United States Patent

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[54] **LIGHTING CONTROL SYSTEM**

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[52] **U.S. Cl.** **315/316,** 315/312, 315/317, 315/318, 315/291, 315/292

[51] **Int. Cl.** **H05b 39/00**

[58] **Field of Search**......315/291, 295, 312, 316, 317, 315/318; 235/151.2, 151.21; 340/172.5, 324 A

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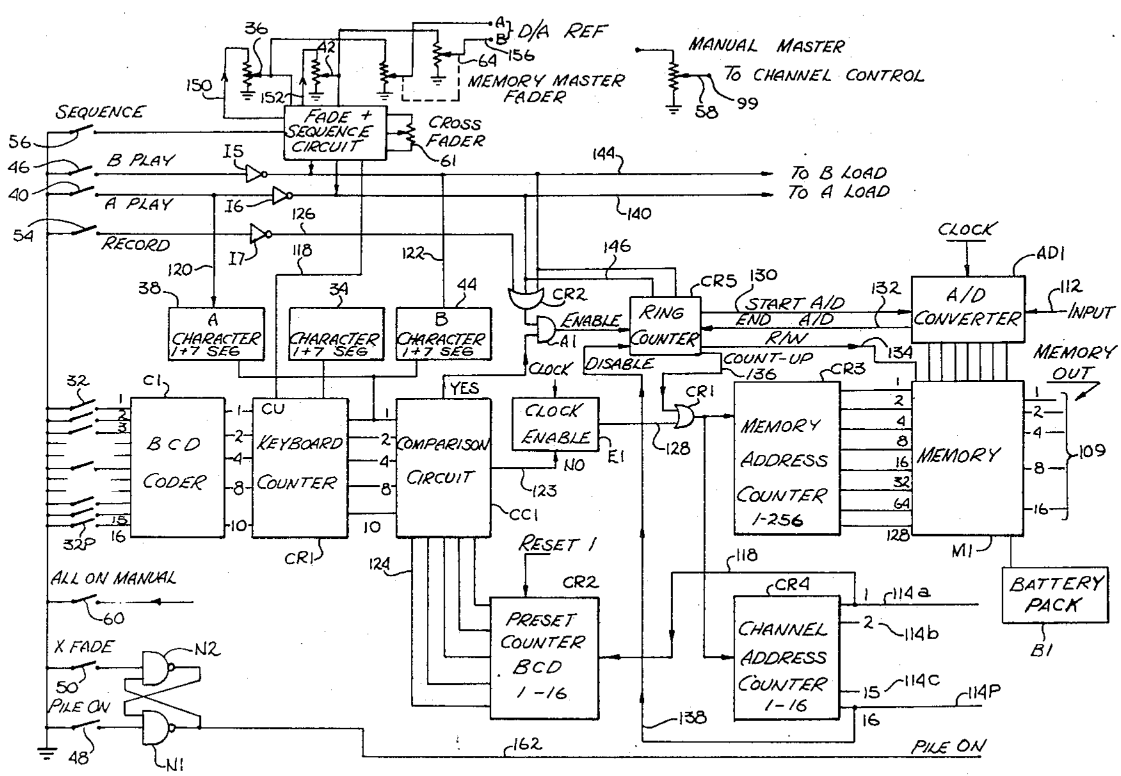
[57] **ABSTRACT**

A light control system for the control of a plurality of lights in a pre-programmed lighting sequence. The system is comprised of a keyboard module and one or more controller modules. Each controller module contains 16 manually operated light controllers and a semiconductor memory capable of storing 16 individual settings for each of the 16 light controllers. The keyboard has 16 pushbuttons through which any of the 16 lighting combinations may be put into memory or selected out of memory for control of the lights. First and second registers are provided for retaining any pair of lighting combinations, with a cross fade control on the keyboard being adapted to provide a smooth transition from one of such lighting combinations to the other combination. An automatic sequencing selection is provided whereby each of the 16 lighting combinations will be automatically selected in sequence through the use of the cross fade control. Other features of the system include the ability to program one lighting combination while playing another lighting combination, to have one or more light controls under manual control while the rest are under control by the memory, and a means for displaying on a meter any stored light control setting.

