Aug. 28, 1928. 1,682,566

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METHOD OF AND APPARATUS FOR CONTROL OF ELECTRICAL CONDITIONS OF CIRCUITS

Filed Jan. 17, 1924

Fig. 1.

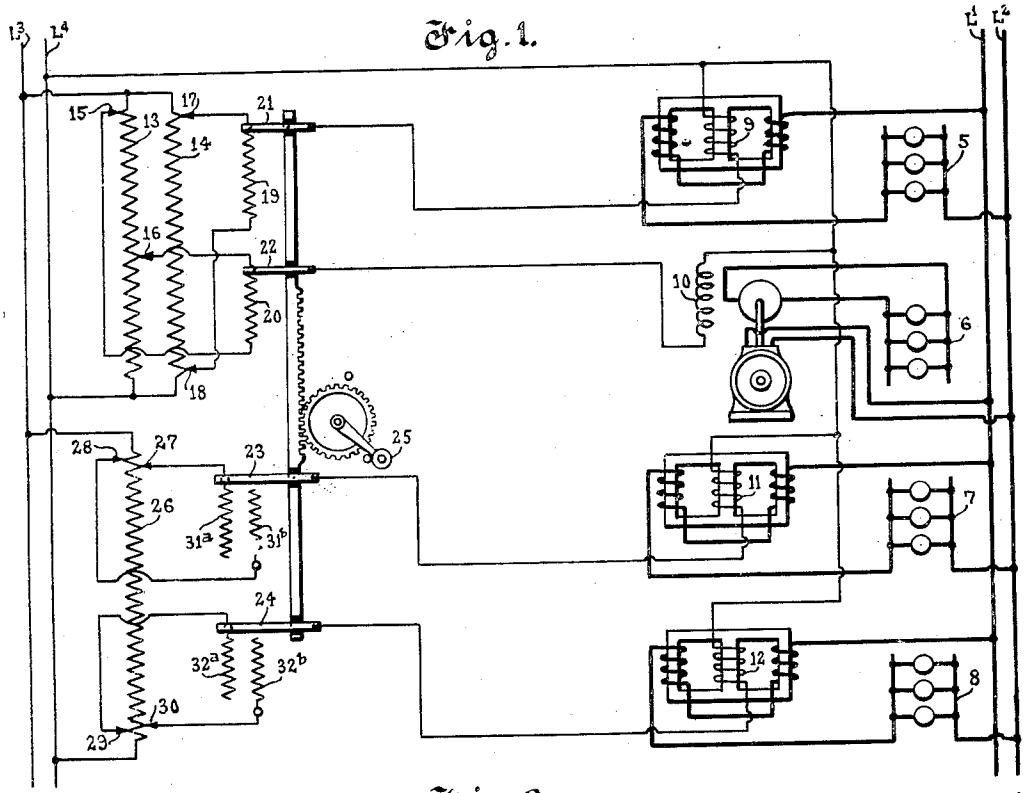


Fig. 2.

