to their failure. Most metals or conducting alloys in granular form would oxidize under like conditions while such metal grains as are not fusible or oxidizable have such a low specific resistance as to make their use impracticable. Moreover, the cost of grains of this latter character would be prohibitive. I have found that the element silicon in the more or less finely divided granular or flake form may have its resistance greatly varied by a variation in pressure. This material is not open to any of the objections above noted as inherent in the materials heretofore used. It is not fusible or oxidizable except at extremely high temperatures. It is also elastic so that it will recover its original form when relieved of pressure and presents a relatively high resistance to crushing thereby permitting the application of considerable pressure. In addition to these advantages the high specific resistance of the element and the fact that it has a positive temperature coefficient when heated to any point below the melting point of silver, which enables it to maintain its resistance fairly well when heated, renders it very desirable as a resistance medium.

In carrying out my invention, therefore, I provide circuit controlling means comprising a mass of silicon in the flake or granular form, in combination with means whereby the mass is compressed so as to decrease its resistance. I also provide means whereby when the resistance of the material is reduced to a predetermined amount by the application of pressure the material is automatically cut out of circuit.

For purposes of illustration, I have shown my invention in connection with a number of different devices but it should be understood that I do not limit my invention in its application to any of the forms shown or described nor do I limit it to the particular material described, since other materials which have the properties which I have enumerated namely, that of being inoxidizable and infusible in addition to having a high specific resistance and a positive temperature coefficient at ordinary temperatures, may be used if such be found.

My invention further consists in the arrangement and combination of elements hereinafter set forth and particularly pointed out in the claims annexed to and forming a part of this application.

In the drawings, Figure 1 is a sectional view of a device embodying my invention, showing the circuit connections; Fig. 2 shows substantially the same arrangement adapted to be operated by centrifugal force; Fig. 3 shows a diagrammatic view of such an

arrangement connected to a three coil winding; Fig. 4 shows a modification thereof; and Figs. 5, 6, 7 and 8 show further modifications of the application of my invention.

In the drawings (Fig. 1) 1 represents a granular mass of uncombined silicon inclosed in a receptacle 2 provided with a lining 2′ of some insulating material, such as mica. The size of the granules may be varied according to the result desired. A plunger 3 is snugly fitted to reciprocate within the receptacle and adapted to bear upon the top of the silicon. A column of silicon is thus formed which may be of any length depending upon the resistance required. The plunger 3 is moved by means of a screw 4 having a ball and socket connection with the plunger, and provided with a hand wheel 5. The screw is threaded into the cover 6 which is secured to but insulated from the casing 7. The receptacle 2 is arranged to reciprocate within the casing 7 the movement being caused by the screw 4. A spring 8 is interposed between the bottom of the casing 7 and the receptacle 2 so as to yieldingly hold them apart, the screw forcing them together against the tension of the spring. The operation of this form of my invention is as follows: With the parts in the position shown in Fig. 1, current will pass from main 9 to conductor 10 and cover 6, screw 4, plunger 3 through the silicon resistance to the base of the receptacle 2, thence to casing 7, terminal 11, conductor 12, and armature A back to main 13. This being the starting condition of the motor, the resistance in circuit is reduced by turning the hand wheel 5 so as to compress the silicon, the spring 8 being of such a strength that the receptacle 2 remains stationary. When, however, the resistance of the silicon is sufficiently reduced, the spring 8 is compressed and the receptacle 2 moves until it makes contact with the stud 14, which closes a shunt circuit around the silicon. The current then passes through the conductor 15 from the cover 6 to the casing 7 instead of passing through the silicon. Upon reversing the movement of the screw 5 the opposite action takes place and the resistance is restored to the circuit.

In Fig. 2 I have shown substantially the same arrangement with the exception that the plunger is operated by centrifugal force. The casings 16 are arranged around the shaft 16′ of the motor and the plungers 17 are made of considerable weight and yieldingly held by means of springs 17′ so as to slightly compress the silicon granules. Circuit connections are made through the silicon mass to the circuits of the rotor 18 of an induction motor of any suitable winding which is put on closed circuit through this resistance.