16 Claims, 5 Drawing Figures



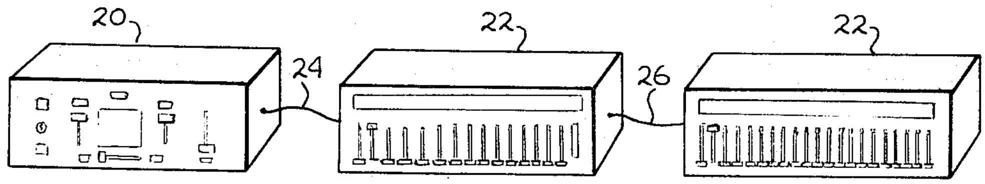


Fig. 1

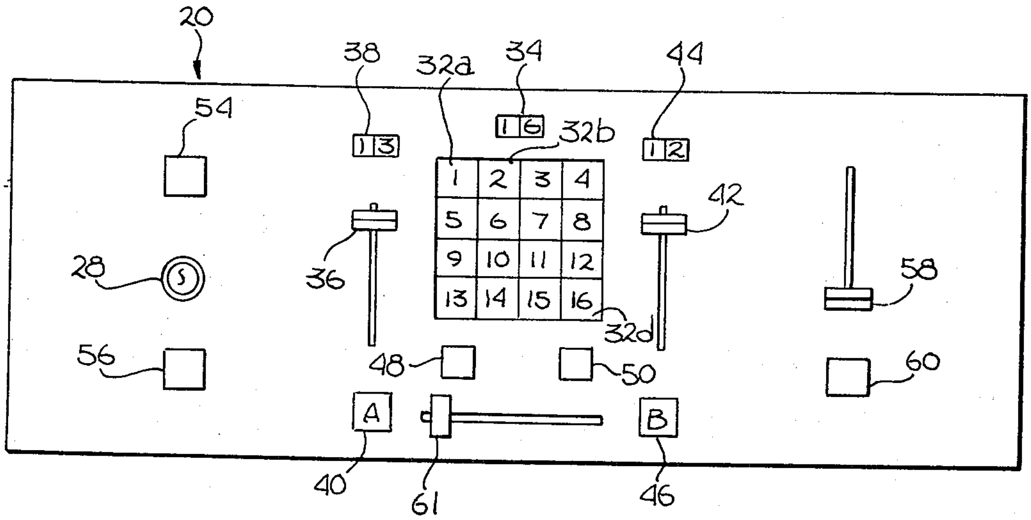


Fig. 2

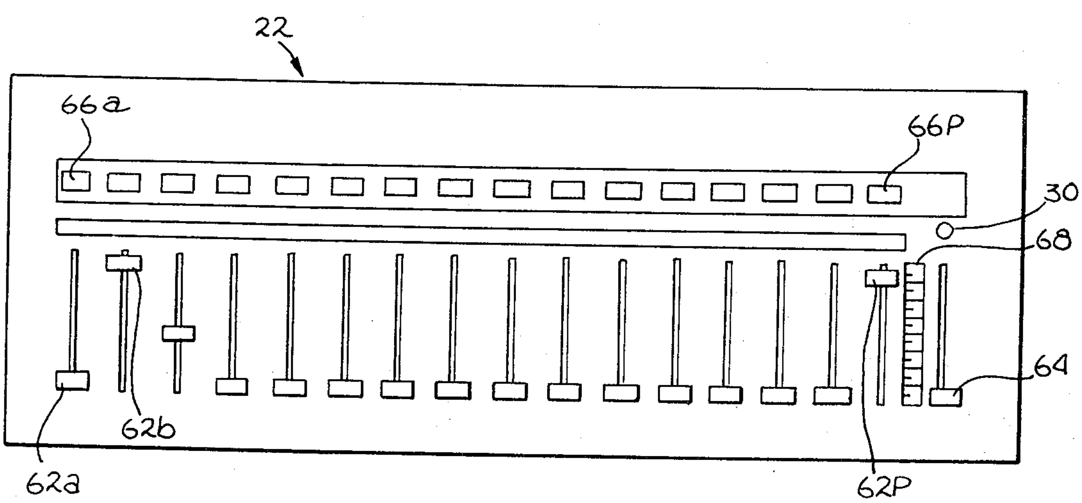


Fig. 3

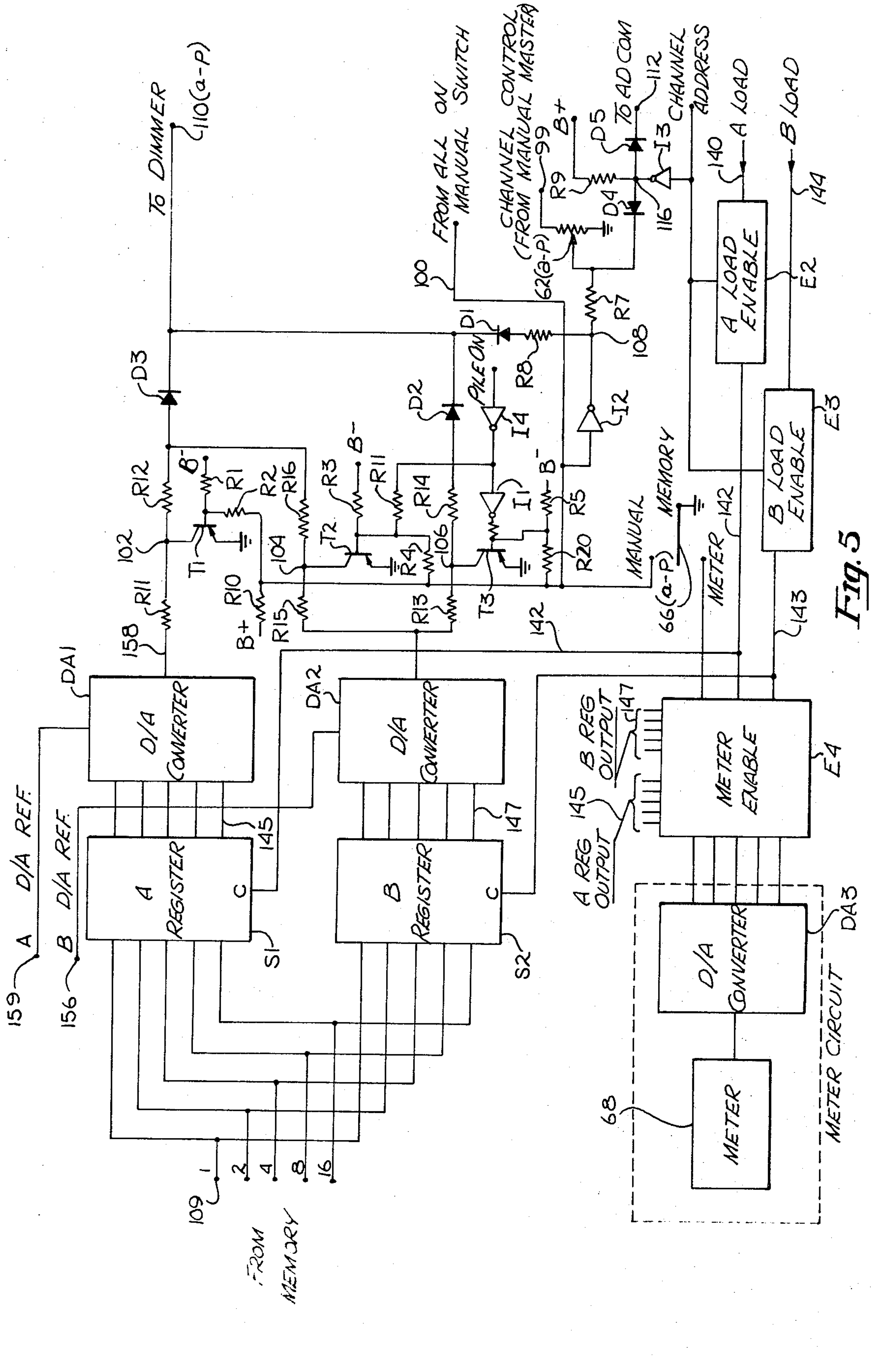

TO DIMMER
110(a-P)
FROM ALL ON MANUAL SWITCH
CHANNEL CONTROL (FROM MANUAL MASTER)
TO AD COM
CHANNEL ADDRESS
A LOAD
B LOAD
A LOAD ENABLE
B LOAD ENABLE
PILE ON
MANUAL
MEMORY
METER
D/A CONVERTER
A REGISTER
B REGISTER
A D/A REF.
B D/A REF.
A REG OUTPUT
B REG OUTPUT
METER ENABLE
METER CIRCUIT
METER
FROM MEMORY

