

June 17, 1941.

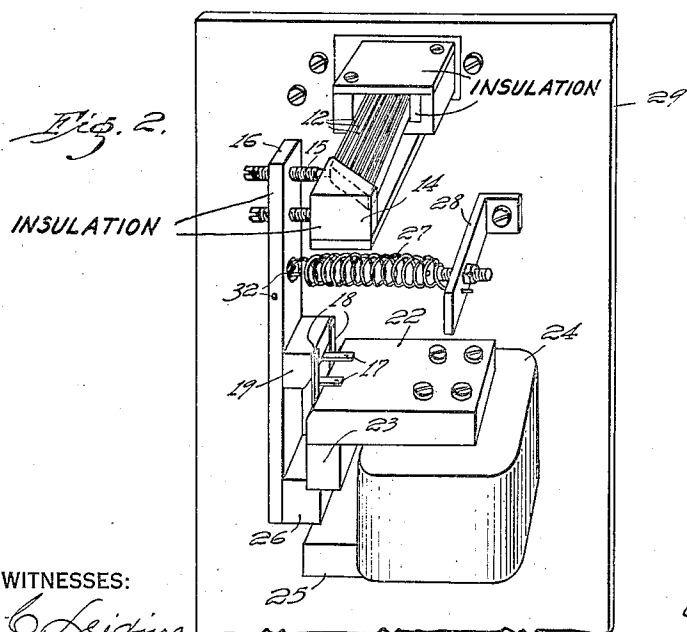
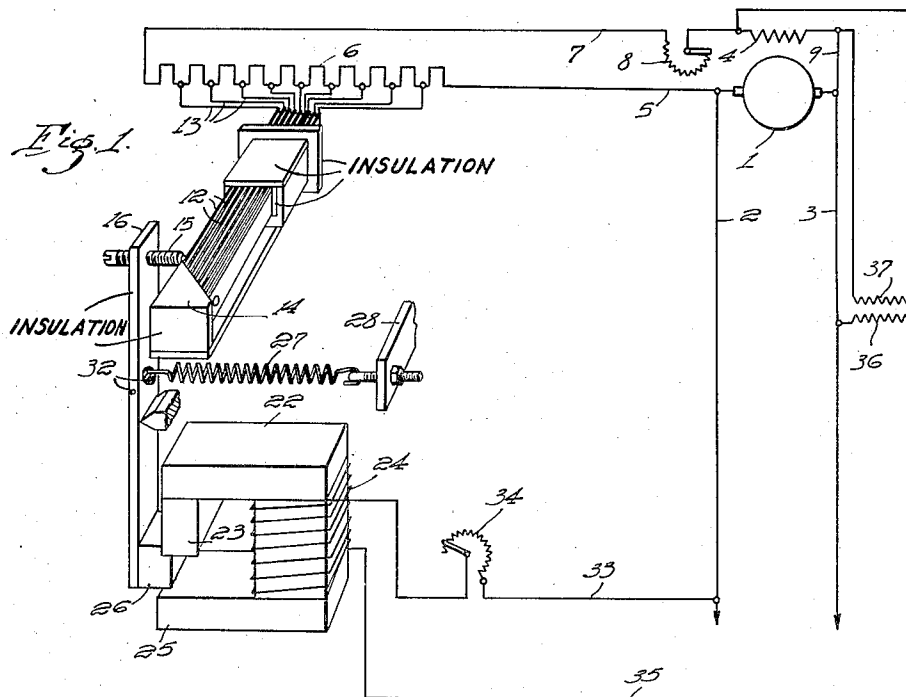
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2,246,301