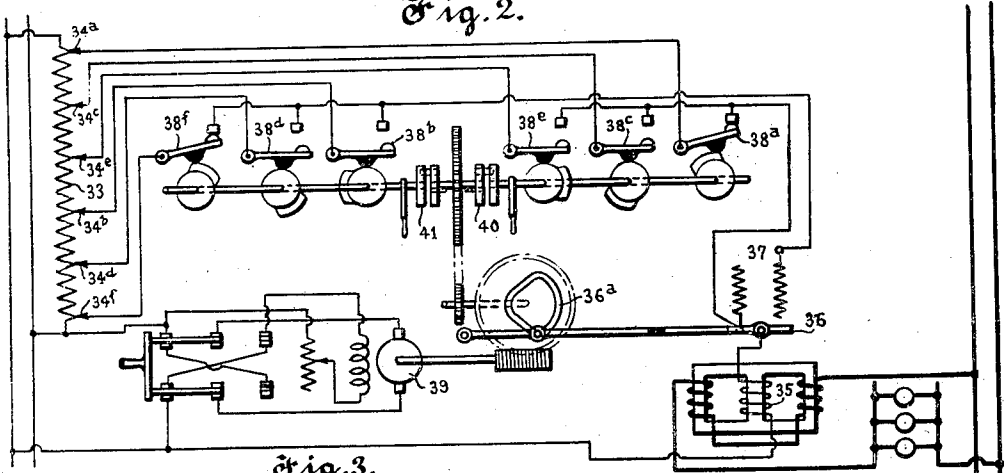
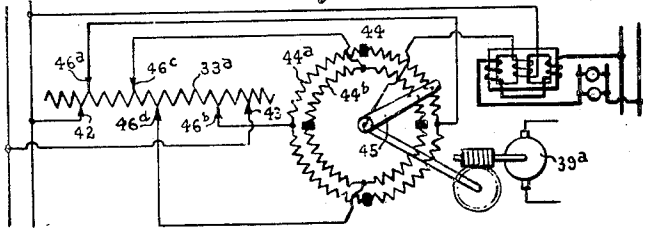


Fig. 3.



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Patented Aug. 28, 1928. 1,682,566

UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR CONTROL OF ELECTRICAL CONDITIONS OF CIRCUITS.

Application filed January 17, 1924. Serial No. 686,935.

This invention relates to methods of and apparatus for control of electrical conditions of a circuit or circuits.

While not limited thereto the invention is particularly applicable to control of theatre dimmers and the like.

Among the objects of the invention is that of providing advantageous and improved methods of potential control of a circuit or circuits.

Another and more specific object is that of providing such methods enabling full electrical joint control of the potentials to which a plurality of associated circuits are individually subjected, such control to include for each circuit smooth and substantially continuous potential variation from any given value to any desired value within the maximum range provided.

Another object is that of providing methods enabling repeated enactment of control as aforecharacterized through actuation of a single instrumentality between predetermined limits.

Another object is that of providing methods enabling enactment of control, as aforecharacterized, of the several circuits continuously throughout the range of movement of such common operating instrumentality.

Another object is that of providing methods of potential control or variation as aforecharacterized including preselective control without necessitating duplication of parts.

Another object is that of providing methods as aforecharacterized including multiple preselection or advance setting.

Another object is that of minimizing the consumption of electrical energy required for the aforedescribed control.

Another object is that of providing advantageous and simple apparatus for performance of the foregoing methods.

Other objects and advantages will hereinafter appear.

In the accompanying drawing, wherein are illustrated certain of the embodiments which the invention may assume in practice,

Figure 1 is a diagrammatic and schematic view illustrative of a proposed construction;

Fig. 2 is a similar view illustrative of a slightly modified and amplified construction; while

Fig. 3 is a similar view also illustrating a slightly modified construction.

Referring to Fig. 1 of the drawing, the same illustrates an adaptation of the here incontemplated methods and apparatus to theatre dimmers and similar installations.

Thus for simplicity the dimmer may be assumed to control banks of lamps 5, 6, 7 and 8, the lamps of each bank being assumed to possess some desired feature of similarity such as color, location or the like such as to warrant joint control thereof, the several banks of lamps or certain thereof being arranged for and adapted to individual control. The several lamp circuits may be supplied with electrical energy from a common source $L' L^2$, subject to magnetic amplifier control as illustrated in conjunction with circuits 5, 7 and 8, or may be supplied by individual generators, subjected to field control as indicated in conjunction with circuit 6, the amplifiers, or generators, being provided with individual control windings 9 to 12, whereby the intensity of illumination of the lamps of each circuit is an approximately exact function of the value of the energization of its associated control winding.

Said control windings may be supplied from any suitable source, such as lines L^3 L^4, of direct current or alternating current of lower frequency than that of the circuit controlled thereby and may be permanently connected terminally to one side of such source as shown, the connections of the opposite terminals of the individual control windings to the opposite side of such source being controllable by the means now to be described.

