United States Patent

Isaac

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[54] **LIGHTING CONTROL APPARATUS WITH A SIGNAL SWITCHING MATRIX**

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[52] **U.S. Cl.** **315/292,** 315/293, 315/295, 315/316, 315/360

[51] **Int. Cl.** **H05b 37/02**

[58] **Field of Search**..................315/291, 292, 293, 295, 313, 315/316, 319, 360

[56] **References Cited**

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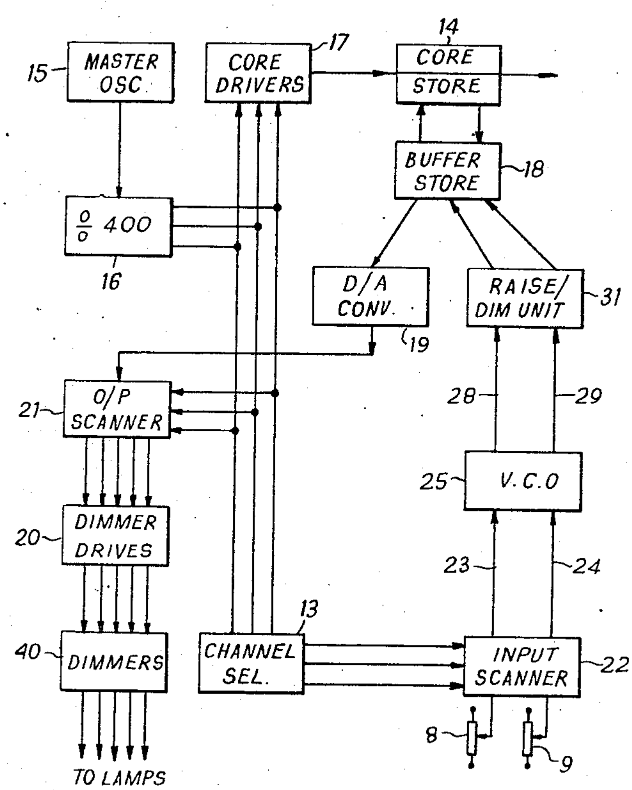
[57] **ABSTRACT**

A light dimming system comprises: a plurality of lamps, a dimmer associated with each lamp, a controller for furnishing signals for controlling the brightness or the rate of change of brightness of each lamp and a signal switching matrix for selecting the proper signal for each dimmer.