REGULATOR

Filed April 23, 1938

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

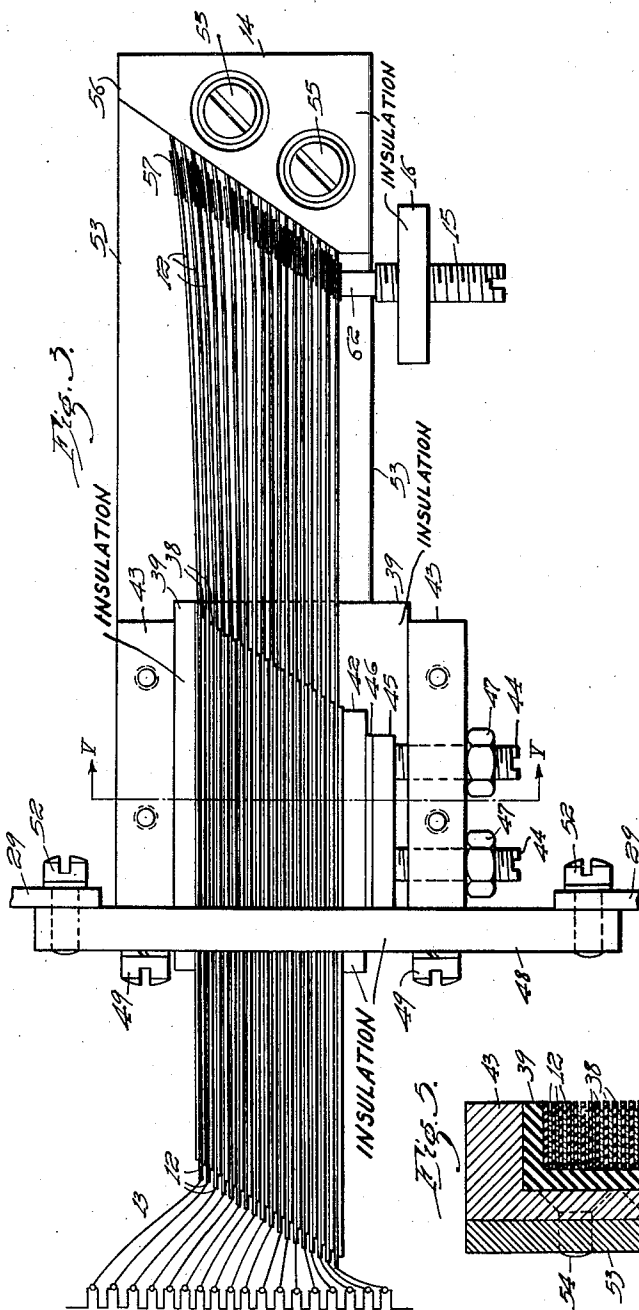


Fig. 3.

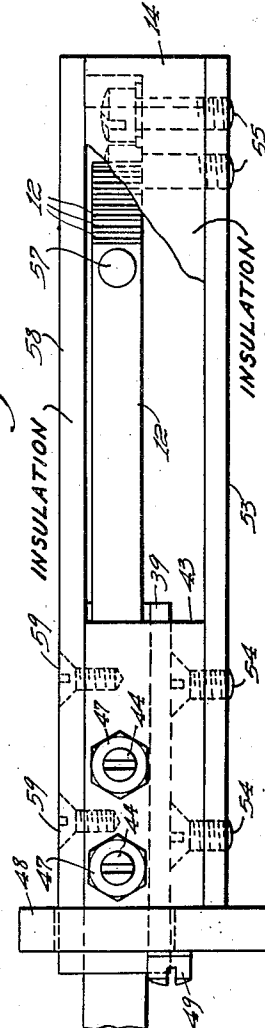


Fig. 4.

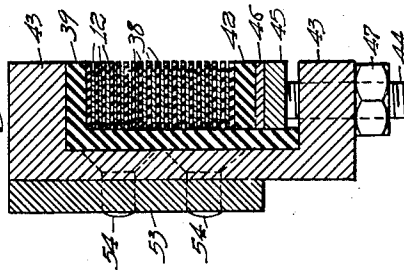


Fig. 5.

