Jan. 23, 1951

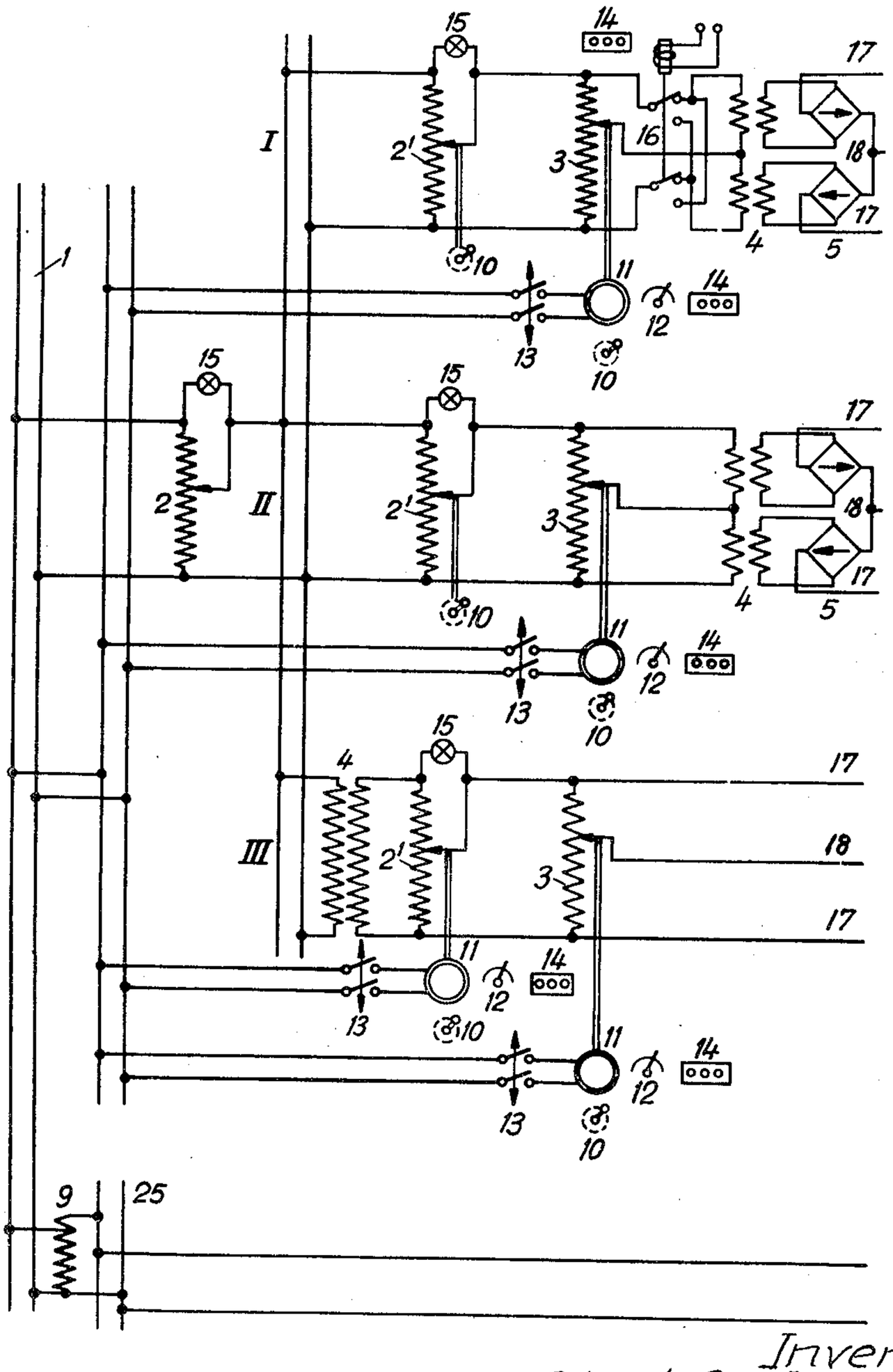
A. ARVIDSSON ET AL
LIGHTING REGULATION SYSTEM FOR
THEATER LIGHTING AND THE LIKE

2,539,111

Filed June 3, 1949

2 Sheets-Sheet 1

FIG. 1a.