5 Claims, 4 Drawing Figures



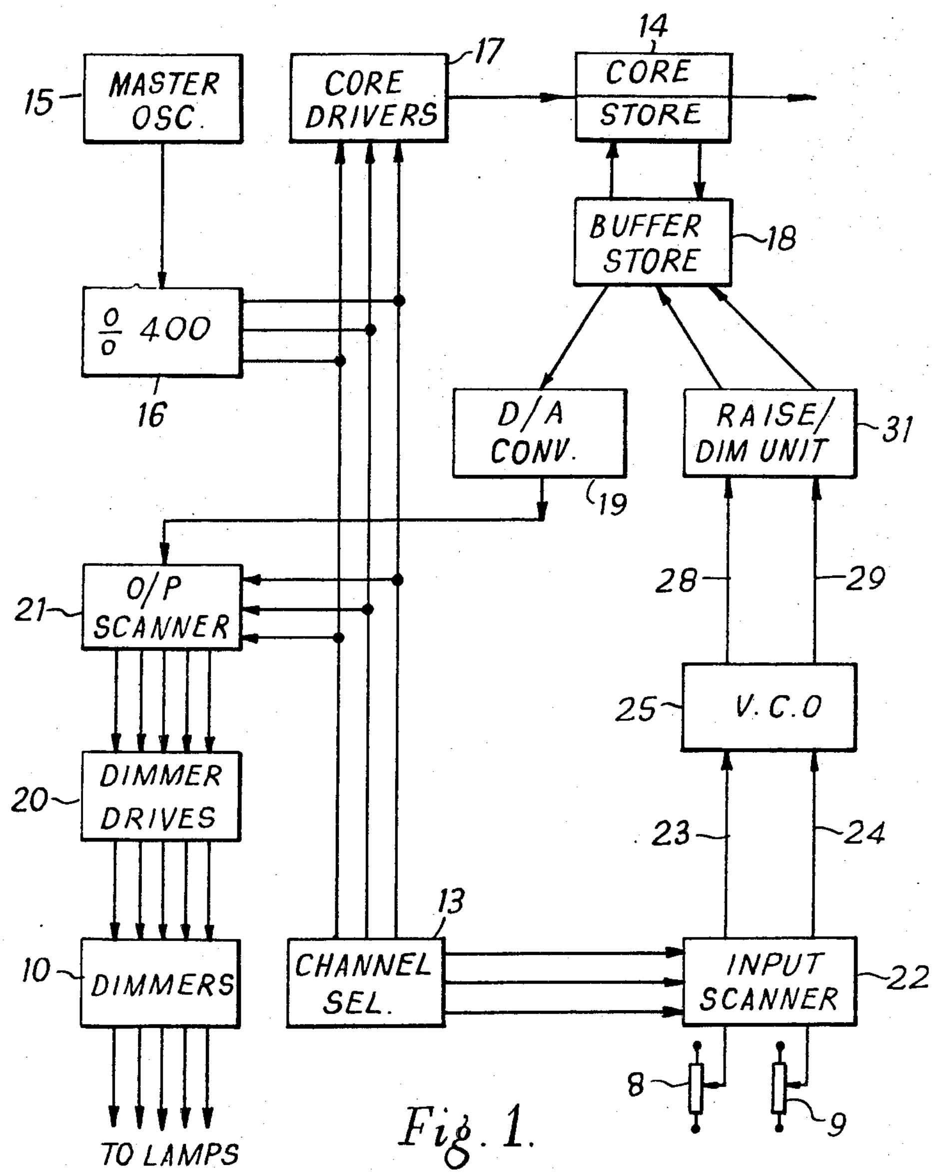


Fig. 1.

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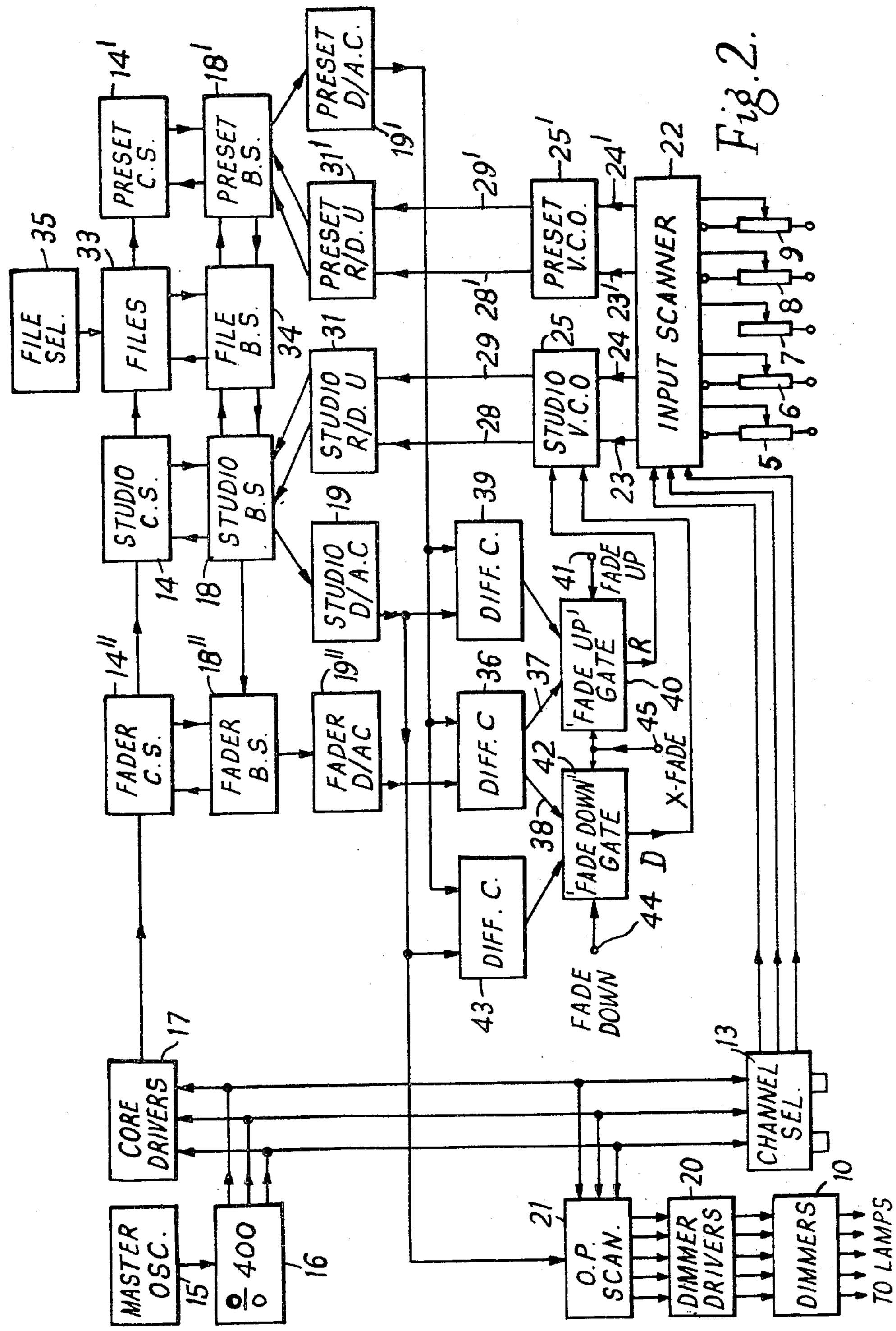

