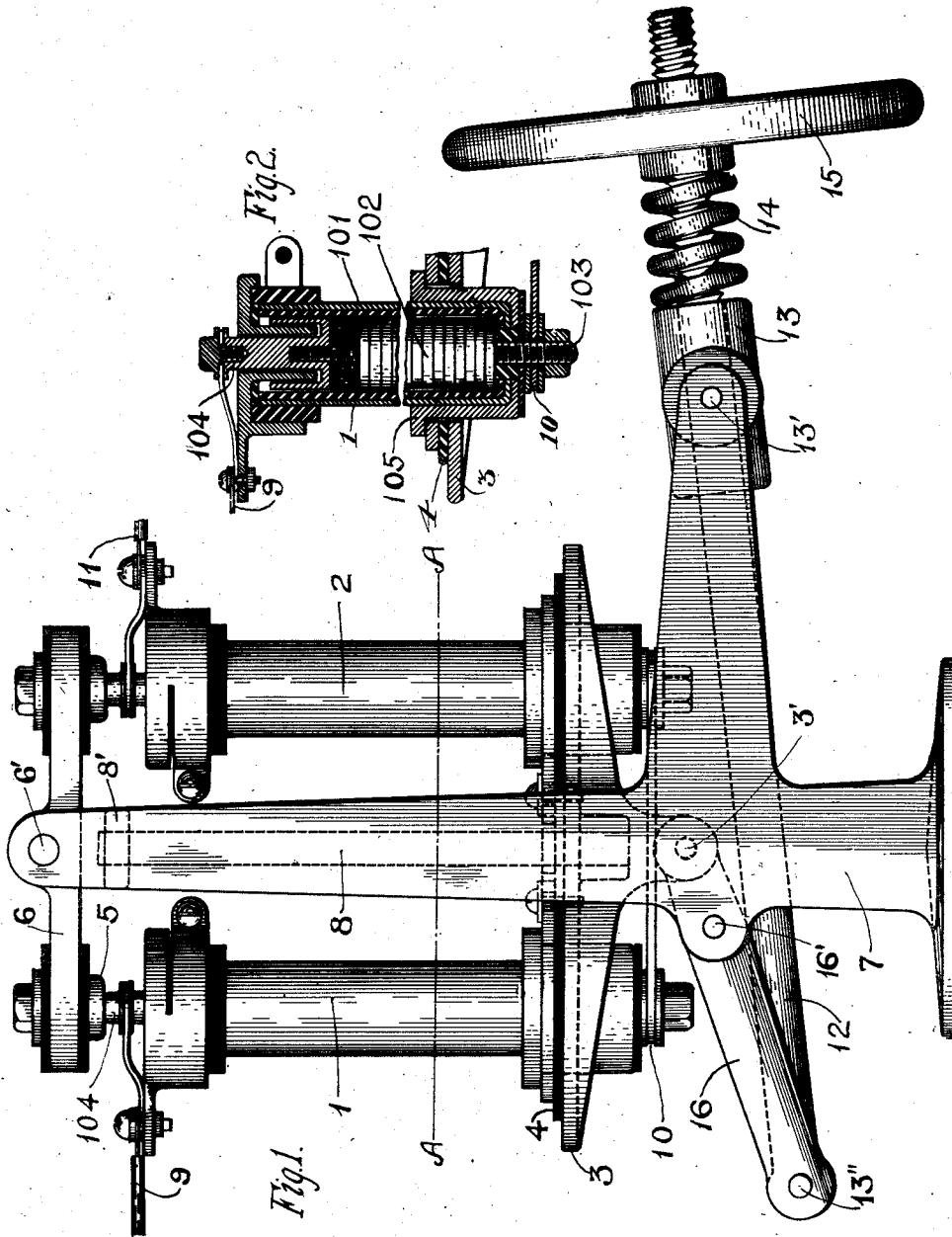


L. BRADLEY.
CURRENT CONTROLLER.
APPLICATION FILED FEB. 8, 1909.

1,043,565.