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2 Sheets-Sheet 2

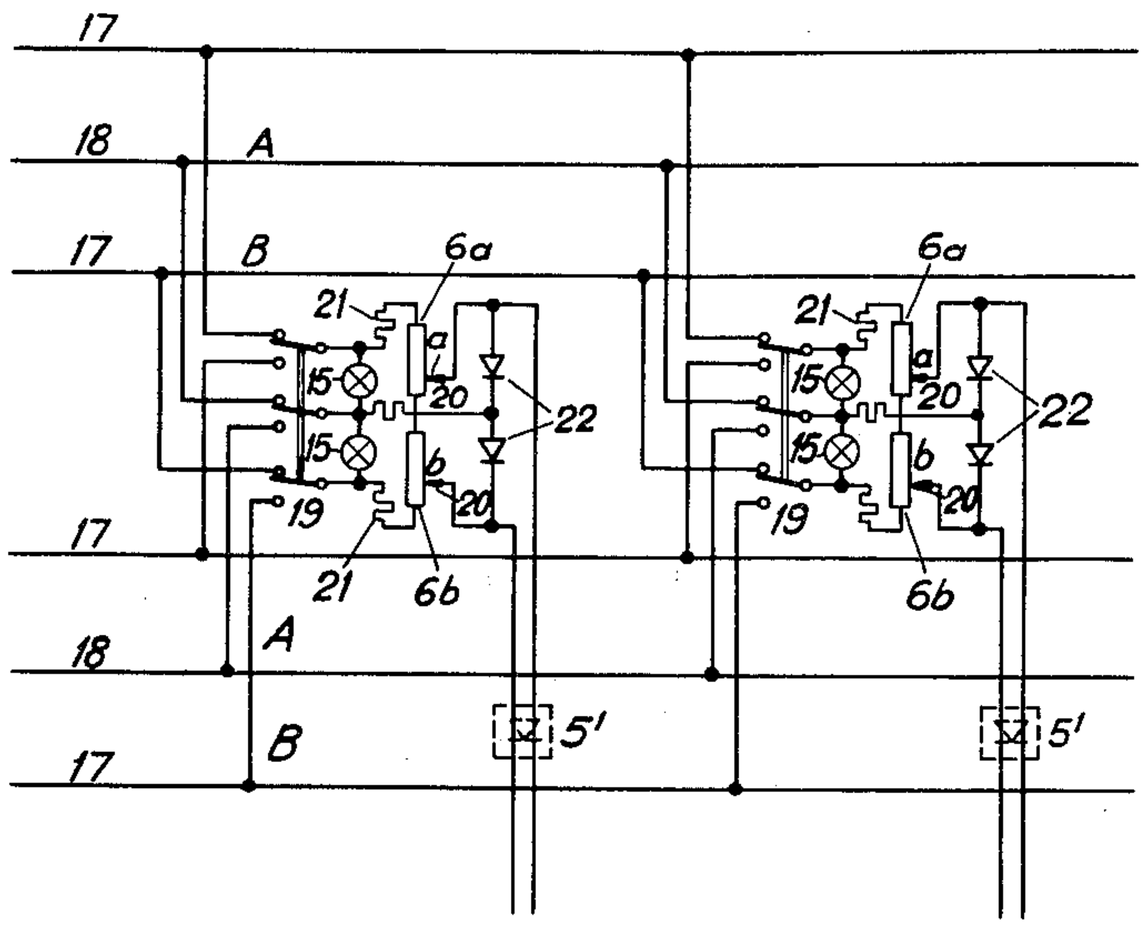
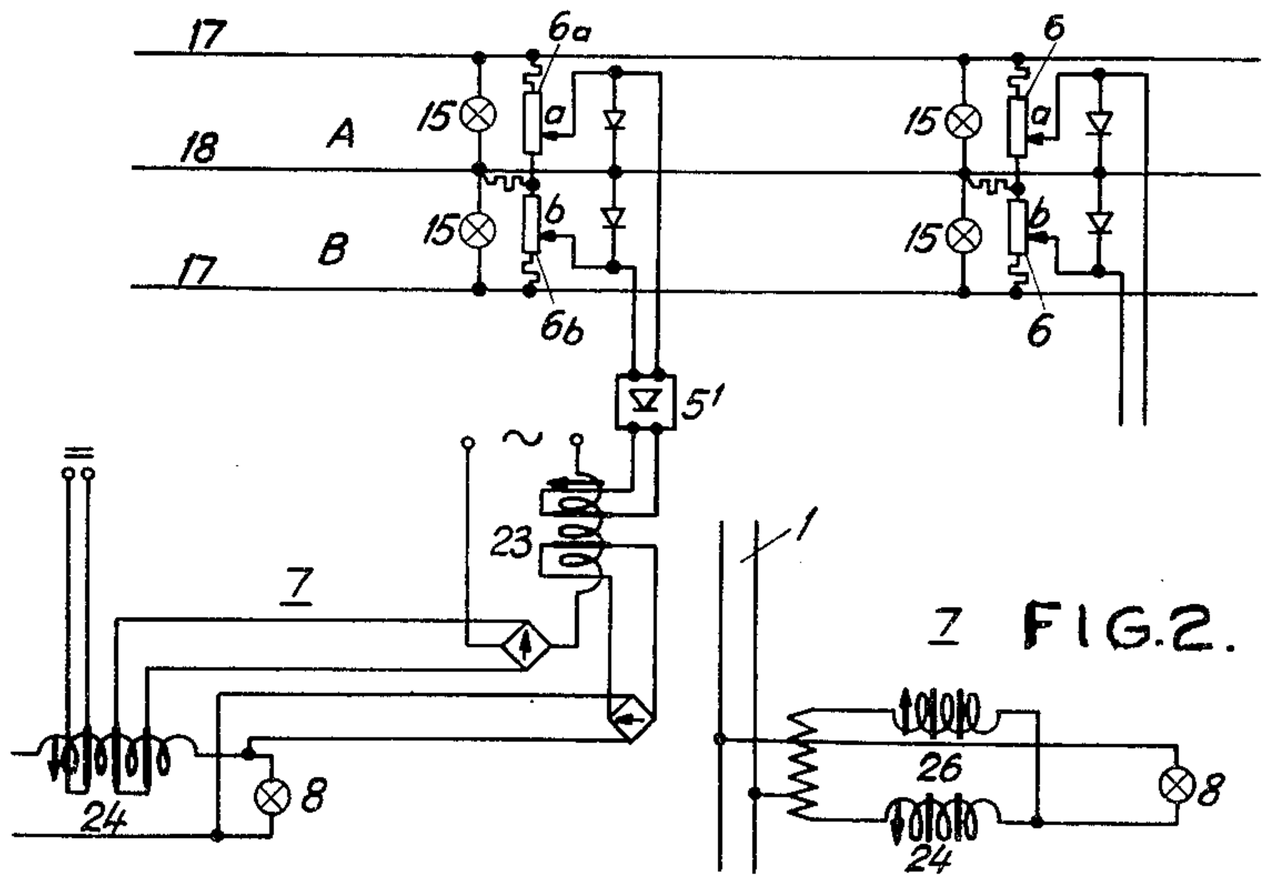


FIG. lb.



7 FIG. 2.

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LIGHTING REGULATION SYSTEM FOR THEATER LIGHTING AND THE LIKE

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18 Claims. (Cl. 315—100)

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In the lighting regulation in theaters, cinemas other rooms, where the setting and changing of the luminous intensity of a large plurality of lamp units in accordance with a predetermined programme is concerned, at present use is preferably made of transductors, since their favourable qualities are especially pronounced for this purpose.

On the other hand, also regulation systems are known in which the luminous intensity of the lamp units or lamp groups—in the course of the description briefly designated "lamps"—are controlled by means of thyratron circuits. These systems, however, have some disadvantages. The tubes have limited life, the supplying voltage of the system must be transformed with respect to optimal plate voltage and power line harmonics require the provision of especial attenuation and filtering means. Furthermore, stray capacitance currents flowing in the grid circuits must be shielded. Considering this, the fact that the transductors do not work completely inertnessless is of less importance, because the minimal delay of time which occurs due to current variations within an inductive circuit viz. in the direct current windings of the transductors is practically of no account with respect to the own inertia of the lamps.

The object of the present invention is to provide a system for the regulation of the illuminous intensity, particularly in theater lighting, in which by virtue of a combination of devices and means, and by their co-operation a system is created which to a high degree fulfils all demands for simplicity, reliability, and handiness which are made upon the modern lighting technique in this domain. The new system is distinguished by surveyability, simple maintenance, and long life of the particular apparatus. These advantages are obtained by the new and useful combination of connection-elements and means partly known per se in the art.

The purpose of the invention is to accomplish a lighting programme consisting of a plurality of lighting scenes and in which the circuits may be subdivided into several lighting groups.

Apparatus used in the system and its connections will appear from the following description in connection with the accompanying drawing by way of example wherein three control circuit groups for the dimming and the scene-to-scene changing are shown. Obviously, the invention is not limited to the connections shown.

Figs. 1*a* and 1*b* combine and constitute a wiring diagram illustrating schematically the principal control means and the wiring connections thereto, Fig. 1*a* showing the left-hand half of the diagram and Fig. 1*b* showing the right-hand half thereof. Fig. 2 illustrates as modification of the current control means for one lamp circuit.

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The constituent parts of the system according to the invention are elements which, in accordance to their purposes, will be designated as follows, in order to facilitate the description:

(1) Dimmers, i. e. potential dividers which cause the supplying voltage to be altered between zero and a maximum value, whereby the light in the complete system or in the individual circuit groups may be dimmed.

(2) Scene-to-scene faders, i. e. potential dividers which cause continous variation between zero and maximum value of the voltage supplied to each scene circuit. Thereby the circuit to each scene alternately may be established or short circuited, that is "faded."

(3) Selectors, i. e. voltage selecting means, such as rheostats or potential dividers, by means of which the voltages applied to the individual lamps may be selected.

(4) Lighting intensity regulators, i. e. current regulating means such as transductors, the direct current windings of which are supplied with the comparing voltages for the control voltages of the particular lamps. Thereby the luminous intensity of the lamps may be regulated.

On the accompanying drawing, exemplifying the invention in a network where the control current source is an alternating current source, **1** designates the supplying network, **2** a dimmer for the total system, and **2'** are dimmers for the assumed three control circuit groups; **3** are scene-to-scene faders, **4** insulating and step-down transformers, each comprising two separate transformer units but having their primary windings connected in series, and common mid tappings connected to the movable contacts of the dimmers, **5** are rectifiers, **6** selectors, **7** the intensity regulators, each associated with one lamp, the luminous intensity of which may be controlled. Only one said current regulating means is shown on the drawing exemplified on a transductor arrangement and connected to the selectors, and on the lower right hand part of the drawing an alternative embodiment of such transductor arrangement is illustrated schematically. **9** is a transformer having an additional winding for the main transductors of the intensity regulators **7**. Further auxiliary means which are important for the invention will be explained as the description proceeds.

According to the invention, the dimmers 2 and 2', respectively, are of the auto-transformer type in which movable contacts slide along bare winding parts. These auto-transformers, compared with rheostats, have the advantage to be adapted to apply to the scene circuits voltage components, which have a constant well defined ratio with respect to the voltage supplied, and to consume less power. The dimmers may be controlled manually or electrically. The apparatus required for this purpose is shown diagrammatically. 10 thus are hand wheels for manual control; 11 are motors having regulators 12 and start relays 13 as well as push-button control 14. 15 designates signal lamps.

The scene-to-scene faders 3, which also may be operated manually or electrically, have the purpose to successively decrease the voltage across the one scene circuit, such as A, while it in a corresponding degree increases the voltage across the other, such as B. Owing to the structure of the system, the changing-over is made entirely continously. If it is desired that the intensity of certain lamps should not be changed during the changing-over, this is accomplished by setting the contacts *a* and *b* of the selectors 6 into the same position. It will be remembered that it is a feature of this fader type, that the sum of the two voltage components applied always is constant, so that the voltage across one part of the selector increases as fast as the voltage across the other decreases during the changing-over. Since under certain conditions it may be desirable to accomplish the change instantaneously, there is provided a switching-over device 16, which also may be controlled either manually or by the push-button control 14.