Fig. 2.

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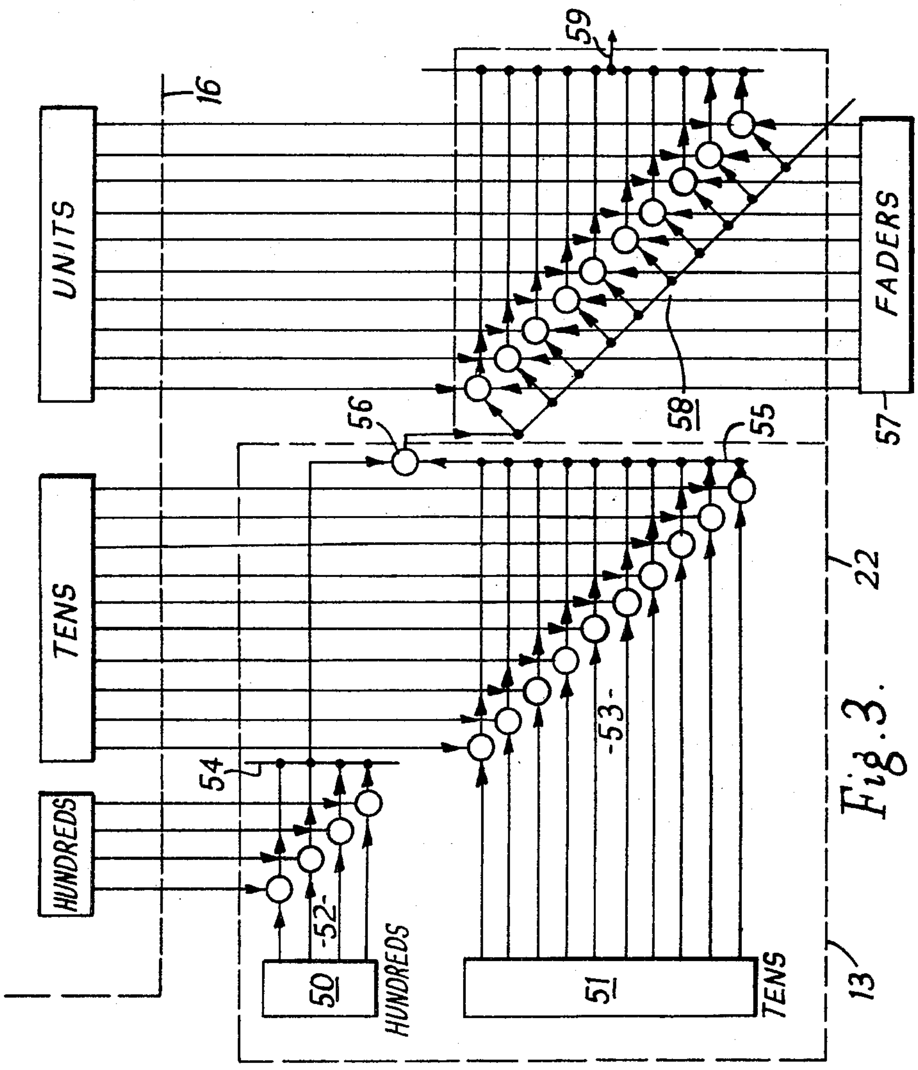

Fig. 3.