To such end, individual conductive elements 13 and 14 which may comprise resistors of continuous duty type are connected across said lines L^3 L^4, said resistors having sliders or equivalent devices 15 and 16, and 17 and 18, respectively, each movable irrespective of the position of the other, throughout the extent of its associated resistor. Further, the respective pairs 15, 16 and 17, 18 of said sliders are electrically connected through additional devices, preferably comprising

resistors 20 and 19 respectively. Said latter resistors are respectively provided with sliders 22 and 21 which are respectively electrically connected with the terminals of said individual control windings 10 and 9. The corresponding connections of control windings 11 and 12 may be effected by means of elements which are duplicates of those just described, whereas the connections actually shown for said latter windings differ only or chiefly in details to be later described.

Thus assuming all of said control windings to be provided with controllable connections as aforedescribed, and assuming all of sliders 21 to 24 inclusive to be provided with a common operating means as shown, the operation of the device may be described as follows: Obviously upon movement of handle 25 from one to the other of its limits, all of sliders 21 to 24 are caused to traverse unidirectionally the extent of their respectively associated resistors.

However, the character and extent of the changes so effected in electrical condition of the individual control windings is determined by the setting of the sliders associated with the main resistors.

Thus with the illustrated setting of sliders 17, 18 and 21 it is apparent that control winding 9 is connected directly across supply lines L^3 L^4 and hence subjected to the full line potential. Further, upon full upward movement of handle 25 with resultant full downward movement of slider 21 (together with sliders 22, 23 and 24), a gradually increasing value of the resistance of resistor 19 is interposed between said winding 9 and line L^3, until in the final downward position of slider 21 said control terminal of winding 9 is connected directly back to line L^4, to which the opposite terminal of said winding is also connected. The aforedescribed full upward movement of handle 25 thus serves to vary the value of the potential impressed upon winding 9 uniformly from maximum to minimum value.

Considering now the setting of sliders 15, 16 and 22, it is apparent that the control terminal of winding 10 is connected to a medial point of resistor 13 whereby said winding is subjected to a value of potential approximately midway between maximum and minimum. Also upon full upward movement of handle 25 said control terminal becomes electrically connected directly with line L^3 whereby winding 10 is subjected to full line potential.

Considering now the setting of sliders 27, 28 and 23 associated with winding 11, it may be observed that sliders 27 and 28 are placed in opposition, in the relation corresponding with maximum potential of said winding 11 whereby at either extreme position of slider 23 said coil is subjected to full line voltage. It is moreover apparent that during transit of said slider 23 between extreme positions such impressed potential is somewhat changed as a result of inclusion of portions of the auxiliary or transfer resistor in circuit. However, such effect is restricted to a maximum value corresponding to the joint ohmic value of the two halves of said transfer resistor connected in parallel, whereas, assuming suitable design and characteristics of the magnetic amplifier or its equivalent and of the resistor element employed, any effect of the foregoing upon the illumination intensity may be reduced below a sensible or appreciable value.

Obviously the relation of sliders 29 and 30 associated with winding 12 is such that minimum potential is applied to said winding for all positions of slider 24.

Thus a single upward movement of handle 25 serves to vary gradually the lamps controlled by winding 9 from full brilliancy to full out, the lamps controlled by winding 10 from half bright to full bright, those controlled by winding 11 being maintained full bright and those controlled by winding 12 being maintained full out. Obviously return of said handle to the position shown serves gradually to restore the various lamp circuits to their former condition.

Next it should be observed that with handle 25 in either extreme position, one of the sliders of each pair directly coacting with a line connected resistor is active for enactment of the effect then in progress, whereas the other slider of each of such pairs is inactive.