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3 Sheets-Sheet 3

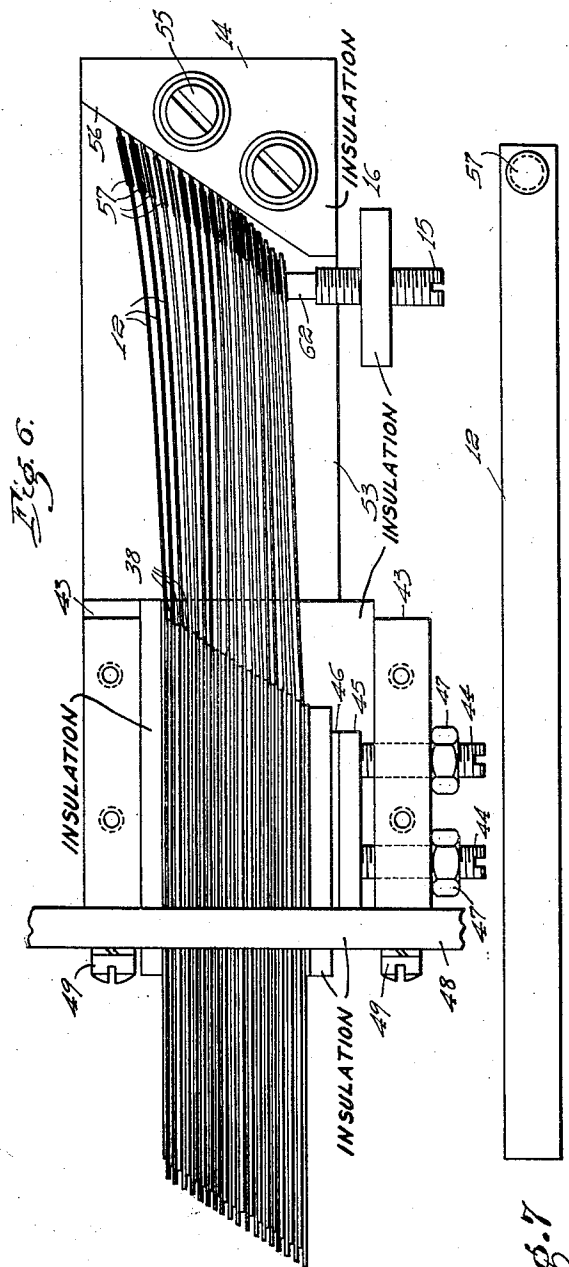
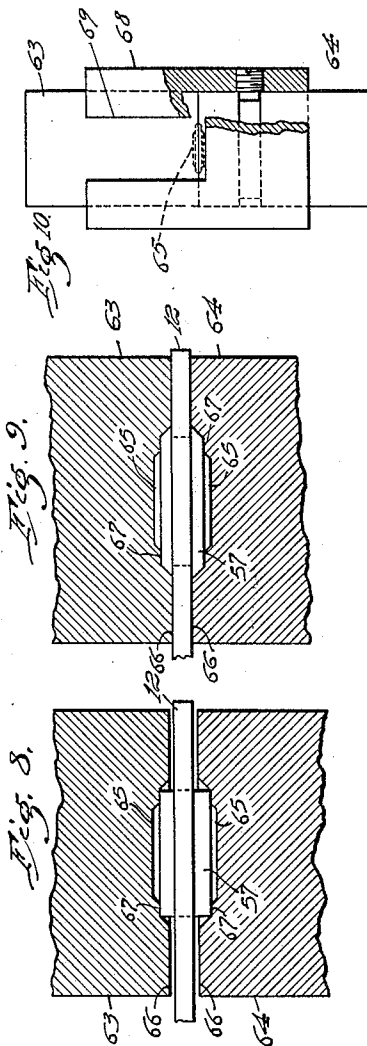


Fig. 7



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2,246,301

REGULATOR

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Application April 23, 1938, Serial No. 203,876

10 Claims. (Cl. 200—1)

Our invention relates to regulators and particularly to regulators of the rheostatic type such as are effective for controlling the field winding of dynamo-electric machines.

