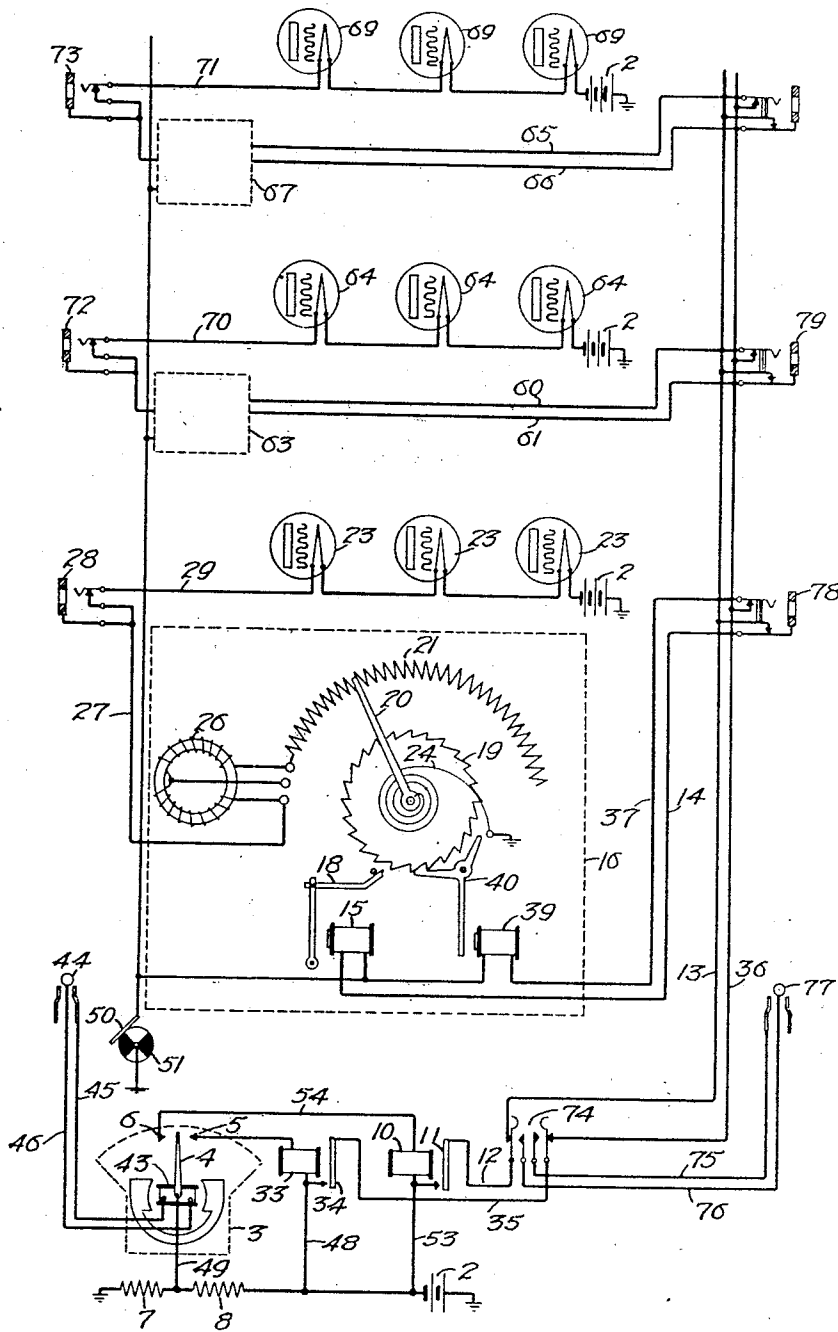


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R. D. CONWAY.
ELECTRIC REGULATOR.
FILED DEC. 9, 1919.



Inventor:
Roy D. Conway
by W. E. Beatty. Att'y

UNITED STATES PATENT OFFICE.

ROY D. CONWAY, OF CHATHAM, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ELECTRIC REGULATOR.

Application filed December 9, 1919. Serial No. 343,559.

To all whom it may concern:

Be it known that I, ROY D. CONWAY, a citizen of the United States, residing at Chatham, in the county of Morris, State of New Jersey, have invented certain new and useful Improvements in Electric Regulators, of which the following is a full, clear, concise, and exact description.

This invention relates to arrangements for regulating an electrical characteristic of a circuit, such as the intensity of current flowing therethrough. One of the objects of the invention is to provide a method and means for insuring a constant flow of current over a circuit. Another object consists in providing means for automatically increasing the resistance in a circuit whenever the current flow therethrough has a tendency to increase and also means for automatically reducing the resistance in said circuit as the current flow tends to decrease. Other objects of this invention will appear in the detailed description to be given later.

