

WIRELESS MULTITRACK RECORDING SYSTEM

DETAILED DESCRIPTION

As required, a detailed illustrative embodiment of the present invention is disclosed
5 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
10 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
15 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
20 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**

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**.
5 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
10 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
15 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 TIMECODE
20 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

reference signal is a Society of Motion Picture and Television Engineers ("SMPTE") timecode signal containing information regarding the hour, minute, second, frame, type of timecode (i.e., nondrop or drop frame), and **???? [GLENN-WHAT TYPE OF USER DEFINABLE INFORMATION IS INCLUDED IN THIS SIGNAL??]** This time reference

5 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 timecode number as all other local audio devices **102**. The timecode number is then used during playback and recording to ensure that the replayed and recorded audio from all local audio devices **102** is

10 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

15 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

20 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

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**

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 memory **316**, analog-to-digital converter (“ADC”) **324**, digital-to-analog converter (“DAC”) **326**, 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. In some embodiments of the present invention, local clock **304** may include a voltage controlled oscillator, crystal oscillator, or the like.

Local memory **316** of local audio device **102** locally stores audio recorded by local control unit **310**. Local control unit **310** receives recordable audio from 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 timecode numbers that indicate when, during the live audio event, each segment of audio occurred in local memory **316**. The timecode 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 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 timecode 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 timecode number. The use of timecode 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 ALSO TRANSMITTED OR DOES IT PLAY UNTIL IT RUNS OUT OF DATA?]]

5 **[[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
10 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
15 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
20 **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 timecode 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

such a signal, audio may be recorded by recorder **108**, which may be any commercially

5 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 timecode

signal allows recorder **108** to repair any problems that occurred during the original

transmission of audio from local audio devices **102**. The embedded timecode signal also

allows recorder **108** to record the timecode signals generated by local audio devices **102**

10 along with the retransmitted audio. **[[GLENN-ARE THE TIMECODE 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.

15 **[[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**

20 **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
5 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**
10 **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
15 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
20 **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
ITEMS IS THAT THERE MUST BE ENOUGH INFORMATION TO TEACH ONE OF SKILL
5 IN THE ART TO CREATE A TRX900 WITH LOCAL AUDIO AND WITH A LOCAL
RECEIVER – WE HAVE NOT ANSWERED THIS QUESTION]]

Referring now to FIG. 4, illustrated is a flow diagram of one embodiment of a process
for operation of a local audio device such as local audio device **102** in synchronous
timecode generator mode in accordance with one embodiment of the present invention.

10 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 FIGS. 1 and
3. Also, a director may be equipped with a control unit such as remote control unit **104**.
Process **402** then proceeds to **404**.

At **404**, initialization occurs. During initialization, the local control unit such as local
15 control unit **310** or other form of central processing unit is reset. Thereafter, the local
transmitter, local receiver, ADC, DAC, sample rate generators, and local timecode generator
are initialized. The process then proceeds to **406**, at which the sampling rate of the ADC is
set. In some embodiments of the present invention, a sample rate of 48,000 Hz is
incorporated.

20 Next, at **408**, wireless receive channels are established between the local audio
device and one or more wireless devices such as remote control units (e.g., remote control
unit **104**), receivers, and audio recorders. To establish the channel, the local receiver of the
audio device receives one or more data packets from the remote wireless device and stores

the packets in a designated buffer. For example, when establishing wireless communication with a remote control unit, the local audio device may receive one or more data packets containing information such as a timecode timestamp, transport status command (i.e., current timecode and transport mode of a master recorder), and the like. These packet(s) are then stored in an RX buffer (i.e., a reserved segment of memory used to hold data while it is being processed). Process **400** then proceeds to **410**.

At **410**, the local control unit reads the timecode timestamp contained in the RX buffer and jam syncs the local timecode generator with the timecode. The jam sync synchronizes the local audio device with the remote control unit while allowing the local audio device to supply its own timecode. Local supply of synchronized timecode ensures proper timing during periods in which the remote control unit timecode data cannot be read (e.g., the remote control unit is temporarily unstable, wireless communication dropouts, etc.).

Next, at **412**, process **400** queries the transport status command stored in the RX buffer. If at **412**, the transport status command is stop, process **400** returns to **410**. However, if at **412**, the transport status command is record, process **400** proceeds to **414**. At **414**, a new audio file is created in memory (e.g., on a flash card) and the timecode is stored in the header of the newly created file. Process **400** then proceeds to **416**.