It is an object of our invention to provide a regulator of the rheostatic type for use in controlling the excitation of dynamo-electric machines requiring a large range of excitation control that is simple in construction and operation and that is quickly sensitive to slight changes in the regulated quantity.

A further object of our invention is the provision of a regulator of the above-indicated character that requires a small amount of energy to operate and in which the rheostat controlling element is movable through a small range of travel for effecting a large correction in the regulated quantity.

Other objects and advantages of our invention will be apparent from the following description of one preferred embodiment of the invention, reference being had to the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating circuits and apparatus employed in one application of the invention;

Fig. 2 is a perspective view showing the construction of the regulator control element;

Fig. 3 is a plan view of the leaf spring assembly constituting a part of the regulator control element with the cover removed;

Fig. 4 is a side view of the leaf spring assembly showing a portion thereof cut away;

Fig. 5 is a sectional view along the lines 5—5 in Fig. 3;

Fig. 6 is a plan view of the leaf spring assembly showing a portion of the contact members in engagement;

Fig. 7 is a view showing one of the leaf springs used in the assembly; and

Figs. 8, 9 and 10 are detailed views showing the arrangement of dies used for inserting the silver contact buttons in the ends of the leaf springs.

Referring particularly to Figures 1 and 2, a regulator of our invention is illustrated as arranged for controlling the voltage of a generator having an armature 1 connected to supply current to circuit conductors 2 and 3, and a field winding 4 connected in shunt relation to the armature through conductor 5, regulating resistor 6, conductor 7, generator field rheostat 8, field winding 9, and conductor 3. A plurality of leaf springs 12 are provided and arranged in a stack having their fixed ends insulated from each other and connected by conductors 13 to a plurality of points along the resistor 6. The other ends of the leaf springs 12 are free to move and have a biasing force toward the left, as viewed in Figs. 1 and

2, into engagement with a stop block 14 of insulating material for limiting their motion in one direction and for spacing the free ends of the spring elements 12 out of contact engagement with one another, except as moved into engagement by a driving member 15 carried on a moving arm 16 for controlling the position of the leaf springs 12 to control the resistor 6. The moving arm 16 is mounted by means of horizontal springs 17 and vertical springs 18, opposite ends of which are attached to a block 19 carried on the arm 16 and to the portion 22 of the magnet structure in the manner shown.

The operating magnet structure includes a portion 23 extending downwardly from the portion 22, a winding leg portion within the coil 24, and a lower portion 25 extending below the portion 23 to provide a space therebetween for accommodating an armature 26 of magnetic material carried on the lower end of the movable member 16. The arrangement of the magnet structure and the mounting of the movable arm thereon may correspond to that disclosed in copending application of Clinton R. Hanna, Serial No. 118,554, filed December 31, 1936, for Voltage regulators, the essential characteristics of which provide a frictionless pivot mounting for the moving member 16 along the planes of intersection of the supporting spring members 17 and 18, and a substantially constant total air gap comprising the two gaps between upper and lower surfaces of the armature 26 and the adjacent portions 23 and 25, respectively, of the magnetic structure. A spring 27 is provided, one end of which is attached to a bracket 28 extending from the panel-board 29, and the opposite end of which is attached to a pin 32 in the moving arm 16. The regulator coil 30 is connected between circuit conductors 2 and 3, the voltage of which is to be regulated by a circuit including conductor 33, voltage adjusting rheostat 34, winding 35, conductor 36, and one winding 36 of a damping transformer having an inductively related winding 37 connected across the generator field winding 4.

