WIRELESS MULTITRACK RECORDING SYSTEM

DETAILED DESCRIPTION

As required, a detailed illustrative embodiment of the present invention is disclosed herein. However, techniques, systems and operating structures in accordance with the present invention may be embodied in a wide variety of forms and modes, some of which may be quite different from those in the disclosed embodiment. Consequently, the specific structural and functional details disclosed herein are merely representative, yet in that regard, they are deemed to afford the best embodiment for purposes of disclosure and to provide a basis for the claims herein, which define the scope of the present invention. The following presents a detailed description of one embodiment (as well as some alternative embodiments) of the present invention.

Referring first to FIG. 1, depicted is recording system **100** in accordance with one embodiment of the present invention. Recording system **100** wirelessly broadcasts and/or records live audio events, such as performances, news announcements, etc. having one or more speakers. In one aspect of the present invention, recording system **100** automatically corrects for any audio data lost due to wireless transmission problems such as dropout, interference, etc. In another aspect of the present invention, each speaker's audio is fed back to the respective speaker such that the feedback delay is minimized or eliminated. In yet another aspect of the present invention, audio may be sent wirelessly from a remote location to one or more speakers without the need for a second local device (e.g., a body pack).

In the embodiment of the present invention depicted in FIG. 1, recording system **100**

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includes local audio devices **102**, remote control unit **104**, receiver **106**, and audio recorder **108**. In one embodiment, remote control unit **104** is a radio frequency ("RF") transmitter capable of transmitting one or more of a time reference signal, digital commands, and audio to one or more of local audio devices **102**, receiver **106**, and audio recorder **108**. Additionally, remote control unit **104** is capable of remotely controlling local audio devices **102**, receiver **106**, and audio recorder **108** to perform tasks such as audio playback, mixing of remote director audio with local speaker audio, etc. as discussed in further detail herein.

Although recording system **100** is depicted in FIG. 1 as including a receiver **106** and recorder **108**, some embodiments of the present invention may omit one or more of these elements. For example, embodiments of the present invention are envisioned without receiver **106** and recorder **108**. In such an embodiment, recording and synchronized playback features may not be available, however, local audio feedback and mixing of local and remote audio shall be available.

FIG. 2A depicts a block diagram of one embodiment of remote control unit **104** in accordance with the present invention. In this embodiment, remote control unit **104** includes, *inter alia*, remote transmitter **208** and external interface **210**. **[[GLENN - WE NEED TO ADD MORE DETAIL – THE LEGAL STANDARD IS THAT YOU MUST DISCLOSE ENOUGH INFORMATION TO TEACH SOMEONE OF SKILL IN THE ART TO MAKE THIS DEVICE – ALSO - SHOULD THIS UNIT INCLUDE A CLOCK OR TIME CODE GENERATOR AND A CONTROL UNIT SUCH AS A PC??]]**

Remote transmitter **208** allows remote control unit **104** to transmit a time reference signal, digital commands, audio, and the like to other devices such as local audio devices **102**, receiver **106**, and audio recorder **108**. In one aspect of the present invention, the time

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reference signal is a Society of Motion Picture and Television Engineers ("SMPTE") time code signal containing information regarding the hour, minute, second, frame, type of time code (i.e., nondrop or drop frame), and **???? [GLENN-WHAT TYPE OF USER DEFINABLE INFORMATION IS INCLUDED IN THIS SIGNAL??]** This time reference signal provides a time reference for all local audio devices **102**, which use this information to synchronize their respective local clock **304** (FIG. 3). Such synchronization ensures that all local audio devices **102** store all locally recorded audio with the same time code number as all other local audio devices **102**. The time code number is then used during playback and recording to ensure that the replayed and recorded audio from all local audio devices **102** is synchronized.

[[GLENN-WE SHOULD ADD MORE INFORMATION REGARDING THE FORM AND METHOD OF TRANSMITTING THE DIGITAL COMMANDS TO THE LOCAL AUDIO DEVICES??]]

In embodiments of the present invention wherein remote control unit **104** is capable of transmitting audio, a director of an audio event may transmit directions, in the form of spoken dialogue, to one or more speakers of the audio event either individually or simultaneously. For example, such audio may be received by audio receiving device **212** (e.g., a microphone), which is connected to remote control unit **104** via audio input port **214**. In this embodiment, mixer(s) **318** (FIG. 3) of receiving local audio device(s) **102** mix the audio received from remote control unit **104** with the feedback audio generated locally at local audio device **102** as discussed in greater detail below. Mixing these two audio signals locally at local audio device **102** minimizes, or eliminates, the external processing delay common with remote mixing of such digital signals, thereby providing a better overall

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performance. Using the present invention, the speaker receives the fed back audio nearly instantaneously allowing the speaker to more quickly correct or optimize any deficiencies in the performance, announcement, etc.

Also, the present invention allows a director or other user of remote control unit **104** to remotely control the local mixing of the audio received at local audio device **102** from remote control unit **104** with the locally generated feedback audio. The mixing parameters are dictated by remote control unit **104** to one or more local audio devices **102** via a control signal embedded in the audio transmitted from remote control unit **104** to local audio device **102**. **[[GLENN-WE SHOULD ELABORATE ON THIS]]** For example, such commands may direct local audio device **102** to mix the director's remotely transmitted audio with the locally generated feedback audio through side tone injection, **[[GLENN-WHAT OTHER METHODS OF MIXING ARE AVAILABLE?]]**, or the like.

Remote control units **104** may be handheld units such as the remote control unit **104** depicted in FIG. 2B. **[[GLENN-I WOULD LIKE TO ADD A VIEW OF THE FACE OF THE IFB TO DEMONSTRATE HOW PLAYBACK IS INITIATED THEREFROM-IF YOU PROVIDE A HAND SKETCH OR PICTURE, WE WILL CONVERT IT TO A VISIO DRAWING]]** However, non-handheld embodiments are also envisioned such as tabletop models, personal computer ("PC") models, etc. Also, remote control unit **104** may be equipped with external interface **210** (FIG. 2A) to facilitate connection of remote control unit **104** to a PC, laptop PC, dumb terminal, or the like. Such an interface allows a user to control local audio devices **102** via a graphical user interface or other software that may operate on a larger user interface. Such an interface may provide more features and functions than that available on a portable, handheld device such as **[[GLENN-PLEASE**

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PROVIDE EXAMPLES]]

Turning next to FIG. 3, depicted is a block diagram of one embodiment of local audio device **102** in accordance with the present invention. In one aspect of the present invention, local audio devices **102** are digital, wireless audio transceivers. Such audio devices may be manufactured in the form of body-packs, such as those typically worn by news announcers, performers, and the like. In the depicted embodiment, local audio device **102** includes, *inter alia*, local receiver **302**, local transmitter **308**, local clock **304**, local recorder **306**, and local control unit **310**. Local audio devices **102** receive a time reference signal and digital commands from remote control unit **104** via local audio device receiver **302**. The time reference signal synchronizes local clock **304** to the master time reference signal transmitted by remote control unit **104** as described above.

Local recorder **306** of local audio device **102** locally records audio received via audio receiving device **312**. Audio receiving device **312** is also worn by the speaker and connects to local audio device **102** at audio input port **314**. The locally recorded audio is stored along with time code numbers that indicate when, during the live audio event, each segment of audio occurred in local memory **316**. The time code numbers are generated based upon the time provided by local clock **304**, which is synchronized with the master time reference signal transmitted by remote control unit **104**. Simultaneously, audio received from audio receiving device **312** is transmitted via local transmitter **308** to receiver **106** to allow live recording of the audio event.

Furthermore, in some embodiments of the present invention, local audio device **102** processes the received audio locally and feeds it back to the speaker. In such embodiments, locally generated audio is received by local transmitter **308** as described

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above and is input to a mixer such as mixer **318**. The locally generated audio may then be transmitted to the speaker through audio producing device **320** (e.g., headphones, earpiece, speaker, etc.), which may be connected to local audio device **102** via audio output port **322**. Alternatively, locally generated audio may be mixed with audio received from a remote location prior to transmission to audio producing device **320**.

Local memory **316** may be virtually any type of commercially available memory including, but not limited to, flash memory cards. Use of flash memory cards and the like allow local memories **316** to be easily removed and inserted into a PC or the like for electronic mixing of the recorded audio data. Such electronic mixing may be performed via commercially available software such as Pro Tools or the like and may be performed in addition to or in lieu of live wireless recording of the audio event.

In addition, whenever playback of locally recorded audio is required, remote control unit **104** transmits a digital command to all local audio devices **102** to playback the audio data stored in the respective local memories **316** that occurred starting with and subsequent to a specific time reference as indicated by a time code number. The digital command is received by local receivers **302**, which transmit or relay the command to their respective local control unit **310**. Thereafter, local control units **310** access the data stored in the respective local memory **316** and cause this data to be played or transmitted sequentially via local transmitter **308** starting with the data associated with the requested time code number. The use of time code numbers and synchronization of local clocks **304** with remote control unit **104** allow multiple local audio devices **102** to replay audio with the exact timing that occurred during the original transmission of the audio during the live audio event.

[[GLENN-HOW IS THE END OF THE PLAYBACK INITIATED? IS AN END TIME

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ALSO TRANSMITTED OR DOES IT PLAY UNTIL IT RUNS OUT OF DATA?]]

[[GLENN-WE NEED TO ADD INFORMATION REGARDING THE FUNCTION OF LOCAL CONTROL UNIT 310 – IF WE ARE INTENDING TO PATENT THE TRX900, THIS INFORMATION MUST BE DETAILED]]

Although local audio device **102** as depicted in FIG. 3 includes local audio recorder **306**, local memory **316**, local clock **304**, and mixer **318**, some embodiments of the present invention may omit one or more of these elements. For example, embodiments of the present invention are envisioned having mixer **318** without local audio recorder **306**, local memory **316**, and local clock **304**. In such an embodiment, synchronized playback may not be available, however, local audio feedback and mixing of local and remote audio shall be available. Similarly, embodiments of the present invention are envisioned having local audio recorder **306**, local memory **316**, and local clock **304** without mixer **318**. In such an embodiment, synchronized playback may be available, however, local audio feedback and mixing of local and remote audio shall not be available.

Referring back to FIG. 1, both live and replayed audio transmitted by local audio devices **102** may be received at receiver **106** and recorded by audio recorder **108**. Receiver **106** receives the wireless RF signals generated by all active local audio devices **102** (e.g., modulated RF carrier signals) and converts the signals to a format capable of being recorded by a commercially available recording device. In some embodiments, such commercially available recording devices utilize an SMPTE-compatible time code signal. Such formats include, but are not limited to… **[[GLENN-WHAT TYPE OF FORMATS??]] [[IS THERE SOMETHING UNIQUE ABOUT THIS CONVERSION FOR THIS INVENTION OR IS THIS RECEIVER A COMMERCIALLY AVAILABLE DEVICE?]]** After conversion to

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such a signal, audio may be recorded by recorder **108**, which may be any commercially available audio recorder including, but not limited to, Zaxcom, Inc.'s DEVA® recorder. The ability to playback audio and transmit this replayed audio along with an embedded time code signal allows recorder **108** to repair any problems that occurred during the original transmission of audio from local audio devices **102**. The embedded time code signal also allows recorder **108** to record the time code signals generated by local audio devices **102** along with the retransmitted audio. **[[GLENN-ARE THE TIME CODE SIGNALS EMBEDDED IN THE AUDIO OR ARE THEY CREATED IN THE RECORDER BASED UPON DIGITAL INFORMATION PROVIDED TO OR RECEIVED FROM THE IFB?]]**

In some embodiments of the present invention, receiver **106** automatically senses an error in transmission caused by, for example, a communication loss, interference, etc. **[[GLENN-IS THIS AUTOMATIC SENSING COMMONLY AVAILABLE OR A NOVEL ASPECT OF THE INVENTION?]]** Upon sensing a transmission error, receiver **106** transmits a request to remote control unit **104** requesting playback of the audio recorded locally on local audio devices **102** beginning at a time reference prior to the occurrence of the transmission error. **[[GLENN-DOES THIS MEAN THAT THE RECEIVER ALSO CONTAINS A CLOCK THAT IS SYNCHRONIZED WITH THE IFB?]] [[WHAT FORM DOES THIS SIGNAL TAKE? A DIGITAL DATA PACKET? WE SHOULD INCLUDE A BIT CHART OF THE DATA PACKET]]** In response, remote control unit **104** transmits a digital command to all local audio devices **102** to playback the audio stored in the respective local memory **316** that occurred subsequent to the time reference requested by receiver **106** in the manner described above with respect to FIG. 3.