Fig. 5

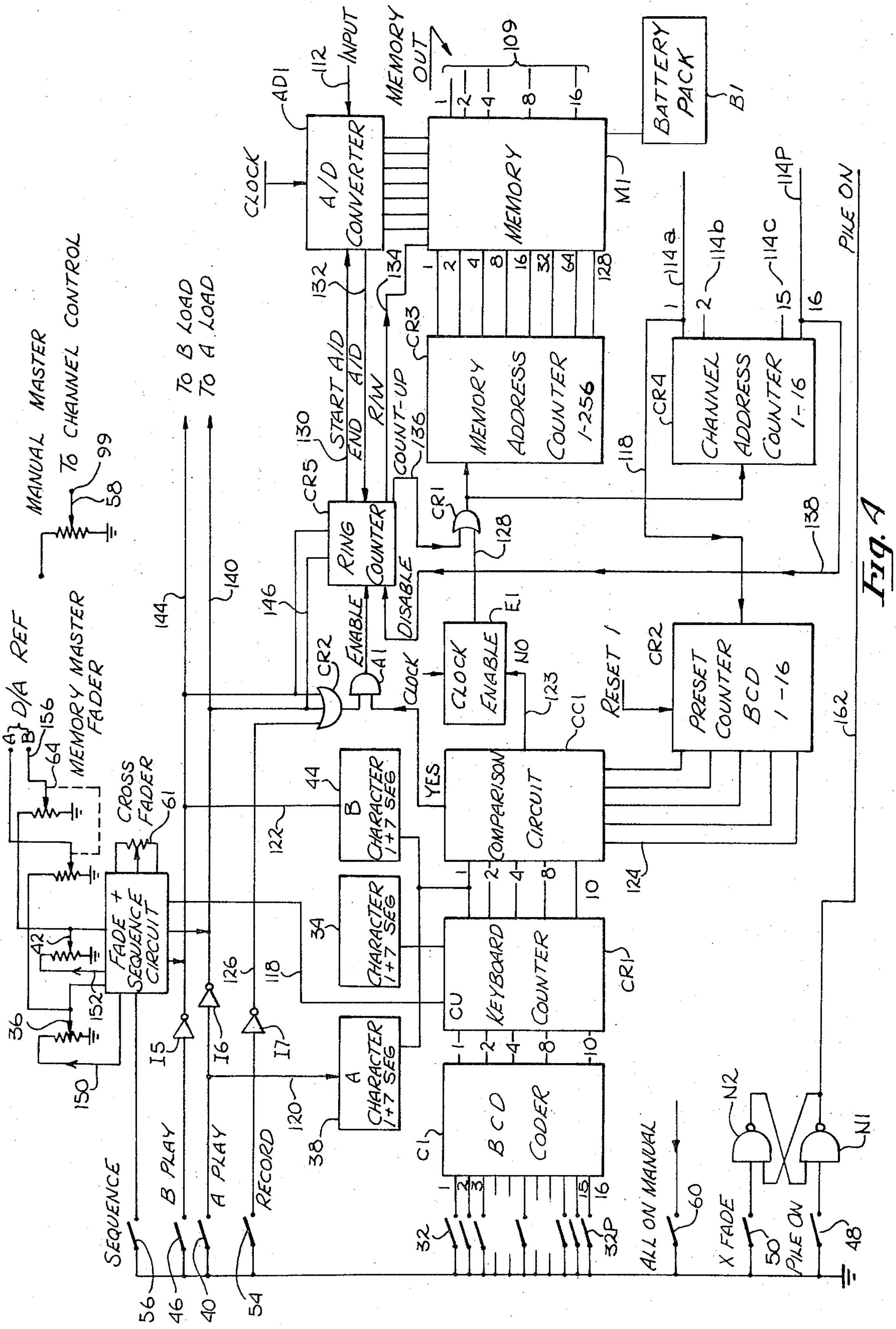

MANUAL MASTER
TO CHANNEL CONTROL
D/A REF
MEMORY MASTER FADER
CROSS FADER
FADE + SEQUENCE CIRCUIT
TO B LOAD
TO A LOAD
CLOCK
A/D CONVERTER
INPUT
MEMORY OUT
MEMORY
BATTERY PACK
START A/D
END A/D
R/W
COUNT-UP
RING COUNTER
ENABLE
DISABLE
MEMORY ADDRESS COUNTER 1-256
CHANNEL ADDRESS COUNTER 1-16
CLOCK ENABLE
YES
NO
RESET 1
PRESET COUNTER BCD 1-16
COMPARISON CIRCUIT
KEYBOARD COUNTER
CU
B CHARACTER 1+7 SEG
CHARACTER 1+7 SEG
A CHARACTER 1+7 SEG
BCD CODER
SEQUENCE
B PLAY
A PLAY
RECORD
ALL ON MANUAL
X FADE
PILE ON

Fig. 4

LIGHTING CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates to the field of lighting control systems, such as may be used for the sequential control of stage lighting and the like.

2. Prior Art

Lighting systems for theaters and the like are generally adapted to allow the independent control of various lights or groups of lights so as to achieve various desired lighting combinations. By way of example, for a stage show, various scenes will require various lighting intensities and lighting color combinations so as to enhance the color of costumes, simulate daylight, moonlight, etc., to contribute to the mood and spirit of such scenes. Since such productions are normally repeated a number of times, it is highly desirable that the lighting be easily controllable in a repeatable manner.

Various means are well known in the prior art for the control of such lighting. One of the earliest of such means to find general application is the variable autotransformer. These devices are comprised generally of a single layer toroidal winding on a magnetic core, with each lead of the winding connected to one of the terminals of the alternating current power source. One terminal of the lights to be controlled is connected to the lead connected to one terminal of the power source, and the other terminal of the lights is coupled to a wiper disposed so as to variably contact a bare surface of the wires forming toroidal winding in a readily controllable manner. Thus, with the wiper adjacent the end of the winding which is also coupled to the lights to be controlled, the voltage and power delivered to the lights is substantially zero. As the wiper is moved along the toroidal winding, an increasing voltage and power is delivered to the lights, with the maximum generally being limited to the voltage of the power source. Such devices are commonly found in the older systems, and though they perform the desired function, are not convenient to use for a number of reasons. The control of such devices is entirely manual and is very subject to human error. Further, the number of individual controls that may be readily handled is very limited and, therefore the flexibility in the lighting combinations is similarly limited. The autotransformers are relatively large (to handle the power required) and, therefore, are generally immovable, require a substantial amount of space, and dissipate a considerable amount of power, thereby requiring a permanent installation of adequate space and cooling.

With the advent of silicon controlled rectifiers (SCR's) and their ability to readily control considerable levels of AC power, newer lighting systems have SCR controllers interposed in the power lines to the lights, and have used smaller and more readily handled devices for controlling the SCR controllers. By way of example, potentiometers have been used to control the signal directed to the SCR controllers. This type of control does not dissipate as much power and requires less space than the autotransformer type of control, though it still has certain disadvantages. By way of example, in the present invention, individual controls for sixteen light controllers may be pre-programmed for the semi-automatic control of lighting through sixteen lighting combinations, with the mere manual control of a single

cross fade potentiometer control. However, in prior art systems using all potentiometer control, 256 potentiometers would be required for pre-setting, and an additional sixteen potentiometers for use as faders would be required. In such a system, a first row of 16 potentiometers would be set in accordance with the first desired lighting combination. The second row of 16 potentiometers would be set in accordance with the second desired lighting combination, etc., with the signal to each of the SCR controllers being the sum of the signals for the corresponding potentiometer in each of the 16 rows. To bring up the first lighting combination, the master fader from the first row would be brought up to the on position, with the other 15 master faders in the off position. To change from one lighting combination to another lighting combination, the master fader for the previous lighting combination is smoothly moved to the off position while the master fader corresponding to the desired new lighting combination is moved to the on position. Thus, 272 potentiometer controls, in addition to other switches and the like, are required on the control panel, and, thus, such systems are also relatively bulky, immobile and difficult to preset and use.

In a few prior art systems, information regarding the desired lighting combinations throughout a sequence of combinations is stored in digital form in a magnetic core memory of the type commonly used in digital computers. These systems have the advantage that a number of controls, equal in number to the light controllers to be controlled for any one lighting combination, may be set in the desired manner, the settings stored in the memory, and then reset and similarly memorized for each subsequent lighting combination. In this manner, the number of controls may be reduced to that required for one lighting combination rather than that required for all lighting combinations. However, such systems as have utilized a digital memory of any type, and specifically of the magnetic core type, have been very expensive and large capacity systems, being limited in practical and economic operation in those situations requiring extensive and numerous lighting combinations.

There is, therefore, a need for a light control system which is small and generally movable, which combines the desirable features of storage of information in digital form in a memory of some form, which is easy to operate, susceptible of substantially automatic operation, and programmable before or during playback of the various lighting combinations so as to be practical and economical in those applications not justifying the magnetic core memory systems, such as for school auditoriums and the like.

BRIEF SUMMARY OF THE INVENTION

A light control system for the control of a plurality of lights in a pre-programmed lighting sequence. The system is comprised of a keyboard module and one or more controller modules which may be coupled in series and operated from the single keyboard module. Each controller module contains 16 manually operated light controllers in the form of potentiometer controls and a semiconductor memory capable of storing in digital form 16 individual settings for each of the 16 light controllers. The keyboard has 16 pushbuttons with which any of the 16 lighting combinations may be put into memory or selected out of memory for control of the lights. The lighting combinations are put into memory by setting the manually operated light controllers to the desired position, pushing a keyboard switch indicating the number to be assigned to the lighting combination and pushing a record switch which causes the sequential analog to digital conversion of each of the 16 light controller settings and the loading of the respective digital information into the appropriate memory spaces.

