United States Patent [19]

Callahan et al.

[11] **Patent Number: 4,550,276**

[45] **Date of Patent: Oct. 29, 1985**

[54] **BUSS STRUCTURES FOR MULTISCENE MANUAL LIGHTING CONSOLES**

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[21] Appl. No.: **388,230**

[22] Filed: **Jun. 14, 1982**

[51] **Int. Cl.**[4] **H05B 37/00;** H05B 39/00; H05B 41/00

[52] **U.S. Cl.** **315/312;** 315/314; 315/316; 315/294; 315/299; 330/298; 361/18

[58] **Field of Search** 315/293, 294, 295, 312, 315/299, 314, 315, 316; 330/298; 361/18

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CAE, Inc. Rainbo TM Console, Brochure and Photos.
Capron Lighting "Eagles" Console Photo.
Capron Lighting "CSN" Console Photos.
Lighting Methods, Ltd. "248" Console Photo.
FM Productions Lighthesizer TM Console Brochure.
Theater Techniques 5-Scene Console Brochure.
Lighting Methods, Ltd. "212" Brochure and Photos.
Advanced Manual Console by the applicants.
"AVO" Console Brochure and Photos.
Strand Century Mantrix TM Console Brochure.
Kliegl Entertainer TM Console Brochure.
Lighting Methods Designer TM Console Brochure.
Berkey Patchman TM Console Brochure.
Electro-Controls Celebrity TM Console Brochure.
E.F.S. Celco Gamma TM Console Brochure.
General Electric Radio City Music Hall Console Photo.
Kliegl Performance TM Console Brochure.
Berkey Channeltrack TM Console Brochure.
Electronics Diversified TAM Console Brochure.
Strand Century Micro-Q TM Console Brochure and Photo.
Kliegl Performer TM Console Brochure.

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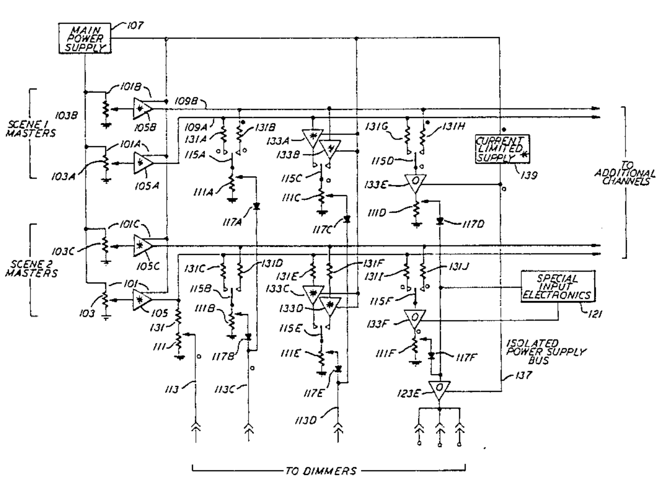
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

In a lighting console which provides outputs to dimmers which include master controls for at least two scenes and channel controls for each of a plurality of channels with the channel controls including at least a first and second scene preset potentiometer, the channel controls and master controls cooperating to allow presetting, and which also includes a buss, with one of the preset potentiometers for each of a plurality of the channels connected to the buss and an output from the master controls being used through suitable amplifiers to drive the buss, a plurality of nondestructive current limiting fault isolating devices are provided for each scene, each connected between the master and at least one of the preset potentiometers for that scene. As a result, the effects of a fault causing abnormal currents to flow which develops after the fault isolating means will not disrupt the operation of channel potentiometers connected to other fault isolating means. In addition, the console permits the separation of the assignment selection of potentiometers and the assignment indication of that selection. The console also includes distributed multiplexing devices which reduces the back plane wiring requirements in the console.

39 Claims, 13 Drawing Figures



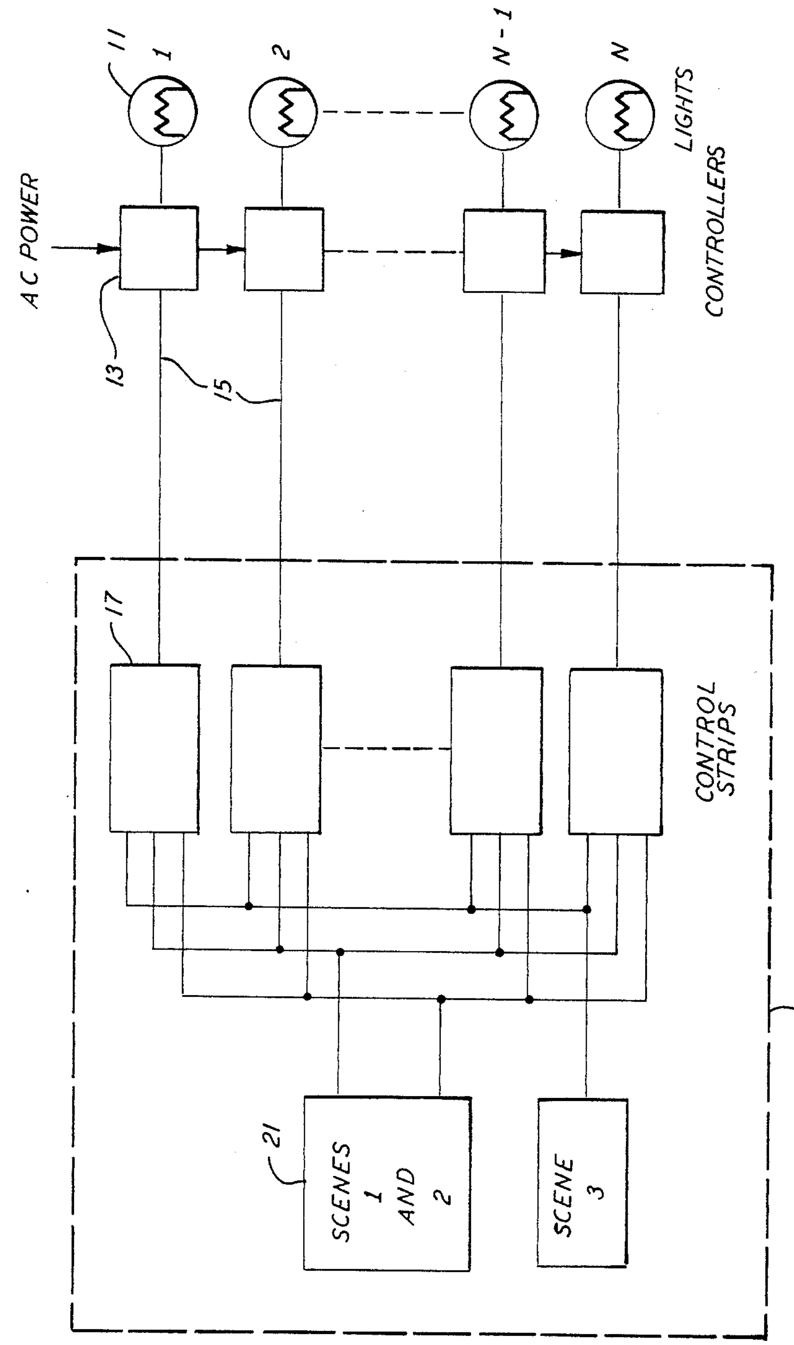

11
1
2
N - 1
N
LIGHTS
A C POWER
CONTROLLERS
13
15
17
CONTROL STRIPS
19
21
SCENES 1 AND 2
SCENE 3

FIG. 1

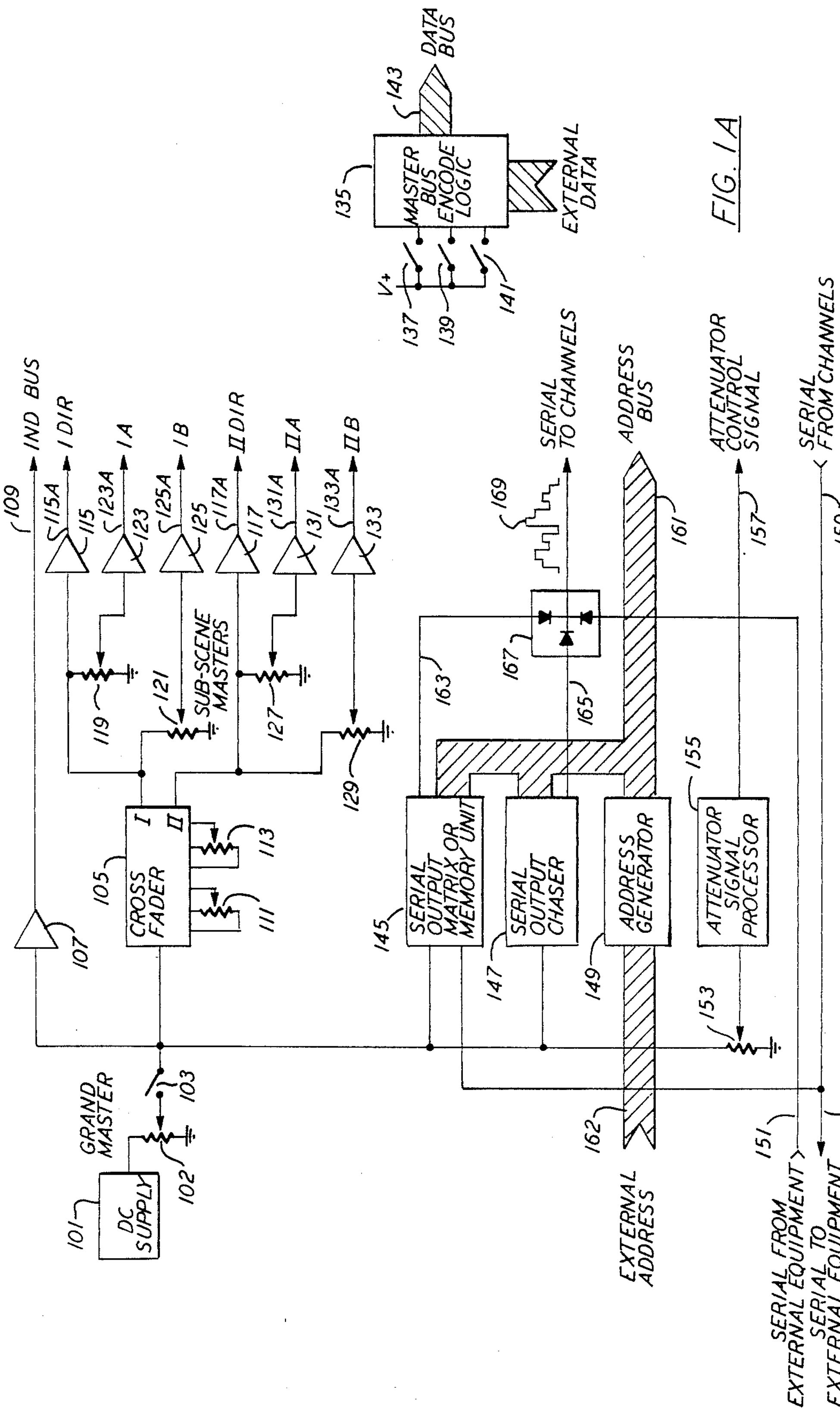

DATA BUS
143
MASTER BUS ENCODE LOGIC
135
EXTERNAL DATA
V+
137
139
141
IND BUS
I DIR
I A
I B
II DIR
II A
II B
109
115A
115
123A
123
125A
125
117A
117
131A
131
133A
133
SUB-SCENE MASTERS
119
121
127
129
CROSS FADER
105
107
111
113
I
II
GRAND MASTER
DC SUPPLY
101
102
103
SERIAL TO CHANNELS
ADDRESS BUS
ATTENUATOR CONTROL SIGNAL
SERIAL FROM CHANNELS
169
167
163
165
161
157
159
SERIAL OUTPUT MATRIX OR MEMORY UNIT
145
SERIAL OUTPUT CHASER
147
ADDRESS GENERATOR
149
ATTENUATOR SIGNAL PROCESSOR
155
153
162
151
159
EXTERNAL ADDRESS
SERIAL FROM EXTERNAL EQUIPMENT
SERIAL TO EXTERNAL EQUIPMENT

FIG. 1A

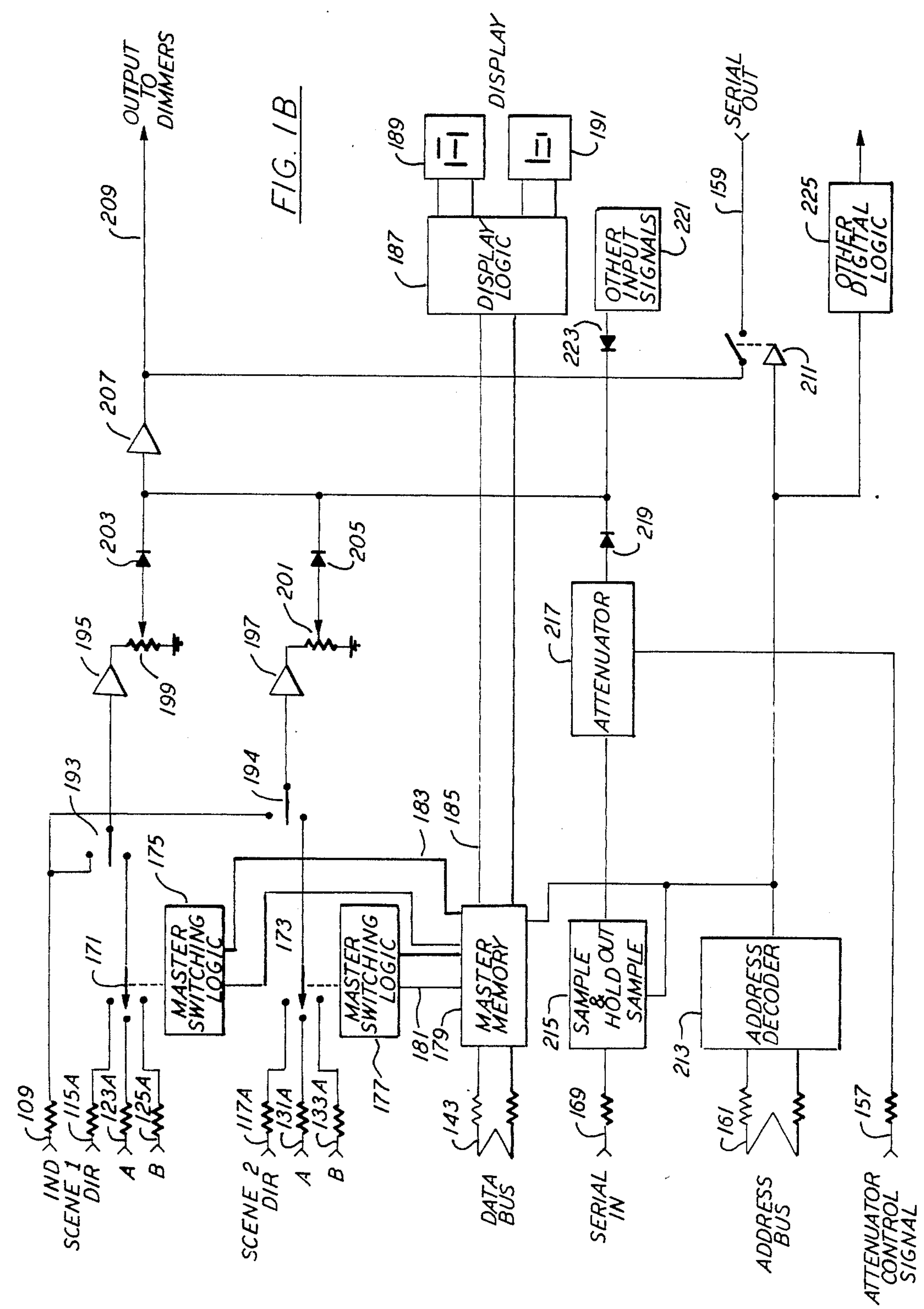

OUTPUT TO DIMMERS
DISPLAY
DISPLAY LOGIC
OTHER INPUT SIGNALS
SERIAL OUT
OTHER DIGITAL LOGIC
ATTENUATOR
MASTER SWITCHING LOGIC
MASTER SWITCHING LOGIC
MASTER MEMORY
SAMPLE & HOLD OUT SAMPLE
ADDRESS DECODER
IND
SCENE 1 DIR
A
B
SCENE 2 DIR
A
B
DATA BUS
SERIAL IN
ADDRESS BUS
ATTENUATOR CONTROL SIGNAL
109
115A
123A
125A
117A
131A
133A
143
169
161
157
171
173
175
177
179
181
183
185
187
189
191
193
194
195
197
199
201
203
205
207
209
211
213
215
217
219
221
223
225
159

FIG. 1B

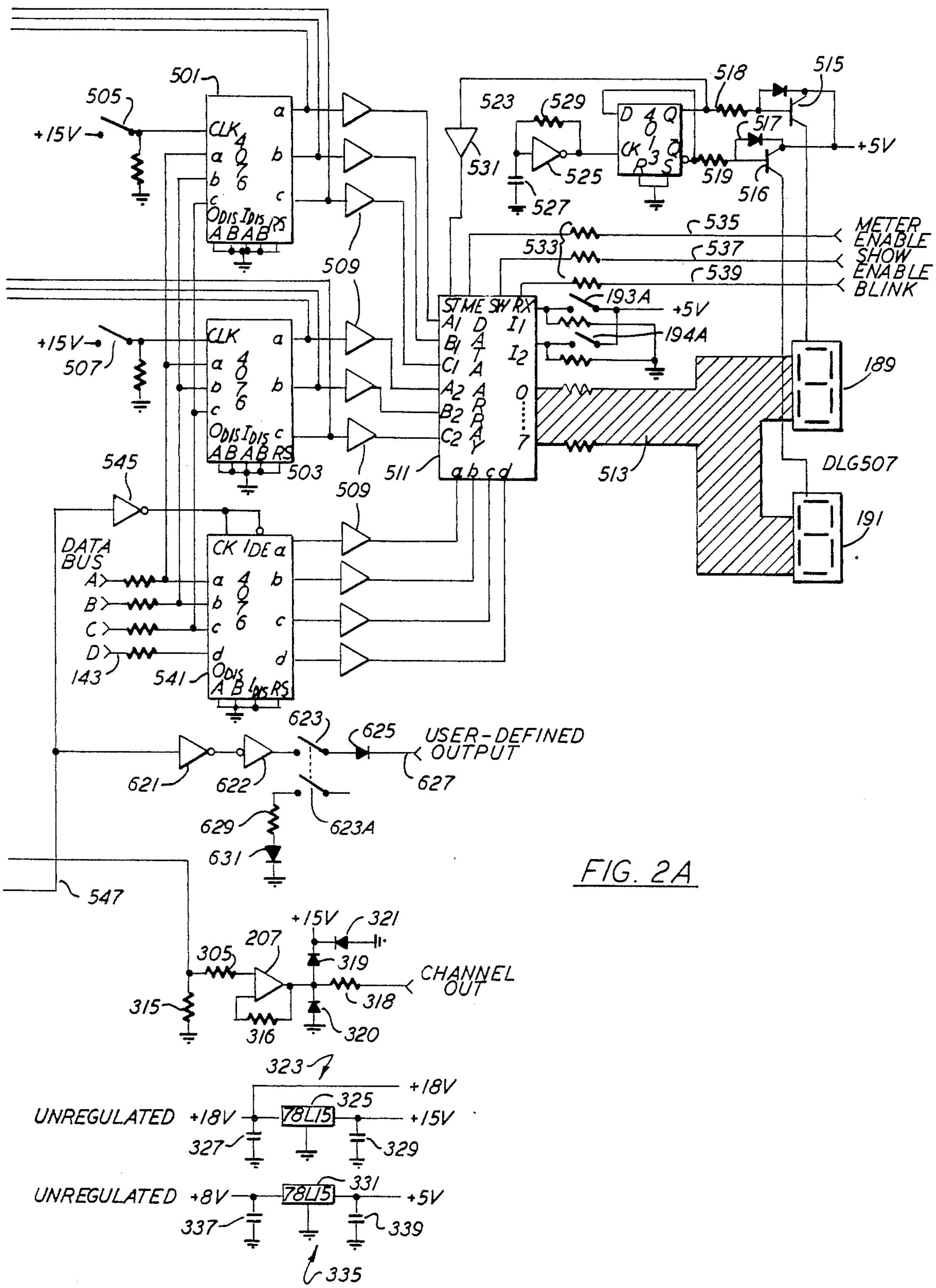

501
505
+15V
CLK
4076
ODIS IDIS RS
ABAB
509
+15V
507
503
545
DATA BUS
A
B
C
D
143
541
CK IDE
4076
511
STME SW RX
A1 B1 C1 A2 B2 C2
DATA ARRAY
I1 I2
0
7
abcd
523
529
531
525
527
D 4013 Q
CK
R S
518
515
517
519
516
+5V
535
537
539
533
METER ENABLE
SHOW ENABLE
BLINK
193A
194A
+5V
189
DLG507
513
191
623
625
USER-DEFINED OUTPUT
621
622
627
629
623A
631
547
+15V
321
305
207
319
CHANNEL OUT
318
315
316
320
323
+18V
325
UNREGULATED +18V
78L15
+15V
327
329
331
UNREGULATED +8V
78L15
+5V
337
339
335

FIG. 2A

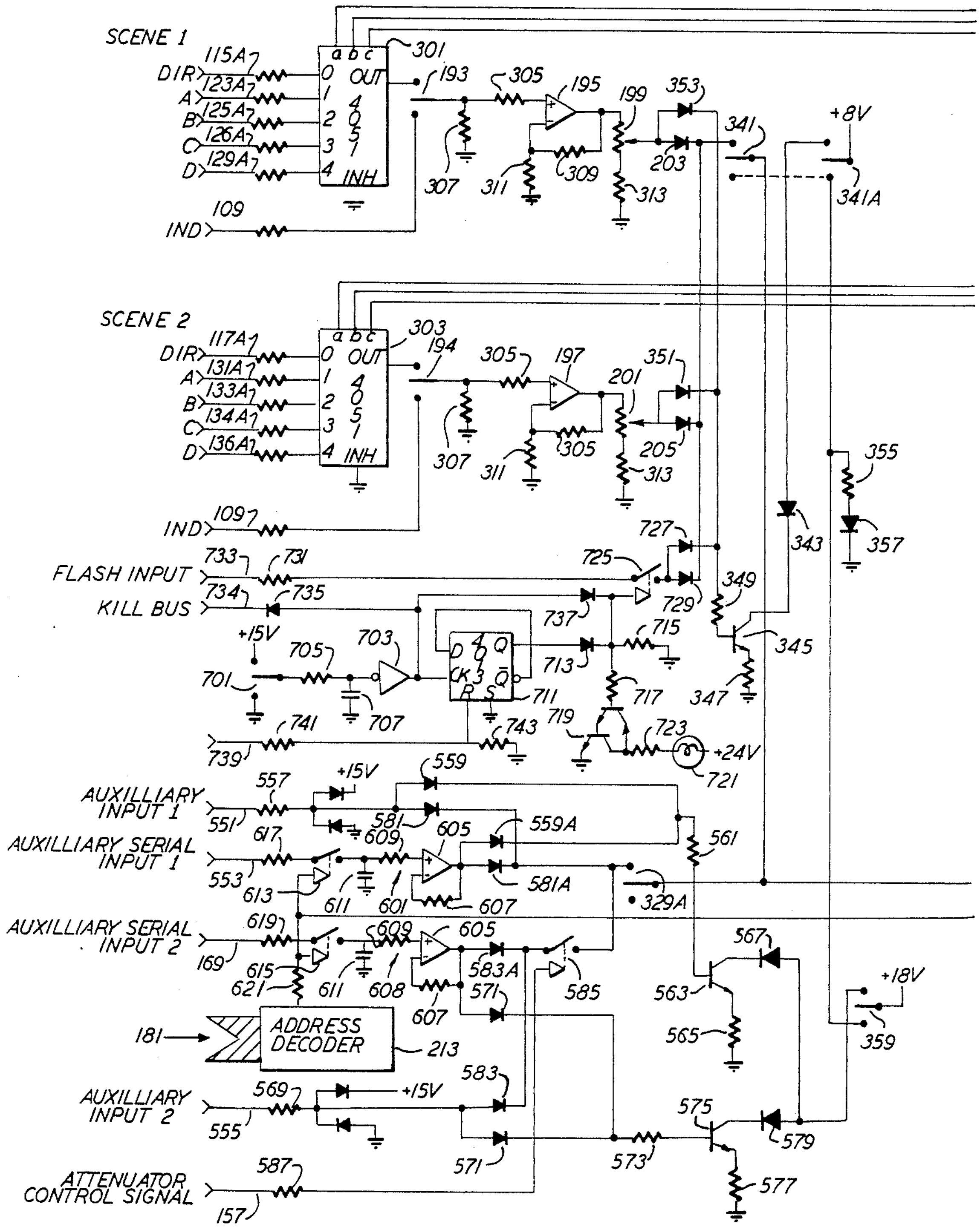

SCENE 1
DIR
A
B
C
D
IND
SCENE 2
FLASH INPUT
KILL BUS
AUXILLIARY INPUT 1
AUXILLIARY SERIAL INPUT 1
AUXILLIARY SERIAL INPUT 2
ADDRESS DECODER
AUXILLIARY INPUT 2
ATTENUATOR CONTROL SIGNAL
+8V
+15V
+24V
+18V

FIG. 2B

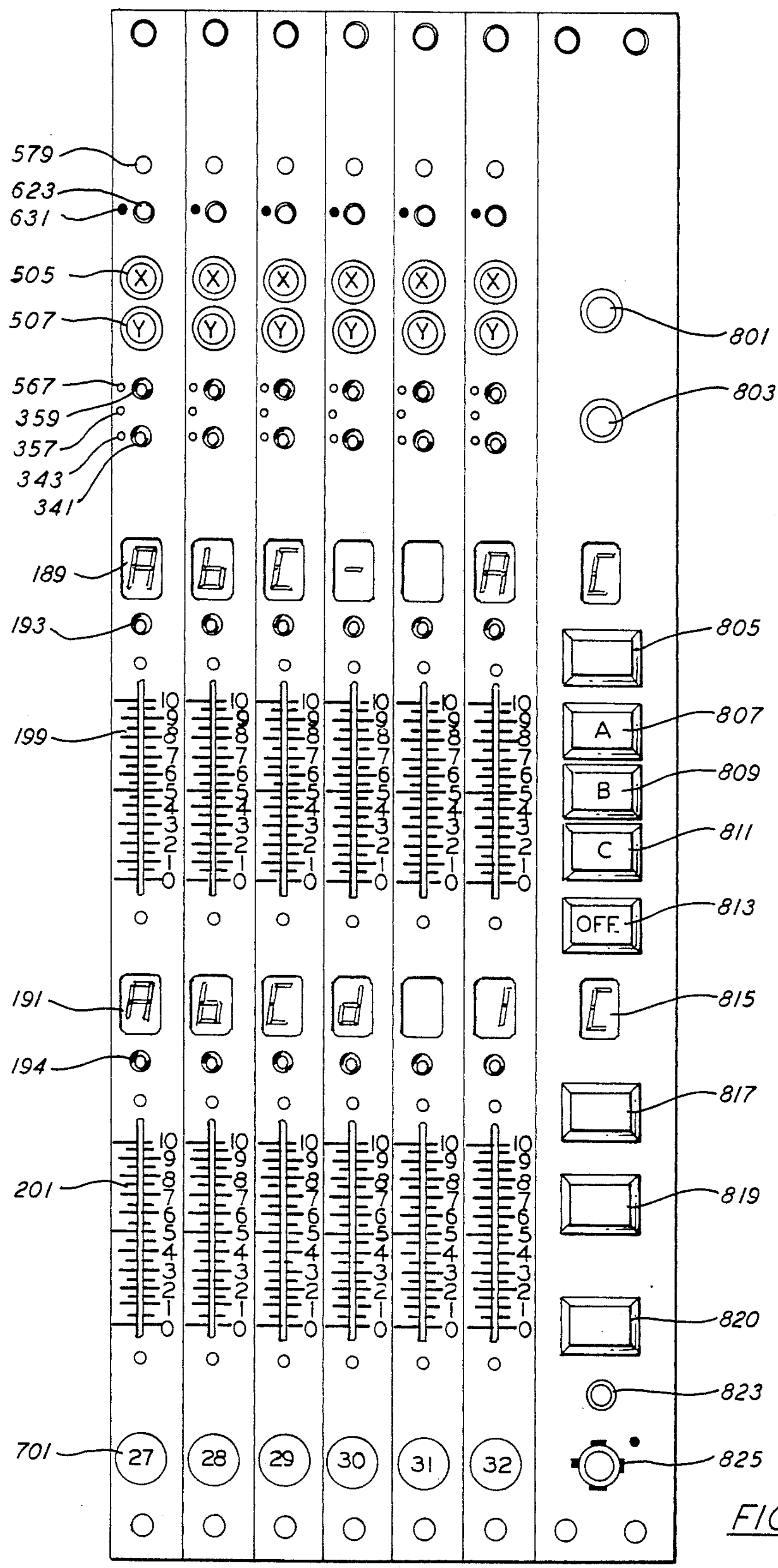

579
623
631
505
507
567
359
357
343
341
189
193
199
191
194
201
701
801
803
805
807
809
811
813
815
817
819
820
823
825
A
B
C
OFF.
27
28
29
30
31
32

FIG. 3

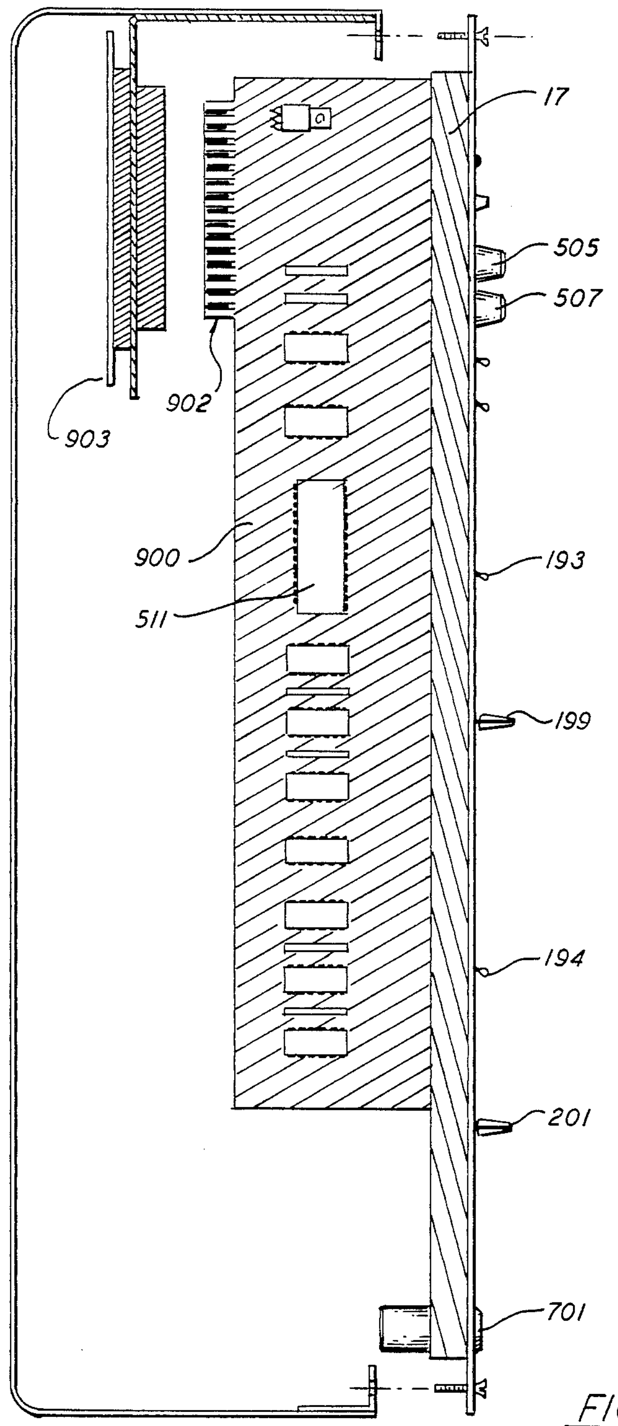


FIG. 3A

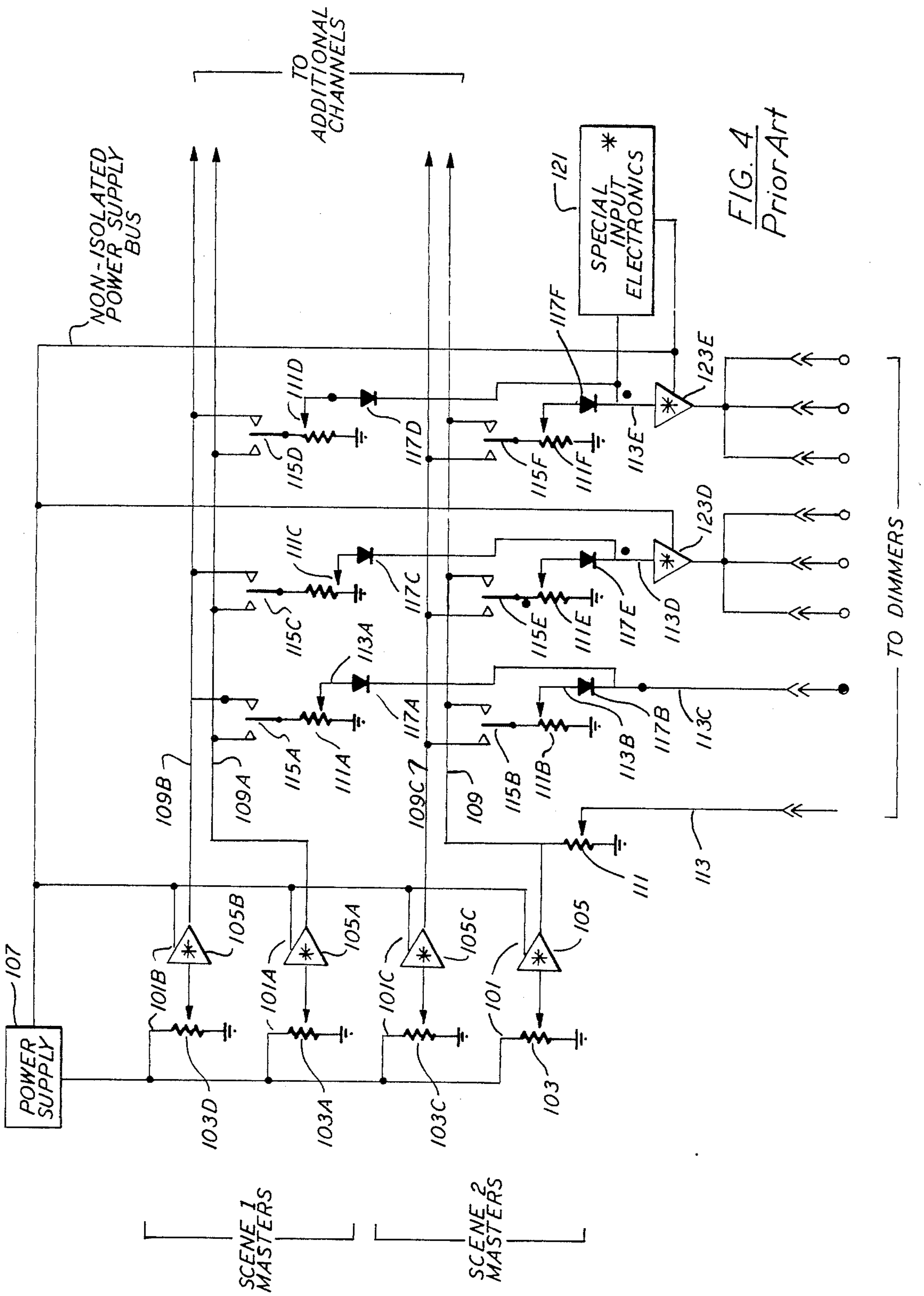
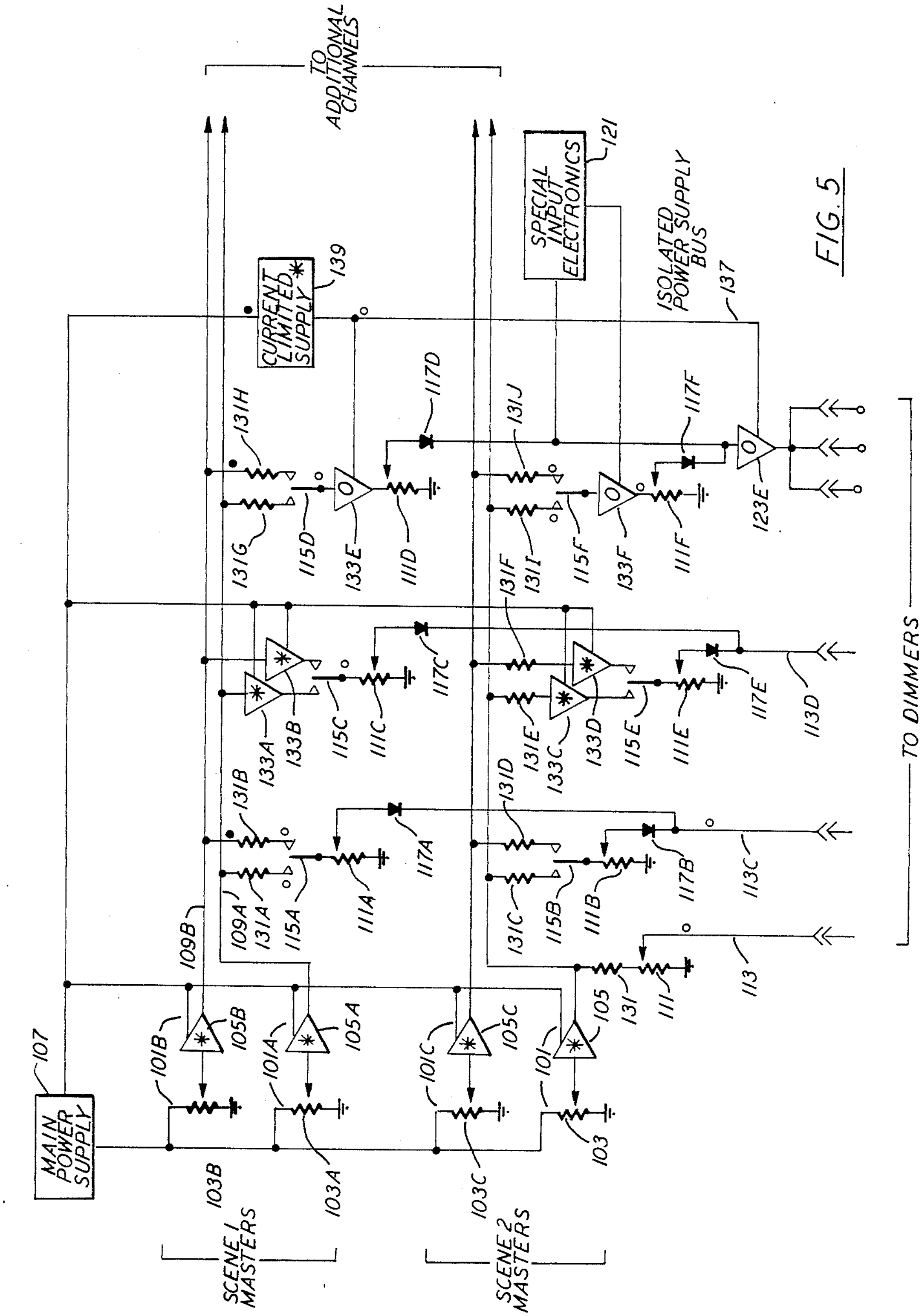
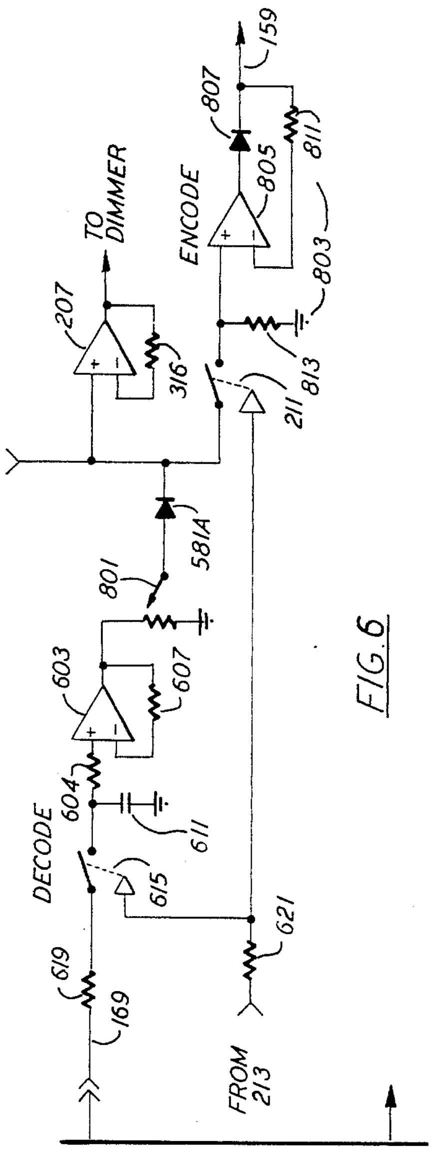


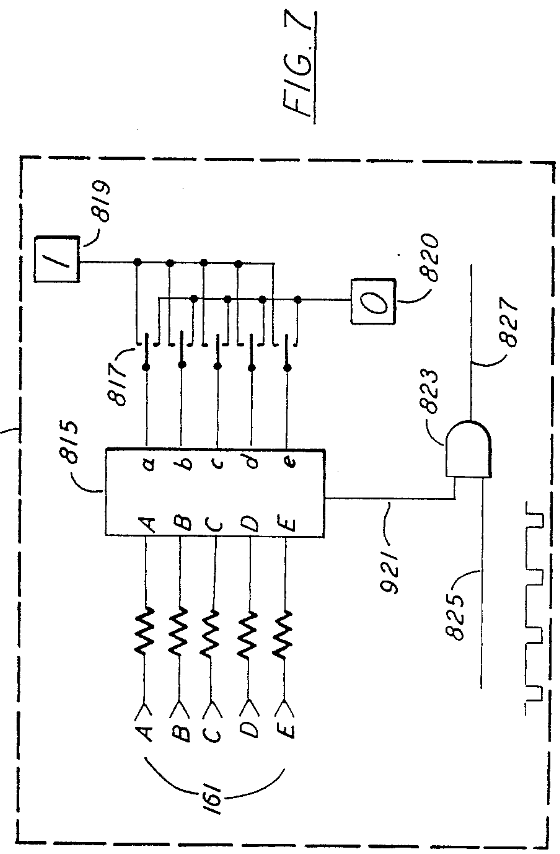
FIG. 4
Prior Art


TO ADDITIONAL CHANNELS
SPECIAL INPUT ELECTRONICS
121
ISOLATED POWER SUPPLY BUS
137
CURRENT LIMITED SUPPLY
139
MAIN POWER SUPPLY
107
SCENE 1 MASTERS
SCENE 2 MASTERS
TO DIMMERS
101B
105B
101A
105A
101C
105C
101
105
103B
103A
103C
103
109B
109A
131A
115A
111A
117A
131B
131C
115B
111B
117B
131D
113C
113
131
111
133A
133B
115C
111C
117C
131E
133C
133D
115E
111E
117E
113D
131F
131G
131H
115D
133E
111D
117D
131I
131J
115F
133F
111F
117F
123E
FIG. 5



TO DIMMER
ENCODE
DECODE
FROM 213
207
316
807
159
805
811
803
813
211
581A
801
603
607
604
611
615
619
169
621

FIG. 6



213
819
820
817
815
823
827
921
825
161
A B C D E
a b c d e
1
0

FIG. 7

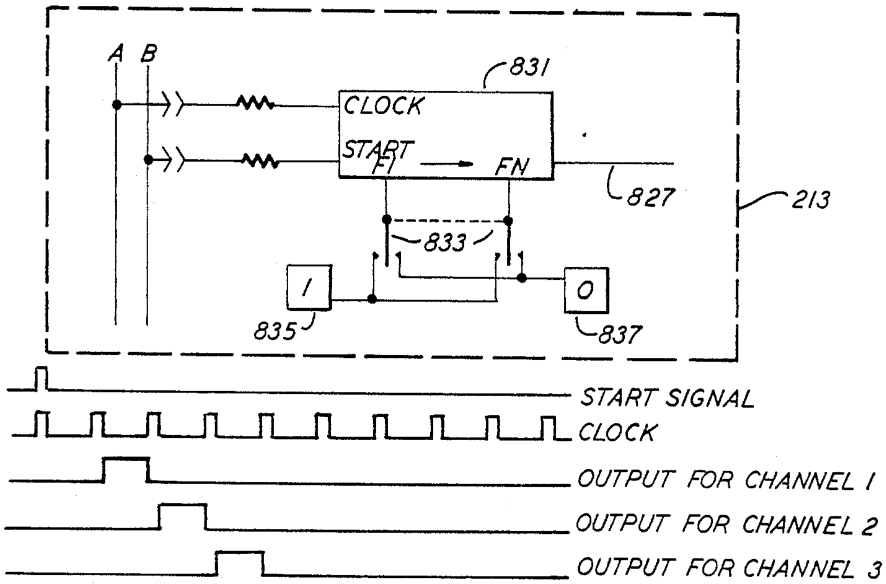

A
B
831
CLOCK
START
F1
FN
827
213
833
1
0
835
837
START SIGNAL
CLOCK
OUTPUT FOR CHANNEL 1
OUTPUT FOR CHANNEL 2
OUTPUT FOR CHANNEL 3

FIG. 8

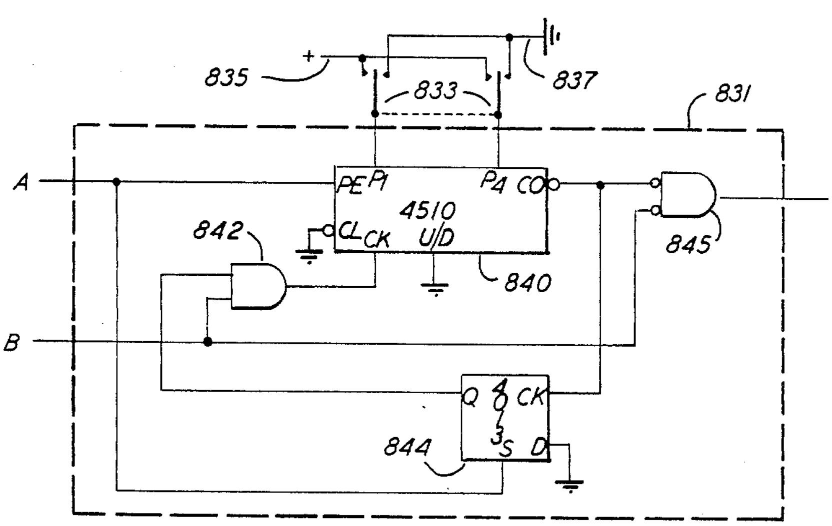

835
+
833
837
831
A
PE
P1
P4
CO
4510
CL
CK
U/D
842
840
845
B
Q
CK
4013
S
D
844

FIG. 8A

BUSS STRUCTURES FOR MULTISCENE MANUAL LIGHTING CONSOLES

BACKGROUND OF THE INVENTION

This invention relates to theater lighting in general and more particularly to a lighting console which provides increased capability of control, increased reliability, increased serviceability, and increased economy of interfacing manual and memory capabilities, particularly in portable use.

In the area of traditional performance lighting, separate manual consoles and memory consoles have been developed. For a background in the manual multi-scene console, reference can be made to U.S. Pat. No. 3,946,273. Descriptions of computer-based memory systems are well established in the patent art.

While each type has proved useful in certain applications, neither has been found completely satisfactory for the many applications in which both the adaptability provided by manual capability and some form of preset storage are both required. As a result, these applications have required the use of either both a manual console and a separate memory console and a separate memory console, at considerable expense and inconvenience to the operator, or of a new class of hybrid manual/memory console providing both multi-scene manual capability and increasingly elaborate memory and effects subsystems. Such consoles, which are based on traditional manual console design, have problems:

The number of channels to be controlled in the manual scenes is so large that extensive mastering capabilities are required with a consequently large number of possible master assignments for each channel's potentiometers. No satisfactory control for making that assignment which satisfies all of the necessary electronic and human factors criteria is currently known in the art.

These manual sections must be interfaced increasingly with electronic storage systems which require and produce serial data systems which require and produce serial data streams. To date, parallel/serial conversion subsystems have been installed, requiring considerable additional interconnecting wiring.

The electronic complexity of such consoles; the amount of interconnecting wiring; and the degree to which various functions for a single channel are distributed in many different locations within the console have made such consoles less than fully reliable and very difficult to troubleshoot.

Furthermore, in addition to the need for a console which is reliable, particularly when transported with a touring production, there is a need for flexibility in console design. The ideal console should be as large or small as needed for the application without requiring a major electronic redesign and should give operational flexibility.

It is the object of the present invention to produce a console meeting all these needs.

SUMMARY OF THE INVENTION

The present invention provides a lighting console which achieves these and additional objects through number of unique features.

First, the console of the present invention, incorporates strip module construction. That is, each channel, i.e. discrete output to a light or group of lights to be separately controlled, is a separate plug-in module and contains the electronics associated with the channel. This gives ease of mechanical assembly, allows subsequent expansion, and permits the design of a console to any size requirement. Furthermore, field-servicing is quite simple, since repairs in the field can be accomplished by replacement of the whole strip module with a spare, and the failed strip module sent back to the shop for repair.

The second main feature of the present invention resides in distributed electronics. The strip modules, in addition to being mechanically separate, achieve a great degree of electrical independence. Through the use of various fault isolating techniques and separate control of power supply, a failure in one channel does not spread through the console, temporarily disabling or permanently damaging other channels or sections. This is accomplished by means of various fault-isolating resistors and amplifiers, the amplifiers being fed with their own power supply. This method of console construction gives the further advantage of permitting expansion, since the number of channels in a console is not limited to the power capabilities built into the master amplifiers as has been the case in the past.

The present console provides for the capability of assigning each channel potentiometer to any one of six modes: directly to the scene master; to the submasters, such as Sub A, Sub B, or Sub C; to an Independent buss, or to off. In the past, it had been the practice to combine the switching function and the indication of the selected mode in the same device.

However, no method satisfactory in all respects, has been achieved in the prior art. The present invention solves the master assignment problem by separating the indicating function and the switching function. Thus, in accordance with the present invention, each strip module; i.e. each channel, includes its own seven-segment LED displays driven through a logic device. By using this method, only one set of mode d can selection switches is required for the whole console along with only two "Assign" pushbuttons for each channel (assuming two scenes per channel and a separate assignment possible for each scene). With this arrangement, the operator selects the n desired assignment using the master mode selector switch bank, whereupon all the channel potentiometers to be assigned to that master are assigned by pressing their assign pushbuttons with an indication immediately thereof on associated LED displays.

The present invention also provides independent, control. The ability to switch a channel potentiometer to an r independent buss is an important feature in a lighting controller to simplify difficult cues and to speed an operator's response to the unexpected. Because of the speed with which it is generally necessary to enter independent, it is important ce that the method of doing so be fast and simple. In accordance with the present invention, independent control is provided for the potentiometers in each scene. It is entered by throwing a miniature switch located directly above the affected potentiometer. Furthermore, because of the manner in which the odes: independent control is implemented electronically, the normal, master assignment is unaffected. Simply restoring the independent control to its normal position returns the potentiometer to its normal assignment. It is also possible with the ce. present invention to change a potentiometer's assignment while in the independent mode.

Furthermore, the present console includes the ability to review the assignments of the channel potentiometers of the console and to display other data through what are known as "show me" buttons.

To determine which of the channel potentiometers is assigned to a given mode with particular speed, ease, and accuracy; it is simply necessary to select the appropriate mode on the master mode selector switch bank and then depress the "show me" button and the displays for all potentiometers assigned to other functions will go out. This allows the operator to immediately determine which potentiometers are assigned to that mode by simply noting which displays remain lit. Similarly, the capability is provided for locating, in the same manner, all of the channels in which independent has been selected and further includes the ability to review levels set in a memory system or other data. In the "show me" modes there is no effect on the actual assignment, this being only a display feature.

Also included in the console of the present invention are flash buttons. The flash button permits operation in four modes: safe or off; momentary flash of the channel to the level set by a central "flash" master potentiometer; electronically held, push-on/push-off action with a central reset button useful for setting up an additional "preset" at high speeds; and a "kill" mode in which depresing a channel's flash button flashes it to the level of the flash master while automatically blacking out all other channels.

The console of the present invention also provides additional features. Included is a channel kill switch which disables that channel's potentiometers and flash button. An auxiliary kill switch disables inputs tc the module from sources outside of it, such as the console's memory and effects sections and/or outboard units. This auxiliary kill switch may be used to temporarily delete a channel from stored presets without altering the matrix or memory. An indication through a light-emitting diode is provided when one or both of the kill switches is engaged. In addition, displays are provided to indicate whether the channel is being driven from inputs on the module or from off the module. In addition, there is an indication of the availability of inputs from an external memory board or the like.

In this last regard, the console of the present invention is adapted to interface with onboard or offboard matrix, memory, and effects units. In accordance with the present invention, each strip module has four inputs for levels originating outside the module, whether elsewhere in the console of the present invention or from outboard units. The console of the present invention has further distributed the components necessary for serial conversion to the strip modules, allowing the console of the present invention to both produce and accept serial data streams for use with onboard or outboard memory and effects units and for connection to the dimmers over a serial link, without the traditional necessity for a separate conversion subsystem and the interconnect wiring required to it, with considerable savings in cost and increase in reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall block diagram of the console of the present invention.

FIG. **1A** is a more detailed block diagram of the master section of the console of the present invention.

FIG. **1B** is a more detailed block diagram of a single channel strip module used in the console of the present invention.

FIGS. **2A** and **2B** are a detailed schematic-block diagram of a single channel in the console of the present invention.

FIG. **3** is a plan view of a portion of the console of the present invention.

FIG. **3A** is a side view of a portion of the console.

FIG. **4** is a schematic diagram illustrating a typical prior art arrangement in consoles of this nature.

FIG. **5** is a similar drawing illustrating the manner in which fault isolation is achieved by the present invention.

FIG. **6** is a diagram showing the manner in which encoding and decoding of levels is done in a channel.

FIG. **7** illustrates a first embodiment of address decoder of the present invention.

FIGS. **8** and **8A** illustrate a second embodiment of address decoder according to the present invention.

DETAILED DESCRIPTION

FIG. **1** is an overall block diagram of the lighting control system of the present invention. At the right of the figure are shown a plurality of n lights **11** to be controlled. Typically, the device according to the present invention might have 64 channels, i.e., control 64 separate lights or groups of lights **11**. For each of the lights **11**, a dimmer **13** of conventional design is provided. Dimmers **13** receive AC power and provide it in a controlled manner, in accordance with the control input on a line **15**, to their associated lights **11**. The signal on line **15** is a DC voltage which controls an electronic circuit which in turn controls a triac, SCR or the like. The individual control signals on lines **15** are developed in individual control strip modules **17** on a lighting console **19**, one such strip being provided for each channel. As will be seen in more detail below, each strip, in addition to other functions, permits selecting for each of two scenes, scene I and scene II, any one of five master, submaster control inputs developed in a master control portion **21**. Master control **21** which will typically include a crossfader for crossfading between scenes I and II. These control outputs will, for example, be provided to scene I and scene II submaster potentiometers, the outputs of which are provided as the inputs to the control strips **17**. Naturally, buffering and amplification as necessary will be provided.

FIGS. **1A** and **1B** are more detailed block diagrams of the lighting control system of the present invention. FIG. **1A** illustrates the basic units contained in the master control **21** of FIG. **1**. FIG. **1B** illustrates the basic blocks contained in one control strip **17** of FIG. **1**.

Referring now to FIG. **1A**, the control signal is first generated from the output of a reference DC supply **101**. The reference DC supply provides this output to a potentiometer **102** which is the grand master potentiometer. Its output is coupled through a grand master blackout switch **103** to a crossfader **105**. It is also coupled to an amplifier **107** which provides an output on what is known as an independent bus **109**. The crossfader **105**, which comprises a pair of scene master potentiometers **111** and **113**, provides outputs for the scenes I and II. One output for scene I is provided directly into an amplifier **115**. Similarly one output from scene II is provided into an amplifier **117**. Outputs are also provided through submaster A and B potentiometers **119** and **121** to amplifiers **123** and **125** for scene I and through submaster A and B potentiometers **127** and **129** to amplifiers **131** and **133** for scene II. Although only two potentiometers are shown for each scene, at this, the submaster, level, a greater number may be provided.

The present invention also includes encoding logic **135** accepting inputs from the master mode selector switch bank **137**, **139** and **141**; and providing a parallel output representing the mode selected on buss **143**.

The system of the present invention is also usable with presently existing electronic memory systems. These may be full feature stand-alone memory boards well known in this art, or the simpler more specialized sutstitutes which are coming into increasing use. Memory units of this type produce serial output which provides all channel intensity data. When used with traditional consoles, serial to parallel conversion subsystems are required. The discrete outputs of the systems are connected with combining diodes at the channels using individual conductors. To be able to also provide this kind of information but without a large number of interconnecting wires which would otherwise be necessary is desirable. And, the arrangement of the present invention provides such. Thus, as illustrated by FIG. 1A the master control also includes a serial output matrix or memory unit **145**, serial output chaser **147**, and address generator **149** and provisions for coupling in an external signal on a line **151**. In addition, the output from the grand master is coupled through a potentiometer **153** to an attenuator signal processor **155** providing its output on a line **157**. Serial data from the channels is provided back on a line **159** which can be multiplexed to dimmers, for example, and is also fed back into the matrix or memory unit to permit storing information which is set up on the individual channels.

Unit **149** is an address generator providing parallel information on the address buss **161**. This address information is used to synchronize the operation of the serial encoding and decoding circuitry distributed throughout the console. The address generator's output is further used to synchronize the operation of the matrix or memory unit **145** and the chase/effects unit **147** so that their serial analog outputs on lines **163** and **165** contain the correct channel's level during its sample interval. On one of these lines will be a series of levels such as shown by the waveform of line **169**. Each sample interval is associated with a particular channel and the value on the serial line during that interval corresponds to the desired level for that channel. The serial outputs of the memory or matrix **145**, the chase unit **147**, and the input on line **151** from an external source of serially-encoded level information are combined through diodes in block **167**.

Inputs from these sources are provided to the channel modules by means of bus **169** and the address information is distributed on bus **161** and may be treated as an additional scene or scenes. In the event that an external system is connected with the console by means of line **151** then the external system must be synchronized to the console's address generator **149** or the console's address buss **161** connected to that of the external system.

It will be apparent that the functions of address generation and master mode selection can also be accomplished by means of a microprocessor. Provision is made for external address information on a bus **162** which will be coupled through to bus **161** to synchronize with the analog information on line **151**. An additional scene or scenes can be provided by means of the serial information just described and provided as outputs on line **169** and addresses on bus **161**.

FIG. 1B shows how these various outputs are connected in each of the plurality of channels **17**. For each of the two scenes, a direct and two submaster inputs are provided as inputs to switches **171** and **173** respectively. These switches are controlled by respective switching logic **175** and **177** receiving inputs from a master memory device **179** which in turn receives its input from the bus **143**. The master memory **179** provides outputs on buses **181** and **183** to switching logic **177** and **175**. It also provides an output on bus **185** to display logic **187** which drives displays **189** and **191** displaying respectively the selection for each of the two scenes. The output from switches **171** and **173** is coupled to switches **193** and **194**. These switches respectively permit switching between one of the submasters or the direct crossfader output and the independent bus **109**. The signal, whether it be from the independent bus or one of the master or submaster controls, is then coupled through an amplifier **195** or **197** to a respective scene preset pot (potentiometer) **199** or **201**. These outputs are combined through diodes **203** and **205** into an output amplifier **207** which provides its output on line **209** to dimmers. This output is also coupled through a switch **211**, enabled by an address decoder **213** coupled to the address bus **161**, to provide serial analog output information on line **159** when that particular channel is being addressed by the address bus **161**, permitting feedback to the matrix or memory unit **145** of FIG. 1A and/or serial dimmer control.

The serial analog input data on line **169** is sampled and held in a sample and hold device **215** which is enabled by the same output from address decoder **213**. The attenuator control signal on line **157** is coupled into an attenuator **217**, the output of which is coupled through a diode **219** to the amplifier **207**. Furthermore, it is indicated that there may be a source **221** of other signals coupled through a diode **223** to amplifier **207**. In addition, the address decoder output may be used to enable other digital logic **225**.

In general, operation is as follows in setting up the assignment of channel potentiometers on the console. The first mode, for example, direct, might be selected using the master mode assignment switch bank **137**, **139**, **141** and that mode's designation encoded by the logic **135**. Then all of the channels it is desired to connect to direct are selected by pressing the appropriate assign switches which will cause their master switches **175** and **177** to set their switches **171** and **173** to line **115***a* and **117***a* as required and keep them there. The same is done for the submasters A and B for example. When this is completed, each of the channel potentiometers will have been assigned to a particular master bus. In addition, display logic will display the assignment which has been selected. For example, in FIG. 1B, it is shown that scene I has been assigned to submaster A and scene II to submaster B. Subsequently, then as the crossfader, and subscene masters are operated, the proper channels will follow as desired.

In addition, when it is desired to input information of a serial nature, addresses are generated in serial, one address corresponding to each channel. This occurs on the address bus **161**. At the same time, an analog level is coupled out to line **169**, a separate level for each channel. These levels appear on line **169** of all channels at the input to the sample and hold circuits **215**. However, only when the address of that channel is decoded by address decoder **213** does that channel sample its proper level to be provided as an output through the attenuator **217** to the output amplifier **207**. The attenuation control signal on line **157** can be a pulse code modulated signal of the type described in U.S. Pat. No. 3,946,273. This will then be used to attenuate the signal output of the sample and hold circuit. Other types of attenuators can be used as will be seen below.

In FIG. **1B** essentially all of the inputs are coupled through input resistors. The purpose of these resistors is to aid in fault isolation in a manner that will be seen below in connection with FIGS. **4** and **5**.

In FIGS. 2A and 2B, which is a more detailed logic/-schematic diagram of the channel electronics, the parts which are the same as those of FIG. **1B** will be given the same reference numerals. The input previously described from the master controls including, for example, the independent input on line **109**, the direct input on lines **115***a* and **117***a*, and the various submaster inputs are as before, with the exception that there are additional submaster inputs possible on lines **126***a*, **128***a*, **134***a* and **136***a*. These lines are inputs through input resistors, typically of 10K to analog switch modules **301** and **303**, one switch being provided for each input. These correspond to the switches **171** and **173** of FIG. **1B**. The output of the switch modules is coupled into the switches **193** and **194** which permit switching between the analog switch module outputs and the independent input. The respective outputs from switches **193** and **194** are coupled into the amplifiers **195** and **197**. Each is coupled through an input resistor **305**, typically 2.2K, with a resistor **307** provided to the ground, typically 100K. Each amplifier has negative feedback from its output to its inverting input through a feedback resistor **309**, typically 10K, with a resistor to ground from the inverting input, typically 100K. Potentiometers **199** and **201** are typically 10K pots with an additional resistor **313** at the end of each coupling it to ground. These additional resistors have a low value, for example, of 390 ohms. The output amplifier **207** also has an input resistor **305**, typically 2.2K, with a resistor **315** to ground, typically 200K. It has a feedback resistor **316**, typically 2.2K. The output is coupled through a resistor **318**, typically 10 ohms.

The junction between diodes **319** and **321** is coupled to +15 volts from a separate power supply **323** which includes a regulator **325**, typically a 78L15 with capacitors **327** and **329** on each side in conventional fashion. This regulates the unregulated 18 volts to +15 volts. Similarly, a regulator **331** in a power supply **335** regulates 8 volts to +5 volts. Again capacitors **337** and **339** are provided. Amplifiers **195** and **197** which may be a dual operational amplifier pack are supplied from the regulated +15 voltage, i.e. they operate across +15 volts and ground. Similarly, the amplifier **207** is coupled across the regulated 15 volt supply and ground.

The input to the amplifier **207** from amplifiers **195** and **197**, is through diodes **203** and **205**. These inputs are coupled through a switch **341** designated a channel-kill switch. Channel-kill switch has another pole coupled through an LED **343** to the collector of a transistor **345** with an emitter resistor **347** to ground and a base resistor **349** which is coupled through diodes **351** and **353** to the outputs of the potentiometers **199** and **201** respectively. The movable contact of a second pole **341***a* of switch **341** is coupled to the 18 volt supply and thus provides power to the LED **343** which will be turned on so long as the channel-kill switch is not in the kill position and there is some output from one of the two scenes to turn on transistor **345**. When switch **341***a* is in the kill position, the 18 volts is supplied through a resistor **355** to another LED **357** to indicate that position. LED **357** will also be lit if a switch **359** having its movable contact coupled to +18 volts is in a position indicating an auxiliary kill condition. The function of the auxiliary kill switch will be described in more detail below.

Which of the switches of the analog switch modules **301** and **303** are operated is determined by latch circuits **501** and **503**. These latch circuits receive inputs from data bus **143**. Each has three inputs labelled a, b, c. Similarly, there are outputs a, b and c coupled back respectively to the analog switch modules **301** and **303**. Each of the latches **501** and **503** also has a clock input coupled respectively to an assign I switch **505** and an assign II switch **507**. Pressing the assign I or assign II switches will cause the latch to set with whatever data is on the data bus **143** and continue supplying that data to the analog switches **301** or **303** until a change is made.

The outputs on lines a, b and c of each of the two latches **501** and **503** are also coupled through buffer amplifiers **509** to a field programmable logic array **511** which provides a plurality of seven-segment outputs utilized to drive LED displays **189** and **191**. Only a single seven-segment output bus **513** coupled through resistors, typically 180 ohms, to the seven-segment displays is provided. The common input to each of the displays is supplied by a transistor, display **189** being supplied from transistor **515** and display **191** from transistor **516**. Transistors **515** and **516** have their emitters coupled to the +5 volt supply. Each has a diode **517** between its base and emitter. The base of transistor **515** is coupled through a resistor **518** typically 7.5K to the Q input of a D-type flip-flop. Similarly, the base input of transistor **516** is coupled through an input resistor **519** to the $\overline{Q}$ output of D-type flip-flop **521**. The D input of flip-flop **521** is coupled to its $\overline{Q}$ output and its clock input is coupled to an oscillator **523** comprising an amplifier **525** with a capacitor **527** coupled to its input terminal and a feedback resistor **529**. The RC time constant of the capacitor **527** and resistor **529** which are respectively 0.05 microfarad and 100K ohms establish the frequency of oscillation. This frequency is chosen high enough so that the flicker in the displays **189** and **191** will not be perceptible to the eye. Thus, the output of the latches, in addition to being provided to the switches **301** and **303**, is displayed on displays **189** and **191**.

The logic array **511** has additional inputs. The Q output of flip-flop **521** is coupled through a buffer amplifier or inverter **531** to an input of the logic. This is necessary in order that as the two displays are switched by the transistors **515** and **516**, the proper seven-segment data for the selected display is being provided at the output. In addition, there are three inputs each through a resistor **533** which carry out various control functions. These inputs are respectively what is called "meter enable" input on line **535**, a "show" input on line **537** and a "blink" input on line **539**. A clock signal for example at 1 Hz is provided on this input, line **539**. In addition, the second pole of the individual switches **193** and **194** indicated respectively as **193***a* and **194***a* which couple 5 volts into the logic array **511** are also provided. Thus, when "independent" is selected an indication of this is provided as an input to the custom logic array.

An additional latch **541** is provided for storing and displaying additional data. For example, the data bus can be encoded to indicate a signal level which can be latched into latch **541** in response to a signal on line **543** from an inverter **545**, the inverter being driven by input called "select" on line **547**. This input is the output of the address decoder **213**. When the "meter enable" signal is provided on line **535**, rather than displaying the selected information, the value stored in the latch **541** will be provided.

In addition to the scene I and scene II controls, the embodiment of FIG. **2** also permits control by an auxiliary input on line **551**, there being parallel inputs to each unit, a serial or addressed auxiliary input similar to what was shown on line **169** of FIG. **1B**, and similarly a scene III parallel inputs on line **555** and a scene III serial input on line **169**. In addition, there is the attenuation control input on line **157**.

The auxiliary input on line **551** is coupled through an input resistor **557**, typically a 1K resistor, and through a diode **559** and resistor **561**, typically 15K, to the base of the transistor **563** having a resistor coupling its emitter to ground. Coupled in its collector path is an LED **567** having its anode coupled to the auxiliary kill switch **359**. If the auxiliary kill switch is not in the kill position, and if there is a signal through diode **559**, LED **567** will light. Similarly, the signal on line **555** is coupled through an input resistor **569**, typically 1K, and a diode **571** and resistor **573** to the base of the transistor **575** similarly having a resistor, typically 1K, **577** coupling its emitter to ground with an LED **579** in its collector path also coupled to the auxiliary kill switch **359**. Thus, if there is a signal on line **555**, and if the auxiliary kill switch is not in the kill position, this LED will light. The signals on line **551** is also coupled through a diode **581** and another pole **359*a*** of the auxiliary kill switch to the input resistor **305** of the output amplifier **207**. Similarly, the input on line **555** is coupled through diode **583** and a switch **585** to auxiliary kill switch **359**, thence to the output amplifier. Switch **585** is controlled by the signal line **157** through an input resistor **587** typically 10K. Switch **585** is an analog switch and is used for pulse width modulation of the incoming signal thereby attenuating the signal in the manner disclosed in the aforementioned U.S. Pat. No. 3,946,273.

When signals are provided on line **555** and **551** from a memory board or the like, a separate line is required for each channel. However it is also desirable to provide different levels to different channels on a single line. This is accomplished by means of sample and hold circuits **601** and **603** respectively, each sample and hold circuit includes an amplifier **605** having a negative feedback resistor **607** and an input resistor **609** with a capacitor **611** to grcund at the input to the input resistor **609**. Each also includes an analog switch as its sample switch. Thus, there is shown a switch **613** for the sample and hold **601** and a switch **615** for the sample and hold **603**. Switch **613** is coupled to line **553** through an input resistor **617**, typically a 1K resistor. Similarly, switch **615** is coupled to line **69** through an input resistor **619**, also typically 1K. the control input for the analog switches **613** and **615** is provided from the output of the address decoder **213** through an input resistor **621**, typically 10K. With a signal on line **553** or line **163**, when the address of the particular channel is detected by its address decoder, an output on line **547** occurs, closing the switches **613** and **615** and causing them to sample whatever is on line **553** and/or line **169**. The switch then opens and that value remains stored. The outputs of the sample and hold circuits **601** and **603** are coupled in the same manner as the signals on lines **551** and **553**. Thus, associated with the auxiliary sample and hold circuit **601** is a diode **559*a*** coupling into the auxiliary LED indicator and a diode **581*a*** coupling through the auxiliary kill switch **359*a*** to the output. Similarly, diode **583*a*** couples into the modulating switch **585** and diode **571*a*** couples into the modulating switch **585** and diode **571*a*** couples into the transistor **575** controlling LED **579**.

The select output on line **547** is also coupled through a pair of inverters **621** and **622**, a switch **623** having auxiliary contact **623*a*** and a diode **625** to what is called the "user defined output" on line **627**. This is a common bus shared by all channels and permits providing feedback information through the closure of switch **623**. The auxiliary contact **623*a*** is coupled to 18 volts and when closed couples the 18 volts through a resistor **629**, typically 15K, to light an LED **631** indicating that it is closed.

Although the present embodiment is for a hardware device, it should be clear that many of the functions can also be performed with microprocessor. The present embodiment is also shown with level information distributed in serial analog form, although it will be clear that with the appropriate components, this information could be accepted, processed, and produced in digital form. Further, while the present embodiment shows the mode selected for a channel potentiometer stored at the module; it is clear that the mode selection could be recorded on a data carrier at a central location by either sampling the outputs of the channel latches or by deriving notice of assign switch closure by a method similar to the "user defined switch" **623** to create a duplicate record. This data carrier would allow the operator to recreate the control assignments for a given production by reading back the carrier into the console. Finally, it will be apparent that, when manufacturing volume permits, it will be desirable to replace the current, separate assign switches **505** and **507** with a mechanical, pressure, or capacitive switch integral with the window covering the displays in order to reduce panel area requirements and further improve operability.

Associated with each channel is what is called a flash or bump button **701**. This is a switch capable of coupling either +15 volts or ground through an inverter **703** having a resistor **705**, typically 10K, at its input with a capacitor **707**, typically 0.01 F to ground. The output of the inverter **703** is the clock input to a D-type flip-flop **711**. The $\overline{Q}$ output of flip-flop **711** is tied back to its D input. This means that absent any other signals, as it is clocked, it will change state at the clock rate. The Q output is coupled through a diode **713** to the junction of a resistor **715** and a base resistor **717** for a Darlington pair **719**. Resistor **715** has its other end tied to ground. Typically resistor **715** is 100K and resistor **717** is 15K. Resistor **717** couples the output of the flip-flop **711** into Darlington pair **719** which drives an incandescent lamp **721** coupled to +24 volts, a current limiting resistor **723** also being provided in the path. The output at D-type flip-flop **711** is also an input to an analog switch **725**, the output of which is coupled through diodes **727** and **729** to the transistor **345** for the channel LED and the channel kill switch **341** respectively. In addition, through diode **737**, switch **701** directly drives switch **725** and Darlington pair **719**. Switch **725** receives an input through an input resistor **731** from an input on line **733** designated the flash input. The flash input is a level to which the channel will be brought when the bump button is pressed to cause the circuit comprising inverter 703, resistor 705 and capacitor 707 to provide a debounced input to flip-flop 711 and directly to switch 725. The channel output will then receive a signal at the level of the flash input 733. Three possible modes of operation are possible. These are "kill"; "momentary" and "alternate." By pressing switch on and off with flip-flop 711 held reset by a signal on an input line 739 B through resistor 741, typically 10K, with a resistor 743, typically 100K, to ground, flashing is accomplished at the rate at which the switch is operated. In addition, there is a kill bus which is coupled through a diode 735 to the output of the inverter 703. This output can be used in the master section to "kill" all other channels but the one whose switch 701 is pressed, for example. When a reset signal is not present on line 739, alternate operation takes place. Each time switch 701 is pressed, flip-flop 711 changes state.

FIG. 3 is a plan view helpful in conjunction with FIG. 2 in understanding operation of the system. Shown are a plurality of strip modules 17, each containing all the circuits shown in FIG. 2. This modular construction adds flexibility to the system, permitting construction of the system with as many or as few channels as is desired. As illustrated by FIG. 3A, each module 17 has a board 900 with an edge connector 902. This plugs into a connector on a board 903 which is coupled to the master control and supplies all the signals shown as inputs to FIG. 2. The various controls discussed in connection with FIG. 2 are shown in FIG. 3. Thus, the preset potentiometers 199 and 201 which are typically sliding potentiometers for presetting scene I and scene II for the particular channel are shown. Also shown are the LED displays 189 and 191. The flash button, also referred to as the "bump" button, or switch 701 of FIG. 2 is also shown. The independent switches 193 and 194 are shown located directly below their respective seven-segment LED displays 189 and 191.

LED 579 indicating that a scene III input is present is visible at the top of the figure. LED 343 indicating a channel signal is present is located next to the channel kill switch 341. Similarly, the auxiliary LED 567 is located next to the auxiliary kill switch 359. The kill LED 357 is located between the two.

Also shown in FIG. 3 are some of the master controls. Shown are potentiometer controls 801 and 803 for controlling the voltage supplied respectively to the bump buttons 701, more particularly their lamps 721 seen in FIG. 3, and supplied to the various displays to control their brightness. Also shown are a series of push button switches corresponding generally to the switches 137, 139 and 141 of FIG. 1A. These switches include a direct switch 805, submaster A 807, submaster B 809, submaster C 811, and an off switch 813. These switches are electronically interlocked. The one of the switches selected is indicated on an LED display 815 and a corresponding output is provided on bus 143. In addition, there is a "show me" switch 817. This provides the output on line 537 of FIG. 2. There is a "show me level" switch 820 which corresponds to the meter enable line 535 of FIG. 2. There is a "show me independent" switch which also provides an output on 537 and also puts on bus 143 the address corresponding to independent. Finally, there are a pair of controls 823 and 825 which permit providing the various inputs flash, kill, and flash RS-modes on lines 733, 734 and 739 of FIG. 2 to control operation of the bump button 701.

In operation, when it is desired to set up the console, the operator presses one of the buttons 805, 807, 809 or 811. Pressing this button puts a corresponding output on the bus 143 which is provided to all of the three latches 501, 503 and 541 of FIG. 2. If a channel is to be assigned to that submaster, then the assign switch 505 or 507 for that channel is pressed storing that information in the associated latch and thereby controlling the analog switch. Once all the channels to be set up for direct are assigned by pressing their assign buttons 505 and/or 507, the next submaster is set in, for example A, and the process repeated for that, and then for B and C. At each of the channels, the potentiometers 199 and 201 are preset. The control assignment selected will appear on the respective display 189 or 191. When all selections have been made, one can press one of the buttons 805, 807, 809 and 811 and then press the "show me" button 817. This provides an input on the line 537 and causes the displays for all channels not assigned to the selected mode to go out. Those normally assigned to the selected mode but presently in independent will flash. Thus, if, as indicated on the LED display 815, submaster C is selected, all of the displays would go out except those which had selected C.

By throwing independent switch 193 or 194 it is possible to select independent rather than one of the submasters or the direct master control. Pushing the "show independent" will cause all of the channels except those assigned to independent to go out. Finally, pressing the "show me level" switch will cause the information latched in latch 541 to be displayed on the LED to show a level, for example, a level associated with scene III. Note that latch 541 is latched by a clock input from decoder 213. Thus, each channel can store separate level information in this latch.

Pushing one of the bump buttons 701 will cause the associated channel to be brought up immediately to the level set in on the flash bus 733. If there is no input on line 739, pressing the flash button will clock the flip-flop on causing it to latch and close the switch if the switch was off. It will, at the same time, feed this signal back through diode 735. The purpose of this, if "kill" is selected at the master section, is to kill all other channels.

Fault Isolation

As noted above, one of the important aspects of the system of the present invention is in the fault isolation which it provides. To understand the improvements in the fault isolation obtainable in accordance with the present invention, a typical prior art arrangement has been illustrated in FIG. 4. The illustrated embodiment is one in which there are two scenes with two master or submasters for each scene. However, in the simplest type of board, one would simply have a single scene master control, for example, master control 101. In the illustrated embodiment, this comprises a potentiometer 103, the output of which is amplified by an amplifier 105 receiving power from a power source 107. The output of amplifier 105 is placed on a bus 109 and feeds a set of potentiometers, one being provided for each channel, i.e. each light or group of lights. The simplest arrangement in the prior art consists of a potentiometer 111 coupled between this bus and ground the wiper of which provides an output on line 113 to a dimmer for that channel. The dimmer will be driven by the DC voltage produced at the master 101 attenuated by the setting of the channel potentiometer 111. Thus, the simplest type of system would consist of a master control **101** providing an output to a bus **109** with a plurality of potentiometers such as **111** providing outputs for the different channels.

However, in the illustrated embodiment, there is the possibility of an additional scene. Thus, there is also provided a potentiometer **103**_a_ providing its output to an amplifier **105**_a_, this constituting another master control **101**_a_. The output is provided to a bus **109**_a_. Bus **109**_a_ through a switch **115**_a_, to be described below, feeds a channel potentiometer **111**_a_ which has its other end connected to ground. In this case the wiper of the potentiometer provides an output line **113**_a_ which is coupled through a diode **117**_a_ to the final output on line **113**_c_. Similarly, coupled to line **109**_c_ is a potentiometer **111**_b_ providing its output on line **113**_b_ through a diode **117**_b_ to the final output **113**_c_. As indicated, the illustrated embodiment provides the possibility of two masters for each scene and thus there is also shown a master control **101**_b_ comprising potentiometer **103**_b_ and amplifier **105**_b_ associated with scene I, and another master **101**_c_ comprising potentiometer **103**_c_ and amplifier **105**_c_ associated with the scene II master. Switch **115**_a_ and a similar switch **115**_b_ permit selecting between one or the other of the scene I and scene II masters.

Also shown in FIG. **4** are additional controls for two more channels including switches **115**_c_, **115**_d_, **115**_e_ and **115**_f_, potentiometers **111**_c–f_, and diodes **117**_c–f_. Also shown associated with the output **113**_e_ of the last channel are special input electronics **121**. These combine special features having channel outputs through isolating diodes with the output of the two scene potentiometers. They can be the auxiliary or scene III inputs of FIG. **2**. The last two channels having outputs on lines **113**_d_ and **113**_e_ are shown as having buffer amplifiers **123**_d_ and **123**_e_ associated therewith and each is shown as driving plurality of dimmers.

In the illustrated embodiment all of the amplifiers **105** and **105**_a–c_ and amplifiers **123**_d_ and **123**_e_ are fed from the same power supply **107**. An examination of FIG. **4** should make it clear that the loss of one of the amplifiers **105**_a–c_ will result in the complete loss of that function to all channels. However, there are many kinds of faults, particularly short circuits in the channel level wiring attached to the buses **109** and **109**_a–c_ which can alter the load characteristics of the bus causing the amplifier to either temporarily disable due to current limiting or become permanently damaged. This can either result from faults in the switches **115**_a_–**115**_f_ in the potentiometers **111**_a–f_, or wiring after the potentiometer when it is set at a high enough level to make the fault visible enough to the bus. Thus, there are shown on the drawing a number of black dots. Short circuits at these points can disable large parts of the console. These include a short at the output of the switch as shown by switch **115**_a_, on the line leading to the switch as shown in connection with switch **115**_b_, in the switch contact as shown by potentiometer **111**_d_, which is set so high that there is very little resistance between the wiper and the amplifiers. Also, at the output of diode **117**_f_ the potentiometer of **111**_f_ of which is also at a high level a short can cause the massive failure. Also shown in connection with line **113**_c_ are two more black dots indicating that at either side of the connector leading to the dimmer a short circuit through diode **117**_b_ and potentiometer **111**_b_ can cause failure at the amplifier.

Other points on the diagram are shown by asterisks. These are essentially the amplifiers **105**, **105**_a–c_, **123**_d_ and **123**_e_. Failure of these parts can also disable or cause failure in other sections of the console. For example, they can cause the power supply to current limit, thus affecting not only their own channel but other channels as well.

Thus, the present state of the art consoles are subject to serious failures which may be difficult to troubleshoot.

FIG. **5** illustrates the manner in which the present invention minimizes the effect of the faults. In this drawing, parts which are the same as those in FIG. **4** have been given the same reference numerals. In general, the present invention accomplishes fault isolation by means of three measures. The simplest of these is illustrated in connection with potentiometer **111**. In series with the potentiometer a resistor **131** is provided Now, even with the potentiometer at its highest position, a short at line **113** will not result in a failure at amplifier **105**. The value of resistor **131** must be very much lower than the impedance of the channel potentiometer. The master amplifier **105** must be capable of delivering a current which equals the normal operating current of the channel control times the number of channels plus allowance for the current draw of a faulted channel as limited by the resistor **131**, times a number of channels to take into account plural faults. A failure occurring for example on the line **113** can be easily isolated and will be localized.

This same scheme is shown in connection with the potentiometers **111**_a_ and **111**_b_ in which case separate resistors **131**_a_ and _b_ and **131**_c_ and _d_ are provided. Because of this isolation, only if a fault actually occurs at the bus itself or on the side of the resistor connected to the bus will the failure propagate back to the master amplifier.

Although this arrangement can be used in many cases, the arrangement illustrated with the potentiometers **111**_c_ or **111**_e_ is preferred. In this case, buffer amplifiers **133**_a_ through **133**_d_ are provided. Buffer amplifiers **133**_a_ and _b_ are connected directly to the buses **109**_b_ and **109**_a_. The amplifiers **133**_c_ and **133**_d_ are connected through resistors **131**_e_ and **131**_f_. The amplifiers provide additional isolation and furthermore relieve the power requirements on the master amplifier. The master amplifier need no longer drive all of the channel potentiometers. As a result a smaller, simpler, and less expensive and more reliable master amplifier can be used decreasing the chance of failure. Furthermore, added flexibility is provided with this design in that channels can be added afterwards since the master amplifier will still be capable of supplying additional channels each of which will have a high impedance amplifier at their input. In this arrangement, the power supply bus. The arrangement associated with potentiometers **111**_d_ and **111**_f_ avoids this. In these embodiments, the inputs to the switches **115**_d_ and **115**_f_ are coupled through resistors **131**_g_ through **131**_j_. The outputs of the switches **113**_d_ and **113**_f_ are inputs to amplifiers **133**_e_ and **133**_f_ respectively. In this embodiment, the amplifiers rather than being supplied directly from the power supply bus are supplied from an isolated power supply bus **137** which in turn is supplied by a current limited supply **139**. This may be simply a solid state voltage regulator with appropriate filtering capacitors. Now, a failure of amplifiers **133**_e_ and **133**_f_ will only affect their channel and will not propagate back to the power supply bus to affect the whole console. In FIG. **5**, the same convention with respect to massive failures is indicated by a black dot and failure in amplifiers which may spread is indicated by an asterisk. A local failure in amplifier which will not spread is indicated by an open square, and a local failure otherwise by an open circle. With the last embodiment illustrated, it is apparent that the only failures which will be of a massive nature are those which occur on the buses. Any failures past the resistors **131**_g_ and _h_ for example will be local in nature. Thus, in summary, the present invention takes three steps, alone or in combination, to achieve fault isolation. The first step is to provide isolating current limiting resistors such as resistor **31**. The second step is to provide buffer amplifiers either alone or in addition to such resistors. The third step is to supply the buffer amplifers in a given channel from a separate current limited supply.

The channel illustrated in FIG. **2** incorporates all of these features. It has separate supplies for supplying both 5 and 15 volts, includes buffer amplifiers at the output of the master selector, these amplifiers having input resistors which assure further current limiting back to the master. In addition, it is noted that the unit illustrated by FIG. **2** is not only electrically but mechanically isolated, in the design of the present invention, which, of course, adds to the flexibility of the present system in providing from basic building blocks as many channels as are needed for a particular application.

With respect to separate current limited supplies and the other techniques just noted, although illustrated for a single channel, for reasons of economy these measures can be taken for groups of channels. Of course, the isolation will not be as good but it will still be superior to that provided in the present day state of the art equipment.

Encoding and Decoding

FIG. **6** shows a portion of the sample and hold circuit **603** of FIG. **2** and shows how, utilizing a precision half wave rectifier **803** one can, in addition to decoding, encode and output back to the memory board, for example. The encoder follows the switch **211** shown in FIG. **1**B. Upon an input from address decoder **213** through resistor **621**, switch **211** is closed. Whatever voltage is present at the input to the output amplifier **207** is also provided as an input to the encoding circuit which includes an amplifier **805** having in its output coupled through a positively poled diode **807**, the output of which is coupled through a feedback resistor **811** to the inverting input of the amplifier. The non-inverting input of the amplifier which receives the input through the switch is coupled to ground through a resistor **813**. This is a circuit well known for use, a precision halfwave rectifier. It is used here because it combines the effects of diode isolation with the current capability of a buffer. The output of this circuit on line **159** is fed to a bus shared by all channels. Although in this embodiment, both the decoding and encoding are enabled by the same output of the address decoder, it will be recognized that separate decoding and encoding enable pulses could be developed to separately drive switches **211** and **615**.

FIG. **7** shows an example of a local address decoder. Inputs on bus **161** are coupled through fault isolating resistors to a binary decoder **815**. This decoder which may simply comprise a series of gates receives inputs from a set of switches **817** which permit setting each of the inputs to either a "0" or a "1" indicated by inputs **819** and **820**. When the address on the bus **116** matches that set in on the switches **817**, there is coincidence and an output is developed on line **821**. This is one input to an AND gate **823** which receives a clock input on line **825**. The output of gate **823**, **827** controls the switches **613** and **615** of FIG. **2** for example.

Another embodiment is shown by FIG. **8**. In this device only two inputs are required, i.e., the bus **161** need only have two lines. Line B contains a start signal and line A a clock signal. These are inputs through input resistors to a clock and start input of a programmable delay unit. Programmable delay unit **831** has set into it, through a series of switches **833** which can be set to either a 1 input **835** or a 0 input **837**, a desired delay. After receipt of the start pulse, the programmable delay unit counts a number of clock pulses specified by the programming inputs f-l through f-n set in by switches **833**. When the number of clock periods counted equals the number set in the programming input, an output will appear on line **827**. It remains in this state for no more than one clock period. The unit then remains inactive until another start pulse is received. The output on line **827** however will close the switches associated with the sample and hold circuits **601** and **603** long enough to carry out the necessary sampling. Traces E, F and G illustrate the outputs for three successive channels. The first output occurs after counting one clock pulse past the start signal. The output begins on the falling edge of the clock period and ends on the rising edge. Thus, there is a gap of the length of the clock pulse between that of one channel and the output for the next channel to allow data on the serial information bus to stabilize. These outputs are, of course, each generated by separate local pulse generators which form the decoder **213** of FIG. **1**B and FIG. **2**.

FIG. **8**A shows the local pulse generator **831** in more detail. The logic "1" signal is provided by a positive voltage and the logic "0" signal **837** by ground. The inputs of switches **833** are provided as inputs to an up-down counter **840** set to countdown. The B signal is provided as a preset enable signal to the counter presetting it to the value set in on the switches. The clock signal on line A is coupled through an AND gate **842** into the clock input. Gate **842** is enabled by a D-type flip-flop **844**. The start signal, in addition to presetting the counter **840** and enabling it, sets the flip-flop **844** so that its Q output becomes a "1" enabling AND gate **842**. At this time, the output CO (zero count) is a logic "1" at the inverted output. The next clock pulse will be passed by AND gate **842** and counted in the counter **840**. Counting continues until the value set in by switches **833** is counted down to zero. The output CO on the counter will then change state. When the clock pulse goes low, AND gate **846** will, after inversion at its input, have two logic "1" inputs and provide a logic "1" output. On the next clock pulse the count is counted down to all "1s" causing CO to change state and clock the D-type flip-flop. This will cause the "0" on its D input to be transferred to its output. This prevents any further counting by disabling gate **840**. At this time the output of gate **846** also goes to logic "0" again. Thus, through this gating there is no overlap between two subsequent pulses.

Finally, with respect to the attenuation of the scene III signal, it is noted that in addition to the pulse width modulation discussed and described in the aforementioned patent, this attenuation can be done with a voltage controlled amplifier or with a digital attenuator, in which case the signal, rather than being on a single line **157**, would be obtained from the data bus **143**.

What is claimed is:

1. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes; and

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second scene preset potentiometer, said channel controls and said master controls cooperating to allow presetting;

(c) a buss;

(d) one of said preset potentiometers for each of a plurality of channels connected to said buss;

(e) means for driving said buss, said means for driving having an input coupled to one of said master controls, the improvement comprising:

(f) a plurality of nondestructively current-limiting fault isolating means for each scene, each connected between said master, and at least one of said preset potentiometers for said scene whereby the effects of a fault causing abnormal currents to flow which develops after said fault isolating means will not disrupt the operation of channel potentiometers connected to other fault isolating means.

2. The improvement according to claim **1** wherein said fault isolating means comprise resistors.

3. The improvement according to claim **1** wherein said fault isolating means comprise amplifiers, said amplifiers having non-destructively current-limited outputs, and having stable input characteristics.

4. The improvement according to claim **3**, and further including resistors coupling the inputs of said fault-isolating amplifiers to said buss, the value of said resistor providing fault isolation, whereby a failure of the fault isolating amplifier will not disrupt the operation of the channels connected to other fault isolating means.

5. The improvement according to claim **3** or claim **4** wherein a power supply distribution buss is provided for supplying power to said fault isolating amplifiers and further including a plurality of current limiting means each connected between the power supply distribution buss and at least one of said fault isolating amplifiers.

6. The improvement according to claim **5**, and further including additional active electronic components associated with at least one channel, said active electronic components also supplied by said current limiting means.

7. The improvement according to claim **1**, **2**, **3**, or **4** the improvement further comprising at least one of said fault isolating means and its associated preset potentiometer combined on a common mechanical module.

8. The improvement according to claim **1**, wherein a common mechanical module contains all preset potentiometers for a single channel.

9. The improvement according to claim **1**, and further including at least one additional signal source producing discrete channel outputs, the output of said first and second potentiometers being combined with said discrete channel output at a combining point, and a further fault-isolating means located between said discrete output of said additional signal source and said combining point.

10. The improvement according to claim **9**, wherein said further fault isolating means comprises a resistor.

11. The improvement according to claim **9**, wherein said further fault isolating means comprises an amplifier, said amplifier having a non-destructively current-limited output and having stable input characteristics whereby the operation of other channels is not disrupted.

12. The improvement according to claim **11**, and further including a resistor coupling the input of said fault-isolating amplifier to said discrete output, the value of said resistor providing fault isolation whereby the failure of the fault isolating amplifier will not disrupt the operation of other channels.

13. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes; and

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second preset potentiometer, said channel controls and said master controls cooperating to allow presetting; and,

(c) at least one port for communications with an external control means at another location, said port including at least one active electronic component;

(d) at least one positive power supply producing a voltage within the safe operating region of said active electronic component, and means establishing a more negative reference potential within the safe operating region of said active component, the improvement comprising:

(e) means for protecting said active electronic component against damage caused by relative voltage swings greater than said safe operating region comprising:

(f) a first diode coupled between said port and a low impedance path to said positive power supply:

(g) a second diode coupled between said port and a low impedance path to said reference; and

(h) means for current limiting coupled between said diodes and said port, whereby a more positive or more negative voltage imposed on said port will be limited to within the safe operating region of said connected active component.

14. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes; and

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second preset potentiometer each assignable to be responsive to any one of a plurality of said master controls, said channel controls and said master controls cooperating to allow presetting, the improvement comprising:

(c) a plurality of electrically-alterable display devices, each associated with one of said plurality of channels, located in proximity to said first and second preset potentiometers, capable of displaying alpha or numeric symbols within a common display area indicative of the assignment of at least one of said first and second preset potentiometers;

(d) means for storing the master assignment of each of said channel potentiometers;

(e) means for driving said display device coupled to said means for storing.

15. The improvement according to claim **14**, wherein said electronic display device comprises a segmented display.

16. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes; and

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second preset potentiometer each assignable to be responsive to any one of a plurality of said master controls, said channel controls and said master controls cooperating to allow presetting;

(c) master selector means for selecting a master assignment;

(d) assignment switches for each of a plurality of preset potentiometers located in proximity to said preset potentiometers for specifying the potentiometers to be assigned to said master selection; and

(e) means for storing selected master assignments for said potentiometers coupled to said means for selecting and said means for specifying; the improvement comprising:

(f) a plurality of electrically-alterable display devices each associated with one of said plurality of channels, located in proximity to said potentiometers, capable of displaying alpha or numeric symbols within a common display area indicative of the assignment of at least one of said potentiometers; and

(g) means for driving said displays to indicate said selected assignments.

17. The improvement according to claim **16** and further including a precedent assignment to which at least one of said channel potentiometers may be switched, and further including means for switching to said precedent assignment, and means for indicating said precedent assignment on said display.

18. The improvement according to claim **17** and further including means for storing the master assignment selection during the operation of said means for switching, whereby when said precedent condition is deselected, said potentiometer will be returned to said previous assignment.

19. The improvement according to claim **16** and further including means to extinguish said electronic displays of all potentiometers except those assigned to a specified assignment.

20. The improvement according to claim **14** or claim **16**, wherein said electrically-alterable displays are also capable of displaying other numeric data.

21. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes;

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second preset potentiometer, said channel controls and said master controls cooperating to allow presetting;

(c) a plurality of means for producing an output, each associated with one of said plurality of channels, said means for producing an output located in proximity to said channel controls;

(d) means for selectively coupling associated with each of said means for producing an output;

(e) at least one conductor coupled to the output of each of a plurality of said means for selectively coupling;

(f) at least one device at a remote location having at least one serial input coupled to said conductor;

(g) means providing sequential outputs to operate said plurality of means to selectively couple, whereby the output of a plurality of said means for producing may be detected in a sequence at said input of said remote device, the improvement comprising:

(h) said means for selectively coupling distributed to a plurality of locations within the console, each such location in substantially similar proximity to its associated means for producing an output, such that said conductor connecting said means for selectively coupling with said remote device forms an elongated serial buss.

22. The improvement according to claim **21**, wherein said means for producing an output comprise the combined outputs of at least the first and second channel potentiometers.

23. The improvement according to claim **21**, wherein said means for producing an output comprises a switch.

24. The improvement according to claim **21**, wherein said means for producing an output comprises a device maintaining a digitally-encoded value.

25. The improvement according to claim **21**, and further including a fault isolating means connected between said elongated serial buss and at least one of said means for selectively coupling whereby the effects of faults causing the output of said means for selectively coupling to be connected by a low-impedance path to ground, or to a more negative voltage do not disrupt the operation of said buss as it relates to means for selectively coupling connected to other fault isolating means.

26. The improvement according to claim **25**, wherein said fault isolating means comprises a diode.

27. The improvement according to claim **25**, wherein said fault isolating means comprises a precision half-wave rectifier.

28. The improvement according to claim **25**, wherein said means for producing an output and said means for selectively coupling occupy a common mechanical module.

29. The improvement according to claim **28**, wherein a separate mechanical module is provided for each channel.

30. In a lighting console providing outputs to dimming means, said console including:

(a) master controls for at least two scenes; and

(b) channel controls for each of a plurality of channels, said channel controls including at least a first and second preset potentiometer, said channel controls and said master controls cooperating to allow presetting;

(c) at least one device at a remote location producing at least one serial output;

(d) a serial buss comprising at least one conductor coupled to said output of said remote device;

(e) a plurality of means for storing an input signal for each one of a plurality of channels, each coupled to said buss;

(f) a plurality of means responsive to an output each one of a plurality of channels, each coupled to said means for storing;

(g) means providing outputs to sequentially operate said means for storing to sequentially sample said serial buss, the improvement comprising:

(h) said means for storing distributed to a plurality of locations within the console, each such location in substantially similar proximity to said means responsive to an output, such that the conductor connecting said means for storing with said remote device forms an elongated serial buss.

31. The improvement according to claim **30**, wherein the output of said means for storing is combined with the outputs of at least said first and second preset potentiometers.

32. The improvement according to claim 30, wherein said means responsive to an output comprises an indicator.

33. The improvement according to claim 30, wherein said means responsive to an output comprises a device accepting a digitally-encoded value.

34. The improvement according to claim 33, said channel controls further including a numeric display, wherein said means responsive to an output drives said numeric display.

35. The improvement according to claim 30, and further including a fault isolating means connected between said elongated serial buss and said means for storing of at least one channel whereby the effects of a fault developed after said fault isolating means will not disrupt the operation of channels connected to other fault isolating means.

36. The improvement according to claim 35, wherein said fault isolating means comprises a resistor.

37. The improvement according to claim 36, and further including an amplifier, wherein the value of said resistor is selected such that the failure of said amplifier will not disrupt the operation of the serial buss as it relates to the means for storing of channels connected to other fault isolating means.

38. The improvement according to claim 35, wherein said means responsive to an output and said means for storing occupy a common mechanical module.

39. The improvement according to claim 38, wherein a separate mechanical module is provided for each channel.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,550,276

DATED : October 29, 1985

INVENTOR(S) : Michael Callahan and Robert M. Goddard

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

Column 11, line 9, after "739", delete "B".

Column 15, line 11, change "31" to --131--.

Column 20, line 53, after "output", insert --for--.

Signed and Sealed this

Eleventh Day of November, 1986

Attest:

DONALD J. QUIGG

Attesting Officer *Commissioner of Patents and Trademarks*