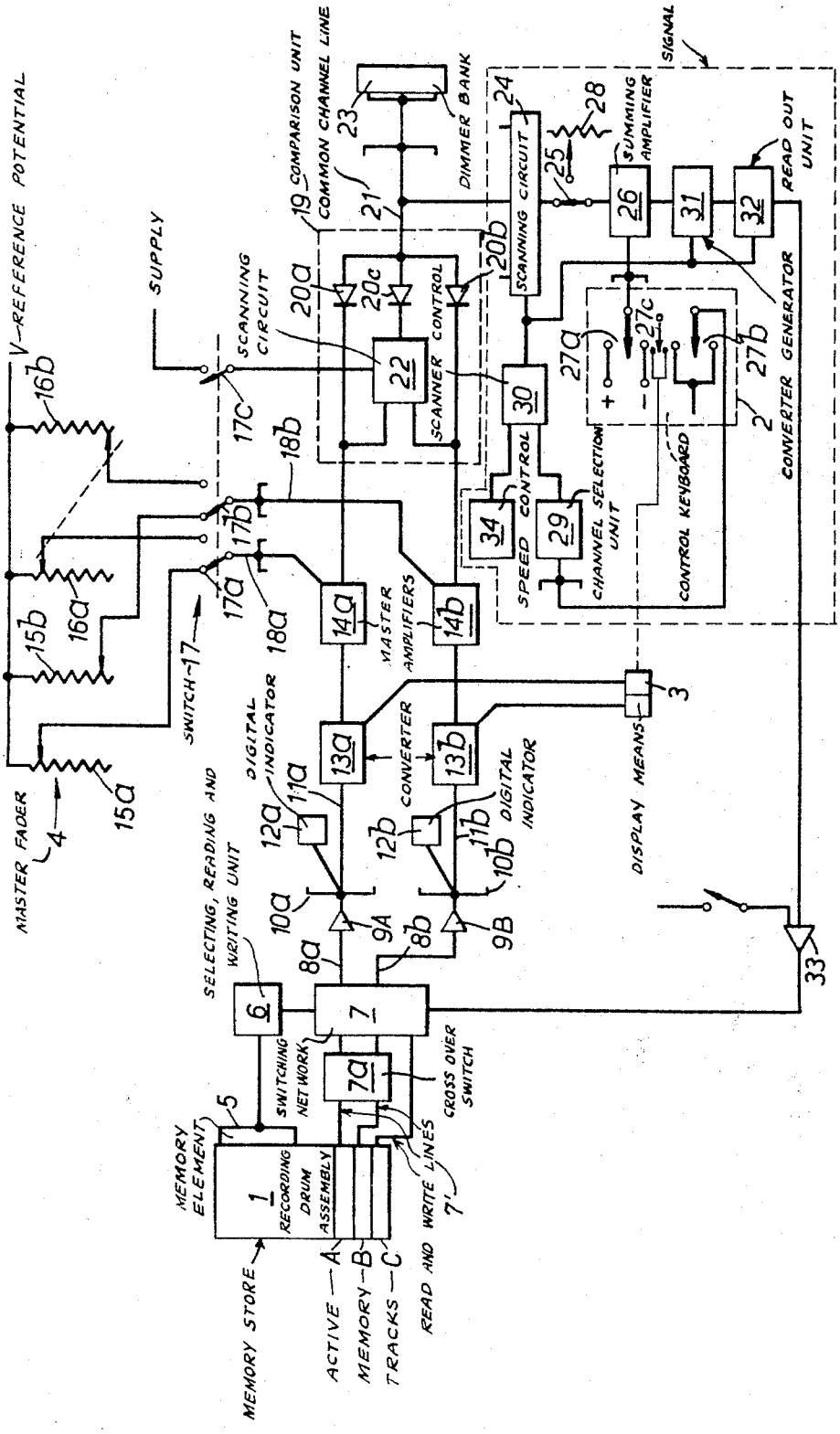
June 3, 1969 F. P. BENTHAM ET AL 3,448,338