At **416**, the local control unit waits for an audio sample interrupt from the ADC. Once an audio sample interrupt occurs, process **400** proceeds to **418**. At **418**, the audio sample is retrieved from the ADC and stored in the local memory. In one aspect of the present invention, the audio sample is stored in the next available address of the local memory. Next, at **420**, the timecode generator counter is incremented, thereby indicating that the time period for one sample of audio has elapsed.

Process **400** then proceeds to **422**, at which the local control unit transmits the audio sample through the local transmitter to the other wireless devices such as remote control units, receivers, audio recorders, and the like. At **424**, process **400** queries the RF buffer of the local receiver to determine the availability of a new timecode packet. If at **424**, a new
5 timecode packet has not been received from the RF receiver, process **400** returns to **416**. However, if at **424**, a new timecode packet has been received, process **400** proceeds to **426**.

At **426**, process **400** executes a feedback loop algorithm, which modifies the speed of the local timecode generator as necessary to maintain its synchronization with the master
10 timecode generator (e.g., the remote control unit). This algorithm may be implemented using any one of a variety of methods. In one embodiment of the present invention, a feedback loop algorithm, such as process **500** depicted in FIG. 5, modulates a low-pass filtered feedback error voltage that is supplied by the local control unit to the local oscillator. The local oscillator then controls the sample rate of the ADC and the timecode generator by
15 supplying the feedback error voltage to the ADC's and timecode generator's clock control inputs.

Referring now to FIG. 5, the feedback loop algorithm begins at **502**. At **504**, the current timecode is retrieved from the timecode generator such as timecode generator **304** and is written to the variable "TCgen". Process **500** proceeds to **506**. At **506**, the current
20 timecode is retrieved from the RX buffer of the local receiver and is written to the variable "TCrx" and process **500** proceeds to **508**. At **508**, variable "TCdiff" is calculated by subtracting TCrx from TCgen. Process **500** then proceeds to **510**, at which process **500** compares TCdiff to zero. If, at **510**, TCdiff is less than zero, process **500** proceeds to **512**,

at which the feedback error voltage supplied to the local oscillator DAC by the local control unit is increased above the previously supplied feedback error voltage. The local oscillator DAC then supplies the new feedback error voltage to the local oscillator, which, in turn, supplies a new clock input voltage to the local timecode generator and ADC. In this manner, the speed of the local timecode generator is increased to maintain synchronization with the master timecode generator.

Alternatively, if at **510** TCdiff is not less than zero, process **500** proceeds to **514**, at which TCdiff is analyzed to determine if it is greater than zero. If yes, process **500** proceeds to **516** and the feedback error voltage supplied to the local oscillator DAC by the local control unit is decreased below the previously supplied feedback error voltage. The local oscillator DAC then supplies the new feedback error voltage to the local oscillator, which, in turn, supplies a new clock input voltage to the local timecode generator and ADC. In this manner, the speed of the local timecode generator is decreased to maintain synchronization with the master timecode generator.

If TCdiff is neither less than zero as determined at **510** or greater than zero as determined at **514**, then TCdiff is equal to zero. In this scenario, the local and master timecode generators are perfectly synchronized and, therefore, no adjustment is made to the speed of the local timecode generator. At this point, process **500** ends at **518**.

Although FIG. 5 depicts one method of performing a feedback loop, many variations of this feedback loop may be substituted without departing from the scope of the present invention. For example, the feedback loop may be implemented as a digital phased locked loop that re-samples the audio in a manner that simulates a hardwired feedback loop as discussed in greater detail below with respect to FIG. XX.

Referring back to FIG. 4, after execution of the feedback loop algorithm at **426**, process **400** proceeds to **428**. At **428**, the local timecode generator is jam synced with the newly received timecode timestamp read from the RX buffer. Next, process **400** optionally proceeds to **430**, at which a timecode sample is stored as an escape sequence in the next available address of the local memory. Process **400** then proceeds to **432**. At **432**, process **400** queries the continuous loop record mode. If at **432** the continuous loop record mode is enabled, process **400** returns to **416** to wait for an audio sample interrupt from the ADC as discussed above. However, if at **432**, the continuous loop record mode has not been enabled, process **400** proceeds to **434**. At **434**, process **400** queries the transport status. If at **434** the transport status is record, process **400** returns to **416** to wait for an audio sample interrupt from the ADC as discussed above. However, if at **434**, the transport status is stop, process **400** returns to **410**, at which process **400** continuously jam syncs the local timecode generator with the timecode timestamps received in the RX buffer until the transport status changes from stop to record at **412**.

