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METHOD OF AND APPARATUS FOR CONTROLLING ELECTRIC CIRCUITS

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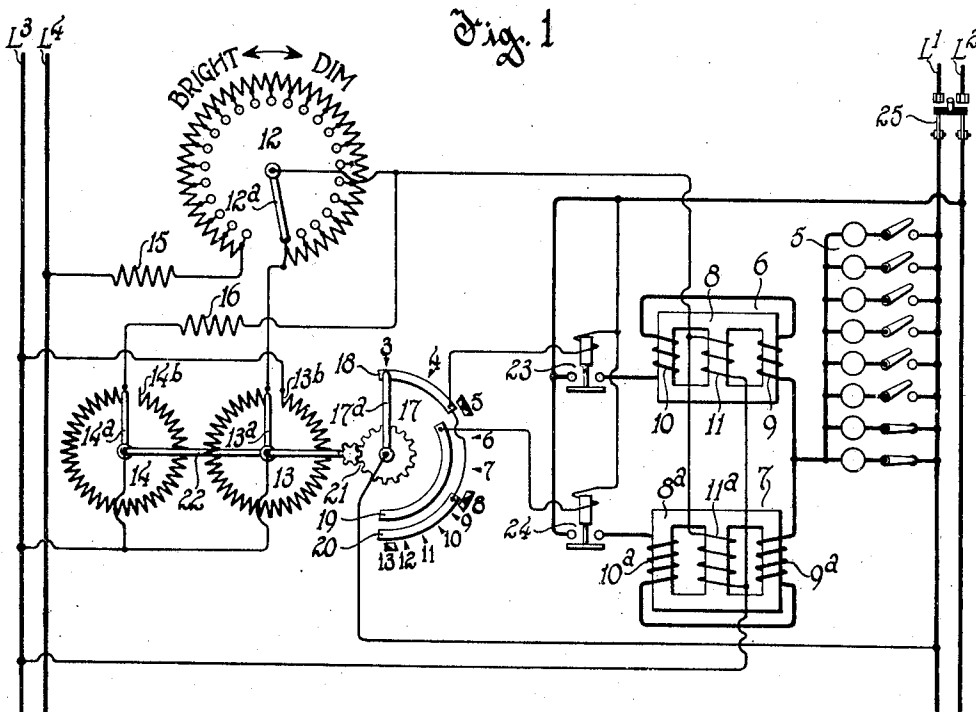
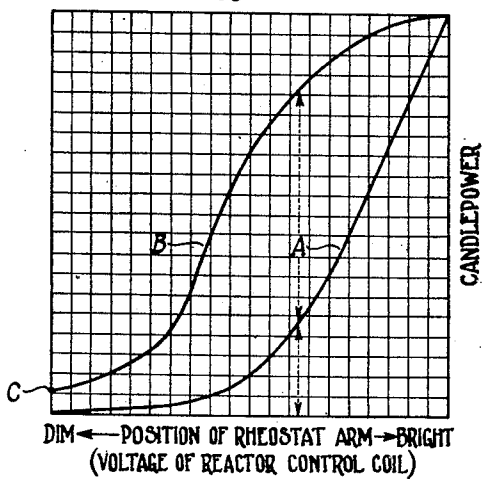


Fig. 2



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METHOD OF AND APPARATUS FOR
CONTROLLING ELECTRIC CIRCUITS

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12 Claims. (Cl. 175—312)

This invention relates to improvements in the regulation of electric circuits. While not limited thereto, the invention is particularly applicable to systems for controlling jointly the intensity of illumination of a multiplicity of lamps which are adapted to be rendered active selectively.

The system hereinafter described employs voltage regulating means of the magnetic amplifier or reactor type which comprises a magnetic structure having windings in circuit with a load to be controlled and having a control coil to be excited by a suitable current. It has been customary heretofore to regulate the excitation of said control coil by means of a rheostat in series therewith. As is well known to those skilled in the art, when the windings of such reactance are energized, due to energization of a load of a given value, such as a lamp or lamps, in circuit therewith, and when the control coil is unexcited, the induced impedance in such reactance serves to check the voltage to said lamps to such an extent that the lamp filaments remain black. Manipulation of the rheostat varies the excitation of said coil, controlling the impedance value of the reactance, whereby the voltage drop across the lamps and consequently the intensity of illumination thereof is varied at will between zero and maximum. The aforescribed characteristic of control may be represented by the curve A on the curve chart designated as Fig. 2 in the drawing accompanying this specification.

