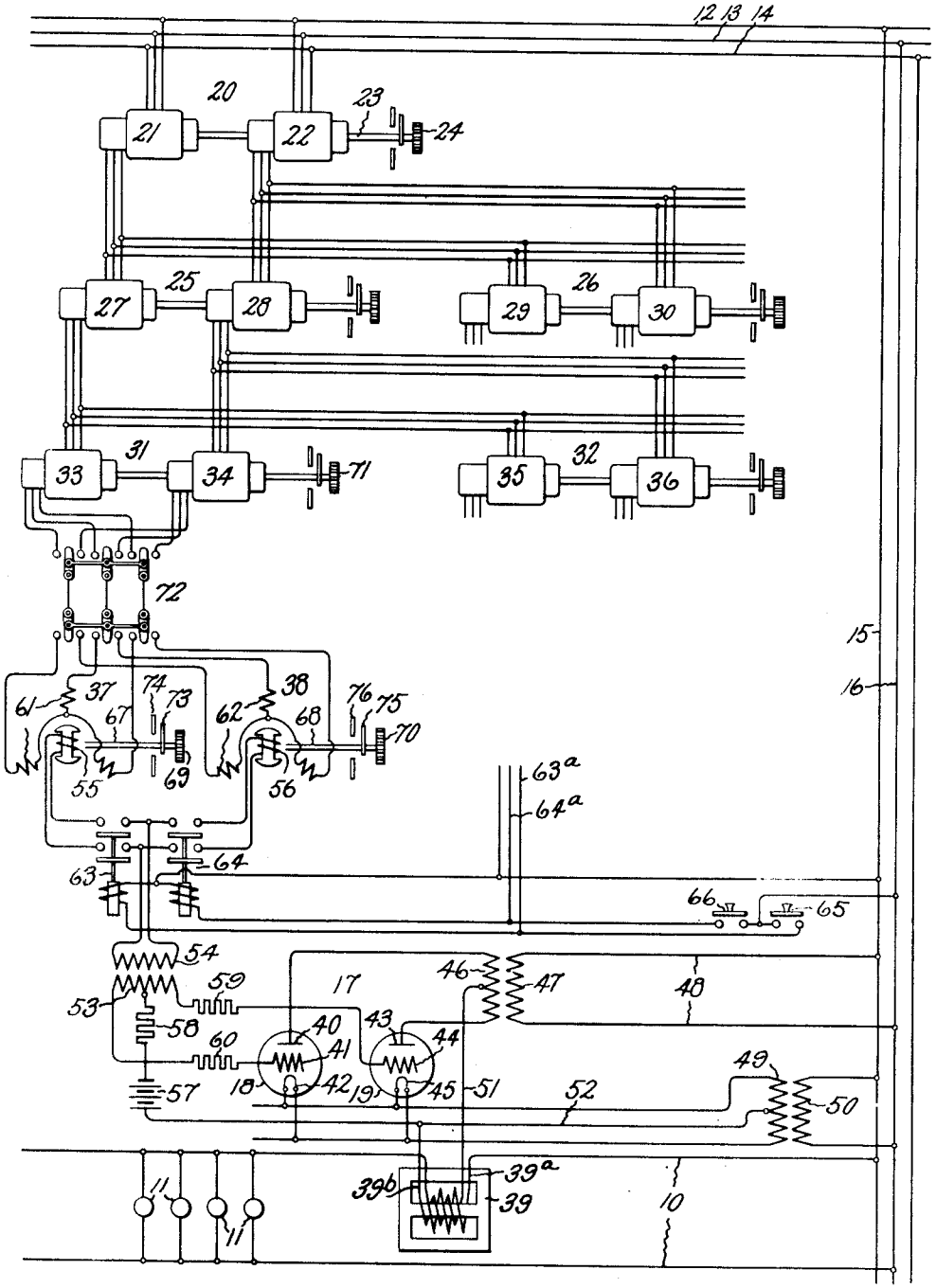
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ILLUMINATION CONTROL SYSTEM

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ILLUMINATION CONTROL SYSTEM

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This invention relates to illumination control systems; more particularly it relates to systems in which each of a plurality of groups of lamps is divided into a plurality of individual circuits and has for an object the provision of a flexible and versatile control system for varying the intensity of illumination of the lamps either by individual control of the lamp circuits or by controlling a group or a plurality of groups of circuits simultaneously.