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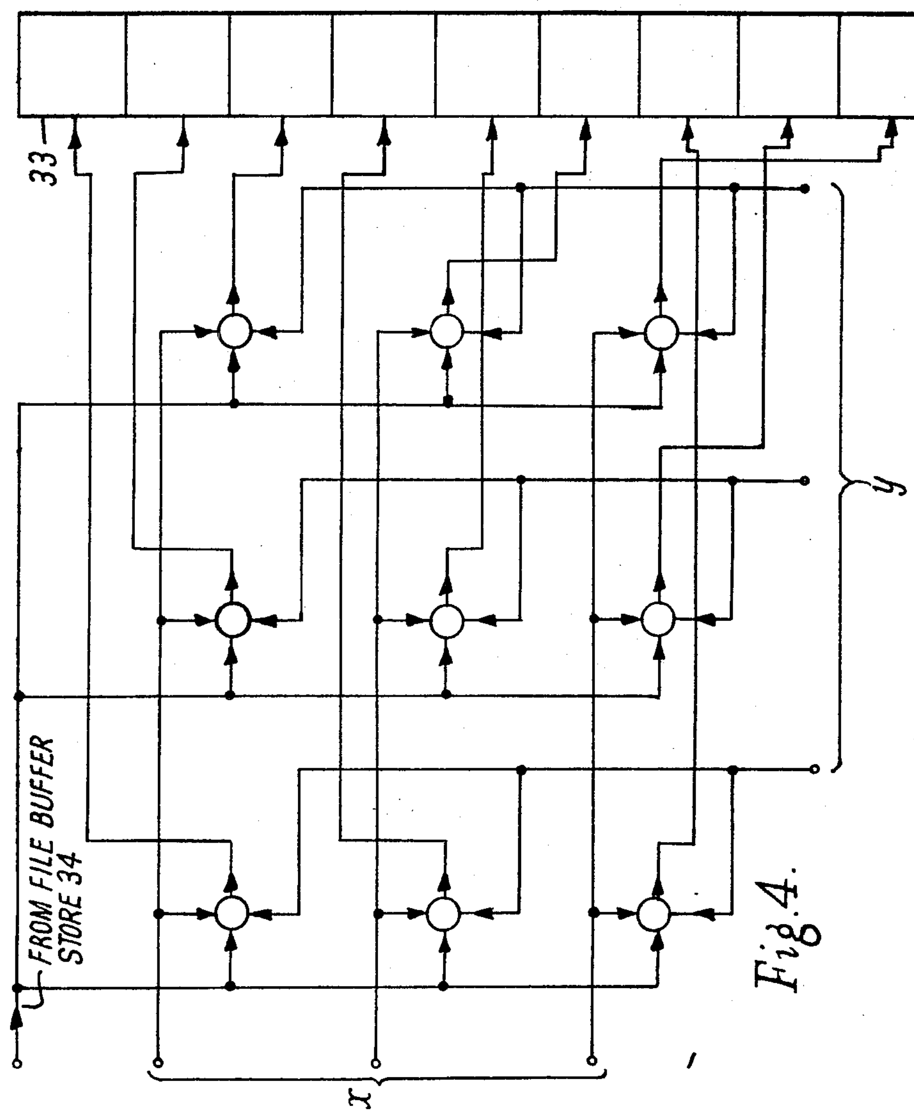

Fig. 4.

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LIGHTING CONTROL APPARATUS WITH A SIGNAL SWITCHING MATRIX

This is a continuation of application Ser. No. 677,215, filed Oct. 23, 1967.

The present invention relates to apparatus for controlling a large number of lamps, or groups of lamps, such as are used in stage or studio lighting systems, with a comparatively small number of controls.

One problem encountered in stage and studio lighting systems is the provision of a control panel which is not cumbersome. A large number of groups of lamps must be controlled but a separate control for each group, which might require 500 or more such controls, cannot be conveniently mounted on a control panel.

Another problem is that of setting, during production, a large number of controls to positions decided on in rehearsal.

According to the present invention there is provided lighting control apparatus, comprising a plurality of lamps, each lamp having dimmer means for setting the brightness thereof, a plurality of control means for supplying signals for controlling lamp brightness or the rate of change of lamp brightness, and a switch matrix, as hereinafter defined, for selecting one of the control means to control the dimmer means.