With the aforescribed arrangement the control characteristic represented by curve A is maintained only under given load conditions, that is, when the load in circuit with the windings of the reactance approximates the maximum capacity value of said reactance. When only a portion of said load is rendered active, that is, when only a part of the number of lamps comprising said load is rendered active; for example, sixty per cent thereof, it has been found that the control characteristic of the reactance deviates considerably from that represented by curve A, such deviation being represented by the curve B. It will be noted from curve B that the same degree of excitation of the reactor control coil for a maximum load and a sixty per cent load respectively, results in widely divergent illumination intensities of the lamps as indicated by the dotted arrows of Fig. 2; furthermore, when the control coil is unexcited, the impedance induced in the reactance by a sixty per cent load is insufficient to reduce the voltage drop across the lamps to a minimum, consequently they will glow a certain amount as represented by point C of curve B.

Obviously, characteristics of control other than those represented by curves A and B would result incident to the load conditions intermediate sixty per cent and maximum, and to those load conditions below sixty per cent.

It is proposed to maintain in the control of a load of variable value a characteristic of control substantially in accordance with that represented by curve A, and it is an object of the present invention to secure such control.

A further object of the invention is that of overcoming the disadvantages of the aforescribed elementary system.

Another and more specific object is to provide a method whereby a predetermined intensity of illumination of the lamps of a given circuit may be insured upon a given setting of the control means, regardless of the load upon the circuit, or in other words, a method whereby variations in the number of lamps which it is desired shall be rendered active may be compensated for to insure a predetermined intensity of illumination thereof upon a given setting of the control means.

Another object is to provide methods of the aforesmentioned character which minimize the skill required for operation of control systems of the character herein described.

Another object is to provide simple and efficient apparatus for performance of the foregoing methods.

Various other objects and advantages of the invention will hereinafter appear.

The accompanying drawing illustrates an embodiment of the invention which will now be described, it being understood that the embodiment illustrated is susceptible of modification without departing from the spirit and scope of the appended claims.

In the drawing,

Figure 1 is a diagrammatic and schematic view illustrative of a system constructed in accordance with my invention.

Fig. 2 is a curve chart, previously mentioned, which graphically represents the control characteristic which it is desired to maintain throughout a wide range of load conditions, as compared with one of the characteristics inherent in an elementary system.

Referring to Fig. 1 of the drawing, the same illustrates a lamp circuit 5, typifying a load circuit to be controlled, said circuit to be supplied from a suitable alternating current source, such as that designated as lines L¹, L². Said circuit comprises a multiplicity of lamps, as for example, spot lights for theatre use, or other portable or

fixed lighting units which may selectively be rendered active or inactive at will, and which it is desired shall be controlled jointly by a single means of intensity control.

5 The means for controlling the illumination intensity of the lamps in circuit 5 includes the reactors 6, 7 of a well-known form comprising the core structures 8 and 8^a, said reactors each having windings 9, 10 and 9^a, 10^a, respectively, 10 and control coils 11 and 11^a. The pairs of windings 9, 10 and 9^a, 10^a are illustrated as being selectively connectable, either individually or jointly in parallel relationship to each other, in series with the lamp circuit 5, whereas each of 15 the control coils 11, 11^a is adapted to be energized from a suitable current source L³, L⁴, preferably of direct current. The potential to be impressed upon the control coils 11, 11^a is adapted to be regulated by a resistance varying rheostat 12. I 20 further provide the resistance varying rheostats 13 and 14, the former being connected in series relation with the rheostat 12 and in parallel relation with the control coils 11, 11^a, and the latter being connected at one end between the rheostat 25 arm 12^a and said control coils, the other end thereof being free; the arrangement of said rheostats being such that variable amounts of resistance are adapted to shunt said control coils to compensate for variations in the number of lamps 30 of circuit 5 which it is desired shall be rendered active, such arrangement providing a compensating flow of current through said control coils which is directly proportional to the value of the load to be controlled, whereby predetermined illumination intensities of a variable number of 35 lamps are insured for given settings of the rheostat arm 12^a, as will be hereinafter more fully described. The circuit of the control coils 11, 11^a further includes the fixed resistance 15 in series 40 with said coils and the rheostat 12, also the fixed resistance 16 in series with the shunt connected rheostat 14.