Therefore, movement of any active slider serves to effect individual control at will of its associated winding and of the lamps controlled thereby, whereas positioning of any inactive slider serves, without substantially influencing the effect in progress, to preselect any desired effect for enactment by subsequent continuous movement of handle 25 to its opposite position, whereby the previous effect is gradually and smoothly merged into the succeeding effect, and such preselective action may be repeated at will. Moreover, the transformation as regards each circuit is continuous throughout the range of movement of said handle and of the sliders operated thereby, whether the resultant change in impressed voltage be small or great, whereas the illumination effect of any circuit or circuits may be maintained substantially unchanged during such movement of said handle. Again it is observed that one or more circuits of lamps may be brightened with concurrent dimming of another circuit or circuits.

The aforementioned special arrangement of the control connections for windings 11 and 12 comprises, as illustrated, utilization of a common line connected resistor element 26 for both of said windings, an arrangement

which in certain cases is entirely permissible or even preferable.

Also auxiliary or transfer resistors 31 and 32 are of special type, comprising individually plural resistors designated as *a* and *b*, each permanently connected terminally to but one of the associated sliders and its opposite end being open, each pair of said plural resistors being arranged to be bridged by a single or common cooperating slider. Further the arrangement is such that for either extreme position of said common slider, circuit through its associated plural resistors is interrupted. This arrangement thus provides for material conservation of electrical energy and also enables use of intermittent duty rather than continuous duty resistors. Further, such arrangement, whereby the aforementioned inactive slider is actually out of circuit while in such condition, serves to relieve the main resistor of influence resulting from movement of such inactive slider with reference thereto. Obviously, individual line connected resistor elements for windings 11 and 12 may be employed if desired.

Referring now to Fig. 2 of the drawing, the same illustrates an extension of the control system aforedescribed, whereby preselection of a multiplicity of changes or effects together with enactment thereof in a predetermined order or at will is enabled. For purposes of simplicity the illustration includes apparatus for control of a single lamp circuit or other circuit, but the same may be duplicated for co-ordinated control of any desired number of circuits.

In said figure a main resistor 33 is connected across the D. C. or low frequency supply lines after the manner of resistors 13, 14 and 26 of Fig. 1 and is provided with a number of sliders 34 equal to the number of changes or effects which it is desired to preset at any given time during inactivity of the device or one more than the number which may be preset while the device is active. Said sliders 34 are designated by auxiliary reference letters *a* to *f*.

The winding or equivalent device 35 whose electrical condition is to be directly controlled is terminally connected to one of said supply lines, its opposite end being connected with a slider 36 adapted to cooperate with a second or transfer resistor 37 in the manner aforedescribed, said resistor being preferably of the plural or normally deenergized type described. The respective terminals of said resistor 37 are adapted to be connected with individual sliders 34 by means of switches 38^a to 38^f which are operable, for example, by means of individual cams which may be driven in synchronism as shown, said cams being set to effect closure of said switches in sequence as indicated by their respective auxiliary reference letters such that no two of said switches associated with the same terminal of the transfer resistor 37 shall become closed concurrently, at least one of said switches, however, being preferably maintained closed during the transfer period.

Slider 36 may also be conveniently arranged for actuation in coordination with that of said switches, as by means of the cam device 36^a to be operated at a speed suitably proportional to that of the switch cam shaft, and so designed as to provide the desired character of operation of said slider. In the illustrated embodiment the coordination provided is such that no commutation of switches 38 is permitted during movement of slider 36 between extreme positions, whereas during each portion of the cycle wherein said slider occupies an extreme position one of said switches is opened and another switch associated with the same terminal of transfer resistor 37 is closed, a third switch associated with the opposite terminal of said transfer resistor being maintained closed.

From the aforedescribed arrangement and cooperation it results that at any time when slider 36 is in an extreme position only one of the sliders 34 is active, all other of said sliders being available for preselection purposes.

The number of preselections provided is thus determined by the number of sliders 34 coacting with resistor 33, each being provided with an individual switch, whereas the number thereof may be increased practically at will to afford a desired number of preselections. Obviously if desired the switches 38 may be replaced by drum controller segments or other equivalent devices.