STAGE LIGHTING CONTROL UNITS

Filed June 24, 1966



nited States Patent ce 3,448,338
Patented June 3, 1969

3,448,338

STAGE LIGHTING CONTROL UNITS

Frederick Percy Bentham, 24 Amherst Road, Ealing, London, W. 13, England, and Phillip Robert Sheridan, "Monalee," 8 Mavelstone Road, Bickley, Kent, England

Filed June 24, 1966, Ser. No. 560,291
Claims priority, application Great Britain, June 28, 1965, 27,314/65
Int. Cl. G05f *1/04;* H05b *37/02, 41/36*
U.S. Cl. 315—295 10 Claims

ABSTRACT OF THE DISCLOSURE

A stage lighting control unit operated by a signal generator which writes into a digital memory store, a master fader unit which senses the stored information, digital-analogue converters, and a bank of dimmers and corresponding display lamps responsive to the stored information read after being converted to analogue form.

This invention relates to stage lighting control units.

Owing to the increase in complexity of stage lighting systems, semi-automatic control units have been devised in which control of the lighting circuits is effected by punched card mechanisms, but such systems are relatively inflexible in use and furthermore the conventional console arrangements used with them become cumbersome in application to large numbers of lighting circuits.

The present invention makes use of memory storage techniques to provide a flexible and practicable control unit for stage lighting.

According to the present invention a stage lighting control unit comprises a memory store including a plurality of lighting effect memory elements each capable of storing, for a particular lighting cue, dimmer control signals corresponding to the dimmer levels necessary in the various lighting channels to produce a desired lighting effect, control means for selectively modifying the dimmer control signals in any chosen memory element to correspond to the dimmer levels producing a desired lighting effect which is to be stored in that memory element, a master fader to control the output of any chosen memory element to set the dimmer levels applied to the various lighting circuits in dependence upon the corresponding dimmer control signals in the chosen memory element, and display means whereby the dimmer level applied to each of the various lighting circuits in a given lighting cue is presented visually in response to the dimmer control signals in the memory element appropriate to the given lighting cue.

The control unit preferably includes an active memory provided to act as intermediate storage means for information being written into and read out of the memory store, and this active memory advantageously comprises two individual active memory elements which are interchangably connectible respectively to write into and read out of the memory store. When two active memory elements are provided, cross-fading means are provided to effect the interchanging. In some circumstances it is advisable to provide isolation of the "reading" active memory element from the memory store.

In a preferred arrangement writing of information into the memory store is effected by a keyboard which for each lighting circuit is provided with a corresponding two-way switch means for increasing or decreasing the dimmer control signal appropriate to that circuit. The display unit then includes a plurality of display elements each positionally associated with a corresponding switch means, each display element being adapted to give a visual indication of the corresponding dimmer level stored in the memory element currently being read out of the memory store into the master dimmer. To increase the usefulness of the display unit it may be adapted also to give a visual indication of the corresponding dimmer levels stored in the memory element next to be read out of the memory store into the master dimmer. Further modification of the display unit enables a signal to be displayed in a display element to signify that rewriting of a memory element is necessary in consequence of an unrecorded change in dimmer setting of the corresponding lighting circuit. This signal may consist of a separate lamp, or may be provided by flashing the existing visual display signal.

It is advantageous to provide a numerical display to indicate the identity of the memory element currently being read out from the memory store and also of the memory element next to be read out from the memory store.

The invention will now be described in greater detail with reference to the accompanying drawing, the single figure of which represents a schematic drawing of a practical embodiment of the invention.

The basic elements of the control unit are a magnetic recording drum assembly **1**, a control keyboard, of which a portion is represented at **2** and which has associated visual display means one of which is indicated at **3**, and a master fader generally indicated at **4**.

The recording drum assembly constitutes a memory store provided with **150** lighting effect memory tracks and three "active" memory tracks A, B and C. Each lighting effect memory track provides two lighting effect memory elements, each occupying 180° of the track.