For reading the memorized information out of memory, first and second registers are provided in each controller channel card for retaining any pair of lighting combinations, with a cross fade control on the keyboard module being adapted to provide a smooth transition from one of such lighting combination to the other combination. An automatic sequencing selection is provided whereby each of the 16 lighting combinations will be automatically selected in sequence through the use of the cross fade control. Other features of the system include the ability to program one lighting combination while playing another lighting combination, to have one or more light controls under manual control while the rest are under control by the memory, and a means for the displaying on a meter any stored light control settings while playing back any lighting combination. The system further includes a battery pack and circuitry to allow power to be continuously applied to the memory to prevent loss of the memorized information when the system is "turned off."

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a keyboard module **20** and two controller modules **22** connected in series thereto;

FIG. 2 is a front view of the keyboard module **20** of FIG. 1;

FIG. 3 is a front view of a controller module **22** of FIG. 1;

FIG. 4 is a diagram showing the circuits and controls therefor which are located in the keyboard module, or are located in the controller module and are associated with all channels of the controller; and,

FIG. 5 is a block diagram of the circuit for each channel in the controller module, and in addition, for the meter circuit in the controller module which is used in conjunction with all channels of the controller module.

DETAILED DESCRIPTION OF THE INVENTION

First referring to FIG. 1, a perspective view of the present invention may be seen. A keyboard module **20** and one or more controller modules **22** are combined to comprise the system. In FIG. 1, two controller modules **22** are shown, with the first of such controller modules connected to the keyboard module through cable **24**, and the two controller modules connected through cable **26**. As shall be further described, the various electrical connections in cable **26** are coupled directly to the equivalent connections in cable **24** and, therefore, a parallel connection, that is, connection of each of controllers **22** to the keyboard module **20**, might also be used. However, the series connection as shown in FIG. 1 is particularly advantageous since it allows the use of a single keyboard module **20** with substantially any number of controller modules **22** without requiring a comparable number of connectors on the keyboard module for connecting to each of the controller modules. This is achieved by providing on each controller module connectors for connection to a cable providing the input to that controller and, in common therewith, additional and equivalent connectors for coupling the same signals through another cable to the next controller module (e.g. there are common male and female connectors on each controller module). Thus, in the preferred embodiment, the output of each controller is buffered so that an unlimited number of controller modules **22** may be coupled in series and controlled with a single keyboard module **20**.

Now referring to FIGS. 2 and 3, a front view of the keyboard module and of a controller module may be seen. The keyboard module has a key switch **28** for activating the various power supplies. A circuit breaker **30** of conventional design on the controller module provides protection for the control power supplies. A keyboard **32**, having 16 numbered momentary switches on the front thereof, is located at the center of the keyboard, with a light emitting diode matrix **34** located thereabove for displaying numbers ranging from 1 to 16 thereon. One fader control is located on each side of keyboard **32** which, for reasons which will hereafter become apparent, are referred to as the A and B fader controls. Thus, the A fader control **36** is located to the left of keyboard **32**, with a light emitting diode matrix **38** similar to the matrix **34**, located thereabove, and an A play switch **40** located thereunder. The B fader **42** is located to the right of keyboard **32** with a light emitting diode matrix **44** thereabove, and a B play switch **46** thereunder. Under the keyboard **32** is a pile switch **48** and a cross fade switch **50** with a cross fader control **61** located thereunder. A pre-set record switch **54** is located at the left of the keyboard module with a sequence switch **56** thereunder, and a manual master fader control **58**, with an all on manual pushbutton **60** thereunder, is located to the right of the keyboard module. Each controller module **22** has 16 fader controls **62*a*** through **62*p*** in side-by-side relationship, with a memory master fader control **64** to the right thereof. Above each of the fader controls **62*a*** through **62*p*** is a three positioned switch **66** (e.g. **66*a*** through **66*p***) located between controller **62*p*** and memory master **64** is a meter **68**. The function of these various switches and controls and the manner in which they are used will be subsequently described in relation to the circuits of the present invention light control system.

The 16 controllers **62*a*** through **62*p*** in the controller module are individual potentiometer controls for each of up to 16 SCR light controllers, coupled to and associated with, each of the controller modules. The 16 pushbuttons on the keyboard **32** correspond to corresponding ones of up to 16 combinations of controller **62** settings which may be stored in a semi-conductor memory in the controller module. Thus, 256 controller **62** settings may be stored in the memory comprising 16 combinations of the 16 controller settings.

Now referring to FIGURES 4 and 5, block diagrams illustrating the circuit, logic and interconnection of the system of the present invention may be seen. FIGURE

4 is a diagram showing the circuits and controls therefor which are located in the keyboard module, or are located in the controller module and are associated with all channels of the controller, whereas FIG. 5, except for the meter circuit thereon, is a block diagram of the circuit for each channel in the controller module, the controller module having 16 printed circuit cards therein, each associated with one of the channels in the controller module, and each containing the circuits indicated in the block diagram.

In general, the individual circuits which in combination comprise the lighting system of the present invention are all well-known circuits, and the logical interrelationship thereof may be best explained in relation to the manner of using the system. Thus, to program this system for 16 selections of sixteen lighting combinations, the following procedure is followed: (in the following explanation it is assumed that the system is used in conjunction with 16 SCR light controllers of conventional design so that one controller module 22 is used with a keyboard module 20, it being understood that additional controller modules as indicated in FIG. 1, may also be used to control through one keyboard more than 16 light controllers.) The key switch 28 is turned on, thereby activating the system and the all-on manual switch 60 is actuated. This logically connects line 100 on each of the channel cards to ground so that transistors T–1 and T–2 are turned on by the biasing of the bases thereof through the voltage dividers defined by resistors R–1 and R–2, and R–3 and R–4, respectively. This shorts points 102 and 104 to ground. Similarly, transistor T–3 is turned on, shorting point 106 to ground as a result of the base current supplied to transistor T–3 through resistor network R–20, R–5 and R–6. As shall subsequently be seen, the values of R–20, R–5 and R–6 are selected such that transistor T–3 is on at all times unless line 100 is not connected to ground, either through the all-on manual switch 60 or through the individual channel switch 66, and simultaneously the output of inverter I–1 is positive. The inverters herein such as inverter I–2 are of the type having a floating output if the input is in the zero state, so that when in the all-on manual mode, the voltage at point 108 will be determined by the position of the channel controller potentiometer 62, with this voltage appearing at the dimmer control terminal 110 through resistors R–7 and R–8 and diode D–1, diodes D–2 and D–3 being back biased at this time since points 102, 104 and 106 are shorted to ground. Thus, the lights are directly controlled by the plurality of potentiometer controllers 62*a* through 62*p* in the all-on manual mode.

At the same time, the dimmer voltage, as determined by the position of the channel control 62, also appears at terminal 112, with resistor R–9 maintaining diode D–4 in a forward biased condition and the dimmer voltage being coupled to terminal 112 through forward biased diode D–5. Terminals 112 on each and every (e.g. 16) channel card in a controller are connected in parallel to the input 112 of the analog to digital converter AD–1 in FIG. 4. A channel address terminal 114 is coupled through an inverter I–3 to resistor R–9 so that when a positive signal is applied to the channel address terminal 114, point 116 is in the zero state, back biasing diode D–4 and decoupling terminal 112 from the output of the channel control 62. Also, in this condition, the analog to digital converter terminal 112 is similarly decoupled from point 116 by the back biasing of diode D–5. Therefore, by applying a positive voltage to terminal 114, that is, a one state for all channels except one, the input to the analog to digital converter AD–1 will be equal to the channel controller 62 for that particular channel, all other channels being decoupled at that time. Thus, it may be seen that in the all-on manual mode, each dimmer may be individually controlled with the channel control 62*a* through 62*p*, and the input to the analog to digital converter AD–1 may be addressed to any of the 16 controller channels by applying appropriate signals to the channel address terminals 114 on the various channel cards.