Patented Nov. 5, 1912.

2 SHEETS—SHEET 1.



Witnesses:

David S. Kulfish.
Wm. Berghahn.

Inventor
Lynde Bradley

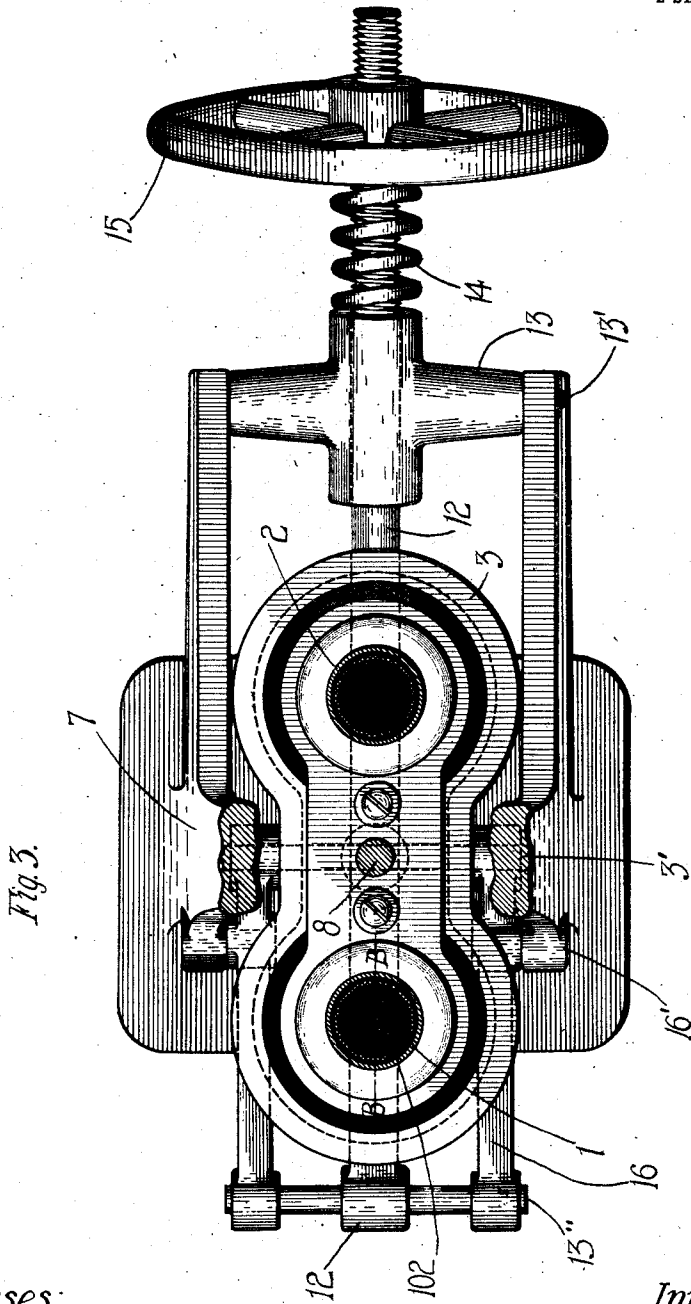
By *M. M. Miller*
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UNITED STATES PATENT OFFICE.

LYNDE BRADLEY, OF MUSKEGON, MICHIGAN, ASSIGNOR TO ALLEN-BRADLEY COMPANY, A CORPORATION OF WISCONSIN.

CURRENT-CONTROLLER.

1,043,565.

Specification of Letters Patent.

Patented Nov. 5, 1912.

Application filed February 8, 1909. Serial No. 476,644.

To all whom it may concern:

Be it known that I, LYNDE BRADLEY, a citizen of the United States of America, and a resident of Muskegon, county of Muskegon, and State of Michigan, have invented a new and useful Improvement in Current-Controllers, of which the following is a specification.

My invention pertains to controllers for electrical currents, and has as its object the provision of mechanical devices for maintaining a uniform current through a compressible variable resistor and at the same time rendering the entire current controlling device adjustable with reference to the extent of its control upon the current flowing through it.