In this specification a switch matrix means an arrangement of switches and enabling terminals, in which the enabling terminals are arranged in at least two groups (each group being equivalent to one dimension of the matrix), and each switch requires a number of enabling signals equal to the number of groups of enabling terminals for operation and is so connected too a single enabling terminal in each group that the application of an enabling signal to one enabling terminal in each group selects and operates one switch only. If at least one group of enabling terminals contains more than one enabling terminal, then the other group or groups may consist of only one enabling terminal.

Selection of a control means for a given lamp by setting, for example with push buttons, an input in each dimension of the matrix, allows a large number of lamps to be controlled by a comparatively small number of push buttons.

The switches may be AND gates, in which that input signal which is to be switched is always present and two or more further input signals are required to open the gate.

Each control means may include a fader which supplies signals representative of a desired brightness, or a desired rate of change of brightness of a selected lamp. It is advantageous to be able to store information representative of lamp brightness, and another form of each control means may therefore include a section of a file store for such information, the switch matrix being used to select sections of the store which contain information representative of different lamp brightnesses.

A number of complete lighting plots decided on in rehearsal can then be automatically set during production from information held in the file store.

A lighting system may thus have two switch matrices, and two groups of control means one including faders and one including a file store.

In one lighting system groups of lamps are allocated channels in a time divided system. In this arrangement the contents of a core store are read into a buffer store sequentially, and the buffer store is connected to control a different dimmer means each time it receives information from the core store. Sections of a file store may be selected to control groups of lamps, by a first switch matrix which connects a selected section of the file store to the buffer store. The information in this section is read sequentially into the buffer store and thus controls the dimmer means. In addition one of a group of faders may be selected to control a group of lamps. A second switch matrix is used to select the fader, but each switch of the matrix has additional timing inputs, which must be present before it operates, to ensure that the fader output signal appears only in the selected channel.

Certain embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a block diagram of a lighting system having lighting control apparatus according to the invention for selecting faders to control the brightness of lamps,

FIG. 2 is a block diagram of a lighting control system of FIG. 1 extended to include lighting control apparatus according to the invention for selecting sections of a file store to control the brightness of lamps,

FIG. 3, shows part of the apparatus of FIGS. 1 and 2 in more detail, and

FIG. 4 shows part of the apparatus of FIG. 2 in more detail.

In the stage lighting system of FIG. 1 a bank **10** of dimmers controls groups of lamps (not shown). The intensity of light from any group of lamps can be changed by moving the control lever, or dolly, of one of 10 faders numbered **0** to **9**, two of which **8** and **9** are shown in FIG. 1. If a dolly is moved in one direction the brightness of a group of lamps selected by a channel selector **13** is continuously increased, at a rate depending on the position of the dolly, until the lamps are at maximum intensity. Movement of the dolly in the other direction dims the lamps continuously.

Each group of lamps is allocated a channel and eight cores in a core store **14**. One of the cores registers a one-bit "ON/OFF" signal, and the other seven register a seven bit brightness count giving the required brightness for the group of lamps. The channels are time divided, or multiplexed, and for this purpose a 40 Kc/S master oscillator **15** supplies pulses to a divider circuit **16**, having two cascaded divide-by-ten stages and two cascaded divide-by-two stages. The first divide-by-ten stage gives a units output, the second divide-by-ten stage gives a tens output, and the two divide-by-two stages give a four state hundreds output. The channels are numbered from one to 400 and have a duration of 25 microseconds. The outputs from the divider circuit are passed to core drivers **17**, which at the beginning of each 25 microsecond channel period, using the conventional half current pulses applied to X and Y axis wires of the matrix of the store **14**, select the eight cores allocated to one of the channels and transfer their contents to a buffer store **18**. The contents of the buffer store is then converted to an analogue voltage by a digital to analogue converter **19**. The resultant voltage is passed to a selected dimmer drive unit **20**, by an output scanner **21** comprising a sampling matrix of an AND gate controlled by the outputs of the divider circuit **16** feeding four hundred reservoir capacitors. The sampling matrix, timed from the main divider waveforms, decommutates the 400-channel time sequential signal from the digital-to-analogue convertor **19** into 400 parallel signals on the 400 reservoir capacitors. These signals, one per lighting channel, are shaped in the dimmer drive units **20** into signals controlling the 400 dimmers, one per lighting channel.

At the end of each 25 microsecond period the contents of the buffer store are read back into the core store, and the contents of the next eight cores corresponding to the next channel are read into the buffer store.

The 10 faders are used to enter the required brightness counts into the store **14** and to change them. Each fader is selected to control one channel by using the channel selector **13**, and an input scanner **22**.

