

- [54] **PLURAL CHANNEL LIGHT DIMMING SYSTEM**
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- [22] Filed: **July 12, 1971**
- [21] Appl. No.: **161,653**
- [52] U.S. Cl. **315/292, 315/295, 315/297, 315/301, 323/24**
- [51] Int. Cl. **G05f 1/40, H05b 37/02, H05b 39/04**
- [58] Field of Search..... **315/292, 293, 294, 295, 299, 315/307, 312, 313, 314, 315, 319, 320, 321; 323/22 SC, 24**

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[57] **ABSTRACT**

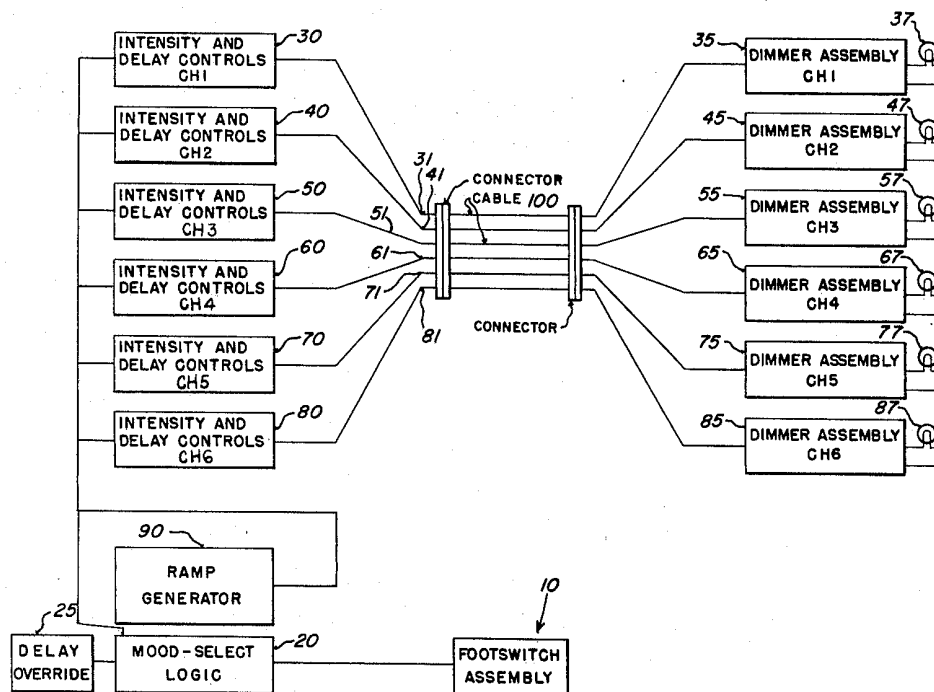
A remote controlled lighting system in which a foot switch assembly operates through a logic network to selectively energize intensity and delay controls in the form of resistance networks controlling the energization of a capacitor which with an output voltage from a ramp generator providing pulsed signals corresponding to an alternating current supply will control operation of a triac connecting the lights to the alternating current supply for proportionate periods of time in each alternating half cycle of the alternating current supply. The circuit includes provisions for delaying the changing in energization levels in a shift from one desired level to a level of energization through switching and further includes a master kill switch to de-energize all controls.

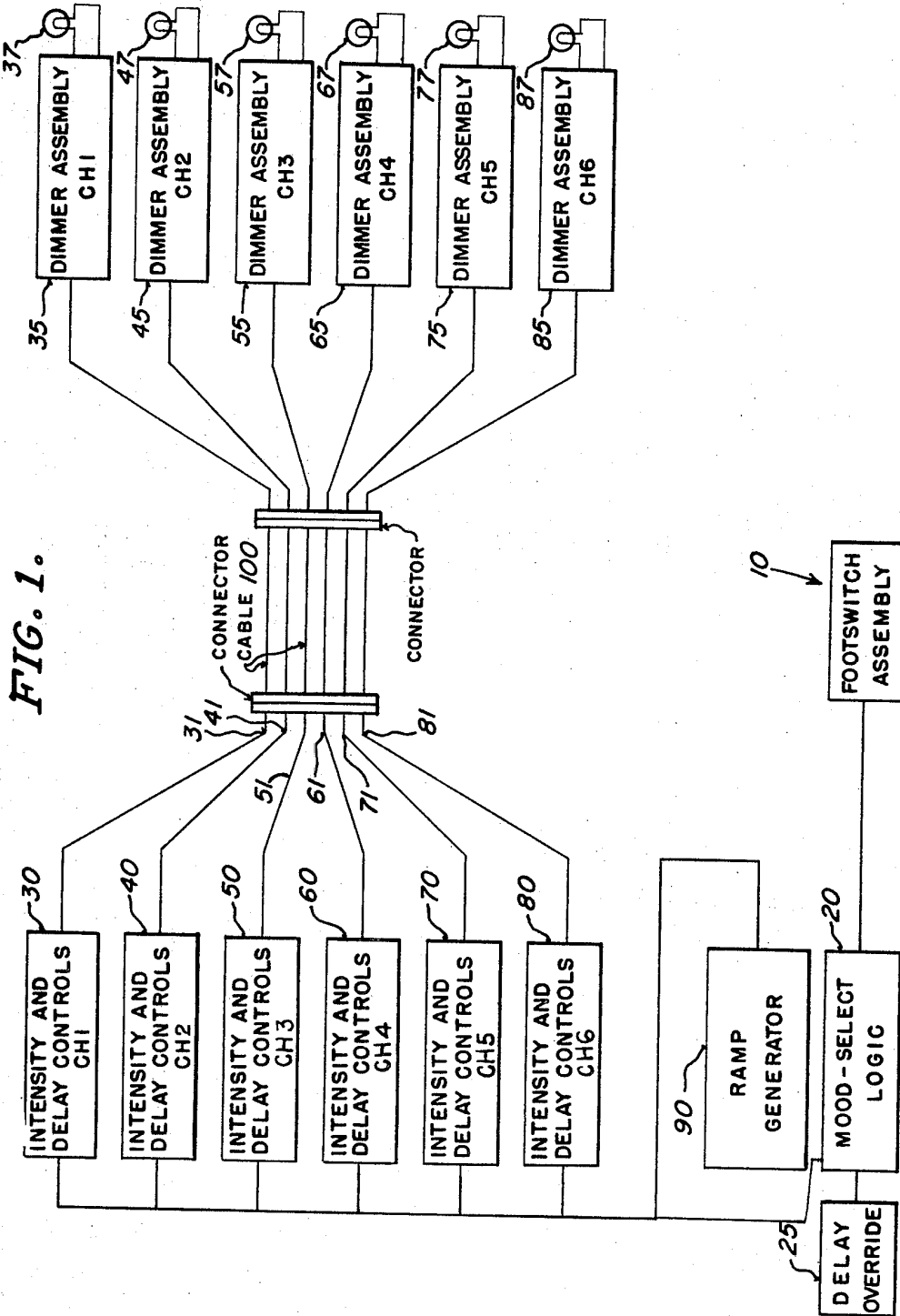
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16 Claims, 3 Drawing Figures





