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[54] **AUTOMATIC AUDIO-VISUAL PROGRAM CONTROL APPARATUS**

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[52] **U.S. Cl. 179/100.2 S,** 179/100.2 MD, 329/107, 332/9 T

[51] **Int. Cl.** **G03b 31/00,** H03k 7/08

[58] **Field of Search** ..... 179/100.2 S, 100.2 MD; 332/9 R, 9 T, 11; 329/107; 328/119; 307/305

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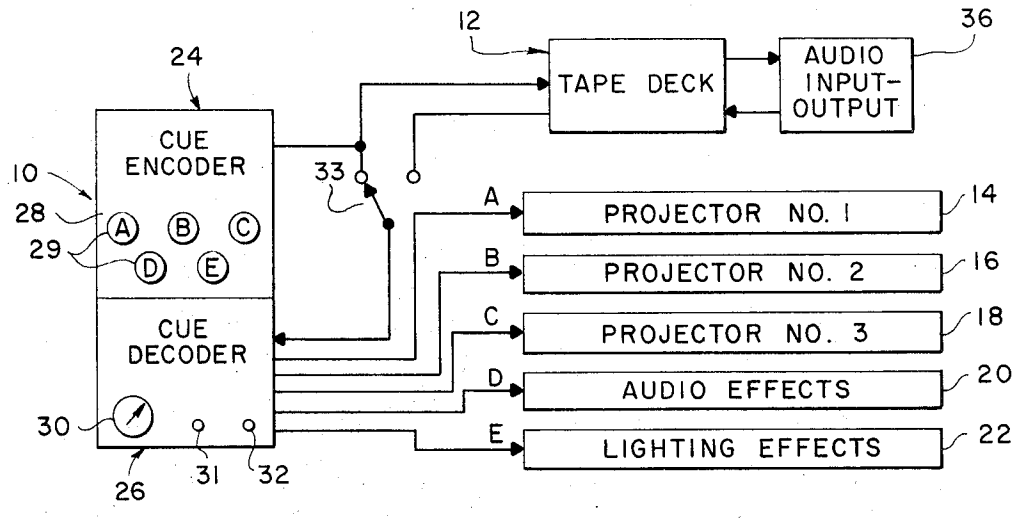
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[57] **ABSTRACT**

There is disclosed an audio-visual program control apparatus for use in multi-media presentation that employ various audio and visual display devices as auxiliary units. The control apparatus provides coded cue signals to a high fidelity tape recorder in a pulse position modulated mode. These recorded cue signals are thereafter played back and decoded for automatic simultaneous operation of a plurality of display devices that operate at predetermined times in step with an audio program recorded on the tape. The control apparatus eliminates the disruptive effects of (1) distortion of the multiplex signals inherent in the tape recorder, and (2) electronic noise generated by the controlled display devices or similar nearby apparatus.

21 Claims, 24 Drawing Figures



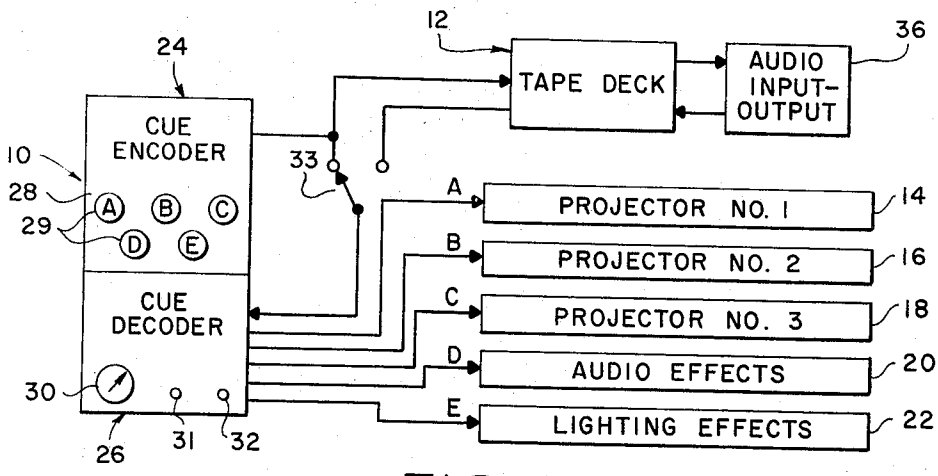


FIG. 1

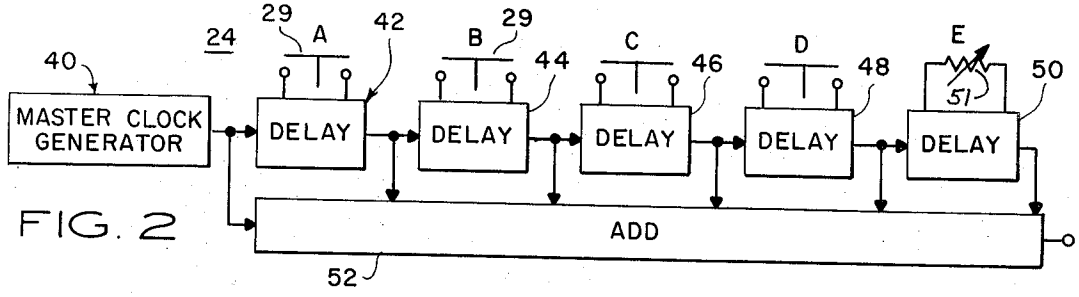
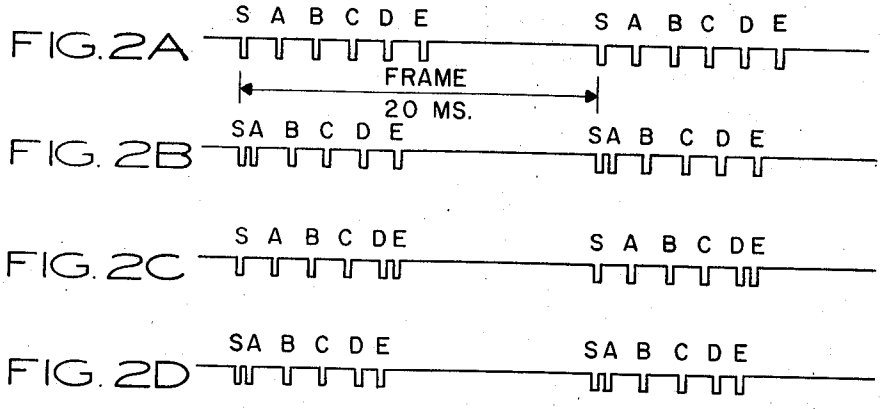


FIG. 2



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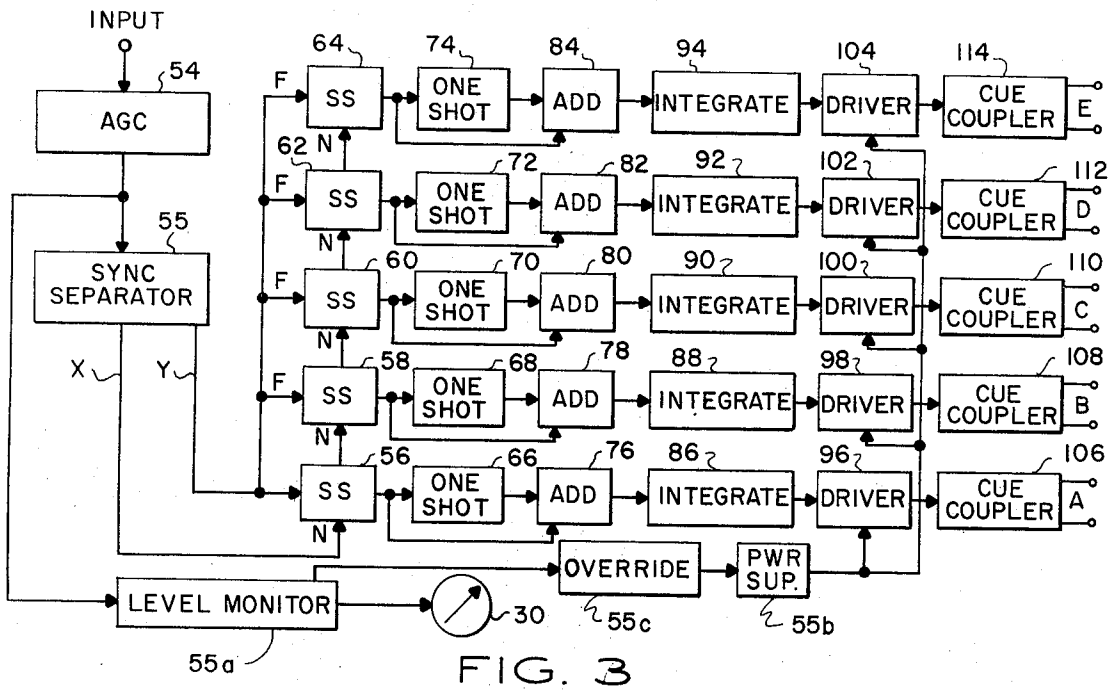
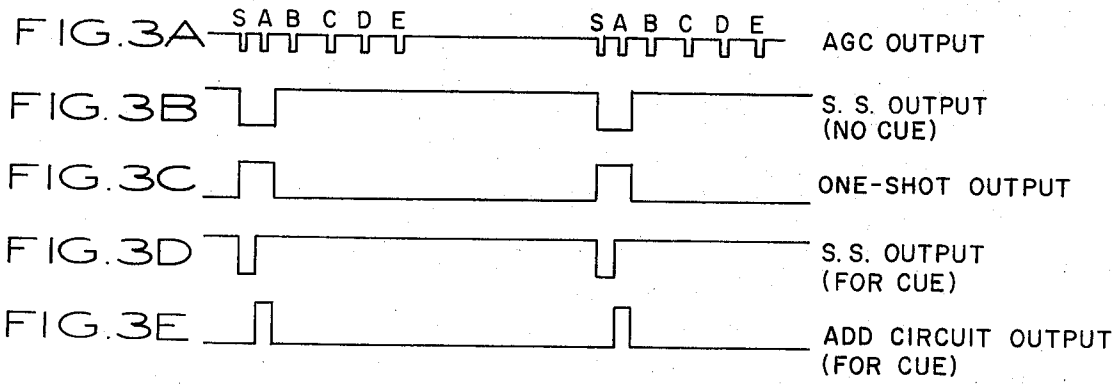