Referring now to FIG. 3, the channel selector has a '100's register **50** and a 10's register **51**, both of which can be set by push buttons (not shown) to give an output corresponding to a selected 100 stage and a selected 10 stage. The stages are connected to corresponding AND gates in matrices **52** and **53**. Each AND gate also receives an input from the stage of the divider **16** corresponding to its input from the registers **50** or **51**. Thus if push buttons 'two' hundred and 'seven' tens were operated inputs would appear on a common output wire **54** of matrix **52** during all channels numbered **200** to **299**, and on a common output wire **55** during all channels who have as a second figure a seven. The wires **54** and **55** are connected to an AND gate **56** which opens for duration of 10 channels; in the example, channels **270** and **279**.

The faders **0** to **9**, shown in FIG. **3** as block **57**, are connected to a further AND gate matrix **58** in the input scanner **22**. Each AND gate in this matrix receives an input from one fader, and enabling inputs from one unit register of the divider **16** and the output of the AND gate **56**. In the above example therefore a common output wire **59** of matrix **58** would receive an output from the fader **0** in the channel period **270**, from the fader **1** in the channel period **271** and so on, the fader **9** providing an output in the channel period **279**.

Each fader provides an output on one wire when its dolly is moved from a central position in one direction and another wire when moved in the other direction. Thus two matrices such as matrix **58** must be used, and in FIG. **1** the wire **59** is replaced by two output wires **23** and **24** corresponding to "raise" and "dim" lamp brightness respectively. The wires **23** and **24** are connected to a voltage controlled oscillator (V.C.O.) **25** which receives pulses of amplitude depending on fader settings from the faders in selected channel periods. The V.C.O. also receives pulses from the divider **16** and provides cyclic series of pulses in each channel on output wires **28** and **29** whose count in a V.C.O. cycle is proportional to the voltage supplied by the fader selected for that channel. The V.C.O. may have the form described in our application entitled "Analogue to Digital Converter" (application Ser. No. 677,217, filed Oct. 23, 1967, now U.S. Pat. No. 3,624,639, issued Nov. 30, 1971, and assigned to the assignee of the present application).

When the brightness count of a group of lamps, represented by the states of eight cores allocated to that group has been read into the buffer store **18**, a raise/dim unit **31** raises or lowers the count at one unit per pulse received along wires **28** or **29** during the appropriate channel period. The number of these pulses received in one cycle of the V.C.O. depends on the position of the dolly of the fader selected for that group of lamps and the brightness count is altered accordingly.

In FIG. **2**. the basic system of FIG. **1**. is modified and facilities for fading lamps according to predetermined lighting plots are provided. The V.C.O., raise/dim unit, buffer store, core store and digital to analogue converter of FIG. **1**. are designated in FIG. **2**. as studio V.C.O., studio raise/dim unit, studio buffer store, studio core store and studio digital to analogue converter. Other units which have the same functions are given the same designations in FIGS. **1** and **2**. A second and third series of units are provided and comprise a preset core store **14'**, a preset buffer store **18'**, a preset V.C.O. **25'**., a preset digital to analogue converter **19'**, and a preset raise/dim unit **31'**, and a fader core store **14''**, a fader buffer store **18''**, and a fader digital to analogue converter **19''**. The input scanner **22** has alternative pairs of output leads so that the channel selector **13** and faders may all be switched together to control the contents of either the preset store **14'** or studio store **14**. The contents of either store may be "filed", or recorded in file store **33**, by push button operation. In filing, or recording the contents of studio or preset store are read-out channel by channel into the appropriate buffer store and thence are registered in a file buffer store **34**. As the studio or preset buffer store contents are written back into the appropriate core store, the file buffer store contents are written into a file core store selected from, for example, a group of 100 such file stores by a file selector **35** operated by pushbuttons. Information may be transferred by push button between the studio and file buffer stores and between the preset and file buffer stores in either direction.

The file selector **35** in one arrangement consists of a matrix of AND gates which is shown in FIG. **4**. In this arrangement the selector **35** is connected between the file buffer store **34** and the file store **33**, instead of being connected in the way shown schematically in FIG. **2**. Each AND gate of the matrix has two enabling inputs applied by push buttons (not shown) from two series of *x* and *y* enabling input terminals. In practise the *x* terminals would be '10's terminals and the *y* terminals 'units' terminals so that one of a hundred gates in the matrix could be selected. Each gate is connected to a corresponding section of the file **33** and the file buffer store, so that when one of the AND gates of FIG. **4** is open information can pass in either direction through the matrix. Two such matrices may be used if it is required that each shall pass information in one direction only.