Turning next to FIG. 5, illustrated is a flow diagram of one embodiment of a process for interpolation of a flash card audio and timecode stream using re-sampling 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**, determines the starting and
5 ending timecode and stores the data in the variables TimeCodeStart and TimeCodeEnd, respectively. Process **500** proceeds to **506**. At **506**, a variable, i, is initialized to a value of zero. The variable i is the index that corresponds to the position of data points in a data array represented by the variable AudioSample[i]. Process **500** then proceeds to **508**.

At **508**, process **500** begins an iterative search for the audio file that matches the
10 desired starting timecode of the output file by comparing the value of TimeCodeStart with the value of AudioSample[i]. If, at **508**, the value of TimeCodeStart is equal to the value of AudioSample[i], process **500** proceeds to **512**. However, if at **508**, the value of TimeCodeStart is not equal to the value of AudioSample[i], process **500** proceeds to **510**. At **510**, the variable i is increased by a value of one thereby allowing the value located in the
15 next position of the audio sample array to be compared to the value of TimeCodeStart when process **500** then returns to **508**.

Thereafter, process **500** proceeds to **512**. At **512**, a variable, n, is initialized to a value of zero. The variable n is added to the variable i to allow remote control unit **104** to continue to traverse the audio sample array while maintaining the location of the audio
20 sample at the starting timecode, represented by the variable AudioSample[i]. Process **500** then proceeds to **514**. At **514**, the value of AudioSample[i+n] is compared to the value of TimeCodeEnd. If at **514**, the value of AudioSample[i+n] is greater than or equal to the value of TimeCodeEnd, process **500** proceeds to **516**. At **516**, the value of AudioSample[i+n]

again is compared to the value of TimeCodeEnd. If at **514**, the value of AudioSample[i+n] is greater than the value of TimeCodeEnd, process **500** process to **526** where process **500** terminates. However, if at **516**, the value of AudioSample[i+n] is equal to the value of TimeCodeEnd, process **500** proceeds to **522**.

5 Conversely, if at **514**, the value of AudioSample[i+n] is less than the value of TimeCodeEnd, process **500** process to **518**. At **518**, the value of AudioSample[i+n] is compared to the value of TimeCodeEscapeSequence. If, at **518**, the value of AudioSample[i+n] is not equal to the value of TimeCodeEscapeSequence, process **500** proceeds to **520** where the variable n is increased by one and process **500** returns to **514**.
10 However, if at **518**, the value of AudioSample[i+n] is equal to the value of TimeCodeEscapeSequence process **500** proceeds to **522**.

 At **522**, the sample rate is calculated by subtracting the value of the time stamp of AudioSample[i] from the value of the time stamp of AudioSample[i+n] and dividing by n. The sample rate is then stored in the variable SampleRate and process **500** proceeds to
15 **524**. At **524**, AudioSamples[i] through AudioSamples[i+n] are re-sampled using the sample rate calculated in **522**.

 Process **500** then returns to **520**. The iterative process continues until the value of AudioSample[i+n] is greater than the value of TimeCodeEnd, whereby process **500** proceeds to **526** where process **500** terminates.

20 Referring now to FIG. 6, illustrated is a flow diagram of one embodiment of a process for operation of a local audio device such as local audio device **102** in non-synchronous timecode generator mode in accordance with embodiments of the present invention. Process **600** begins at **602**. [[For example, at **602**, 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 **602** then proceeds to **604**.

At **604**, a control unit, such as remote control unit **104**, read the transport status and
5 timecode from the RX buffer. Process **600** proceeds to **606**. At **606**, process **600** queries the transport status. If at **606**, the transport status is stop, process **600** returns to **604**. However, if at **606**, the transport status is record, process **600** proceeds to **608**. At **608**, a new audio file is created on the flash card and the timecode is stored in the file's header. Process **600** then proceeds to **610**.

10 At **610**, control unit **104** waits for audio sample interrupt from then ADC. Once audio sample interrupt occurs, process **600** proceeds to **612**. At **612**, the audio sample is received from the ADC and stored in the next available address on the flash card. The audio sample interrupt from ADC is then transmitted at **614** and process **600** proceeds to **616**. At **616**, process **600** queries the availability of a new timecode packet from the RF receiver. If at
15 **616**, a new timecode packet has not been received from the RF receiver, process **600** returns to **610**. However, if at **616**, a new timecode packet has been received from the RF receiver, process **600** proceeds to **618**.