The amount of resistance required to parallel the control coils 11, 11^a is preselected by means 45 of the selector 17 in accordance with the number of lamps of circuit 5 to be rendered active for a particular lighting arrangement. The selector arm 17^a of said selector is mechanically connected as by means of the gearing 21 and the shaft 22 50 to the rheostat arms 13^a, 14^a of rheostats 13, 14 whereby adjustments in the setting of selector arm 17^a result in corresponding proportional adjustments of said rheostat arms.

The electroresponsive switches 23, 24 are adapted 55 to complete energizing circuits for the lamp circuit 5 through the windings 9, 10 and 9^a, 10^a of the respective reactors 6, 7, said switches being adapted to respond individually or jointly, depending upon the setting of selector arm 17^a, 60 and upon such response to render either one or both of the reactors 6, 7 effective to control the intensity of illumination of the lamps of circuit 5. The selector 17 is provided with the contact segments 18, 19, 20, the segments 18 and 20 extending through an angular distance of approximately 60°, while segment 19 occupies an angular 65 distance of approximately 120°, half of which parallels segment 20; and the same are adapted to effect, in cooperation with the selector arm 17^a, the aforescribed response of the switches 23, 24. Engagement of segment 18 by the selector arm 17^a 70 is adapted to effect response of the switch 23, engagement of segment 19 by said arm is adapted to effect response of switch 24, while simultaneous 75

engagement of segments 19 and 20 is adapted to effect joint response of said switches.

The ratio of gearing 21 is 6 to 1; the angular distance between index marks 3 and 5, between 80 index marks 5 and 8, and between index marks 8 and 13 respectively, is approximately 60°; therefore, movements of selector arm 17^a through each of these arcs of 60° results in a complete cyclic 85 traversal of rheostats 13 and 14 by their respective rheostat arms 13^a and 14^a. However, positioning of selector arm 17^a at the upper ends of the index marks 5, 8 and 13 respectively, results 90 in positioning of the rheostat arms 13^a, 14^a at the points 13^b, 14^b of their respective rheostats. It is apparent that setting of selector arms 17^a at points intermediate the marks 3 and 5, 5 and 8, 8 and 13 will result in positioning of rheostat arms 13^a and 14^a at intermediate points of the rheostats 13 and 14.

As indicated in Fig. 1, the reactors 6, 7 are of 95 different capacities, the respective capacity values of each being, for example, 3 k. w. to 5 k. w., and 5 k. w. to 8 k. w., the pair of them being capable jointly of providing for illumination intensity control of a maximum lamp load of 13 k. w. 100

Fig. 1 illustrates the selector arm 17^a as being set at index mark 3 of selector 17 to provide for control of a lamp load of 3 k. w., which, it may be assumed is comprised of the two lamps of circuit 5 which are illustrated as having their associated 105 switches closed. The arm 12^a of rheostat 12 may be set as shown or may be adjusted to any position desired to preselect an initial intensity of illumination of the lamps rendered subject to control by closure of their respective switches. 110 Upon closure of the switch 25 the lines L¹, L² are energized and the switch 23 responds to a circuit through its winding extending from line L¹ to and through selector arm 17^a, segment 18 of selector 17 and through said switch winding to line L². 115 Response of switch 23 completes an energizing circuit for the lamps rendered active for control, said circuit extending from line L¹ through the lamp switches and said lamps, through the windings 9 and 10 of reactor 6 and through the contacts 120 of switch 23 to line L². The lamps thereupon will glow with the degree of luminosity preselected therefor by the setting of rheostat arm 12^a. The intensity of illumination may thereafter be varied and controlled as desired by manipulation of arm 125 12^a in the usual manner. It will be noted that with selector arm 17^a set at the index mark 3 none of the resistance of rheostats 13 or 14 is inserted in parallel with the control coil 11 and the current through said coil is consequently of a relatively 130 low value, even when the arm 12^a is at full bright position, since the relatively greater proportion of current from lines L³, L⁴ is shunted through the arms 13^a, 14^a of rheostats 13, 14. The value of current in the coil 11, however, due to resistance 135 16 in series with the rheostat 14, is sufficient to excite said coil to a degree adequate to counteract the low value of the impedance created by the small lamp load in circuit, since said load is much below the rated capacity of the reactor. When 140 the arm 12^a is moved to full dim position the voltage across coil 11 is gradually decreased to substantially zero value to provide for full dim or black out condition of the lamps.

As aforesaid, the purpose of varying the current available to the control coils 11, 11^a is to provide an excitation thereof which is varied in accordance with variations in the value of the lamp load to be controlled. Assuming full excitation of the coil 11, that is, assuming that the 150

full potential of lines L³, L⁴ is available to said coil in the control of a 3 k. w. load, the lamps rendered active would be at full bright intensity of illumination when the arm 12 is at full bright position.