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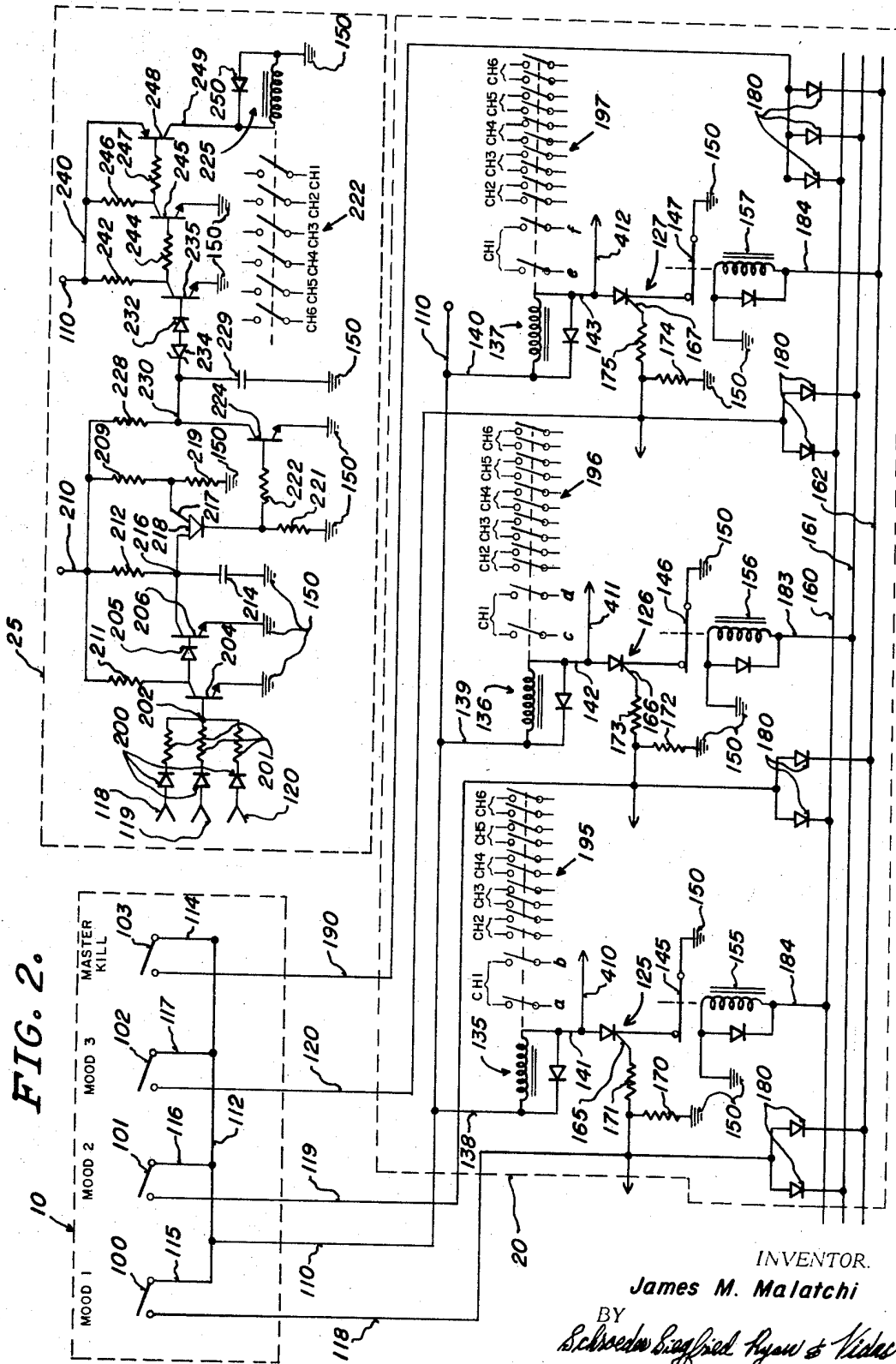


FIG. 2.

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PLURAL CHANNEL LIGHT DIMMING SYSTEM

My invention relates to lighting control systems and more particularly to an improved control system in which a single controller operating through a plurality of individual intensity and delay controls may effect simultaneous control of a plurality of remotely positioned lights connected thereto by a single control conductor respectively to effect control of levels of brilliance and rate of dimming therefrom.

Lighting control systems and in particular dimming control systems in which a plurality of lights are controlled from a single control source to effect selective dimming of the same are well recognized and known. This applies to incandescent as well as fluorescent type lights. Further, the use of low cost power semiconductor of the gate control type such as silicon control rectifiers and triacs is well recognized as an effective control for such lights from an alternating current source and for proportional energization of the same to effect dimming or intensity control through the use of selective energization of the lights during fractional portions of each alternating half cycle of energizing current supply. Similarly, it is recognized to adjust the level of intensity through resistance or electronic controls and to control the rate of change of dimming with respect to such light energization.

The present invention is directed to an improved dimming control apparatus in which a plurality of lights are separately and simultaneously controlled through a plurality of channels each having an intensity and delay control associated therewith and all operated simultaneously from a master controller with the intensity and delay controls being adjustable to selectively set the intensity and delay for any channel. In the improved lighting control system, only a single conductor is employed for each channel extending from the primary control which includes the intensity and delay controls to the lights having associated therewith suitable semiconductor power controls for effecting dimming and delay of change in intensity for each channel. The improved lighting control system employs a master foot switch assembly having a plurality of individual switching circuits each representative of a level of energization which operates into a logic system for selectively connecting various resistance and resistance capacitance networks in each individual intensity and delay controller to effect desired control of a level of energization of the lights for each channel. The control system is synchronized by a ramp generator energized from an alternating current source which operates with the intensity and level controls to provide pulse signal outputs to a semiconductor control at the light and power source through a single conductor and a common ground for each channel with the pulse signals effecting selective energization of the lights through the semiconductor control devices during selected portions of each alternating half cycle of energization of the lights. Thus, a primary control of the source from point remote from the lights and operated through a foot switch and a bank of control circuits defining intensity and delay in the illumination will enable the operator to selectively set desired levels of energization and rates of dimming for each of the respective channels independent of one another with all of the channels being controlled by a master control operating into the intensity and delay controls for preselected

control conditions. The power source and the power controller for the lights includes a triac which will effect energization of the lights from the alternating current source during portions of each half cycle of alternating current supply in accord with control pulse signals generated at the remote primary controller.

It is therefore the object of this invention to provide an improved and simplified dimming control circuit for a plurality of lights having a plurality of channels with each channel being independently adjustable for intensity and delay in lighting and all channels being simultaneously controlled from a primary controller from which various levels of energization may be effected.

Another object of this invention is to provide an improved lighting control of this type in which only a single conductor for each channel is required between the controlling source and the remotely positioned lights which conductors have low voltage signals impressed thereon.

A further object of this invention is to provide in a circuit of this type an improved synchronizing arrangement for effecting control of a semiconductor power controller at the light source.

A still further object of this invention is to provide in a circuit of this type a simplified resistance and resistance capacitance type network control with appropriate switching to effect intensity of illumination and delay in change in intensity control for each channel.

These and other objects of this invention will become apparent from a reading of the attached description together with the drawings wherein:

FIG. 1 is a block diagram of the improved lighting control circuit.

FIG. 2 is a schematic circuit diagram of the foot switch or primary controller and logic selecting portion of the circuit, and

FIG. 3 is a schematic circuit diagram of the remaining components of the lighting control circuit showing apparatus for controlling one channel only.