Each lighting effect memory element contains 301 digital words. The first word represents the identity of the particular element, and is a permanent marking, protected from erasure or obliteration by suitable inhibiting circuitry. Each of the remaining 300 words represents the lighting level, from zero to full illumination, of a corresponding lighting channel. The code used for the lighting level signals is a phase-modulated 5-bit binary code, giving "OFF," "FULL-ON" and thirty intermediate levels.

Information is not written directly from the keyboard into the lighting effect memory elements, nor is it read directly into the master fader, but always passes via the "active" memory tracks.

The selection of a given lighting effect memory element defined by the multiplicity of "write" and "read" lines schematically shown at **5**, and the performance of a "read" or "write" operation between the selected memory element and the active tracks is carried out by a "writing" and "reading" unit **6**. This unit also includes

inhibiting circuits to prevent erasure of the first word in each memory element. A selective switching network **7** linked to the master fader **4** serves to route information from any given one of the active tracks into the unit **6** or from the unit **6** into either the A or the B active track via "read" and 'write" lines diagrammatically shown at **7'**. The cross-over switch **7***a* is provided on the leads from the A and B track heads to allow instantaneous interchange of the functions of the two tracks.

In use, the output from the A and B tracks passes via the network **7** along lines **8***a* and **8***b*, via amplifiers **9***a* and **9***b* to gates **10***a* and **10***b*. The gates **10***a*, **10***b* convert the 301 words on the single line **8***a* and **8***b* respectively, into 301 words each on a corresponding channel line **11***a*, **11***b* respectively. The first of the 301 words is fed to a digital indicator **12***a*, **12***b* which indicates which lighting effect memory element **5** has been written into the A and B active tracks respectively. Each of the remaining 300 words on each of the two active tracks A and B passes along its corresponding channel line **11***a*, **11***b* in its digital form. This is unsuitable for operating dimmers, and consequently a digital-to-analogue converter **13***a*, **13***b* is provided in each channel line. One output from this converter operates the indicating means **3** which in the illustrated embodiment consists of a lamp, located within the corresponding channel key on the keyboard **2**, which is extinguished when the output from the unit **13** is zero and is illuminated fully when that output represents maximum illumination, all intermediate positions being signified by a single "half-way" illumination of the lamp. As will be seen from the drawing, each key includes two such indicator lamps, which may conveniently be distinguished by means of coloured filters, and which represent the A and B track signals respectively.

The other output from each of the converters **13***a*, **13***b* feeds a continuous D.C. analogue signal to corresponding "master amplifier" **14***a*, **14***b*. The amplification factor of the 300 A master amplifiers on the one hand and of the 300 B master amplifiers on the other hand is governed by the master fader **4**. This consists of four variable resistors, two of which, **15***a* and **15***b* are normally in use, and are independently variable. The other two variable resistors **16***a* and **16***b* are ganged together so that when the resistance of either is a maximum that of the other is a minimum. The variable resistors are all connected at one end to a reference potential V, and two poles of a three-pole switch **17***a*, *b*, *c*, are arranged to connect the moving contacts of one of the pairs of variable resistors **15***a*, **15***b* or **16***a*, **16***b* to master amplifier control leads **18***a*, **18***b* respectively. In the condition illustrated in the drawing the moving contact of **15***a* is at a maximum potential and that of **15***b* is at a minimum potential and, since these resistors are coupled by the switch **17** to the leads **18***a*, **18***b*, the amplifiers **14***a* will give a maximum amplification while the amplifiers **14***b* will give a minimum (in the present case zero) amplification.

Coupling is provided between the master fader **4** and the network **7** to control the connection of the A, B and C tracks to unit **6** during a "read" or "write" operation in accordance with the state of the in-use master fader variable resistors and the nature of the operation. In normal use of the control unit these resistors are adjusted as shown, with one at zero and the other at a finite level, generally its maximum position. In these circumstances, during a "read" operation, the A or B track is selected according to whether the A or B resistor respectively is at zero. If for any reason, both in-use master fader resistors are set at zero, then during the "read" operation the A track is automatically selected. During a "write" operation the A or B track is selected according to whether the B or A resistor respectively is at zero. In any other case the C track is selected for "writing" by the network **7**. The nature of the network **7** is such that the C track can only be connected to write information into the unit **6** and not to receive information from it. The coupling between the master faders also acts during normal use to render either the "A" or the "B" track into a state which will, for reasons later apparent, be referred to as "live." When one in-use resistor is set at maximum and the other is at zero then the track mastered at maximum is "live." This state persists until the role of the in-use resistors has been completely reversed, when the "live" function is transferred to the track which was previously mastered at zero.