I provide a resistor whose resistance is variable by pressure, and mount the resistor in an apparatus adapted to subject it to an arbitrarily adjustable pressure. The pressure-applying apparatus in my invention is so constructed that an expansion of the resistor will not be accompanied by an increased pressure, as would result upon a tendency to expand when the resistor is confined between fixed abutments. On the contrary, I provide pressure-applying means of such nature that an expansion of the resistor results in a diminution of pressure upon it.

In resistors of the nature of carbon, having the characteristic of presenting a decreasing resistance when subjected to an increasing temperature, and having at the same time contact surfaces in the electric circuit subject to compression and manifesting a decreasing resistance when subjected to an increasing pressure, the substance also expanding in volume when subjected to an increasing temperature, it will be seen that any preliminary setting of resistance or current value in the resistor would be subject to change by reason of the current subsequently flowing through the resistor because (a) the heat resulting from current flowing through the resistor will reduce the resistance thereof, permitting more current to flow, and (b) the expansion of the resistor due to the heating will increase the pressure upon the resistor either by an effort to expand between fixed abutments or by stretching to greater tension or by placing under greater compression any spring restraining the abutments.

In the current controller of my invention, I provide means for subjecting a compressible carbon resistor to a pressure variable automatically in such a manner as to compensate to a large degree for the electrical differences caused by temperature variations of the resistor. The means which I provide is capable of such design and adjustment as to provide an automatic compensation for the heat coefficient of the resistance of the carbon by opposing against that variable a counter variation in contact resistance. Resultant upon the heat, a change in contact pressure is obtained, which change in contact pressure varies the manifestation of contact resistance in the resistor. By proper design and adjustment, the variation in contact resistance resultant upon a change in temperature may be made to balance approximately the variation in conductivity of the carbon resultant upon the change in temperature, whereby the manifestation of resistance as measured only from terminal to terminal of the current controller will remain substantially unchanged.

By proper design and adjustment of the current controller of my invention, it is possible to approximate a constant current through the device within limiting ranges of voltage variation, the resistance of the internal circuit of the device increasing automatically to compensate for the variation in voltage, and to provide an approximately constant current flow.

In the drawings I show a specific device embodying the principles of my invention, Figure 1 being an elevation; Fig. 2 a section through a compressible resistor element on the line B—B of Fig. 3; and Fig. 3 being a sectional view on the line A—A of Fig. 1.

In Fig. 1, the elements 1 and 2 are integral compressible resistors, suspended in and insulated from the frame-work and compression devices of the supporting mechanism. A section through the resistor 1 is shown in Fig. 2. Within an insulation-lined tube 101 is a column of disks 102, which preferably manifest the characteristics of a low internal resistance and a high contact resistance, such, for instance, as the disks described in my pending application No. 467,352, filed December 14, 1908. The entire compressible resistor 1 may be of the type disclosed in that patent application, or may be of any other type of compressible resistor suitable

or desired. The lower end of the column of resistance disks has the fixed terminal 103, and the upper end has the movable terminal 104, the column of disks being compressible by pressure applied to the top of the terminal 104 and to the lower portion of the tube. The lower portion of the tube is held in a cup or socket 105, which is flanged and rests upon carriage 3, an additional insulation being provided at 4. At the upper end the floating terminal 104 rests in a cavity of the insulated abutment 5, mounted in the rocking equalizer bar 6, which is mounted pivotally at the top of the rigid frame 7. The face of the part 5 may be plane, the tubes 1 and 2 retaining a vertical position by virtue of the diameter of the supporting flanges, and any side strain upon the floating terminal 104 thus may be reduced or eliminated. The carriage 3 is movable vertically, being guided by the central rod 8 which is rigid in the plate 3 and slides in a guide 8' attached to the frame 7. When the carriage 3 is forced upward to compress the resistors by pressing them against the abutments 5, the pressure upon the two resistors will be equalized by the rocking of the bar 6 upon its pivot at 6'.