My improved lighting control system is primarily a system for controlling stage lights from a foot switch located in the stage area. This system provides not only control of intensity of the lights which may be of various colors but also provides control of the rate of change of intensity from one mood setting to another. As disclosed herein, there are three basic conditions or moods defining three levels of intensity of illumination which are preset into controllers. These three conditions or moods are selected settings for various colored lights used to indicate or enhance a desired mood to accompany music being played on the stage. The foot switch assembly includes four momentary contact switches which effect switching of all of the lights between the various mood settings and include one additional switch to extinguish all of the lights. In addition, there are distinct rates of change of illumination between mood settings, one being direct and the other a dimming change which is effected by conditions of operation of the foot switch. Thus, as will be hereinafter noted, a desired mood change can be effected by tapping one of the switches which will provide a preset dimming change, or a direct change from one level of energization or illumination to another may be effected by holding the switch down for a predetermined period of time.

In the block diagram shown in FIG. 1, my improved system is shown to include a foot switch assembly, indicated generally at 10, which operates into a block identified as a mood select logic block, indicated generally at 20. This portion of the circuit has associated therewith a separate circuit identified as delay override and is included in the block indicated at 25. Switching, as will be later identified, is included in the mood logic block which effects a setup of various circuits in a plurality of intensity and delay controls identified by blocks 30, 40, 50, 60, 70 and 80, or for the present disclosure six separate control channels for a lighting control system. These control circuits are provided with a control signal from a ramp generator, indicated by a block 90, which feeds simultaneously all of the control blocks and through appropriate switching from the mood logic block 20 selects various of the circuits included in the respective intensity and delay control to effect a change of the lighting. A single conductor evidenced by the lines 31, 41, 51, 61, 71 and 81 connect the intensity and delay controls through a cabling, indicated generally at 100, to represent the connection between the control console embodying the blocks 20 and 30 - 80 which lead to dimming assemblies indicated by blocks 35, 45, 55, 65, 75 and 85, respectively. Each of the dimming assemblies have associated therewith a separate light or bank of lights which are to be simultaneously controlled from the dimming assemblies. Thus, the numbers 37, 47, 57, 67, 77 and 87 represent the respective lights which may be of the fluorescent or incandescent type to be controlled by the respective dimming assemblies and such lights may be single or plural as desired. Thus, the foot switch assembly 10 is composed of four momentary contact switches three of which are used for the selection of preselected lighting conditions and the fourth is used as a kill switch to turn all the lights off. Mood logic block 20, as will be seen in FIG. 2, is a set of electronics controlling respectively a plurality of relays one for each selected condition or mood which responds to the operation of the foot switch and set up appropriate circuits corresponding to the condition selected. The ramp generator provides a synchronizing signal which initiates switching from the intensity and delay control circuits to provide with the level of energization from the intensity and delay control circuits appropriate pulses indicative of a desired level of illumination which pulses control the respective dimming assemblies through solid state silicon control type rectifiers or bidirectional switches to turn on and off the light and control the amount of power delivered to the respective light bulbs associated therewith.

Referring to FIG. 2, it will be seen that the foot switch assembly 10 is composed of four momentary contact switches indicated at 100, 101, 102 and 103. An energization circuit for controlled relays, to be hereinafter identified, is effected selectively through these switches from a DC power supply indicated by conductor 110 leading through a common conductor 112 which in turn is connected respectively to one of the contacts of each of the switches as indicated by the conductors 115, 116, 117 and 114. The opposite sides of the switches 100, 101 and 102 are connected through conductors 118, 119 and 120 into control circuits in the mood select logic network and to control grids of silicon controlled rectifiers 125, 126 and 127,

respectively. These SCRs control the energization of separate relays as evidenced by the coils 135, 136 and 137, respectively, which are connected at one side to the DC power supply conductor 110 through conductors 138, 139 and 140. As will be seen in FIG. 2, each of the respective relays are connected at their opposite extremity to the anode or power electrode of the respective SCRs as indicated by the conductors 141, 142, 143. The cathode or opposite power electrode of the SCRs 125, 126 and 127 are connected respectively through relay contacts 145, 146 and 147, respectively, to ground connection 150. The relay contacts 145, 146 and 147 are contacts of relays whose coils 155, 156 and 157 are connected at one extremity respectively to common conductors 160, 161 and 162 with the opposite sides of the relays being connected to ground connection 150. The respective relay coils 135, 136 and 137, and 155, 156 and 157 each have diodes connected in parallel therewith in a conventional manner. The control relays 135, 136 and 137 are controllably energized from the SCRs 125, 126 and 127 through signals imparted to the control grids 165, 166 and 167 thereof. These signals are supplied from the conductors 118, 119 and 120, respectively, through operation of the switches 101, 102 and 103. Suitable biasing resistors are included in these energization circuits in a conventional manner. Thus, the conductor 118 is connected through the bias resistor 170 to a ground connection 150 and through a bias resistor 171 to the control grids 165. Similarly, the conductor 119 is connected through a bias resistor 172 to ground 150 and through a bias resistor 173 to the control grid 166. The conductor 120 is connected through a bias resistor 174 to the ground connection 150 and through the resistor 175 to the control grid 167 of the rectifier 127. To insure that only one of the relays 135, 136 or 137 will be operative at any one time, the conductors 118, 119 and 120 are connected through diodes 180 to two of the three conductors 160, 161 and 162 of the logic network for each relay. Thus, the conductor 118 is connected through the diodes 180 to the conductors 161, 162 applying the control signals with operation of switch 100 to these conductors. It should be noted that the relay coils 156, 157 are connected to the common conductors 161, 162 through conductors 183 and 184, respectively, such that power will be applied to these conductors with operation of the switch 100 to energize the relays 156, 157 opening their contacts 146, 147 and preventing operation of the associated SCRs 126, 127 whenever the SCR 125 is operative. Similarly, the conductor 119 is connected through the diodes 180 to the conductors 160, 162 which are common to the relays 155, 157, the relay 156 being connected by conductor 183 to the conductor 161. Thus, with operation of the SCR 126, the SCRs 125 and 127 will be rendered inoperative. Similarly, the conductor 120 is connected through the diodes 180 to the conductors 160 and 161 such that the relays 155 and 156 will be energized with operation of the SCR 127 de-energizing or preventing energization of the SCRs 125, 126.

The fourth switch 103 of the foot switch assembly has its opposite contact connected by the conductor 190 through diodes 180 to all of the conductors 160, 161 and 162. Thus, with the operation of the switch 103, all of the SCRs 125, 126, 127 and associated

relays 135, 136 and 137 will be de-energized for the purpose of killing or turning off illumination of the lighting system, as will be hereinafter identified. The relays 135, 136 and 137 which are operated selectively from the foot switch members 100, 101, 102 each have a plurality of contacts 195, 196, 197 associated therewith. The contacts are connected into the intensity and delay controls 30, 40, 50, 60, 70 and 80, respectively, as shown in FIG. 3. In FIG. 3 only one channel and one dimmer assembly is shown to represent one of the channels of the lighting system, the others being identical therewith. Thus, in FIG. 2, the designations CH1-CH6 represent the six channels shown in the block diagram of FIG. 1 and the individual contacts are lettered a, b, c, d, e and f, respectively, to show switching for the various modes as corresponding to the manual foot switches 100, 101, 102 and the similar relay contacts for the associated delay portions of the intensity and delay control for one channel.