Referring to Figs. 3, 4 and 5, the plurality of individual leaf springs 12 are insulated from adjacent springs by layers of fish-paper 38 spaced between adjacent leaf springs, and which are wider than the springs, as best shown in Fig. 5. The fixed or clamped portions of the stack of leaf springs are positioned between an insulating member 39, which may also extend along the edge of the stack, and an insulating member 42, and these parts are positioned within a channel-shaped bracket 43 in which the stack is fastened by means of set screws 44 extending through bores in one wall of the bracket 43. The inner ends of the set screws 44 engage a plate 45 between which and the insulating plate 42 a spring

46 is provided. In its clamped position, the spring 46 is substantially straight, but it is biased by an initial curvature to urge the clamping plate 45 and the insulating plate 42 away from each other. This spring aids in applying pressure more gradually to the stack of leaf springs and alternate layers of fish-paper, to thereby limit the clamping force, so that the fish-paper will not be given a permanent compression by the leaf springs 12. This clamping pressure permits the progressively overlapping ends of the fish-paper to apply a slight force to the leaves 12 toward the stop 56 while preventing bending them to a permanent set as might occur when clamped too tightly. It also aids in maintaining a definite pressure after the set screws 44 have been tightened. Nuts 47 may be provided for binding the set screws 44 in their adjusted positions.

The assembly is mounted on the plate 48 by means of screws 49 extending therethrough and into the screw threaded bores in the end of the bracket 43. The plate 48 is, in turn, attached to the panel 29 by screws 52.

A plate 53 is provided that is attached to the underside of the bracket 43, as viewed in Fig. 4, by screws 54 and to the outer end of which the stop block 14 is attached by means of screws 55 that extend through openings in the block 14 that are made large enough to permit a certain amount of angular rocking of the block 14 so as to shift the angle of the contact surface 56 upon which the outer ends of the several leaf springs 12 engage. The block 14 is so positioned with respect to the ends of the several cantilever springs 12 that they are brought against the surface 56 with a slight loading or biasing force and are accurately spaced from one another at their free ends, regardless of the lack of straightness of the individual leaves 12. This spacing may be adjusted by angular movement of the block 14 within the limits permitted by the screws 55. When the block 14 is moved so that the surface 56 is shifted in a counter-clockwise direction as viewed in Fig. 3, the spacing of the members 12 will be increased, and when moved in the opposite direction the spacing of the members 12 will be decreased. Upon adjustment of a particular regulator being once made for a required service, further adjustment is unnecessary.

It will be noted that the use of the sloping surface 56 of the block 14 for spacing the members 12 permits the use of a large number of members in a small space since the required space between adjacent leaf springs is small and may be accurately controlled. This arrangement, therefore, permits a free unrestricted movement of the members 12 from the block 14 which does not exist where individual stops are provided between the several members. The close spacing of the members also results in a rheostat having a large number of steps controlled by a slight movement of the driving member. The resistance steps are so arranged and proportioned that the voltage and energy values between any two buttons are kept low in magnitude. This avoids injurious burning or damage to the surfaces of the silver buttons while wiping action as they come together or move apart assures clean surfaces.

Each of the individual leaf springs 12, which may be of bronze, carry silver buttons 57 adjacent the outer free ends thereof through which a circuit may be completed between adjacent leaf springs when so biased as to bring the contact buttons carried by adjacent springs into engage-

ment. It will be noted that the leaf springs 12 are so arranged in the stack that the slope of their free ends is substantially in alignment with the surface 56 of the block 14 when the silver buttons 57 are out of engagement with one another.

In Fig. 4, a portion of the block 14 is cut away to more clearly show the ends of the leaf springs 12. A cover plate 58 is also shown that is mounted above the leaf springs and attached to the bracket member 43 by screws 59.