5 However, movement of said arm toward the dim position would not result in any appreciable decrease in the illumination intensity of the lamps until a relatively extensive movement of said arm had been effected; furthermore, upon movement
10 of said arm into full dim position, the lamps would glow with a relatively high degree of luminosity, due to the high value of current in the coil 11.

When a lamp load in circuit 5 totaling 4 k. w. is rendered active for illumination intensity control,
15 the selector arm 17^a is set at index mark 4, the rheostat arms 13^a, 14^a consequently assume intermediate positions on their respective rheostats to insert given values of resistance in parallel with the control coil 11. Closure of switch 25 effects
20 the aforescribed response of switch 23 to complete an energizing circuit for the lamps. The resistance thus inserted in parallel with the coil 11 is of such a value that with the rheostat arm 12^a in the full dim position the current in such
25 coil produces a reactance drop in coils 9 and 10 which is sufficient to reduce the voltage of the lamps to a value which just dims them to black, and which, upon subsequent manipulation of the arm 12^a of the rheostat 12 will effect predetermined
30 degrees of luminosity of the lamps for given settings of said rheostat arm between full bright and black out control positions thereof, substantially in accordance with the desired control characteristic represented by curve A of Fig. 2.

35 In the control lamp load of 5 kw. which, in this instance, is the maximum load contemplated for control by the reactor 6, the selector arm 17^a is set at the upper end of the index mark 5; that is, at the end of segment 18. The rheostat arms
40 13^a, 14^a will move with said selector arm and assume positions at points 13^b, 14^b respectively of rheostats 13 and 14 to effect insertion of the entire amount of resistance of said rheostats in parallel with the control coil 11. Substantially
45 the entire potential of lines L³, L⁴ will consequently be available to said coil the degree of excitation of which is then subject to control by the rheostat 12.

The control of lamp loads of 5 kw. to 8 kw. is effected by means of the reactor 7 in a manner similar to that aforescribed in connection with the control of lamp loads of 3 kw. to 5 kw., inclusive, by reactor 6. As aforesaid the switch
50 24 is adapted to respond upon engagement of segment 19 by the selector arm 17^a to render the reactor 7 effective for control of the lamp load rendered active. The rheostat arms 13^a, 14^a assume the respective positions illustrated in Fig. 1 to exclude said rheostats from circuit when the
55 selector arms is set at index 5, that is, the upper end of segment 19. Increasing values of resistance are likewise adapted to be inserted for control of loads over 5 kw., until for control of an 8 kw. load by reactor 7 all the resistance of rheostats 13 and 14 is again included in circuit.

60 In the control of lamp loads of 8 kw. to 13 kw. the selector arms 17^a is adapted, as aforesaid, to simultaneously engage the segments 19 and 20 to effect response of the switches 23, 24 to render the reactors 6, 7 jointly effective for control of the lamp circuit 5. When the selector arm 17^a is set at index 8, that is, at the upper end of segment 20, the rheostat arms 13^a, 14^a again
70 assume the positions illustrated in Fig. 1, wherein the resistance of the rheostats 13, 14 is ex-

cluded from circuit. As described in connection with the control of lamp loads up to 8 kw., given values of resistance are in a similar manner adapted to be inserted in parallel with the control coils 11, 11^a of the respective reactors 6, 7,
80 to provide a current in said coils which is directly in accordance with the value of the lamp loads between 8 kw., and 13 kw. It may be stated in this connection that the lamps shown in circuit 5 may be assumed to represent a total load of
85 13 kw.

The function of the fixed resistance 15 is to insure full-bright illumination intensity of the lamps when the rheostat arm 12^a of rheostat 12 is in full-bright position, regardless of the value of the lamp load rendered active. For example, with a load of 3 kw. on the reactor 6, with the arms 13^a, 14^a in the positions illustrated and with arm 12^a in full-bright position, a relatively high current will flow through arm 14^a, resistance 16, arm 12^a and
90 resistance 15, thus creating a relatively large voltage drop in the latter, and a relatively high reactor impedance. As aforesaid, however, there is a current of relatively low value through the control coils 11, 11^a due to the fixed resistance 16 in parallel therewith, said current being
95 of a value which is adequate to excite said windings sufficiently for control of the small lamp loads, which in this case are 3 kw., 5 kw., and 8 kw. With a load of 5 kw. on reactor 6, with the arms 13^a, 14^a at the points 13^b, 14^b of their respective rheostats, and with arm 12^a at full bright position, a current of relatively low value will flow in the resistance 15, and the consequent voltage drop therein and the impedance
100 of the reactor will be relatively low.