A further object of this invention is the provision of means for simplifying the illumination control system described and claimed in my copending application S. N. 374,592 filed June 28, 1929 of which this invention is an improvement.

In carrying this invention into effect in one form thereof, I provide a separate electric discharge device in connection with each individual lamp circuit for controlling the intensity of illumination thereof, together with an electrical control device and purely electrical connections between the control device and a plurality of the electric discharge devices by means of which certain lamp circuits may be dimmed and certain other lamp circuits brightened in response to a single operation of the control device.

In illustrating my invention in one form thereof, I have shown it as embodied in an illumination control system particularly adapted for controlling the intensity of illumination of the lighting system of a theater in which the aggregate of lamps are divided into color groups, each of which is divided into sub-groups, each of the sub-groups in turn being divided into a plurality of individual lamp circuits across which are connected one or more lamps.

For a better and more complete understanding of my invention reference should now be made to the accompanying drawing, the single figure of which is a diagrammatic representation of an embodiment of my invention.

In a theater lighting system, it is necessary that the intensity of illumination of the lamps be variable in various groups, and in combinations of groups and sub-groups from full brilliancy of the lamps to complete darkness thereof, for the successful production of desired lighting effects for various scenes such, by the way of example as sunrise, sunset, moonrise, and storm scenes.

Referring now to the drawing, the total aggregate of lamps in the theater are divided into a plurality of color groups which in turn are sub-divided into a plurality of sub-groups, each of which comprises a plurality of individual circuits such for example as that represented in the drawing by the two conductors 10 across which are connected a plurality of lamps 11. The circuit 10 may be an individual circuit of any color group, for example the red group. Alternating current is applied to the lamps 11 from any suitable source of supply such for example, as the two lines 12 and 13, to which the circuit 10 is connected by the two conductors 15 and 16 respectively and which as shown in the drawing constitute one phase of a three phase supply line represented by the three conductors 12, 13 and 14.

A separate control device 17 comprising the two electric discharge devices 18 and 19, constituting a full wave rectifying device is provided for controlling the intensity of illumination of each individual lamp circuit in the entire system. The intensity of illumination of each individual lamp circuit is controlled by controlling the phase relationship between the potentials applied to the input and to the output circuits of the control devices 17 which control may be effected from any one of a plurality of points so as to control the lamps in groups or sub-groups as desired. Simultaneous control of the intensity of illumination of all the lamp circuits in the system is afforded by a "grand master" controller 20 which consists of two polyphase phase-shifting transformers 21 and 22, each of which is provided with a three phase primary winding and a three phase secondary winding. The primary windings of the phase shifting transformers are connected to the polyphase source of supply 12, 13 and 14 for opposite phase rotation, as shown, and their secondary windings are mounted upon a common shaft 23

in inductive relation with their respective primary windings so that they may be rotated with respect thereto by the knob 24 to control the phase relationship between the input and output potentials of the individual devices 17 with which the secondaries of transformers 21 and 22 are operatively connected.

Separate control of each color group is effected by a plurality of "color masters" such for example as the controllers 25 and 26 interposed in the connections between the grand master 20 and the control devices 17. The color master 25 consists of two polyphase phase shifting transformers 27 and 28 similar to devices 21 and 22, the primary windings of which are respectively connected to the secondary windings of the transformers 21 and 22 of the grand master controller, while the color master 26 consists of two polyphase phase shifting transformers 29 and 30 connected respectively to the transformers 21 and 22 of the grand master. The color master 25 may for example provide independent simultaneous control over all the individual red lamp circuits and the color master 26 may control all the blue lamp circuits. It is to be understood that there will be a separate color master for each color group of lamps in the system.