The circuit of the device enters through conductor 9, passing thence to terminal 104 down through resistor 1, through conducting link 10 and up through resistor 2, making exit through conductor 11. Pressure is placed upon the resistors by the following mechanism: Rod 12 passes loosely through bushing 13 and spiral compression spring 14 to hand wheel 15 threaded upon rod 12. Bushing 13 is pivotally sustained in frame 7 at 13'. Rod 12 is pivotally connected at 13'' to toggle arms 16. Toggle arms 16 are pivotally sustained in frame 7 at 16' and are pivotally connected at 3' to carriage 3. Hand wheel 15 compresses spring 14 and transmits the pressure of that spring to rod 12, which in turn tends to rotate toggle arms 16 upon pivot 16' and thus tends to press carriage 3 upward.

It will be seen that the upward pressure on the carriage 3, due to the spring 14, is dependent not only on the strength of said spring, as influenced by the degree of its compression by the hand wheel, but also upon the angular relation between the various members through which the pressure of the spring is transmitted to the carriage. An inspection of the mechanism will show that as the angle between the center lines of members 12 and 16 approaches zero, the force exerted by the spring to move the carriage upward will approach zero, and conversely as this angle increases to 90 degrees as a maximum, the force of the spring will exert an increasing upward pressure on the carriage 3. It is also obvious that the amount of pressure which the spring is

capable of transmitting to the carriage 3 depends on the ratio of the lever arms of the lever 16, and also upon the angular relation between the lever 16 and the axis of the rod 8 which guides the movement of the carriage.

A linear expansion of the disks of the resistors 1 and 2 will tend to impart a downward movement to the carriage 3, which will reduce the angle between the rod 8 and the lever 16, and the angle between the members 12 and 16, thus decreasing the mechanical advantage at which the spring 14 is working; but simultaneously with the reduction of the angle between the members 12 and 16, the tension of spring 14 is increased. Therefore, by the proper proportioning of the parts the pressure subjected by the carriage 3 upon the resistors may be made to remain constant or to decrease when the carriage is moved downward. Assuming now that the parts are so proportioned as to produce a decrease of pressure upon the resistors when the carriage is moved downward and that current flows in a circuit, including conductors 9-11 and the current controller of my invention, the first manifestation is the production of heat, which simultaneously reduces the internal resistance and expands the volume of the disks of the resistors. By the expansion of the resistors the carriage 3 is pressed downward, resulting in a net decrease of pressure by the carriage 3 upon the resistors, and this decrease of pressure increases the contact resistance of the disks of the resistors 1 and 2, thus, by an increase in contact resistance, compensating for the thermal decrease in internal resistance.

If a constant resistance device is desired, the proportion of parts may be such as to make the compensation exactly equal to the thermal change, thus maintaining the initial resistance for all current values within a predetermined range. If it is desired to maintain a constant current for all impressed potentials within a predetermined range, the design of parts and dimensions may be such as to over-compensate for the thermal change, so that an initial increase of current, due to an increased potential, will be over-compensated by an increase of contact resistance giving a resultant resistance approximately proportional to the increase in impressed potential, so that the resultant current will be reduced to approximate very nearly the initial or predetermined current for which the specific controller is designed and adjusted.

I am aware that many resistance elements other than carbon manifest the characteristics hereinbefore described of the resistor element 102, and that many modifications of the pressure device here shown may be made.

It is obvious that while I have shown two

resistor elements, one, or more than two may be used.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. In an electric current controller the combination of a resistance medium and means adapted to subject said medium to pressure and to automatically diminish the pressure on said medium as its dimension increases.

2. In an electric current controller the combination of a resistance medium and means adapted to subject said medium to pressure and to automatically increase the pressure on said medium as its dimension diminishes.

3. In an electric current controller, the combination of a compressible resistor whose resistance diminishes with an increase of pressure and with an increase of heat, of means diminishing the pressure on said resistor in response to the expansion received from an increase of heat.