The outputs of the amplifiers **14***a* and **14***b* pass along the channel lines **11***a* and **11***b* to a comparison unit generally indicated at **19**. When the switch **17** is in the position shown, the comparison is effected by diodes **20***a* and **20***b* connected at one end to the corresponding channel lines **11***a* and **11***b* and at the other to a common channel line **21**. Whichever channel line is carrying the higher signal the corresponding diode passes that signal which, when it appears at the line **21**, biasses off the other diode. Thus, when the resistors **15***a*, **15***b* are set as shown the output of amplifier **14***a* will pass to line **21** and the diode **20***b* will be biased off. The comparison unit also includes a summing circuit **22**, energisable from a supply via switch pole **17***c*, whose two inputs are fed from the channel lines **11***a*, **11***b* and whose output is connected via a diode **20***c* whose polarity is the same as diodes **20***a*, **20***b* to the common channel line **21**. Whenever the summing circuit is energised its output cannot fall below either of the channel line signals and in this event the diodes **20***a*, **20***b* will both be biased "off" and the output on the line **21** will in all such cases correspond to the output of circuit **22**. Each of the 300 lines **21** from the 300 corresponding comparison circuits passes to the corresponding channel of the bank **23** of dimmers.

The 300 lines **21** are also connected to the 300 inputs of a scanning circuit **24** whose signal output is connected via a switch **25** to one input of a summing amplifier **26**. The other input of the summing amplifier **26** is connected to receive signals from tht 300 keys **27** of keyboard **2**. Each switch **27** is a two-pole, two-way device, having a neutral "off" position. The moving contact **27***a* of each switch **27** is connected to the second input of the summing amplifier **26**, and the two associated fixed contacts are connected to reference positive and negative sources respectively. Tht first input of the summing amplifier **26** is alternatively connectible by means of the switch **25** to the moving contact of a potentiometer **28**. The moving contact **27***b* of each switch **27** is connected to a "channel select" unit **29** operating at clock frequency to search for depressed keys and which in turn is connected to one input of a "scanner control" unit **30**. Tht fixed contacts associated with contact **27***b* are both connected to a negative potential source. When any single key **27***a*, *b* is depressed the contact **27***b* causes the channel selector **29** to register the depression of that particular key and also effects stopping of the unit **29** to "hold" on the channel whose key has been depressed. The scanner control **30** then operates the scanner **24** to select the channel corresponding to the depressed key. Then, when the switch **25** is in the illustrated position, the signal on the line **21** is fed to the first input of the summing amplifier **26**. The output from amplifier **26** is fed successively to an analogue-digital converter **31** and a read-out unit **32**, each of these latter being synchronized by the output from the scanner control **30**. The output from the readout unit **32** is fed to the switching network **7** via a "wipe" amplifier **33**. As explained above the network **7** normally switches the output from **32** on to either the A or B channel whichever is "live" in dependenct on the master controls but will switch it into the C track if the resistors are not in the "normal" state.