In operation therefore if it is required to file, or record a lighting plot, a section of the file store **33** is selected using push button *x* and *y* terminals and information from the studio core store **14** representing the counts in all 400 channels is read into the selected section.

In rehearsal an arrangement of channel brightness counts that is, a "lighting plot", is set up on selected lighting channels; this lighting plot is filed in a first file. A second lighting plot is set up and filed in a second file, and so on. In a production each lighting plot in the files may be read-out non-destructively into the studio store **14** to control the lighting channels. Channels for lighting plots may be preselected using either the studio or the preset store. Channels registered in a selected file may be indicated on an illuminated mimic diagram (not shown), the lamps being operated from the stored one-bit "ON/OFF" signal. Filed plots may be added to an existing plot set-up or registered in the studio or preset stores.

When a first lighting plot is to be gradually changed, that is faded to a second plot the first lighting plot is set up in rehearsal and filed, and the levels of some lighting channels in this plot are now raised to give second plot which is also filed. In a production the first plot is read into the studio store **14** and is also transferred into the fader store **14''**. The second plot is read into the preset store **14'**. A differential comparator **36** produces on one of two output leads an analogue output proportional in any channel period to the difference between the outputs of the preset and fader brightness counts that is the brightness counts registered in the preset and fader buffer stores. This analogue output appears on a "Raise" lead **37** if the preset brightness count is greater than the fader brightness count and on a "Dim" lead **38** if it is less. A differential comparator **39** produces an enabling signal in the period of any channel for which the preset brightness count exceeds the studio brightness count, which is passed together with the output of the differential comparator **36** to a "Fade-Up" gate **40** with a push button control **41**. Analogue "Raise" signals in the channel periods of channels having greater preset brightness counts than fader brightness counts, and substantially proportional in a given channel to the difference between these counts are passed to the studio V.C.O. **25** to produce "Raise" pulses at proportionate rates. On operation of the "Fade Up" control **41** the brightness counts in the studio store **14** change from their starting values (first plot, fader store) to their finishing values (second plot, preset store) at a rate substantially proportional in any channel to the difference in preset and fader brightness counts for that channel. When the studio brightness count for a channel becomes equal to its preset brightness count the enabling signal from comparator **31** disappears and "Raise" pulses in that channel period cease. Since the "Raise" rates are substantially proportional to differences between initial and final brightness counts all channels transfer from initial to final brightness in substantially the same time regardless of the magnitude of brightness change in any channel. This maintains balance during fades.

A "fade-down" is performed in a similar way by taking the "Dim" output **38** of the differential comparator **36** to a fade-down gate **42**, opened when a signal from a differential comparator **43** comparing studio and preset brightness counts, and a signal from a fade-down push button control **44** are both present. The differential comparator gives an output signal proportional to the difference between the studio and preset brightness counts so that when the studio brightness count is equal to the preset brightness count fade down ceases.

A cross-fade between two plots necessitating both raising and dimming is made similarly by a "Cross Fade" push button control **45** energizing both "Fade-Up" and Fade-Down" gates

41 and 44 simultaneously. "Raise" and "Dim" analogue control voltages appear at the outputs of the "Fade-Up" and "-Fade-Down" gates as appropriate to the sense and magnitude of the change to be made in each channel.

Other ways of utilizing the invention will be apparent. For example, instead of 10 faders there may be 100, numbered 0 to 99 respectively, and the channel selector may have four '100's buttons marked 0,100,200 and 300 respectively. If the '300' button is operated faders 0 to 99 operate on channels 300 to 399 respectively, and so forth. Likewise four '100's buttons, ten '10's buttons and 10 'units' buttons marked 0 to 9 respectively may be provided which operate on a 10-state 'units' register, and only a single fader. The channel which this fader controls is selected by operating the appropriate '100's, '10's and 'units' buttons. The system may be extended for, say, 1,000 channels by replacing the four state '100's counter in the main divider chain and the four-state '100's register in the channel selector by 10-state devices, by providing ten '100's buttons marked 0 to 900 respectively and by increasing either the Master Oscillator frequency to 100 Kc/S or the main divider cycle to 25mS. Again, the system may be adapted for any convenient number of faders, say 20 or 50, the '10's buttons in these cases reducing to 0, 20, 40, 60 and 80 or 0 and 50 respectively.