The operation of the regulator here disclosed is as follows: With the several leaf springs 12 in the positions illustrated in Fig. 3, each is in engagement with the surface 56 of the block 14 and the entire resistor 6 is in circuit with the field winding 4 of the generator 1. When the generator is started and the voltage on the output circuit 2-3 is low, the force of the spring 27 is much greater than the magnetic pull on the armature 26, so that the driving member 15 on the moving arm 16 is biased against the nearest leaf spring 12 with sufficient force to raise the ends of the several springs from the surface 56 of the block 14 and bring the silver buttons 57 carried by the several leaf springs into circuit closing engagement. Thus the several portions of the resistor 6 between the several tap connections 13 are shorted from the field winding circuit through the first and last of the bronze springs 12 and the several silver buttons 57. As the voltage of the generator builds up to its desired value, the force on the armature 26 increases, causing the arm 16 and driving member 15 to move to permit a number of the springs 12 to engage the block 14. At the desired voltage value, the pull on the armature 26 just balances the pull of the spring 27, effecting some intermediate value of the resistor 6 determined by the number of portions thereof that are shorted.

Fig. 6 shows a position of the driving member 15 such that the buttons 57 of approximately one-half the stack of leaf springs 12 are shown in engagement, thus shorting out approximately one-half of the resistor 6 from the field winding circuit. If the voltage of the circuit conductors 2-3 increases, the pull on the armature 26 will increase, thus moving the arm 16 against the bias of the spring 27 and moving the member 15 downwardly, as viewed in Fig. 6, or to the left, as viewed in Fig. 2, to permit a larger number of the buttons 57 to be separated upon engagement of their associated individual leaf springs with the surface 56 of the stop block 14, thus removing the short circuit between successive portions of the resistor 6 to increase the resistance in the field winding circuit and decrease the voltage of the generator 1. Correspondingly, if the voltage between conductors 2-3 decreases, the pull on the magnet 23 will decrease, permitting the force of the spring 27 to move the member 15 upwardly, as viewed in Fig. 6, to raise a larger number of springs 12 from engagement with the surface 56 of the insulating stop block 14 and bring their associated silver buttons 57 into engagement with buttons carried by adjacent leaf springs to thereby short circuit an increasing number of portions of the resistor 6 and increase the excitation of the field winding 4 to thereby increase the voltage between the conductors 2-3.

When the voltage is restored to its normal value after any variation therefrom, the magnetic pull on the armature 26 and the pull of the spring 27 are again balanced, and the mov-

ing arm 16 and driving member 15 have changed their position sufficiently to increase or decrease the number of portions of the resistor 6 connected in the field circuit. It will be noted that the regulating action is that of a semi-static reg-
5 ulator and operates only when a correction in voltage is necessary. So long as the circuit conditions remain fixed and the required excitation remains constant, the position of the moving arm 16 will remain constant.

It will also be noted that the regulator is exceptionally quick in operation since the moving parts are substantially frictionless and the effect of inertia of these moving parts is substantially reduced due to the very slight movement of the driving member required to operate the rheostat throughout its complete range. It will be ap-
15 preciated that there is little or no maintenance required since there are no parts requiring re-adjustment or replacement at frequent intervals. The few moving parts are permanently sup-
20 ported by leaf springs, thus eliminating friction, wear and the adjustment of bearings.

Since the regulating resistor is a stationary element, it is unnecessary to use complicated lever and linkage systems, such as are sometimes employed, to mechanically operate a movable re-
25 sistance assembly in order to vary its resistance, and the heating due to the portions of the rheostat connected in the field winding circuit may be sufficiently removed from the controlling con-
30 tact buttons that they are unaffected by the heating of the rheostat resistor. The reduced portion 62 on the inner end of the driving member 15 is formed of insulating material, as are all other parts in contact with the stack of leaf
35 springs 12, so that none of the metal parts of the regulator control relay are alive.