With the foot switch assembly system operating the respective relays 135, 136 and 137, it will be evident that only one relay may be operated at any particular point in time and that with operation of the foot contact 103, all relays will remain or become de-energized. Thus, as will be seen in FIG. 2, closure of switch 100 will cause energization of the conductors 161, 162 along with the control gate 165 of the SCR 125 to energize relay 135. The voltage signal applied to the conductors 161, 162 will cause energization of the relays 156 and 157 to open the contacts 146, 147, respectively and prevent energization or de-energize any previously energized SCR and associated relay. Similarly, switches 101 will cause energization of the relay 136 and de-energization of the relays 135 and 137 while energization or closure of the switch 102 will cause energization of the relay 137 and de-energization of the relays 135, 136, respectively, since in each instance operation of the foot switch will also energize two of the three common conductors to 160, 161 and 162 to cause operation of the relay associated therewith to open the respective SCR circuits with which these relays are associated. Similarly, energization or closure of the circuit by the master kill switch 103 will provide a signal from the conductor 110 to all of the conductors 160 - 162 preventing energization of any of the SCRs and associated relays.

The foot switch assembly 10, in addition to controlling the energization of the mood select logic network 20 or the various relays 135, 136 and 137 thereof, also provides signals to the delay override network 25 shown in FIG. 2. Thus, the conductors 118, 119 and 120 provide signals through diodes 200 and bias resistors 201 to a common point 202 leading to the base of a first transistor 204 which is coupled by a diode 205 to the base of a second transistor 206. The DC power source 210 energizes these transistors respectively through load resistors 211, 212 connected to the collectors of the respective transistors and the emitters of the same are grounded as at 150. Thus, transistor 204 is normally biased off with no signal applied to the base of the same while the transistor 206 is normally turned on with the absence of a signal applied to the conductors 118, 119 and 120. The load resistor 212 also has connected thereto a capacitor 214 which is grounded as at 150 with the common point 216 between the resistor

and capacitor being connected to the collector of the transistor 206. Thus, with no signal applied to the input of the delay override network, the voltage on the capacitor 214 will be approximately zero since its charging circuit will be shunted through the transistor 206 which is normally turned on under these conditions. The common point 216 is connected to one power electrode of a P.U.T. or programmable unijunction transistor 218 whose control electrode 217 is connected to a voltage dividing network formed by resistors 209 and 219 in series connection. The network is connected to the power source 210 at one extremity and grounded at 150 at the opposite extremity. The common point between the resistors 209 and 219 is connected to control electrode 217 of the unijunction transistor 218 and the other power electrode of the same is connected through a bias resistor 221 to ground 150. The P.U.T. or programmable unijunction transistor is normally off with no input to the delay override circuit inasmuch as the one power electrode common to the common point 216 will have no voltage pressed on the same. It will not fire until voltage thereon is brought to the level of the voltage on the control electrode 217. The opposite power electrode is also connected through a bias resistor 222 to the base of the transistor 224 in a conventional resistance coupling. This transistor is normally off with no voltage applied to the base of the same. Its collector electrode is connected through a load resistor 228 to the power source 210 with the load resistor also being connected through a conductor 230 to a capacitor 229 which is grounded as at 150. Thus, the load resistor and power source provide a charging circuit for the capacitor 229. With no energization on the delay override circuit, the voltage on the capacitor 229 is at its highest level being fully charged. Its discharge circuit through the transistor 224, which is normally off, will not be present until the delay override circuit is energized, as will be hereinafter noted. The midpoint between the resistor 228 and capacitor 229, as indicated at 230, is connected through a zener diode 234 and diode 232 to the base of a transistor 235, the collector of which is connected through a load resistor 242 to a power source 110. The emitter of the transistor 235 is grounded as at 150. A coupling resistor 244 couples the collector of transistor 235 to the base of the transistor 245 whose collector is connected to a load resistor 246 to the power source 110 or the common conductor 240 connected thereto. The emitter of the transistor 245 is grounded as at 150. With the voltage from the capacitor 229 applied to the base of the transistor 235, it will normally be biased or turned on with no input energization to the delay override circuit and its conduction will keep the transistor 245 normally off. The latter has its collector connected through a coupling resistor 247 to the base of a transistor 248 whose emitter is connected to the power source 110 at the common conductor 240 and with the collector connected through a conductor 249 to a relay coil 225 whose opposite side is grounded as at 150. A diode 250 is connected across the coil 225 and the relay coil controls the energization of an electromagnet operating relay contacts indicated generally at 222 which are located in each of the respective intensity and delay control channels. The transistor 248 is normally biased off with no conduction from the

transistor 245 hence the relay coil is normally de-energized and the contacts 222 in all of the channels are open.

The delay override circuit provides an arrangement by means of which if any of the switches 100 - 102 are held down for a period of time of more than 0.5 seconds, (as determined by the resistance capacitance 212, 214), the delay override relay 225 will be activated. The contacts 222 of this relay are included respectively in each of the intensity and delay controls 30 - 80 for the purpose of shorting out a delay resistor, as will be hereinafter identified.

Whenever a positive signal appears at any one of the conductors 118, 119 or 120, transistor 204 will turn on. This action will cause transistor 206 to turn off. With the transistor 206 off, capacitor 214 will begin charging through resistor 212. When the voltage on the capacitor 214 reaches a threshold level established at the gate electrode 217 by resistors 219 and 209, the programmable unijunction transistor 218 will turn on transmitting the charge on the capacitor 214 to the base of the transistor 224. This pulse of current will cause transistor 224 to turn on momentarily. This will provide a discharge path for capacitor 229 and will completely discharge the capacitor 229. Whenever the voltage on capacitor 229 or at the common point 230 falls below the reference voltage set by the zener diode 234 and diode 232, transistor 235 will turn off. This will cause transistor 245 to turn on which will cause transistor 248 to turn on putting current through the delay override relay coil 225 and causing all of the contacts 222 to close. The relay 225 will remain on until the capacitor 229 charges to the reference voltage set by the zener diode 234 on the diode 232. When this occurs current will flow into the base of transistor 235 causing it to turn on. This will result in transistor 245 turning off causing transistor 248 to turn off and preventing current flow through the relay coil 225 which had caused the relay contacts to close and thereby return the contacts to the open position. Thus, in the delay override circuit, whenever one of the mood select switches in the foot switch assembly 10 is operated, one of the SCRs 125, 126 or 127 will be energized and one of the input conductors 118, 119, 120 of the delay override circuit will have a current flow therethrough. Depending upon whether this mood select switch is held down for a predetermined period of time or momentarily depressed will determine whether the override circuit will be energized and the relay 225 will be operated. Thus, momentary closure of one of the mood switches will cause the transistor 204 to turn on and the transistor 204 to turn off. At this point the charge on the capacitor 214 will begin to build up. However, if the mood select switch is only momentarily depressed, and then reopened, the de-energization of the transistor 206 will only be momentary after which it will return to its original normally on state. Therefore the charge on the capacitor will not be built up to a level of the voltage on the gate or control electrode 217 of the unijunction transistor 218 to fire the same. When the transistor 206 turns on, it will provide a discharge path for the capacitor 214 maintaining its level of energization at approximately zero. Should the mood select switch which is operated, be held down for the period of time greater than 0.5 seconds or as

determined by the resistance capacitance combination 212, 214, the capacitance will have charged to the level of voltage which equals the programmed voltage on the control electrode 217 as set by the resistors 209, 219. At this point a pulse of current therethrough will cause the transistor 224 to turn on momentarily. Its energization will provide a discharge path for the capacitor 229 which will completely discharge the capacitor 229. The instant that the voltage level on the capacitor 229 begins to decay below the level set by the zener diode 234 and diode 232, the transistor 235 will turn off and the transistors 245 and 248 will turn on energizing the relay 225 and closing the contacts 222. Although the energization or operation of the transistor 224 is only momentary, its discharge of the capacitor 229 is such that with subsequent deenergization of the transistor 224 to open the discharge circuit provides a time delay through the energization circuit of resistor 228 and source 210 to again charge capacitor 229. This delay in energization will be determined by the resistance capacitance combination 228 and 229 with the result that when the capacitor 229 has again reached its maximum level of charge, or that set by the zener diode 234 and diode 232, the transistor 235 will again turn on resulting in the de-energization of transistor 245, 248 and the de-energization of the relay 225. Thus, with momentary deflection of the foot switch, the delay override circuit will not come into control of the relay 225 but the closure of one of the mood select switches of the foot switch assembly beyond a predetermined period of time will cause the relay 225 to turn on closing the relay contacts 222 which will remain closed for a predetermined period of time and thereafter open. The purpose of this delay switching function will become evident from a discussion of the intensity and delay controls and its operation on the dimmer control, to be hereinafter identified.