It has often been found desirable to associate with a work circuit including translating devices such, for example, as a circuit including the filaments of vacuum tube repeaters, an arrangement for regulating the current flow therethrough. This is because the voltage of the source which supplies the electric current for the circuit may have a tendency to vary beyond the limits within which satisfactory operation of the apparatus will result. As it has been found that a vacuum tube repeater will give better service if the current flow in its filament heating circuit remains constant, the regulating apparatus comprising this invention has been provided.

The preferred form of this invention comprises a voltmeter relay sensitive to slight variations in voltage, the winding of which is connected to the source which supplies current for the work circuit. An increase in the voltage of this source will cause a circuit to be closed over the needle and one of the contacts of the voltmeter, thereby operating resistance-varying mechanism to add a certain amount of resistance to the work circuit, and to the circuit including the winding of the voltmeter. The resistance varying mechanism will con-

tinue to operate and will add further resistance to the circuit including the voltmeter winding and the work circuit until the increase in current flow has been counterbalanced and the voltmeter needle returns to neutral position. If the current flow from the source decreases, a circuit is closed over the needle and another contact in the voltmeter which serves to operate the resistance-varying mechanism to reduce the resistance in the voltmeter circuit and the work circuit in proportion to the decrease in voltage.

In the preferred form this resistance varying mechanism comprises a two-way motion step-by-step switch under the control of the contacts of the voltmeter. This step-by-step switch serves to vary the amount of resistance in the work circuit and at the same time causes a proportional change in the resistance of the voltmeter circuit. In case there are a plurality of work circuits to be regulated this invention contemplates employing a step-by-step switch for each work circuit, all the switches normally being adapted to be placed under the control of but one voltmeter. The connections are such that the voltmeter may be made responsive to changes in only one of the work circuits to control a plurality of the work circuits. Connections are also provided for placing under the control of the voltmeter only one of the work circuits so that each circuit may be given its initial adjustment automatically without interfering with the adjustment of the other associated work circuits.

This invention will be better understood by reference to the following detailed description taken in connection with the accompanying drawing which represents the preferred form of the circuit arrangements of this invention.

Connected to a battery 2, is a voltmeter relay 3, which has a needle 4 located between two stationary contacts 5 and 6. Since these contacts are extremely delicate and easily burnt out, needle 4 is connected to an intermediate point of a circuit containing the high resistances 7 and 8 and source of voltage 2, so that only a fraction of the total potential of battery 2 may be applied

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to the voltmeter needle in the case where the total potential of battery 2 would be injurious to the contacts if applied directly. Under the control of voltmeter needle 4 and contact 6 is a relay 10, which, in turn, through its movable contact 11, conductors 12, 13 and 14 control the magnet 15 of the two-way motion switch 16. Magnet 15 serves to operate the stepping pawl 18 to step around the ratchet wheel 19, thereby serving to rotate contact arm 20 in a counter-clockwise direction over the resistance 21. Variable resistance 21 is included in a circuit with cathodes 23 of a plurality of vacuum tube repeaters by the following path: from ground, coiled spring 24 of rotary switch 16, contact arm 20, resistance 21, retard coil 26, conductor 27, jack 28, conductor 29, cathodes 23 to battery and ground. The operation of the stepping pawl 18 by magnet 15 therefore serves to decrease the amount of resistance in the heating circuit for cathodes 23.

Under the control of voltmeter needle 4 and contact 5, is a relay 33 which, through its movable contact 34, conductors 35, 36 and 37 controls the operation of magnet 39 of rotary switch 16. Magnet 39 serves to operate the escapement pawl 40 to allow the spring member 24 to turn contact arm 20 in a clockwise direction thereby increasing the amount of resistance 21 which is included in the heating circuit for cathodes 23.

The winding 43, of voltmeter 3 is adapted to be connected in series with resistance 21 and cathodes 23 by the insertion of a plug 44 in jack 28. With such an insertion the connection is as follows: from ground, contact arm 20, resistance 21, conductors 27 and 45, voltmeter winding 43, conductors 46 and 29, cathodes 23 to battery and ground.