Said cam shafts may conveniently be power operated jointly as by the reversible and speed variable motor 39 illustrated. Also if desired the driving shafts for the groups of switches 38^a, 38^c and 38^e, and 38^b, 38^d and 38^f, respectively, may be released from their common operating means, said shafts being thereafter operable independently as by the handles shown, but each to be operated preferably only while the auxiliary slider 36 occupies an extreme position such as to render the switches and sliders associated with that particular shaft temporarily inactive. This arrangement provides for closure of said switches and consequent enactment of the several preselected effects in any desired sequence. Clutches 40 and 41 provide for so releasing said shafts, said clutches being provided individually with pins and sockets or equivalent means insuring against recoupling of the shafts to their common drive except in a relation suitable for joint operation of the shafts and their associated parts.

Again, obviously, the several switches may be arranged for voluntary operation singly if desired.

Now considering Fig. 3 of the drawing, the same illustrates a further slight modification

of the control systems of Figs. 1 and 2, wherein an auto transformer coil 33^a is substituted for the resistor element 33 of the preceding figure, said coil having suitable sliders 42, 43 or equivalent devices for connecting selectable portions thereof across supply lines L^3 L^4, the same being in this instance assumed to supply alternating current of lower frequency than that of the associated lamp circuit.

Also in this construction a special type of transfer resistor 44, particularly adapted to continuous rotatory motion of its cooperating slider 45 is provided. Said resistor may comprise concentric annular resistor elements 44^a and 44^b as shown having spaced taps to be electrically connected with the respective sliders 46^a, 46^b, 46^c and 46^d as shown, and also having intermediate insulated sections, the taps and insulated sections of one resistor being angularly displaced with reference to those of the other. Slider 45 having the control winding terminal electrically connected thereto is adapted to rotate and sweep over said resistors jointly whereby with the number and arrangement of taps and insulated sections shown the effect is that of four series related resistor elements each similar in function to the corresponding resistor element 37 of Fig. 2.

Said slider 45 may be preferably power driven as by a reversible and speed variable motor 39^a similar to that illustrated in Fig. 2, the drive being effected through suitable reduction gearing.

Control apparatus similar to the foregoing may be provided for each winding circuit or other circuit to be controlled, such apparatus to be operated or driven either jointly or individually and either in step or out of step as desired. Also it is apparent that if desired a plurality of relatively insulated sliders similar to slider 45, and each connected in an individual circuit to be controlled, may be driven jointly about and with reference to a compound transfer resistor similar to that indicated at 44, whereby the latter may be adapted to act with reference to several circuits concurrently, in such case the several sliders 45 being insulated from one another and so spaced angularly as to prevent more than one slider from engaging the same resistor unit at one time.

The operation of the construction last described as well as numerous advantages thereof will be apparent from the foregoing. However, it may be observed that the use in this construction of an auto transformer or its equivalent, which feature may also be employed in the other described construction if desired, enables subjection of the terminals of the transfer resistor to a broadened range of values of potential derived from but not limited by the source potential.

The foregoing are merely exemplary of ways in which associated resistors connected across the line and in cascade relation may be utilized for affording smooth and continuous variations in electrical condition of a plurality or multiplicity of circuits which may include amplifier control or generator circuits for ultimate regulation of lamps or other electrical energy consuming devices, while maintaining substantial proportionality of the values of corresponding electrical conditions of the several circuits, such variations to be positive, neutral or negative at will and to be capable of practically unlimited preselection.

What we claim as new and desire to secure by Letters Patent is:—

1. In apparatus for controlling an electrical condition of a circuit having a connection with a source of constant potential, the combination with an individual resistor for said circuit and means for subjecting the respective terminals of the former to selectable values of potential derived from said source, of associated means for subjecting said circuit to the effect of such potential values modified by a selectable ohmic value of the resistance of said resistor.

2. In apparatus for controlling an electrical condition of a circuit having a connection with a source of constant potential, the combination with an individual resistor for said circuit and means for subjecting the respective terminals of the former to selectable values of potential derived from such source, of associated means for subjecting said circuit to potential conditions which are the effect of such selected values modified by selectable values of the resistance of said resistor.