It will be seen from the above description that, if both the A and B tracks are empty and track A is rendered "live" by operation of the master fader **4** then the signal on each of the 300 lines **21** will be zero and the 300 dimmers **23** will correspondingly be adjusted to zero under

the control of "live" track A. If it is now desired to illuminate lighting channel No. 1 on the stage, the key **27** corresponding to lighting channel No. 1 is depressed from its "neutral" to its "increase" position. The contact **27***b* causes the channel selector **29** to register the depression of the key of lighting channel No. 1 and the signal control **30** operates the scanner **24** to connect the channel line **21** of lighting channel No. 1 to the input of summing amplifier **26**. The signal on this input will in fact be zero, but by the operation of contact **27***a* of the channel key an increment of voltage will be fed into the second input of the summing amplifier. Thus, when converter **31** and unit **32** are pulsed for operation at a time corresponding to the position of lighting channel No. 1 signal on the periphery of the drum **1**, a digital signal equivalent to the increment of voltage will be wed via the network **7** to be recorded on the live active track. On the next revolution of the recording drum this incremental signal will be passed along the channel line **11***a* of lighting channel No. 1 and will cause adjustment of the appropriate dimmer **23** to illuminate lighting channel No. 1 by an amount corresponding to the increment of voltage applied to the amplifier **26**. It will be seen that if the key **27** remains depressed a second increment of voltage will be added by the circuit and this new value will again be recorded on the live active track. The process will repeat until a maximum illumination has been reached in the lighting channel. During the whole of the adjustment the operator will be able to follow the visual effect on stage and if necessary can reduce the lighting level in the channel by pressing the switch **27** in its opposite direction thereby reducing the illumination by increments in a manner which will be obvious from the above description. In this way the **300** lighting channels may all be adjusted to produce a desired lighting effect. Extra contacts **27***c* indicated in the switches **27** are connected to the corresponding display units **3** so that when any switch has been operated the indicator lamp representing the "live" track in the display unit corresponding to the operated switch is caused to flash intermittently, thus providing an indication to the operator of when it is necessary to rewrite an effect into the memory store. Assuming that the first lighting effect of a lighting programme has been set up in this way unit **6** is operated to select lighting memory element No. 1 and actuated to write the sequence of signals from the line of active track into that memory element. The action of writing also causes cancelling of the flashing of the indicator lamps. The second lighting effect of the programme can now be set up, using the same live active track as previously and when this second lighting effect is satisfactory it is recorded in lighting memory element No. 2 by means of the unit **6**. Throughout these operations the current state of each lighting channel controlled by the live active track will be displayed in the display units **3** in the manner described above. By repeating the process a complete lighting programme of up to 300 lighting effects may be stored in the 300 lighting effect memory elements.

As the recording process is normally too rapid to follow visually, a "speed" control **34** is provided to slow down the operation of the scanner control **30**. Thus, for example, by omitting every other clock timing signal the rate of change of lighting channel signal will be halved.

It is possible to set the lighting channels without reference to the stage lighting if this is required, for example in setting up a known lighting effect. This is done by operating the switch **25** to disconnect the signal output from the summing amplifier **26** and to connect into circuit the potentiometer **28**. Coupling of switch **25** to the network **7** acts at the same time to maintain the stage lighting under the control of the "live" active track, while causing information from the keyboard to enter a "non-live" active track for transfer to the main memory store. Then, by adjusting the potentiometer **28** to produce a voltage corresponding to a given lighting level, and pressing the appropriate switch **27** to synchronise the readout units **31** and **32**, a signal is applied at the appropriate portion of the live active track corresponding to the lighting level represented at the potentiometer **28** plus or minus one increment applied by the switch contact **27***a*. Since the output of the scanner **24** is not connected to the summing amplifier **26**, no further "regenerative" modification of the channel signal will occur. In this mode of operation it is clearly not necessary or desirable to slow the recording by means of the speed control.

If at any time it is required to extinguish all the lighting channels this can be done by means of the "wipe" amplifier **33** which transmits a "write all zeros" signal to the network **7**.

The stored lighting programme is normally used in the following manner. Assuming that track A is the "live" active track, and is set with all channels at zero, then all stage lights are extinguished. At the same time, the operation of network **7** is such that track B is arranged to receive signals from unit **6**. In order to set up the first lighting combination on stage the contents of memory element No. **1** on the drum are duplicated in track B via unit **6** and network **7**, and then the functions of tracks A and B are reversed, making B the "live" track, with the result that the on-stage lighting is now controlled by the signals on track B. Thus the stage lighting now corresponds to the signals stored in memory element No. 1. Track A is of course now in its turn in position to receive signals from the memory element. To continue the lighting programme, the contacts of memory element No. 2 are duplicated in track A via unit **6** and network **7**. Then, when the change from lighting cue No. 1 to lighting cue No. 2 is required, the functions of tracks A and B are again reversed, when track A controls the stage lighting in accordance with the signals in memory element No. 2 and track B is ready to receive signals from memory element No. 3 in preparation for the next lighting change. In this way the complete stored lighting programme can be run through.