Figs. 8, 9 and 10 illustrate a method of in-
serting the silver discs or buttons 57 in the ends
40 of the leaf springs 12. A simple die consisting of two parts 63 and 64 is provided, each having a recess 65 that is set back sufficiently from the faces 66 of the die to accommodate the central portion of the button 57. A narrow rim 67
45 is provided for causing the flow of the silver radially when the two portions of the die are forced together in the position shown in Fig. 9. The two parts of the die 63 are positioned in a guid-
50 ing member 68, shown in Fig. 10, having a slot 69 for accommodating the bronze spring 12 in which a hole has previously been punched. In using the die, a silver button 57 is placed in one recess and the hole in the bronze spring aligned with the button, the other half of the die being positioned above the button, as shown
55 in Fig. 8. The upper and lower dies are forced together in an arbor press causing the silver to flow radially to fill the slight clearance provided within the hole in the bronze spring 12 and to cause the edges of the button to flow
60 slightly over the opposite surfaces of the spring to rivet the silver button to the spring. The size of the hole in the bronze spring must be such that buckling of the leaf spring 12 does
65 not occur no matter how much force is applied by the press. It, therefore, becomes necessary to determine the permissible ratio of hole diameter to bronze thickness such that no buck-
70 ling of the bronze strip will occur under the hydrostatic pressure of the flowing silver. The yield point of the flowing silver is about 30,000 pounds per square inch, and this represents the maximum pressure which the silver can exert
75 against the sides of the hole.

It will be apparent to those skilled in the art that modifications in the details of construction disclosed may be made within the scope of our invention, and we do not wish to be limited oth-
erwise than by the scope of the appended claims.

We claim as our invention:

1. In a rheostat, circuit controlling mechanism comprising a plurality of self-biasing flexible members arranged with corresponding ends clamped in fixed relation, said fixed ends being insulated from one another, the other ends of said flexible members being free to move, a movement limiting stop having a continuous smooth surface positioned at an angle to the general direction of the flexible members and against which the free ends of said flexible members are biased for positioning them in spaced relation, and means for actuating said flexible members from engagement with said stop and into circuit closing engagement with adjacent mem-
bers.

2. In a rheostat, circuit controlling mechanism comprising a plurality of members arranged in a stack with corresponding ends supported in fixed relation, said fixed ends being insulated from one another, the other ends of said members being free to move and arranged in the stack with successively overlapping ends, a movement limiting stop having a continuous smooth surface against which the free ends of said mem-
bers are biased for positioning them in spaced relation, and means for actuating said members from engagement with said stop and into circuit closing engagement with the adjacent members, said stop being movable angularly to adjust the spacing of the free ends of the flexible members along the face of the stop.

3. In a rheostat, circuit controlling mechanism comprising a plurality of flexible members arranged in a stack with corresponding ends clamped in fixed relation, said fixed ends being insulated from one another, the other ends of said flexible members being free to move and arranged in the stack with successively overlapping ends, contact buttons attached to the flexible members at their free ends and having contact faces on opposite sides thereof positioned to engage like contact buttons on adjacent flexible members, a movement limiting stop having a continuous smooth surface positioned at an acute angle to the general direction of the flexible members against which the free ends of said flexible members are biased for positioning them in spaced relation, and means adapted to engage the contact button on the innermost of said flexible leaf spring members for actuating said flexible members from engagement with said stop and into circuit closing engagement with the adjacent members, said stop being movable angularly to adjust the spacing of the free ends of the flexible members.

4. In a rheostat, circuit controlling mechanism comprising a plurality of flexible members arranged in a stack with corresponding ends clamped in fixed relation, said fixed ends being insulated from one another, the other ends of said flexible members being free to move and arranged in the stack with successively overlapping ends, contact buttons attached to the flexible members at their free ends and having contact faces on opposite sides thereof positioned to engage like contact buttons on adjacent flexible members, a movement limiting stop having a continuous smooth surface against which the free ends of said flexible members are biased for

positioning them in spaced relation, a driving member positioned to engage the innermost of said flexible leaf spring members for progressively moving said members from engagement with said stop into circuit closing relation with adjacent members.

5. In a circuit controlling device having a series of self-biasing elongated circuit controlling members arranged with one end of each supported in fixed relation to each other, said fixed ends being insulated from one another, the other ends of said members being free to move, stop means having a continuous smooth surface against which the free ends of the circuit controlling members are biased for limiting the spacing of the free ends, said stop means being arranged to permit movement of the circuit controlling members away from the stop means that is unlimited within the range of operation of the device.