4. In an electric current controller, the combination of a compressible resistor whose resistance diminishes with an increase of pressure and with an increase of heat, and one of whose dimensions increases with an increase of heat, of means diminishing the pressure in response to an increase of that dimension, said diminution of pressure in response to an increase of heat of the resistor acting to increase the resistance of the resistor to compensate for the diminution in resistance due to the heat.

5. In an electric current controller, a compressible resistor and pressure-varying means compensating for changes in temperature in said resistor.

6. In an electric current controller, a resistor whose resistance is variable by pressure; means for applying a variable pressure to said resistor, and further means controlled by the dimension of the resistor to vary the applied pressure consequent upon a variation in dimension of the resistor.

7. In an electrical current controller, the combination of a resistance medium and a mechanical means for automatically maintaining the resistance of said medium constant.

8. In an electric current controller, the combination of a compressible resistor medium and abutments therefor adapted to hold said resistor medium under pressure, one of said abutments being movable, a lever engaging said movable abutment, a rod engaging the end of said lever, a spring tending to move said lever through said rod, said rod passing near the fulcrum of said lever.

9. In an electric current controller, a compressible resistor and abutments therefor adapted to compress said resistor with a

variable pressure, one of said abutments being movable, a lever engaging said movable abutment, a rod engaging the end of said lever, a spring tending to move said lever through said rod, said rod passing near the fulcrum of said lever, said variable pressure being dependent in value upon the position of said lever on its fulcrum, said position being dependent upon the dimension of the resistor, whereby a change in dimension of the resistor will change the value of the pressure placed upon it by the spring acting through said rod and said lever.

10. In an electric current controller, the combination of a resistance medium, a lever acting to compress said medium, a rod engaging the end of said lever, and a spring tending to move said lever through said rod; said spring acting upon said lever in a line forming a large chord of the constructive circle of the point of attachment of the said spring around the fulcrum of the said lever, whereby a change in dimension of the said resistance medium by varying the position of the said lever will vary the distance from the fulcrum of the line of direction of force of said spring, and thereby will vary the resultant pressure upon the resistor.

11. In an electric current controller, a pair of compressible resistors; a movable abutment for one end of said resistors; a pressure-equalizing abutment for the remaining end of said resistors; and means for applying to the movable abutment a pressure varying with the position of the abutment.

12. In an electric current controller, a pair of compressible resistors; a movable abutment for one end of said resistors; a pressure-equalizing abutment for the remaining end of said resistors; a lever adapted to move said movable abutment to compress said resistors; and a spring acting through said lever to effect such compression, the effective pressure of the spring upon the resistors being due to the position of the lever and the position of the lever being in turn due to the position of the abutment.

13. In an electric current controller, a pair of compressible resistors; a movable abutment for one end of said resistors; a pressure-equalizing abutment for the remaining end of said resistors; and means for applying to the resistors, through the movable abutment, a pressure which decreases as the dimension of the resistors along the line of compression increases.

14. In an electric current controller, a compressible resistor; a movable abutment therefor; a lever tending to compress said resistor through said abutment and extending at an oblique angle to the line of compression; a spring acting upon said lever in a direction forming an oblique angle with said lever and extending from said lever through a fixed point, whereby its angle

with said lever is varied as said lever turns upon its fulcrum.

15. In an electric current controller, a compressible resistor; a movable abutment therefor; a lever tending to compress said resistor through said abutment and extending at an angle to the line of compression; a spring acting upon said lever in a direction forming an oblique angle with said lever and extending from said lever through a fixed point, whereby its angle with said lever is varied as said lever turns upon its fulcrum.

16. In an electric current controller, a compressible resistor whose dimension in-

creases with heat, and whose resistance varies with pressure and with heat; a lever operating to compress said resistor; and a spring acting upon said lever with an effective force variable by a change in dimension of the resistor.

Signed by me at Muskegon, county of Muskegon and State of Michigan, in the presence of two witnesses.

LYNDE BRADLEY.

Witnesses:

JOSIE VANDERWERP,
OSCAR E. WAER.