Each color group of circuits is in turn divided into a plurality of sub-groups and a plurality of separate group masters such as the controllers 31 and 32 are provided in the connections between each color master and sub-groups of control devices 17 in that particular color group, whereby one or more sub-groups in a particular color group may be independently controlled. The group master 31 consists of two polyphase transformers 33 and 34 respectively connected to the secondaries of the transformers 27 and 28 of the color master 25 and likewise group master 32 consists of two polyphase transformers 35 and 36 similarly connected to the color master 25.

Lastly a separate pair of controllers 37 and 38 is provided in connection with each control device 17 to provide individual control for each lamp circuit in the system.

The output circuit of each electric discharge rectifying device 17 is operatively connected to the individual lamp circuits through the agency of a variable reactance comprising a soft iron core 39 having a reactive winding 39*a* wound thereon which is connected in the circuit 10 in series relationship with the lamps 11. The core 39 is further provided with a control or saturating winding 39*b* connected in the output circuit of the full wave rectifying device 17, shown in the drawing as the two electrostatically controlled vapor electric discharge devices 18 and 19 of the type marketed under the trade name Thyratron. This type of electric discharge device is a three electrode tube differing from the ordinary three element vacuum tube in that after exhaust a small quantity of an inert gas such for example as mercury vapor is introduced into the envelope, the presence of which changes the pure electron discharge from the cathode into an arc stream so that the device becomes an electrostatically or grid controlled arc rectifier.

In the drawing the tube 18 is provided with an anode 40 a grid 41, and filamentary cathode 42; the tube 19 being provided with similar elements designated by the reference numerals 43, 44 and 45 respectively. As shown these tubes are connected in a well understood manner for full wave rectification i. e. an output circuit for the rectified current of the tube is provided by connecting the anodes 40 and 43 to the opposite terminals of the secondary winding 46 of an anode transformer, the primary winding 47 of which is connected by conductors 48, 15 and 16 to a suitable source of supply such as the phase 12—13 of the three phase supply line 12—13—14. The filamentary cathodes 42 and 45 are heated by current supplied thereto from the terminals of the secondary winding 49 of a filament transformer, the primary winding 50 of which is supplied with alternating current from the phase 12—13 of the supply source 12—13—14 by conductors 15 and 16. The output circuit of the rectifier also includes the control or saturating winding 39*b* of the variable reactance of the lamp circuit 10, opposite terminals of the winding 39*b* being connected to the mid points of the secondary winding 46 of the anode transformer and to the mid point of the secondary winding 49 of the filament transformer by the conductors 51 and 52 respectively.

The grids 41 and 44 of each pair of electric discharge devices, i. e., each full wave rectifying device are connected to opposite terminals of the secondary winding 53 of a grid transformer, the primary winding of which may be supplied with a single phase alternating potential from either of the single phase secondary windings 55 or 56 of the individual biasing transformers 37 and 38 repectively.

A slight negative bias is imparted to the grids 41 and 44 by biasing or "C" battery 57, the positive terminal of which is connected to the mid point of the secondary winding 53 of the grid transformer through current limiting resistor 58. Protective current limiting resistors 59 and 60 are interposed in the connections between the grids 44 and 41 and the terminals of the secondary of the grid transformer to prevent destruction of the grids by the passage of heavy currents.