It is apparent from the foregoing that the function of the present system, briefly stated, is to vary the ratio between the value of the resistance of rheostat 12 and the resistance 15 as one quantity and the value of the resistance of the control coils 11, 11^a, rheostats 13, 14 and resistance 16 as the other quantity. Variation of this ratio in accordance with variations in the value of the lamp load to be controlled insures a uniform characteristics of control as represented by the curve A of Fig. 2.

Although the system herein described provides for the control of illumination intensities of a lamp load of variable value in accordance with a predetermined uniform characteristic, it is to be understood that systems of a similar character may be constructed to provide for voltage regulation in accordance with a predetermined uniform control characteristic of substantially any other sort of variable load, such as a group of electric motors, which may be selectively rendered active for operation, and the speed of which it may be desired shall be controlled jointly.

The simplicity with which the aforescribed system may be operated is apparent from the drawing and the foregoing description; it being necessary for the operator only to determine the value of the lamp load rendered active for control and to then position the selector arm 17^a at the index mark of the selector 17 which corresponds to that value. When the lamp circuit is subsequently energized the illumination intensities of the lamps rendered active may be varied thereafter by the manipulation of the rheostat arm 12^a in the usual manner.

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

1. In a system of the character described, in combination, a reactor control winding to be ex-
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cited from a source of substantially constant potential, one end of said winding being connected to one side of said source, a resistance connected across said source, an adjustable member connected to the other end of said winding and movable over a portion of said resistance to vary the excitation of said winding, a second resistance connected in series relation with said first mentioned resistance and in parallel relation with said winding, a second adjustable member connected to one side of said source and movable over said second mentioned resistance, a third resistance connected at one end between said first mentioned adjustable member and said winding, the other end thereof being free, a third adjustable member connected to one side of said source and movable over said third mentioned resistance to provide for inclusion of a variable portion of the latter in parallel relation with said winding and said second mentioned resistance, and means for effecting simultaneous operation of said second mentioned and third mentioned adjustable members, for the purpose set forth.

2. In a voltage regulating system, the combination with a load of variable value to be supplied from a source of alternating current, of a reactor in circuit with said load, the impedance value of which is adapted to be varied to regulate the voltage impressed upon said load, saturation means for said reactor to be excited from a suitable source of current, control means having an element thereof adjustable for varying the excitation of said saturation means, and cooperable control means arranged to vary the degree of energization of said saturation means for given positions of said adjustable element directly in accordance with variations in the value of the load, whereby the controlling effect of said first mentioned control means upon said saturation element may be definitely predetermined regardless of the value of said load.

3. In a voltage regulating system, the combination with a load of variable value to be supplied from a source of alternating current, of a reactance having windings in circuit with said load, saturation means adapted to vary the impedance value of said reactance, said saturation means to be excited from a suitable source of current, control means for varying the excitation of said saturation means, and means cooperable with said control means whereby the control effect of the latter upon said saturation means may be definitely regulated directly in accordance with variations in the value of the load.

4. In a voltage regulating system, the combination with a load of variable value to be supplied from a source of alternating current, of a reactance in circuit with said load, a control coil for said reactance adapted to vary the impedance value thereof, said coil to be excited from a suitable source of current, control means to vary the excitation of said coil, and means associated with said control means to vary the effect of the latter upon said coil directly in accordance with variations in the value of the load, whereby given voltage values for said load may be insured for given settings of said control means.

5. In a voltage regulating system, the combination with a load of variable value to be supplied from a source of alternating current, of a reactor in circuit with said load, the impedance value of which may be varied to regulate the voltage impressed upon said load, a reactor control winding to be excited from a suitable source

of current, a resistance having an adjustable element movable over the same for varying the excitation of said winding, a second variable resistance connected in series relation with said first mentioned resistance and in parallel relation with said winding, a third variable resistance connected at one end between said adjustable element and said winding, the other end thereof being free, said second mentioned and last mentioned resistances being arranged to vary the degree of energization of said control winding for given positions of said adjustable element directly in accordance with variations in the value of the load, whereby predetermined voltage values for said load may be insured for given positions of said adjustable element.