If the input scanner uses 100 faders and the channel selector has only a '100's register the channel selector output pulse covers channel periods 200 to 299 of the main divider, the '200' button being operated. The input scanner now has gates matrixing the '10's outputs as well as the 'units' outputs of the main divider with the '100's output of the channel selector and with the analogue voltages from faders 0 to 99 to produce sequential samples of these 100 fader outputs in channels 200 to 299 of the main divider cycle when the '200' button is operated.

If the input scanner is coupled to only one fader the channel selector has a '100's, a '10's and a 'units' register. The states of these are matrixed with the states of the '100's, 10's and 'units' stages of the divider to give a pulse occuring only when the divider is in the one selected state. This pulse operates in the input scanner on the analogue voltage from the one fader to produce one sample of this analogue output in the chosen channel period of each complete cycle of the main divider, the sample occuring whenever the main divider is in the chosen state. In this case the input scanner has only one fader output to sample and degenerates into a simple sampler.

Thus it will be seen that, for example, for a four hundred channel lighting system a control panel can be provided which is compact and has the following controls;

14 push buttons to select one of 10 faders to control a group of lamps on a fade time, 10 fader controls; 20 file select buttons to select one of a hundred file sections for storing lighting plots and fade information; push buttons controlling reading into, and out of the file store; and push buttons controlling the preset store. The operation of a push button may be indicated by the illumination of a signal lamp in or adjacent to the button, and channels registered in a selected file may be indicated on an illuminated mimic diagram, the lamps of which are operated from the stored one bit ON/OFF signal.

What I claim is:

1. A lighting control circuit having dimmers for controlling the brightness of lamp groups, at least one fader for controlling the dimmers, selectors controlling switches to assign each fader to any one of a set of dimmers, and means for

recording lighting plots representing brightness settings of all dimmers and for controlling the dimmers in accordance with the recorded lighting plots, characterized by a time multiplex system having a register, each state of which defines a channel corresponding to a different one of the dimmers, and by a matrix comprising an arrangement of the said switches and of groups of enabling terminals, one group being connected to the register and at least two other groups to separate sets of selectors and the connection of the switches to the enabling terminals being such that operation of one selector in each set selects a channel for connection to a fader.

2. Lighting control apparatus comprising a plurality of lamps, individual dimmer means for setting the brightness of each of said lamps, a plurality of control means generating lamp brightness control signals, and a switch matrix connected to the control means to select one of the control means to control the dimmer means, said switch matrix comprising a plurality of switches, and at least two groups of enabling terminals, each switch being connected to a single enabling terminal in each group whereby each switch is operated only when an enabling signal is applied to each of the enabling terminals to which that switch is connected, wherein each said control means comprises a section of a file store for information representing lamp brightness, in which each control means comprises a fader which supplies signals representative of a desired brightness or a desired rate of change of brightness, and the switch matrix is connected to select one of the faders to control one of the dimmer means, wherein one group of enabling terminals of the switch matrix is connected to a timing circuit supplying a repeated sequence of pulses for operation of the switches in sequence to repeatedly scan the faders.

3. Apparatus as claimed in claim 2 in which another group of enabling terminals comprises a common terminal connected to a second switch matrix, the second matrix having a group of enabling terminals connected individually to selector switches and a second group connected individually to the timing circuit whereby a pulse is passed to the common enabling terminal of the first switch matrix to select a group of time-divided channels corresponding to each operated selector switch.

4. Apparatus as claimed in claim 2 wherein the output of the first switch matrix is applied by way of an analogue to digital converter to a buffer store coupled to a core store, the core store holding brightness control information for the lamps and being driven by the timing circuit to read out the stored information into the buffer store sequentially, the output of the switch matrix then serving to change the brightness control information for each of the time-divided channels corresponding to a lamp or group of lamps as required by the fader settings, and the buffer store is connected by way of a digital to analogue converter and a scanner driven by the timing circuit to the dimmer means for the individual lamps.

5. Apparatus as claimed in claim 4 in which the analogue to digital converter comprises a counter driven by the timing circuit, a series of resistors each of which is coupled to a single stage of the counter, the most significant counter stage being coupled to the highest valued resistor and the less significant resistors to resistors of progressively lower values, and a comparator for comparing the analogue input from the first switch matrix with the discrete signal levels formed by the combined currents through the resistors for each state of the counter.

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