6. In a circuit controlling device having a large number of control steps, circuit controlling mechanism comprising a series of self-biasing elongated circuit controlling members arranged with one end of each supported in fixed relation to each other, said fixed ends being insulated from one another, the other ends of said members being free to move, stop means against which the free ends of the circuit controlling members are biased by the self-biasing action of the members for spacing the free ends, said stop means having a contact surface at an angle to the general direction of the elongated circuit controlling members arranged to permit unrestricted movement of the contact members away from the stop means, and means for actuating said contact members progressively from engagement with said stop into circuit closing relation with adjacent contact members to successively vary circuit connections therethrough.

7. In a circuit controlling device having a large number of control steps, circuit controlling mechanism comprising a series of self-biasing elongated circuit controlling members arranged with one end of each supported in fixed relation to each other, said fixed ends being insulated from one another, the other ends of said members being free to move, stop means having a continuous smooth contact surface at an angle to the general direction of the elongated circuit controlling members against which the free ends of the circuit controlling members are biased by the self-biasing action of the members for spacing the free ends, and means for actuating said contact members progressively from engagement with said stop into circuit closing relation with adjacent contact members to successively vary circuit connections therethrough, said stop means being movable angularly with respect to the direction of said elongated circuit controlling members to adjust the spacing of the free ends of the members along the contact surface of the stop means.

8. In a circuit controlling device having a large number of control steps, a series of self-biasing elongated flexible circuit controlling members positioned with corresponding ends arranged in a stack comprising alternate layers of the circuit controlling members and strips of insulating material clamped in a supporting structure, the strips of insulating material in the stack having progressively elongated ends to apply a slightly greater pressure on corresponding sides of the series of circuit controlling members than on

the opposite sides for biasing said members in the same direction, the other ends of said members being free to move, stop means against which the free ends of the circuit controlling members are biased by the self-biasing action of the members for spacing the free ends, said stop means having a continuous contact surface at an angle to the general direction of the elongated circuit controlling members arranged to permit unrestricted movement of the contact members away from the stop means within the range of operation of the device, and means for actuating said several contact members progressively from engagement with said stop into circuit closing relation with adjacent contact members of the series to successively vary circuit connections therethrough.

9. In a circuit controlling device having a large number of control steps, a series of self-biasing elongated flexible circuit controlling members positioned with corresponding ends arranged in a stack comprising alternate layers of the circuit controlling members and strips of insulating material clamped in a supporting structure, the strips of insulating material in the stack having progressively elongated ends to apply a slightly greater pressure on corresponding sides of the series of circuit controlling members than on the opposite sides for biasing said members in the same direction, the other ends of said members being free to move, stop means against which the free ends of the circuit controlling members are biased by the self-biasing action of the members for spacing the free ends, said stop means having a continuous contact surface at an angle to the general direction of the elongated circuit controlling members arranged to permit unrestricted movement of the contact members away from the stop means within the range of operation of the device, and means for actuating said several contact members progressively from engagement with said stop into circuit closing relation with adjacent contact members to successively vary circuit connections therethrough, said stop means being movable angularly with respect to the direction of said elongated circuit controlling members to adjust the spacing of the free ends of the members along the contact surface of the stop means.

10. In a circuit controlling device having a large number of control steps, a series of self-biasing elongated flexible circuit controlling members positioned with corresponding ends arranged in a stack comprising alternate layers of the circuit controlling members and strips of insulating material clamped in a supporting structure, the strips of insulating material in the stack having progressively elongated ends to apply a slightly greater pressure on corresponding sides of the series of circuit controlling members than on the opposite sides, the other ends of said flexible members of the series being progressively elongated and free to move, a movement limiting stop having a continuous smooth surface positioned at an acute angle to the general direction of said flexible members against which the free ends of said flexible members are biased for positioning them in spaced relation, and means for actuating said flexible members progressively from engagement with said stop and into circuit closing engagement with adjacent members of the series.

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