As is well understood by persons skilled in this art, the time of starting of the output

current of a vapor electric discharge device such as the device 17 with respect to the beginning of each half cycle of the wave to be rectified, can be controlled by the grid. After starting, the grid has no further control over the arc either to modulate, to limit or to extinguish it; the instantaneous value of the magnitude of the current depending almost entirely upon the impedance of the external circuit. However, since the time of starting can be controlled in each half cycle, it is clear that the average value of the current in the output circuit can be controlled and as a result of this control in the particular connections shown in the drawing, the value of the current in the saturating winding 39*b* of the reactance, the value of the reactance itself and likewise the value of the current flowing in the lamps 11 may be controlled.

Accordingly the terminals of the distributed three phase primary windings 61 and 62 of the biasing transformers 37 and 38 respectively are supplied with a three phase potential derived from the three phase supply source 12, 13, 14 through intermediate connections and devices, the functions and operations of which will be described more fully hereinafter.

The terminals of the primary winding 54 of the grid transformer may be connected to either of the single phase secondaries 55, 56 of the biasing transformers depending upon which of the two "scene change" contactors 63, 64 may have been actuated to the closed position in response to depression of either of the "scene change" switches 65 and 66; it being understood that only one of the two contactors 63 or 64 may be closed at any one time.

Although but a single pair of scene change contactors 63, 64 is shown in the drawing, it is to be understood that there will be a similar pair of contactors for each individual lamp circuit in the entire system, as indicated by the open end connections 63, 64*a*, and that all of these pairs of contactors operate simultaneously in response to depression of the push buttons 65, 66 in the manner already described for the pair of contactors 63, 64.

In the following discussion it will be assumed that scene switch 65 has been depressed and that scene change contactor 63 has been operated to the closed position in response thereto.

Persons skilled in the art will understand that when the terminals of a distributed three phase winding such as the winding 61 is connected to a three phase source of supply that a resultant magnetic field will be set up which will rotate in space at synchronous speed. Consequently a single phase coil such as the coil 55 placed in an inductive relation with the distributed three phase winding 61 will have an alternating current induced therein which will be of a frequency depending upon the speed of rotation in space of the rotating field, which is to say the frequency of the induced current will be a function of the frequency of the supply source 12, 13, 14. Coils 55 and 56 are rotatably mounted upon shafts 67 and 68 respectively and hence the time phase of the voltages induced in either of these coils and supplied by them to the grids 41 and 44 may be varied as desired with respect to the potentials supplied to the anodes 40 and 43, by the simple expedient of rotating the shafts 67 and 68 by means of the knobs 69 and 70 with which the shafts are provided.

At this point in the specification it is desired to emphasize that for each individual lamp circuit 10 in the entire system there is a control unit similar to that just described in detail. Thus it will become apparent that rotation of the secondary 55 of the biasing transformer with respect to its primary winding 61 will vary the phase relationship between the grid and anode potentials, the rectifying output current flowing in the control or saturating winding 39*b* of the reactor, and also the reactance of the reactor itself and the intensity of illumination of the lamps 11. When the grid and anode voltages are exactly in phase, the rectified output current will be maximum, the reactance of the reactor minimum, and the intensity of illumination of the lamps 11 maximum; whilst when the grid potential lags the anode potential by 180 electrical degrees, the output current flowing in the saturating winding is minimum, the reactance of the reactor maximum, and the intensity of the illumination of the lamps 11 minimum. Thus by rotation of the knobs 69 the intensity of the illumination of lamps 11 may be varied from maximum brilliance to complete darkness, or vice versa.

In a theater illumination system it is also often necessary during certain scenes to vary the intensity of the illumination of large numbers of the lamps simultaneously. For example in a sunrise scene, it might be necessary to dim all the blue lamps and simultaneously to brighten all the red lamps. The individual circuits in such a system are as a general rule so numerous that it will at once be apparent that simultaneous control of large numbers of these groups may only be effected by remote control devices controlling the circuits in groups. Another requisite for a successful theater lighting system is the ability to preset the "next scene" during the "present scene".

