

[54] LIGHT CONTROL CIRCUIT

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[58] Field of Search..... 315/322, 323, 324, 315/313, 294; 307/223 B, 252 B

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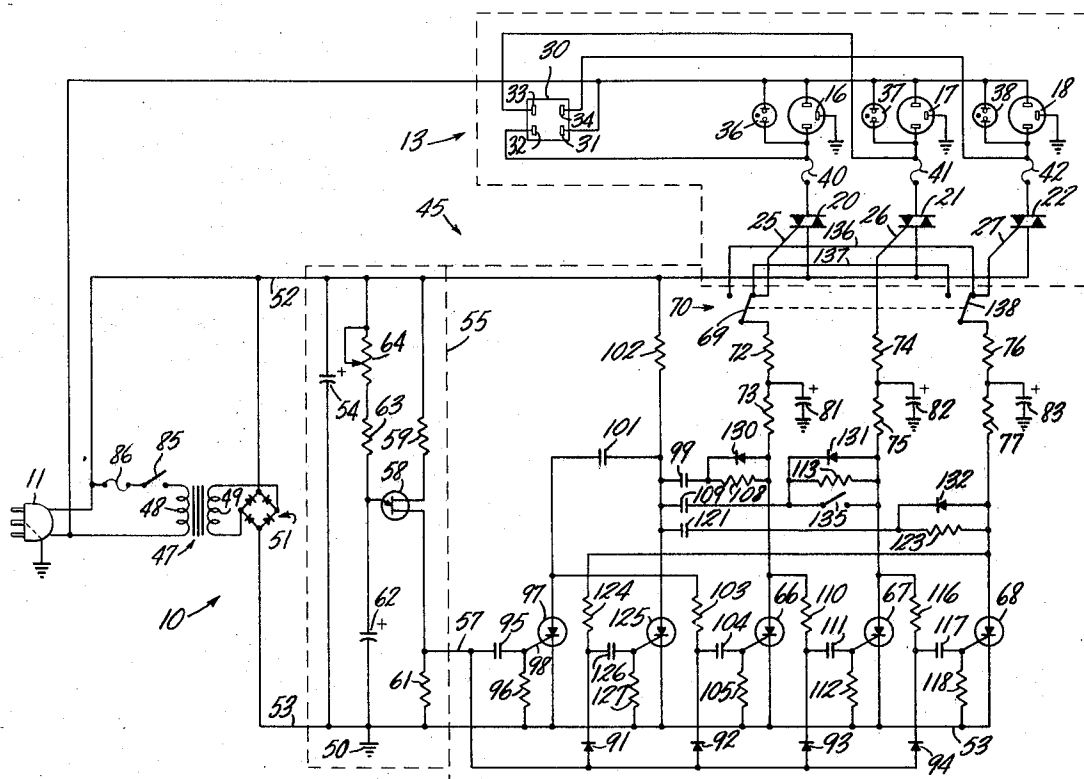
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[57] ABSTRACT

A two mode chase light control circuit. Three triacs energize three respective outputs to three lamp banks. Oscillator timed control circuitry sequentially triggers the triacs. Three triggering SCRs, each connected with a triac gate, conduct sequentially to fire the triacs. In the first mode each SCR conducts until a fourth quenching SCR connects commutating capacitors across the triggering SCRs. In the second mode, a switch bypasses a resistor between one commutating capacitor and a triggering SCR. This reduces the series resistance in a circuit interconnecting the triggering SCRs. The second and third triggering SCRs quench the first and second, diverting current to commutating capacitors. The quenching SCR quenches the third triggering SCR. To reverse the lighting sequence, a switch reverses the trigger connections to the first and the last triacs. Remote discharge lamps indicate the lighting mode, sequence, and timing. A commonly controlled slave triac package controls additional lamps from a separate source.