The actual method of interchanging the functions of the A and B tracks varies according to the type of change-over required. For instantaneous change-over, the switch **7***a* is used, giving a simple change from "A live" to "B live" and vice versa. However, such a rapid change-over is not always required, and provision for a gradual change is made by means of the ganged resistances **16***a* and **16***b*. As described above, when these resistances are selected by the switch **17***a, b, c,* the summing circuit **22** is energised and the output in each channel is equal to the sum of the outputs of the two corresponding master amplifiers **14***a* and **14***b*. This effect ensures a smooth transition between the A and B values without a dip in the illumination of any channel as the crossfade proceeds. Thus, a visually acceptable cross-fade is achieved. As a third method of interchanging the functions of the A and B tracks, in visual effect between the sudden change of the switch **7***a* and the smooth transition of the cross-fade resistors **16***a*, **16***b* in conjunction with summing circuit **22**, the resistor **15***a* and **15***b* can be used. In this mode of operation each lighting channel changes over from the first "live" channel value to the succeeding "live" channel value at a point when the falling mastered signal from the first channel drops below the rising mastered signal from the succeeding channel. Thus, as the transition proceeds, each channel lamp will fall in intensity from its first value until the corresponding change-over takes place, after which it will rise to its succeeding value.

Having now described the normal recording and running through of a lighting programme, the use of the C active track will be considered. As set out above, writing of information is effected automatically into track C when the "normal" adjustment of the master controls does not obtain. Then the output on each line **21** will depend on the two corresponding signals on the A and B active tracks respectively, and the combination of signals so

presented on the lines **21** will be recorded on track C. The synthesis of the two tracks may be effected either by taking the higher value of the two mastered signals appropriate to the given line **21**, using the resistances **15***a*, **15***b*, or alternatively, by taking the sum of the mastered values by using the cross-fade resistances **16***a*, **16***b*. When the synthesised lighting combination has been finalised, the signals on tack C can be transferred via network **7** and unit **6** to a desired lighting effect memory element without interference to the signals on the A and B tracks. It will be seen that by use of the C track, a series of lighting effects corresponding to a step-wise transition between any two given lighting combinations can be recorded in the memory store. The C track is not used to control the dimmers **23** directly.

Although the specific embodiment described is based on a magnetic drum memory, it is possible to use any equivalent memory element which is capable of erasure and re-recording, for example a magnetic core matrix could equally well be used.

In addition to the system described above, where an individual key is used for each lighting circuit, may be modified to take advantage of the shift system described in our U.S. patent specification No. 3,004,193, whereby any given control key or set of keys may be employed to control a plurality of lighting circuits.

Although the embodiment which has been described above is only a single example described in relation to use on a stage, it is nevertheless not intended to be limiting. For example, the described and illustrated embodiment is also useful in stage and television studio lighting. Technical details which may be varied are, for example, the number of memory elements, the number of lighting channels, the number of code bits per dimmer signal or the type of code modulation.

We claim:

1. A stage lighting control unit comprising in combination:

(a) a memory store having "write" and "read" lines and defining a plurality of lighting effect memory elements and a continuously modifiable "active" memory element,

(b) a dimmer control signal generator having an output which is connectible to the "write" line corresponding to said "active" memory element, said generator, when said output is so connected, operating continuously to modify the contents of the "active" element thereby defining a sequence of dimmer control signals in said "active" memory element for storage in a corresponding lighting effect memory element from said plurality thereof,

(c) a master fader unit having an input that receives the concurrent value of a sequence of dimmer control signals from the "read" line of said "active" memory element,

(d) a plurality of dimmers having corresponding inputs connected to said output of said master fader whereby each of said dimmers is controlled in dependence upon the concurrent value of the corresponding dimmer control signal in the sequence in said "active" memory element subject to continuously variable control by the dimmer control signal generator, and

(e) display means associated with each of said dimmers and having an input connected to a second output of said master fader thereby to indicate the application of control signals to each of said dimmers.