When in the all-on manual mode, the controllers 62*a* through 62*p* are set to give one of the desired lighting combinations. (The controllers 62*a* through 62*p* are coupled to the manual master fader 58 through line 99, which should be at (or near) its maximum position for recording). To record the lighting combination in the desired sequential position, one of the switches 32*a* through 32*p* on keyboard 32 is momentarily depressed. This provides an input to the BCD coder C–1 which codes the input and parallel loads the BCD keyboard counter CR–1. The counter CR–1 is of the type susceptible of parallel loading through multiple lines, and further, of countup from any previously loaded number upon receipt of an appropriate countup pulse, specifically through line 118. The output of the keyboard counter CR–1, also a binary coded decimal number, is displayed on the character display 34, which in the preferred embodiment is a light emitting diode array having a seven segment character preceded by a one, with the one driven from the ten line on the output of the keyboard counter and the seven segment character driven from a decoder coupled to the first four binary output lines.

The output of the keyboard counter CR–1 is also applied to a similar character display 38 and 44, though is not yet displayed on either of these displays because of the absence of an enabling signal on lines 120 and 122. The output of the keyboard counter CR–1 is further coupled to a plurality of gates comprising a comparison circuit CC–1 which compares the output of the keyboard counter CR–1 with the output of a pre-set counter CR–2. If a comparison is not obtained, a signal is applied through line 123 to a clock enabling circuit E–1, which provides as an output a clock pulse train on line 125 through OR gate or OR–1 to a memory address counter CR–3 and a channel address counter CR–4. The memory address counter is an eight bit binary counter (one through 256) and the channel address counter is a one through 16 counter providing a decoded output to address one controller card at a time, and each controller card in sequence in the manner hereinbefore described. Thus, the first 16 clock pulses through OR gate OR–1 advance the memory address counter and the channel address counter through 16, with the 17th pulse moving the memory address counter to seventeen and effectively re-setting the channel address counter to one. The return of the channel address counter output to one is coupled through line 118 to the pre-set counter CR–2, which in turn is coupled to the comparison circuit CC–1 through lines 124.

When one of the keyboard switches **32***a* through **32***p* is depressed, the keyboard counter is loaded with the corresponding number in BCD form and the number is displayed on display **34**. The number is also presented in BCD form to the comparison circuit **CC1**, and when the record button **54** is depressed, the memory address counter CR–3 and the channel address counter CR–4 are re-set, and the pre-set counter CR–2 is re-set to one by a re-set pulse generated by conventional re-set circuits (not shown). If the number presented to the comparison circuit is one. (e.g., switch **32***a* was depressed), a comparison is immediately obtained and no enabling signal is applied to the clock enable E–1. On the other hand, if any number other than one is punched in, the clock enable E–1 will provide a train of clock pulses through OR gate OR–1 to the channel address counter, and each time the counter counts through 16, the pre-set counter CR–2 is advanced by one count. Thus, it may be seen that the pre-set counter is advanced one count for every 16 counts of the channel address counter, and since the channel address counter is coupled to each of the channel cards in the controller, the controller cards are addressed once in sequence for each advance of the pre-set counter CR–2. Though this couples an input to the analog to digital converter AD–1 through terminal **112**, no information is loaded into the memory M–1 because of the absence of a write signal on line **134**.

When a comparison is obtained, the clock signal is disabled and an enabling signal is applied through line **128** to AND gate A–1. The pre-set record switch **54** also applies a signal through line **126** and OR gate OR–2 to the AND gate A–1. (Inverters I5, I6, and I7 provide a logical inversion for the switches **46**, **40** and **54**, respectively). Thus, with both enabling inputs to the AND gate A–1, an enable signal is delivered to the ring counter CR–5. The ring counter, in turn, is coupled to the analog to digital converter AD–1 to the memory M–1 and to the OR gate OR–1 and when enabled, provides a start pulse to the analog to digital converter AD–1. Since the channel address counter is then addressing the first channel card, the input to the A to D converter is the controller setting **62***a* for the first channel on the controller module.

The analog to digital converter converts the analog input to a five bit binary coded output which is coupled directly to the memory M–1. The specific analog to digital converter used in the preferred embodiment is of the type wherein sequentially, the most significant bit is set and all other bits are re-set, the digital output is converted to an analog signal by means of a resistor network comprising a digital to analog converter, the D to A output signal is compared with the analog input signal, and by appropriate gating, the most significant bit is re-set if the D to A output is greater than the analog input. Thereafter, the next most significant bit is set, then re-set if the error signal changes sign, etc., until the least significant bit has been similarly processed, whereupon the analog to digital conversion is complete. This type of analog to digital converter is well-known in the prior art and may be found in many reference books on the subject, such as that hereafter specifically mentioned. At the end of the analog to digital conversion, the ring counter CR–5 is advanced by a signal on line **132**, which provides a write pulse on line **134** so as to cause the digital output of the analog to digital converter to be stored in the memory M–1. The ring counter CR–5 then provides a pulse to the memory address counter CR–3 and the channel address counter CR–4 through line **136** and OR gate OR–1, thereby addressing the next memory location and the next channel card. The ring counter CR–5 then initiates the next A to D conversion cycle by a signal on line **130**, and continues in this cycle until the channel address counter CR–4 addresses the last or 16th channel card, at which time the addressing of the 16th channel card is coupled through line **138** to the ring counter CR–5 to disenable the ring counter from further counting.

Thus, it may be seen that the first 16 memory word locations are used to store the first 16 controller settings, the second 16 memory word locations are used to store the second 16 controller settings, etc. and upon pushing any of the 16 numbered keyboard switches, the memory is automatically addressed to the first of the proper 16 memory word locations, whether to subsequently write the information into the memory as hereabove described or to read the information out of memory as shall subsequently be described.

In the preferred embodiment, the analog to digital converter AD–1 provides a five bit binary output, thus dividing the substantially continuous controller settings into 32 discrete settings. The memory M–1 in the preferred embodiment is a semiconductor memory, specifically an MOS LSI memory manufactured by Intel Corporation of Mountain View, California, as their part No. 1101. Each 1101 unit provides a 256 bit memory, and five of such units are used, one for each bit of the five bit binary number. Thus, the first storage space in the first 1101 is used to store the first bit in the binary number representing the first controller position for the first keyboard selection. The second storage space is used to store the first bit in the second controller position binary number, etc. The first storage space in the second 1101 is used to store the second bit in the binary number representing the first controller setting for the first keyboard selection, the second storage space is used for the second bit in the second controller setting for the first keyboard selection, etc. Thus, addressing each of the five 1101 units simultaneously with the same address provides a parallel read and a parallel write capability for each five bit binary number.