6. In a voltage regulating system, the combination with a plurality of translating devices adapted to be rendered active selectively, said translating devices to be supplied from a source of alternating current, of voltage regulating means for said devices comprising a reactor in circuit therewith, a reactor control winding adapted to vary the impedance value of said reactor, said winding to be excited from a suitable source of current, a resistance in circuit with said winding, an adjustable element movable over said resistance, a second variable resistance connected in series relation with said first mentioned resistance and in parallel relation with said winding, and a third variable resistance connected at one end between said adjustable element and said winding, the other end thereof being free, said second mentioned and last mentioned resistances being arranged to definitely regulate the potential rendered available to said winding, whereby a predetermined control characteristic of said first mentioned resistance may be insured, regardless of the number of translating devices rendered active for control.

7. In a voltage regulating system, the combination with a plurality of translating devices adapted to be rendered active selectively, said translating devices to be supplied from a source of alternating current, a reactance in circuit with said devices, a reactance control coil adapted to vary the impedance value of said reactance, said coil to be excited from a suitable source of current, a rheostat to vary the excitation of said coil, variable resistance means cooperable with said rheostat to definitely regulate the current supply to said control coil to provide variations in the characteristic of said reactance which are directly in accordance with the number of translating devices rendered active for control by said reactance.

8. In a system for controlling the intensity of illumination of a lamp load of variable value, in combination, a plurality of lamps adapted to be rendered active selectively, said lamps to be supplied from a source of alternating current, a reactance in circuit with said lamps, a reactance control coil adapted to vary the impedance value of the latter, said coil to be excited from a suitable source of current, a rheostat to vary the excitation of said coil, and variable resistance means cooperable with said rheostat for definitely preselecting the degree of energization of said control coil directly in accordance with the value of the lamp load rendered active for control.

9. In a system for controlling the intensity of illumination of a lamp load of variable value, in combination, a plurality of lamps adapted to be rendered active selectively, said lamps to be supplied

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plied from a source of alternating current, a reactance in circuit with said lamps, a reactance control coil adapted to regulate the impedance value of the latter, said coil to be excited from a suitable source of current, a rheostat to vary the excitation of said coil, and variable resistance means cooperable with said rheostat to definitely regulate the current available to said coil whereby the characteristic of said reactance may be varied directly in accordance with variations in the value of the lamp load rendered active, the arrangement being such that given intensities of illumination of the lamps are insured for given settings of said rheostat, regardless of the value of the lamp load rendered active.

10. In a system for controlling the intensity of illumination of a lamp load of variable value, in combination, a plurality of lamps adapted to be rendered active selectively, said lamps to be supplied from a source of alternating current, a reactance having windings in circuit with said lamps, a reactance control coil to be excited from a suitable source of current, a control rheostat to vary the excitation of said coil, a second and a third rheostat cooperable with said control rheostat to modify the effect of the latter upon said coil, adjustable members for said latter rheostats to be movable over the same, selective switching means adapted to energize the lamp load rendered active and to render the reactance effective to control said load, means associated with said switching means and said adjustable members whereby movement of said switching means into given positions results in a corresponding proportional movement of said adjustable members into definite positions to provide the aforementioned modification of the effect of said control rheostat in direct accordance with the value of the lamp load rendered active.

11. In a system for controlling the intensity of illumination of a lamp load of variable value, in combination, a plurality of lamps to be rendered active selectively, said lamps to be supplied from a source of alternating current, a plurality of reactances in circuit with said lamps, control coils for the respective reactances to be excited from a suitable source of current, a control rheostat to vary the excitation of said control coils, a second and a third rheostat cooperable with said control rheostat to modify the effect of the latter upon said coils, adjustable members for said latter rheostats to be movable over the same, calibrated selective switching means adapted to energize the lamp load rendered active, said switching means being adjustable to selectively render the reactances effective, individually or jointly, for control of said load, connective means associated with said switching means and said adjustable members whereby positioning of said switching means at given calibrated positions results in corresponding definite positioning of said adjustable members to provide the aforementioned modification of the effect of said control rheostat in direct accordance with the value of the lamp load rendered active.

12. In a method of controlling the intensity of illumination of a lamp load of variable value, wherein the lamps are subjected to a voltage controlled by a reactor, and wherein the impedance value of said reactor may be varied at will to effect such voltage control, the step which consists in definitely modifying the control of said impedance value directly in accordance with the value of the lamp load to be controlled, whereby a predetermined characteristic of voltage control for the lamp load is insured.

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