In the system shown in the drawing remote control of the phase relationship between the grid and anode voltages of each control device 17 and consequently of the intensity of the illumination of the individual lamp circuit associated therewith is

effected by remote phase shifting devices interposed in the connections between the source 12, 13, 14 and the ultimate biasing transformer 37 or 38 associated with each individual lamp circuit. These remote phase shifting devices are the grand master 20, color masters 25, 26 etc., group masters 31, 32 etc. which have been described at a previous point in this specification.

From the connections described above, it will be clear that the voltages induced in the secondary windings of the transformers 33 and 34 comprising the group master 31 will be of opposite phase sequence since the transformers 21 and 22 of the grand master 20 to which they are respectively connected are connected with the net 12, 13, 14 for opposite phase sequence as indicated in the drawing.

With the above understanding of the various elements and control devices comprised in a system embodying my invention, the invention itself both as to its organization and manner of operation will readily be understood.

It will be clear from what has already been described of the operation of the system that manual operation of the knob 69 (assuming scene change contactor 63 to be operated to the closed position) will vary the intensity of the illumination of the lamps connected across an individual circuit 10 either from full brilliancy to complete darkness or to full brilliancy by one half turn of the knob.

If it be desired to vary the intensity of illumination of all the circuits in a group simultaneously this may be done by rotating the knob of the group master which is connected to the control devices of the group of circuits, the intensity of illumination of which it is desired to vary. For example, let it be desired to vary the intensity of illumination of all the individual lamp circuits associated with group master 31 which it will here be assumed is one of the group masters belonging to the red color group, and controls a plurality of individual red lamp circuits such as the circuit 10. The upper contacts of all the direction switches 72 will be actuated to the left hand position to connect each of the "present scene" biasing transformers 37 in that group to the transformer 33 of the group master 31.

Rotation of knob 71 will then vary the position in space of the secondary of transformer 33 with respect to its primary, and as a result the time phase of the rotating magnetic fields of the windings 61 of each biasing transformer 37 in the group, the time phase of the voltages induced in the secondary windings 55 and the phase relationship between the potentials supplied to grids and anodes of each thyratron in the group will be varied in the same proportion and the effect of varying the time phase relationships between the grid and anode potentials will effect variation of the average values of the current in the output circuits of each of the vapor electric devices and consequently a proportional variation of the intensity of illumination of each of the circuits 10 in the group.

If the rotation of knob 71 just described resulted in brightening of the lamps (and this will be assumed here) with the direction switches 72 actuated to the left hand position to connect the individual phase biasing transformers 37 to the transformer 33 of group master 31, then it will be clear that rotation of the knob 71 in the same direction would have effected dimming of the lamps had the switches 72 been actuated to the right hand position to connect the individual biasing transformers 37 to transformer 34 of group master 31. This is because the phase sequence of transformer 34 is the opposite of the phase sequence of transformer 33, which is due to the fact that the transformers 21 and 22 of the grand master to which the transformers 33 and 34 of the group master are connected respectively, are connected to the net 12, 13, 14 for opposite phase rotation. Thus it will be seen that all the lamp circuits comprising a group may either be brightened or dimmed responsively to uni-directional rotation of the shafts of the group masters.

Should it be desired to vary the intensity of illumination of an entire color group, this may be done by manipulation of a color master in the manner just described for the group masters. For example let it be assumed as before that the color master 25 is the red color master. Since this color master controls all the red group masters 31, 32 etc. which in turn control all the individual red circuits in the theater, it will be seen that operation of the red color master which is to say rotation of the secondary winding of the color master with respect to its primary winding will be effective to vary the phase relationships between the input and output potentials of all the electric discharge devices controlling red circuits, and in a direction to brighten or to dim these circuits as determined by the setting of the direction switches 72 for each individual circuit as explained above.

Quite obviously manipulation of the knob 24 of the grand master 20 which connects through the color masters and group masters to all of the individual circuit controllers will be effective to simultaneously vary the intensity of illumination of every lamp circuit in the theater in a manner similar to that just described for the group masters and the color masters.