FIG. 3



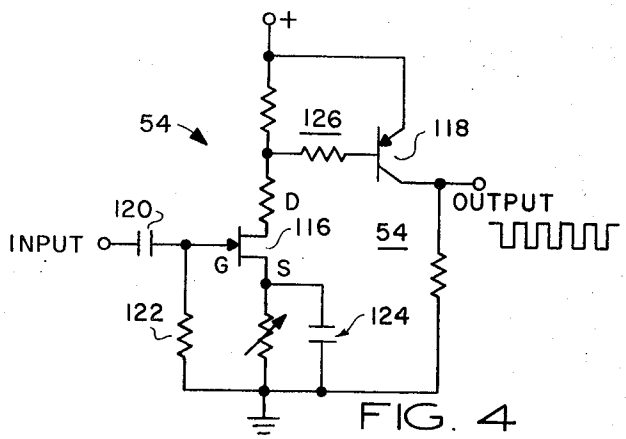


FIG. 4

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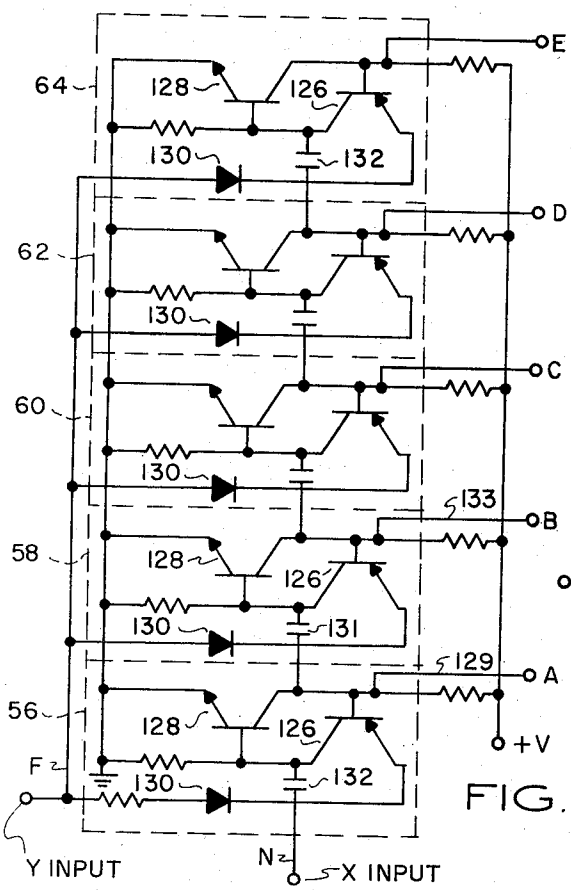