Alternatively, playback may be requested manually by a user of a recording system such as recording system **100**. In this scenario, upon hearing that a transmission error (i.e., a loss of audio data) has occurred, the user manually prompts remote control unit **104** to transmit a digital command to all local audio devices **102** to playback the audio stored in local memory **316** that occurred subsequent to a time reference entered at remote control unit **104** by the user. **[[GLENN- I WOULD LIKE TO REFERENCE A FIG DEPICTING THE FACE/CONTROL PANEL OF THE IFB HERE]]** Such prompting may occur after the audio event ends or immediately upon hearing the transmission error. If the latter option is chosen, prompting playback of a specific segment of the audio event may index the local audio devices to store the requested data in a protected memory location until the end of the audio event to avoid disrupting the live recording. In this scenario, all requested audio shall be replayed after the performance ends. In embodiments of the present invention in which data is recorded in a loop (i.e., when memory is full, new data overwrites previously recorded data), writing the data to a protected memory location removes it from the loop and protects it from being overwritten.

[[GLENN-IS THIS THE FIRST WIRELESS MICROPHONE TO HAVE LOCAL RECORDING CAPABILITY? IF YES, WE SHOULD ADD CIRCUIT DIAGRAMS OR MORE DETAILED TECHNICAL INFORMATION RE HOW THE RX-900 IS ABLE TO RECORD LOCALLY – IF WE DO NOT, YOU CANNOT CLAIM PATENT PROTECTION FOR THIS – SO FAR WE ARE ONLY COVERING THE METHOD OF USING LOCAL AUDIO RECORDING TO AVOID DATA LOSS, BUT NOT THE ACTUAL ABILITY TO LOCALLY RECORD. WE HAVE THE SAME ISSUE IF THIS IS THE FIRST DEVICE TO INCLUDE A LOCAL RECEIVER. THE LEGAL STANDARD FOR BOTH OF THESE

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ITEMS IS THAT THERE MUST BE ENOUGH INFORMATION TO TEACH ONE OF SKILL IN THE ART TO CREATE A TRX900 WITH LOCAL AUDIO AND WITH A LOCAL RECEIVER – WE HAVE NOT ANSWERED THIS QUESTION]]

Turning next to FIG. 4, illustrated is a flow diagram of one embodiment of a process for recording audio in accordance with embodiments of the present invention. Process **400** begins at **402**. For example, at **402**, one or more speakers may each don a local audio device, such as local audio device **102** as described with respect to FIG. 2. Process **402** then proceeds to **404**.

At **404**, a control unit, such as remote control unit **104**, transmits a master time code reference signal to each local audio device, and process **400** proceeds to **406**. At **406**, each local audio device synchronizes its respective time clock with the master time code reference signal received from the control unit, thereby synchronizing all local audio device clocks. Process **400** then proceeds to **408**. At **408**, local audio devices begin recording audio. Local audio devices then transmit the recorded audio to receivers such as receivers **106** in real time, wherein all audio includes synchronized time code reference data (e.g., embedded time code numbers). The receivers may broadcast or record the data, or prepare it for broadcasting or recording by other equipment.

Process **400** then proceeds to **410**. At **410**, process **400** queries the initiation of audio replay. The initiation of audio replay may be manual or automatic. For example, if a user detects a loss of audio, the user may manually initiate audio replay beginning at the specific time code reference at which the transmission error occurred. Alternatively, if a loss of audio is automatically detected by the receiving equipment, a playback request may be sent from the receiving equipment to the control unit. In response, such control unit may

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command the local audio devices to replay or retransmit the missed audio to the receiving equipment.

[[GLENN- IS THE DETECTION OF A TRANSMISSION ERROR NOVEL? HOW IS THIS ERROR CONVERTED TO DATA THAT IS TRANSMITTED TO THE IFB??]]

If, at **410**, audio replay is not initiated either manually or automatically, process **400** returns to **408**. However, if, at **410**, audio replay is initiated, process **400** proceeds to **412**. At **412**, a control unit, such as remote control unit **104**, sends a signal to the local audio devices requesting playback of the stored audio starting at a specific time code number.

Next, at **414**, each local audio device processes the playback command and synchronizes playback to the time code reference contained in the playback command. In addition, at least one local audio device transmits the synchronization data to the receiving equipment (e.g., receiver **106**, recorder **108**, etc.) to synchronize recording of the replayed audio. Process **400** then proceeds to **416**. However, in alternate embodiments of the present invention, the receiving equipment and the local audio devices may simultaneously receive the synchronization and time reference data from the transmitting equipment (e.g., a control unit).

At **416**, one or more local audio devices transmit its respective stored audio starting with the audio that corresponds to the time specified by the time reference data. The receiving equipment simultaneously records the replayed audio at the same time reference point. That is, the receiving equipment may insert the replayed audio data that was not recorded during the live audio event due to wireless transmission errors into the original recording at the exact time at which the missed audio originally occurred, thereby compensating for any transmission losses. Process **400** then proceeds to **418**. At **418**, one

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or more local audio devices continue to replay audio while the receiving equipment re-records the audio.

At **420**, process **400** queries the status of audio replay. If, at **420**, the audio has been fully replayed, process **400** proceeds to **408**. At **408**, the local audio devices may record a new audio event or may replay a different segment of recorded data. Otherwise, if, at **420**, all requested audio has not been replayed or re-recorded, process **400** returns to **418**.

Turning next to FIG. 5, illustrated is a flow diagram of one embodiment of a process for locally mixing local feedback audio with audio received from a remote location in accordance with embodiments of the present invention. Process **500** begins at **502**. For example, at **502**, one or more speakers may each don a local audio device, such as local audio device **102** as described with respect to FIG. 2. Also, a director may be equipped with a control unit such as remote control unit **104**. Process **502** then proceeds to **504**.

At **504**, a control unit, such as remote control unit **104**, receives the audio generated by its user. In addition, the control unit receives instructions for mixing the audio received by the control unit with the audio generated locally at one or more local audio devices. Such instructions may be input via a keypad, voice recognition, or the like. The control unit then embeds the mixing instructions within the audio signal to create one single audio signal, and process **500** proceeds to **506**.

At **506**, the control unit transmits the single audio signal to one or more local audio devices. Process **500** then proceeds to **508**. At **508**, the local audio devices receive the single audio signal and process it to determine whether the local audio devices should be indexed to an interrupt or non-interrupt state. However, alternate embodiments are envisioned in which such a state may be set locally by the speaker or by either of the

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speaker or the director. If the local audio device is to be indexed to an interrupt state, process **500** proceeds to **510** at which the local audio device is indexed to the interrupt state. Alternatively, if the local audio device is to be indexed to a non-interrupt state, process **500** proceeds to **512** at which the local audio device is indexed to the non-interrupt state. **[[GLENN-THIS SHOULD BE EXPANDED AND ADDED TO THE HARDWARE SECTION – HOW ARE THE STATES INDEXED? IS DATA WRITTEN TO A REGISTER?]]**

Thereafter, process **500** proceeds to **514**. At **514**, the local audio device outputs the mixed audio signal (i.e., the combination of the locally received feedback audio and the remotely generated audio) as per the instructional data contained in the single audio signal. For example, such data may direct the local audio device to mix the remotely transmitted audio with the locally generated feedback audio through side tone injection, **[[ADD OTHER TYPES]]**, or the like. Finally, process **500** returns to **508**.

While the present invention has been described with reference to one or more embodiments, which embodiments have been set forth in considerable detail for the purposes of making a complete disclosure of the invention, such embodiments are merely exemplary and are not intended to be limiting or represent an exhaustive enumeration of all aspects of the invention. The scope of the invention, therefore, shall be defined solely by the following claims. Further, it will be apparent to those of skill in the art that numerous changes may be made in such details without departing from the spirit and the principles of the invention.

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