3. In apparatus for controlling an electrical condition of a circuit having a connection with a source of constant potential, the combination with an individual resistor for said circuit and means for connecting the terminals of the former with said source, said means including means for subjecting said resistor to selectable values of potential, of associated means for subjecting said circuit to potential conditions which are the effect of the selected potential values modified by selectable values of the resistance of said resistor.

4. In apparatus for controlling an electrical condition of a circuit having a connection with a source of constant potential, the combination with a resistor and means for including selectable portions thereof in said circuit, of associated means for subjecting said resistor to selectable values of potential, said latter means comprising a resistor connected across said source and means cooperating therewith for connecting the respective terminals of said first mentioned resistor with selectable points of said second resistor.

5. In apparatus for controlling the electrical conditions of a plurality of associated circuits jointly, each of said circuits having a connection with a source of constant potential, the combination with individual resistors for said circuits and means for including different portions of each in circuit, of associated means, comprising a resistor connected across said source and independently movable means to cooperate therewith for subjecting each of said first mentioned resistors to selectable values of potential, and joint control means for said circuits comprising means for varying simultaneously and similarly the value of said first mentioned resistors included in circuit.

6. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source and having a terminal connected with said source, the combination with a plurality of resistors to be included in said circuit, of means for connecting said resistors with said source in cascaded across the line relation, and means for including selectable portions of said resistors in said circuit.

7. Combined control apparatus, comprising means for providing a circuit across supply lines of opposite polarity, means for impressing upon said circuit a selectable value of the line potential, means for preselecting a different value of such potential to be impressed upon said circuit and means for varying the circuit impressed potential from the former to the latter value in increments each substantially proportional to the difference of said values.

8. In apparatus for control of an electrical condition of a circuit to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon said circuit, of means for varying the circuit impressed potential between selected values thereof in regular increments substantially proportional to the difference in said values.

9. In apparatus for control of an electrical condition of a circuit to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon said circuit, of means for varying the circuit impressed potential between selected values thereof in increments substantially proportional to the difference in said values, said last mentioned means comprising a contacting element to be moved continuously between predetermined limiting positions.

10. In apparatus for control of an electrical condition of a circuit to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon said circuit, said means comprising a resistor connected across said source and a plurality of contactors to be connected individually with selectable points of said resistor, of means for varying the circuit impressed potential between the values so selected in increments substantially proportional to the difference in said values.

11. In apparatus for potential control of a circuit to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon said circuit, said means comprising a resistor connected across said source and a plurality of contactors to be connected individually with selectable points of said resistor, of means for varying the circuit impressed potentially between values so selected in increments substantially proportional to the difference in said values, said last mentioned means comprising a contacting element to be moved continuously between predetermined limiting positions.

12. In apparatus for potential control of a circuit to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon said circuit, of potential control means comprising a contactor to be moved continuously between predetermined limiting positions and adapted when so moved to vary the circuit impressed potential continuously between values so selected in increments substantially proportional to the difference between such values.

13. In apparatus for joint potential control of a plurality of circuits each to be supplied from a suitable source, the combination with means for preselecting values of potential to be impressed sequentially upon the individual circuits, of potential control means comprising individual resistors for the circuits and individual cooperating contactors to be moved jointly and continuously between predetermined limiting positions and adapted when so moved to vary jointly and continuously the potentials impressed upon the several circuits between values so selected, in increments substantially proportional to the difference between such consecutively impressed values.

14. In apparatus for potential control of a plurality of circuits, each to be supplied from a suitable source, the combination with means for preselecting substantially without influence upon the existing potential of a given circuit a multiplicity of values of potential to be subsequently impressed thereon, of means for shifting from any impressed values to any selected values of potential of the several circuits simultaneously and in increments substantially proportional to the value of the total change so effected in each circuit.

15. The method of controlling an electrical condition of a circuit to be supplied from a suitable source, which comprises preselecting values of potential to be applied sequentially to said circuit and impressing

such potential conditions upon the circuit singly, shifting from an impressed to a selected value of potential of the circuit smoothly and in increments substantially proportional to the total resultant change in circuit impressed potential.