FIG. 5

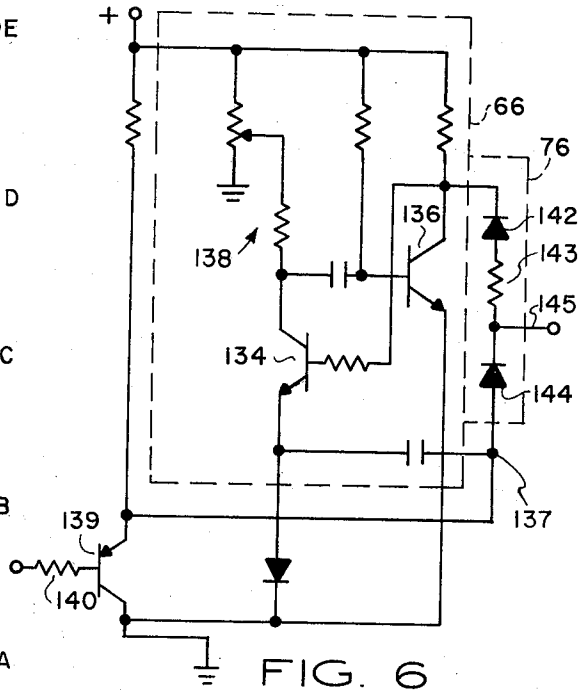


FIG. 6

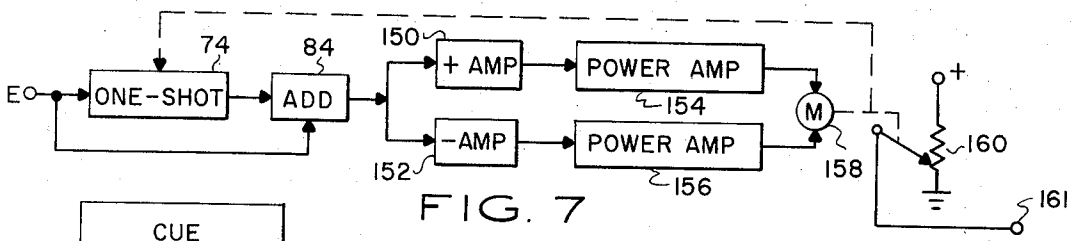


FIG. 7

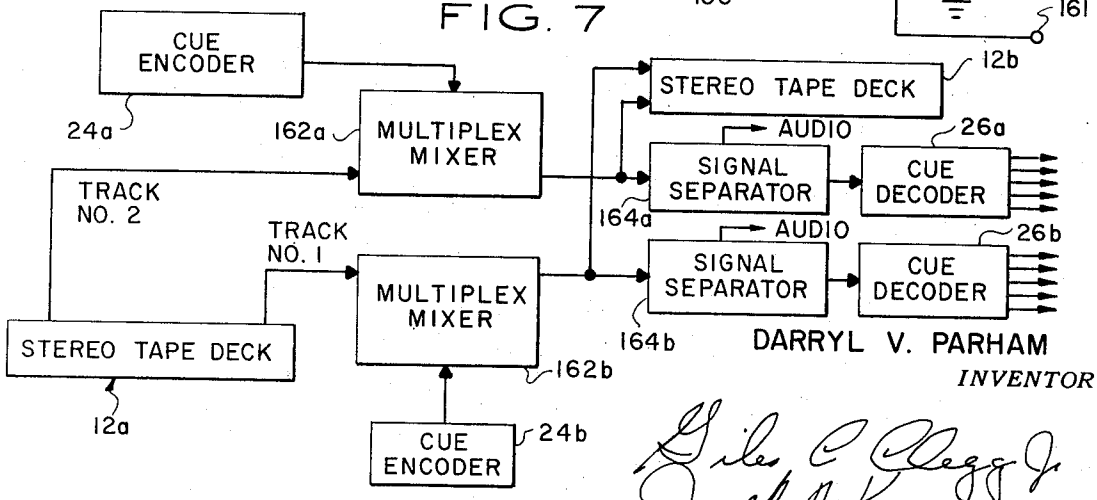


FIG. 8

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FIG. 9A

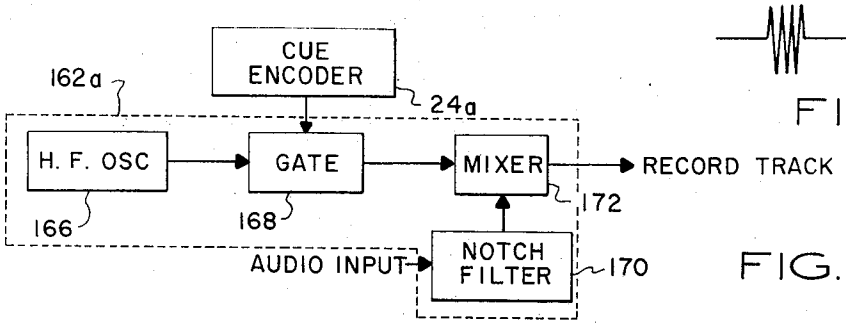


FIG. 9

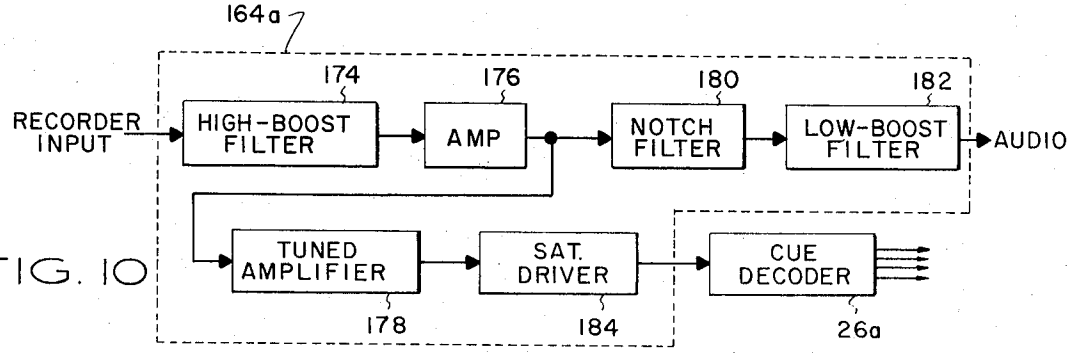


FIG. 10



FIG. 10A



FIG. 10B

FIG. 11

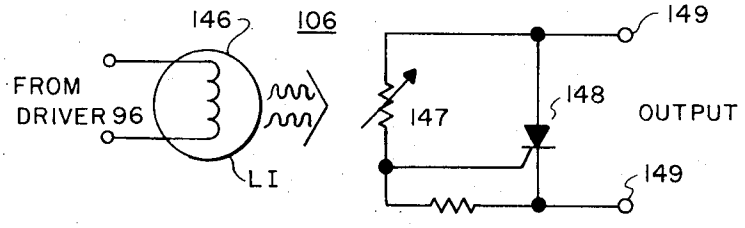


FIG. 6A

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AUTOMATIC AUDIO-VISUAL PROGRAM CONTROL APPARATUS

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to program control apparatus generally and more particularly to automatic audio-visual control apparatus for use in multi-media presentation.

In the presentation of educational lectures, fashion shows, art exhibits, theatrical performances or the like, it is extremely desirable to accompany the prerecorded audio portion of the presentation with various visual effects that operate at a predetermined time, such as, coordinated lighting, slides or movie presentations, or sound effects to go therewith and to accompany same. In the past, however, in presenting demonstrations of the sort, various mechanical methods were used to control one display device. Most of these involved mutilation of the tape itself, i.e., cutting notches, applying conductive coating, or punching holes, which then made the tape useless for any other recording and very difficult to duplicate for mass distribution. A variation on this method uses punched paper tape or punched cards with holes as the cue's storage means which tape or cards are advanced one set of holes at a time by a tape recorder. These various mechanical methods still only had one channel of tape control information and if more than one effect had to be controlled then a stepper relay or a similar apparatus had to be used. The auxiliary devices could not be controlled simultaneously. Overlooking the obvious reliability problems of detecting these mechanical cues with a switch or feeler wire, it is very difficult to program this type of apparatus for there is no way for the operator to view the results of the cues in "real" time. What was needed and is disclosed herein is an inexpensive correctable magnetic tape system which will store the coded cue signals and replay them to provide a multi-media show without relying on mechanical devices to provide a plurality of controlled auxiliary effects. However, recording of complex signals on magnetic tape is a formidable task and in the past apparatus for doing this tended to be very bulky and expensive making them unsuitable for most audio-visual applications. It is the primary object of this invention to provide an inexpensive and reliable multiplexing system for audio-visual multi-media presentation that is small and portable and utilizes standard home entertainment magnetic tape deck equipment.

In accordance with the primary object of this invention, there is provided an audio-visual display system including a control unit which comprises a cue encoder-decoder which cooperates with the ordinary home entertainment type tape recorder and common auxiliary visual and audio display devices such as movie projectors, lighting units or phonographic recorders to provide a correlated presentation of the audio and visual material. One channel of the stereo tape recorder provides the primary audio portion of the presentation. On the other channel, a series of cue signals for operation of the auxiliary display devices is provided by the encoder during the programming of the master tape. Then, during presentation, it is merely required that the primary audio portion of the lecture be played off one track of the stereo tape deck and the other track automatically provides signals to the control unit for decoding. The cue signals from this second track then switch or control a plurality of auxiliary units in a synchronous correlated manner to complete the presentation. If a mistake is made, during the programming of the master tape, the tape is simply stopped and is easily erased and changed without reviewing the entire program.

One of the inherent problems to overcome in simultaneous presentation of multiple effects by the foregoing system, is the normal tape recorder distortion, i.e., signal dropout or flutter, caused by the tape head or magnetic tape oxide irregularities which interrupt the decoding process. It is an object of this invention to provide a system having distortion immunity. It is another object of this invention to provide a system which continuously monitors the incoming pulse position modulated cue signals and trips an alarm if the signal deteriorates beyond a certain predetermined safe level. This monitor then automatically warns of tape breakage and day-to-day wear on recorder heads and tapes.

It is a further object of this invention to provide a decoding circuit which separates the cue signals and directs the separated signals to individual cue comparison units for control of a plurality of auxiliary units in either a continuous or stepping mode.

It is another object of this invention to provide a system that can be selectively actuated by an operator while listening to the prerecorded audio program material. This system will then generate the coded cue signals and send both the audio and cue signals to the tape deck and to the decoding circuit so that the operator can both see and hear the result of his programming instantly. The operator is, in effect, performing the multi-media show in "real" time during the programming of the master tape.

It is another object of the invention to provide a cue coupling device which separates the electrical noise generated by the controlled auxiliary devices and similar apparatus from the decoding process, thereby preventing disruptive effects caused by ground loops or signal conductors.

It is a still further object of the invention to provide a cue pulse width comparison circuit for each of these selectively actuated cue channels to monitor the time between the multiplexed pulses as the basic cue information. When the length of time exceeds a certain value for a certain period, the circuit determines that a proper cue has been received and distributes the same to the unit to be controlled. This type of cue detection is completely immune to variations in signal amplitude (which represents most of the noise on high fidelity tape decks) and represents a significant improvement in the signal-to-noise ratio of such system.

Another object of the invention is to provide a system having a highly regulated power supply which filters out any electronic noise or line fluctuations which would cause false triggering of the audio-visual system. It is another object of this invention to provide circuits with solid state components either in discrete or integrated circuit form that will allow for light weight and reliable operation.

In accordance with the foregoing objects, there is provided a control unit which comprises means for encoding cues and placing them on the tape, means for decoding the cue signals to an input for each cue comparison circuit that indicates when a cue has been detected, an automatic gain, or level, control for eliminating the effects of spurious variations in the cue signals

from the recorder and, finally, a cue coupling circuit which isolates the control unit from the audio-visual devices which are being controlled. These latter devices consume large amounts of electrical power and are notorious generators of noise. This can be from any of several sources such as motors, arcing and sparking contacts, solid state thyristors or controls on the intensity or speed of the audio-visual devices. If this noise is not isolated it can return to the control unit via ground loops formed by the connector wires running between the control unit and the devices being controlled and disrupt the decoding process.

In previous attempts to provide multi-media audio-visual presentation equipment, there has been suggested the use of various mechanical means of cue storage and detection such as punched tape systems or the like. Such systems have the disadvantage that if an error is made in the preparation of same or modification of the original presentation is desired, the overall presentation must be completely revised. In accordance with the invention there is provided a system wherein the programming of the presentation is on magnetic tape and therefore easily changed or erased at will. Further, the tapes for the presentation are readily duplicated for mass distribution.

For a better understanding of the present invention, together with other and further objects and features thereof, reference is had to the following description taken in connection with the accompanying drawings, the scope of the invention being pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings:

FIG. **1** is a block diagram of a first embodiment of an audio-visual program presentation system constructed in accordance with the present invention;

FIG. **2** is a block diagram of a cue encoder used in the control unit of FIG. **1**;

FIGS. **2***a* – **2***d* depict pulse trains produced by the FIG. **2** encoder;

FIG. **3** is a block diagram of a cue decoder used in the control unit of FIG. **1**;

FIGS. **3***a* – **3***e* are waveforms depicting the pulse timing of the FIG. **3** decoder;

FIG. **4** is a circuit diagram of an AGC unit used in the FIG. **3** decoder;

FIG. **5** is a circuit diagram of a decommutator portion of the FIG. **3** decoder;

FIG. **6** is a circuit diagram of one of the cue comparison subsystems of the FIG. **3** decoder;

FIG. **6***a* is a circuit diagram of one of the cue couplers used in the FIG. **3** decoder;

FIG. **7** is a block diagram of a modified cue comparison subsystem which can be used in the FIG. **3** decoder;

FIG. **8** is a block diagram of a second embodiment of an audio-visual program presentation system constructed in accordance with the present invention;

FIG. **9** is a block diagram of one of the multiplex mixtures used in the FIG. **8** system;

FIG. **9***a* is a waveform of a signal developed by the FIG. **9** mixer;

FIG. **10** is a block diagram of one of the signal separators used in the FIG. **8** system;

FIGS. **10***a* and **10***b* are waveforms of signals developed by the FIG. **10** signal separator; and

FIG. **11** is a block diagram of a third embodiment of an audio-visual program presentation system constructed in accordance with the present invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

As shown in FIG. **1**, the system includes an audio-visual control unit **10** and an ordinary home entertainment type two-channel tape recorder **12**. First, second and third projectors **14, 16** and **18**, respectively, an audio effects display **20** and a lighting effects display **22** are shown forming the auxiliary devices for an overall multi-media presentation.