12 Claims, 2 Drawing Figures



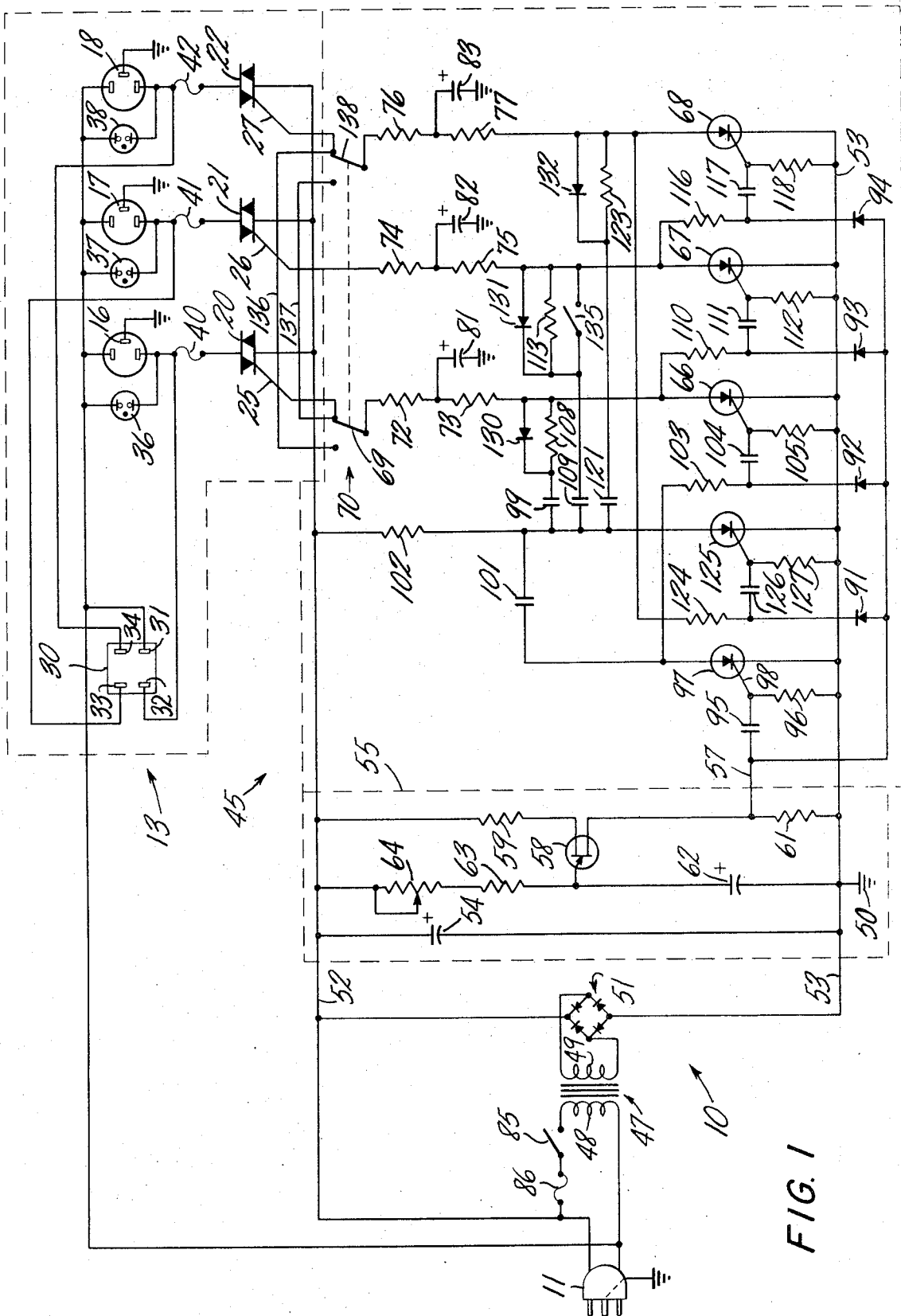


FIG. 1

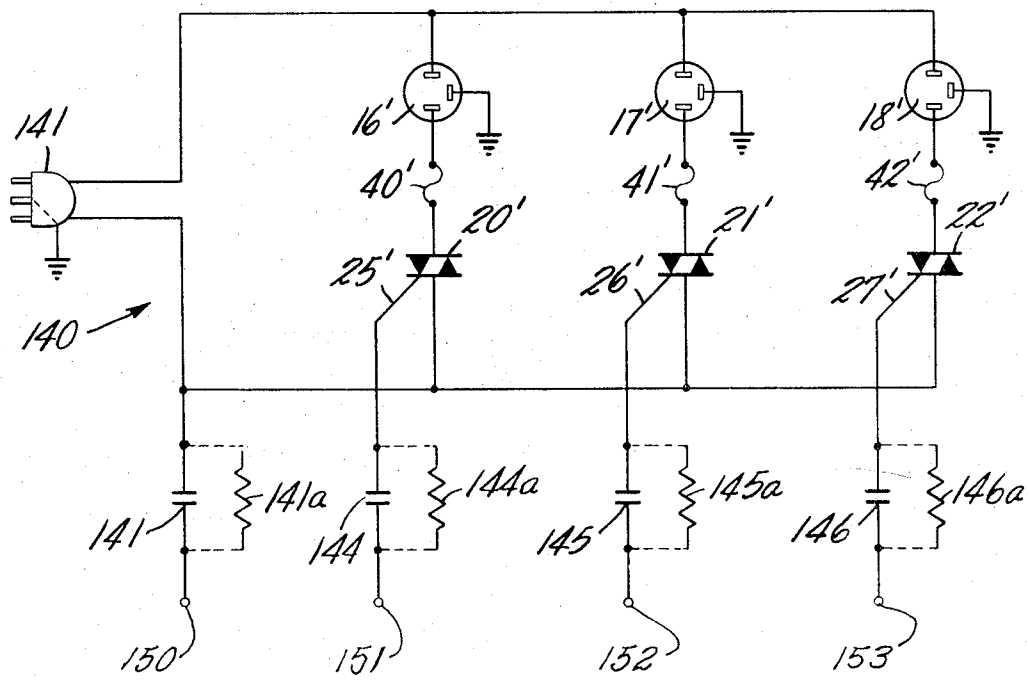


FIG. 2

LIGHT CONTROL CIRCUIT

BACKGROUND OF THE INVENTION

This invention relates to a lamp control circuit, and more particularly to a circuit for sequentially energizing groups or banks of lamps.

Chase lights are familiar attention getting light arrangements in which banks of many incandescent bulbs are lighted sequentially to give the effect of moving lights. Once associated primarily with theatre or movie marquees, chase lights now find use in traffic control situations to point the direction in which automobile traffic should move and to direct airplane traffic at airports, and appear as indoor advertising displays and special effects stage lighting for television and legitimate theatre.

Commonly, mechanical switching arrangements have sequentially energized groups of lamps to produce the chase lighting effect. Motor controlled switch actuating cams often control the timing and the duration of switch closure.

Arcing at the contacts of repeatedly opened and closed switch contacts, particularly those making and breaking high current circuits, soon causes contact carbonization and pitting. Because increased currents are required, these difficulties become worse as the number of lamps increases. Mechanical switching for this purpose, then, requires considerable maintenance, and if repairs are not timely made, switch overheating and failure often occurs.

Mechanical switching is noisy and inefficient. Electrical noise is worse than its acoustical counterpart; T.V. and radio reception, public address and intercom systems suffer in the vicinity of repeatedly opening and closing mechanical switches. If a motor driven cam controls the switching, the motor itself continuously consumes more power than need be. Repeatedly mechanical switching occurs without reference to the magnitude of the current being switched. The result often is switch closure or opening at peak current values in the sinusoidal alternating current wave form. Aside from the effects on the switch contacts, this causes increased cold filament surge currents in the lamps, greater sudden expansion and like contraction when the current is interrupted. All of this affects the life of the lamps, and lamp life is a very important consideration when many lamps are being repeatedly switched on and off.

Known chase light switching arrangements have been notoriously lacking in flexibility. Timing, mode of operation, and lighting sequence have been difficult or impossible to alter without rewiring. Remote monitoring of a display has been overlooked as well.