The operation of the circuit arrangement may now be explained as follows. Assuming that plug 44 is in jack 28, voltmeter 3 is responsive to current flowing in circuit containing cathodes 23. As long as the current in this heating circuit is equal to the desired constant value for the heating current, voltmeter needle 4 remains in neutral position. As soon, however, as the value of the heating current has changed due, for example, to a change in the voltage of source 2, voltmeter needle 4 will be deflected either to the right or to the left so as to control rotary switch 16 to vary the effective value of resistance 21 until the heating current has been changed back to its original value. Thus, if the voltage of source 2 were to increase, due to the charging of the battery, for example, voltmeter needle 4 would be deflected to the right. Relay 33 would then be energized due to the closing of the following circuit: from ground, battery 2, conductor 48, winding of relay 33, contacts 5, needle 4, conductor 49 to ground. The closing of this circuit will en-

ergize relay 33 thereby causing its movable contact 34 to be pulled up to close the following circuit: from ground, battery 2, conductor 48, movable contact 34, conductors 35, 36 and 37, winding of magnet 39, contact 50 of motor driven interrupter 51 to ground. After this circuit has been closed and the motor driven interrupter 51 has moved to a position giving contact 50 a conductive connection to ground, magnet 39 will be operated to release the escapement pawl 40 to cause contact arm 20 to move clockwise so as to increase the amount of resistance in the heating circuit. If the increase in the effective value of resistance 21, due to a single release of escapement pawl 40 is sufficient to counter-balance the increase in current in the heating circuit, due to change in voltage of battery 2, voltmeter needle 4 will return to neutral position thereby deenergizing relay 33. The deenergization of relay 33 will, by a path previously traced, remove battery from magnet 39 before interrupter 51 has rotated a sufficient distance to ground again contact 50. In order that this may be accomplished the period of rotation of interrupter 51 should be so timed that needle 4 and relay 33 will have had time to operate before the second conductive connection to ground occurs for contact 50. In general, it may be said that the circuit arrangement will operate satisfactorily if interrupter 51 serves to make and break the circuit from 4 to 16 times per second.

If, however, the increase in resistance 21 is not sufficient to counter-balance the increase in voltage of source 2, voltmeter needle 4 will remain deflected to the right, thereby keeping energized relay 33 and maintaining the battery connection for magnet 39. As soon as interrupter 51 has rotated to give contact 50 a second ground connection, magnet 39 will be operated and escapement pawl 40 will be released to allow a second shift in a clockwise direction of contact arm 20. If the amount of resistance added by the second shift of contact arm 20 is sufficient to restore the heating current to its original desired value, voltmeter needle 4 will return to neutral position, thereby deenergizing relay 33 and removing battery from magnet 39 before sufficient time has elapsed for interrupter 51 to give a third grounded connection for contact 50. If the amount of resistance added by the second shift is not sufficient to restore the original value of the current, voltmeter needle 4 will remain deflected to the right thereby keeping energized relay 33 and maintaining the battery connection for magnet 39. It follows, therefore, that magnet 39 will continue to increase the amount of resistance in the voltmeter circuit and work circuit until the original value of the heating current has been regained.

If now, we assume that the current in the

heating circuit for cathodes 23 should decrease, below the desired constant value, needle 4 of the voltmeter will be deflected to the left and relay 10 will be energized due to the closing of the following circuit: From ground, battery 2, conductor 53, winding of relay 10, conductor 54, contact 6, needle 4, conductor 49 to ground. The energization of relay 10 will pull up its movable contact 11 and close the following circuit. From ground, battery 2, conductor 53, movable contact 11, conductors 12, 13 and 14, winding of magnet 15, contact 50 through interrupter 51 to ground. As soon as interrupter 51 has given contact 50 a connection to ground, magnet 15 will operate to cause stepping pawl 18 to shift contact arm 20 a certain distance in a counter-clockwise direction, thereby decreasing the amount of resistance in the circuit with the voltmeter winding 43 and cathodes 23. If this decrease in resistance is sufficient to counter-balance the decrease in voltage of battery 2, and is sufficient to restore the original value of the filament heating current, voltmeter needle 4 will return to neutral position, thereby deenergizing relay 10 before sufficient time has elapsed for magnet 15 to be operated a second time. However, if the decrease in resistance is not sufficient to counter-balance the decrease in current, voltmeter needle 4 will remain deflected to the left, thereby keeping relay 10 energized. In this condition, magnet 15 will be operated a second time as soon as contact 50 has been given a conductive connection to ground through interrupter 51, thereby operating stepping pawl 18 to cause a second decrease in the amount of resistance 21 included in the voltmeter circuit and in the work circuit. If this second decrease is sufficient to counter-balance the decrease in current, needle 4 will return to neutral position, thereby deenergizing relay 10 and preventing the third operation of magnet 15. However, if the second decrease in resistance is not sufficient, it follows that voltmeter needle 4 will remain deflected to the left until magnet 15 has operated a sufficient number of times to secure the proper decrease in the amount of resistance 21.