A theater illumination system must be sufficiently flexible to permit of increasing the brilliance of certain circuits or groups of

circuits simultaneously with decreasing brilliance of certain other circuits or groups of circuits. For instance in a sunrise scene, it may be required to dim the blue group simultaneously while increasing the intensity of illumination of the red and white groups whilst in the production of sunsets or approaching storm scenes, exactly the reverse variation of lighting effects may be required. These simultaneous reverse effects for the different groups may easily be accomplished in my system as follows:

Assume that each of the knobs 69 for each individual phase biasing transformer for all of the individual lamp circuits of one or more entire color groups, for instance the red and white color groups, have been rotated to the position for maximum dimness and that all of the knobs 69 of the individual circuits of the remaining color groups have been pre-set for maximum brilliance as indicated by the pointers 73 which cooperate with suitably calibrated scales 74. Then by operating all of the direction switches 72 for all the individual circuits of the red and white color groups to the left hand position and allowing the direction switches 72 for the individual circuits of the remaining color groups to remain in the right hand position, rotation of the knob 24 of grand master 20 will effect increasing intensity of illumination of all the red and white circuits and decreasing intensity of illumination of all the individual circuits of the remaining color groups.

Presetting of the "next scene" during the "present scene" may be accomplished by rotating the secondaries 56 of the idle biasing transformers 38 for the desired degree of illumination of each individual circuit as indicated by the pointers 75 which cooperate with suitably calibrated scales 76. When the scene change is to be made the "present scene" switch 65 is operated to the open position thereby de-energizing and opening all of the scene changing contactors 63 in the system whilst the "next scene" switch 66 is operated to the closed position thereby energizing and operating all of the scene change contactors 64 to the closed position thereby connecting the secondaries 56 of all of the phase biasing transformers 38 to the primary windings 54 of their respective grid transformers for all of the individual circuits in the system. The lower contacts of the direction switches 72 will then be operated to the righthand position to connect the phase shifting transformers 38 to the group masters with which they are associated. Thereafter, the desired remote control of circuits either individually, by sub-groups, groups, and combinations of groups and sub-groups may be effected by manipulation of the group masters, color masters or grand master in the manner explained above.

It will be clear to persons skilled in this art that almost an infinite variety of lighting effects may be produced by the system just described; the few combinations which have been described in detail being merely for the purpose of illustration.

Although in accordance with the provisions of the patent statutes, I have disclosed and explained the best form of the invention now known to me. I would have it understood that the invention is not limited to the exact form illustrated since modifications, alterations, and equivalent arrangements will readily suggest themselves with persons skilled in the art without departing from the true spirit of my invention or from the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an illumination system, a lamp circuit, an electric discharge device provided with an input circuit and with an output circuit operatively associated with said lamp circuit, a pair of polyphase electrical devices for supplying alternating electromotive forces having opposite phase sequence to said input circuit, and a switching device for selectively connecting said input circuit with said devices.

2. In a theater illumination control system, a lamp circuit, an electric discharge device provided with an input circuit and with an output circuit operatively connected with said lamp circuit, means for supplying an alternating potential to said output circuit, means comprising a polyphase source, a pair of transformers each having a polyphase primary connected to said source and a polyphase secondary for supplying an alternating potential to said input circuit, said primaries being connected to said source for opposite phase sequence means mounting said secondaries for rotation with respect to said primaries for controlling the phase relationship between said input and output potentials and means for selectively connecting said input circuit with said secondaries.

3. An illumination control system comprising a lamp circuit, an electric discharge device provided with an input circuit, and with an output circuit operatively connected to said lamp circuit, means for supplying an alternating potential to said output circuit, means comprising a polyphase source of power, a transformer having a polyphase primary connected to said source and a single phase secondary connected to said input circuit for supplying an alternating potential to said input circuit, means including a pair of polyphase transformers interposed in circuit between said first mentioned transformer and said source for varying the phase relationship between said input and said output circuits, and a switching device for selectively connecting said first mentioned transformer with said polyphase transformers;

the secondaries of said polyphase transformers being rotatably mounted on a common shaft, and their primaries being connected to said source for opposite phase rotation.