SUMMARY OF THE INVENTION

According to this invention a lamp circuit with several outputs for sequentially lighting groups of lamps uses a timing and control circuit to control, in two modes, repeated energization of the outputs. The timing and control circuit employs controlled semiconductor switching arrangements which conduct sequentially. In the first mode of operation, a quenching or conduction stopping portion of the circuit stops the semiconductor switching arrangements' conduction simultaneously. In this mode lamp banks light sequentially and darken together. In the second mode, a switch alters the circuit to cause previously conducting

semiconductor switch arrangements to stop conduction as, respectively, the next conducts. This mode gives one at a time lamp bank lighting.

The timing and control circuit couples the semiconductor switching arrangements with the gate electrodes of plural controlled semiconductor switches, each connected with an output jack. These jacks or output connections energize respective lamp banks when the semiconductor switches are triggered into conduction.

The lamp control circuit is, with the exception of manual control switches which switch only low control currents, entirely solid state. The result is reliable operation with neither audible nor electrical noise, and minimal power consumption by the circuit because only low level control signals are needed. The complete control unit is very light and easily portable. Neon discharge lamps connected in parallel with the output connections for the lamp banks permit remote monitoring of the mode, timing, and sequence of the light display. An auxiliary universal output jack is useful for a single easy to use connection to the lighting display.

The solid state switching devices that make and break the circuit to the lamp banks are triacs which begin and end conduction at the current cross-over point in the current waveform. The current that is switched to the lamps is thus always applied at current cross-over and increases with the sinusoidal alternating current waveform. This is easier on the lamp filaments than repeated abrupt switching into the high current part of the sine wave with consequent abrupt filament expansion. Likewise, interruption occurs at cross-over, and lamp filaments are less abruptly contracted. Fewer lamp replacements result.

Reversing the control connection from the transistor switching arrangements of the first on and last on triacs reverses the lighting sequence. This is effected by a switch accessably mounted on the control circuit package. Oscillator timing permits easy manual change of the timing by variation of a single potentiometer.

A slave unit increases the capabilities of the basic control arrangement. Additional slave triacs are controlled from the respective outputs of the master unit to control switching to additional lamps from a separate A.C. source. This arrangement can multiply power handling capability of the invention many times.

BRIEF DESCRIPTION OF THE DRAWING

A better understanding of the invention is available upon consideration of the following detailed description of a preferred, exemplary embodiment, considered with the accompanying drawings. In the drawings:

FIG. 1 is a diagrammatic illustration of a circuit for controlling three lamp banks from three triac-controlled output jacks.

FIG. 2 is a diagrammatic illustration of an auxiliary slave unit controllable by the master unit of FIG. 1 for controlling the lighting of three additional lamp banks.

DESCRIPTION OF A PREFERRED EMBODIMENT

In FIG. 1 an exemplary lamp control circuit according to the invention is generally designated by the numeral 10. A plug 11 connectable with a common 115 volt, 60 cycle outlet applies alternating current to a power switching section 13 of the lamp control circuit 10. Three output jacks 16, 17 and 18 are respectively connected in series with three triacs 20, 21 and 22, in parallel across the volts A.C. supplied from the plug 11.

The jacks 16, 17 and 18 are intended for connection to separate banks of lamps sequentially to be energized as controlled by the circuit 10. The triacs 20, 21 and 22 are bidirectional semiconductor controlled rectifiers which are the solid state or semiconductor lamp current switches for energizing the outputs 16, 17 and 18, respectively. The triacs have gate electrodes or control connections 25, 26 and 27 which, in response to an appropriate bias, enable the triacs to conduct.

Connected in parallel with the jacks 16, 17 and 18 is a single universal output jack 30 with a common connection 31 connected with one of the 115 volt lines of the plug 11. Three further universal jack connections 32, 33 and 34 are each connected to a point between a triac-output jack pair to be connected with the remaining 115 volt line when an associated triac fires. The universal plug 30, then, is an alternate set of three output connections paralleling the jacks 16, 17 and 18 and providing a single jack and plug connection for control of three lamp banks.