Once the memory is loaded as desired, a lighting combination may be played back out of the memory in any desired order or, if desired, in sequence. To play the lighting combination back in sequence, the cross fader **61** is placed in the left hand position (FIG. **2**), the keyboard switch **32***a* is depressed, and the A play button **40** is then depressed. By depressing the keyboard switch **32***a*, the input to the comparison circuit is set as in loading. Similarly, when the A play switch **40** is depressed, the various counters are reset as in loading (e.g. when the record button is depressed), a signal is applied through line **140** to the A load enable circuit E–2 and simultaneously through line **146** to the ring counter CR–5 to disenable the write signal on line **134** coming therefrom, and to enable the operation of the ring counter through OR gate OR–2 and AND gate A–1. Thus, the ring counter again addresses the next 16 memory positions and the 16 channel cards. (In the preferred embodiment, an analog to digital conversion by the analog to digital converter AD–1 actually occurs, as hereinbefore described, though because the write signal on line **134** is disabled, no writing into memory occurs). As the individual channel cards are addressed through terminals **114***a* through **114***p*, the A load enable circuit E–2 of each channel card provides a pulse on line **142** which strobes the memory output on lines **109** into the A register S–1 on the particular channel card. Thus, when the first channel card is addressed, the memory output corresponding to the controller setting for that channel for the particular keyboard selection (in the example keyboard setting number one) is strobed into the A register S–1. Also, an enable signal is applied through the enable line **120** to the A character display **38** so as to display the keyboard counter number corresponding to the information loaded into the A registers of the various channel cards. The character display **38**, as in character display **44** for the B channel, contains a register so that once the character is strobed into the register by the enable signal, that character will remain displayed until a new character is strobed in, even if the keyboard counter CR–1 count subsequently changes.

To load the B registers in the various cards, another keyboard setting may be selected, (for sequential operation keyboard switch **32***b* will be depressed), and the B play button **46** will then be depressed. As in channel A, the depression of keyboard switch **32***b* followed by depression of the B plug switch **46** addresses the appropriate memory position and provides a signal on line **144** to the B load enable signal E–3 and starts a read cycle by a signal coupled to the ring counter CR–5 through line **146**. Thus, as before, as each channel card is addressed, the B load enable signal E–3 on the various channel cards will strobe the appropriate information into the appropriate B registers S–2.

The all-on manual switch **60** is an alternate action switch and when off the information stored in the A registers and B registers may be played back in a variety of ways. The cross fader **61** is coupled to a fade and sequence circuit F–1, and by control thereof oppositely varying signals may be applied through lines **150** and **152** to the A fader **36** and the B fader **42**, respectively. Thus, with the cross fader **61** in the maximum left hand position, the maximum signal is applied through line **150** to the A fader **36**, whereas the signal applied through line **152** to the B fader **42** is substantially zero. By moving the cross fader to the right hand position, the signal applied to the A fader **36** linearly decreases to zero whereas the signal applied to the B fader **42** increases to a maximum. The potentiometer wiper signals of faders **36** and **42** are coupled to a pair of mechanically coupled potentiometers forming the memory master fader **64**, with the outputs of the wipers coupled on lines **154** and **156** to the digital to analog converters DA–1 and DA–2, respectively. These converters are of the well-known resistor network type wherein a signal output voltage is provided which is a fraction of the reference voltage applied thereto as determined by the binary input. Thus, the digital to analog converter outputs on lines **158** and **160** are analog signals which are dependent upon the cross fader **61** position, the information stored in the A or B register and the position of the A or B fader. Assuming both the A and B faders are at their maximum position, the output of the digital to analog converter DA–1 may be caused to linearly decrease from the number stored in register S–1 to zero and the output of the digital to analog converter DA–2 linearly increased from zero to the value corresponding to the binary number in register S–2 by moving the cross fader **61** from the left hand position to the right hand position.

When the all-on manual switch **60** is open, (and the corresponding switch **66** is in the open position), transistor T–1 is turned off by a voltage applied to the base thereof through resistors R–10 and R–2. Thus, the signal on line **158** is coupled through resistors R–11 and R–12 and diode D–3 to the dimmer control signal **110** for that channel. The signal on line **160** from the B channel may be combined with the signal from the A channel two ways. When the pile switch **48** is depressed, a positive or one signal is applied through line **162** to the inverter I–4. The zero output is coupled to resistor R–11 and because of the coupling of the base of transistor T–2 through R–3 to the negative voltage supply, transistor T–2 is turned on. This shorts point **104** to ground and prevents the coupling of the signal on line **160** to point **164**. The zero output of inverter I–4 is also coupled to inverter I–1 giving a one output therefrom which turns off transistor T–3 through resistor R–6. Thus, the output of the B register is coupled to resistors R–13 and R–14 and to diode D–2 to the dimer control terminal **110**. It is apparent that because of the diodes D–2 and D–3, the signal appearing at the dimmer control terminal **110** will be the higher of the output signals of the D to A converters DA–1 and DA–2. In the pile on mode, the cross fader **61** is switched out of the circuit and a reference voltage is switched directly to the A and B faders. Thus, by decreasing the position of the A fader **36**, the lighting combination stored in the A registers will linearly decrease, with each dimmer signal decreasing until the corresponding output of the B register (dependent on the position of the B fader **42**) increases to the same value, whereupon the output from the B register will control and increase the light to the corresponding setting. Thus, a change from one lighting combination to another lighting combination is achieved, though a significant and observable dip in lighting may occur.

When the cross fade switch **50** is depressed, a low signal is applied through line **162** to the inverter I–4 giving a high signal through resistor R–11 to the base of transistor T–2, thereby turning it off and providing a low signal through inverter I–1 and resistor R–6 to the base of transistor T–3, turning it on. This shorts out point **106** and prevents the signal being delivered through diode D–2 to the dimmer control **110**, and at the same time couples the output of the B channel on line **160** through resistors R–15 and R–16 to point **164**. Thus, the combination of resistors R–11, R–12, R–15 and R–16 provide a resistive summing network, with the signal applied to diode D–3, and thus to the dimmer terminal **110**, being the average of the two output signals of the two digital to analog converters DA–1 to DA–2. Thus, with the cross fade switch depressed, a linear and dipless transition from the lighting combination stored in the A register to the lighting combination stored in the B register and vice-versa may be achieved through the cross fade control. Also, it should be noted that the pile switch **48** and the cross fade switch **50** are mutually exclusive conditions and a flip-flop comprised of NAND gates N–1 and N–2 are set or re-set in accordance with the last of the switches to be depressed.

From the above description, it may be seen that the memorized lighting combinations may be played back in any order and a smooth transition obtained from any one combination to any other combination. When the sequence switch **56** is depressed, the memorized lighting combinations may be played back in sequence. By way of example, the first lighting combination may be stored in the A registers and a one will be displayed in the A display **38**. Thereafter, the second lighting combination may be stored in the B registers with a two being displayed in the B display **44**. At this point, the keyboard counter CR–1 will have loaded thereinto the binary number two. Assuming that the cross fader **61** is in the left hand position, the first lighting sequence as stored in the A registers will be provided to the light controllers, and as the cross-fader is moved to the right hand position the lighting combination will change to the second combination as stored in the B registers (both being also individually controllable through the A and B faders **36** and **42**, respectively, or simultaneously controlled by the memory master fader **64**). The position of cross fader **61** is sensed by the fade and sequence circuit F–1 and as the cross fader approaches its maximum position, the fade and sequence switch provides a countup pulse on line **118** to the keyboard counter CR–1, thereby, in effect, setting the keyboard counter as if the next keyboard select switch **32** had been depressed. At the same time, a signal is applied by the fade and sequence circuit F–1 to lines **140** or **144** so as to enable the loading of the next light combination into either the A or B registers of each channel card. By way of example, when the cross fader **61** is moved to the right hand position, whereby the light controllers are controlled by the information in the B registers, a signal will be applied to line **140** by the fade and sequence circuit F–1 so as to enable the reloading of the A registers, with the countup pulse applied to the keyboard counter advancing that counter from a two count to a three count, thereby changing the information heretofore stored in the A registers from that corresponding to the first lighting combination to the third lighting combination. In a similar manner, when the cross fader **61** is moved to the left hand position, the keyboard counter CR–1 is advanced to the number four and a signal applied by the fade and sequence circuit F–1 to line **144**, thereby changing the information loaded in the B registers from that corresponding to the second lighting combination to that corresponding to the fourth lighting combination. Thus, by moving the cross fade switch back and forth as the lighting combinations are changed, the light control system will automatically cycle through 16 pre-memorized lighting combinations.

It should be noted that this automatic sequencing may be achieved in either the pile mode, as controlled by the switch **48**, or in the cross fade mode as controlled by switch **50**, and, further, once information is loaded into the A and B registers out of memory, the light controllers may be controlled from the information in the A register, in the B register, or in any combination through the cross fade control **61**, and at the same time the keyboard switches **32*a*** through **32*p***, the pre-set record switch **54** and the 16 controllers **62*a*** through **62*p*** may be used to program other memory locations. Thus, if more than 16 lighting combinations are to be played back, a few of the first combinations may be played back in sequence, and once played back, these memory locations may be used to store the additional lighting combinations desired.

The manner of loading the memory and of playing the information out of memory has been hereabove described. In certain instances, it may be desired, while playing back one lighting combination, to read out of memory the settings in any of the other lighting combinations. This may be achieved as follows: assuming that a lighting combination is being played back out of the A register, that is, with the cross fader control **61** in the left hand position, any lighting combination may be loaded into the B register without affecting that play back by pushing the appropriate keyboard switch **32** followed by the B play button **46**. This will load the information for the selected lighting combination into the B registers. At the same time, the output of the B load enable E–3 will be coupled through line **143** to the meter enable circuit E–4, which in turn is coupled to the A register output **145** and a B register output **147**, (these lines not being connected to the register outputs in FIG. **5** only for purposes of clarity). The meter enable circuit E–4 includes a flip-flop which is set or reset in accordance with the last load enable signal received, that is, either the A load enable or the B load enable. Thus, since the last enable signal in the above example received was from the B load enable circuit E–3, the meter enable circuit will disable the A register output, and upon depression of the appropriate switch **66** to the meter position, enables the B register output to be coupled to the digital to analog converter DA–3, similar in construction to the digital to analog converter DA–1 and DA–2, except for the use of a fixed voltage reference. The output of the digital to analog converter DA–3 is coupled to the meter **68**. It should be noted that each channel has a meter enable circuit E–4 and all 16 meter enable circuits of the 16 channel cards are coupled in parallel to the digital to analog converter DA–3. However, the meter enable circuit E–4 provides a decoupled zero output unless the particular meter enable circuit is in fact enabled. Therefore, the meter enable circuit E–4 which has the highest output controls the digital to analog converter DA–3, and since only one of the switches **66*a*** through **66*p*** will be depressed to the meter position at once, any individual memorized controller setting may be read out on meter **68**. (It should be noted that switches **66*a*** through **66*p*** are three position switches, and in the upper position put the respective channel in the manual mode. When in that condition, each such channel may be manually controlled by the master controller **58** and one of the respective ones of controllers **62*a*** through **62*p***, while the rest of the channels are controlled out of memory).

The type of semiconductor memory used in the present invention will not retain the memorized information if power is interrupted or shut off. Thus, a rechargeable battery pack B1 is provided in the controller module to maintain a memory sustaining power level to the memory when the main power is interrupted or shut off. Very little power is required to maintain the memory, as semiconductor memories generally have separate power lines for the memory cells and the addressing, buffering, etc. circuitry and only the memory cells themselves need be energized for memory retention. Such battery packs and the circuitry for connection thereof so as to be self charging when the power is on are known in the art and therefore are not described in further detail herein.

There has been described herein a light controller which may be used to memorize and play back 16 combinations of 16 or more light controller settings, to smoothly change from one combination to any other combination, or to change combinations in their memorized sequence, which is capable of being caused to memorize additional combinations while playing back any of the previous memorized combinations, which is capable of indicating on a meter any of the memorized controller settings while playing back any of the combinations and which includes other and further features which will be apparent from the drawings and specifications herein. The detailed circuits making up the various counters, coders, decoders, registers and the like may be any of the corresponding well-known circuits for such devices having the characteristics as described herein. Such circuits are well known in the field of digital devices and computers and many of these circuits are available in integrated circuit form from any of a number of manufacturers. The circuits, wiring and use thereof are described in detail in the respective manufacturers'products information sheets, and the circuits in general are described in any of the many reference books on the subject, such as, by way of specific example, "DIGITAL COMPUTER COMPONENTS AND CIRCUITS" by R. K. Richards, a 1957 Van Nostrand Company, Inc. publication. There has been disclosed and described herein the basic logic and information flow in the present invention light control system and, where particularly applicable, specific circuits which may be used in the present invention system. However, the specific circuits, memory devices and the like disclosed herein are disclosed only by way of example, and other circuits, memory devices and the like may be used, Thus, while the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

I claim:

1. A lighting control system for storing and playing back a plurality of combinations of light control signals comprising:

a keyboard having a plurality of keyboard switches thereon;

a plurality of manual light controls for individually controlling a plurality of SCR light controllers;

means coupled to said light controls for converting the setting of each of said light controls to a digital signal representing said setting;

read-write semiconductor memory means for storing digital information and presenting said digital information responsive to a memory address signal and a read-write signal;

means coupled to said keyboard switches and responsive to each of said keyboard switches to address the first of a unique series of memory locations in said memory means by the operation of each of said keyboard switches;

a record switch;

means coupled to said record switch for providing a write signal to said memory means, for selecting the digital signal corresponding to the setting of the first of said light controls, and for sequentially advancing said memory address signal and selecting the signal corresponding to the setting of the next of said light controls until the digital information corresponding to the setting of each of the plurality of said light controls has been stored in said memory;

first and second registers for each of said plurality of light controls, the input of said registers being coupled to the output of said memory means, each of said registers being responsive to a load signal to store the output of said memory;

first and second play switches;

means coupled to said first play switch for providing a read signal to said memory means, for sequentially advancing said memory address signal and sequentially providing a load signal to each of said first registers, whereby the digital signal corresponding to the setting of each of the plurality of said light controls for the last keyboard switch to be actuated may be stored in said first registers;

means coupled to said second play switch for providing a read signal to said memory means, for sequentially advancing said memory address signal and sequentially providing a load signal to each of said second registers, whereby the digital signal corresponding to the setting of each of the plurality of said light control for the last keyboard switch to be activated may be stored in said second registers;

conversion means coupled to each of said first and second registers associated with each of said light controls for converting digital signals in said first and second registers to analog signals; and

combining means coupled to said conversion means and operative by a single control to variably combine the outputs of said conversion means so as to provide a plurality of analog output control signals for control of an SCR controller, each of which is a variable combination of the analog signals corresponding to the digital signal stored in the corresponding first and second registers.

2. The light control system of claim 1 further comprised of a switch means associated with each of said light controls and means coupled to said last named switch means for causing any of said analog output control signals to be controlled by the setting of the respective said light control instead of by the digital signal stored in the respective first and second registers.

3. The light control system of claim 2 further comprised of an all-on manual switch means and a variable manual master control means, said all on manual switch means being a means for causing all of said analog output control signals to be controlled by the respective said light control, said variable manual master control means being a means for changing all of

said analog output control signals in response to the setting of said variable manual master control means.

4. The light control system of claim 1 further comprised of a rechargeable battery pack, said battery pack being coupled to said semiconductor memory and being a means for providing power to the memory cells when the main power is off so as to provide retention of digital information stored in said memory.

5. The light control system of claim 1 wherein said control for said combining means is operative between first and second positions to vary said analog output control signals from the signals corresponding to the digital signals stored in said first registers when in said first position to the signals corresponding to the digital signals stored in said second registers when in said second position, further comprised of a means coupled to said combining means for automatically causing the digital signals stored in said memory means corresponding to the memory locations associated with the one of said keyboard switches immediately following the one of said keyboard switches corresponding to the digital signals stored in said first registers to be stored in said second registers when said control is moved to said first position, and the digital signal stored in said memory means corresponding to the memory locations associated with the one of said keyboard switches immediately following the one of said keyboard switches corresponding to the digital signals stored in said second registers to be stored in said second registers when said control is moved to said second position, whereby said analog output control signals may be caused to sequentially and smoothly vary through a series of combinations by the movement of said control for said combining means between first and second positions.

6. The light control system of claim 1 further comprised of first and second fader control means associated with said conversion means coupled to said first and second registers respectively, said first fader control means being a means for varying the outputs of said conversion means for said first registers in accordance with the setting of said first fader means, and second fader means being a means for varying the outputs of said conversion means for said second registers in accordance with the setting of said second fader means.

7. The light control system of claim 6 further comprised of a memory master fader control means, said memory master fader control means being coupled to said first and second fader control means and operative to vary the output of said conversion means for said first and second registers in accordance with the setting of said memory master fader means.

8. The light control system of claim 1 further comprised of first, second and third light display means, coupled to said keyboard switches, said first light display means being a means for displaying characters corresponding to the last of said keyboard switches to be actuated, said second and third light display means being further coupled to said first and second play switches, respectively, and responsive thereto to display characters corresponding to the keyboard switch associated with the digital signals stored in said first and second registers, respectively.

9. A lighting control system for storing and playing back a plurality of combinations of light control signals comprising:

a keyboard having a plurality of sequentially numbered keyboard switches thereon;

a plurality of manual light controls of the potentiometric type for individually controlling a plurality of SCR light controllers;

an analog to digital converter coupled to said light controls through a set of first gates for selecting and converting the setting of each of said light controls to a digital signal representing said setting;

a read-write semiconductor memory for storing digital information and presenting said digital information in parallel form responsive to a memory address signal and a read-write signal;

a first coder coupled to said keyboard switches to provide a parallel digital output signal in response to the actuation of any of said keyboard switches;

a keyboard counter adapted for parallel loading coupled to said first coder;

a reference clock; provided a continuous train output

a comparison circuit;

a preset counter;

a channel address counter adapted to repetitively count through a number equal to the number of said plurality of light controls;

a memory address counter coupled to said memory means, said comparison circuit being coupled to said keyboard counter and said pre-set counter and adapted to provide an enable signal to couple said clock to said memory address counter and said channel address counter until a comparison is obtained between said keyboard counter and said pre-set counter outputs, said channel address counter being coupled to said first gates whereby said light controls will be sequentially coupled to said analog to digital converter as said channel address counter counts up to its largest count, said channel address counter being coupled to said preset counter to advance said preset counter by one count when said channel address counter returns to its lowest count;

a record switch;

control means coupled to said record switch and said channel address counter for sequentially enabling the operation of said analog to digital converter, for providing a write signal to said memory means to store the output of said analog to digital converter in the memory location corresponding to said memory address counter count, and for advancing the count of said memory address counter and said channel address counter by one count, said channel address counter being coupled to said control means to disenable said control means after the analog to digital conversion and storage in said memory means of each of said light control settings;

first and second registers for each of said plurality of light controls, the input of said registers being coupled to the output of said memory means, each of said registers being responsive to a load signal to store the output of said memory;

first and second play switches;

means coupled to said first play switch and responsive thereto for providing a read signal to said memory means, for sequentially advancing said memory address signal and sequentially providing a load signal to each of said first registers, whereby the digital information corresponding to the setting of each of the plurality of said light controls associated with the count in said keyboard counter may be stored in said first registers;

means coupled to said second play switch for providing a read signal to said memory means, for sequentially advancing said memory address signal and sequentially providing a load signal to each of said second registers, whereby the digital information corresponding to the setting of each of the plurality of said light controls associated with the count in said keyboard counter may be stored in said second registers;

conversion means coupled to each of said first and second registers associated with each of said light controls for converting digital signals in said first and second registers to analog signals; and

combining means coupled to said conversion means and operative by a single control to variably combine the outputs of said conversion means so as to provide a plurality of analog output control signals for control of an SCR controller, each of which is a variable combination of the analog signals corresponding to the digital signal stored in the corresponding first and second registered.

10. The light control system of claim **9** further comprised of a switch means associated with each of said light controls and means coupled to said last named switch means for causing any of said analog output control signals to be controlled by the setting of the respective said light control instead of by the digital information stored in the respective first and second registers.

11. The light control system of claim **10** further comprised of an all-on manual switch means and a variable manual master control means, said all on manual switch means being a means for causing all of said analog output control signals to be controlled by the respective said light control, said variable manual master control means being a means for changing all of said analog control signals in response to the setting of said variable manual master control means.

12. The light control system of claim **9** wherein said keyboard counter is adapted to count up in response to a count up pulse applied thereto and said control for said combining means is operative between first and second positions to vary said analog output control signals from the signals corresponding to the digital signals stored in said first registers when in said first position to the signals corresponding to the digital signals stored in said second registers when in said second position, further comprised of; means coupled to said combining means, said means coupled to said final and second play switches and said keyboard counter for automatically causing a countup pulse to be coupled to said keyboard counter and for activating said means coupled to said second play switch when said control is moved to said first position, and for automatically causing a countup pulse to be coupled to said keyboard counter and for activating said means coupled to said first play switch when said control is moved to said second position, whereby said analog output control signals may be caused to sequentially and smoothly vary through a series of combinations by the movement of said control for said combining means between first and second positions.

13. The light control system of claim **9** further comprised of first and second fader control means associated with said conversion means coupled to said first and second registers respectively, said first fader control means being a means for varying the outputs of said conversion means for said first registers in accordance with the setting of said first fader means, and second fader means being a means for varying the outputs of said conversion means for said second registers in accordance with the setting of said second fader means.

14. The light control system of claim **13** further comprised of a memory master fader control means, said memory master fader control means being coupled to said first and second fader control means and operative to vary the output of said conversion means for said first and second registers in accordance with the setting of said memory master fader means.

15. The light control system of claim **9** further comprised of first, second and third light display means, coupled to said keyboard switches, said first light display means being a means for displaying characters corresponding to the last of said keyboard switches to be actuated, said second and third light display means being further coupled to said first and second play switches, respectively, and responsive thereto to display characters corresponding to the keyboard switch associated with the digital signals stored in said first and second registers, respectively.

16. The light control system of claim **9** further comprised of a rechargeable battery pack, said battery pack being coupled to said semiconductor memory and being a means for providing power to the memory cells when the main power is off so as to provide retention of digital information stored in said memory.

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