4. In an illumination control system, a polyphase source, a pair of polyphase transformers having their primaries connected to said source for opposite phase sequence, and having their secondaries mounted on a common shaft for rotation with respect to their primaries, a lamp circuit, an electric discharge device provided with an input circuit and with an output circuit operatively associated with said lamp circuit, means for supplying an alternating potential to said output circuit, and means for supplying an alternating potential to said input circuit, said means comprising a third transformer having a polyphase primary and a single phase secondary connected to said input circuit and a switching device for connecting said third transformer with either of the transformers of said pair.

5. In an illumination control system, an electric discharge device provided with an input circuit and with an output circuit, a lamp circuit operatively connected with said output circuit, means for supplying an alternating potential to said input circuit, means comprising a three phase source of power, a transformer having a three phase primary, a single phase secondary connected to said input circuit, and connections between said primary and said source for supplying a resultant single phase voltage to said input circuit, means comprising a pair of three phase transformers interposed in said connections for varying the phase relationship between said input potential and said output potential, said transformers being connected for opposite phase sequence and having their secondaries rotatably mounted upon a common shaft to effect oppositely directed displacements of said resultant voltage, and a switching device for selectively connecting said first mentioned transformer with said pair of transformers.

6. In an illumination control system the combination with a lamp circuit of an electric discharge device provided with an input circuit and with an output circuit operatively assocaited with said lamp circuit, means for supplying an alternating potential to said output circuit, a biasing transformer having a three phase primary winding and a single phase secondary connected to said input circuit, a three phase source of power and a pair of three phase transformers having their primaries connected to said source for opposite phase sequence, a connecting device for selectively connecting said biasing transformer with one of said pair of transformers, and a common shaft mounting the secondaries of said pair of transformers for rotation with respect to their primaries, whereby uni-directional rotation of said shaft effects oppositely directed displacements of the potential applied to said input circuit with respect to the potential applied to said output circuit.

7. In an illumination control system, a plurality of lamp circuits, a control unit for each of said circuits, each of said units comprising an electric discharge device provided with an input circuit and with an output circuit operatively connected to said lamp circuit, means for supplying an alternating potential to said output circuit, and a polyphase biasing transformer having its secondary connected to said input circuit for supplying a resultant potential thereto; a pair of polyphase transformers connected for opposite phase rotation, connections between all of said biasing transformers and said pair of transformers, a plurality of pairs of polyphase transformers interposed in the connections between groups of said biasing transformers and said first mentioned pair of transformers for controlling the phase relationship between the potentials supplied to said input circuits and said output circuits selectively in groups.

8. A theater lighting system comprising a plurality of individual lamp circuits, a control device for each of said circuits, each of said devices including an electric discharge device provided with an input circuit and with an output circuit connected to said lamp circuit, means for supplying an alternating potential to said output circuit, and a polyphase biasing transformer having a single phase winding connected to said input circuit for supplying an alternating potential thereto; means for simultaneously varying the phase relationship between said input and output potentials, said means including a polyphase source of power, a pair of polyphase transformers connected thereto for opposite phase sequence and connections between said biasing transformers and said pair of transformers, means comprising a plurality of pairs of transformers interposed in said connection between groups of said biasing transformers and said pair of transformers for selectively controlling said lamp circuits in groups, a common shaft mounting the secondaries of each of said pairs of transformers for rotation with respect to their primaries whereby uni-directional rotation of said shaft effects oppositely directed displacement of the anode and grid potentials of the electric discharge devices controlled thereby.

In witness whereof, I have hereunto set my hand this 24th day of July, 1929.

ALLEN E. BAILEY, JR.