The switching control 10 and the relays of the mood logic block 20 operate to control the plurality of contacts located in the various intensity and delay control units 30 - 80 in the system. While I have shown six channels controlling six separate dimmer assemblies for six light banks or individual lights, it will be understood that this number may vary and that the individual number of conditions to be controlled or the number of dimming steps may vary as desired. In FIG. 3 I have shown the ramp generator 90 which provides the synchronizing control for the entire six channels and one of the intensity and delay controls, such as is indicated by the block 30 in FIG. 1, operating through one of the low voltage conductors 31 to an associated dimmer assembly 35 controlling the light 37. It will be understood that the individual channels and the components of the same, that is the intensity and delay controls together with the dimmer assembly and lights will be identical for each channel and capable of separate and independent settings.

Thus, in FIG. 3 the ramp generator or synchronizer is provided to develop a ramp voltage which is synchronized with a 60 cycle alternating current line voltage energizing the individual lamps through the solid state conductor control devices or triacs, to be hereinafter identified. As shown in FIG. 3 in the block 90, an alternating current supply 260 is connected through a step-down transformer 262 to reduce the

voltage of the same with the transformer 262 to reduce the voltage of the same with the transformer secondary winding 264 having its extremities connected through diodes 265, 266 and to a common point 268. The center tap of the transformer is grounded at 270 and with the diodes provides a conventional full wave rectifier from the transformer. This output of this circuit is completed through the bias resistor 267 which is grounded at 270. The output of the rectifier is fed to one side 271 of a comparator, indicated by the block 275, with the opposite side of the comparator 272 being connected to a common point between resistors 281, 286 in a voltage dividing network. The network is comprised of the resistors 281 and 286 connected between a voltage supply 210 and ground 270. The comparator also has a positive and negative direct current voltage source 210 and 280 connected thereto for conventional operation. Thus, the resultant wave configuration or voltage from the full wave network is a wave form shown on the drawing at 290 to be generally sinusoidal pulses of the same polarity. The voltage dividing network 281, 286 provides the signal to the opposite side of the comparator 272 which sets the reference voltage for the comparator at approximately 1 volt. Whenever the sinusoidal wave crosses the 1 volt level, an output appears since the comparator changes state. The wave form at the output of the comparator is indicated generally at 292 compared with the output of the full wave rectifier. The output of the comparator is connected through a diode 295 and bias resistor 296 to the base of a transistor 300 for the purpose of switching the transistor on and off. The emitter of this transistor is grounded as at 270 and its collector is connected to one side of a capacitor 310 which is charged from a constant current generator to be hereinafter described. The constant current generator is defined by a transistor 326 whose emitter is connected through resistors 331, 332 to the B+ source 210. The base of transistor 326 is connected to a network formed by a zener diode 325 and a resistor 326. The network is connected between ground 270 and the source 210 with the midpoint between the resistor and diode being connected to the base of transistor 326. The collector of the transistor 326 is connected to one side of capacitor 310 which is grounded at 270 and to the base of a transistor 330 which defines an emitter follower for the voltage signal output from the generator which selectively charges the capacitor 310 and which capacitor is provided with a discharge path through operation or switching of the transistor 300. The emitter of the transistor 330 is connected through a load resistor 322 to ground 270 and through a conductor 335 leading to the various intensity and delay control networks as will be seen in FIG. 1. The collector of the emitter follower circuit or transistor 330 is connected to the B+ supply. Thus, the output of the comparator will have a wave form as indicated at 292 swinging from plus to minus and will operate to turn transistor 300 on and off. The transistor 326 with its bias through the zener and resistor 326 applied to the base thereof provides a charging circuit for the capacitor 310 connected to its collector such that it would charge linearly. This constant charging current on the capacitor will produce a linear ramp voltage on the capacitor which will be reflected through the emitter follower circuit as the voltage out-

put signal, indicated by the wave form 336. This wave form or sawtooth type voltage signal having a linear voltage increase from zero to a peak will be provided for each half cycle of alternating current supply from the energizing source 260 and will provide the synchronizing signal and control signal for the delay and intensity controls operating into the dimmer control for each lamp or group of lamps included in each of the channels.

As will be seen in FIG. 3, the output of the ramp generator is applied to the intensity and delay controls with the conductor 335 being connected to each of the separate control modules 30, 40, 50, 60, 70 and 80 of the intensity and delay controls. For simplicity in FIG. 3 I have shown only one intensity and delay control module or panel being connected through one of the conductors 31 to one of the dimming assemblies 35 controlling one of the lights or banks of lights 37. It will be understood that each control panel and dimming assembly form a separate panel controlling separate lights and each will be identical with the other. The adjustability of the intensity and delay controls may vary from channel to channel and each will incorporate three mode settings and three separate delay circuits, as will be hereinafter identified. The intensity control is basically a resistance network energized from the DC power supply 210 connected through a voltage adjusting level resistor 336 to a network formed by three potentiometers 340, 341 and 342, respectively, with one side of the resistance element being connected in common to the end of the voltage adjusting resistor 336 and the other side being grounded as at 270. The wipers of the respective potentiometers are connected through relay contacts of the relays 135, 136 and 137 as evidenced by the numbers 195a, 196c and 197e. The opposite sides of of the contacts are connected in common as at 337 and to the base of a transistor 345 with a bias resistor 346 connected thereto and being grounded as at 270. The collector of the transistor 345 is connected through the conductor 347 to the B+ supply 210 and the emitter is connected through a load resistor 348 to ground 270. The emitter is also connected through a load or coupling resistor 349 to a second resistance network forming the delay controls. These are represented by three potentiometers 350, 351 and 352 connected in parallel with one another and in series with the resistor 349. Each of the potentiometers having contacts of the relays 135, 136 and 137, respectively, in series circuit therewith. Thus, it will be seen that the potentiometer 350 has the relay contact 195b in series therewith while the potentiometer 351 has the relay contact 196d in series therewith and the potentiometer 352 has the relay contact 197f in series therewith. The opposite sides of these contacts are connected in common through a conductor 354 to a capacitor 355 which is grounded as at 270. Connected in parallel with the potentiometers and respective switches is the shorting contact 222 of the delay override relay 225. Thus, it will be seen that the individual relays 135, 136 and 137 representing the separate mood relays each having a set of contacts in each of the respective intensity and delay controls for each separate channel and one contact will selectively connect one of the mood intensity level adjusting potentiometers in the circuit along with a correspond-