16. The method of controlling an electrical condition of a circuit to be supplied from a suitable source, which comprises preselecting values of potential to be applied sequentially to said circuit and impressing such potential conditions upon the circuit singly, shifting from an impressed to a selected value of potential of the circuit smoothly and at a controllable rate, in increments substantially proportional to the total resultant change in circuit impressed potential.

17. The method of controlling corresponding electrical conditions of a plurality of associated circuits each to be supplied from a suitable source, which comprises preselecting for each circuit values of potential to be impressed thereon sequentially, and simultaneously varying the potentials of the circuits each from an impressed to a selected value, in increments substantially proportional to the total resultant change in impressed potential thereof.

18. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source, the combination with a plurality of resistors, of means for connecting said resistors in cascaded across the line relation suitable for energization by potential derived from said source, certain of said resistors comprising electrically distinct resistor elements, and associated means comprising a bridging element and means for effecting relative movement of said bridging element and said resistor elements jointly for including selectable values of said latter mentioned resistor elements in said circuit.

19. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source, the combination with a plurality of resistors, of means for connecting said resistors in cascaded across the line relation suitable for energization by potential derived from said source, certain of said resistors comprising electrically distinct resistor elements, and associated means comprising a bridging element and means for effecting relative movement of said bridging element and said resistor elements jointly to intermediate positions for including selectable values of said latter mentioned resistor elements in said circuit and to an extreme position for deenergization of a portion of said resistor elements.

20. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source, the combination with a plurality of resistors, of means for connecting said resistors in cascaded across the line relation suitable for energization by potential derived from said source, certain of said resistors comprising electrically distinct resistor elements and associated means comprising a bridging element and means for effecting relative movement of said bridging element and said resistor elements jointly to intermediate positions for including selectable values of said latter mentioned resistor elements in said circuit and to opposite extreme positions for deenergization of portions of said resistor elements selectively.

21. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source, the combination with a plurality of resistors, of means for connecting said resistors in cascaded across the line relation suitable for energization by potential derived from said source, certain of said resistors comprising electrically distinct resistor elements, and associated means comprising a bridging element and means for effecting relative movement of said bridging element and said resistor elements jointly to intermediate positions for including selectable values of said latter mentioned resistor elements in said circuit and to opposite extreme positions for deenergization of portions of said resistor elements selectively and for excluding said resistor elements from said circuit.

22. In apparatus for controlling an electrical condition of a circuit to be supplied from a suitable source, the combination with a resistor to be energized by potential derived from said source, of means providing a continuous sequence of series related resistance devices, each comprising electrically distinct resistor elements having each a terminal to be connected with selectable portions of said first mentioned resistor, and relatively movable bridging means for said resistor elements for connecting selectable values of each of said resistance devices sequentially and cyclicly in said circuit.

23. In control apparatus for dimmers and the like having a multiplicity of separately controllable lamp circuits and each circuit having an associated control circuit for providing amplified control of an electrical condition thereof, the combination with individual control means for said second mentioned circuits comprising resistors to be connected in cascaded across the line relation with a suitable source and with said control circuits, means for selecting the value of the source derived potential impressed upon certain of said resistors, and means for varying jointly the values of said resistors included respectively in the several circuits.

24. In control apparatus for dimmers and the like having a multiplicity of separately controllable lamp circuits and each circuit having an associated control circuit for providing amplified control of an electrical condition thereof, the combination with indi-

vidual control means for said second mentioned circuits comprising resistors to be connected in cascaded across the line relation with a suitable source and with said control circuits, means for selecting the value of the source derived potential impressed upon certain of said resistors said means including means to impress upon the resistors a potential higher than that of said source, and means for varying jointly the values of said resistors included respectively in the several circuits.

In witness whereof we have hereunto subscribed our names.

RICHARD B. HUNTER.
CLARENCE T. EVANS.