Fig. 3 shows a diagram of the circuit arrangement of my device for a three coil winding which winding is short-circuited from plunger 19 to contact 20 through a silicon resistance.

Fig. 4 shows the circuit arrangement with my device applied to a modified form of winding, it being understood that the winding may be greatly modified as to the number of circuits and polar relations without departing from the spirit of my invention.

In Fig. 5 I have shown an arrangement involving the construction shown in Fig. 2 in connection with the short-circuiting device of Fig. 1. The operation of this form of my invention will be readily understood from the foregoing without further description. When the silicon 21 is compressed a predetermined amount by centrifugal action of the plunger 22, spring 23 is compressed closing the circuit through the contact 24 and stud 25, thereby short-circuiting the silicon resistance. Instead of the means above described for applying force to the plunger to compress the silicon it may be communicated from other parts of the apparatus.

In Fig. 6 I have shown a weight 26 pivoted at 27 which transmits its centrifugal force as it revolves to plunger 28. When the silicon reaches the desired degree of compression the weight closes the shunt circuit around the silicon through contacts 29 and 30. The tension of the spring 31 may be adjusted by means of a screw 31′ to cause the resistance to allow such current to pass as is desired. This adjustment may also be accomplished by varying the length and section of the silicon granules and their degree of fineness.

Fig. 7 shows substantially the same arrangements as Fig. 6 but applied to a pulley of an electric motor. The weight 32 in this case operates to compress the silicon and the pulley is counter-weighted at 33.

Fig. 8 shows a still further modification of my device. In this case a dash-pot 34 is used to check the application of the compressing force which is applied through a weight 35 mounted upon a lever 36 pivoted at 37. The lever is connected to the rod 38 of the piston 39 by means of a link 40. Plunger 41 mounted upon the lever 36 is arranged as above described to compress the silicon 42. When the lever 36 is raised carrying with it the weight 35, the piston 39 which has a downwardly opening valve 43 is freely elevated relieving the tension of the spring 44 and diminishing the pressure on the silicon 42. Upon the release of the lever it gradually descends, being opposed by the piston of the dash-pot and gradually compresses the spring 44 until the silicon is short-circuited by the contacting of the casing 45 with the stud 46. This device is very similar to that shown in Fig. 1 and is designed as an alternative arrangement for said device.

Many further modifications of my invention will suggest themselves to those skilled in the art, for it should be understood that I

have shown the various constructions above described for the purpose of illustrating a few of the possible applications of my invention. The material silicon which I use is the only one at present known to me which is sufficiently cheap and has the desired properties, but I do not wish to limit myself to this particular material as others may be produced which will partake sufficiently of the nature of this material as to fall within the scope of my invention as set forth in the claims.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. A circuit controlling device comprising a silicon resistance, and means for varying the compression thereof.

2. A circuit controlling device comprising a mass of granular silicon, and means for varying the pressure therein.

3. A circuit controlling device comprising a silicon resistance, means for compressing the same, and means for short-circuiting said resistance after a predetermined pressure is attained.

4. A circuit controlling device comprising a granular silicon resistance, a container for holding said material in place under pressure, and means for varying said pressure.

5. A circuit controlling device comprising an elastic granular resistance material, a container for holding said material in place under pressure, means for varying said pressure, and means for automatically short-circuiting the said material when the resistance thereof is reduced a predetermined amount.

6. A circuit controlling device comprising a granular resistance material, a yielding container therefor, means for compressing said material, and means for short-circuiting the same by the movement of said container when the resistance is reduced a predetermined amount.

7. A circuit controlling device comprising a non-oxidizable, elastic, granular resistance material, a movable container therefor, means for compressing said material, and means for short-circuiting the same by the movement of said container when the pressure reaches a predetermined amount.

8. A circuit controlling device comprising a silicon resistance, a movable container therefor, means for compressing said silicon, and means for short-circuiting the same by the movement of said container when the resistance is reduced a predetermined amount because of said pressure.

In witness whereof, I have hereunto set my hand this twenty-fifth day of September, 1905.

ELIHU THOMSON.

Witnesses:
JOHN A. MCMANUS, JR.,
HENRY O. WESTENDARP.