ing delay adjusting potentiometer in a circuit to control the energization of the capacitor 355. Because of the interlock between the respective mood relays, only one circuit for each of the intensity branches and delay branches will be energized and in the event of override, as to be hereinafter identified, the delay potentiometer may be shorted out by the override relay contact 222 depending upon the operation of the manual foot switch. Thus, the resistance networks in the intensity and delay controls provide that the voltage of the wiper of the potentiometer or resistor selected by the mood relay will be transmitted through the emitter follower 345. This voltage will charge the condenser 355 through the resistors 349 and one of the associated delay potentiometers which is then connected in the circuit. The values of the resistors 349 and the delay potentiometers 350, 351 or 352 are very, very small compared to the input impedance of the isolation amplifier 360 to which the conductor 354 is connected. Thus, the voltage charge of the condenser 355 will be approximately equal to the voltage at the emitter of the transistor 345 after approximately five time constants. An isolation amplifier is shown in block form and is energized from a B+ and B- supply indicated by the conductors 210, 280 with a feedback loop 361 connected from the output thereof, as evidenced by the conductor 362, to the opposite input 363. A voltage clamp is provided from the power supply 210 through a voltage level adjusting resistor 365 which has connected thereto a second voltage source or B- source 280 through a resistor 366 to a common point 367 with the common point being connected through a diode 368 to one side of the capacitor 355 common to the conductor 354 in one input of the isolation amplifier. The output voltage of the isolation amplifier will follow the voltage charge or level of the condenser 355 and is evidenced on the circuit diagram by the wave form or level line 376. The delay in reaching that level will be effected by the resistance combinations of the delay controls and the level of energization will be determined by the respective intensity controls. This output voltage from the isolation amplifier is coupled through a resistor 372 to a comparator amplifier 375 whose second input as indicated by the connection 376 is coupled through a resistor 377 to the output conductor 335 of the ramp generator. Thus, the wave form 336 or the sawtooth pulsed voltage wave for each half cycle of alternating current energization will be impressed on the other side of the comparator. The output of the isolation amplifier 360 or level voltage as indicated by the wave 370 becomes the reference voltage for the comparator such that whenever the ramp voltage on the conductor 335, as evidenced by the wave form 336, crosses the reference voltage. The output of the comparator at the output conductor 386 will change state and this output wave form is indicated at 382 with appropriate reference timewise to the wave form 336 and 370. Thus, whenever the output voltage of the ramp generator crosses the reference voltage or output of the isolation amplifier from the intensity and delay controls, a negative pulse wave form is obtained from the comparator 375 which will move from a plus to a negative state and remain at a constant level to the termination of the half cycle of the ramp voltage wave form. This voltage or signal is connected through to the

coupling cabling on single conductor 31 through appropriate connectors indicated at 385 and to a connector 386 at the associated dimmer assembly 35.

In FIG. 3, the dimmer assembly 35 is shown to include a transistor 390 coupled to the primary winding 395 of a pulse transformer 394 whose secondary winding 397 is connected to the control grid of a triac 400 controlling energization of the lamp 37 from the alternating current supply 260. In the dimmer assembly, the emitter of transistor 390 is connected through a load resistor 391 to the B+ supply 399 with the collector 392 being connected through the primary winding 395 to ground 270. The base of the transistor 390 is connected through a diode 393 to a charging network formed by a resistor 401 connected to the B+ supply and a capacitor 402 coupled to the connector or conductor 31. This charging circuit will provide a voltage charge on the capacitor 402 applied to the base of the transistor 390 to normally shut the same off. With each negative going pulse of the comparator, a change in level of the voltage at the condenser applied through the diode 393 will turn on the transistor 390 for a short period of time providing a pulse of current through the primary winding of the pulse transformer 395. The secondary output of this pulse will be applied to the gate electrode 396 of the triac 400 for each half cycle of alternating current energization effecting a turn on of the triac to connect the lamp in series with the alternating current supply. The energization circuit for the lamp includes a fuse 405 in series with the lamp and triac with the opposite electrode of the triac being connected to the opposite side of the alternating current supply. An appropriate resistor 407 and capacitor 408 are connected in series and in parallel with the triac or to its power electrodes to insure that the current flow will be extinguished at the end of each half cycle of alternating current supply. The approximate wave forms of the current pulse through the transformer is indicated at 397 corresponding timewise to the negative going pulses 382 from the comparator impressed on the low voltage conductors connecting the intensity and delay controls with the dimmer assembly which is normally located at the light and power source and remote from the intensity and delay controls.

In the operation of my improved remote control lighting system, operation of the foot switch assembly 10 will selectively control the energization of any one of the mood logic relays 135, 136 or 137 through its respective SCRs resulting in operation or closure of the respective relay contacts in the intensity and delay controls. The intensity and delay circuit provides a voltage output or reference signal from the isolation amplifier which will coact with the saw-toothed ramp voltage to provide the triggering pulse or negative going pulses from the comparator which will operate to turn on for short periods of time the transistor 390 in the dimmer control to provide the pulsed operation or output from the transformer to control the triac for each alternating half cycle of alternating voltage supply applied to the incandescent lamps. The ramp generator which is energized by the same alternating current supply provides a synchronizing signal by means of which the triac may be turned on for proportionate lengths of time during each alternating current half cycle of the supply to effect control of energization of the lamp by controlling

the amount of current flow during each alternating half cycle thereby effecting control brilliance of the lamp. The foot switch assembly also includes a master kill switch 103 which provides the voltage signal from the B+ conductor 110 to all of the common conductors 160, 161 and 162 of the mood logic network of FIG. 2. This energizes all of the respective cut-out relays 155, 156, and 157 simultaneously to insure that all of the relays 135, 136 and 137 representing the separate moods and delays will be cut off. The mood logic network includes additional conductors in the energization circuit of the respective relays 135, 136 and 137 as evidenced at 410, 411 and 412, respectively, which are connected into a kill energization circuit for the ramp generator. Thus, in FIG. 3 these input conductors are connected respectively through diodes 413, 414 and 415 to a common point or conductor 420 connected to one side of a capacitor 421 whose opposite side is grounded as at 270. The B+ conductor 110 is connected through a bias resistor 422 to the capacitor 421 to provide a charging circuit for the same. The common point between the resistor 422 and capacitor 421 is connected through a conductor 425 and a zener diode 426, a diode 427 and a conductor 428 to the base of the transistor 300 in the ramp generator. Thus, whenever all of the relays 135, 136 and 137 are turned off, a voltage will be applied to the conductors 410, 411 and 412 respectively, which will be the B+ voltage from the conductor 110. When this condition exists, current will flow through the resistor 422, diode 426 and 427 into the base of the transistor 300. This will hold the ramp voltage at 0 volts by insuring that the transistor 300 will not change state with operation of the output from the comparator 275. When the ramp voltage disappears, none of the comparators in the intensity and delay control sections will fire, that is the comparators 375 will have no input signal or ramp voltage applied to their respective input sections 376 of the comparators. Thus, there will be no trigger pulses generated at the pulse transformers in each of the respective channels to turn on the lights and all of the lights in the system will turn off.

My improved lighting system is one particularly adapted for use in controlling stage lights from a foot switch or foot switch assembly located in a stage area with the lights being remote therefrom. This system provides not only control of intensity of the lights which may be of varying color but also provides control of the rate of change of intensity from one mood setting to another. In the disclosure herein, three separate moods or levels of intensity are provided each of which are separately adjustable for each channel. Where colored lights are used, these intensity levels will be altered to indicate or enhance a desired mood when the lighting is used to accompany music. The foot switch assembly 10 includes separate switches, one for each mood and one master kill switch and the operation of the same will dictate whether intensity of the lighting will change directly or delayed to provide a dimming effect between mood settings. To effect a direct change, the desired mood switch or foot switch is held down for a period of time longer than one quarter of a second. The existing mood setting then changes directly and enters into the selected mood setting of evidence by the switch operated. To effect a dimming

change, the desired mood switch is tapped but not held down and the existing mood setting then changes smoothly into the next mood setting at a rate preset by the delay controls.