It therefore follows that voltmeter 3, through the intermediary of relays 10 and 33 serves to control rotary switch 16 so as to maintain substantially constant the current flow in work circuit 29. By connections similar to those already described the voltmeter 3 may be made to control a plurality of rotary switches 16 each of which in turn controls the amount of resistance in an individual work circuit. As shown in drawing, conductors 13 and 36 leading from the relays 10 and 33 are also connected to conductors 60 and 61 which lead to a ro-

tary switch 63. This rotary switch 63 may control in turn the amount of resistance in the circuit containing the filaments of vacuum tube repeaters 64. Conductors 65 and 66 are also electrically connected to the main conductors 13 and 36 so that the rotary switch 67 in response to voltmeter 3 may control the amount of resistance in the work circuit containing the filaments of vacuum tube repeaters 69. In a similar manner there may be connected to the main line conductors 13 and 36, any desired number of leads to other rotary switches which may be employed to vary the amount of resistance in work circuits in response to the energization of relays 10 and 33. With plug 44 in jack 28 it therefore follows that the amount of resistance in work circuits 29, 70 and 71 will be varied in response to changes in the current flowing in work circuit 29. This arrangement of having the characteristic of a plurality of work circuits change in response to a condition in one of the work circuits will work most satisfactorily when the work circuits are similar so that a change in the current of one will be accompanied by a corresponding change in each of the others. If desired, plug 44 may be inserted in either jack 72 or jack 73 so as to make voltmeter 3 responsive to the current in either work circuit 70 or 71.

It may frequently be found desirable to cause voltmeter 3 to adjust the resistance in only one of the work circuits at one time. Thus if, for example, one or more new vacuum tubes have been placed in the work circuit 29, it will generally be necessary to readjust the amount of resistance originally included in the circuit to give the desired value of heating current for the filaments. In accordance with this invention this individual readjustment of the amount of resistance in any one of the work circuits may be accomplished by moving switch 74 to its second position so as to connect conductors 12 and 35 with conductors 75 and 76. If now the plug 77 is inserted in jack 78, relays 10 and 33 will be connected through conductors 75, 76 and 37 and 14 to the controlling magnets of rotary switch 16, but the conductors for rotary switches 63 and 67 will be removed from the control of relays 10 and 33 so that these two relays will actuate only rotary switch 16. If now plug 44 is inserted in jack 28, voltmeter 3 will be responsive to the current in work circuit 29 and will, through plug 77 and jack 78, cause rotary switch 16 to make any necessary change in the value of the resistance included in the work circuit in order to secure the desired value of the heating current for the cathodes of the vacuum tube repeaters. Similarly if it is desired to secure the individual adjustment of work

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circuit 70, plug 44 should be inserted in connections whereby said solenoid controls jack 72, and plug 77 should be inserted in said resistances either collectively or individually at will. With such a connection only the rotary switch 63 will be controlled by voltage meter 3.

Some of the broader aspects of this invention are disclosed and claimed in my copending application Serial No. 313,033, filed July 24, 1919, on "electric regulators". It is to be understood that this invention is not limited to the particular form described above but it may be variously modified without departing in any wise from the spirit of this invention as defined in the appended claims.

What is claimed is:

1. In combination, a plurality of similar work circuits, a source of voltage for said work circuits, a variable resistance for each of said work circuits and a solenoid responsive to a condition of only one of said circuits for controlling the amount of said resistance in each of said work circuits.
2. In combination, a plurality of work circuits, a source of voltage for said work circuits, a variable resistance individual to each of said work circuits, a solenoid, and means for causing said solenoid to be responsive to a condition of any one of said circuits whereby said solenoid controls the amount of resistance in each of said work circuits.
3. In combination, a plurality of work circuits, a source of voltage for said work circuits, a variable resistance individual to said work circuits, a solenoid responsive to the condition of one of said circuits, and switching means and connections whereby said solenoid controls the amount of resistance in any one of a plurality of said circuits to the exclusion of others.
4. In combination, a plurality of work circuits, a source of voltage for said work circuits, a variable impedance for each of said work circuits, a solenoid, means for causing said solenoid to be responsive to a condition of any one of a plurality of said work circuits and switching means whereby said solenoid controls individually the impedance in each of said work circuits.
5. In combination, a plurality of work circuits, a source of voltage for said work circuits, a variable resistance for each of said work circuits, a solenoid, means for causing said solenoid to be responsive to a condition of any one of a plurality of said circuits to the exclusion of others and switching means whereby said solenoid controls collectively the resistances in each of said work circuits.
6. In combination, a plurality of work circuits, a source of voltage for said circuits, a variable resistance individual to said circuits, a solenoid, means for causing said solenoid to be responsive to the current in any one of a plurality of said circuits to the exclusion of others and switching means and
7. The method of regulating a plurality of work circuits wherein are employed a variable resistance individual to each of said work circuits, and a solenoid responsive to a condition of one of said work circuits, said method comprising controlling at times said resistances individually in response to the energization of said solenoid and at other times controlling said resistances collectively in response to the energization of said solenoid.
8. The method of regulating a plurality of work circuits wherein are employed a variable resistance individual to each of said work circuits, and a solenoid responsive to a condition of one of said work circuits, said method comprising controlling at times the energization of said solenoid successively in response to the current in each of a plurality of said work circuits and controlling said resistances successively in response to the energization of said solenoid and at other times controlling said solenoid in response to one of said work circuits and controlling said resistances collectively in response to the energization of said solenoid.
9. In combination, a plurality of work circuits, a source of voltage for said work circuits, a variable resistance for each of said work circuits, a solenoid adapted to be connected in series with any one of said resistances and said source of voltage, whereby said solenoid is made responsive to the current in the work circuit containing said last mentioned resistance, and switching means and connections whereby said solenoid controls the amount of resistance in any one of a plurality of said circuits.
10. In combination, a plurality of work circuits, a source of voltage for said work circuits, variable resistances individual to said circuits, a solenoid responsive to the current of one of said circuits, switching means and connections whereby said solenoid controls the amount of resistance in any one of a plurality of said circuits to the exclusion of another and means for continuously interrupting said connections.
11. In combination, a plurality of work circuits, a source of voltage for said circuits, variable resistances individual to said circuits, a solenoid responsive to the current of one of said circuits to the exclusion of another, switching means and connections whereby said solenoid controls collectively said resistances in each of said work circuits and means for continuously interrupting said connections.
12. In combination, a plurality of work circuits, a voltmeter relay, connections for placing said voltmeter under the control of any one of a plurality of said circuits, a

source of voltage for said circuits, variable resistances individual to said circuits, a solenoid responsive to said voltmeter for increasing the value of said resistances when the current in one of said work circuits tends to increase and a second solenoid responsive to said voltmeter for decreasing the value of said resistances when the current in one of said work circuits tends to decrease.

10 13. In combination, a plurality of work circuits, a source of voltage for said circuits, variable resistances individual to said circuits, a voltmeter, connections for placing said voltmeter in series with the resistance
15 and said source in any one of a plurality of said circuits, a solenoid responsive to said voltmeter for an increase in the current of one of said circuits, a solenoid responsive to said voltmeter for a decrease in the current in one of said circuits, circuit connections under the control of said first solenoid for increasing the value of said resistances, circuit connections under the control of said second solenoid for decreasing the value of
25 said resistances and means for continuously interrupting said connections.

14. In combination, a plurality of work circuits, a source of voltage for said work circuits, variable resistances individual to
30 said circuits, a voltmeter, connections for placing said voltmeter under the control of any one of a plurality of said work circuits to the exclusion of another, a solenoid responsive to said voltmeter for an increase in
35 the current of one of said circuits, a second solenoid responsive to said voltmeter for a decrease in current in one of said circuits, magnetic means for varying each of said resistances, energizing circuits for said magnetic means, switching means for placing
40 one of said energizing circuits under the control of said solenoids to the exclusion of another of said energizing circuits and

means for continuously interrupting said energizing circuits.

15. In combination, a plurality of similar work circuits, current supplying means therefor, a regulating element for each of said circuits, and a control element responsive to a condition of only one of said circuits for controlling the regulating elements.

16. In combination, a plurality of work circuits, current supplying means for said circuits, a regulating element for each of
55 said circuits, a control element responsive to the condition of one of said circuits, and switching means and connections whereby said control element controls the regulating element in any one of a plurality of said
60 circuits.

17. In combination, a plurality of work circuits, current supplying means therefor, a regulating element for each of said circuits, a control element, means for causing
65 said control element to be responsive to a condition of any one of a plurality of said circuits, and switching means whereby said control element controls individually the regulating element in each of said work circuits.

18. In combination, a plurality of work circuits, a source of voltage for said work circuits, a regulating element for each of
75 said work circuits, a control element, means for causing said control element to be responsive to a condition of any one of a plurality of said circuits to the exclusion of others, and switching means whereby said control element controls collectively the regulating
80 elements in said circuits.

In witness whereof, I hereunto subscribe my name this 5th day of December, A. D., 1919.

ROY D. CONWAY.