Three neon glow lamps or discharge tubes 36, 37 and 38 parallel the three output jacks 16, 17 and 18 respectively. These are indicator lamps to be mounted on a face panel of the circuit package to provide remote monitoring of the controlled lamp banks. Three fuses 40, 41 and 42 in series between the triacs 20, 21 and 22 and their respective outputs protect each of the three triac controlled circuits.

A combined timing and control circuit 45 controls the sequence and duration of lamp energization, and the mode of operation by controlling the bias to the gates 25, 26 and 27 of the triacs 20, 21 and 22. An appropriate D.C. reference voltage for the semiconductor devices of the timing and control circuit 45 is provided by the conventional combination of an isolation transformer 47, with a primary 48 connected across the 115 volt input, and a secondary 49 supplying a full wave rectifier 51. The rectifier 51 applies rectified A.C. voltage to lines 52 and 53, and capacitor 54 smooths the rectified A.C. conventionally to provide the appropriate D.C. reference voltage between line 52 and 53. A ground connection 50 establishes line 53 as the circuit ground for the timing and control circuit 45.

A conventional unijunction transistor relaxation oscillator 55 supplies timing pulses as an output to line 57. The oscillator 55 has a unijunction transistor 58 with a temperature compensating resistor 59 connected with base-two and an output resistor 61 connected with base-one. A capacitor 62, a resistor 63, and a potentiometer 64 in the emitter circuit determine the timing of the output pulses at line 57. Potentiometer 64 is preferably manually controlled to set the flash rate of the controlled lamp display.

Three semiconductor controlled rectifiers or SCRs 66, 67 and 68 control the three triacs 20, 21 and 22. These are the controlled semiconductor switch means that open or close the gate circuits to the triacs to bias the triacs into or out of conduction. For example, when SCR 66 conducts, a circuit is completed from the control connection 25 of the triac 20, through a switch arm 69 of a switch 70, through a pair of series resistors 72 and 73, through the SCR 66, to the grounded reference line 53. This completed circuit from the triac control connection 25 biases the triac 20 into conduction, assuming lamps are connected across the output 16. Such lamps are lighted whenever SCR 66 conducts. Likewise, lamps connected across the output 17 light when

SCR 67 conducts, and lamps connected with the output 18 light when SCR 68 conducts.

In the three SCR controlled gate circuits, series resistors 72, 74 and 76, are current limiting resistors. Three capacitors 81, 82 and 83 are connected to ground across three further series resistors 73, 75 and 77. Each combination provides a filter section, filtering out spurious signals which might activate the triacs 20, 21 and 22.

In operation, closure of an off-on switch 85 in series with a protective fuse 86 in the primary circuit of the input transformer 47 establishes the D.C. reference voltage across lines 52 and 53. The unijunction relaxation oscillator 55 begins producing its series of output pulses at line 57. These pulses are applied to four diodes 91, 92, 93 and 94. The first output pulse of the oscillator 55 is applied, via a capacitor 95, across a resistor 96 connected with a gate 98 of a starting control rectifier or SCR 97. This SCR conducts first. The starting SCR 97 is in series with a capacitor 101 and a current limiting resistor 102. Upon conduction, the starting SCR 97 connects one end of a resistor 103 to ground, thereby removing a reverse bias from the diode 92 and permitting the previously blocking diode 92 to conduct the next output pulse from the oscillator output 57.

Unlike the diode 92, the remaining diodes 91, 93 and 94 remain reversely biased and blocking at this time and they do not conduct the pulse applied to their commonly connected anodes. A capacitor 104 applies the current pulse through diode 92 across a resistor 105 connected from the gate of the SCR 66 to ground, biasing the SCR 66 into conduction, biasing the triac 20 into conduction, and lighting any lamps connected with the output jack 16 or connected across the output connections 31 and 32 of the universal jack 30. As all of this occurs, the starting SCR 97 has stopped conducting.

Conduction by the SCR 66 connects a resistor 108 to ground, charging a commutation capacitor 99 which is in series with the resistor 108 and the resistor 102 between the D.C. reference lines 52 and 53. Conduction by the SCR 66 has also connected one end of a resistor 110 to ground to remove the reverse bias across the diode 93. For the SCR 67, the SCR 66 has now served the function initially served by the SCR 97, readying the SCR 67 for conduction. When the oscillator 55 produces its next output pulse, the diode 93 and a capacitor 111 conduct, the appropriate bias potential is established across a resistor 112, and the second triac controlling SCR 67 fires. Triac 21 conducts now and any lamps connected with the output jack 17 or the output connections 33 and 31 of the universal jack 30 light. A second commutation capacitor 109 now charges through a series resistor 113 connected to ground by the conducting SCR 67. Again a resistor 116 is connected to ground removing the reverse bias from the diode 94.

The diode 94 applies the next subsequent output pulse of the oscillator 55 via a capacitor 117 and a resistor 118 to fire the SCR 68 and illuminate the third lamp bank connected with the output jack 18 or universal jack connections 34 and 31. All triacs now are conducting and all lamps are lighted. Again a commutation capacitor 121 is charged through a resistor 123. Again a resistor 124 is connected to ground by the con-

ducting SCR 68. A fifth and final SCR, a quenching SCR 125, is now ready to conduct.

To stop conduction of the conducting trigger SCRs, the quenching SCR 125 fires with the next output pulse of the timing oscillator 55 thanks to the diode 91, now forward biased, a capacitor 126, and a resistor 127. Conduction by SCR 125 clamps the positively charged sides of the capacitors 99, 109 and 121 to ground. Three diodes 130, 131, and 132 are forward biased and conduct to the temporarily lower than ground side of the commutation capacitors 99, 109, and 121 from the three triac trigger circuits which include respectively the SCRs 66, 67, and 68. Sustaining current having been diverted, these latter three SCRs are thus quenched, opening the respective triac trigger circuits as the commutation capacitors discharge. All lamps are extinguished. A single sequence of the circuit's first mode, the chaser mode, is complete. With the next timing oscillator output the sequence begins again with the conduction of the starting SCR 97, which, when it conducts, quenches the quenching SCR 125 by connecting the capacitor 101 in parallel.

Open until now, a manually operable mode selection switch 135 converts the circuit to the second mode, the ring counter mode, when closed. As before, an output pulse from the timing oscillator 55 causes the SCR 97 to conduct and remove the reverse bias from diode 92. This permits the SCR 66 to be triggered into conduction by the next pulse activating the first triac 20 and lighting the first lamp bank. Again the conduction of SCR 66 readies SCR 67, and a subsequent pulse from the oscillator 55 causes SCR 67 to conduct, triac 21 to conduct, and output jack 17 to be energized, illuminating the second bank of lamps.

Now however, with the single pole, single throw switch 135 closed to short circuit the resistance 113 and diode 131, the RC time constant of the series circuit which includes resistor 108, commutation capacitor 99, commutation capacitor 109, and the switch 135 is reduced significantly. Capacitors 99 and 109 are connected by the SCR 67 across the first triac-controlling SCR 66 in series with the resistor 108, and they quench the SCR 66 to extinguish the first bank of lamps as the second is lighted, diverting sustaining current from the SCR 66.

Just as before, conduction by the second triac-controlling SCR 67 readies the third triac-controlling SCR 68 by removing the blocking, reverse bias across the diode 94. Once again the oscillator 55's next output pulse turns on SCR 68 to fire the triac 22 and light the third lamp bank. Conduction by the SCR 68 again has the effect of quenching the previously conducting SCR 67. Closure of the mode selection switch 135 has reduced the time constant in the further series circuit including the switch, the commutation capacitors 109 and 121, and the resistor 123. Connection of this series circuit in parallel across the previously conducting SCR 67 diverts current from the SCR 67 to quench that SCR as the SCR 68 begins the conduct. Hence the second lamp bank is extinguished as the third is lighted.

The next subsequent timing pulse from the oscillator 55 triggers the quenching SCR 125 into conduction just as occurred in the chaser mode, the SCR 68 having removed the reverse bias from the diode 91. The ring counter mode has completed a first sequence. The second ring counter sequence begins with the next pulse from the timing oscillator triggering the starting SCR

97, enabling the first triac controlling SCR 66, and quenching the SCR 125.

In both modes described above, the lighting sequence has been, first, the lamps controlled by triac 20, then those controlled by triac 21, and last, those of triac 22. If the sequence reversing switch 70 is thrown from its position illustrated in FIG. 1 to the remaining position the sequence reverses. The first trigger signal is conducted by switch arm 69 and a line 136 to the triac 22, the second triac to fire remains the triac 21, and the third triac is triac 20 whose gate circuit is closed via a line 137 and a switch arm 138 of the switch 70.

For desired operation, the value designations of the circuit elements in FIG. 1 will be easily determined conventionally by those skilled in the art. Appropriate timing for the charging and discharging of the commutation capacitors and successful quenching of the SCRs was achieved by the selection of 1 K Ω resistors for the resistors 108 and 113, a 100 Ω resistor for the resistor 123, a 220 Ω resistor for the resistor 102, and 0.47 μ f capacitors chosen for capacitors 99, 101, 109, and 121.

FIG. 2 illustrates a slave unit 140 which can be connected easily to the basic circuit of FIG. 1 to take its control from the FIG. 1 master circuit. A standard 115 volt plug 141 separately supplies the slave unit and thus doubles the number of lamps that can be controlled by using both the FIG. 1 lamp connections and three additional lamp connections 16', 17', and 18' of the slave unit 140. Three additional slave triacs 20', 21', and 22' control the energization of jacks 16', 17', and 18'. Each of the three slave triacs form, with their respective output jacks, three series branches connected in parallel across the supplied 115 volts.

Three fuses 40', 41', and 42' protect the three parallel series branches of the slave circuit 140. A capacitor 141 and its apparent parallel resistance 141a form an isolation coupling with the FIG. 1 or master circuit. The coupling, with, for example, a connector 150 is connected with one side of the A.C. power circuit 13 of FIG. 1, for example at the common connection 31 of the universal outlet 30. Three capacitors 144, 145, and 146 and their apparent parallel resistances 144a, 145a, and 146a form isolation couplings for three gates or control electrodes 25', 26', and 27' of the triacs 20', 21', and 22'. These control couplings, with connectors 151, 152, and 153, if desired take their control signals directly from the corresponding series circuits of FIG. 1, those controlled by triacs 20, 21 and 22. Connections to the master circuit are convenient, for example, at the connections 32, 33 and 34 of the universal outlet 30 of FIG. 1. The control of the slave unit 140, then, is the same as that of its master, opening or closing the mode selection switch 135 of FIG. 1 causing chaser or ring counter operation and the double pole double throw switch 70 controlling the lighting sequence.

The exclusively semiconductor timing, control and power switching arrangements of FIG. 1 provide a light control that is light and portable, silent, efficient and reliable. The slave unit of FIG. 2 is a similarly advantageous means for increasing power capabilities. Mode switching occurs with only a single pole single throw switch effecting a minimal circuit change. In the circuits of both FIGS. 1 and 2, many alterations and substitutions of equivalents will be apparent to persons skilled in the art. All such modifications are within the inventive concepts embodied in the preferred embodi-

ments just described and defined in the appended claims. Such modifications are thus intended to be covered by the appended claims.

I claim:

1. In a lamp circuit having plural output connections for sequentially energizing plural groups of lamps, a timing a control circuit for selectively providing the repeated application of electrical energy to the plural output connections in one of two available modes and including plural controlled semiconductor switch means, means for causing the semiconductor switch means sequentially to begin to conduct, means for stopping conduction of all of said semiconductor switch means simultaneously to complete a sequence of the first of the two modes, circuit means operatively coupling together several of the semiconductor switch means and including circuit modifying switch means for altering said circuit means to cause sequentially conducting semiconductor switch means to stop the conduction of previously conducting semiconductor switch means for one at a time conduction of the semiconductor switch means in the second of the two modes.

2. The lamp circuit of claim 1, wherein the means for stopping conduction of all semiconductor switch means is connected with and stops the conduction of only the last conducting semiconductor switch means in the second mode.

3. The lamp circuit of claim 1, wherein the semiconductor switch means are a set of semiconductor controlled rectifiers, the means for stopping conduction includes a further semiconductor controlled rectifier and commutation capacitors connected by the semiconductor controlled rectifier of the conduction stopping means to the set of semiconductor controlled rectifiers to quench the semiconductor controlled rectifiers of the semiconductor switch means, and the selectively operable switch means is connected to connect the commutation capacitors and the subsequently conducting semiconductor controlled rectifiers of said set in current diverting relationship to previously conducting semiconductor controlled rectifiers of said set to quench the previously conducting semiconductor controlled rectifiers.

4. The lamp circuit of claim 1, including a further selectively operable switch in circuit with at least two of the semiconductor switch means and operable to change the output connections controlled by the semiconductor switch means to thereby change the sequence in which the output connections are energized.

5. The lamp circuit of claim 1, including controlled semiconductor lamp current switches, each in series with an output connection for conducting current to lamps connected with the output connections and each having a control connection in circuit with one of the semiconductor switch means for activation by the semiconductor switch means.

6. The lamp circuit of claim 5, further including a slave circuit comprising additional controlled semiconductor lamp current switches, each connected in series with an additional slave output connection for an additional group of lamps, for conducting current to lamps connected with the output connection, and each semiconductor lamp current switch having a control connection in circuit with one of the first mentioned output connections for simultaneous control of energization of

the additional slave output connections with the first mentioned output connections.

7. The lamp circuit of claim 6, including separate means for supplying electrical energy from separate sources to said slave circuit and to the first mentioned output connections and semiconductor lamp current switches in circuit.

8. The lamp circuit of claim 5 further including indicator lamps each connected with one output connection to provide a remote indication of the sequence, mode, and timing of energization of the output connections.

9. The lamp circuit of claim 5, wherein the output connections include a universal connector with one common connection and other connections each controlled by one semiconductor lamp current switch.

10. The lamp circuit of claim 1, wherein the plural controlled semiconductor switch means are three controlled rectifiers, the means for stopping conduction includes a further controlled rectifier connected with commutation capacitors and conductable to connect the commutation capacitors in current diverting parallel relationship to each of the three other controlled rectifiers to complete a single sequence of the first mode, and the selectively operable switch means is a switch connected in circuit with at least one of the commutation capacitors and two of the three controlled rectifiers of the controlled semiconductor switch means, said switch being closable to place at least one of said commutation capacitors and the second-conducting of said three controlled rectifiers in current diverting parallel relation to the first-conducting of said three controlled rectifiers and to place at least another of said commutation capacitors and the third-conducting of said three controlled rectifiers in current diverting parallel relation to the second-conducting of said three controlled rectifiers, said further controlled rectifier of the conduction stopping means being conductable to place a commutation capacitor in current diverting parallel relation to the third-conducting of said controlled rectifiers to complete a single sequence of the second mode.

11. The lamp circuit of claim 10, wherein each controlled rectifier of a semiconductor switch means is connected to a control connection of a semiconductor lamp current switch means in series with one of the output connections, the circuit further including a reversing switch connected with the first-conducting and the third-conducting controlled rectifiers and actuatable alternatively to interconnect the first and third controlled rectifiers with a first or third of said semiconductor lamps current switches, whereby the control signals only are reversed to reverse the sequence of output energization without switching the much higher lamp currents to the outputs.

12. A lamp circuit having plural output connections for sequentially energized plural groups of lamps, oscillator means for controlling the timing of sequential energization, semiconductor controlled switch means for conducting in response to energization of a control electrode thereof, a commutating quenching circuit interconnecting the semiconductor controlled switch means and including commutating capacitors for each semiconductor controlled switch means, a further controlled quenching switch means connected with the quenching circuit for completing a circuit including a commutating capacitor across each semiconductor

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controlled switch means to simultaneously quench all of said semiconductor controlled switch means in a chaser mode of operation, and manually selectable impedance altering switch means in said quenching circuit for changing the time constant of the quenching circuit to cause successively conducting semiconductor

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switch means to establish a commutating circuit across a previously conducting semiconductor switch means to quench said previously conducting semiconductor switch means in a ring counter mode of operation.

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