With the system energized, alternating current will be supplied to the ramp generator to develop the ramp voltage 336 which will be fed to all of the channels of the lighting system simultaneously. The purpose of the ramp generator is to develop the ramp voltage which is synchronized with the sixty cycle line voltage energizing the light source. The ramp voltage is developed from the alternating current supply 260 by providing a step-down in voltage through the transformer 262 and a rectification of the same to provide pulsed signal output from the full wave rectifier which is generally sinusoidal pulses of the same polarity. This voltage is fed to one side of the comparator with the opposite side being set by a reference voltage so that as the pulsed wave form for each half cycle crosses the reference voltage, the comparator 275 will fire or change state. The output therefrom is a negative going voltage for each half cycle which is used to switch the transistor 300 on and off. With the transistor 300 on, it discharges the capacitor 310 which is energized from a constant current generator formed by the transistor 326 having the resistor combination 331, 332 connected to the emitter and the zener diode 325 and resistor 326 connected to the base. The condenser 310 charges linearly and this voltage is transmitted through the emitter follower 330 as the ramp voltage to all of the channels. Thus, except under conditions when the master switch 103 has been energized, the ramp voltage will be applied to the intensity and delay controls of all channels. In establishing a level of lighting, one of the level switches is operated in the foot switch assembly and if held down momentarily will cause the respective relay associated therewith to pull in. The foot switches provide a signal to the respective gate electrode of silicon control rectifier associated with the respective relay to cause the relay to pull in and stay in as long as the condition exists where no other mood is established by subsequent operation of another foot switch. Thus, whenever one of the mood relays is energized, it will remain energized until a succeeding foot switch operation. As it is energized, its relay contacts in the intensity and delay controls will set up circuits therethrough which correspond with the mood switch and hence, the relay associated therewith. This will cause the voltage in the intensity controls and at the wiper of the respective potentiometer connected by the relay contacts associated with the relay so energized to be applied to the base of the emitter follower 345 in the intensity control. This voltage will charge the condenser 355 in the intensity and delay control through a pair of resistors which are selected by operation of a corresponding relay contact of the same relay operated. The latter will delay the charging of the condenser for a given period of time but permit charging to a level of voltage at the emitter of the transistor 345. This voltage is applied to the isolation amplifier and the resulting voltage is a constant level voltage which will energize or be the reference in the comparator 375 of the intensity and delay controls. The ramp voltage signal as it increases each half cycle to the level of the reference voltage from the isolation amplifier 360 will cause the com-

parator 375 to turn on and provide a negative going pulse wave output from the comparator which is fed to the associated dimmer assembly. This negative going pulsed wave provides for a change in state or conduction of the transistor 390 to provide a pulse of current to the pulse transformer which in turn is applied to the gate electrode of the triac to turn on the triac on each half cycle at a predetermined time point determined by the reference voltage from the isolation amplifier and in accord with the level of energization set by the respective intensity controls.

When the foot switch assembly or one of the mood select switches is depressed, one or the other of the SCRs 125 - 127 will be operative. An energizing signal will be placed on the delay override circuit 25 and it will be seen that as soon as the mood foot switch is operated, transistor 204 in the delay override circuit will turn on and transistor 206 will turn off allowing the voltage on the capacitor 214 to begin rising. If the foot switch so operated is held down long enough, the voltage on the capacitor 214 will rise to the reference set at the control electrode 217 of the programmable unijunction transistor 218 which will then fire causing the relay 225 to pull in or be energized. This is brought about by the conduction of the transistor 224 discharging the capacitor 229 and turning off the transistor 235 while turning on the transistor 245 and 248. The relay will remain energized with the continued energization of the delay override circuit by a signal on one of the conductors 118 - 120 only for a predetermined length of time determined by the time it takes for the capacitor 229 to again recharge to the level set by the zener diode 234 and diode 232. Since the operation of the unijunction transistor 218 is only momentary, the transistor 224 when fired will remain energized only as long as it takes to discharge the capacitor 229. Thereafter, the charging circuit for the capacitor will be in effect and a delay will take place during which time the relay 225 will remain energized until the capacitor 229 is again charged. This results in the energization of the transistor 235 and the deenergization of the transistors 245 and 248 connected thereto. The relay 225 will be energized and will remain energized for a predetermined period of time which will be longer than any of the delays introduced by the delay controls in the intensity and delay control network. Thus, the delay override relay will operate causing its contact to short out the respective resistors in the delay controls and cause the emitter voltage to be applied directly to the capacitor 355 to energize the same or bring it substantially to a simultaneously level corresponding with the output at the emitter of the transistor 345. Thus, the intensity of the light will shift substantially instantaneously except for a minor time delay eliminating the dimming effect between mood settings. With the operation of any one of the foot switches, the remaining relays associated with the remaining switches will be automatically de-energized through the logic network which includes the selective energization of the conductors 160, 161 and 162 in the logic network to energize the cut-out relays associated with the SCRs of the remaining relays. Thus, for example, with foot switch 100 closed, the SCR 125 will fire controlling energization of the relay 135 and setting up an energization circuit for the potentiometer 340 and delay potentiometer

350. With this energization, the logic conductors 161 and 162 will be energizing the cut-out relays 156, 157 and opening the energization circuits for the remaining SCRs 126, 127 to prevent energization of the relays 136 and 137. The mood selected will remain energized until change by the operation of another foot switch. The delay override network will provide for energization of the delay override relay only with a change in mood setting by operation of another mood switch and under conditions where the foot switch is held down for a sufficiently long period of time (one quarter of a second) to cause energization of the relay through the delay override network. If the operation of the next mood switch or switch in the foot switch assembly is momentary, the delay override network will not be energized and the delay in changing from one mood setting to another will be effected by the resistor combinations in the respective delay controls which will cause delay in charging of the capacitor or its reaching the voltage level dictated by the respective intensity control through the emitter follower 345. Whenever a switch is operated to set up a particular mood, the relay associated therewith will be energized and remain energized such that respective contacts in the intensity and delay controls will remain closed providing for continuous operation of the comparator to provide an output voltage to the respective dimmer assembly which will proportionately energize the triac on each half cycle of alternating current supply to vary the amount of current flow to the lamp controlled thereby and hence, the brilliance of the same. The master kill switch in the foot switch assembly when depressed will provide for de-energization of all of the relays by opening the kill relays 155, 156 and 157 of the mood logic network preventing energization of any of the relays 135, 136 and 137. Consequently, in the intensity and delay controls, none of the resistance networks will be connected into the energization circuit of the isolation amplifier. In addition, the ramp generator 90 will have its output killed by current flow into the base of the transistor 300. With all of the SCRs 125, 126 and 127 open or de-energized, the charge on the capacitor 421 will reach a level set by the zener diode 426 and diode 427 to cause current flow through the conductor 428 to the base of the transistor 300. This will turn the transistor 300 on continuously and all of the current flow from the constant current generator will then flow through the transistor 300. Since the transistor 300 was saturated, the voltage at its collector will be substantially zero since the capacitor 310 will not have an opportunity to charge. Thus, the transistor 330 whose base is connected to the collector of the transistor 300 and the capacitor 310 will be turned off presenting no ramp voltage signal on the conductor 335 to the intensity and delay controls. Thus, there will be no signal applied to the dimmer controls to turn on the lamps and they will remain off.