2. A stage lighting control unit as claimed in claim **1** in which are provided two continuously modifiable "active" memory elements, said two "active" memory elements being alternatively connectible to said lighting effect memory elements, said output of said dimmer control signal generator also being alternatively connectible to either of said two "active" memory elements and said input of said master fader unit being connected to the "read" line of the "active" memory element of which said output of said dimmer control signal generator is connected at any time.

3. A stage lighting control unit as claimed in claim **2** in which said display means are connected to master amplifier units to indicate the concurrent dimmer signals in both "active" memory elements.

4. A stage limghting control unit as claimed in claim **2** in which the display means is connected to said master amplifier unit and to said dimmer control signal generator and thereby displays a distinctive condition signifying when a dimmer control signal in the "active" memory element concurrently controlled by the signal generator has been modified prior to its transfer into its corresponding lighting effect memory element.

5. A stage lighting control unit as claimed in claim **2** in which said master fader controls said alternative connections.

6. A stage lighting control unit as claimed in claim **5** in which said master fader includes two master amplifier units, the amplification factors of which are independently variable by the faster fader control function, and in which the dimmer control signals pass along corresponding lines from said two "active" memory elements to said two master amplifier units respectively.

7. A stage lighting control unit as claimed in claim **6** including a plurality of comparison circuits each having two inputs and a common output, the two inputs of each comparison circuit being connected to the outputs of two corresponding channel master amplifiers from the two master amplifier units and the common output being connected to the corresponding dimmer.

8. A stage lighting control unit as claimed in claim **7** comprising a digital memory store, dimmers controlled by analogue information, and digital-analogue converters in said signal sequence generator and master amplifier units.

9. A stage lighting control unit as claimed in claim **7** in which there is provided numerical display means connected to an output line of each gate in said master amplifier units for receiving an identifying signal from said digital memory store and displaying a numerical indication of the memory elements currently associated with the active memory elements.

10. A stage lighting control unit comprising in combination:

(a) a memory store having "write" and "read" lines and defining a plurality of lighting effect memory elements including a continuously modifiable "active" memory element,

(b) selective switching means connected to both the "active" memory element and to each of the remaining lighting effect memory elements,

(c) a "writing" and "reading" unit connected between said "active" memory element and said lighting effect memory elements and responsive to commands to transfer information between them,

(d) a master fader unit having an input that receives the concurrent value of a sequence of dimmer control signals from the "read" line of said "active" memory element,

(e) a plurality of dimmers having corresponding inputs connected to said output of said master fader whereby each of said dimmers is controlled in dependence upon the concurrent value of the corresponding dimmer control signal in a sequence,

(f) a dimmer control signal generator having an output which is connectible to the "write" line corresponding to said "active" memory element for continuously modifying the contents of the "active" element independently of and without affecting, the contents of the lighting effect memory element with which it is concurrently associated by said selective switching means, to define a desired sequence of dimmer control signals in said "active" memory element, and

(g) display means associated with each of said dimmers

and having an input connected to a second output of said master fader thereby to indicate the application of control signals to each of said dimmers.

References Cited

UNITED STATES PATENTS

2,939,372	6/1960	Baumbach et al.	95—75
3,004,193	10/1961	Bentham et al.	315—295
3,060,347	10/1962	Burski	315—316
3,147,469	9/1964	Buchsbaum	340—336
3,207,949	9/1965	Rice	315—196
3,221,214	11/1965	Wolff et al.	315—292
3,265,932	8/1966	Pettersson et al.	315—292

JOHN W. HUCKERT, *Primary Examiner.*

SIMON BRODER, *Assistant Examiner.*

U.S. Cl. X.R.

315—312