The tape recorder **12** as contemplated by the invention may be a standard two-channel home entertainment stereo recorder but also may be any tape recorder having at least two or more channels for recording and playback of audio information. Such recorder includes the standard tape drive, pickup and recording heads and an audio input-output system. In the preferred embodiment, the recorder should have sound-with-sound capability. In other words, recorder **12** should preferably have the capability for playback on channel **1** while simultaneously recording on channel **2**. The projectors **14, 16** and **18** may be standard slide projectors which are indexed to a new slide by a cue signal or may be dual slide projectors wherein the light is shifted from one prepared slide in place to another by a similar signal. One of the controlled projectors may be a movie projector if, during a certain sequence of the presentation, a short film clip is to be presented. The audio effects device **20** may be a tape recorder of the single channel or multi-channel type, a phonographic recorder player unit or any other similar audio device. Such an audio effect device might be used during the course of a lecture presentation for placing a background musical environment behind the speech being given. The lighting effects display **22** may merely be a spot light of variable colors, a continuously variable intensity light source, or an entire lighting system.

The control unit **10** is divided into two main sections, a cue encoder **24** and a cue decoder **26**. The cue encoder **24** includes a keyboard **28** including a plurality of keys **29** individually having different ones of the channel designations A – E marked thereon. The cue decoder **26** includes a multiplex quality indicator **30** and signal lights **31** and **32**. The cue decoder **26** is shown connected to one of the playback channels of the stereo tape deck **12** after going through the function switch **33**, while the cue encoder **24** is connected to the recording input of the same track on the stereo tape deck **12** and also to switch **33**, which switch is depicted in FIG. **1** in a position for the purpose of recording cues on the previously mentioned recording input of the magnetic tape. In the recording position of switch **33**, it will be noted that the cues from the cue encoder **24** are not only sent to the tape input but also directed to the cue decoder for the purpose of controlling the various display devices **14** through **22**, respectively. During the course of preparation of the tape thus depicted, the system operates in the following manner. An audio presentation is first recorded on one of the channels of the stereo tape recorder. Track No. **2** thereof may be used for the receipt of the audio portion of the presentation through utilization of its standard audio input-output section **36**. After preparation of this audio portion of the presentation on track No. **2** of ste-

reo tape deck 12, the tape is then replayed with the audio-output on so that the operator may hear the audio presentation and track 1 is set to the record mode and all of the slide presentations and visual effects are turned on for viewing. During the course of the audio presentation, the operator will then push cue keys 29 at appropriate times during the audio presentation to activate or switch the display devices 14 to 22 at appropriate times during the audio presentation. The cue encoder output signals will be directed to the cue decoder through switch 33 to operate these display devices 14 to 22 while simultaneously placing on the magnetic tape the proper coded information (assuming the recorder deck has sound-with-sound capabilities). This mode of programming has proven to be far superior to any other known method and provides the operator with a large measure of personal satisfaction upon reviewing the results. When the cue signals for the auxiliary display units have thus been coded onto the first channel of the stereo tape for the entire presentation, the switch 33 may be set to its playback position (contact on right) and the tape rerun for verification of the operation of the auxiliary display units in proper synchronization with the audio program. Thus, the encoded signals present on the tape will be directed through the cue decoder for operation of the display devices. Obviously because of the use of magnetic tape, corrections or additions of cue information may be readily made. The cue decoder includes a signal quality protective monitoring system with outputs such as the signal level gauge 30 and signal lights 31 and 32 to indicate proper operation of the cue coding information from the magnetic tape. These monitor devices are very important when the audio-visual show must operate for extended periods as they give the operator warning of problems before they interrupt the show. These problems are, for example, tape and head wear and oxide build-up on the recorder playback mechanism.

FIGS. 2 and 2*a*–2*d* depict the details of the cue encoder 24 and the waveforms provided thereby to control the operation of the display devices 14 to 22. The cue encoder 24 comprises a master clock generator 40 and a series cascade connected group of delay circuits 42 to 50. Each of the encoder keys 29 are associated with respective delay circuits 42 – 50 respectively. The clock generator 40 is free running and designed to provide successive synchronization pulses which define a fixed and nonvariable frame interval of for example 20 ms. The cascaded delay circuits 42 – 50 duplicate the synchronization pulse delayed in time and, through adder-line 52, provide a train of cue pulses to the input amplifier of the stereo tape deck 12 and to switch 33. The train of pulses thus produced is depicted in FIGS. 2*a* – 2*d* with the pulse output of each respective delay circuits designated A, B, C, D, and E. Each of the delay circuits 42 – 50 provides a fixed delay of, for example, 1.5 ms. between each pulse when none of the encoder keys 29 are depressed. This would be a "no-cue" condition. FIG. 2*a* depicts the waveform when no-cue coding is provided to change the auxiliary devices 14 to 22 accompanying the presentation. When a coding key 29 is depressed the time delay provided by the circuit is modified to either increase or decrease the delay of the pulse output therefrom. In the preferred embodiment of this invention, the effect of the key depression for keys 29 A–D is to decrease the pulse time delay to about one-half of the set delay, for example, 0.8 ms. This is effected by changing the time constant of the delay circuit. It should be understood that separate channels can be provided by using both shorter and longer delays on the same pulse. Also, by providing proper width detection decoding, several trip points can be utilized in each direction. This would of course require several keys for each delay circuit, some for longer and some for shorter delays. Key 29*e*, which could be a dial, is connected to a variable resistance 51 to provide continuous variations of the time delay of circuit 50. FIG. 2*b* depicts the waveform when the encoder key 29*a* has been depressed, FIG. 2*c* with key 29*e* depressed and FIG. 2*d* with keys 29*a* and 29*e* depressed. Thus, it will be seen that when no key is depressed the inverval between all of the pulses remain at a fixed interval, 1.5 ms. When the key 29*a* was depressed only the interval between the sync pulse S and the A-pulse was changed while when both the 29*a* and 29*e* keys were depressed the intervals between the S and A pulses and between the D and E pulses were changed. Thus, each channel is provided with pulse position modulation (PPM) with a decrease or increase in spacing between a given channel pulse and the preceding pulse being used to represent the cue information. Channels A to D are provided with only finite encoding delay times while channel E may vary in analog manner for the purpose explained hereinafter. It should be noted that since the cue information is a shift of time and not amplitude of pulses or frequency of tones, that the PPM cue encoding provides distortion immunity against flutter and dropout.

Since the different channels are time multiplexed, the overall system can be described as being a multichannel time multiplexed pulse position modulation system. It is to be noted that during the operation of the system when a key is depressed by an operator it will be depressed for some tenths of a second. Consequently, the corresponding channel pulse will be shifted for several successive frame intervals. This mode of cueing aids the system in overcoming the inherent distortion of the home entertainment stereo tape deck by requiring a certain number of successive frame intervals (each containing a PPM cue pulse change representing a cue) to occur before a cue is sent from the decoder to any of the effects devices 14 – 22, for reasons to be described in more detail hereinafter.

The cue decoder unit 26 is depicted in FIG. 3 and comprises an automatic gain control (AGC) unit 54 which performs an amplitude discriminating and pulse shaping function. The AGC unit 54 discriminates against signal amplitudes above and below a predetermined range. Signal values in the intermediate desired range that neglect both flutter and drop-out on the high end and tape hiss or noise on the low end are amplified to provide a train of pulses which assuming no tape flutter or drop-out from playback from the stereo tape deck will correspond to the train of coded pulses depicted for example in FIG. 3*a*.

The output train of pulses from the AGC unit 54 (FIG. 3*a*) is connected to a sync separator 55 and a level monitor 55*a*. Sync separator 55 has two output lines designated as X and Y. Sync separator 55 operates to separate out and to reproduce on the X output line only the recurring sync pulses S shown in FIG. 3*a*, with these separated sync pulses on line X being of positive polarity. The sync separator 55 operates to pro-

duce on the output line Y the complete train of pulses as represented in FIG. 3*a* with these pulses being of negative-going polarity. Sync separator output lines X and Y are connected to a decommutator formed by a series of cascade connected saturable switch circuits **56 – 64.** Each of the saturable switch circuits **56 – 64** is bistable and includes a first input terminal N whereat a positive-going level change applied thereto will turn such circuit "on." A second input terminal F is provided for each such circuit whereat a negative-going level change applied thereto will turn the circuit "off."