While I have shown a lighting system in terms of three preset conditions which are adjustable and in a system having six channels, it will be noted that any number of preset conditions may be incorporated by the addition of appropriate logic relays and any number of channels may be controlled from the foot switch assembly simultaneously by the addition of additional intensity and delay controls and dimmer controls. There-

fore, in considering this invention it should be remembered that the present disclosure is illustrative only and the scope of the invention should be determined by the appended claims.

What is claimed is:

1. A remote control lighting system comprising, a plurality of lights, a plurality of control means each adapted to be connected to said plurality of lights respectively to connect said lights to a source of power for variably energizing the same, a primary control positioned remote from said lights and said plurality of control means and connected thereto by a low voltage control cabling having only one conductor for each control means controlling each light, said primary control including a plurality of preset controllers with variable settings and with switching means to switch from one setting to another, manually controlled switching means included in the primary control and having selectively operated switches corresponding to the settings of the preset controllers connected to the controllers for simultaneously switching all controllers from one setting to another, means responsive to the operation of each preset controller and connected respectively to said conductors of the cabling for providing variable low voltage control signals on the conductors to each of the lighting control means to vary the energization of said plurality of lights in accord with the operation of the manually controlled switching means and the settings of the preset controllers, and including a synchronizing means connected to the means responsive to the operation of the preset controllers to synchronize the operation of the controllers with an alternating current supply energizing the lights.

2. The remote control lighting system of claim 1 in which the synchronizing means is a ramp generator adapted to generate a pulse signal for each half cycle of alternating current supply.

3. The remote control lighting system of claim 2 in which the control means connected to the plurality of lamps are silicon controlled rectifiers controlling the energization of the lamps selectively for varying portions of each half cycle of alternating current supply to vary the intensity of illumination of the same.

4. The remote control system of claim 3 in which the silicon controlled rectifiers include a pair of silicon controlled rectifiers connected for bi-directional energization of the lights from the alternating current supply.

5. The remote control lighting system of claim 1 in which the preset controllers include resistance and resistance capacitance networks with switches for selectively connecting the networks to control the level of energization of an amplifier means with an output signal from the amplifier means providing a variable voltage signal with a variable rate of change of said voltage signal which signal cooperates with a synchronizing means to control respectively the plurality of controllers energizing the light source.

6. A remote control lighting system comprising, a plurality of lights, a plurality of control means each adapted to be connected to said plurality of lights respectively to connect said lights to a source of power for variably energizing the same, a primary control positioned remote from said lights and said plurality of control means and connected thereto by a low voltage

control cabling having only one conductor for each control means controlling each light, said primary control including a plurality of preset controllers with variable settings and with switching means to switch from one setting to another, manually controlled switching means included in the primary control and having selectively operated switches corresponding to the settings of the preset controllers connected to the controllers for simultaneously switching all controllers from one setting to another, said preset controllers including resistance and resistance capacitance networks with switches for selectively connecting the networks to control the level of energization of an amplifier means with an output signal from the amplifier means providing a variable voltage signal with the rate of change of said voltage signal, means responsive to the operation of each preset controller and connected respectively to said conductors of the cabling for providing variable low voltage control signals on the conductors to each of the lighting control means to vary the energization of said plurality of lights in accord with the operation of the manually controlled switching means and the settings of the preset controllers, and a synchronizing means connected to the means responsive to the operation of the preset controllers to synchronize the operation of the controllers with the alternating current supply energizing the lights, said means responsive to the energization of the preset controllers being a comparator receiving signals from the synchronizing means and signals from the preset controllers and providing an output signal for each half cycle of alternating current energization of the control means controlling the energization of the lights to vary the portion of each half cycle in which power is supplied to said lights and the rate of change of said signals to effect variation in intensity and rate of change of intensity of the lights.

7. The remote control lighting system of claim 6 in which the manually controlled switching means includes a plurality of switches connected respectively to networks having multiple switches therein interconnected in each of the plurality of control channels associated with each of the lights and in which said manually operated switching means includes further switching means for de-energizing the plurality of control means associated with the lights.

8. The lighting control system of claim 7 in which the synchronizing means is a ramp generator providing a sloped voltage signal for each half cycle of alternating current energization of the same corresponding with the alternating current energization of the lights which sloped energization signal is compared with a fixed output signal from the preset controllers to determine what point in a half cycle of alternating current switching is to be effected in connection with energization of the lights and in which the control means controlling energization of the lights from an alternating current source includes triac means responsive to the output signal from the comparator to effect energization of the lights at varying points in each half cycle of alternating current supply.

9. The remote control lighting system of claim 7 and including additional means responsive to a predetermined length of time during which the manually operated switching means is operated to short circuit a

portion of the preset controllers effecting delay in the change in the level of lighting.

10. A light controlled system comprising, a light adapted to be controllably energized from an alternating current source power, a switching control for operating the light in various stages of illumination, said switching control including separate switch means for each of a plurality of stages of desired illumination of the light, said switching control including further separate relay means responsive to each of the separate switches to provide separate control circuits, an illumination intensity and delay control including separate resistance and resistance and capacitance networks corresponding to the predetermined stages of intensity and desired delays in illumination change of the light, circuit means connected respectively to the separate relay means and in controlling relationship with the resistance and resistance capacitance networks, means responsive to the output of the resistance and the resistance capacitance network for providing a signal having a variable voltage level indicative of the desired level of intensity and with a change in said desired voltage level upon switching being controlled timewise by the resistance capacitance network, means providing continuous synchronizing pulses corresponding to the alternating current supply, comparator means responsive to the synchronizing pulse signal and the voltage level signals for providing a control pulse signal at variable times on each half cycle of the alternating current supply depending upon the magnitude of the voltage level signal, and means connected to and responsive to the control pulse signals, said last named means selectively connecting the light to the alternating current supply to energize the lights proportionately during each half cycle of alternating current supply in accord

with the timing of the control pulse signals.

11. The light control circuit of claim 10 in which the connection between the last named means and the comparator means is a single conductor.

12. The light control system of claim 11 in which the light and the means responsive to the control pulse for controlling the energization of the light are physically separated from the switching control, intensity and delay control and comparator means and positioned remote therefrom with the control pulse signal being a low voltage signal reduced from the magnitude of the alternating current supply.

13. The light control system of claim 12 in which the means connected to and responsive to the control pulse and controlling energization of the light from an alternating current supply includes a triac.

14. The light control system of claim 13 in which the synchronizing signal producing means produces a ramp voltage signal having a uniform slope between zero and a maximum voltage for each half cycle of alternating current supply.

15. The light control circuit of claim 14 and including means responsive to the length of time in which said respective switching means are operated to a closed position and connected to said circuits including the intensity and delay controls being operative to override the delay introduced by the resistance capacitance network with change in said switching means.

16. The lighting circuit of claim 15 and including additional switching means included in the switching control and operative to deactivate and de-energize all of the separate circuits included in the intensity and delay control to prevent energization of the light from the alternating current source.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3706913 Dated December 19, 1972

Inventor(s) James M. Malatchi

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 67, after "262" delete "to reduce the

Column 9, line 1, before "to reduce" delete "voltage
of the same with the transformer
262"

Column 12, line 7, after "control grid" insert
-- 396 --.

Signed and sealed this 15th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents