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(54) **SYSTEMS AND METHODS FOR ENCODING  
A DMX DATA STREAM AND DECODING AN  
AES DIGITAL AUDIO STREAM**

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**H04J 3/02** (2006.01)

(52) **U.S. Cl.** ..... **700/94**; 381/77; 370/537;  
370/542

(58) **Field of Classification Search** ..... 700/94;  
340/825.24, 825.25; 379/101.01  
See application file for complete search history.

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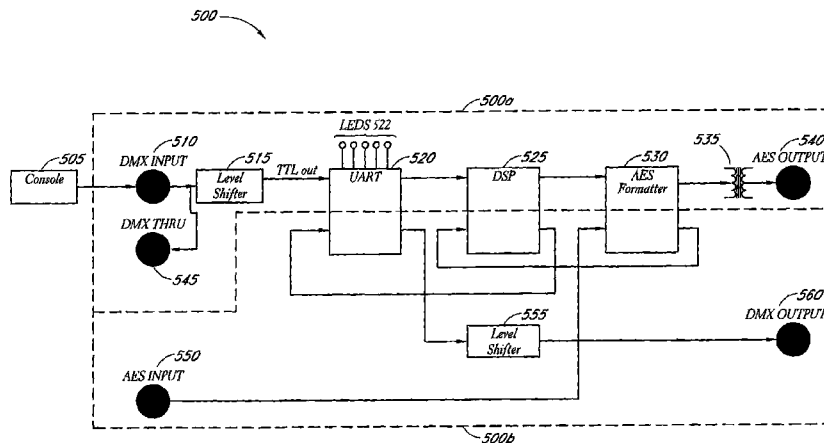
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(57) **ABSTRACT**

A tunneling system includes an encoding module, which is typically located in the production studio, and a decoding module, which is typically located in the entertainment venue. The encoding module is configured to incorporate DMX codes into an Audio Engineering Society (AES) digital audio stream to provide additional scenes, props, special effects, lights, sounds, and music in the entertainment venue. The DMX codes are typically incorporated into the AES digital audio stream so that they are synchronized with the performance recorded on the digital video stream. The encoding module is used to add, embed or record the AES digital audio stream with DMX codes, e.g., lighting data or queues, etc., which control the equipment in the entertainment venue. The recording module is used to make the standard AES/European Broadcasting Union (EBU) audio channels hold codes such as lighting data to enhance the entertainment experience.

**20 Claims, 10 Drawing Sheets**



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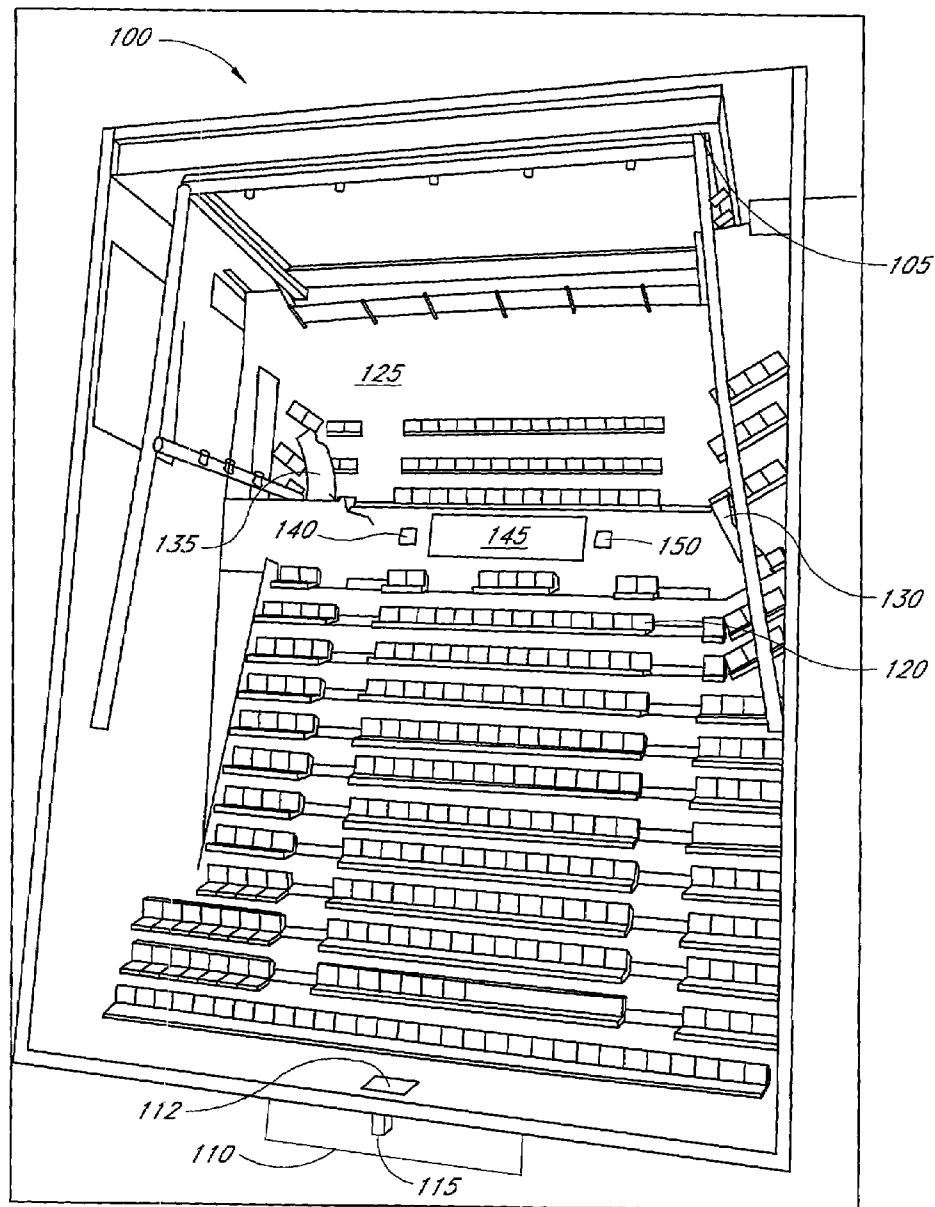
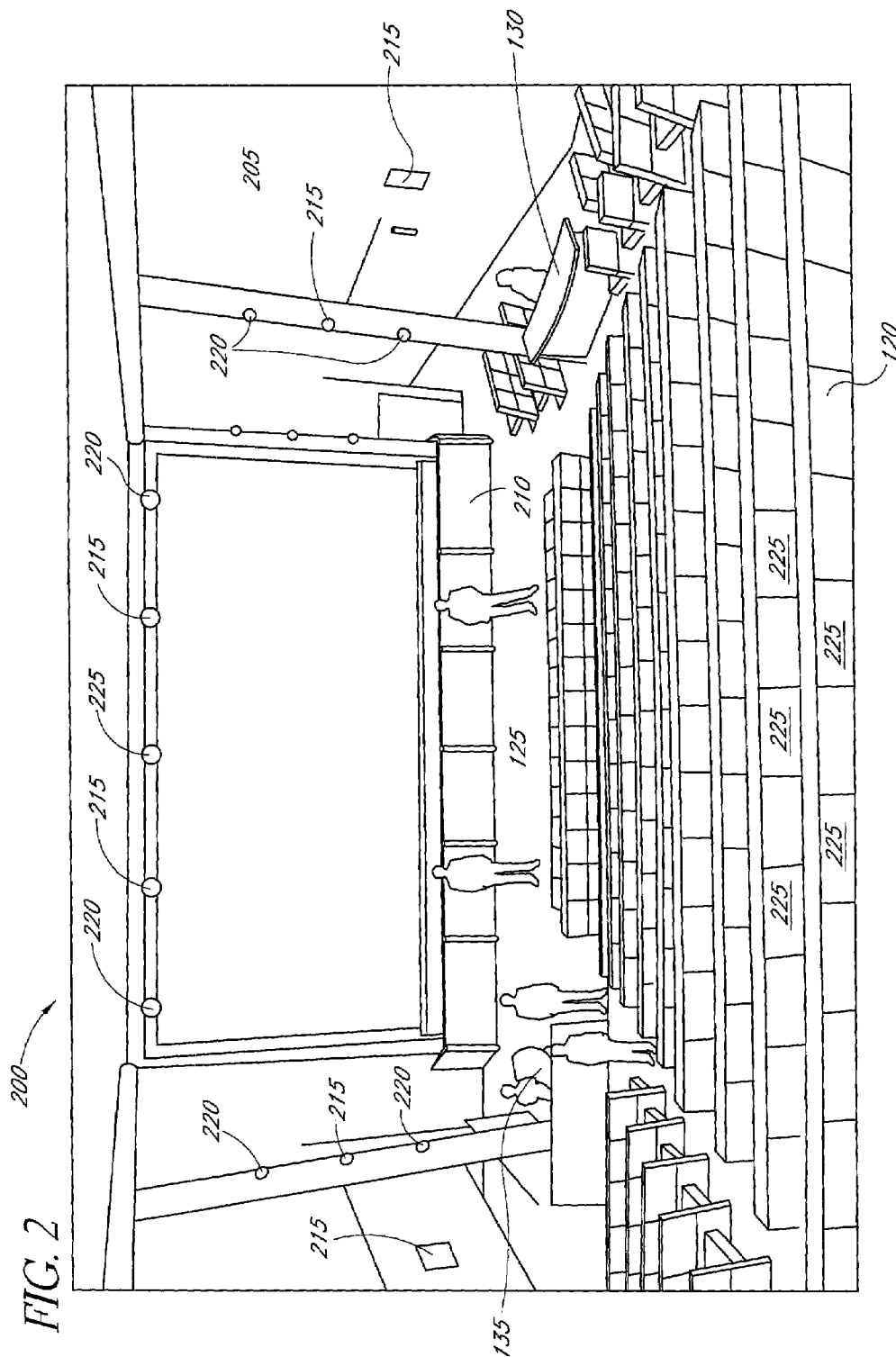
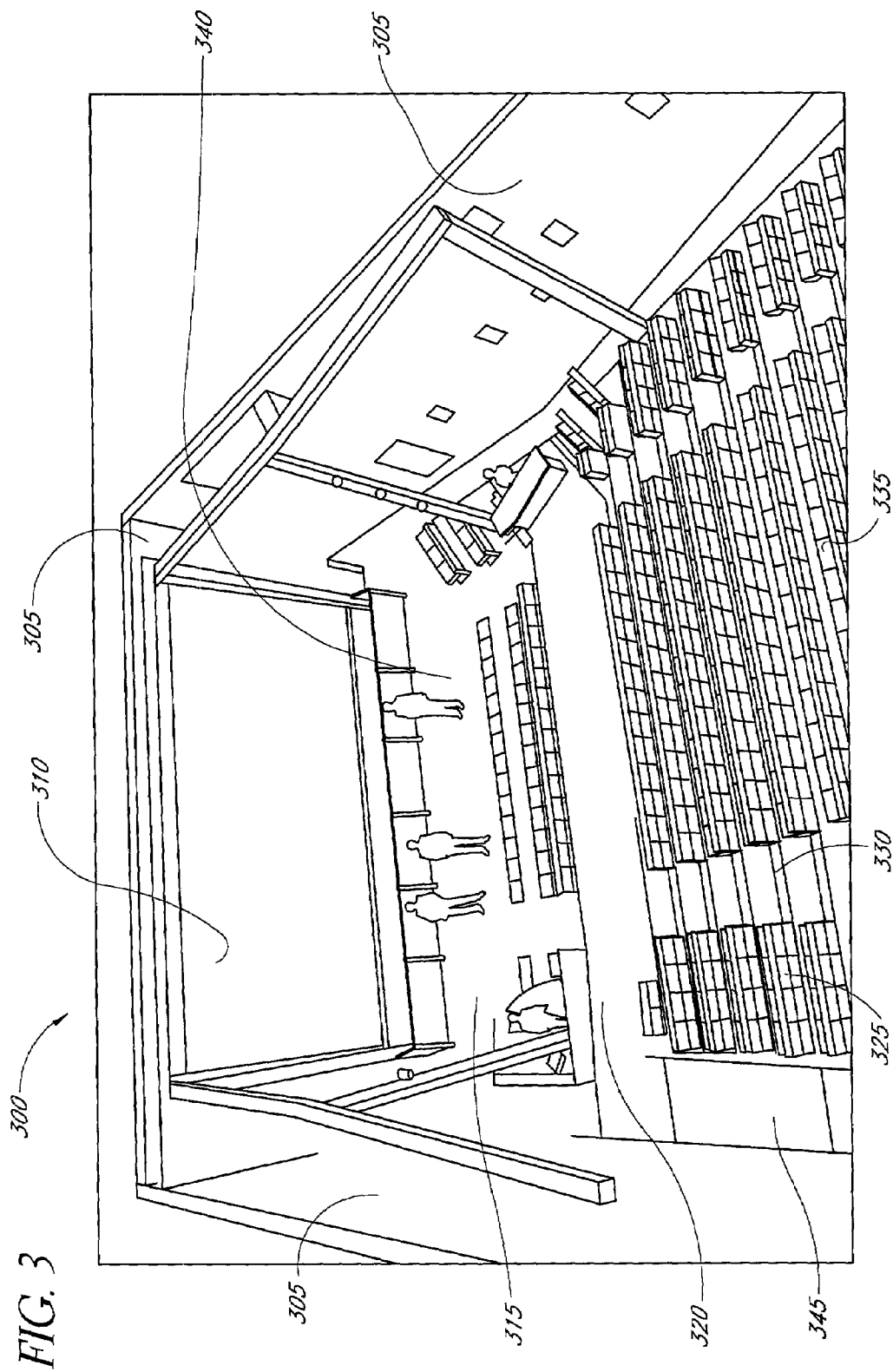


FIG. 1

FIG. 2





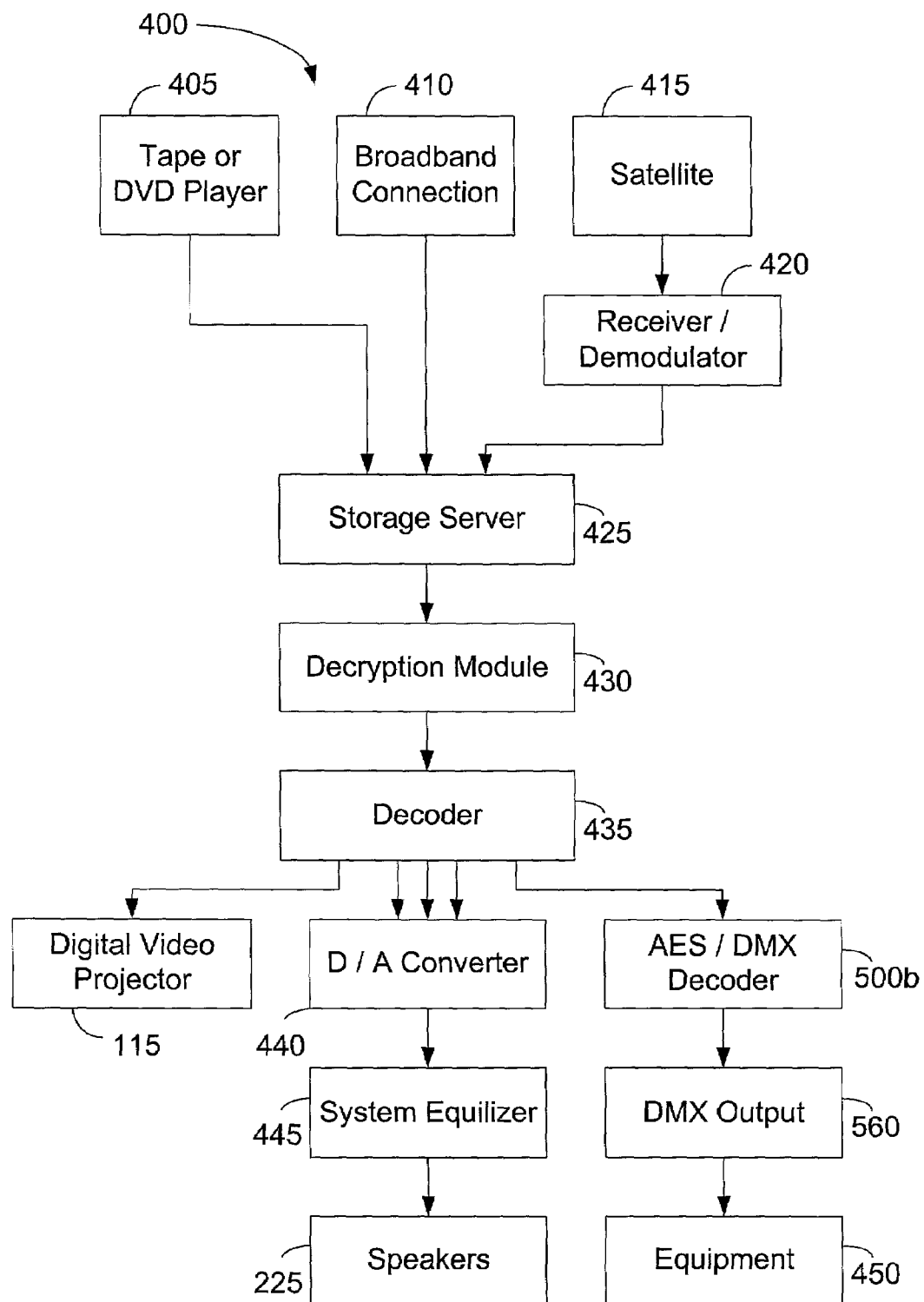
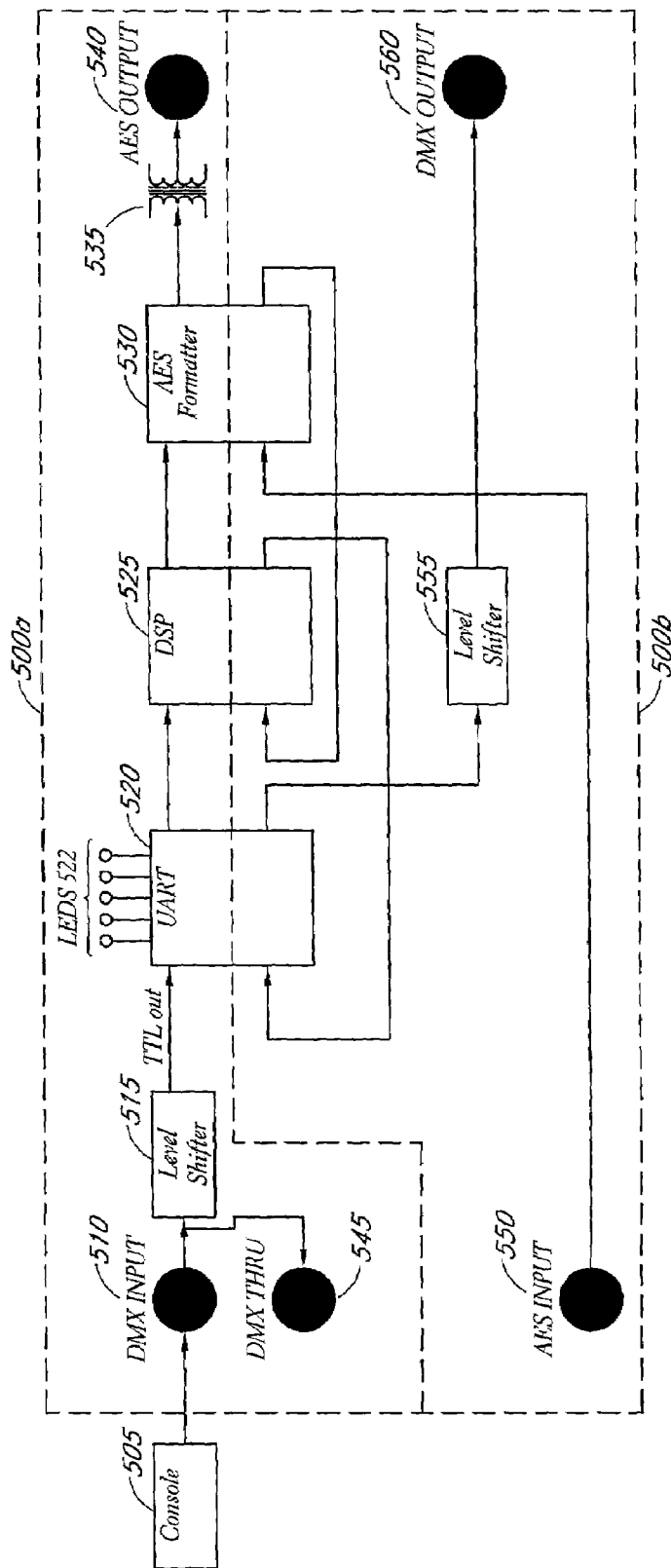


FIG. 4

FIG. 5



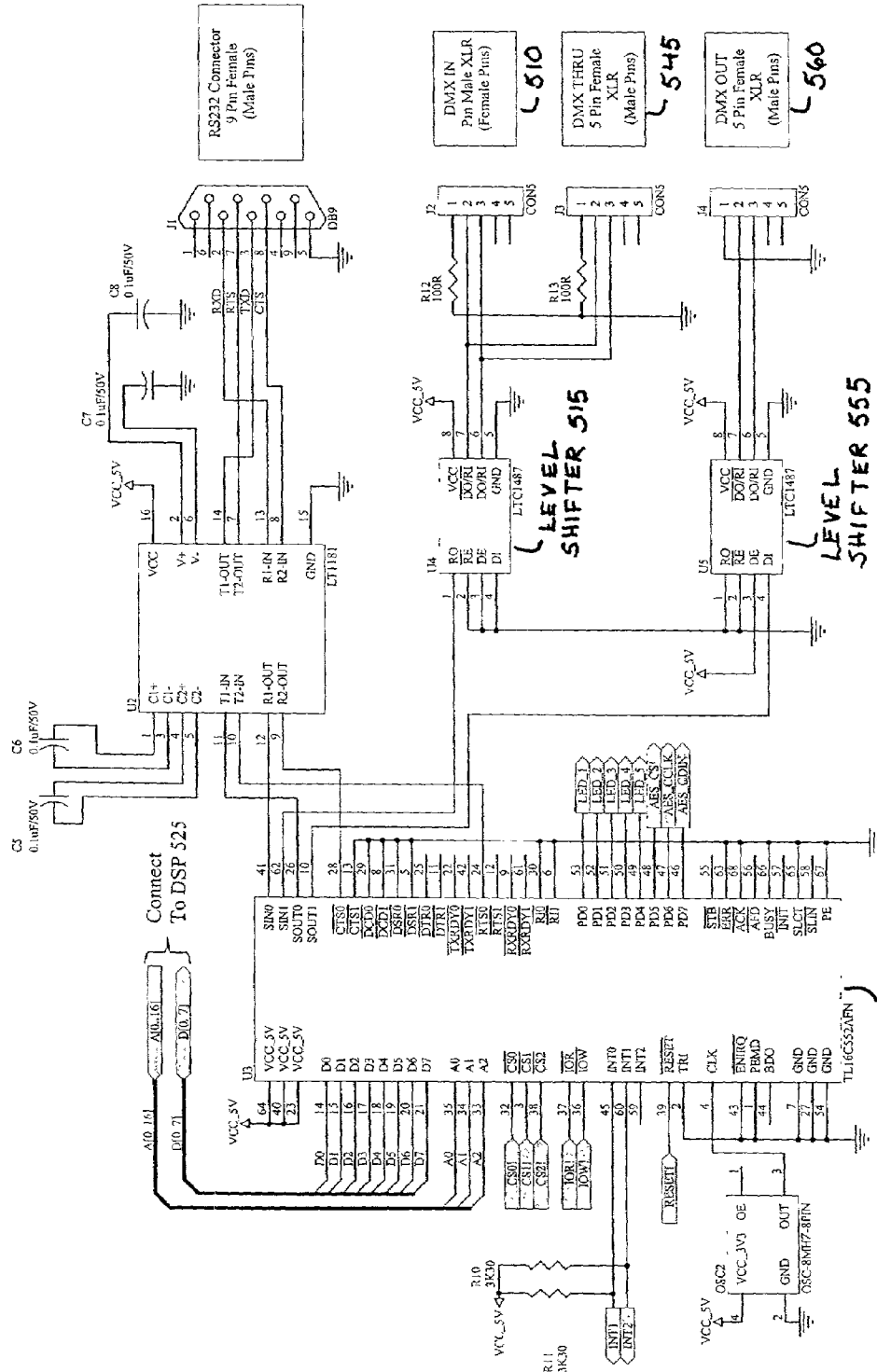


FIG. 6

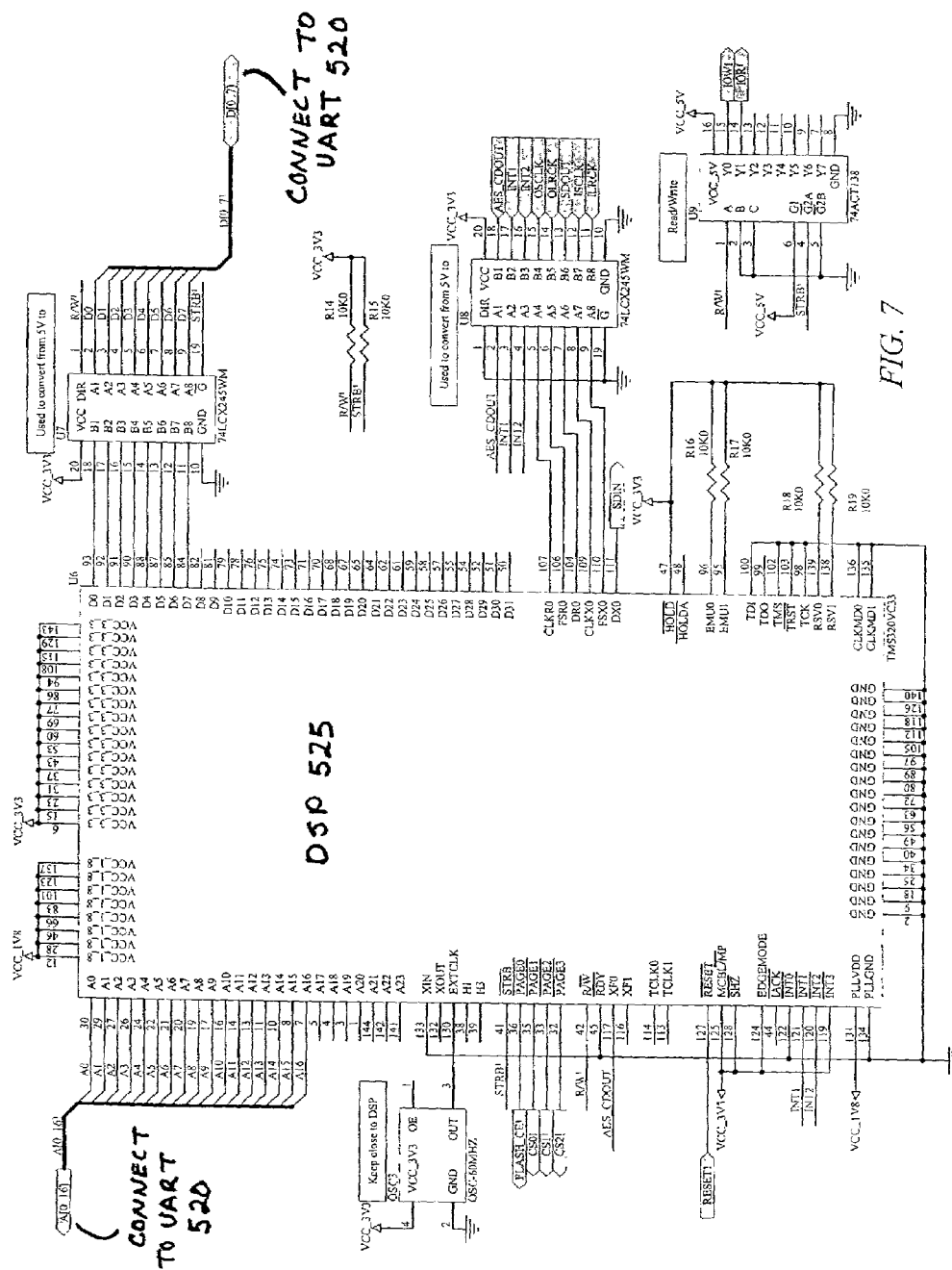


FIG. 7

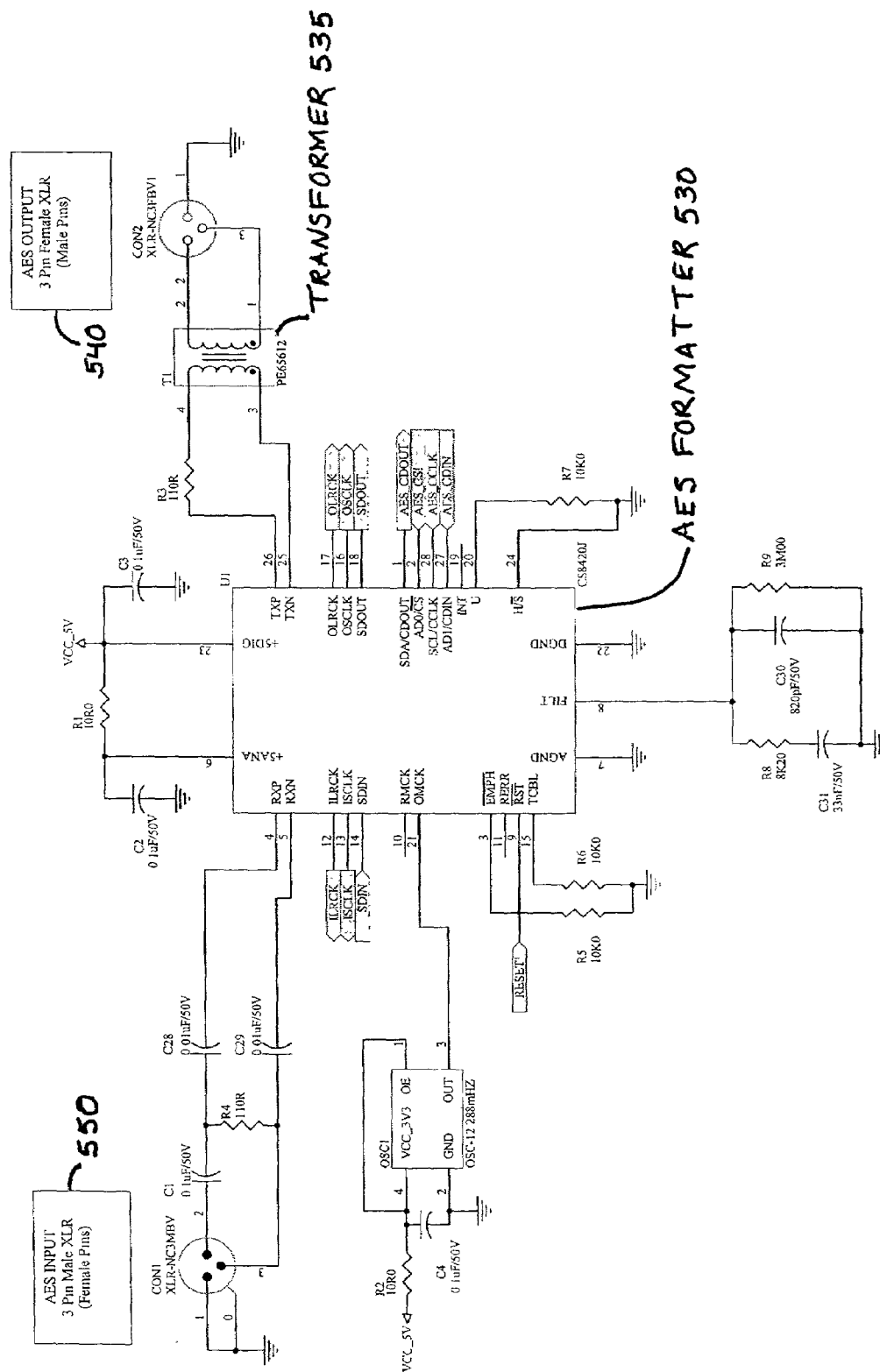


FIG. 8

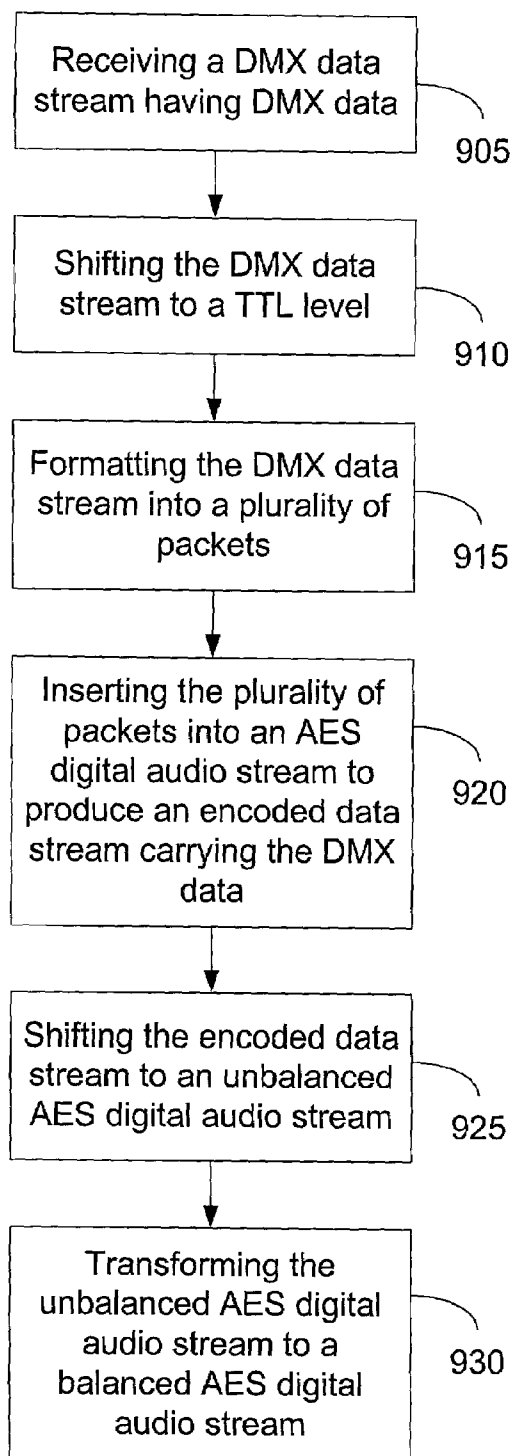


FIG. 9

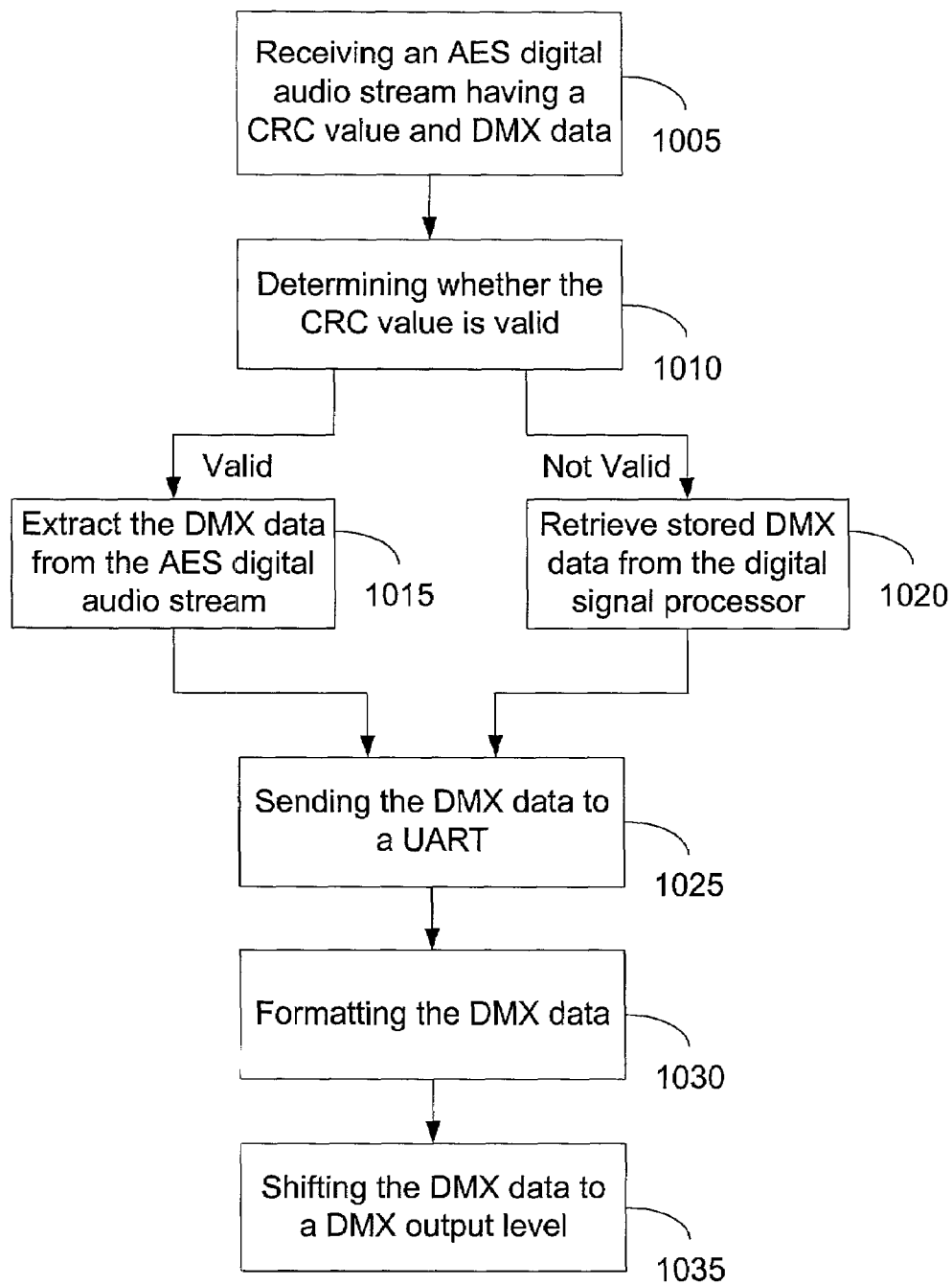


FIG. 10

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# SYSTEMS AND METHODS FOR ENCODING A DMX DATA STREAM AND DECODING AN AES DIGITAL AUDIO STREAM

## REFERENCE TO RELATED APPLICATION

The present application claims priority benefit under 35 U.S.C. § 119(e) from U.S. Provisional Application No. 60/271,527, filed Feb. 26, 2001, entitled "Integrated, Adaptable Theater and Multiplex." The present application incorporates the foregoing disclosure herein by reference in its entirety.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention is related to systems and methods for encoding and decoding data, and in particular, to systems and methods for encoding a DMX data stream and decoding an AES digital audio stream.

### 2. Description of the Related Art

While live concerts, plays, operas, and sporting events are a popular form of entertainment, many customers are looking for alternative forms of entertainment due to the high cost of travelling to these events, potential dangers of attending these events, and difficulty in obtaining tickets to these events. For example, parents might find it dangerous and expensive to send their children to a rock concert. Attempts have been made to provide adequate security at the events, however, the large crowds and dark concert halls have made it difficult to control the crowds.

As an alternative, conventional movie theaters have sometimes been used to play concert films. However, conventional movie theaters have failed to provide an adequately exciting environment for the viewing of certain types of entertainment content. For example, one reason that concert films are often not sufficiently successful at the box office is that passive viewing of a concert film at conventional movie theaters fail to approach the excitement and immediacy of an in-person live performance.

The concert films have also been released on DVDs in an attempt to attract customers to view the concert on large screen televisions with home surround sound systems. However, home television rooms are too small, and hence fail to create the concert-like atmosphere. Moreover, the small seating capacity and lack of any special effects have resulted in the DVDs option being relatively unsuccessful.

Hence, what is needed is a system and method of creating a realistic and exciting entertainment experience that will attract more customers into public entertainment venues, thereby increasing customer safety and enjoyment.

## SUMMARY OF THE INVENTION

The present invention advantageously provides a digital video distribution system configured to transmit a digital video from a live event, e.g., a sporting event, to an exciting, realistic, event-based entertainment venue, which includes a digital video projection system configured to project the live event. The entertainment venue is configured to simulate and recreate the live event and to provide additional experiences and features not available at the live event.

In one embodiment, a distribution system is provided which includes a server configured to receive an encrypted digital data stream, a decryption module configured to decrypt the encrypted digital data stream to produce a digital data stream, and a decoder configured to parse the digital

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data stream into a digital audio stream and a digital video stream and to send the digital video stream to a digital video projector. The distribution system might also include a digital-to-analog converter configured to receive a first portion of the digital audio stream and to convert the first portion of the digital audio stream to analog audio, and a decoder configured to receive a second portion of the digital audio stream, to extract a DMX code from the second portion of the digital audio stream, and to send the DMX code to equipment.

The present invention also provides a tunneling system, which includes an encoding module, which is typically located in the production studio, and a decoding module, which is typically located in the entertainment venue. The encoding module is configured to incorporate DMX codes into an Audio Engineering Society (AES) digital audio stream to provide additional scenes, props, special effects, lights, sounds, and music in the entertainment venue. The DMX codes are typically incorporated into the AES digital audio stream so that they are synchronized with the performance recorded on the digital video stream. The encoding module is used to add, embed or record the AES digital audio stream with DMX codes, e.g., lighting data or queues, etc., which control the equipment in the entertainment venue. The recording module is used to make the standard AES/European Broadcasting Union (EBU) audio channels hold codes such as lighting data to enhance the entertainment experience. Hence, the codes are typically placed on the audio portion or track of the original video.

In one embodiment, a DMX encoder is provided which includes a DMX input port configured to receive a DMX data stream having DMX data, a level shifter configured to shift the DMX data stream to a TTL level, and a universal asynchronous receiver and transmitter configured to format the DMX data stream into a plurality of packets. The DMX encoder further includes a digital signal processor configured to insert the plurality of packets into an AES digital audio stream to produce an encoded data stream carrying the DMX data, an AES formatter configured to shift the encoded data stream to an unbalanced AES digital audio stream, and a transformer configured to transform the unbalanced AES digital audio stream to a balanced AES digital audio stream.

After the DMX codes are added to the AES digital audio stream, the DMX codes can be decoded from the AES digital audio stream and can be played back in the entertainment venue without any human controlling the movement, color, intensity and timing of the lights during the performance. Furthermore, the AES digital audio stream with DMX codes avoids humans from having to attempt to synchronize the lights with the audio and video of the performance.

In one embodiment, a DMX decoder is provided which includes an AES formatter configured to receive an AES digital audio stream having a cyclic redundancy code value and DMX data, and a digital signal processor configured to receive the AES digital audio stream, to determine whether the cyclic redundancy code value is valid, and to extract the DMX data from the AES digital audio stream if the cyclic redundancy code value is valid and to retrieve stored DMX data if the cyclic redundancy code value is not valid. The DMX decoder further includes a universal asynchronous receiver and transmitter configured to receive the DMX data, and a level shifter configured to shift the DMX data to a DMX output level.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a theater, club or auditorium according to one aspect of the present invention;

FIG. 2 is a perspective view of a theater, club or auditorium according to one aspect of the present invention;

FIG. 3 is a perspective view of a theater, club or auditorium according to one aspect of the present invention;

FIG. 4 is a distribution system used to distribute digital content according to one aspect of the present invention;

FIG. 5 is a block diagram of a tunneling system according to one aspect of the present invention;

FIG. 6 is a schematic diagram showing the connections and layout of a DMX input, two level shifters, a UART, a DMX thru-output, and a DMX output according to one aspect of the present invention;

FIG. 7 is a schematic diagram showing the connections and layout of a DSP according to one aspect of the present invention;

FIG. 8 is a schematic diagram showing the connections and layout of an AES formatter and a transformer according to one aspect of the present invention;

FIG. 9 is a simplified flow chart of the operations of the DMX/AES encoder of FIG. 5 according to one aspect of the present invention; and

FIG. 10 is a simplified flow chart of the operations of the AES/DMX decoder of FIG. 5 according to one aspect of the present invention.

DETAILED DESCRIPTION OF THE  
PREFERRED EMBODIMENT

The present invention has applicability in the field of entertainment in general. For illustrative purposes, however, the following description pertains to theaters, clubs or other venues of entertainment. To facilitate a complete understanding of the present invention, the remainder of the detailed description describes the present invention with reference to the drawings, wherein like reference numbers are referenced with like numerals throughout.

The present invention advantageously provides an enhanced, event-based theater going experience. As will be described in greater detail below, one embodiment of the present invention enables live and/or pre-recorded videos of live performances, such as music concerts, to be reproduced with great realism and encourages theater attendees to act and feel more as participants and less as passive viewers. Further, theaters configured in accordance with the present invention enable customers to experience realistic, exciting, pre-recorded concerts, including behind the scenes footage, in the comfort and safety of a local movie theater. The present invention has combined elements from live events with elements from theaters, clubs or other venues of entertainment. Advantageously, in addition to screening concerts, the theater may be used to exhibit pre-recorded or remote live sporting events, business presentations, educational seminars, Broadway shows, plays, operas, religious events, and cultural events. In addition, national or history making events, such as coronations, royal weddings, inaugurations, state funerals, can be remotely presented in the theater, thereby providing a group setting for remotely participating in such important events. These events can be broadcast across the world.

FIG. 1 is a perspective view of a theater, club or auditorium 100 according to one aspect of the present invention. The theater 100 includes a projection screen 105, a projection room 110 having a projection window 112 and a

projector 115, seats 120, which optionally may be retractable and re-configurable, a communal area 125, an MC (master of ceremonies) station 130, and a cocktail lounge and/or a bar 135. Of course, in other embodiments, not all of the theater elements need to be included and some elements, such as the bar 135 or the MC station 130 may be removable.

The projector 115 is located in the projection room 110 and is positioned so that the video is projected through the projection window 112 and onto the projection screen 105. Optionally, the projector 115, or a portion thereof, is mounted on a movable platform so that the projector 115 can be easily moved to accommodate reconfigurations of the shape and size of the theater 100. The projector 115 can be a digital video projector, a movie projector or a conventional video projection system. By way of example, the digital video projector 115 can use direct-drive image light amplification, a reflective liquid crystal implementation in which electronic signals are directly addressed to the liquid crystal. In another example, the digital video projector 115 can be implemented using digital micro mirror devices. In another example, the digital video projector's light source is a laser. Preferably, the digital video projector 115 provides at least enough brightness to meet the 12-foot lamberts on-screen Society of Motion Picture and Television Engineers (SMPTE) film standard, though other brightness levels may be used as well. Optionally, the projection system can be a high definition system, providing resolutions of 1280×1024 pixels or even more.

In one embodiment, the seats 120 are arranged in parallel rows. In addition, a performance stage (not shown) is optionally positioned in front of the screen 105. The stage can be interchangeable with the communal area 125 or can be provided in addition to the communal area 125 by being positioned between the screen 105 and the communal area 125. The stage may be used to provide a performance area for live entertainers, such as dancers, who perform before, during, and after the screened show to add more of a human presence to the screened presentation. The communal area 125 (sometimes referred to as a mosh pit) is a defined area directly in front of the screen 105 on which a concert or a movie is being displayed, where people can gather and dance in time to the music, adding excitement to the performance. Optionally, the communal area 125 is located at the back of the theater 100 behind the last row of seats 120. The communal area 125 can also have a plurality of phone or television jacks. The phone jacks can be used to connect to the Internet or to make phone calls to place bets on events such as boxing, horse racing, basketball and football games.

In addition, the theater 100 may optionally include a dining area 140, including tables 145 and chairs 150, where diners can enjoy a meal while viewing a video, a pre-recorded or remote concert, a pre-recorded play, or the like. In the theater 100, some or all of the seats 120 can also be replaced with tables 145 and chairs 150 to enhance the dining and viewing experience.

The theater 100 may further include a concession stand 155 so that customers can order food, alcoholic and/or non-alcoholic drinks, merchandise such as shirts, jackets, hats, souvenir items or novelties related to the show being viewed, and have the item delivered to their seats 120. Optionally, a terminal 160 may be provided at each seat 120 from which customers can order food or other items from a menu displayed on the terminal 160. The terminal 160 can include a card swipe, which can be used by the customer to pay for the ordered items. The terminal 160 may be mounted on an arm rest of each seat 120 or on the back of each seat

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120 and is networked to a terminal in a theater kitchen, which can display the customer's order. The terminal 160 may alternatively be used as a audience response system connected to a central server.

To further make the entertainment experience more pleasurable and less stressful, customers can optionally be able to reserve assigned seating within the theater 100. Therefore, the customer does not have to arrive early to be ensured a good seat or to keep their party together. The customer may optionally be charged a premium to reserve an assigned seat. In one embodiment, if the customer has an assigned seat, the customer can put the ordered food on a "tab," where for a given showing, the seat is associated with the customer's credit card and the tab will be billed to the credit card. In addition, if the customer has an assigned seat, the customer can pre-order food or other items over the phone, by mail, or via the Internet before arriving at the show. The customer can further specify how long after the start of the film the food should be brought to the customer. Once the customer arrives at the theater 100, the food or other items will be brought to the customer in accordance with the customer's instructions. For convenience, a retractable eating tray can be stored within the customer's seat armrest or a tray can be lowered from the seat in front of the customer.

Tie-ins with the on-screen presentation being presented may be provided. For example, promotional items, which carry logos related to the presentation resembling characters in the presentation, or that carry logos of sponsors may be given away. The promotional items may be given to the entire audience, to the first predetermined number to arrive, or randomly. In addition, the promotional items can be dropped in coordination with events appearing on screen from nets suspended from the overhead grid at appropriate moments.

FIG. 2 is a perspective view of a theater, club or auditorium 200 according to another aspect of the present invention. The theater 100 may be changeably configured with scenic designs and other devices so that the theater interior does not appear to look like a traditional movie theater. The theater 200 can include one or more of the elements described for the theater 100.

The theater 200 can also include scenic elements 205, props 210, special effects machines 215, special effects lights 220, speakers 225, and the like that are supported and positioned in the theater 200. To enhance the realism of an event, the theater 200 can be reconfigured with unique scenic elements 205 that are determined based on the type of performance at the theater 200, e.g., the video content being shown, and that obscure the fact that customers are sitting in the theater 200. For example, for the showing of video content of an outdoor concert, outdoor scenery, including scenic backdrops painted with trees, fields, clouds, a famous outdoor stadium, crowds of people, or the like may be used as the scenic elements 205. Similarly, if a pre-recorded video of a rock concert is being shown in the theater 200, the scenic elements 205 might include banners and pictures of the members of the group. The scenic elements 205 may be ground supported, roof supported, and/or wall supported (as shown in FIG. 2). For the showing of a video of a play, ornate "walls" painted on a fabric may be lowered from the roof supports. The walls may be painted to resemble those of a famous playhouse or may be an original design. If a religious service is to be presented, backdrops and props 210 corresponding to a church, synagogue, temple, mosque, as appropriate, may be used.

In addition, sculptures, statues or mannequins can be used as the scenic elements 205 or the props 210, which can be

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positioned in or around the communal area 125. For example, cars, planes, trees, architectural elements, such as columns or arches, and the like may be used as the scenic elements 205 or the props 210. Similarly, the dining area 140 and the communal area 125 can be configured with appropriate scenery, such as coconut trees to resemble the famous, historical Coconut Grove nightclub or other nightclub.

The special effects machines 215 might include, for example, fog, mist or rain machines that are positioned to produce a mist on the patrons and the special effects lights 220 might include, for example, lasers, strobe lights or different colored lights that project toward the seats 120 or other places. The speakers 225 can be located overhead or attached to seats 120 in front of the patrons. In addition, the trusses may support catwalks, lighting bridges and a control platform from which sound, lighting and projection equipment may be controlled. Optionally, the sound, lighting, projection, and/or lifting equipment may be computer controlled to automate management of the equipment. Some or all of the elements listed above can instead be mounted to frames positioned substantially parallel to one or more walls.

To further enhance the theater going experience and add to the realism of the event, additional special effects machines 215 are provided. For example, an odor generator can be provided wherein the odor generator disperses mist or the like bearing odor compounds, such as compounds that emulate the smell of hay or fruit trees for more of an outdoors feeling. Further, the odor generator can be coordinated with a video or audio track. For example, if fireworks are exploded in a video sequence, the corresponding burnt smell can be generated at that time by the odor generator. In addition, "snow" making machines can be provided. By way of example, if viewers are watching a skiing event, flurries of snow can be generated at appropriate moments.

In addition, the special effects lights 220 can be computer controlled intelligent lights that are coordinated with the audio or video track of the concert footage. For example, bursts of high intensity lights can be set off in coordination with an on-screen fireworks explosion to simulate the light emitted by the fireworks explosion. The movement and operation of the special effects lights 220 are controlled by codes, e.g., DMX data. In another example, if strobe lights are being pulsed on-screen, strobe lights in the theater 200 can be set to pulse at the same frequency as the on-screen strobe lights. In still another example, when presenting an on-screen athletic competition, lights, strobes, music, and sound effects can be coordinated, such as by pulsing in time, to an audio track playback of an athlete's breathing, heart-beat or footfalls. Lasers can be coordinated to scan or pulse in a pattern similar to lasers in a video sequence. Smoke generators, coordinated with the audio or video track, can also be used to create a rock concert feeling. Further, small, explosive squibs may be used to simulate pyrotechnic sounds and smells.

The speakers 225 can be configured as a surround sound system having at least left front, right front, center, left surround, right surround, and/or rear surround channels to provide a more accurate and realistic reproduction of the audio portion of a screened event. For example, the theater 200 can include a 6 track or more of discrete digital or analog audio or one or more of the Digital Theater Systems (DTS™), the Dolby Digital™ system, or the Sony Dynamic Digital Sound™ (SDDS) system. In addition, the theater sound system and physical properties may be compatible with THX™ guidelines and standards. The speakers 225 can be suspended from the grid and moved as needed for

different events and different theater size and shape configurations. Seat vibrators coupled to the sound systems can be used so viewers can better “feel” the sound.

FIG. 3 is a perspective view of a theater, club or auditorium **300** according to another aspect of the present invention. The theater **300** may be custom built to include some or all of the elements described herein, or the theater **300** may be a standard movie theater modified or converted to include some or all of the elements described herein. The theater **300** may include four walls **305** with one or more projection screens **310** mounted on one or more of the walls **305**. One screen **310** can be located at the front of the theater **300**, while other screens **310** can be positioned so that attendees will be surrounded on two, three, or four sides by screens **310** and thereby feel more immersed in the presentation.

The theater **300** may include a floor **315** located directly in front of the front screen **310**. The floor **315** is flat and sized to provide a stable platform for dancing, movable chairs, and/or tables for dining. Rearward of the flat portion of the floor **315** is a ramped section **320** on which seats **325** are situated to provide good forward visibility. Optionally, instead of the ramped section **320** or further rearward of the ramped section **320**, the floor **315** has steps **330** to provide stadium seating. Stadium seating means that the height differential between adjacent steps **330** is large enough to provide a person in a higher row, e.g. the fifth row, to have an adequate view over persons sitting in lower rows, e.g., fourth. The steps **330** may be fixed, as in conventional theaters, or may be created using removable platforms or retractable seats **335** on a flat floor. The use of removable platforms or retractable seats **335** allows the theater **300** to be quickly reconfigured for different type of “events.” Thus, for example, if the video being shown is of a band that plays disco music and most of the anticipated customers are likely to dance, some or all of the platforms or retractable seats **335** may be removed to create or extend a dance floor **340**. In various configurations, the seating area will hold between 200 and 450 people. Other configurations can have larger or smaller capacity seating areas. In the example illustrations, a ramped entryway **345** is provided toward the rear of the theater **300**, though other types of entryways may be used as well.

To further enhance the adaptability of the theater **300**, optionally the theater size and shape can be adjusted as needed. Removable dividers, which may be in the form of scenic backdrops, can be suspended from the trusses and can be positioned to modify the theater size and shape. For example, if the video to be shown is of a chamber orchestra or a jazz trio, it may be desirable to create a relatively smaller, more intimate theater space. In such applications, the theater dividers may be moved inward to create the smaller space. By contrast, if a presentation of a large outdoor concert is being shown, then a larger theater space may be desirable and the dividers may be moved accordingly.

In another embodiment, one or more of the theater’s **300** non-load bearing walls, as opposed to lowered dividers as described above, may be movable and/or removable so that the size of can be adjusted. In a multi-theater complex (hereinafter “multiplex”), all or portions of one or more theaters **300** may be joined together by moving or removing walls to create a larger or differently shaped space. Alternatively, one theater **300** may be dedicated to providing the enhanced entertainment experience described herein, and other multiplex theaters may be utilized as conventional movie theaters.

To further make theater attendance a fun and realistic experience, a vestibule **350** to the theater **300** can be configured to appear to be the backstage of a venue, such as a rock concert, an opera house, a playhouse, or the like, that corresponds to the event or subject matter of the film being shown. For example, the vestibule **350** may contain a “green room,” makeup areas, and dressing rooms for the “performers.” The dressing rooms can be decorated with guitars, “personal” photographs, and the like, to correspond to a rock star performing in a concert film being shown. Actors pretending to be members of the rock band can further enhance the experience. Free snacks may be served backstage as well. Thus, when members of the audience arrive, they are greeted with all the excitement of being “backstage.” The vestibule may be located at the rear of the theater, behind the front screen, or along either side of the theater. In another embodiment, the “backstage” area is located in front of the screen, in the main portion of the theater **300**. Before the main on-screen presentation begins, a backstage on-screen presentation, showing the backs of the on-screen entertainers, can be shown to emulate the backstage feeling. When it is time for the main presentation to begin, the on-screen presentation is “flipped” 180 degrees to show the front of the entertainers to the theater attendees, indicating that the attendees are now the “audience.”

FIG. 4 is a distribution system **400** used to distribute digital content according to one aspect of the present invention. The analog or digital recording of the live event or performance is typically stored on a storage device such as an analog or digital tape, a digital memory chip or card or a digital video diskette (DVD). In one embodiment, the audio of the event is stored on a first storage device and the video of the event is stored on a second storage device. A tape or DVD player **405** can be used to play the tape or DVD. Optionally, as the live event is being filmed, the content can be sent via a broadband connection **410**, e.g., a DSL, T-1 or T-3 line, or can be transmitted to a receiver/demodulator **420** via a satellite dish **415**.

The content is typically encrypted using known encryption methods. The encrypted digital data stream is stored on a storage server **425** and sent to the decryption module **430**. The encrypted digital data stream is typically decrypted using known decryption methods, e.g., a conditional access decryption method. The digital data stream is then sent to a decoder **435**. The decoder **435** parses the digital data stream into a digital audio stream and a digital video stream. The digital video stream is sent to the digital video projector **115** in a particular format, for example, a 292M video format, for projecting the digital video stream on the projection screen **105**. The digital video stream can be projected using one or more projectors **115** in one or more projection rooms **110**. For a given event, the content may include multiple views of the same event. The multiple views are projected on multiple screens within the theater **100**, thereby providing a more exciting and realistic screening of the event.

The digital audio stream is further parsed into four or more AES pairs of digital audio. For example, the first three AES pairs, tracks 1–6, are sent to a D/A converter **440**, and the fourth AES pair, tracks 7–8, are sent to the AES/DMX decoder **500b**.

The D/A converter **440** converts the digital audio stream into six or more channels of analog audio, which are sent to a system equalizer **445** for equalizing the analog audio. From the system equalizer **445**, each channel is coupled to an amplifier and then to speaker **225**.

The AES/DMX decoder **500b** takes the fourth or another AES pair of digital audio, also referred to as the AES digital

audio stream, extracts DMX data from the AES digital audio stream, and sends the DMX data to the equipment **450** via a DMX output port (discussed below). The AES digital audio stream has embedded DMX synchronization codes used to automatically coordinate presentation of the media content with lighting, special effects, scenery changes and the like. Thus, for example, the digital video stream can be synchronized with the digital audio stream, which controls the equipment **450** for the theater effects, e.g., the scenic elements **205**, props **210**, special effects machines **215**, special effects lights **220**, speakers **225**, etc. Upon receiving an appropriate DMX code, the AES/DMX decoder **500b** sends the DMX codes to the equipment **450**, which then perform as commanded.

If the projector **115** is a standard film projector, cue tapes attached to the film or magnetic tapes synchronized with the film may be used to automatically coordinate the film and the equipment **450** for the theater effects. A cue tape is generally a short strip of metal fastened to the edge of the film at a specific location. At the appropriate time, the film passes two electrical contacts within the projector **115** and the cue tape completes a circuit between the contacts. The completed circuit then triggers a command to be sent to the equipment **450** to perform the specified instruction.

To make the on-screen presentation more realistic, optionally the video might not include any previews, credits or titles during the opening sequences or at the end of the presentation. Instead, the video presents the recorded event as if it were being viewed live, with the on-screen presentation introduced by either an MC or announcer within the video itself, or by a live MC or announcer in the theater **100**.

One embodiment of the present invention advantageously provides a certain level of interactivity with the audience. A control system (not shown) can be configured to monitor the audience noise or applause. For example, if the audience applauds louder than a predetermined noise level or for a prolonged period of time at the end of a pre-recorded performance, then the control system sends a command to the storage system **425** to play one or more pre-recorded encores. The number of encores can be related to the loudness or length of the applause. In another example, if the audience is making a great deal of noise during a performance, such as by singing along with a pre-recorded performance, the control system can be configured to adjust, i.e., increase, the volume of the speakers **225** to compensate for the additional noise.

FIG. **5** is a block diagram of a tunneling system **500** according to one aspect of the present invention. The tunneling system **500** is a system that is used to add, embed or record the original pre-recorded digital audio stream with codes, e.g., lighting data or queues, etc., that control the equipment **450** for the theater effects. In other words, the tunneling system **500** provides a system that is used to make the standard Audio Engineering Society (AES)/European Broadcasting Union (EBU) audio channels hold codes such as lighting data to enhance the entertainment experience. Hence, the codes are typically placed on the audio portion or track of the digital audio stream.

The tunneling system **500** allows an entertainment designer the ability to uniquely design each performance by incorporating various codes into the digital audio stream to provide additional scenes, props, special effects, lights, sounds, and music in the theater **100**. In one embodiment, using a lighting control console **505** such as the Whole Hog II, the entertainment designer can view and listen to the original analog or digital audio and video stream while simultaneously adding lighting queues to the digital audio

stream. Thus, once the lighting queues are added to the digital audio stream, the AES digital audio stream can be played back in the theater **100** without any human controlling the movement, color, intensity and timing of the lights during the performance. Furthermore, the AES digital audio stream avoids humans from having to attempt to synchronize the lights with the audio and video of the performance.

The tunneling system **500** includes an encoder **500a**, which is typically located in the production studio (full size replication of a movie theater) and is used to create the AES digital audio stream, and a decoder **500b**, which is typically located in every theater **100** and is used to play back the AES digital audio stream. The encoder **500a** includes a DMX input **510**, a level shifter **515**, a Universal Asynchronous Receiver and Transmitter (UART) **520**, a Digital Signal Processor (DSP) **525**, an AES formatter **530**, a transformer **535**, an AES output **540**, and a DMX thru-output **545**. The encoder **500a** can also be referred to as an embedding module, or DMX to AES encoder. The decoder **500b** includes an AES input **550**, the UART **520**, the DSP **525**, the AES formatter **530**, a level shifter **555**, and a DMX output **560**. The decoder **500b** can also be referred to as an AES to DMX decoder.

FIG. **6** is a schematic diagram showing the connections and layout of the DMX input **510**, the level shifter **515**, the UART **520**, the DMX thru-output **545**, the level shifter **555**, and the DMX output **560**. In one embodiment, the level shifter **515**, **555** is one manufactured by Linear Technologies, model number LTC1487. The UART **520** is one manufactured by Texas Instruments, model number TL16C552AFN. One of ordinary skill in the art will understand that other similar level shifters and UART can be used while still maintaining the spirit and scope of the present invention.

FIG. **7** is a schematic diagram showing the connections and layout of the DSP **525**. In one embodiment, the DSP **525** is one manufactured by Texas Instruments, model number TMS320VC33. One of ordinary skill in the art will understand that other similar DSPs can be used while still maintaining the spirit and scope of the present invention.

FIG. **8** is a schematic diagram showing the connections and layout of the AES formatter **530** and the transformer **535**. In one embodiment, the AES formatter **530** is one manufactured by Cirrus Logic, model number CS8420J. The transformer **535** is one manufactured by Pulse Engineering, model number PE65612. One of ordinary skill in the art will understand that other similar formatters and transformers can be used while still maintaining the spirit and scope of the present invention.

As shown in FIGS. **5-8**, the encoder **500a** and the decoder **500b** can utilize some or all of the same circuit components, thus providing a more robust design.

FIG. **9** is a simplified flow chart of the operations of the DMX/AES encoder and FIG. **10** is a simplified flow chart of the operations of the AES/DMX decoder. References to FIGS. **9** and **10** will be made in the discussion of FIG. **5**.

Referring back to FIG. **5**, the DMX input **510** is connected to the lighting control console **505**. To begin adding the DMX codes to the original AES/EBU video, the entertainment designer uses the lighting control console **505** to select, while the digital video stream is being played, which codes and when the codes are to be placed in the digital audio stream. For example, as the digital video stream is being played on the lighting control console **505**, the entertainment designer selects the codes that are to be stored in the digital audio stream. Each code represents one or more operations to be performed by the equipment **450**. The codes are stored

in the lighting control console **505**. The DMX input **510** is configured to receive the digital audio stream having DMX codes or data (state **905**). Hence, the recording of the codes is synchronized with the digital video stream.

The DMX thru-output **545** is configured to connect to the equipment in the production studio so the entertainment designer can view, feel, and listen to the created effects. The equipment in the production studio is similar to the equipment **455** in the theater **100** and provides the entertainment designer with a realistic, real-time representation of the created effects. For example, if one red light is selected to turn on at the beginning of the video, the entertainment designer can view the red light turning on in the production studio after the selection has been made.

Once the codes have been inserted into the digital audio stream, the level shifter **515** receives the digital audio stream and shifts the digital audio stream to a Transistor-Transistor-Logic (TTL) level (state **910**). The UART **520** is configured to format or parse the digital audio stream into a plurality of packets of approximately equal size (state **915**).

The DSP **525** is configured to request and receive the plurality of packets from the UART **520**. The DSP **525** is also configured to insert the plurality of packets into an AES digital audio stream to produce an encoded data stream carrying the DMX codes (state **920**). For each DMX code, the DSP **525** creates a Cyclic Redundancy Code (CRC) code and merges the CRC code into the plurality of packets. Hence, a number of codes are embedded into each of the plurality of packets.

The DSP **525** is also configured to store a plurality of DMX codes representing pre-programmed scenes, props, special effects, lights, sounds, and music. Therefore, rather than receiving the codes from the UART **520**, the DSP **525** can retrieve the plurality of pre-programmed codes from memory, creates the CRC codes, and merge the CRC codes into the plurality of packets. In one embodiment, the DSP **525** is configured to store a plurality of pre-programmed test codes representing a pre-programmed test for the equipment. The pre-programmed test codes provide codes that instruct the equipment **450** to operate in the theater **100** to ensure the equipment **450** is operating and functioning correctly.

Furthermore, the DSP **525** is configured to store a plurality of scaler DMX codes for each theater. For example, the scaler DMX codes can include the range of motion for each light, the maximum intensity for each light, the maximum volume for the speakers **225**, maximum rate of fog dispersed from each fog machine, etc. Using the scalars, the DSP **525** can verify if the code is within the specified parameter and, if not, the DSP **525** can adjust the code accordingly.

The AES formatter **530** is configured to shift the encoded data stream to an unbalanced AES digital audio stream (state **925**). The AES formatter **530** is also configured to generate the AES digital audio stream or receive the AES digital audio stream from the AES input port **550**. An AES word clock signal that is derived from the AES input port can be sent to the AES formatter **530** for synchronizing the output of the AES formatter **530**. The transformer **535** is configured to transform the unbalanced AES digital audio stream to a balanced AES digital audio stream (state **930**).

Once the AES digital audio stream having at least one CRC code and DMX codes has been created, each theater **100** can decode the DMX codes from the AES digital audio stream using the AES/DMX decoder **500b**. The AES digital audio stream might be stored on a server that is located at each theater **100**. The server has an output for the AES

digital audio stream that is connected to the AES input port **550** of the AES/DMX decoder **500b**. The AES input **550** is connected to the AES formatter **530**, which is configured to receive the AES digital audio stream having the CRC code and the DMX data (state **1005**). The AES formatter **530** is further configured to verify that the AES digital audio stream is a valid AES stream and to convert the AES digital audio stream to a TTL level. Thereafter, the AES formatter **530** sends the AES digital audio stream to the DSP **525**.

The DSP **525** is configured to receive the AES digital audio stream and to determine whether the CRC code is valid (state **1010**). Determining the validity of the CRC code ensures that the DMX codes within the AES digital audio stream are not corrupt. If the CRC code is valid, the DSP **525** extracts the DMX data from the AES digital audio stream (state **1015**). If the CRC code is not valid, the DSP **525** retrieves stored DMX data from the memory of the DSP **525** (state **1020**). The memory of the DSP **525** stores a plurality of DMX codes that are pre-programmed. Each pre-programmed plurality of DMX code represents a particular scene. The DSP **525** is also configured to connect to an RS **232** cable, which can be connected to a computer that can be used to download the DMX codes to the memory of the DSP **525**. The DSP **525** is also configured to send the DMX codes to the UART **520** (state **1025**).

The UART **520** is configured to format the DMX codes and transmits the DMX codes to the level shifter **555** at specific times (state **1030**). The level shifter **555** is configured to shift the formatted DMX codes to a DMX output level (state **1035**) and to send the DMX codes to the DMX output **560**, which is coupled to the equipment **450** (see also FIG. 4). The DMX codes are sent to the equipment **450** to perform functions and operations represented by the DMX codes.

Thus, as described above, the present invention provides an enhanced, event-based theater going experience. A theater configured in accordance with the present invention permits screenings of pre-recorded videos of live performances to be reproduced with such realism that the audience feels as if they are at the actual live event.

Although this invention has been described in terms of certain preferred embodiments, other embodiments that are apparent to those of ordinary skill in the art are also within the scope of this invention.

What is claimed is:

1. A Digital Multiplex lighting protocol (DMX) encoder, comprising:

- a DMX input port configured to receive a DMX data stream having DMX data;
- a level shifter configured to shift the DMX data stream to a Transistor-Transistor-Logic (TTL) level;
- a universal asynchronous receiver and transmitter configured to format the DMX data stream into a plurality of packets;
- a digital signal processor configured to insert the plurality of packets into an Audio Engineering Society/European Broadcasting Union (AES) digital audio stream to produce an encoded data stream carrying the DMX data;
- an AES formatter configured to shift the encoded data stream to an unbalanced AES digital audio stream; and
- a transformer configured to transform the unbalanced AES digital audio stream to a balanced AES digital audio stream.

2. The DMX encoder as defined in claim 1, wherein the AES digital audio stream is received from the AES formatter.

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3. The DMX encoder as defined in claim 1, wherein the AES formatter is configured to generate the AES digital audio stream.

4. The DMX encoder as defined in claim 1, further comprising an AES input port coupled to the AES formatter.

5. The DMX encoder as defined in claim 4, wherein the AES formatter is configured to receive the AES digital audio stream from the AES input port.

6. The DMX encoder as defined in claim 4, wherein the AES formatter is configured to receive an AES word clock signal that is derived from the AES input port.

7. The DMX encoder as defined in claim 6, wherein the AES word clock signal synchronizes an output of the AES formatter.

8. A method of encoding a Digital Multiplex lighting protocol (DMX) data stream into a balanced Audio Engineering Society/European Broadcasting Union (AES) digital audio stream, the method comprising:

receiving a DMX data stream having DMX data;

shifting the DMX data stream to a Transistor-Transistor-Logic (TTL) level;

formatting the DMX data stream into a plurality of packets;

inserting the plurality of packets into an AES digital audio stream to produce an encoded data stream carrying the DMX data;

shifting the encoded data stream to an unbalanced AES digital audio stream; and

transforming the unbalanced AES digital audio stream to a balanced AES digital audio stream.

9. The method of encoding as defined in claim 8, further comprising generating the AES digital audio stream.

10. The method of encoding as defined in claim 8, further comprising receiving the AES digital audio stream.

11. The method of encoding as defined in claim 8, further comprising receiving an AES word clock signal for synchronization.

12. A Digital Multiplex lighting protocol (DMX) decoder, comprising:

an Audio Engineering Society/European Broadcasting Union (AES) formatter configured to receive an AES digital audio stream having a cyclic redundancy code value and DMX data;

a digital signal processor configured to receive the AES digital audio stream, to determine whether the cyclic redundancy code value is valid, and to extract the DMX data from the AES digital audio stream if the cyclic redundancy code value is valid and to retrieve stored DMX data if the cyclic redundancy code value is not valid;

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a universal asynchronous receiver and transmitter configured to receive the DMX data; and  
a level shifter configured to shift the DMX data to a DMX output level.

13. The DMX decoder as defined in claim 12, wherein the AES formatter is further configured to convert the AES digital audio stream to a Transistor-Transistor-Logic (TTL) level.

14. The DMX decoder as defined in claim 12, wherein the AES formatter is further configured to verify that the AES digital audio stream is a valid AES stream.

15. The DMX decoder as defined in claim 12, wherein the digital signal processor is further configured to store a plurality of DMX codes representing a particular scene.

16. The DMX decoder as defined in claim 12, wherein the universal asynchronous receiver and transmitter is further configured to format the DMX data.

17. A method of decoding an Audio Engineering Society/European Broadcasting Union (AES) digital audio stream into a Digital Multiplex lighting protocol (DMX) data stream, the method comprising:

receiving an AES digital audio stream having a cyclic redundancy code value and DMX data;

sending the AES digital audio stream to a digital signal processor;

determining whether the cyclic redundancy code value is valid;

if the cyclic redundancy code value is valid, then extract the DMX data from the AES digital audio stream, and

if the cyclic redundancy code value is not valid, then retrieve stored DMX data from the digital signal processor;

sending the DMX data to a universal asynchronous receiver and transmitter;

formatting the DMX data; and

shifting the DMX data to a DMX output level.

18. The method of decoding as defined in claim 17, further comprising storing a plurality of DMX codes in the digital signal processor, the plurality of DMX codes representing a particular scene.

19. The method of decoding as defined in claim 17, further comprising storing a plurality of scaler DMX codes in the digital signal processor.

20. The method of decoding as defined in claim 19, wherein the digital signal processor compares the plurality of scaler DMX codes with the DMX output level to ensure that the DMX output level is not greater than one or more of the plurality of scaler DMX codes.

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