Assuming initially that all of the saturable switch circuits **56 – 64** are in their "off" condition, then the next occuring sync pulse on line X serves to turn on the first saturable switch circuit **56.** The next occurring pulse on line Y, namely, the channel A pulse, serves to turn the switch circuit **56** off again. This produces at the output of switch circuit **56** a width modulated negative-going pulse having a width corresponding to the time spacing between the S and A pulses which produced it. The positive-going trailing edge of the negative pulse at the output of switch circuit **56** serves to turn on the next saturable switch circuit **58.** The next occuring pulse on line Y, namely, the channel B pulse, then serves to turn the second saturable switch **58** off. This produces at the output of the second saturable switch circuit **58** a negative-going width modulated pulse having a width corresponding to the time spacing between the A and B channel pulses which produced it. This sequential turning on and off of the saturable switch circuits progresses down the chain so that there is produced at the output of the third saturable switch circuit **60** a negative-going width modulated pulse corresponding to the time spacing between the B and C pulses on line Y, at the output of the fourth saturable switch circuit **62** a negativegoing width modulated pulse corresponding to the time spacing between the C and D pulses on line Y and at the output of the fifth saturable switch circuit **64** a negative-going width modulated pulse corresponding to the time spacing between the D and E pulses on Line Y. Thus, the separate cue channels (each corresponding to one of the variable delay networks **42 – 50** of the encoder **24**) are divided out, each to be processed separately.

The outputs of the saturable switch circuits **56 – 64** are individually connected to different ones of width reference one-shot multivibrator circuits **66** to **74** and add circuits **76** to **84** for separately discriminating the pulse widths of the width-modulated pulses for the different cue channels. Integrator circuits **86** to **94** and driver circuits **96** to **104** operate respective ones of cue coupling circuits **106** to **114** when the proper number of width-modulated pulses of the proper width appear at the outputs of the respective ones of the saturable switch circuits **56–64.**

Each of the one-shots **66** to **74,** when triggered on by the leading edge of the width-modulated pulse from its respective one of saturable switches **56–64,** produces a positive-going pulse having a width (e.g., 1.5 milliseconds) corresponding to the "no cue" spacing between the pulses generated by encoder **24.** If the encoder **24** provides for various widths of pulses, multiple sets of one-shot multivibrator and add circuits need to be provided. The output pulse of each saturable switch circuit **56–64** is compared with the output pulse of the corresponding one of one-shots **66 – 74,** such comparison being performed by the corresponding one of add circuits **76 – 84.** Waveforms representative of typical ones of these signals are depicted in FIGS. 3*b* – 3*e*. Assuming the PPM cue signals to be of the form of FIG. 2*a* (i.e., "no cue"), the output pulses from each of saturable switch circuits **56 – 64** will be of standard width, that is, 1.5 milliseconds (no cue key depressed). Typical such "no cue" pulses from one of the saturable switches **56 – 64** are shown in FIG. 3*b*. Such negative-going pulses cancel the positive-going reference pulses (FIG. 3*c*) from the corresponding one of the one shot circuits **66 – 74** producing no net signal at the output of the corresponding one of add circuits **76 – 84.** Thus, no cue signal is supplied to the corresponding auxiliary device. When a channel has been coded by depressing a cue key, then the decoded negative pulses (FIG. 3*d*) from the corresponding saturable switch circuit are approximately one-half of the width of the pulses (FIG. 3*c*) from the one-shot circuit and net positive pulses (FIG. 3*e*) appear at the input of the corresponding one of integrator circuits **86 – 94.** Integrators **86 – 94** are designed to respond only to a positive input. Such an input produces an output signal which is sent to the corresponding one of couplers **106 – 114** to produce a change in the corresponding auxiliary device connected to the output thereof.

Integrators **86 – 94** provide an accumulator function which serves to eliminate the effects of spurious signals in the tape recorder output and removes the effects of signal dropout. The integrators **86 – 94** capacitatively store the signals received from the corresponding ones of add circuits **76 – 84** until a sufficient number, approximately five, have been received to trigger the driver amplifier circuits **96 – 104** to effect operation of the cue coupler circuits **106 – 114.** Thus, a spurious signal frame will be insufficient to effect operation of the drivers, while compensation is made for signal loss for one or more frames since usually the encoder cue key will be depressed for several frames.

It should be noted that with the novel circuits of this invention working together to remove the effects of noise, flutter and dropout, the system has to experience quite a severe loss of signal for several frame intervals before any malfunction or miscues occur. The value of the level monitor **55***a* is apparent since when the signal deteriorates beyond a safe value at the output of the AGC, the level monitor switches off power supply circuit **55***b* which supplies operating voltage to the drivers **96 – 104** and no cues can be sent. This power supply voltage will stay off until the signal recovers or the level monitor is manually overridden by means of override circuit **55***c*. Thus, the system is protected from tape breakage or recorder malfunction.

The cue coupler circuits **106 – 114** may drive the auxiliary devices directly or, alternatively, may drive silicon controlled rectifier or triac switching circuits which, in turn, drive the auxiliary devices, thus providing a very wide versatility in the type of effect that can be controlled by the system. While the decoded add circuit pulses (FIG. 3*e*) to the integrators **86 – 94** have been described as positive, it is obvious that polarities could be reversed to use negative pulses. Further, one or more of the encoder keying switches **29** and associated ones of delay circuits **42 – 50** could be constructed selectively to either increase or decrease the corresponding channel pulse delay, the use of increased delay producing negative-going pulses at the output of the corresponding one of add circuits **76 – 84.**

An additional integrator circuit responsive only to negative-going pulses could then be connected to such add circuit to supply control signals to an additional driver and an additional cue coupler to provide an additional cue control channel. These changes would have the effect of increasing the number of channels available without increased demands on the tape deck.

As noted, the cue decoder unit **26** depicted in FIG. **3** comprises an automatic gain control (AGC) unit **54** which performs an amplitude discriminating a pulse shaping function. A present preferred embodiment of AGC unit **54** is depicted in FIG. **4** and comprises a field effect transistor (FET) **116** and an inverting transistor **118.** The input to the AGC unit **54** is to the gate electrode G of the field effect transistor **116** through a coupling capacitor **120** and resistance **122** connected between the gate electrode and ground. A network **124** is connected to the source electrode S of the field effect transistor **116** and is provided with a variable resistance for varying the sensitivity of the circuit. The output from the drain electrode D of the field effect transistor **116** is connected to the base of the inverting transistor **118** through a bias network **126.** The collector electrode of the transistor, which is coupled to ground, forms the output of the circuit.

Transistors **116** and **118** are normally conductive. It is thus seen that the negative-going pulses obtained from tape recorder **12** and applied to the gate electrode of the field effect transistor **116** through capacitor **120** have the effect of turning said transistor off, provided said pulses have amplitudes in excess of a first predetermined value. The turning off of the field effect transistor **116** raises the voltage at the base of the inverting transistor **118** which reduces the bias available to the base emitter junction and turns said transistor off. When the transistor **118** turns off, its collector electrode returns toward a ground potential and saturates there as long as a pulse is present and the amplitude of such pulse is in excess of a second and somewhat greater predetermined value. It is thus seen that both the minimum and maximum amplitude values of the cue pulses are controlled. Thus, as shown by FIG. **3***a*, the output of the AGC circuit is a negative-going PPM pulse train that has a controlled amplitude and clearly retains the width information needed for precise decoding. Since the output of the encoder is negative going and the output of the tape deck is negative going, the position of switch **33** has no effect on the output of the AGC unit **54.** The field effect transistor **116** is turned off only by a negative-going pulse of sufficiently high value to overcome the bias set by the RC network **124** and the positive portion of the pulse waveform increases the voltage on the gate of the field effect transistor **116** to turn it back on. The rise of the voltage at the base of transistor **118** caused by the turning off of the field effect transistor **116** turns off transistor **118.** Transistor **118** remains off until such time as the field effect transistor **116** is turned back on, which event lowers the voltage to the base of the transistor **118** and turns the same back on. Because of the threshold bias provided by network **124** and the limiting action provided by the saturation of transistor **118,** only signal values in an intermediate desired amplitude range provide the amplified output of the AGC unit **54.** As long as the output from the tape recorder is greater than 10 to 20 percent of the recorded amplitude, perfect sets or frames of PPM cue pulses will be produced at the output of AGC unit **54.** Should the signal input to the AGC drop below a safe operative point, the level monitor **55***a* disconnects the power to the drivers and warns the operator to clear up the malfunction.

The saturable switch circuits **56** – **64** for the preferred embodiment of the invention are depicted schematically in greater detail in FIG. **5** wherein it will be noted that each saturable switch circuit comprises a pair of complementary transistors, namely, a PNP transistor **126** and an NPN transistor **128.** The Y output from the sync separator unit **55** is applied to the emitters of each of the transistors **126** through blocking diodes **130.** The synchronizing pulses on the X line of the sync separator unit **55** are applied to the saturable switch circuit **56** through a coupling capacitor **132.** The greater majority of the time, transistors **126** and **128** will be non-conductive or turned off, this being one of the two bistable states of the switch circuit **56.** Assuming this to be the case, a positive-going sync pulse through coupling capacitor **132** to the collector of transistor **126** and base of transistor **128** of switch circuit **56** biases these transistors to turn them on. The resulting current flow thereafter maintains transistors **126** and **128** in the "on" state, this being the second bistable state. In the condition state or "on" state, the voltage appearing at the circuit point intermediate the base of transistor **126** and the collector of transistor **128** and hence on output line **129** goes to substantially ground level and stays there for the entire duration of the time delay for channel A. The next occurring pulse on the Y output line of sync separator **55,** namely, the negative-going channel A pulse is applied by way of coupling diode **130** to turn off transistor **126.** This, in turn, turns off transistor **128.** This causes the voltage on output line **129** to rise back up to the +V power supply level. Thus, it can now be seen that the output waveform (line **129**) for the saturated switch circuit **56** is negative-going and has the exact same width as the original time spacing between the sync pulse S and the channel A pulse as set by the encoder **24** and its channel A key switch **29.**

The positive-going trailing edge of the output pulse of the first switch circuit **56** is supplied by way of coupling capacitor **131** to turn on the transistors **126** and **128** in the second switch circuit **58.** The next occuring pulse on line Y, namely, the channel B pulse, serves to turn the transistors in the second switch circuit **58** back off again. This produces on the output line **133** a negative-going pulse having a width equal to the time spacing between the channel A and channel B position modulated pulses. This process is thereafter repeated in sequence for the remaining switch circuits **60, 62** and **64.** In this manner, the cue information for each channel is separated from the others and appears at the output of a single one of the switch circuits **56** – **64** for further decoding.

Obviously, one saturable switch circuit is required for each position modulated cue pulse in the complete frame. However, each saturable switch circuit may drive more than one one-shot width detector thus having the effect of making available two or more cue channels for each frame pulse and saturable switch circuit used without increasing any demands made on the tape recorder **12.**

Referring to FIG. **6,** there is shown the details of a preferred form for the one-shot multivibrator **66** and the add circuit **76.** The other one-shot and add circuit

pairs may be of this same construction. As previously indicated, one-shot **66** and add circuit **76** provide a pulse width discrimination function for the width modulated pulses appearing at the output of the saturable switch **56**. The one-shot multivibrator portion of FIG. **6** comprises a pair of cross-coupled transistors **134** and **136** with an RC timing network **138** being used to set the width of the positive-going reference pulses or comparison pulses (FIG. 3*c*) generated by such one-shot circuit. Such width is set equal to the "no cue" width of the pulses (FIG. 3*b*) appearing at the output of saturable switch circuit **56**. The output of saturable switch circuit **56** is connected to transistor **139** through resistor **140**, transistor **139** being utilized only when there are several multivibrators connected to a single saturable switch circuit. If a single multivibrator is utilized for each saturable switch circuit, elements **139** and **140** may be deleted and the output of the saturable switch circuit connected directly to circuit point **137** of the one-shot. The leading edge of each negative-going pulse from the saturable switch circuit **56** triggers the multivibrator to generate a positive-going pulse which is applied to the upper end of diode **142** in add circuit **76**. The negative-going pulse output of the saturable switch circuit is applied to the lower end of diode **144** in add circuit **76**. There is produced on output line **145** of add circuit **76** a signal pulse corresponding in width to the lack of coincidence, if any, between the positive-going one-shot reference pulse and the negative-going saturable switch pulse. If both pulses are of the same width, they completely offset one another and no net pulse appears on output line **145**. If the saturable switch pulse is shorter, a net positive pulse appears on line **145** (see FIGS. 3*c* – 3*e*). If longer, a net negative pulse appears. Output line **145** is connected to the input of the integrator circuit **86** (FIG. 3). Each integrator and driver circuit is designed to respond only to either positive or negative pulses from the add circuit but not to both at the same time.

The coded pulse signals may be utilized for on-off switching or control action as mentioned above or may be used for continuous control as, for example, varying the intensity of a lighting effects display **22**. Thus, in FIG. **2**, the key **29E** is disclosed as providing a continuously variable resistor or potentiometer for modifying the delay of delay circuit **50** in a continuous manner. Thus, the coded output from the Channel E saturable switch circuit **64** need not be merely a pulse of half-width as explained previously, but may be a pulse of any width. A circuit for fully utilizing such a pulse output is depicted in FIG. **7**. As there shown, the Channel E width modulated pulse is compared with the output of the one-shot **74** in the add circuit **84**. Since the coded signal is assumed to be a pulse of variable width, thus producing either a positive or negative output, the compared signal from add circuit **84** is directed to either a positive signal responding amplifier **150** or a negative signal responding amplifier **152**. Power amplifiers **154** and **156** are provided to drive a servo motor **158** in either what may be considered the positive or negative direction. The servo motor **158** drives, for example, a rheostat **160** to control the lighting intensity of device **22** which is connected to terminal **161**. The servo motor also drives a potentiometer which is a part of the RC time constant network (see FIG. **6**) of the one-shot multivibrator **74** to adjust the width of the pulse output thereof. Thus, for example, if the output of the add circuit **84** is a positive net signal, the servo motor **158** is driven in the positive direction and the potentiometer of the one-shot multivibrator is adjusted to decrease the pulse width thereof until the output of the add circuit **84** is reduced to zero. At this time, the motor **158** stops and the width of the one shot pulse matches exactly with the time delay set by the operator of the cue encoder **24**. Similarly, if the output of the add circuit **84** is such that the coded signal has produced a negative output at the output of add circuit **84**, the servo motor **158** will be driven in the negative direction while simultaneously adjusting one shot **74** to increase its pulse width until a zero add circuit output signal is developed, whereupon the motor **158** stops. In this manner, the width of the coded pulse can be utilized to provide continuous analog control of any output device. This could be used to control the intensity of lights or the speed of a motor or the volume of sound from a sound source.

The cue coupling device **106** of FIG. **3** is shown in greater detail in FIG. **6***a*. The other cue couplers **108** – **114** are of this same construction. As shown in FIG. **6***a*, a light bulb **146** shines on a light dependent or photosensitive element **147** which may be a light dependent resistor such as, for example, a cadmium sulfide cell or a PN junction diode, light bulb **146** and element **147** being contained in a light-tight box (not shown). Since only light radiation connects the input bulb **146** and an output switching device **148**, which might be an SCR, as shown, or a triac or an electromechanical relay, the cue encoding system will be completely electrically isolated from the operation of the auxiliary device connected across output terminals **149**. Preferably, each cue coupler should be located with its projector or other auxiliary device and the driving lines running from the control unit **10** to the cue couplers **106** – **114** should be of low impedance. When this is done, the control unit **10** is very effectively insulated from any ground loops and disruptive circuit current surges.

If it is desired to record audio program material on both channels of the stereo tape, the system may be made frequency responsive and utilize the coded PPM signal superimposed over one or both of the channels. A system of this type is shown to FIG. **8** and would allow full stereo sound and independent control of a plurality of auxiliary devices with completely silent cues utilizing an ordinary home entertainment type stereo tape recorder. Two stereo tape recorders **12***a* and **12***b* are illustrated together with two cue encoders **24***a* and **24***b* and two cue decoders **26***a* and **26***b*. All of these components are similar to those previously explained with respect to the system of FIG. **1**. Interposed between the cue encoders **24***a* and **24***b* and the channels of these stereo tape decks **12***a* and **12***b* are multiplex mixers **162***a* and **162***b*. Signal separators **164***a* and **164***b* are interposed between the channels of the tape deck **12***b* and cue decoders **26***a* and **26***b*.

The multiplex mixer **162***a* is shown in more detail in FIG. **9**. The second mixer **162***b* is of this same construction. Mixer **162***a* includes a high frequency audio oscillator **166** which produces a high frequency audio tone signal in, for example, the 10 to 15 kilohertz range. This high frequency audio tone is fed to a gate **168** which is controlled by the PPM cue pulses from the cue encoder **24***a* to produce at the output of gate **168** bursts of high frequency oscillation corresponding to the pulses produced by the cue encoder **24***a*. The cue infor-

mation is now represented by the time spacing between the bursts of high frequency energy, a portion of the output of gate **168** being represented by the waveform of FIG. 9*a*. The time between bursts is the same as the time between the pulses shown in FIG. 2*a*. The audio program signal from one channel (Track 2) of the stereo tape deck **12***a* is fed through a notch filter **170** which passes all frequencies except for a very narrow band of frequencies centered at the frequency of oscillation of the high frequency oscillator **166.** Because of the narrowness of the stop band of the notch filter, the audio program signal will remain essentially unaffected even though a narrow band of frequencies has been removed from such audio program signal. The pulses of high frequency oscillations from the gating circuit **168** and the audio program signal from the notch filter **170** are fed to a mixer circuit **172** which superimposes the high frequency tone bursts onto the audio signal. The resulting composite signal appearing at the output of mixer **172** is directed to the tape receorder **12***b* for recording on one track of the magnetic tape contained therein.

It should be noted that a primary object of this type of frequency multiplexing is to keep the cueing signals from being heard by the listening audience during the subsequent presentation of the audio program material. Therefore, while the audio program material is mixed through mixer **172** at a high level, the tone bursts are mixed through at a much lower level, of, for example, 20 to 25 decibels below the level of the program material. It should also be clear that it is desirable to remove with notch filter **170** all frequency components from the audio program that might be mistaken as a cue signal by the signal separator **164***a*. This latter feature precludes any stray energy from the much larger audio program signal from causing false triggering of a high gain tuned amplifier **178** located in signal separator **164***a* and to be considered hereinafter.

In the operation of the system of FIG. **8** it is assumed that the desired stereo program material is first recorded by the first stereo tape deck **12***a*. Upon playback of the tape by tape deck **12***a*, an operator may encode one or more channels with cue information by operation of the cue keys of cue encoders **24***a* and **24***b*, which information is recorded on the channels of the second stereo tape deck **12***b* along with the stereo program material. If a stereo tape deck of the type having a simultaneous playback and recording capability is used, the audio inputs and outputs of the frequency encoders **162***a* and **162***b* may be directly connected therewith and the use of a second stereo tape deck is unnecessary.

Simultaneously with the encoding of the audio and cue signals on both channels of the magnetic tape in recorder **12***b*, cueing signals are stripped from the two composite signals by signal separators **164***a* and **164***b*. Both of these signal separators **164***a* and **164***b* are of the same construction, the former being shown in greater detail in FIG. **10.** As there seen, signal separator **164***a* comprises a high boost filter **174** which attenuates the lower frequency portion of the audio spectrum relative to the higher frequency portion of the audio spectrum, the latter including the cue signal tone frequency. This modified signal is amplified by an amplifier **176** and supplied to a tuned amplifier circuit **178** and a notch filter **180.** The notch filter **180** passes all audio frequencies except for a very narrow band of frequencies centered at the cue signal tone frequency. The filtered signal is supplied to a low boost filter **182** which attentuates the higher frequency portion of the audio spectrum relative to the lower frequency portion of the audio spectrum in a manner which is the exact converse of the attentuating action in the earlier high-boost filter **174.** The net overall effect of the high-boost filter **174** and the low-boost filter **182** is to provide an essentially flat passband from the input of the former to the output of the latter excepting, of course, the frequencies in the stop band of notch filter **180.** The resulting audio program signal at the output of low-boost filter **182** is supplied to an appropriate amplifier and loudspeaker system (not shown) for presentation to a listening audience. Because of the tone signal loss in notch filter **180** (−20 to −25 decibles) and the original low level of the tone bursts, the cue information is not heard by the listening audience.

The tuned amplifier **178** is sharply tuned to the frequency of the high frequency audio oscillator **166,** i.e., the cue signal tone frequency, and has a very high gain for amplifying thecue signal bursts which are then supplied to a saturable driver circuit **184** which converts the high frequency tone bursts into a rectangular wave output of the type originally appearing at the output of the cue encoder **24**a. Each time the tuned amplifier **178** produces at its output a high frequency tone burst (FIG. **10***a*), the normally "off"]saturated driver circuit **184** turns "on" for the duration of the burst, thus producing a waveofrm as shown in FIG. **10***b*. These detected cue signals are inverted by an output stage in the driver circuit **184** to produce negative-going pulses which are then supplied to and decommutated by the cue decoder circuit **26***a* in the manner explained perviously.

While the foregoing system of FIG. **8** has been illustrated as encoding and decoding different cue information on both channels or both tracks of the magnetic tape, it will be understood that, if desired, only a single encoder could be used to encode cue signals on only one of the tape channels. As a further alternative, the same cue information could be encoded on both tape channels for checking one against the other for minimizing the effect of tape dropout on playback.

The stereo system of FIG. **8** may be converted into a monaural system by simply cutting the FIG. **8** system in half. In other words, monaural tape recorders would be used in place of the stereo tape decks **12***a* and **12***b* and only one set of the remaining components, for example, cue encoder **24***a*, multiplex mixer **162***a*, signal separator **164***a* and cue decoder **26***a*, would be used in connection therewith. The operation would be the same as described above and would allow a monaural tape unit to provide a completely automatic audio-visual program presentation.

Referring to FIG. **11,** there is shown a modified form of monaural system having a pair of monaural tape recorders **186***a* and **186***b*. A multiplex mixer **162***c* is provided with a keying switch **188** for actuating the gating circuit thereof. In other words, mixer **162***c* is of the same construction as shown in FIG. **9** with the keying switch **188** being connected to the gate **168** in place of the cue encoder **24***a*. Closing of switch **188** causes gate **168** to produce a tone burst at the output thereof. Upon playback of the previously recorded audio program material by the monaural tape recorder **186***a*, tone burst cueing pulses are mixed with the program

signal at the appropriate points by a momentary closing of switch **188** and the resulting composite signal is supplied to the second monaural tape recorder **186***b* for recording on the tape therein. The signal separator **164***c*, which may be of the same construction as that shown in FIG. **10**, utilizes the high frequency cue pulses to drive an output switch circuit **190** for an auxiliary device by directing each separator output pulse through a direct-current amplifier circuit **192** which converts same into a power pulse for driving the output switch **190**. The FIG. **11** system is a simplified monaural system for use with a single slide projector or other auxiliary device, the advancement mechanism or control mechanism in such projector or other device being connected to the output of the output switch **190** by way of an appropriate connector cable.

While the tone frequency produced by the high-frequency audio oscillator **166** in the multiplex mixers has been disclosed as being near the upper end of the human audible range, it may in some cases be necessary to utilize a lower tone frequency, particularly if the tape recorders contemplated to be used are not of sufficient fidelity to handle frequencies in the higher range.

While there have been described what are at present considered to be preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An audio-visual display system comprising:

magnetic tape recorder means for recording audio program signals on magnetic tape and for reproducing same during playback of a recorded tape;

a plurality of auxiliary display units for producing audio effects or visual effects or both;

cue encoding means coupled to the tape recorder means for recording plural channel cue signals on the magnetic tape at desired points in the audio program, said cue encoding means including means for producing time-multiplexed signals which comprise repetitive groups of pulses and means for independently changing the time interval between each of a plurality of selected pulses and a corresponding adjacent pulse in each group to thereby provide a plurality of independnet control channel cue signals for control channels designated by the selected pulses;

and cue decoding means coupled to the tape recorder means and to the auxiliary display units during tape playback and responsive to reproduced control channel cue signals for automatically and independently controlling the different auxiliary display units in step with the playback of the recorded audio program signals.

2. An audio-visual display system in accordance with claim **1** wherein the cue encoding means includes:

a clock pulse generator;

a series of cascaded delay circuits, the first of which is coupled to the clock pulse generator;

means for adding the output signals from the clock pulse generator and the delay circuits to produce a train of cue pulses;

and means for independently changing the time delay of each delay circuit for providing a plurality of independent control channel cue signals.

3. An aduio-visual display system in accordance with claim **2** wherein the time delay changing means for at least one of the delay circuits comprises an analog device for varying the time delay in a continuous manner.

4. An audio-visual display system in accordance with claim **1** wherein the system further includes:

multiplex mixer means coupled between the cue encoding means and the tape recorder means for converting the control channel cue signals to tone burst signals and combining same with at least some of the audio program signals for enabling the combined signals to be recorded on a common track on the magnetic tape;

and frequency selective signal separator means coupled between the tape recorder means and the cue decoding means during tape playback for separating the cue signal tone bursts from the intermingled audio program signals and for converting same to pulse type signals for use by the cue decoding means.

5. An audio-visual display system in accordance with claim **4** wherein:

the multiplex mixer means is constructed so that the level of the recorded cue signal tone bursts is substantially less than the average level of the recorded audio program signals with which it is combined;

and the signal separator means includes frequency selective means for boosting the level of the cue signal tone bursts relative to the level of the lower frequency components of the intermingled audio program signals before the cue signal tone bursts are separated from the audio program signals.

6. An audio-visual display system in accordance with claim **4** wherein the multiplex mixer means comprises:

an audio-frequency oscillator;

gate circuit means coupled to the output of the oscillator and responsive to the control channel cue signals produced by the cue encoding means for producing at the output of such gate circuit means tone burst signals corresponding in position and duration to the pulses of the control channel cue signal;

and circuit means for mixing the tone burst signals with an audio program signal.

7. An audio-visual display system in accordance with claim **4** wherein the signal separator means comprises:

high-boost filter circuit means for boosting the level of the cue signal tone bursts relative to the level of the lower frequency components of the intermingled audio program signals;

sharply tuned bandpass circuit means coupled to the high-boost filter circuit means for passing substantially only the cue signal tone bursts;

circuit means coupled to the output of the bandpass circuit means for converting the tone bursts to pulse type signals and for supplying same to the cue decoding means;

and low-boost filter circuit means for boosting the level of the lower frequency components of the audio program signals relative to the higher frequency components, such circuit means being constructed so that the low frequency boost equalizes the low frequency attenuation experienced in the

high-boost filter circuit means to develop an audio output signal for use by a loudspeaker type reproduction system.

8. An audio-visual display system in accordance with claim 7 wherein the multiplex mixer means comprises:
an audio-frequency oscillator;
gate circuit means coupled to the output of the oscillator and responsive to the control channel cue signals produced by the cue encoding means for producing at the output of such gate circuit means tone burst signals corresponding in position and duration to the pulses of the control channel cue signals;
and circuit means for mixing the tone burst signals with an audio program signal to provide the combined signals for the magnetic tape recorder means.

9. An audio-visual display system in accordance with claim 1 wherein one pulse in each group is a sync pulse and the other are position-modulated cue pulses for different control channels and wherein the cue decoding means comprises:
automatic gain control circuit means for receiving and conditioning the cue pulses;
sync separator means responsive to the sync pulse in each group for producing separate sync signals;
saturable switch circuit means responsive to the cue pulses and the separate sync signals for producing separate sets of width modulated pulses on a plurality of output lines, the pulses on any given output line being width modulated in accordance with the position modulation of the pulses for a particular one of the control channels;
a plurality of width detector circuit means individually coupled to different ones of the saturable switch circuit output lines for producing separate control signals for the different control channels;
and a plurality of signal coupling means for individually coupling the width detector circuit means to different ones of the auxiliary display units.

10. An audio-visual display system in accordance with claim 9 wherein the cue encoding means comprises:
a clock pulse generator;
a series of cascaded delay circuits, the first of which is coupled to the clock pulse generator;
means for adding the output signals from the clock pulse generator and delay circuits to produce a train of cue pulses;
and means for independently changing the time delay of each delay circuit for providing a plurality of independent control channel cue signals.

11. An audio-visual display system in accordance with claim 9 wherein the cue pulses received by the automatic gain control circuit means are negative-going pulses and such automatic gain control circuit means comprises:
a field effect transistor having gate, source and drain electrodes;
circuit means for biasing the field effect transistor to a normally conductive condition;
circuit means for enabling the gate electrode of the field effect transistor to receive the incoming negative-going cue pulses;
a p-n-p transistor having bare, emitter and collector electrodes;
circuit means for coupling the base electrode of the p-n-p transistor to the drain electrode of the field effect transistor and for biasing the p-n-p transistor to a normally conductive condition;
and output circuit means coupled to the collector electrode of the p-n-p transistor for providing negative-going amplitude discriminated and conditioned cue pulses.

12. An audio-visual display system in accordance with claim 9 wherein the saturable switch circuit means comprises:
a series of cascaded switch circuits each comprising n-p-n transistor, circuit means for applying operating voltage between the emitter and collector electrodes of the n-p-n transistor, a p-n-p transistor having its collector electrode connected to the base electrode of the n-p-n transistor and having its base electrode connected to the collector electrode of the n-p-n transistor and circuit means for biasing both transistor to a normally non-conductive condition;
circuit means for supplying the separate sync signals to the base electrode of the n-p-n transistor in the first switch circuit in the series for repetitively turning such first switch circuit on;
circuit means for coupling the n-p-n collector electrode of each switch circuit to the n-p-n base electrode of the next switch circuit in the series for turning the latter switch circuit on when the earlier switch circuit turns off;
circuit means for supplying the cue pulses to the p-n-p emitter electrodes of all of the switch circuits for turning off the switch circuit which is turned on when a cue pulse occurs;
and the output lines for the saturable switch circuit means being individually coupled to the n-p-n collector electrodes in different ones of the switch circuits.

13. An audio-visual display system in accordance with claim 9 wherein each width detector circuit means includes:
one-shot multivibrator circuit means coupled to one of the saturable switch circuit output lines and responsive to the leading edge of each width modulated pulse appearing on such output line for producing a reference pulse of predetermined width;
add circuit means responsive to each width modulated pulse and to the one-shot reference pulse produced by the leading edge thereof for producing an output pulse having a width corresponding to the difference in widths of the width modulated pulse and the reference pulse;
and integrator circuit means for integrating the add circuit output pulses for producing a control signal for the particular control channel with which the width detector circuit means is associated.

14. An audio-visual display system in accordance with claim 9 wherein each signal coupling means includes:
light emitting means coupled to the output of one of the width detector circuit means for emitting light in response to the appearance of a control signal at such output;
light responsive means responsive to light emitted by the light emitting means for producing a control effect;

and circuit means coupled to the light responsive means and to one of the auxiliary display units and responsive to the control effect produced by the light responsive means for controlling the auxiliary display unit in accordance therewith.

15. An audio-visual display system in accordance with claim **9** wherein:

the cue encoding means includes a clock pulse generator; a series of cascaded delay circuits the first of which is coupled to the clock pulse generator, means for adding the output signals from the clock pulse generator and the delay circuits to produce a train of cue pulses, and means for independently changing the time delay of each delay circuit for providing a plurality of independent control channel cue signals, the time delay changing means for at least one of the delay circuits comprising an analog device for varying the time delay in a continuous manner;

and the width detector circuit means and signal coupling means for the control channel employing the analog device includes one-shot multivibrator circuit means responsive to the leading edge of each width modulated pulse for the analog control channel for producing a comparison pulse, comparing circuit means for comparing the width modulated pulses with the comparison pulses for producing an error signal, a servo mechanism controlled by the error signal for enabling a continuous adjustment of the auxiliary display unit controlled by the analog control channel, and means coupled to the servo mechanism for adjusting the pulse width of the one-shot comparison pulses until a practically zero error signal is produced by the comparing circuit means.

16. An audio-visual display system comprising:

magnetic tape recorder means for reproducing audio program signals and plural channel cue signals recorded on a magnetic tape wherein the recorded cue signals are in the form of repetitive groups of time-multiplexed pulses wherein one pulse in each group is a sync pulse; and the others are position-modulated pulses for different control channels;

a plurality of auxiliary display units for producing audio effects or visual effects or both;

automatic gain control circuit means coupled to the tape recorder means during tape playback for receiving and conditioning the cue signal pulses;

sync separator means responsive to the sync pulse in each group for producing separate sync signals;

saturable switch circuit means responsive to the cue signal pulses and the separate sync signals for producing separate sets of width modulated pulses on a plurality of output lines, the pulses on any given output line being width modulated in accordance with the position modulation of the pulses for a particular one of the control channels;

a plurality of width detector circuit means individually coupled to different ones of the saturable switch circuit output lines for producing separate control signals for the different control channels;

and a plurality of signal coupling means for individually coupling the width detector circuit means to different ones of the auxiliary display units for automatically and independently controlling the different auxiliary display units in step with the playback of the recorded audio program signals.

17. An audio-visual display system comprising:

magnetic tape recorder means for recording audio signals on magnetic tape and for reproducing same during playback of a recorded tape;

an auxiliary display unit for producing audio or visual effects;

means for producing cue signals in the form of audio-frequency tone bursts in which the frequency of the oscillations in each tone burst is greater than a predetermined frequency;

signal combining means for combining such tone bursts with an audio program signal and supplying the combined signals to the magnetic tape recorder means for recording same on a common tract on a magnetic tape;

first frequency selective circuit means coupled to the magnetic tape recorder means during tape playback for separating the cue signal tone bursts from the audio program signal; said circuit means including high-boost filter circuit means for boosting the level of signal components at frequencies greater than the predetermined frequency relative to the level of signal components at frequencies less than the predetermined frequency and sharply tuned bandpass circuit means coupled to the output of the high-boost filter circuit means for passing substantially only the cue signal tone bursts;

means responsive to the separated cue signal tone bursts for automatically controlling the auxiliary display unit in step with the playback of the recorded audio program signal;

and second frequency selective circuit means coupled to the magnetic tape recorder means during tape playback for separating the audio program signal from the cue signal tone bursts for providing an uncontaminated audio program signal for use by a loudspeaker type sound reproduction system, said second circuit means including low-boost filter circuit means coupled to the output of the high-boost filter circuit means for boosting the level of signal components at frequencies less than the predetermined frequency relative to the level of signal components at frequencies greater than the predetermined frequency, such low-boost filter circuit means being constructed so that the low frequency boost equalizes the low frequency attenuation provided by the high-boost filter circuit means.

18. An audio-visual display system in accordance with claim **17** wherein the signal combining means includes notch filter circuit means sharply tuned to the frequency of the tone burst oscillations for minimizing tone burst frequency components in the audio program signal before it is combined with the cue signal tone bursts.

19. An audio-visual display system in accordance with calim **17** wherein the second frequencey selective circuit means includes notch filter circuit means sharply tuned to the tone burst oscillation frequency for minimizing tone burst frequency components in the audio program signal to be supplied to the sound reproduction system.

20. An audio-visual display system in accordance with claim **17** wherein:

the first frequency selective circuit means includes notch filter circuit means sharply tuned to the tone burst oscillation frequency for minimizing tone burst frequency components in the audio program

signal before it is combined with the cue signal tone bursts;

and the second frequency selective circuit means includes notch filter circuit means sharply tuned to the tone burst oscillation frequency for minimizing tone burst frequency components in the audio program signal to be supplied to the sound reproduction system.

21. An audio-visual display system comprising:

magnetic tape recorder means for recording audio program signals on magnetic tape and for reproducing same during playback of a recorded tape;

at least one auxiliary display unit for producing audio effects or visual effects or both; and

cue encoding means coupled to the tape recorder means for recording channel cue signals on the magnetic tape at desired points in the audio program, said cue encoding means including means for producing signals which comprise repetitive groups of at least two pulses and means for independently changing the time interval between a selected pulse and a corresponding adjacent pulse in each group to thereby provide a control channel cue signal for a control channel designated by the selected pulse further including cue decoding means coupled to the tape recorder means and to the auxiliary display unit during tape playback and responsive to a reproduced control channel cue signal for automatically controlling the auxiliary display unit in step with the playback of the recorded audio program signals.

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