At **618**, the timecode sample is stored as an escape sequence in the next available address in the flash card and process **600** proceeds to **620**. At **620**, process **600** queries
20 the record mode status. If at **620**, the record mode status is continuous loop record mode, process **600** returns to **610**. However, if at **620**, the record mode status in not continuous loop record mode, process **600** proceeds to **622**. At **622**, process **600** queries the transport status. If at **622**, the transport status is record, process **600** returns to **610**. However, if at

620, the transport status is stop, process **600** returns to **604**.

Referring now to FIG. 7, illustrated is a flow diagram of one embodiment of a process for separating files based on directory listing of the master recorder in accordance with embodiments of the present invention. [[Process **700** begins at **702**. For example, at **702**,
5 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 **700** then proceeds to **704**.

At **704**, a control unit, such as remote control unit **104**, receives an audio file directory listing from the master recorder's disc. Process **700** proceeds to **706**. At **706**, remote control unit **104** determines the starting and ending timecode and stores the data in the
10 variables TimeCodeStart and TimeCodeEnd, respectively, and process **700** proceeds to **708**. At **708**, a variable, x, is initialized to a value of zero. The variable x is the index that corresponds to the position of data points in a data array represented by the variable AudioSample[x]. Process **700** then proceeds to **710**. At **710**, the variable x is increased by one and process **700** proceeds to **712**. At **712**, process **700** compares the value of
15 TimeCodeStart to the value of AudioSample[x]. If at **712**, the value of TimeCodeStart is not equal to the value of AudioSample[x], process **700** returns to **710**. However, if at **712**, the value of TimeCodeStart is equal to the value of AudioSample[x], process **700** proceeds to **714**.

At **714**, AudioSample[x] is extracted and process **700** proceeds to **716**. At **716**, the
20 variable x is increased by one and process **700** proceeds to **718**. At **718**, process **700** compares the value of TimeCodeEnd to the value of AudioSample[x]. If at **718**, the value of TimeCodeEnd is not equal to the value of AudioSample[x], process **700** returns to **714**. However, if at **718**, the value of TimeCodeEnd is equal to the value of AudioSample[x],

process **700** proceeds to **720**. At **720**, AudioSample[x] is extracted and process **700** proceeds to **722** where process **700** terminates.

Turning next to FIG. 8, illustrated is a flow diagram of one embodiment of a process for recording audio in accordance with embodiments of the present invention. Process **800** begins at **802**. For example, at **802**, 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 **800** then proceeds to **804**.

At **804**, a control unit, such as remote control unit **104**, transmits a master timecode reference signal to each local audio device, and process **800** proceeds to **806**. At **806**, each local audio device synchronizes its respective time clock with the master timecode reference signal received from the control unit, thereby synchronizing all local audio device clocks. Process **800** then proceeds to **808**. At **808**, 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 timecode reference data (e.g., embedded timecode numbers). The receivers may broadcast or record the data, or prepare it for broadcasting or recording by other equipment.

Process **800** then proceeds to **810**. At **810**, process **800** 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 timecode 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 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 **810**, audio replay is not initiated either manually or automatically, process **800** returns to **808**. However, if, at **810**, audio replay is initiated, process **800** proceeds to **812**. At **812**, 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 timecode number.

Next, at **814**, each local audio device processes the playback command and synchronizes playback to the timecode 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 **800** then proceeds to **816**. 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 **816**, 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 **800** then proceeds to **818**. At **818**, one or more local audio devices continue to replay audio while the receiving equipment re-

records the audio.

At **820**, process **800** queries the status of audio replay. If, at **820**, the audio has been fully replayed, process **800** proceeds to **808**. At **808**, the local audio devices may record a new audio event or may replay a different segment of recorded data. Otherwise, if, at **820**,
5 all requested audio has not been replayed or re-recorded, process **800** returns to **818**.

Turning next to FIG. 9, 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 **900** begins at **902**. For
10 example, at **902**, 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 **900** then proceeds to **904**.

At **904**, 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
15 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 **900** proceeds to **906**.

At **906**, the control unit transmits the single audio signal to one or more local audio
20 devices. Process **900** then proceeds to **908**. At **908**, 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

speaker or the director. If the local audio device is to be indexed to an interrupt state, process **900** proceeds to **910** 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 **900** proceeds to **912** at which the local audio device is indexed to the non-interrupt

5 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 **900** proceeds to **914**. At **914**, the local audio device outputs the mixed audio signal (i.e., the combination of the locally received feedback audio and the
10 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 **900** returns to **908**.

While the present invention has been described with reference to one or more
15 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
20 changes may be made in such details without departing from the spirit and the principles of the invention.