The transformers 4 are arranged to supply their individual dry plate rectifiers 5, which are connected with each other on the direct current side in such a manner, that there are formed two lighting scene circuits A and B, comprising two separate outers 17 and a common middle wire 18. In the diagram of connections shown, the whole system is divided into three control circuit groups I, II, and III, for obtaining groupwise control. The lower circuit III on the drawing, for instance, is provided for flood-lights and foot-lights in the auditorium, whereas the lamps on the stage within the upper two main circuits I and II may be distributed individually as one desires. Before each selector 6 associable with the two circuits, therefore a change-over switch 19 is inserted, by which the desired change-over circuit may be selected. This is an appreciable measure of convenience in order to avoid changing-over too many selectors in changing the light of a less number of lamps, or in order to allow the dimming of certain lamps while the others remain undimmed.

The selectors 6*a* and 6*b*, respectively, for each scene and lamp are connected in series between the outers 17. The interconnectors of the selectors are connected to the common middle wire 18. As previously mentioned, the tension is successively taken off from the selectors 6*a* and 6*b*, respectively, so that one scene may be set while the other is in progress. By means of the two movable contacts 20*a* and 20*b* the comparing voltages are applied from the selectors to the transductor arrangements 7. Therefore the voltage supplied from the dimmer over the fader will lie across the preset range of the selector 6*a* in one lighting scene and across the preset range of the selector 6*b* in the future scene or vice versa. By this also the comparing voltage for the transductor arrangement and therefore for the lamp will be determined in one scene by the position of the contact 20*a* on the selector 6*a*, and in the future scene by the position of the contact 20*b* on the selector 6*b*.

The luminous intensity of one lamp thus having been set by means of the selector to, let us say, 30 per cent in one scene, and to 80 per cent in the future scene, the light will be varied continously during the changing operation and approximately with constant speed between the mentioned values. It is clear that the changing-over of all lamps which are connected with the same fader takes the same time, independent of how much the luminous intensity, as viewed percentually, is altered, with the result, that the luminous intensity is changed with different speed for the individual lamps, dependent on the magnitude of the variation which has been set. By this way, all sudden changes in the intensity both of the particular lamp units and of the total stage illumination are avoided, and this is an effect of considerable value which could not be attained with earlier types of controls using levers with stops.

Uni-directional valves 22, such as selenium rectifiers, inserted between the conductors from the selectors 6*a* and 6*b* and the common middle conductor 18 have the purpose to shunt the current flowing to the transductor arrangements 7 across that selector which is ineffective during the actual scene but is being switched in for the next scene.

In order to enable the idle lever on either selector 6*a* or 6*b* to be moved without perceptible fluctuations in the illumination as the valves 22 do not work fully perfectly, and in order to obtain absolutely linear changing-over of the light from one scene to the future scene, series resistances 21 are inserted in the feeders before the selectors, 6*a* and 6*b*, respectively, and before their junction points. By suitably dimensioning the series resistances, it is possible to avoid said valves 22. In this case it is also possible to dispense with the rectifiers 5, and instead of them to insert rectifiers 5' (designed by dotted lines on the drawing in the control circuits I and II), individual to each transductor arrangement 7, that is in the circuits from the selectors to the transductors. The transformers 4 then have their secondary coils connected in the same manner as their primary coils. The advantage of this arrangement is, that the total effect of the rectifiers 5' becomes one order of magnitude less than the effect of the rectifiers 5, and that greater reliability of service is obtained, due to the fact that the number of elements common to the whole system can be diminished. If the incoming alternating voltage of the system and the voltage applied to the transductors is chosen in such a manner that the ratio of the transformers 4 would be 1:1, the transformers 4 may be avoided, as shown in the control circuit III. However, therewith the disadvantage occurs, that the selectors and the control windings of the transductors or other current regulating means are connected directly to the network. The transformers 4 thus also serve as insulating transformers. This can also be obtained by inserting either a common insulating transformer before or behind the dimmer 2, or one for each control circuit before the dimmers 2' or the faders 3, for instance. (See control circuit III.)

As seen from the mechanical point of view, the

pairs of lighting selectors constitute one unit. The setting of the selectors is accomplished by levers movable substantially in vertical direction along a scale preferably common to two selectors. The switching conditions for the different lighting scenes are indicated by variously coloured signal lamps.

From the particular lighting selectors **6** the comparing voltage is supplied to the transductor arrangements **7** for each lamp **8**. Each arrangement substantially comprises a self-excited transductor **23**, carrying direct current windings for comparing excitation and sensing excitation thereof, and an alternating current winding which feeds through a rectifier the control winding on a self-excited main transductor **24**, provided with pre-excitation. The alternating current windings of the main transductors are connected through bus-bars **25** to the network **1** over a transformer **9** having an additional winding compensating for the voltage drop of the transductors.

Instead of the connections shown, the feeders to the rows of selectors for each scene may be separated. In this case each transductor is provided with as many direct current windings as there are scenes in the stage lighting programme in which the change is accomplished. The addition of the voltage components, in this case, under the changing-over operation, is made magnetically on the transductors, unlike the galvanic addition in the changing-over operation previously described.

In order to enable even lamps having extremely low rated output to be extinguished, an additional transductor **26** can be connected in parallel to the load as indicated on Fig. 2 of the drawing, which transductor is supplied by an additional voltage derived from the feeding voltage. This transductor starts if the main transductor is not able to take up the voltage which keeps burning the lamps having very low rated output under low load conditions. Since this arrangement only is required in exceptional cases, it is advisable to construct it as a self-contained supplementary means, which may be connected to the ordinary transductor means if required.

Obviously, there are switches for instantaneously blacking out and switching in the entire system or the individual circuits.

In smaller system, i. e. in systems having a small number of lamps, the potential dividers serving as dimmers and faders may be rheostats or voltage regulator transductors.

In the example described and illustrated for the explanation of the present invention, it has been assumed that the control circuits are fed with alternating current, and that the lighting intensity regulators are transductors. Obviously, such modifications are comprised within the scope of the invention, where the control circuits are fed with direct current, whereby the insulating and step-down transformers and the rectifiers are omitted and where other known current regulating means are used.

By virtue of the useful combination of the means and devices according to the invention, as described above, connection means are obtained for lighting regulation systems especially in theater lighting, which constitute a self-containing system, need less control effect, can easily be mounted on any suitable place and yield a lighting control without disturbant flashings or unintentional light variations. The system disclosed is especially economic since it has a minimum number of movable elements which render it surveyable, simple and safe.

We claim as our invention:

1. A theater lighting control system, comprising a plurality of lamp circuits, means for controlling the currents through the individual lamp circuits, saturable reactors inductively connecting said controlling means to said circuits, at least one main control circuit group connected to two scene-to-scene control circuits and having connected thereto a first potential divider as a dimmer and a second potential divider for the transition from one scene to another, rows of voltage-selecting means, one for each lamp circuit and scene and connectible to said scene-to-scene control circuits and provided for the voltage regulation of said last-mentioned control circuits, said selectors consisting of resistors for applying said desired currents to said means for controlling the lamp currents.

2. A theater lighting control system, according to claim 1, having a plurality of main control circuit groups comprising a common bus bar for the main control circuit group, a control current source, and a main potential divider interconnected between said bus bar and said control current source.

3. A theater lighting control system, according to claim 2, wherein the control current source is an alternating current source, comprising two transformers for each control circuit group having their primary sides and secondary sides, respectively, connected in series to each other, the primary junction points of said transformers being connected to movable contacts of the scene-to-scene potential divider and the secondary windings thereof being connected to associated scene-to-scene circuits, and rectifiers connected between said scene-to-scene circuits for rectifying the control currents.

4. A theater lighting control system, according to claim 3, wherein said rectifiers are inserted between said transformers and said selecting means.

5. A theater lighting control system, comprising a plurality of lamp circuits, means for controlling the currents through the individual lamp circuits, saturable reactors inductively connecting said controlling means to said circuits, at least one main control circuit group, each connectible to two scene-to-scene control circuits and having connected thereto a first potential divider as a dimmer and a second potential divider for the transition from one scene to another, rows of voltage-selecting means, one for each lamp circuit and scene and connectible to said scene-to-scene control circuits and provided for voltage regulation of said last-mentioned control circuits, said selectors consisting of resistors for applying said desired currents to said means for controlling the lamp currents, and switch-over means for alternately connecting said selectors to either of the main control circuits.

6. A theater lighting control system, according to claim 5, comprising switch-over means behind said scene-to-scene dividers for simultaneously changing the scenes.

7. A theater lighting control system, according to claim 1, wherein the scene-to-scene circuits each consists of two outer conductors and one common middle conductor for the interconnection of selector rows for two scenes.

8. A theater lighting control system, according to claim 1, wherein the scene-to-scene circuits

each consists of two outer conductors and one common middle conductor for the interconnection of selector rows for two scenes, and comprising undirectional electrical valves inserted in the circuits leading from the selectors to the current-controlling means for shunting selectors being ineffective but actually switched in.

9. A theater lighting control system, according to claim 1, wherein the scene-to-scene circuits each consists of two outer conductors and one common middle conductor for the interconnection of selector rows for two scenes, and comprising series resistances inserted in the conductors ahead of the selectors for obtaining linear regulation during the transition from one scene to the other.

10. A theater lighting control system, according to claim 1, wherein the scene-to-scene circuits each consists of two outer conductors and one common middle conductor for the interconnection of selector rows for two scenes, and comprising series resistances inserted in the conductors ahead of said selectors for obtaining linear regulation during the transition from one scene to another, said series resistances having such ohmic values that unidirectional valve means may be dispensed with.

11. A theater lighting control system, comprising a plurality of lamp circuits, means for controlling the currents through the individual lamp circuits, saturable reactors inductively connecting said controlling means to said circuits, at least one main control circuit group connectible to two scene-to-scene control circuits and having connected thereto a first potential divided as a dimmer and a second potential divider for the transition from one scene to another, rows of voltage-selecting means, one for each lamp circuit and scene and connectible to said scene-to-scene control circuits and provided for voltage regulation of said last-mentioned control circuits, said selectors consisting of resistors for applying said desired currents to said means for controlling the lamp currents, each scene-to-scene control circuit having two separate conductors for the selector rows for each scene and each current-controlling transductor being provided with as many direct current control windings as there are scenes.

12. A theater lighting control system, according to claim 1, wherein each current-controlling means comprises a self-exciting amplifier saturable reactor and a self-excited main saturable reactor, the magnetization of said main saturable reactor being controlled by the difference between the comparing voltage fed from the associated selector and the sensing voltage derived from the load through rectifier means, these voltages being supplied to the direct current winding of said amplifier saturable reactor.

13. A theater lighting control system, according to claim 1, wherein the current-controlling means comprises a self-exciting amplifier saturable reactor and a self-exciting main saturable reactor, the magnetization of said main saturable reactor being controlled by the difference between the comparing voltage fed from the associated selector, and the sensing voltage derived from the load through rectifier means, these voltages being supplied to the direct current winding of said amplifier saturable reactor, said saturable reactor being pre-excited.

14. A theater lighting control system, according to claim 1, comprising an additional saturable reactor connectible substantially in parallel to individual lamps having an extremely low rated output, the alternating current winding of said additional saturable reactor being fed from an additional voltage derived from the line voltage for enabling said lamps to be extinguished under low-voltage conditions.

15. A theater lighting control system, according to claim 1, wherein said potential dividers consist of saturable reactors of the voltage regulation type having a comparing and a sensing direct winding.

16. A theater lighting control system, according to claim 1, wherein said potential dividers consist of rheostats.

17. A theater lighting control system, comprising a plurality of lamp circuits, means for controlling the currents through the individual lamp circuits, saturable reactors inductively connecting said controlling means to said circuits, at least one main control circuit group connected to two scene-to-scene control circuits and having connected thereto a first potential divider as a dimmer and a second potential divider for the transition from one scene to another, rows of voltage-selecting means one for each lamp circuit and scene and connectible to said scene-to-scene control circuits and provided for the voltage regulation of said last-mentioned control circuits, said selectors consisting of resistors for applying said desired currents to said means for controlling the lamp circuits, a common bus bar for the main control circuit group, a control current source, a main potential divider interconnected between said bus bar and said control current source, two transformers for each control circuit group having their primary sides and secondary sides respectively connected in series to each other, the primary junction points of said transformers being connected to movable contacts of the scene-to-scene faders and the secondary windings thereof being connected to associated scene-to-scene circuits, rectifiers connected between said circuits for rectifying the control currents, said rectifiers being inserted in the circuits leading from said selecting means to said current controlling means.

18. A theater lighting control system, according to claim 1, wherein the potential dividers are provided with means for electrical operations.

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